Genuine Progress Index for Atlantic Canada / Indice de progrès véritable - Atlantique

MEASURING SUSTAINABLE DEVELOPMENT

APPLICATION OF THE GENUINE PROGRESS INDEX TO NOVA SCOTIA

THE ENERGY ACCOUNTS *for the* NOVA SCOTIA GENUINE PROGRESS INDEX

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EXECUTIVE SUMMARY

Introduction: Energy and the GPI Framework

Energy is essential to all life on earth. Whether as nourishment to sustain individual organisms or as fossil fuels to run modern societies, every activity on earth is dependent on a constant, abundant, reliable source of energy. An interruption to modern energy supplies can have serious consequences for economy and society, jeopardizing current standards of living. But the intensive use of energy, especially that obtained from fossil fuels, is also the primary cause of a number of environmental, social, and economic concerns. Current energy production and consumption patterns have been linked to global climate change, local health impacts, and regional impacts such as air and water pollution, damage to marine and other wildlife, land-use conflicts, security implications, resource depletion, and soil contamination. Until recently however, attention has been given predominantly to developing new fossil fuel based energy sources and securing existing ones, with little regard for the health and environmental impacts these create. The benefits of abundant supply were considered to outweigh the social and environmental costs of maintaining that abundance. When those costs are included in the equation, as in this study, the current model is seen to be unsustainable.

The failure to count full benefits and costs, and thus to evaluate energy supply and demand accurately and comprehensively, stems largely from the fact that conventional economic theory sees the human economy as a closed system in which firms produce and households consume. That assumption is the basis for calculating the GDP and the economic growth rates on which we currently, and mistakenly, base our assessments of prosperity and social wellbeing. In addition to ignoring production of goods and services and capital items that traditionally have no market value, the conventional assumption is flawed in an even more fundamental way. The human economy is not a closed system. It exists as a sub-system within, and completely dependent upon, an encompassing ecosystem that provides vital life-support services to human society. The energy and matter that enter the human economy from the ecosystem also return to the ecosystem, partly as waste. The capacity of the ecosystem to absorb that waste in turn affects the functioning of the human economy. The conventional view that ignores the dynamic interaction between the human economy and the encompassing ecosystem on which the economy depends helps perpetuate our unsustainable energy system.

By contrast, the GPI accounts acknowledge the reality of that dynamic interaction and define wealth more broadly to include valuations of natural capital, social capital, and human capital in addition to the conventional produced capital. This report starts with physical indicators of progress towards a sustainable energy sector and examines trends over time to assess whether energy use is becoming more or less sustainable. An economic valuation of some of the full costs of energy use follows the presentation of these indicators; but the underlying physical indicators, rather than the economic valuation, provide the direct means to track progress. This is because environmental restoration measures such as greenhouse gas and pollutant reductions are defensive expenditures that may be interpreted either as compensation for past damage or as positive investments in natural capital. Measures of genuine progress therefore always rely on the underlying physical indicators on which the economic valuations are based.

While the GPI is being developed here as a macro-economic and social measurement instrument that can establish benchmarks of progress for Nova Scotia, the GPI method also has practical utility at the micro-policy or project level. Unlike conventional assessment tools that are not capable of factoring long-term social and environmental impacts into the cost-benefit equation, the GPI is based on "full-cost accounting" principles that are essential to promote optimal economic efficiency. At the micro-level, the GPI can therefore be used to evaluate program effectiveness in a more comprehensive way than conventional instruments that account only for market interactions. Thus, the methods outlined in this report can also be used to assess whether particular policies designed to implement the recommendations noted above and to move the province towards a more sustainable energy system are working or not.

GPI Energy Accounts

The GPI Energy Accounts are organized in nine chapters:

- Chapter 1 provides an overview of the GPI approach as it applies to energy, examines sustainability principles, and defines sustainable energy.
- Chapter 2 provides a snapshot of the current energy system in Nova Scotia.
- Chapter 3 is an overview of the social, economic, and environmental impacts of energy use.
- A discussion about indicators, indicator frameworks, and indicator selection criteria used in this report is contained in Chapter 4.
- Chapters 5-7 provide detailed discussions and time series for some of the indicators identified in Chapter 4 and for some of the impacts discussed in Chapter 3, They also provide some information on additional economic and institutional aspects of energy use.
- Using the data presented in Chapters 5-7, Chapter 8 provides estimates on the monetary costs of our current energy choices.
- Chapter 9 is the most important chapter for policy makers and concerned citizens as we summarize the main findings of the report and make recommendations on three levels: first, how to improve and expand this report on genuine progress in the energy sector in the future; second, to identify where more research is needed and where new data need to be collected in order to track sustainability in the energy sector more effectively; and third, to point towards policy actions that can achieve greater energy sustainability.

The term energy in this report refers principally to the power used by Nova Scotian society for electricity, heat, and industrial processes. Transportation is also a fundamental component of the energy sector but is not discussed extensively in this report, as it has been presented separately in the **GPI***Atlantic* Transportation Accounts.

Energy Overview

As in most parts of the world, energy demand in Nova Scotia is heavily dependent on fossil fuels. Almost 70% of demand in the province is for oil products while electricity (mostly from coal) accounts for 21%. Some indigenous resources are used here, such as biomass for heating and hydro for electricity, but these amount to less than 10% of final demand. All of the province's oil is imported and only a small portion of the province's electricity is generated with domestic fuels. Although the province has some natural gas reserves that have been tapped since 1999, production has been in decline for the past three years and only a small fraction of the gas is used domestically. Domestic coal production declined substantially in the 1990s and amounted to only 32 kilotonnes in 2003. Imported coal is the dominant fuel used to generate electricity, representing about 75% of the fuel mix in 2001. While significant domestic coal reserves remain, these are not currently being extracted, primarily for economic reasons. In addition, the damage to land, water, and air from coal extraction and combustion make this an undesirable fuel from an environmental point of view.

Currently about 9% of electricity in the province is generated from renewable energy sources - mainly hydro and tidal power and more recently some wind. Hydro power is not expected to expand significantly because the best sites have already been used. Nova Scotia's geography and climate provide a favourable wind regime. However, wind only produces a fraction of a percent of the province's primary energy. Similarly, geo-thermal and solar energy remains untapped with only a handful of mine-water systems in the Springhill area, some residential heat-pumps, and a few homes and businesses using solar applications. Wood provides heat for an estimated 100,000 homes in Nova Scotia while a number of large industrial and institutional facilities use wood for heating and energy needs.

End use demand is attributable to (in descending order) the transportation, residential, industrial, commercial, public administration, and agricultural sectors. Energy demand in Nova Scotia declined rapidly in the early 1980s due to the 1970s oil crises. The fact that energy use levels in Nova Scotia have remained below the highs of the 1970s is a positive indicator from the perspective of sustainability. However, since 1991 end use energy demand has increased 12%. Although data are suppressed for the total amount of energy used in the province, it appears that at the current per capita energy use level, Nova Scotians are among the highest energy users in the world, well above the average for OECD nations.

The current dependence on non-renewable and polluting fossil fuels in Nova Scotia indicates a highly unsustainable energy system. Sustainable energy is defined in this report as an energy system that provides "adequate energy services for satisfying basic human needs, improving social welfare and achieving economic development throughout the world without endangering the quality of life of current and future generations of humans or other species." In addition, a sustainable energy system is one based on replenishable resources with a minimised waste stream that does not exhaust the absorptive capacity of the biosphere. In general, a sustainable energy system includes the following components:

- Reducing demand for and dependence on conventional energy supplies (i.e. fossil fuels and nuclear energy) through changes in consumption patterns, including changes in individual, household and social behaviour and more efficient use of energy;
- A greater reliance on renewable sources of energy;
- Using cleaner sources of conventional energy, such as natural gas, as a bridging fuel and developing ways to reduce the impact of more polluting sources.

From the perspective of the principles of sustainability and particularly of inter-generational equity outlined in this report, it is clearly not ideal to rely on non-renewable energy sources to any extent, as current consumption habits are *ipso facto* denying future generations a source of cheap energy and a feedstock for a host of products. However, a "cold turkey" switch to complete reliance on renewable energy sources is also not possible or realistic. Therefore, the key mark of a sustainable energy system in the present, which honours the principle of inter-generational equity, is the continued use of non-renewable energy supplies at such a rate as allows their gradual replacement by affordable and renewable alternatives.

Indicators of Energy Sustainability

Measurement is needed to determine if our energy system is moving us towards or away from a healthier society, a cleaner environment, and a more robust economy, and also to identify what institutional decisions in the energy sector are achieving or hindering the attainment of these objectives. This study identified and assessed 30 indicators to measure progress in the energy sector in Nova Scotia. The indicators were grouped into the following categories: socio-economic, health and environment, and institutional. Only two of the 30 indicators (particulate matter and mercury emissions) are showing clear signs of progress towards sustainability based on the definition of sustainability presented, and even in those two cases, emissions levels remain unacceptably high.

Socio-Economic Indicators

Approaches to energy service delivery must allow economic activities to continue without harming human health or the environment. The types of energy used and produced, where it comes from, its costs, the jobs created, and the reliability and affordability of supply, are all important factors to consider when examining the relationship between energy and economy. The indicators developed for this section are summarised in Table E1.

Table E1. Overview of socio-economic indicators

Area of Concern	Indicators
Energy production and supply	1. Current energy mix - total units per year by primary fuel type 2. Units of primary energy produced in the province vs. units of imported energy by fuel type 3. Percent of electricity generated from renewable sources, natural gas, and other fuels
Energy consumption (by end use and fuel type)	4. Total energy consumption by fuel type 5. Total energy consumption by end use
Energy efficiency	6. Equipment efficiency 7. Building efficiency 8. Process efficiency (in industry) 9. Electricity generation and transmission efficiency (I.e. Improve the input:output ratio in energy production and use in all these areas.)
Employment	10. Number of person months employed on energy-related jobs (by industry – direct and indirect employment) 11. Number of person months lost due to energy industry accidents
Affordability	12. Percentage of households living in fuel poverty
Reliability	13. Number of household hours per year without power 14. Business hours lost due to power failure

There is a serious lack of data at the provincial level concerning the socio-economic aspects of energy production and use, including total primary energy, fuel poverty, energy efficiency, subsidies, and employment costs and benefits. The limited available information in these areas suggests the following trends: In terms of affordability and security, energy prices over the last two decades remained relatively stable until recent oil price increases revealed the vulnerability of dependence on imported supplies that will become increasingly insecure, costly, and unstable with the impending advent of peak oil production. Despite a paucity of information on energy efficiency in the province, the available data suggest that minimal progress has been made over the last two decades. There was insufficient information to identify trends for the other socio-economic indicators, and improved data collection and monitoring are needed to assess the socio-economic sustainability of the energy system accurately.

Health and Environmental Indicators

The production and consumption of energy, regardless of the source, always has some impacts on human health and the environment. However, not all forms of energy have equal effects, with some sources having far fewer or less intense impacts than others. Choices between different energy options require that advantages and disadvantages be accurately weighed, and indicators provide a key means of doing that. The environmental and health indicators developed in this report are presented in Table E2. Air pollutant and greenhouse gas (GHG) emissions were the only ones that could be fully developed based on existing data sources. Although most pollutant emissions from the energy sector have been decreasing over the long term, Nova Scotia remains one of the highest per capita emitters of all these pollutants in the OECD. High domestic emissions combine with transboundary pollution to produce continued acid deposition damage to forests and waterways and incidences of elevated ground-level ozone in the province.

Table E2. Summary of selected health and environment trends (pollutant and GHG emissions) for the energy sector

Indicator	30-Year Trend	10-Year Trend	Movement Towards Sustainability[c]
CO emissions total[a]	Unknown	Unknown	?
TPM emissions total	Decreasing	Decreasing	Yes
SO_x emissions total	Decreasing	Increasing	No
NO_x emissions total[b]	Decreasing	Increasing	No
VOCs emissions total[a]	Unknown	Unknown	?
Mercury emissions total	Unknown	Decreasing	Yes
GHG emissions total	Unknown	Increasing	No

Notes: a) Changes in emissions estimates attributable to changes in data reliability make actual trends unclear. b) Recent emission increases following historical declines indicate new measures are needed to ensure continuing improvement. c) "Sustainability" is used here in a relative sense only to indicate the directionality of trends. It is not used here to signify that current emissions levels are sustainable by any more absolute standard.

High energy-related air pollutant emissions in Nova Scotia are due primarily to two factors: the dominance of coal-fired electricity generation and the use of wood for home heating. The use of coal is largely responsible for the elevated emissions of sulphur oxides (SO_x), nitrogen oxides (NO_x), mercury (Hg), and to some extent GHGs. NSPI is the 4th largest emitter of air pollutants in Canada and has three of the top four most polluting coal-fired power plants in terms of acid gas emissions on a per MWh basis (Energy Probe, 2005; PollutionWatch, 2005). Nova Scotia's per capita SO_x emissions from stationary energy sources alone are seven times the level of the rest of the country and four times higher than the OECD average *total* SO_x emissions from all sources. Wood combustion produces elevated emissions of carbon monoxide (CO), total particulate matter (TPM), and volatile organic compounds (VOCs). As a locally available renewable source of energy, wood may be a desirable source of energy from a sustainability perspective. However, provincial and federal standards are needed for wood burning devices in order to reduce harmful emissions that not only affect local ambient air quality but may also lead to poor indoor air quality. There are technical solutions to greatly reduce the levels of air pollutant emissions from coal burning. However, there are many impacts from the mining stage, to the release of greenhouse gases, to the disposal of toxic ash that currently have no or only partial solutions.

The indicators noted here represent only those for which enough information is available to track trends. Unfortunately, the effects of our energy use on land and water quality, on land use, on terrestrial and aquatic ecosystems, and on peoples, soils, water and air in other countries remains largely unknown due to lack of research and data in these areas. Some of these other impacts are broadly discussed in Chapter 3.

Institutional Indicators

Institutional indicators provide a means for institutions to assess how well they are managing the interactions between the economy, society and the environment and how they themselves measure up against the sustainability goals and targets that they propose for society as a whole. They also provide the enabling framework for sustainable development, because they assess the effectiveness of the underlying rules and organizational structures that direct society in a sustainable direction. Institutional indicators related particularly to governmental action in the energy field cover four areas – leading by example, creating societal change, reporting, and evaluating (see Table E3).

It is hoped that the development of these institutional indicators will strengthen the role of the Nova Scotia government both in setting the rules and targets for a sustainable energy system and in ensuring that these rules and targets are implemented, supported by financial instruments, and enforced when necessary.

Table E3. Summary of institutional indicators for the energy sector

Area of interest/concern	Indicators
Institutional	
Leading by example	Internal government efforts to promote sustainable energy: • Green energy procurement • Ensuring energy efficient government buildings
Creating societal change	Regulatory, educational and fiscal measures: • Incentives for sustainable energy use and disincentives for excess consumption and unsustainable use • Efforts to educate the public about sustainable energy options • Enforcement of regulations and standards
Reporting	Overseeing energy sector activities while ensuring transparency and equity: • Target setting and progress reporting • Level of indicator development
Evaluation	Efforts to monitor and improve how government addresses energy concerns: • Integration within government departments and among levels of government

While some policies in Nova Scotia do address the impacts of energy production and use on the larger economy, on society, and on the natural environment, many policies are also outdated and require reassessment. Moreover, there is a void in terms of data and indicator development for these important institutional factors. The evidence that does exist indicates that provincial and federal governments have thus far made inadequate effort to address the heart of our unsustainable energy system, including high and increasing demand levels, and the dominance of limited, polluting, and non-renewable fossil fuels.

The Full Cost of Energy

Environmental or "full-cost" accounting attempts to provide a more accurate and comprehensive picture of the full or true costs of economic activity by assigning explicit value to externalities. For example, some of the effects of pollutant emissions on health and on changes in environmental quality can be assessed in pecuniary terms if there are demonstrated impacts on health care expenditures, productivity losses, pollution cleanup expenses, lost recreational opportunities, and other such costs. Other environmental externalities include oil spills that contaminate water and cause wildlife destruction; degradation of habitat and soil erosion due to poor forestry practices; and acid drainage from coal mines. Some of the "damages" accounted for may not result in immediate costs to the dollar economy as full costing exercises often include estimates of what individuals will pay to protect a resource or be compensated for its loss. Likewise some of the damages will occur in the future or in other geographic locations.

The economic valuation of Nova Scotia's energy system in this report was only able to produce monetary dollar values for a limited number of currently unaccounted impacts, including greenhouse gases (GHG) and a number of air pollutants. A number of other important costs were not included in the valuation either because physical data were not available or because costing methodologies were not sufficiently developed. Potential valuation methods and examples of monetary estimates have been referenced and described where relevant for affordability, energy security, resource consumption and depletion, subsidies, employment and land use.

Total damage costs resulting from air pollutant and GHG emissions attributable to energy use in Nova Scotia were calculated to lie between $387 million (low estimate) and $2.5 billion (high estimate) in 2000, depending on assumptions and methodologies used. These are presented in Table E4. As the higher-end estimates include the costs of shocks, catastrophic damages, and massive produced and natural capital infrastructure loss, such as occurred recently in Hurricane Katrina, it is not difficult to see that the potential climate change damage costs attributable to greenhouse gas emissions, as predicted by some scientists and economists, can be very high.

Table E4. Nova Scotia stationary energy-related air pollutant and GHG damage cost estimates, 2000

Pollutant	Emissions (tonnes)	Low Estimate		High Estimate	
		$C2000/tonne	Damage Costs	$C2000/tonne	Damage Costs
CO	52,782	$2	$105,560	$6	$316,690
TPM	14,467	$2,120	$30,670,040	$5,180	$74,939,060
SOx	146,621	$1,380	$202,336,980	$10,500	$1,539,520,500
NOx	30,547	$1,410	$43,071,270	$12,450	$380,310,150
VOCs	11,474	$2,000	$22,948,000	$8,240	$94,545,760
Hg	0.267	$8,180,400	$2,184,160	$11,521,500	$3,076,240
GHG	13,750,000	$6.27	$86,212,000	$36.55	$502,562,000
Total			**$387,528,000**		**$2,595,270,000**
Per Capita			**$415**		**$2,779**

Notes: Monetary estimates for damage costs were adjusted for inflation and converted to Canadian dollars from the foreign currencies used in the literature. The first column heading "pollutant" applies literally to the first six categories of emissions but not to the seventh (GHGs). Cost estimates for GHGs are the net present value of projected climate change damage costs attributable to greenhouse gas emissions, but the latter are not literally considered a "pollutant."

Full-cost accounting is a challenging endeavour that may yield results that are contentious, complex and incomplete, and that vary considerably depending on the assumptions employed. Costs will vary from place to place because there are many national and regional variations that affect the full value of energy choices. Because of these and other challenges, a "full" cost accounting of energy production and use in Nova Scotia is simply not possible at this preliminary stage, and this report is only able to point to a few key costs of energy that are not considered in conventional accounting mechanisms. Despite the uncertainties and the preliminary nature of the data in this report, this initial attempt at economic valuation is a vitally important exercise, since not assigning a value to non-market goods and services implies that they have zero monetary worth (which is highly inaccurate).

Conclusions and Recommendations

The evidence presented in this document shows quite clearly that Nova Scotia is not making significant or adequate progress towards sustainability in its energy system, and that the production and use of energy are the leading causes of a number of serious environmental problems. But energy is also a vital component of a healthy society and vibrant economy. Balancing the tradeoffs between environmental health, social wellbeing, and economic development is not an easy task but one that must be undertaken if we are to protect the environment and the health and wellbeing of Nova Scotians. Based on the principles of sustainability established in this report, the evidence makes it clear that the Nova Scotia energy system does not:

- Achieve inter-generational equity since non-renewable resources are being depleted at faster rates than they can be replaced by other energy sources, thereby depriving future generations of 'cheap' energy sources;
- Respect the carrying and absorptive capacity of the earth, since per capita air pollutant and greenhouse gas emissions and other wastes resulting from the energy sector in Nova Scotia are extremely high by OECD standards, and are causing serious and potentially irreversible damage to land, air, and water;
- Adhere to the precautionary principle, since where there are threats of serious or irreversible damage, lack of full scientific certainty is often still used as a reason for postponing measures to prevent environmental degradation;
- Internalize negative externalities, since polluters do not generally pay for the damage they create;
- Take both qualitative and quantitative integrity into consideration since the current system is not concerned to leave both ample supplies and high quality forms of energy for future generations. Sustainability requires that energy sources are matched both in scale and in energy quality to end use needs so that both quantity and quality are ensured;
- Adequately address both the supply and demand side in energy management. Suggested and enacted regulatory measures are incomplete and fail to ensure that both producers *and* consumers of energy take responsibility for the consequences of their actions and of their consumption patterns by reducing overall energy demand and providing the remaining consumption needs through environmentally and socially benign processes.

The definition and principles of a sustainable energy system require action on two main levels. First, there must be ample investment in renewable energy development and deployment in order to accelerate sharply the rate of its adoption and use. Equally importantly, the current rate of non-renewable energy consumption must be drastically slowed to delay the advent of peak oil production and the end of cheap non-renewable supplies, and to decelerate and then reverse the serious environmental consequences of fossil fuel combustion including climate change and air pollution. This can be achieved by concerted conservation efforts and sharp efficiency improvements, both of which can also reduce costs or at least absorb gradual price increases.

While acknowledging the improvements (reductions) in energy-related air pollutant emissions over the past 30 years; the small but growing renewable energy industry; and other efforts towards greater sustainability in the energy field outlined in this report, the evidence indicates the need for much more concerted and effective movement towards a truly sustainable energy system. Recommendations to this end have been provided in five areas: data needs; goals and targets; energy supply and demand; institutional actions; and future research.

For many of the social, economic and environmental impacts of energy use there is still little or no adequate data. These gaps make it impossible to assess progress towards energy sustainability fully and properly, and increase the likelihood that policy and economic decisions will be based on inadequate data, information and knowledge; that past mistakes will be repeated; and that existing environmental and social problems will be compounded. While this study attempts to compile and synthesize existing energy-related data for Nova Scotia and thereby to paint a more comprehensive portrait of the energy picture in Nova Scotia, the evidence in this report indicates the need for a much deeper strategic commitment by government and other institutions to collect, analyze and publish essential data on a more regular basis.

Creating a sustainable energy system in Nova Scotia is not unattainable. What is needed is visionary and practical leadership that will establish clear goals towards which we can work that will both increase the portion of energy that comes from renewable sources and decrease overall energy demand. To achieve these two basic goals, concerted action is needed on many fronts. This is not the responsibility solely of governments or the energy industry. Nor does the solution lie only in producing more renewable energy, for renewable energy has social, economic and environmental impacts as well, and there are limits to the amounts that can be produced. We must also address demand, which creates responsibilities for individuals, households, businesses and all consumers and users of energy. It must be acknowledged that higher-income households consume considerably more energy than low-income households and they are correspondingly responsible for a larger proportion of the reduction in demand. Efforts to reduce energy demand must ensure equitable access to energy services.

In partnership with other sectors, therefore, the evidence points to the need for government to lead on a number of fronts that include the following initiatives:

- An improved data collection and analysis system aiming to fill key data gaps in primary energy, efficiency, affordability, employment, air monitoring, land and water impacts, wood use, mercury emissions, subsidies, and government reporting.
- Establish targets and develop tools to improve efficiency in all areas of energy use including: electricity generation where the use of combined heat power and distributed generation has great potential; improved building and appliance efficiency codes for homes and offices; and new industrial processes and improved industrial technology.
- Establish targets and develop tools to increase substantially the portion of energy in the province deriving from renewable sources in the electricity, heating, and transportation sectors. For example, with the highest property tax burden on wind energy in all of Canada the province needs to reevaluate taxes, subsidies, and incentives to ensure that renewable energy is encouraged.
- Aim to exceed Kyoto targets for reduction of greenhouse gas emissions in the energy sector and move towards a low carbon future through both supply and demand actions.
- Develop a comprehensive strategy to combat fuel poverty (i.e. finding permanent solutions for those who struggle to- or cannot meet their basic energy needs).
- Establish more ambitious long term reduction targets for all energy-related emissions, using as models the best practices and highest targets that currently exist globally.
- Establish provincial efficiency and emissions standards for wood burning devices and encourage the federal government to do likewise.
- Provide easily accessible information to all citizens and businesses about the impacts of energy choices and ways to reduce demand through conservation and efficiency.
- Use full-cost accounting analyses in relation to all energy related policy, especially major infrastructure and electricity generation decisions such as the construction of new power plants and the establishment of taxation rates, in order to weigh the true costs and benefits of all energy activities.

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Inspiration for the Nova Scotia Genuine Progress Index came from the ground-breaking work of Redefining Progress, which produced the first GPI in the United States in 1995. Though **GPI***Atlantic*'s methods differ in many ways, we share with the original GPI the attempt to build a more comprehensive and accurate measure of wellbeing than can be provided by market statistics alone. **GPI***Atlantic* also gratefully acknowledges the pioneers in the field of natural resource accounting and integrated environmental-economic accounting on whose work this study and the GPI natural resource accounts build.

*Needless to say, any errors or misinterpretations, and all viewpoints expressed, are the sole responsibility of the authors and **GPI**Atlantic.*

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LIST OF ABBREVIATIONS

ABM	Atlantic Business Magazine
AIMS	Atlantic Institute for Market Studies
ANE	Access Northeast Energy Inc.
ARSN	Atlantic Regional Solidarity Network
AUS	Australian
BC	British Columbia
Bcf/day	Billion cubic feet per day
BTU	British thermal unit
CAPP	Canadian Association of Petroleum Producers
CBC	Canadian Broadcasting Corporation
CBIP	Commercial Buildings Incentive Program
CCGTs	Combined-cycle gas turbines
CCME	Canadian Council of Ministers of the Environment
CND	Canadian
CEC	California Energy Commission
CEPA	Canadian Environmental Protection Act
CESD	Commissioner of the Environment and Sustainable Development
CFL	Compact fluorescent light
CH_4	Methane
CHP	Combined heat and power
CHRA	Canadian Housing and Renewal Association
CIEEDAC	Canadian Industrial Energy Efficiency Data and Analysis Centre
CNEG/ECP	Conference of New England Governors and Eastern Canadian Premiers
CNSOPB	Canada - Nova Scotia Offshore Petroleum Board
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2 eq.	Carbon dioxide equivalent
CSD	Commission on Sustainable Development
CSERA	Canadian Systems of Environmental and Resource Accounts
DEA	Danish Energy Authority
DG	Distributed generation
DSF	David Suzuki Foundation
EMGC	Electricity Marketplace Governance Committee
EMR	Energy Mines and Resources Canada
EPEA	Environmental Protection Expenditure Accounts
ESCOs	Energy service companies
EU	European Union
FCA	Full-Cost Accounting
FPACAQ	Federal-Provincial Advisory Committee on Air Quality
FRG	Federal Republic of Germany (West Germany)
LNG	Liquefied Natural Gas
GDP	Gross Domestic Product

GDR	German Democratic Republic (East Germany)
GHG	Greenhouse Gases
GNP	Gross National Product
GoC	Government of Canada
GoDK	Government of Denmark
GoG	Government of Germany
GoM	Government of Manitoba
GoNS	Government of Nova Scotia
GoQL	Government of Queensland
GPI	Genuine Progress Index
GWh	Gigawatt hour(s)
ha	Hectare
HFCs	Hydrofluorocarbons
Hg	Mercury
HVAC	Heating, ventilating and air conditioning
ICRE	International Conference for Renewable Energies Secretariat
ICTA	International Center for Technology Assessment
IEA	International Energy Agency
IER	Institut für Energiewirtschaft und Rationelle Energieanwendung
IISD	International Institute for Sustainable Development
IPA	Impact Pathway Approach
IPCC	International Panel on Climate Change
IPPs	Independent power producers
ISE	Institute for Sustainable Energy
ISIS	International Strategic Information Services
ITOPF	International Tankers Owners Pollution Federation Ltd.
kg	Kilogram
kt	Kilotonnes
kW	Kilowatt
kWh	Kilowatt hour
LEED	Leadership in Energy and Environmental Design
LIHEAP	Low Income Home Energy Assistance Program
LM	Load management
LNG	Liquefied natural gas
MA	Millennium Ecosystem Assessment
MAC	Maximum Acceptable Concentration
MDC	Maximum Desirable Concentration
mg/l	Milligram per litre
MMcf/d	Million cubic feet per day
MNECB	Model National Energy Code for Buildings
MTC	Maximum Tolerable Concentration
MW	Megawatt
N_2O	Nitrous oxide
NAAQO	National Ambient Air Quality Objective (Canada)
NACEC	Commission for Environmental Cooperation of North America
NBDOE	New Brunswick Department of Energy

NBPower New Brunswick Power Corporation
NEB National Energy Board
NEG/ECP New England Governors and East Coast Premiers
NGLs Natural gas liquids
NO_x Nitrogen oxides
NPRI National Pollutant Release Inventory
NRCan Natural Resources Canada
NRTEE National Round Table on the Environment and Economy
NS Nova Scotia
NSDE Nova Scotia Department of Environment
NSDEL Nova Scotia Department of Environment and Labour
NSDF Nova Scotia Department of Finance
NSDH Nova Scotia Department of Health
NSDLF Nova Scotia Department of Lands and Forests
NSDNR Nova Scotia Department of Natural Resources
NSDOE Nova Scotia Department of Energy
NSPC Nova Scotia Power Corporation
NSPD Nova Scotia Petroleum Directorate
NSPI Nova Scotia Power Incorporated
NSWEPA New South Wales Environmental Protection Authority
NWCC National Wind Coordinating Committee
O_3 Ozone
OECD Organization for Economic Cooperation and Development
OEE Office of Energy Efficiency
OGM Oil and Gas Magazine
OMA Ontario Medical Association
PEI Prince Edward Island
PEIDEE Prince Edward Island Department of Environment and Energy
PFCs Perfluorocarbons
PJ Petajoules
PM Particulate Matter
PM_{10} Particulate matter $\leq 10 \mu m$ in diameter
$PM_{2.5}$ Particulate matter $\leq 2.5 \mu m$ in diameter
ppb Parts per billion
pphm Parts per hundred million by volume
ppm Parts per million
PV Photovoltaic
RFF Resources for the Future
RPS Renewable Portfolio Standard
SF_6 Sulphur hexafluoride
SHW Solar hot water
SO_2 Sulphur dioxide
SOEP Sable Offshore Energy Project
SO_x Sulphur oxides
StatsCan Statistics Canada
tcf Trillion cubic feet

TCLNG	The Center for Liquefied Natural Gas
THCs	Total hydrocarbons
TJ	Terajoules
TPM	Total Particulate Matter
UARB	Utility and Review Board
U.K.	United Kingdom
UKDEFRA	United Kingdom Department for Environment, Food and Rural Affairs
UKDFID	United Kingdom Department for International Development
UKDTI	United Kingdom Department of Trade and Industry
UKDT	United Kingdom Department of Transport
UN	United Nations
UNDP	United Nations Development Program
UNDPI	United Nations Department of Public Information
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
UNHCHR	United Nations High Commissioner on Human Rights
U.S.	United States of America
USDOE	United States Department of Energy
USDHHS	United States Department of Health and Human Services
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
VOCs	Volatile Organic Compounds
WB	World Bank
WCED	World Commission on Environment and Development
WEC	World Economic Council
WHO	World Health Organization
WMO	World Meteorological Organization
WNA	World Nuclear Association
WWF	World Wildlife Fund
µm	Micrometres
$\mu g/m^3$	Micrograms per cubic meter

* As a result of government restructuring in October 2000, the former Nova Scotia Department of Environment (NSDOE), the Department of Labour, and other regulatory agencies combined to become what is currently Nova Scotia Department of Environment and Labour (NSDEL).

THE ENERGY ACCOUNTS *for the* NOVA SCOTIA GENUINE PROGRESS INDEX

1. Introduction

1.1 Measuring Progress & Accounting for Full Costs

As a society we currently measure our progress primarily according to rates of economic growth. If the gross domestic product (GDP—the sum total value of all goods and services exchanged for money)1 is growing at an ever-increasing rate, we describe the economy as "robust," "dynamic," and "healthy." This, we assume, translates into social wellbeing and prosperity. That assumption guides our policy decisions and even determines what issues make it onto the policy agenda.

What we fail to acknowledge is that in our current (fossil-fuel based) economy, the faster the economy grows, the more rapidly we may be depleting our non-renewable natural resources, and the more air pollutants we may be emitting. Because our conventional accounting mechanisms assign no value to our natural capital, we mistakenly count its depreciation as economic gain, with no regard to the reduced flow of services that may result in the future. When we use economic growth measures to assess progress, we also mistakenly count pollution clean-up costs as contributions to prosperity.

Economists at the World Resources Institute, Repetto and Austin (1997), remark on the problem with this caution:

> A country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared (p.61).

To address this shortcoming of current economic valuations, **GPI***Atlantic* is constructing an index of sustainable development, the Genuine Progress Index (GPI), for the Province of Nova Scotia, which is designed to provide a more accurate picture of our wellbeing as a society. Unlike

[1] According to Statistics Canada: "Gross domestic product (GDP) is a popular indicator used to estimate the value of economic activity. GDP measures two things at once over a given period of time: the total income of everyone in the economy and the total expenditure on the economy's output of goods and services produced within the country" (Statistics Canada, 2003).

the GDP, which values only human-made produced capital, the GPI also values natural, social, and human capital. Therefore, among its 22 social, economic and environmental components, the Nova Scotia GPI includes natural resource accounts. These assign explicit value to our soils, forests, fisheries, water, air and non-renewable resources—and assess the sustainability of our harvesting practices and consumption habits. This instalment of the **GPI***Atlantic* Accounts addresses activities and consequences of the Nova Scotia energy sector.

The energy sector

Energy is essential to all life on earth. Whether as nourishment to sustain individual organisms or as fossil fuels to run modern societies, every activity on earth is dependent on a constant, abundant, and reliable source of energy. An interruption to modern energy supplies can have serious implications for both the economy and society, jeopardizing current standards of living. The price shocks and fuel shortages of the 1970s and the more recent dramatic increase in fuel prices in the wake of Hurricane Katrina indicate the profound social impact of such disruptions. This report is interested in the type of energy on which industrialised societies in general, and Nova Scotia in particular, depend to run their economies. This is energy used principally to provide power for electricity, heat and industrial processes. Transportation is not discussed extensively in this report, but presented separately in the **GPI***Atlantic* Transportation Accounts.[2]

At present, energy services are provided predominantly by fossil fuels—oil, natural gas and coal. Fossil fuels provide approximately 80% of all primary energy supplies in the world today. Nuclear energy contributes about 7%, while the remaining 13% comes from renewable energy sources, predominantly traditional biomass (wood and plant by-products) and large hydro projects. Less than 1% (0.5%) of global primary energy comes from new renewable energy sources such as wind power, solar and geothermal (IEA, 2005).

The energy mix in Nova Scotia is largely comparable to the global energy profile. Nuclear energy, however, is not a direct part of this mix except for limited electricity imports from New Brunswick where nuclear power contributes to the electricity generation portfolio. Fossil fuels dominate the energy mix for industrial processes, electricity generation, heating and transportation in Nova Scotia. Biomass is used for some industrial applications and for some residential heating. Small scale hydro is used to produce some electricity in the Province (9%). Although wind power is gaining momentum in Nova Scotia, it still makes only a marginal contribution to the energy profile (less than 1%). Geothermal and applied solar energy also contribute only a tiny proportion to the overall energy mix (less than 0.1%).

The intensive use of energy obtained from fossil fuels and nuclear sources is the primary cause of a number of environmental, social and economic problems in the world today. With regard to the environment, the most noteworthy of these concerns is global climate change. However, there are also many local and regional problems resulting from energy use, including: compromised air and water quality; damage to marine and other wildlife; land use conflicts;

[2] Because transportation represents a large and unique component of the energy sector it is discussed in a separate *GPIAtlantic* report. Consequently, most of the discussion in this study refers to non-transportation energy. In some cases however, where it is useful for illustration, energy use data with and without transportation are provided. These instances are clearly labelled.

security implications due to reliance on foreign supplies; resource depletion; and land contamination (Johansson and Goldemberg, 2002; Ramage, 1997). The principal environmental problems associated with intensive energy use can be summarised as:

- ***Resource depletion.*** Conventional energy sources—most notably oil and natural gas which contribute more than 80% of global energy demand—are finite resources. Supplies of these two sources are predicted to peak within a generation and thereafter decline leaving the world with a shortfall in supply (Goodstein, 2004; Heinberg, 2003). Scarce resources can lead to social unrest and political strife brought about by widening inequality between the "haves" and the "have-nots." Coal resources and uranium for nuclear energy are available in far greater abundance but are also finite, and carry with them numerous unresolved environmental and social problems (RFF, 2005). Oil sands development has been linked to water depletion, among other concerns.
- ***Climate change.*** The emission of greenhouse gases from the combustion of fossil fuels (coal, oil and natural gas) is believed to be the principal cause of the enhanced greenhouse effect. This has led to a disruption of the natural equilibrium of the earth's atmospheric regulation system and resulted in increases in the average global temperature. These temperature changes can disrupt weather and global climatic patterns, producing more severe droughts, floods, storms and hurricane activity. The latest estimates predict a mean global temperature increase of 4.5^{o}C by 2100 (IPCC, 2001b), the consequences of which could be devastating for many human and non-human systems (GoC, 2001:101; Environment Canada, 1997).
- ***Air quality deterioration.*** Air pollutant emissions—mercury, sulphur dioxide, nitrogen oxides, particulate matter and volatile organic compounds, among others—also result from the combustion of fossil fuels. The combination of these emissions in the atmosphere leads to acid rain, smog, ground level ozone and a range of other conditions which have detrimental effects on human health and the environment (Environment Canada and Health Canada, 1999).
- ***Land and water contamination.*** Contamination can occur from air emissions that fall back to earth and enter ecological systems, as well as from other pollutants that leach into the ground from mineral and energy resource extraction processes. Intensive extraction of fossil fuel and uranium often leaves land contaminated, while oil spills and other accidents lead to detrimental pressures on aquatic life as well as on terrestrial ecosystems (ITOPF, 2005; UKDTI, 2002).

Collectively these problems leave no human or biological system untouched, and carry implications for ecological integrity, human health, social wellbeing, and long-term economic prosperity. Growing concern with the environmental, social, and economic implications of the world's continuing dependence on conventional fuel sources has prompted calls for an energy system that reduces these impacts, often referred to as a sustainable energy system (Geller, 2003; Johansson and Goldemberg, 2002; UNEP, 1993). Assessing whether this is being achieved is an important task to which these **GPI***Atlantic* Energy Accounts are designed to make a small contribution by identifying the full implications of our current energy system and establishing measures of progress towards more sustainable energy choices.

This chapter begins with a discussion of the principles of sustainability and presents a working definition of sustainable energy as used in this report. This is followed by a more detailed discussion of the limitations of current accounting practices and how **GPI***Atlantic*'s approach to measuring progress attempts to remedy these deficiencies by accounting, to the extent that data allow, for the full costs of energy.

1.2 Defining Sustainability

The terms *sustainable*, *sustainable development* and *sustainability* are widely and often interchangeably used, and have come to mean many things to many people. In one of its earliest and now most famous uses, sustainable development was defined by the Brundtland Commission as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). At its simplest, this means reducing the adverse impacts of development on environment and society (e.g. human health) while supporting economic prosperity. This was the initial intent when the phrase "sustainable development" was popularized by the World Commission on Environment and Development in 1986.

With the increasing intensity of many ecological crises since that time however, such as the collapse of the Atlantic ground fish stocks and the growing evidence of global warming, sustainable development has come to represent a new worldview for many people.[3, 4] This is a perspective that recognizes the ecological limits of the world in which humanity exists, and broadens the definition of sustainable development to include living within the natural carrying capacity of the world's ecosystems.

This broader view argues that if we are to preserve the ecological integrity of the environment that is our life-support system, then we need to alter the way we think about and behave in our relationship with the natural world. For a long time many saw (and many still do see) the environment as a corollary to the economy and society, a relationship that suggests an equal balance between the three spheres. This relationship is sometimes described as "triple bottom-line accounting" or as a three-legged stool, and is often depicted as three overlapping circles that represent environment, society and economy.

But representations of this sort may be misleading. We know that both economy and society depend on the environment for climate regulation, pollination, nutrient and hydrological cycling, waste filtration and assimilation, and many other essential services, as well as for the wide range of products and services provided by natural resources. As a result, a new image of the

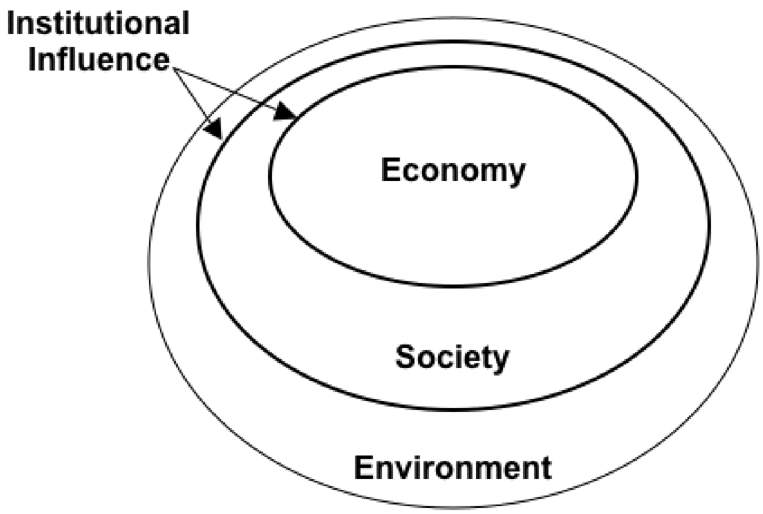
[3] A recent report to confirm this deepening crisis is the Millennium Ecosystem Assessment, a UN study that synthesized the work of more than 1,300 researchers from 95 countries. The study found that 15 of 24 global ecosystems are in decline (MA, 2005).

[4] "Worldview" is used here to mean the composite set of presuppositions, beliefs and values a person possesses that shape how s/he sees reality and determines how s/he will act. It refers to the collective set of fundamental convictions people hold and on which they base their actions.

human/nature relationship that fully acknowledges the dependence of the former on the latter needs to be understood and accepted. The three concentric circles shown in Figure 1 more accurately represent the dynamic relationship between environment, society and economy than the traditional three-legged stool. In reality, the economy exists within society and serves social goals, and both the economy and society exist within the encompassing natural environment on which they depend.

Institutions are a fourth component shown in the diagram because they are also recognised as essential for achieving sustainability (Spangenberg, 2002; UNEP, 1993). The institutional dimension is important because it can guide the choice of actions by which society and the economy interact with each other and with the environment. This includes law and government policy; municipal planning rules; health, safety and environmental standards; and any other rules that try to determine how the system components interact.

Figure 1. A sustainable view of the relationships between economy, society and environment



Source: Modified from Prescott-Allen, 2001.

Adopting a sustainability worldview and framework for action is seen by many as the only way of tackling the many environmental and social problems faced around the globe. This worldview embraces six important principles:

1. ***Working for inter- and intra-generational equity.*** The Brundtland report explicitly recognised the equity dimension of sustainable development. The world's richest people, comprising about 20% of the world's population, consume, 45% of all meat, 58% of all energy, and 84% of paper, and own 87% of vehicles; the rich also deplete resources at a faster rate than the poor. In fact, 70% of the world's population lives within the carrying capacity of the earth (Monette et al, 2003). Reducing the disparity within generations (intra-generational) and between current and future generations (inter-generational) is

essential in order to achieve sustainability. In the energy context this means that all people in the world should have access to adequate energy services, requiring those who over-consume to reduce their usage. It has been suggested that improving equity in the energy sector means ensuring affordable access to modern energy services for the two billion people who currently rely solely on traditional energy sources (UKDFID, 2002). Inter-generational equity means that we develop and use both renewable and non-renewable energy sources in such a way that future generations will have access to adequate resources.

2. ***Living within the carrying and absorptive capacities of the earth.*** This requires reducing the demands we make on environmental services to absorb human waste and pollutants, as well as the demands we make on natural resources to satisfy our appetites for material goods. In the energy sector this implies, for instance, recognising the geophysical limits of fossil fuel supplies and the atmosphere's absorptive capacity to "digest" ever-increasing amounts of carbon dioxide and other pollutants.

3. ***Adhering to the precautionary principle.*** Because the future impacts of many of our actions are uncertain, but potentially damaging, we need to proceed with caution. The precautionary principle is a dictum enshrined in many international, national and regional agreements and acts.[5] As first outlined in the Rio Declaration on Environment and Development: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation" (UN General Assembly, 1992). The applicability of this principle to greenhouse gas reduction is clear. While the science of climate change is fraught with uncertainties and its link to human activity still debated in some circles, the precautionary principle indicates the availability of sufficient evidence on potentially devastating impacts to warrant immediate action to reduce GHG emissions.

4. ***Internalization of negative externalities.*** Typically, the environmental consequences of an action are borne by society at large, rather than by the polluting entity (whether that is a large industry or an individual). Instead, a sustainability perspective requires that causal agents be held accountable for environmental damage and pay for damages that result from their actions. At the moment, most environmental impacts from the energy system are borne by society as a whole and potentially by future generations. Internalizing the costs of environmental damage means that those responsible pay for the impacts and those charges then be used to control or, where possible, fix the damage. Internalizing costs can act as a strong disincentive to pollute. A carbon tax is used in some countries to reduce and discourage the combustion of energy sources with high carbon content. These "polluter pay" principles are already applied in limited respects in Canada and Nova Scotia, but there is still much further to go in assigning the full social and environmental costs of our energy (and all other) activities to the responsible entities.

[5] The precautionary principle is written into some of Canada's international environmental commitments, and recently enforced in a Supreme Court of Canada ruling. It is also enshrined in the 2001 Nova Scotia Environment Act (Boyd, 2003:236).

5. ***Taking both qualitative and quantitative integrity into consideration.*** When taking remedial action on environmental damage we often consider only quantitative measures and neglect other aspects; that is, we replace one-for-one but not like with like. But a natural ecosystem can be quantitatively depleted (as in over-harvesting) or qualitatively degraded. The problem is common in the forestry industry where replanting a clear-cut former old growth forest with a single species of tree saplings is often considered acceptable and "sustainable" replenishment practice, simply because the total fibre content of a forest does not change significantly. After replanting there may be as many trees as there were prior to harvesting, but in itself this does not restore the forest to its former condition. Qualitative aspects must also be considered. In this example, that would include the diversity of species and age classes and even the diversity within species, which promotes resilience to disease and infestation, and leads to a wider variety of concomitant vegetative, insect and animal life, as well as other environmental benefits.

   In terms of energy this qualitative dimension implies that we must be concerned with leaving both ample supplies of energy for future generations ***and*** high quality forms of energy (e.g. energy rich compact liquid fuels vs. heat energy). In short, sustainability requires that both quality and quantity be addressed and restored when damaged.

6. ***Addressing all problems from both the supply and demand side.*** When considering the attainment of sustainability we often tackle the particular problem from either the supply side or the demand side, but not necessarily both together. Supply-side analyses tend to put the onus of responsibility for sustainability on foresters, farmers, fishermen and resource extraction industries, who are admonished to harvest in more sustainable ways. But the consumers who create the demand for these products are generally not required to take responsibility. For example, when acid rain was discovered to come mainly from sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions, industries producing these emissions were targeted for reduction. Although a very important action, it overlooked the demand side of the equation. What was not sufficiently considered or addressed in the action was the responsibility of those demanding the goods and services that lead to SO_2 and NO_x releases. From a strong sustainability perspective, therefore, the responsibility for the negative effects of the current energy system lies with *both* producers *and* consumers (i.e. as much with the people who use large amounts of energy often wastefully as with those who supply the energy). This approach requires both a reduction in overall energy demand and meeting the remaining consumption needs through environmentally and socially benign processes.

These six principles are the foundations of sustainability and must be considered when assessing whether a system, action or product is sustainable. With these criteria in mind, sustainable energy can then be described as an energy system that provides "adequate energy services for satisfying basic human needs, improving social welfare and achieving economic development throughout the world without endangering the quality of life of current and future generations of humans or other species" (Geller, 2003:16). In addition, a sustainable energy system is one based increasingly on replenishable resources with a minimised waste stream that does not exhaust the absorptive capacity of the biosphere.

There are many variations on this definition but, regardless of the nomenclature, almost all modern societies have made sustainability (at some level) a goal to strive for in energy planning and policy. In this report *sustainable energy* refers to an energy system that is increasingly in accord with the definition and criteria presented above.

Moving towards sustainable energy

Increasing the use of renewable energy and using energy more efficiently are generally considered to be central components of a more sustainable energy system. This trend is evident in energy policy developments around the world. Thinking (and action) around the integration of energy and sustainability was initiated by the United Nations Conference on Environment and Development (also known as the Earth Summit), which was first convened in 1992 and then again in 2002. Clause 9.11 of *Agenda 21* calls for the promotion of policies and programmes to "increase the contribution of environmentally sound and cost-effective energy systems, particularly new and renewable ones, through less polluting and more efficient energy production, transmission, distribution and use" (UNEP, 1993).[6]

Nova Scotia has also begun to strive for sustainability in its energy system. Energy policy documents for Nova Scotia list sustainability as a central goal. Although the term "sustainable" is not always defined, the stated goals include protection of the environment, greater self-sufficiency, and price stability (NSPD and NSDNR, 2001). The first of these objectives reflects awareness of the imperative to act on national and international commitments to protect the environment. The second recognises the volatility of international energy markets and the concomitant need to reduce Nova Scotia's dependence on energy supplies from abroad. The third, price stability, is important for preventing disruptions to economic and social activities. These are important objectives given the Province's heavy dependence on imported fossil fuels. These goals are ambitious but attainable in view of the Province's endowment with renewable energy sources, such as effective wind regimes amenable to an expansion of wind power, and the considerable potential for using energy more efficiently. In this report **GPI***Atlantic* explores the current energy choices being made in Nova Scotia and the implications of those choices. Additionally we measure progress towards energy sustainability in this Province.

As we move through the progress assessment, it is important to bear in mind that progress towards sustainability has both a relative (directional) and an absolute (threshold) dimension. Activities in the energy sector may trend towards sustainability (e.g. a reduction in greenhouse gas emissions) and therefore be interpreted as positive progress towards sustainability, while it remains a long way from the earth's carrying capacity. For example, greenhouse gases will continue to accumulate in the atmosphere and likely contribute to further global warming even if the Kyoto targets are reached. The point of "absolute" sustainability is that at which the atmosphere, oceans and soils can effectively absorb all carbon emitted by human activity without increasing the earth's temperature. Without an understanding of absolute sustainability, which has to do with meeting defined thresholds or targets, simple directional trends towards sustainability may produce complacency and a sense that we are doing or have done all that is

[6] *Agenda 21* is a 300-page plan for achieving sustainable development in the 21st century. It was developed at the 1992 Earth Summit in Rio de Janeiro and was adopted by all participating countries as a guide for moving towards sustainable development (UNEP, 1993).

necessary by becoming more sustainable. In fact, the message can be particularly misleading for jurisdictions that begin from very poor performance, where almost any positive action will trend towards greater sustainability, compared to a jurisdiction with an excellent environmental record, where the positive trend may be harder to maintain. In sum, analysis of relative directionality should always be accompanied by a more absolute assessment of whether defined targets are being reached. The terms 'strong' or 'genuine sustainability' are also often used to provide this distinction.

Components of a sustainable energy system

Although Nova Scotia's energy policy documents contain some important recommendations for moving towards a more sustainable energy system, the evidence in this report indicates that there are many areas that are still not adequately addressed, in particular for achieving absolute sustainability. Furthermore, in order to measure progress towards greater energy sustainability, we need to establish a clear vision of what that system looks like. From this vision it is possible to develop a plan and set targets by which progress can be assessed. Although the details may vary from one place to another based on the resources available, in general, a sustainable energy system includes the following components:

- ***Reducing demand for and dependence on conventional energy supplies (i.e. fossil fuels and nuclear energy) through changes in consumption patterns including changes in behaviour and more efficient use of energy.*** Energy efficiency is defined as using less energy to accomplish a given function. This requires the development and implementation of technologies that allow greater efficiency in energy conversion processes. Reductions can also be accomplished through conservation.
- ***A greater reliance on renewable sources of energy***. Renewable energy is "energy obtained from the continuous or repetitive currents of energy recurring in the natural environment" and as such cannot be depleted (Twidell and Weir, 1986). Energy from the sun, gravity and the earth's rotation are the ultimate sources for these currents. These are further identified by the element from which they originate to include energy from: the wind; the sun; biomass; heat from the earth (geothermal); and different forms of water movement (wave, tidal, run-of-river, hydro dam) (Boyle, 1996).
- ***Using cleaner sources of conventional energy, such as natural gas, as a bridging fuel and developing ways to reduce the impact of more polluting sources.*** Natural gas is the cleanest and least carbon-intensive fossil fuel and combined-cycle gas-fired power plants are significantly more efficient than other conventional electricity generating technologies, making natural gas an important energy choice for sustainability in the short term. This resource is not without its problems however, and should be seen as a bridging fuel until the previous two options are implemented (Geller 2003; Johannson and Goldemberg 2002).
- ***Ensuring accessibility to adequate energy services at reasonable cost for all sectors of the population in the most environmentally sustainable ways.*** The real challenge, as Geller (2003) notes, is balancing the social (equity), economic and environmental dimensions of sustainability in accordance with the principles noted above.

1.3 Measuring Progress

More than 12 years have passed since the signing of *Agenda 21* with its commitment to sustainable development and sustainable energy. In that time there have been many additional discussions about sustainable energy, and actions have been taken to move in that direction at an international, national and regional level. There are few regions in the world today where there has not been reflection and attempted action on sustainability commitments. Nova Scotia is no exception in this regard. This Province has stated aims of working towards sustainability in most facets of society and economy, including the energy sector. But how are we doing on that commitment? How far are we from genuine sustainability and how do we know if progress has been made? These are some of the questions addressed in this study.

The need for a new accounting system

Conventional economic theory sees the human economy as a closed system in which firms produce and households consume. That assumption is the basis for calculating the GDP and economic growth rates on which we currently, and mistakenly, base our assessments of prosperity and social wellbeing.

In addition to ignoring the production of goods and services and capital items that traditionally have no market value, the conventional assumption is flawed in an even more fundamental way. The human economy is not a closed system. It exists as a sub-system within, and completely dependent upon, an encompassing ecosystem that provides vital life-support services to human society. The energy and matter that enter the human economy from the ecosystem also return to the ecosystem, partly as waste. The capacity of the ecosystem to absorb that waste in turn affects the functioning of the human economy.

The fundamental flaws in our national accounting system, which result in resource depletion being counted as economic gain, are now widely acknowledged. Unfortunately, we still take our cues on economic health from an accounting system that was devised at a time when natural resources were thought to be limitless, and ecosystem services "free" and infinite.

We continue to adhere to this flawed construct in part because the new accounting systems that will include natural resource wealth are still being developed. This is an area in which Canada has been a leader on the international stage. Statistics Canada has taken the first important steps toward integrated environmental and economic accounting through its new Canadian System of Environmental and Resource Accounts (CSERA) (Statistics Canada, 1997 and 1997a). The National Round Table on the Environment and the Economy also recommended that Canada expand its national accounting system to include measures of natural, human and social capital (NRTEE, 2003). It is efforts such as these that will help Canada meet the new recommendations for the assessment of national wealth established by the United Nations (UN), the Organisation for Economic Co-operation and Development (OECD), the World Bank (WB), and the internationally recognized System of National Accounts (SNA).

The work done by Statistics Canada through CSERA attempts to bring natural resource accounts onto the national balance sheets for the first time. Resource and waste flow measures are also designed to appear in the input-output tables. The CSERA framework further includes a set of Environmental Protection Expenditure Accounts (EPEA) that will provide important data for analysts who wish to recalculate a "green GDP" or "net domestic product" that subtracts pollution abatement expenditures and clean-up costs from the conventional GDP.

In fact, it can be expected that integrated environmental/economic accounting will eventually be the basis of the new economy of the next millennium. In the year 2000 budget, Canada's Finance Minister Paul Martin announced that, in the years ahead, measures of sustainable development, "could have a greater impact on public policy than any other single measure one might introduce."

The integration of natural resource accounts into our core economic indicators attests to a profound change in our assumptions. At first glance the notion of "integrated accounts" could imply that economic, social and environmental factors have equal footing in our new approach to measuring progress. In truth, the change in thinking must be even more profound, recognising that the human economy is completely dependent upon resource and energy flows from the natural world. Irreversible changes that occur in natural ecosystems, such as climate change and species extinction, can seriously imperil the functioning of human economies. Therefore, in the GPI accounts, economic and social factors are considered as subsystems of an encompassing ecosystem as illustrated by Figure 1 above.

Indeed, a genuine integration of environmental and economic indicators requires a much longer-term view of the relationship between economic health and human stewardship of the planet than we have taken to date. Changes that occur today can profoundly affect the ecosystem and its inhabitants in 100 years, 500 years, one thousand years and beyond, a reality that short-term current income accounting mechanisms are incapable of assessing. Only measures of progress that point to long-term prosperity, rather than short-term gain, can provide a genuine and accurate guide to policy makers concerned with the wellbeing of future generations as well as our own.

While the Genuine Progress Index attempts to place a monetary value on natural resources, and damages to these resources, we acknowledge that this practice is only necessary as a temporary strategic measure because we do not currently value our natural resources in and of themselves. Indeed, there is no price that can adequately value our natural resources and ecosystem services that may be irreplaceable. Therefore an economic valuation of the full costs of energy follows the indicators; but the physical indicators, rather than the economic valuations, provide the direct means to track progress.

The role of indicators

It is important to emphasize that, although the GPI points towards a new expanded ***accounting*** framework that includes measures of natural, human, and social capital, it is based first and foremost, as noted above, on a set of physical ***indicators*** of genuine progress. While the accounting procedures include ***economic*** valuations of non-market goods and services, the indicators are based on ***physical*** data, with genuine progress always being assessed by trends in these physical data rather than by costing mechanisms. For this reason, all **GPI***Atlantic* reports begin with assessments of trends in key indicators, and then, as a separate exercise, build on a system of economic valuation that expands current accounting mechanisms to include factors conventionally ignored.

For example, indicators of a sustainable energy sector include energy-related greenhouse gas and pollutant emissions. These indicators are measured in physical terms, such as tonnes of carbon dioxide, particulate matter, nitrogen oxides, and volatile organic compounds emitted. Reductions in emissions signify genuine progress and movement towards a more sustainable energy system.

Assessing an energy system for sustainability is a contentious task given the many interpretations of sustainability that abound. In particular, weaker definitions of sustainability may ignore qualitative factors, assume that natural capital can be replaced by manufactured or financial capital and neglect the demand side of the equation. Weak definitions can also be too relativist – assuming that movement in the right direction signifies ample progress without reference to more absolute factors like the earth's carrying capacity. The latter requires consideration not only of directionality but of *how much* progress is being made to ensure that targets are reached before critical natural thresholds based on carrying capacity are passed. As noted in the principles of sustainability listed above, we have adopted here a stronger definition of sustainability that includes assessment of qualitative degradation as well as quantitative depletion, assumes the irreplaceability of some forms of natural capital, includes both the demand and supply sides of the sustainability equation and accounts for considerations of carrying capacity and the size of movement towards sustainability as well as directionality.

Moreover, covering all four components of sustainability—environmental, social, economic and institutional—is problematic given the trade-off that often has to occur between them. Yet, however difficult the task of assessing progress towards sustainability, it is one that urgently needs to be undertaken in order to understand and accurately monitor our progress towards a sustainable energy system that will serve future generations as well as our own. The aim of the **GPI***Atlantic* Energy Accounts is to identify and explore what progress means in the energy sector in Nova Scotia and to assess the distance between our current energy system and where we need to be to approach sustainability.

There is a strong need for better information about how energy affects the effort to achieve a sustainable society. According to the National Roundtable on Environment and Economy:

> [M]ost of the measures society uses to judge success do not take into account the long term implications of our current actions. In particular, many economic indicators fail to measure the sustainability of those factors on which we depend for continued quality of life, such as services provided by the environment (NRTEE, 2001).

This is as true for the energy sector as it is for the economy as a whole. To address this problem sustainability indicators are being developed at all levels of society by government, non-government, business and academic groups alike. Indeed, there is today such a consensus on this goal that the question is no longer *whether* it is necessary to assess progress towards sustainability but only *how* it can best be done.

Using indicators to track activities and impacts is a common way of determining progress towards a particular end and provides information that can be helpful when making decisions between competing choices (Farrell and Hart, 1997). Indicators form an important part of the measurement apparatus since they summarize key information about complex systems. Such summaries provide decision-makers and the public at large with signals of progress and with the information needed to make rational choices between different options.

What is unique about the process described in this report is not the development of indicators, but the systematic application of indicators to the question of energy sustainability in Nova Scotia. Although much has been written on this topic for other regions, this is the first attempt at developing a comprehensive set of energy indicators in the Province. Thirty indicators have been identified and presented in this report under the categories: socio-economic; health and environment; and institutional. They are discussed in detail in Chapters 5-8.

Full-cost accounting of energy

Following the analysis of indicator trends, **GPI***Atlantic* compiles a set of economic valuations in order to assess the true costs of energy, and the economic savings that could ensue from genuine progress and from movement towards greater sustainability. For example, the potential damage costs of climate change and of pollutant impacts on health and ecosystems are referenced from the ecological economics literature and the costs per tonne are then applied to the physical data.

The Genuine Progress Index (GPI) is not intended as an academic exercise but as a practical, policy-relevant tool that can assist policy-makers in assessing the long-term benefits and costs of alternative development and investment options. While the GPI is being developed as a macro-economic and social measurement instrument to establish benchmarks of progress for Nova Scotia, the GPI method also has practical utility at the micro-policy or project level. Thus the methods used here can be applied to specific strategies for sustainable energy production and used to determine the most cost-effective policies for meeting sustainability goals. How can policy-makers determine the most cost-effective means available that will yield multiple long-term benefits to society with a minimum of cost and hardship? Unlike conventional assessment tools that are incapable of factoring long-term social and environmental impacts into the cost-benefit equation, the GPI is based on "full-cost accounting" principles that are essential to promote economic efficiency.

In 1992, the Nova Scotia Round Table on Environment and Economy urged that full-cost accounting be adopted as the essential basis of any strategy of sustainable development for the Province (Walker et al, 2001). But this has not yet happened. Instead, the designation of social and environmental costs as "externalities" continues to shift the burden of payment from the consumer of the product onto ecosystems, future generations and the general public.

Conventional accounting offers insufficient incentive for producers and consumers to conserve energy or to improve efficiency. To the degree that social and environmental impacts are not included, the market economy will function wastefully since there are few inherent incentives to reduce energy use, costs, social expenditures, or pollution costs. Instead, these costs are often borne by the general public, sometimes generations later, as we are now experiencing with the Sydney Tar Ponds and the Halifax Harbour clean-up. Full-cost accounting procedures at the production, marketing, and sales stages can help obviate the need for heavy-handed government regulation after damage has occurred (Walker et al, 2001).

Assigning monetary value to impacts like polluted air or contaminated water is not an easy task because these represent services (clean air and water) that are not valued or are under-valued in the market economy.

> Because ecosystem services are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions. The economies of the Earth would grind to a halt without the services of ecological life-support systems, so in one sense their total value to the economy is infinite (Costanza et al, 1997).

This all or nothing dichotomy (i.e. no value versus infinite value) makes the task of calculating the full costs of any activity very contentious. The need to do so is now widely accepted but the values to be assigned to the various impacts of our actions are an area of great debate. We will return to that debate in Chapter 8, where we undertake cost calculations for energy use in the Province.

While full-cost accounting mechanisms are an essential strategy to ensure that energy is properly priced to include public costs like pollutant damages and hospital bills, they cannot thereby be used to assess progress. Marilyn Waring (1998) notes that, in an ideal world, a central triad of indicators based on environmental, time use and market statistics would be used both to assess progress and to evaluate all policy options. Presently, however, market statistics dominate the policy arena, so the economic valuation of non-market variables is often necessary to ensure that social and environmental benefits and costs that are hidden in conventional accounting systems are not ignored in policy and planning processes. But that is a different purpose and function than assessing progress.

1.4 The GPIAtlantic Energy Accounts

In order to develop measures of genuine progress, we must start by delineating our goals for society. Therefore we continually draw the attention of the reader to our working definition of a sustainable energy sector. This formulation helps to provide a framework from which we can develop more specific goals and indicators of genuine progress. In this case a sustainable energy sector is considered to be the goal against which genuine progress in the area of energy use and production can be measured. As noted above, a sustainable energy sector is one in which energy services meet basic human needs and support improving social welfare while maintaining the environment in such a form as not to endanger the quality of life of future generations (Geller, 2003). This can be accomplished through reduced demand for fossil fuels and nuclear power both through reducing energy use and the development of renewable forms of energy.

The title of this study, *Energy Accounts for Nova Scotia*, is intended to reflect the attempt to account for the full costs of energy in this Province, but should not be confused with a complete quantitative assessment of all costs and benefits of energy in the Province. As explained above, and in subsequent chapters, identifying and assigning a monetary value to all impacts and costs that result from the energy sector is an enormous and difficult task, well beyond the resources available for this study. Moreover, great uncertainty still exists in many of the valuation areas and lack of data prevents completion of many key indicators. However, **GPI***Atlantic* is confident that this work represents a reasonably robust and comprehensive first attempt in our aspiration to develop a better accounting process, recognising that this is only the beginning of a long process. This is the first version of what is hoped will lead to further iterations of this report, as more people join the discussion and as our knowledge of the issues improves.

Report outline

The GPI *Energy Accounts* are presented in nine chapters:

Chapter 1: Measuring Progress and Accounting for Full Costs. This chapter begins with an overview of the main energy-related concerns in the world today and of the widely accepted need to move towards greater sustainability. This is followed by a review of the key principles of sustainability and the definition of sustainable energy used in this report. The chapter also explains the place of the full-cost accounting work in these procedures and why it is important.

Chapter 2: Overview of Energy in Nova Scotia. This chapter provides a snapshot of the current energy system in the Province including the principal sources and consumers of energy and an overview of Provincial energy policy.

Chapter 3: Impacts of Energy Use. As argued in the introduction, energy has significant effects on the environment, society and the economy. Many of these impacts are not well measured at the Provincial level and so not all can be developed in the indicators section of this report. Here all major impacts are at least mentioned, and those not elaborated in the indicators chapters are discussed in more detail.

Chapter 4: Indicators and Indicator Criteria. In Chapter 4 we provide more detail about indicators, indicator frameworks and indicator selection criteria. There are numerous frameworks for indicator selection and these are explained in the context of the choices made for this study.

Chapter 5: Socio-Economic Indicators. Considerations that relate to human wellbeing and economic prosperity are presented in this chapter. These include energy supply and demand, efficiency, affordability and reliability, among others.

Chapter 6: Health and Environmental Indicators. In this chapter indicators for measuring health and environmental progress are presented. Seven indicators are presented.

Chapter 7: Institutional Indicators. Progress towards sustainability depends very much on rules and regulations imposed by governing institutions. In Chapter 7 indicators of institutional progress towards ensuring sustainability in the energy sector are presented and discussed.

Chapter 8: Assessing the Full Cost of Energy in Nova Scotia. Using the indicator data collected in the previous three chapters, in Chapter 8 we calculate some of the costs of our current energy choices and discuss the valuation of those impacts that cannot be fully quantified at this time.

Chapter 9: Pulling it All Together (Conclusions and Recommendations). Here we summarize the main findings of the report and provide some concluding statements based on our current knowledge of the energy sector in Nova Scotia. In the process of researching and preparing this report many ideas for moving towards greater sustainability came to light. In this final chapter we therefore make recommendations based on the evidence presented on three levels: first, how to improve this report in future updates; second, where more research is needed and more data need to be collected in order to track sustainability in the energy sector more effectively; and third, policy recommendations and suggestions for how Nova Scotia can realistically achieve greater sustainability in energy production and use.

2. Energy in Nova Scotia Overview

2.1 Nova Scotia Overview

Nova Scotia is Canada's second smallest Province in land area and fourth smallest by population. The Province is about 55,000 square kilometres in size and home to just over 930,000 people (NSDF, 2004). The economy is predominantly service-based, with the service sector accounting for more than 75% of total gross domestic product (GDP) in Nova Scotia in 2002. The other 25% of GDP comes from goods production, including manufacturing, construction, utilities, and primary industries such as oil and gas extraction (NSDF, 2004). Nova Scotia's island-like geography includes over 7,400 km of coastline while the average width of the Province is just 130 km. Nova Scotia is connected to the rest of Canada via the isthmus of Chignecto which links Nova Scotia to the Province of New Brunswick.

Energy is an important service as well as a commodity in this Province, as elsewhere. In this chapter we present an overview of the current energy situation in Nova Scotia, explaining what sources are used and where. The focus here, as throughout the document, is on non-transportation energy sources and uses, since **GPI***Atlantic* has carried out a separate study of the transportation sector (Walker et al, 2005). In some cases—where the numbers are difficult to separate, or to illustrate a point—the total energy figure is given (i.e. transportation energy combined with energy use in all other sectors for refined petroleum products); such instances are noted as they occur.

2.2 Energy Terms

Energy is usually presented in two categories – primary and secondary. Primary energy refers to energy in the form of raw resources, such as wood, coal, oil, natural gas, uranium, wind, hydro power, and sunlight. Secondary energy refers to the more useable forms to which primary energy may be converted, such as electricity and gasoline. Statistics Canada categorizes electricity in a slightly more complex way by dividing electricity into both primary and secondary categories depending on the resource used to generate the electricity. Statistics Canada describes electricity as secondary energy if it has been generated from fossil fuels and wood (i.e. thermal electricity) but it considers nuclear, hydro and wind derived electricity as primary energy. In converting primary energy into secondary forms, some energy is lost in the form of heat. An example of an energy conversion loss is the steam coming from stacks at coal-fired power plants. That steam comes from energy contained in the fuel (coal in this instance) that was not converted to electricity but was lost as heat.

Primary energy forms can also be classified as renewable or non-renewable. Renewable energy results from the continuous or repetitive currents of energy recurring naturally, and can come from the wind; the sun; biomass; heat from the earth (geothermal); and different forms of water movement (wave, tidal, run-of-river, hydro dam) (Twidell and Weir 1986; Boyle, 1996).

By extension, electricity generated from these sources is therefore also renewable. Fossil fuels and uranium are non-renewable forms of energy because the time for their replenishment is measured in millions of years and they are therefore not renewable in human time frames.

Energy can also be described in terms of who uses it (e.g. industry, households, institutions, etc); where the energy comes from – domestic vs. imported; and other supply and demand attributes. The word 'domestic' requires some explanation in a federalist country, since it can refer to either provincial or national production depending on the jurisdiction being discussed. A similar problem occurs when talking about imports and exports. These terms can be interpreted to mean importing energy from another country into Canada or Nova Scotia, or importing from another Canadian province into Nova Scotia. The focus of this report is on Nova Scotia and therefore, to avoid confusion, the word 'domestic' has generally been replaced by the words 'provincial' or 'national' as the situation requires, and energy imports to Nova Scotia have generally been identified based on their origin as coming either from other Canadian provinces or from another country.

For the purposes of this report, *energy production* includes fossil fuel exploration, extraction, processing, and the actual production of usable energy for electricity, heating and other purposes. *Fuel reserves* here refer to provincial deposits of fossil fuels. This category can be divided into *recoverable reserves* (i.e. known deposits, the extraction of which is technologically and economically feasible); *proven reserves* (includes recoverable reserves and other measured reserves that may or not be easily extracted); and *projected reserves* (deposits, both recoverable and not recoverable, the existence of which is plausible but has not been definitively demonstrated). Renewable resources are not described in terms of reserves but in terms of resource availability and technical potential.

On the demand side (otherwise referred to as consumption or energy use), it is possible to break the analysis into demand by fuel type and by end use or end user. End users can use both primary and secondary forms of energy. For example, homeowners may heat their homes with wood (a primary form) while lighting their homes with electricity (a secondary form). Final demand figures from Statistics Canada do not include some primary energy, such as the energy losses due to converting from primary to secondary forms, losses in transmissions lines, etc., that is used or lost before arriving at an "end user" location. The best figure to describe actual total energy use within a given jurisdiction is therefore total primary energy, not final demand, as the former represents a more comprehensive figure. However, data on total primary energy use in Nova Scotia are not available from Statistics Canada, nor is a break-down of primary energy use by fuel because of confidentiality agreements. Therefore, we have presented data on energy use, final demand, by end user (i.e. energy used by homes, businesses, and institutions) in this chapter. Both total primary energy use and final demand data are important and reveal different aspects of energy consumption. However, ultimately, total primary energy use must be addressed in order to have a sustainable energy system, and this report strongly recommends that these data be made publicly available. This issue is discussed further in Chapter 5.

2.3 Energy Supply and Demand in the Province

Energy use, final demand in Nova Scotia is heavily dependent on oil products and electricity. Together these sources account for approximately 90% of total end use energy consumption in the Province, with shares of about 69% and 21% respectively (NEB, 2003) (Figure 2).[7,8] Of the oil products (i.e. refined petroleum products) about 50% are used in transportation. If transportation energy use is excluded from the energy balance the refined petroleum products become less dominant as a fuel source (only 51%) but they still constitute the largest energy source (Figure 3).

Wood and waste wood is the third most important fuel in the Province, accounting for 7% of final demand. This source is used for residential heating by about one-third of Nova Scotian households (most commonly in rural areas), and in the pulp and paper industry for heat and power needs (NEB, 2003).

Although natural gas is currently being extracted off the coast of Nova Scotia, it is still in limited use in this Province and the majority is exported. In 2001 less than 1% of all end use energy was supplied by natural gas. In 2001 and 2002 Nova Scotia Power Incorporated (NSPI) started to burn natural gas at its Tufts Cove generation plant, but this was short-lived since an increase in natural gas prices resulted in the discontinued use of this fuel source by the utility (Emera, 2004, 2003, 2002, 2001). The use of various fuels by utilities, in this case natural gas by NSPI, are not shown in energy use, final demand as utilities are not considered end users. Natural gas liquids (NGLs) account for less than 2% of end use. These come in several forms—mainly propane, bhutane and condensate—and are used for various industrial activities (NSPD and NSDNR, 2001a) as well as heating; propane is used as a substitute for wood and oil (NEB, 2003).

[7] Energy use, final demand includes only the energy used by "end users".

[8] 2001 was used because wood energy estimates were available for that year.

Figure 2. Energy use, final demand, Nova Scotia (including transportation and wood), by fuel, 2001 (184.5 PJ)

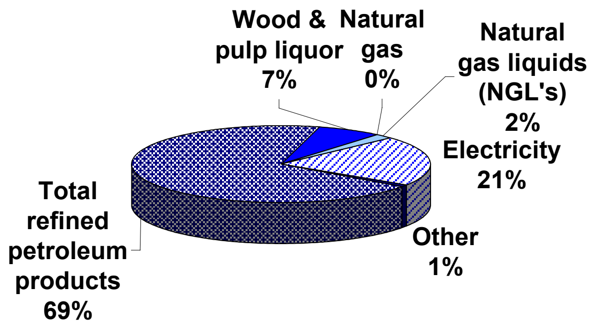
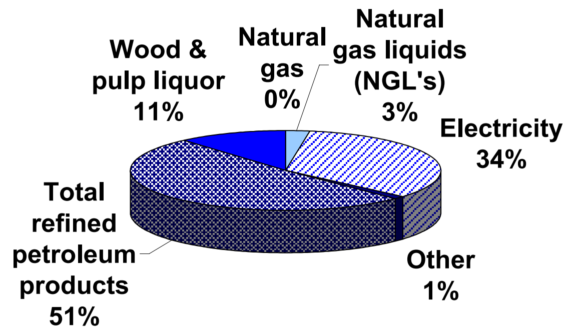


Figure 3. Energy use, final demand, Nova Scotia (including wood, excluding transportation), by fuel, 2001 (116.1PJ)



Notes Figure 2 and Figure 3: "Other" includes steam, coal, coke, and coke oven gas. 2001 values were used because the data for NGLs were suppressed after 2002. Note Figure 3: The total for transportation use of refined petroleum products (67,630 terajoules (TJ) in 2001 found in StatsCan table 128-00021) was subtracted from the value for refined petroleum products as reported by the NEB for 2001.

Source Figure 2: NEB, 2003.

Source Figure 3: Adapted from NEB, 2003 and StatsCan, 2005.

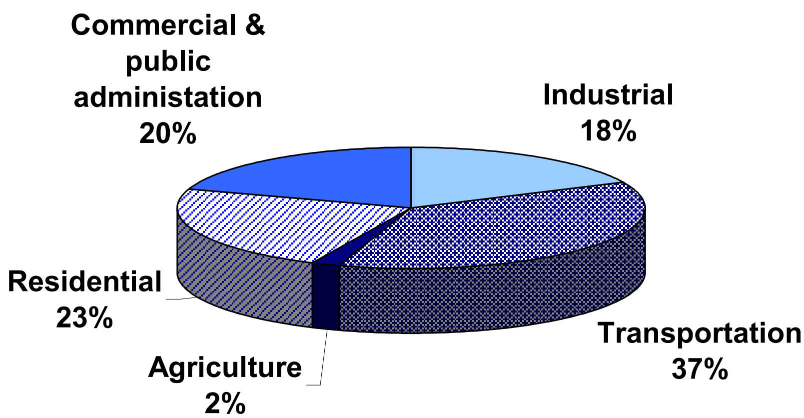
Energy demand by end use

The National Energy Board (NEB) provides an estimate of energy use, final demand which includes wood for 2001. NEB figures put energy use final demand for Nova Scotia at 184.5 PJ (Figure 4).[9] At 37% in 2001, the transportation sector accounted for the largest share of end user energy consumption in the Province. This was almost entirely in the form of refined petroleum products. Although some experimentation with bio-fuels has begun, the contribution of this source remains negligible (GoC, 2005a). The commercial and residential sectors accounted for about 20% and 23% of final consumption respectively. Demand in these categories is mainly for electricity and heating fuels (oil and propane). The industrial sector, with 18% consumption, also represents a significant proportion of final demand. The fuel type in demand varies from one industry to another with some industries relying entirely on electricity while others use both electricity and various petroleum products. The forestry industries rely more heavily on wood energy. Electricity demand in the Province is typically divided between three main sectors: residential, commercial and industrial (including manufacturing). These sectors accounted for

[9] The term "energy use, final demand" as used by NEB and Statistics Canada (StatsCan) does not include energy losses due to conversion of fuels to electricity, in-house energy consumption by refineries, and non-energy uses of petroleum products (e.g. in agriculture and plastics). Therefore this total does not express overall energy demand for the province. Total primary energy use data are suppressed by Statistics Canada for confidentiality reasons (this value still excludes wood). Natural Resources Canada (NRCan) in a 1999 report used a number of assumptions to determine the total primary energy for Nova Scotia in 1997 based on the available StatsCan data. NRCan estimated that total primary energy demand was 262.1 PJ. Oil accounted for 153.7 PJ; coal, 87.5 PJ; wood, 23.1 PJ; and hydro/tidal, 3.5 PJ.

37%, 27%, and 32% of electricity consumption, respectively, in 2003. The remaining 4% is made up by non-specified users (Emera, 2004).

Figure 4. Nova Scotian energy use, final demand (including wood), by end use, 2001 (184.5 PJ)



Source: NEB, 2003.

Energy supply and production

Nova Scotia has indigenous energy sources including natural gas, coal, biomass, hydro, wind, solar and geothermal. In 2001 Nova Scotia became a net energy exporter through the production of natural gas by the Sable Offshore Energy Project (NSPD and NSDNR, 2001). Since then, production levels have declined so that the Province is again a net importer (StatsCan, 2005). Even with substantial natural gas production, the majority of energy used in the Province comes from imported fuel (coal and oil), while most of the natural gas is exported to New Brunswick and the eastern United States. It is estimated that about 10% of total primary energy use in Nova Scotia comes from renewable sources: hydro, biomass and, to a limited extent, wind.[10] The bulk of demand is for oil and oil-based products, and coal (for electricity); all of these are imported. The Province has its own coal resources but finds it cheaper to import (Emera, 2003). This section provides a snapshot of current energy supply and production by sources used and/or available in Nova Scotia. Energy use trends over time in the Province and compared to other regions will be discussed in Chapter 5.

[10] As noted above, total primary energy data for Nova Scotia are suppressed by Statistics Canada for confidentiality reasons. Furthermore, Statistics Canada and other organizations have long struggled to develop accurate estimates of wood use in Canada. A large portion of wood is used for home heating and is either cut for personal use or sold in the informal economy. It appears that renewable energy (e.g. wood and hydro) represented about 10% of primary energy use in 1997 (NRCan, 1999). The only major changes in energy in Nova Scotia since 1997 have been the production and use of natural gas at Sable Island and increasing demand. However, after 2002 demand provincial use of natural gas decreased. Therefore, it is felt that these numbers are likely to be unchanged today.

Crude oil

Between 1992 and 1999 Nova Scotia produced more than 44 million barrels of crude oil at Canada's first offshore project, Cohasset-Panuke (CAPP, 2004). Although exploration has continued—over 120 petroleum and coal-bed methane wells have been drilled, and seismic data charting more than 3,800 kilometres of ocean floor have been amassed—there has been no further production of crude oil in the Province (NSDOE, 2004a). Consequently, refined petroleum products used in Nova Scotia are developed from imported oil. Much of the oil is delivered as crude and refined at Imperial Oil's Dartmouth plant, which has a processing capacity of 82,000 barrels a day and ran at 100% capacity in 2003. Imperial Oil reports that the major sources of crude oil for this refinery are Venezuela and the North Sea (Imperial Oil, 2004b). The Irving Oil facility in St. John, New Brunswick, is Nova Scotia's other major source of refined petroleum products. Irving does not disclose information on its crude oil sources.

Natural gas

After more than 30 years of offshore exploration activity, natural gas from the Province's first offshore project—Sable Offshore Energy—began to flow in December, 1999. The first three fields of the Sable Offshore Energy Project (SOEP), known as Tier I, averaged production of around 500 million cubic feet per day (MMcf/d) (NSDOE, 2004d).

Work for the project's second phase (Tier II) is under way and began production in the fourth quarter of 2003. In 2003, output averaged 451 MMcf/d with production coming on stream from a fourth field and construction started on a fifth field (CNSOPB, 2005; Imperial Oil, 2004). In 2004, output averaged 418 MMcf/d but fell to 386 MMcf/d in the first two months of 2005. Natural gas from SOEP is transported through the Maritimes & Northeast Pipeline to markets in New Brunswick, the eastern United States and Nova Scotia (Emera, 2003).

In the late 1990s and early 2000s, Nova Scotia's natural gas discoveries amounted to between 4.5-5.0 trillion cubic feet (tcf). Estimates of additional gas resources range from 15 to 41 tcf, but have not yet been confirmed (CNSOPB, 2002). Moreover, in 2003, estimates of SOEP reserves were downgraded for the third straight year to 1.35 tcf from 3.6 tcf (Kumagai, 2004). A decline in findings has also been reported at Deep Panuke. Since SOEP, no new major gas-producing wells have been confirmed, and in the last year several sites have been abandoned. For example, Imperial Oil Resources Ventures Limited drilled a deepwater well approximately 300 kilometres southeast of Halifax but abandoned it without encountering significant hydrocarbons (NSDOE, 2004d). In 2004, three additional exploratory wells were discontinued (CNSOPB, 2005). The development of Deep Panuke has been an on-again/off-again prospect with new plans being developed since fall, 2004 (NSDOE 2004d, 2004e).

Exploration interest and activities continue in Nova Scotia, though at a greatly reduced rate. Two new offshore wells were drilled in 2004 with an additional new well beginning in 2005. As of fall, 2004, the Nova Scotia Department of Energy also expected one onshore well to be drilled in 2005. There have been nine onshore wells drilled since 1999 (NSDOE, 2004b). The decrease in interest is marked by the Canada-Nova Scotia Offshore Petroleum Board's decision not to proceed with a call for bids for new exploration licenses and furthermore a number of companies did not request an extension to the current licenses (Hughes, L., 2005). The Atlantic Institute for Market Studies (AIMS) estimates that current exploratory drilling rates are not high enough for the Nova Scotia oil and gas industry to sustain itself (Kumagai, 2004).

The majority of Nova Scotia's natural gas is exported to markets in the U.S. and New Brunswick, with only a small proportion used in this Province. In 2003, over 90% of natural gas produced in Nova Scotia was used outside the Province (StatsCan, 2004b). The distribution infrastructure developed for natural gas in Nova Scotia is currently quite limited. Therefore few consumers have access to this energy source.

Heritage Gas is the main natural gas distribution agent in Nova Scotia. This means the company holds the franchise for distribution, but other parties can also sell natural gas. Heritage Gas has approval (from the Province's Utility and Review Board) to sell gas in Cumberland, Colchester, Pictou and Halifax Counties; the town of Goldboro; and the Municipality of the District of East Hants. Strait Area Gas Corporation has approval to sell gas to Antigonish, Inverness, Richmond and Guysborough counties (UARB, 2003). Currently the Heritage Gas pipeline system extends to Dartmouth and Amherst with a total of 400 customers (Heritage Gas, 2005). The "anchor-load" in Dartmouth is NSPI's Tufts Cove power plant.[11]

Incentives for natural gas use are available through Natural Resources Canada in partnership with the Province. Rebates are provided to residential and commercial consumers who purchase qualifying (i.e. Energy Star rated) natural gas boilers (Heritage Gas, 2004).[12] The Province has also tried to assist the transition to natural gas by establishing the Gas Market Development Fund. This $20 million endowment is financed by gas producers in Nova Scotia and is intended to assist individual Nova Scotians who are making the transition to natural gas, as well as for extension of the pipeline system (NSDOE, 2003). However, given that one kilometre of pipeline costs about $932,000 to install, the fund could finance at maximum a 20 km extension (Hughes, 2003).

Liquefied natural gas

Although there are currently no liquefied natural gas (LNG) facilities in Nova Scotia, several sites have been considered for constructing such facilities, and one terminal in Bear Head, Cape Breton, has been approved for construction by the Province (ABM, 2005). Two other companies have announced plans for LNG facilities: one near Bear Head and the other in Goldboro near the Sable Offshore Energy Plant. These facilities are intended to address the growing demand for natural gas in North America and would supply markets in the U.S. and Canada via the Maritimes & Northeast Pipeline. The proponent of the approved LNG project, Access Northeast Energy Inc. (ANE), states that the development would include:

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[11] An anchor-load is a large energy user that helps make the large initial infrastructure development of building a lateral line economic.

[12] Energy Star is a U.S. government-backed program that tests, sets standards for, and labels business and residential devices for superior energy efficiency.

> [M]arine offloading, LNG storage and re-gasification facilities to deliver gas into the Maritimes and Northeast Pipeline, which services the Eastern Canada and Northeast U.S. gas markets. Pending receipt of appropriate permits, the proposed Bear Head LNG terminal would be in commercial operation with 750 mmcf/day to 1 Bcf/day of send-out capacity by November 2007 (MarineLog, 2003).

Coal

With significant indigenous resources, coal has played a central role in Nova Scotia's economy since the 1700s. Until the last decade almost all coal burned in the Province for electricity generation and for industrial and (in some cases) residential use, came from local sources. In the mid-90s several coal mines closed and in 1996 the Province began to import coal from abroad, initially from U.S. suppliers but eventually from Colombia and Venezuela (NSPD and NSDNR, 2001; Marston, 2004). The shift to imported coal was a result of the end of federal subsidies for the operations of the Cape Breton Development Corporation (Devco), and Devco's inability to achieve commercial viability; not because of a shortage in indigenous supply (GoC, 1999; Huskilson, 2004). Although there is ongoing discussion of reviving the Nova Scotia coal mining industry, no mines have been opened to date (NSDOE, 2004c; NSPD and NSNDR, 2001a).

Nova Scotia's dependence on coal has not been constant. Up to the 1950s coal was a principal source of energy in the Province; however, a steep decline in coal use was experienced in the late 50s as a result of an abundance of relatively cheap imported oil. This decline in oil prices affected Provincial exports of coal, as its high transportation costs could not compete with cheaper oil imports (Toombs, 2004; Calder, 1985). When oil prices rose sharply in the early 70s the Province was greatly affected by its heavy reliance on imported oil. In response, an Energy Planning Organisation for Nova Scotia was formed which advocated, among other things, a return to indigenous coal for electricity generation in the Province (Conley, 1983). Although a gradual switch was made to coal-fired generating plants, almost all the Province's fuel sources are once again imported. In 2003, 75% of electricity in Nova Scotia was generated from coal, almost all of which was imported (Emera, 2004). Coal production in Nova Scotia fell from a recent high of 4,488 kilotonnes (kt) in 1992 to 1,166 kt in 2000, almost all of which was sold to Nova Scotia Power Incorporated for electricity generation (StatsCan, 2005a; NSPD and NSDNR, 2001b). With the closure of Devco in December 2001, coal production declined further to just 32 kt in 2003. Meanwhile 2,210 kt of coal was imported in 2003 (StatsCan, 2004b).

Nova Scotia's coal resources are located in four main sites around the Province. The majority is found in the Sydney coalfield (2.65 billion tonnes), with the next largest fields at Mabou (143 million tonnes), Springhill (77 million tonnes) and Pictou County (70 million tonnes). The remaining coalfields contain resources totalling approximately 16 million tonnes. According to the Natural Minerals Branch of the Provincial Department of Natural Resources, "less than 20 percent of the resource is classified as measured (proven), indicating that much is yet to be learned about the Province's coal resources. Recoverable coal (reserves) is estimated at one billion tonnes" (Calder, 1985).

Despite its poor environmental performance (see Chapter 3), we are unlikely to see a significant decline in the use of coal in the electricity sector in the near future, as the current coal-fired generating stations in Nova Scotia have a remaining economic life of five to 20 years. The NS Energy Strategy points out that "it is economically preferable that they continue to operate for the duration of their economic life if this can be achieved in the context of environmental constraints" (NSPD and NSDNR, 2001). It remains to be seen if more environmentally-friendly generating technologies will be adopted as these facilities reach the end of their economic life.

Hydro and tidal power

In 2003, about 9% of electricity in Nova Scotia (1080 GWh / 3,887 TJ) was generated from hydro power. This includes a 20 megawatt tidal power station in Annapolis Royal. Along with the tidal plant, Nova Scotia Power owns and operates 34 hydro-electric sites in the Province making up 404 MW of NSPI's generating capacity (Emera, 2004).

The majority of NSPI's hydro dams are located in the western part of the Province including numerous facilities on the Mersey and Black Rivers (NSPI, 1999). All of the watersheds in and around Kejimukijik National Park have been dammed for hydro power generation. In total there are 16 watersheds that have been affected. In addition to the Mersey and Black Rivers these include the Annapolis River, Avon River, Bear River, Dickie Brook, Fall River, Harmony River, Lequille River, Nictaux River, Paradise River, Roseway River, Sheet Harbour, Sissiboo River, St. Margaret Bay, Tusket River and Wreck Cove (NSPI, 2005d). There are also four private hydro power generators including Black River Hydro Ltd., Morgan Falls Power Co., Minas Basin Pulp and Power and the Berwick Electric Commission (Bradley, 2005). Most of the facilities were originally constructed in the early 1900s with the most recent additions being at Morgan Falls in 1996 and Wreck Cove in the 1970s. The capacity of the hydro stations range from 200 to 115,000 kilowatts. One dam on the Mersey River provides about 25% of the hydro energy annually. Only about a third of the hydro sites include upstream or downstream fish ladders or similar fish aiding systems.

Almost all sites suitable for river hydro generation have been tapped in the Province, hence this resource is not expected to expand significantly (Richards, 2004; Conley, 1983). The only scope for expansion is through efficiency upgrades at existing sites and small scale applications.

Annapolis Tidal Power station—one of only three tidal barrage projects in the world—was built in 1983 with funding from the Canadian and Nova Scotia Governments. This 20 MW station was intended as a demonstration project to assess the feasibility of tidal barrage power generation. Annual output has been about 30 gigawatt hours (GWh) per year. Extensive studies were conducted of tidal barrage power potential in the Bay of Fundy. These studies identified three sites in the Bay with a total capacity of 8,500 MW and an annual production of 22,000 GWh (NRCan, 2002). A tidal barrage works like a hydro electric dam in that a dam or barrage is constructed across a bay or river mouth. The height differential between one side of the dam and the other needed to move the generators is created by storing the tide waters on one side of the dam. In Annapolis, power is only generated as the tide falls; however, the world's largest tidal barrage, located in France, generates power both on incoming and outgoing tides. High economic costs combined with ecological concerns such as altered tidal regimes leading to wetland and habitat destruction and physical obstruction to fish have prevented further tidal power developments in Nova Scotia (NSPD and NSDNR, 2001a).

Other hydro or tidal sources being explored in other parts of the world include capturing power from marine currents and waves (Soares, 2002; Boyle, 1996). Most ocean energy technologies are still in the demonstration phase, therefore no commercial applications are expected in Nova Scotia in the short term. If these technologies are proven to be effective, Nova Scotia's geography could be very suitable for capturing ocean energy for power production. Nova Scotia along with New Brunswick and a number of U.S. states have partnered to pay for a feasibility study to assess the potential for using tidal flow generators in the Bay of Fundy (NSDOE, 2005a). This technology is very new with only a few test turbines in use around the world. A small scale commercial project is planned for New York City's East River (Pearson, 2004).

Although a significant source of electricity in the Province, hydro and tidal power constitute only about 1% of total primary energy use.

Biomass

Biomass, mainly in the form of wood and waste wood, is commonly used in Nova Scotia for home heating and some industrial and institutional purposes. An estimated 100,000 homes in Nova Scotia rely on wood as a heat source, either as their principal fuel or as a complementary source to oil (NSPD and NSDNR, 2001a). Wood and pulp liquor account for a 7% end use fuel share in Nova Scotia (NEB, 2003). Because wood for home heating is often sold in the informal economy, precise data are not available for how much biomass is used in Nova Scotia. NSDOE estimates 365,000 cords (447,000 tonnes) of wood are used for home heating annually (Dobbelsteyn, 2005).

There are several large industrial users of biomass in the Province, particularly in the forest products industry, that currently consume about 1.2 million green tonnes of wood waste to generate electricity and produce process steam. The largest biomass burning facility in Nova Scotia is the Brooklyn Energy Power Corporation which burns about 450,000 tonnes of wood waste each year (NSPD and NSDNR, 2001a). Other facilities that use biomass (in varying quantity) include Taylor Lumber; Comeau Lumber; Stora Enso; Kimberly Clark; Minas Basin Pulp and Paper; the Nova Scotia Agricultural College; South Shore and Annapolis Hospitals; numerous sawmills including MacTara and Shaw; and a number of commercial greenhouses including Avon Valley, Gordon's, and Stokdijk (Hayes, 2005). In terms of the total energy picture, biomass is an important source of energy, though it remains below 10% of primary energy use (NRCan, 1999).

Wind energy

There are currently two commercially operated wind turbines and one wind farm in Nova Scotia. Other wind power applications are limited to several test and home-application turbines. NSPI's turbines in Little Brook, Annapolis County, and Grand Etang, Cape Breton, have a combined generating capacity of 1.2 MW (NSPI, 2002). A new commercial wind farm was completed in May, 2005, at Pubnico Point on Nova Scotia's Western Shore where seventeen turbines with a total generating capacity of about 31 MW have been installed by Atlantic Wind Power Corporation (Demond, 2005). The Pubnico Point Wind Farm is anticipated to generate approximately 100 GWh (100,000,000 kWh) of electricity per year, the equivalent of power demanded by about 12,000 average Canadian homes per year (NSDEL, 2004).[13] Nova Scotia Power will purchase the energy produced by this facility (Emera, 2003).

NSPI has made several recent announcements about its plans for further wind development in the Province. These include notice of a community partnership for wind development with the Eskasoni Band Council. The most significant development, however, was a 2004 call for proposals for 60 MW of new renewable generation.[14] The request included calls for small (under 100 kW), medium (100 kW to 2 MW), and large (greater than 2 MW) renewable energy projects. In October 2004, NSPI announced the results of the under 2MW category. NSPI accepted all 17 projects which will add 28 MW of renewable power including two biogas, one biomass and 14 wind projects (NSPI, 2005e, 2004b). In 2005, two more wind farm developments were announced. One is a 12 MW wind farm to be constructed next to NSPI's Lingan generating station in Cape Breton and the other is a 31 MW farm to be built on the Tantramar Marsh along the Trans Canada Highway (NSPI, 2005e, 2005f). Combined with Pubnico Point, these projects should increase total renewable generation capacity by about 100 MW when they are completed (NSPI, 2005).

Nova Scotia’s geography and climate produce a relatively favourable wind regime with coastal areas being the most suitable. Some estimates for offshore developments show that wind energy could provide ten times Nova Scotia’s current electricity needs (Hughes, 2001a). Environment Canada has developed the *Canadian Wind Energy Atlas*, a meso scale wind resource map (Environment Canada, 2005c). This map is based on meteorological data and basic typography. It is useful for identifying regions with good potential for wind energy development but is too coarse to be useful for turbine citing and detailed planning applications. Figures recent enough to show the increase in wind power as a portion of total primary energy use are not available and more research is needed on wind resource mapping for the Province.

Geothermal energy

In the late 1980s, with support from the Federal and Provincial Governments, Ropak Can Am Ltd. installed several mine-water geothermal systems at Springhill, Nova Scotia. A manufacturer of plastic packaging products, Robak is using geothermal energy from floodwater in abandoned mines to provide heating and cooling at its manufacturing facilities (IEA, 2003). According to the International Energy Agency (IEA, 2003), this is the first industrial site in Canada to demonstrate the economic and technical viability of this energy source, saving the equivalent of about 600,000 kWh of heat energy, compared to conventional systems. Due to the success of the original project, further mine-water systems have been installed since and there are now around 12 sites using geothermal energy in the Springhill area (NSPD and NSDNR, 2001a).

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[13] Given the intermittent nature of wind, it is impossible to power homes continuously with wind power. Therefore, the number given is for illustration purposes. It indicates that this amount of electricity will enter the electricity grid over one year and, were it available in constant supply, could power this number of homes.

[14] These renewable proposals can be hydro, biomass, biogas, or wind developments however the vast majority have been wind.

In addition to the mine-water systems there are several other geothermal applications in the Province. These include groundwater and ground-source heat pumps for institutional and commercial facilities as well as several residential scale heat pump applications (NSPD and NSDNR, 2001a). Exact figures for the number of systems and the energy supplied by these systems are not publicly available. Although these developments are important and there is much potential for geothermal energy, thus far it represents an insignificant proportion of total energy supply (estimated to represent a fraction of one per cent).

Solar energy

Apart from some household level installations of solar hot water (SHW) and solar photovoltaic (PV) systems, as well as some passive solar energy designed buildings, solar energy is not used extensively in Nova Scotia and no official data are collected on its application in the Province (McLean, 2004). However, there is significant potential to use solar energy more extensively. Despite its temperate weather, Nova Scotia has a relatively good solar climate (often better than locations with warmer temperatures). Studies have shown that Halifax has Canada's third best solar climate due to mild winters and many clear days annually (NSDOE, 2005). Through passive solar design, about 30% of a conventional home's space heating needs can be supplied directly by the sun. There is also substantial potential to offset energy use through solar hot water heaters in residential, commercial and industrial settings, and using solar PV and other active forms of solar technology to offset electricity use. Combined with efficiency and conservation measures, solar energy could become an important source of primary energy in the Province.

2.4 The Nova Scotia Electricity Industry

Electricity is an important form of energy in Nova Scotia accounting for 21% of energy use, final demand or 33% when transportation is excluded. The vast majority of electricity in the Province is supplied by Nova Scotia Power Incorporated (NSPI); a privately operated, fully-integrated electric utility owned by Emera Inc. NSPI became a private entity in 1992 when the Provincial Government sold all shares in this previously crown-owned corporation (NSPD and NSDNR, 2001a). In 2002, NSPI supplied 97% of the generation, 99% of the transmission and 95% of the distribution of electric power in Nova Scotia, serving 450,000 residential, commercial and industrial customers (Emera, 2003). The remaining three percent of generating capacity is provided by independent power producers (IPPs) who either self-generate or sell their power to NSPI.

NSPI had a total installed electricity generating ***capacity*** of 2,243 (MW) in 2003, the majority of which came from five thermal generation stations. There are three plants in Cape Breton (Lingan, Point Aconi and Point Tupper), and two in mainland Nova Scotia (Trenton and Tufts Cove). Coal accounts for the majority of this capacity at 55%, followed by oil and gas at 27%. The oil and natural gas is used at Tufts Cove, which is a duel-fuel plant (Emera, 2004). The remaining 18% of capacity is supplied by hydro-power and wind (Emera, 2004). The actual generation in 2003 amounted to 12,329 GWh. In 2003, the electricity ***fuel mix*** in NS was dominated by coal (75%); oil (12%); hydro (including tidal power) and wind (9%); generation and purchases from independent power producers and/or imports (3%); and natural gas 1% (Emera, 2004).

Generating capacity and fuel mix show different aspects of power generation. Capacity is the nameplate rating of a generating station indicating the maximum power that can be generated at any given moment. However, no plant runs 100% of the time each year. Because electricity demand is not constant (it varies by season and by time of day) and because the generating utility must maintain excess capacity in case a plant fails, this means that a generating utility can choose to use one type of plant more often than another. For NSPI, coal fuel prices are the lowest (with the exception of hydro and wind), therefore the coal fired plants are used as much as possible to provide base load power for the grid while oil and natural gas are used to meet demand during peak periods. Accordingly, coal is by far the largest portion of the fuel mix at (75%), while it represents a more modest proportion of capacity (55%).

Figure 5 presents NSPI's 2003 fuel mix while Figure 6 shows the 2002 fuel mix. The substantial use of natural gas in 2002 was an anomaly as it is the largest amount of natural gas ever used in the Province, while it was barely used in 2003 because oil was cheaper (Emera, 2004). Natural gas has only been used since 2001.

Figure 5. NSPI fuel generation mix, 2003

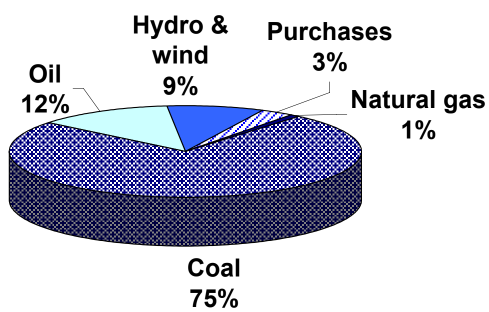
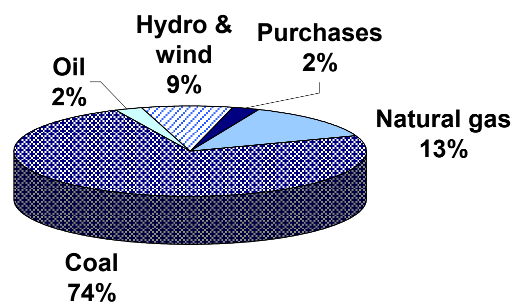


Figure 6. NSPI generation mix, 2002



Source Figure 5: Emera, 2004

Source Figure 6: Emera, 2003

NSPI owns and operates 34 hydroelectric generation stations, including the Annapolis Tidal Generating Station (NSPI, 2005a). In 2002 NSPI installed 1.2 MW of wind powered generation, but this accounts for less than 1% of total installed capacity in the Province (Emera, 2003). NSPI has contracted for electricity from renewable sources with six independent power producers in Nova Scotia. These include two hydro, three biomass, and one wind producer. As of 2002-2003 the total power generated from these sources accounted for about 1% of NS electricity generation, i.e., 25 MW are fed into the Provincial grid (Dorey, 2004). The statistics on generation from IPPs are changing (e.g. the 2005 completion of 31 MW wind farm at Pubnico Point), so these numbers provide only a snapshot of the situation in 2002-2003.

Electricity regulation

The Nova Scotia Utility and Review Board (UARB) is the utility regulator in Nova Scotia. It was created in 1992 by proclamation of the *Utility and Review Board Act*. This act combined the Board of Commissioners of Public Utilities, the Nova Scotia Municipal Board, the Expropriations Compensation Board, and the Nova Scotia Tax Review Board. Additional duties of the UARB relate to natural gas distribution, pipelines, victims' rights and services, railways and several other controls not related to the energy sector (UARB, 2005a). The Board is an independent quasi-judicial tribunal which reports to the Legislative Assembly through the Minister of Environment and Labour (NSDOE, 2004).

As a public utility, NSPI is subject to regulation by the UARB, which means that the latter has supervisory powers over NSPI's operations and expenditures. For instance, electricity rate changes must be approved by the UARB before coming into effect. In Nova Scotia there is no annual rate review process, but rather rate hearings are called at those times when changes are being considered. These hearings can be requested by the UARB or by NSPI (UARB, 2005a). In 2005 NSPI increased its electricity rates. There are several rate structures depending on user group, usage levels and other conditions. Rates for residential users increased 6.1% in April, 2005. Some commercial users had a smaller increase while industrial users had an increase of about 10.4% (UARB, 2005b). NSPI currently has another request for rate increases on the order of 15% before the UARB. Hearings are scheduled to begin in November 2005.

2.5 Nova Scotia Energy Policy

Political jurisdiction and decision-making in the energy sector in Canada is a shared responsibility of the Federal and Provincial Governments. Responsibility is determined in part by resource ownership: on-shore resources are owned and managed by the province in which they are located, while offshore resources are owned by the Federal Government (Doern and Gattinger, 2003). Provinces can and do negotiate decision-making about offshore resources with the Federal Government. The Canada Nova Scotia Offshore Petroleum Board (CNSOPB) is an example of such a partnership (GoNS, 2004). Nova Scotia and Newfoundland and Labrador recently negotiated agreements with the Federal Government that have seen substantial offshore revenues channelled into provincial coffers.

Energy policy is largely left to individual provinces to formulate and implement, but the Federal Government plays an important regulatory role in energy matters of inter-provincial and international scope. For example: international trade of energy; energy project developments in federal jurisdictions (e.g. oil and gas exploration offshore); and negotiation of international treaties such as the North American Free Trade Agreement and the Kyoto Protocol, all fall within the competence of the Federal Government (Doern and Gattinger, 2003). In these instances the Federal Government either implements policies at a national level or works with the Provinces to develop strategies appropriate to the provincial level. The Provinces are then left to design their individual energy policies within this national framework. This includes decisions about the market structure and regulation of the industry at the provincial level (Doern and

Gattinger, 2003). There is generally a great deal of scope for each province to develop its own unique approach to dealing with energy matters.

Energy policy in Nova Scotia is the responsibility of the Provincial Department of Energy, which was created in June of 2002 to serve as the Government's focal point in the development of the Province's energy resources. The Department:

> [P]romotes, supports, coordinates, administers, and gives policy advice concerning the development of a prosperous, clean, efficient, and sustainable energy industry for the maximum advantage of Nova Scotians. Its mission is to help Nova Scotians build a better future by ensuring responsible resource management of Nova Scotia's energy resources, and maximising financial, economic, industrial, and employment benefits that flow from the development and use of the province's energy resources (NSDOE, 2004).

The principal energy policy document in Nova Scotia is entitled *Seizing the Opportunity: Nova Scotia's Energy Strategy*, and is presented in two volumes. It was prepared by the Nova Scotia Petroleum Directorate (NSPD) and Department of Natural Resources (NSDNR) and published in 2001. At the time the energy strategy was prepared there was no Department of Energy—the Department of Natural Resources was responsible for energy-related decisions with the exception of matters related to oil and gas exploration, which fell to the Nova Scotia Petroleum Directorate. One of the agenda items laid out in the energy strategy was the formulation of a Department of Energy that would take responsibility for all energy-related decisions, thereby subsuming the Petroleum Directorate.

Nova Scotia's Energy Strategy presents a broad spectrum of energy policy for the Province but appears to leave much of the detail regarding implementation open to future consideration. It provides a description of the direction in which the Province would like to move with regard to all energy sources in the Province, and includes guidelines for oil and gas exploration, electricity generation, "clean" coal development, renewable energy, energy efficiency, co-generation and ameliorating the environmental impacts of energy (NSPD and NSDNR, 2001, 2001a).[15] The wording in the strategy, however, is often weak, with little consideration given to how particular policies will be implemented. The Government makes very few commitments to action under the strategy and the document lists few targets by which achievements can be measured. The energy strategy is complemented each year by progress reports, prepared by the Department of Energy, intended to inform the public about developments in the energy sector. Progress reports have been published for 2002/2003 and 2003/2004 (NSDOE, 2004c; NSDOE, 2003). None is available for 2004/2005.

An outcome of the energy strategy was the formation of the Electricity Marketplace Governance Committee (EMGC). Its mandate was to make recommendations to the Minister of Energy about "the implementation, development, structure and rules for the future electricity sector" (NSPD and NSDNR, 2001). It has since deliberated on developments in the electricity sector and

[15] The strategy repeatedly uses the term "clean coal." At best, technology currently being developed will make the burning of coal for electricity clean*er* than at present—but there will still be some emissions, toxic ash, and other adverse impacts of mining, transportation and combustion of coal.

submitted a list of 89 recommendations. The EMGC was established to provide specific recommendations to the Energy Minister regarding the implementation of the electricity provisions in the Province's Energy Strategy. The Government has endorsed all 89 EMGC recommendations. Some of the near-term recommendations have been incorporated into the Province's Electricity Act that was passed in the Fall of 2004. However, the Energy Act which was developed to include more aspects of the energy strategy than simply electricity has not yet been presented to the legislature and therefore is not enshrined in Nova Scotia law. It is not certain when this process will be completed (McCoombs, 2005a).

Goals of the Energy Strategy

Several themes emerge when reviewing the stated goals and principles of *Nova Scotia's Energy Strategy*: economic growth; environmental protection; and securing the future for Nova Scotians. Volume 1 of the strategy provides a vision statement for the energy sector. It also sets goals for the energy strategy and identifies the foundation of values and principles on which the energy strategy should be developed.

> Vision
>
> An energy industry balancing economic growth, social goals and respect for the environment for generations of today and tomorrow is essential for Nova Scotia to achieve its vision of becoming one of the best places in the world to live and work (NSPD and NSDNR, 2001).
>
> Goals

- To create a world-class energy sector that achieves sustainable economic development in balance with high social and environmental standards;
- To optimise financial, economic and social benefits in the Province's rapidly expanding offshore energy sector;
- To improve the Province's environment and enhance the quality of life of Nova Scotians (NSPD and NSDNR, 2001).

The values and principles outlined in the strategy can be summarized as follows:

1. Public consultation, fairness, transparency, accountability and responsible regulatory practices.
2. Encouragement of consumer choice and competition.
3. Private sector involvement.
4. Nova Scotians as primary beneficiaries.
5. Improving the environment.
6. Having a diversity of reliable energy sources and pursuing efficiency and conservation initiatives (NSPD and NSDNR, 2001).

2.6 Chapter Summary

Energy use in Nova Scotia is highly dependent on oil products and coal. Stated more precisely, final demand in Nova Scotia is heavily dependent on oil products and electricity (which is largely generated from coal) which together account for approximately 90% of total final demand. Wood and waste wood is the third most important fuel in the Province, accounting for 7% of final demand. Of the oil products, about 50% are used in transportation. If transportation energy use is excluded from the energy balance, the refined petroleum products become less dominant as a fuel source, though they still constitute the largest energy source.

Based on Statistics Canada data which exclude wood use, the total primary and secondary energy end use, final demand, in Nova Scotia was 174 PJ in 2002, and 181 PJ in 2003. The same statistics show that end use demand was attributable to the following sectors in order of magnitude: transportation; residential; industrial; commercial; public administration; and agricultural.

Nova Scotia has indigenous energy sources including natural gas, coal, biomass, hydro power, wind, solar energy, and geothermal energy. Despite this endowment, Nova Scotia is a net importer of energy, predominately of crude oil and coal. The Province has substantial coal resources, but uses imported sources due to lower economic costs.

It is estimated that about 10% of total primary energy use in Nova Scotia comes from renewable sources: hydro power; biomass; and some wind power. Considering the very small quantity of indigenous coal and natural gas used in the Province, this 10% figure is essentially representative of the proportion of total primary energy use derived from Provincial energy resources (i.e. not imported either from other provinces or outside of Canada).

Although there are currently no liquefied natural gas (LNG) facilities in Nova Scotia it appears that LNG will soon become a part of the energy landscape. One site has been approved and two more sites are under active consideration. However, these facilities are being developed to provide natural gas to the eastern United States and the production costs will probably be higher than for non-liquefied Provincial natural gas production, making it unlikely that LNG will be widely used within the Province in significant quantity. Therefore, like current Provincial natural gas production, the bulk of LNG energy will be used out of province.

Almost all sites in the Province suitable for river hydro generation have been tapped, therefore this resource is not expected to expand significantly. Biomass, mainly in the form of wood and waste wood, is in common use in Nova Scotia for home heating and some industrial and institutional purposes. Wind energy, though in limited use, is gaining momentum and holds great potential for Nova Scotia. Developments in solar and geothermal energy are minimal.

The vast majority of electricity in the Province is supplied by Nova Scotia Power Incorporated from five thermal generation stations. In 2003 the electricity fuel mix in Nova Scotia was dominated by coal (75%), with oil (12%) and hydro (9%) making up most of the remaining generation. There are currently about six independent power producers in Nova Scotia that NSPI has contracted for electricity from renewable sources.

Energy policy is largely the responsibility of the Provincial Government. The Provincial Government outlined its vision for the energy sector in the 2001 Energy Strategy, which among other things recommended the creation of an energy department that has been in existence since 2002. A number of major aspects of the energy strategy have been actualized through policies and regulations, though the yet to be debated energy act will further clarify energy policy in Nova Scotia.

This brief overview of the current energy system in Nova Scotia serves as the starting point for the remaining chapters. The following sections discuss the implications of our energy choices and present indicators that can be used to assess progress over time towards a more sustainable energy system in the Province.

3. Impacts of Energy

3.1 Introduction

All energy applications have side effects that can lead to environmental and social damage. These unwanted consequences—otherwise known as negative externalities—can occur at any stage of energy supply (exploration, production, transportation, storage, conversion, distribution) as well as at the demand end (driving a car, heating a building, manufacturing a widget, among other end uses). When striving for energy sustainability it is important to recognize that there will always be some unwanted negative consequences that result from energy production, distribution and use, but that reducing these impacts is both possible and necessary (Geller, 2003; Ramage, 1997).

The energy sector produces substantial environmental effects covering a diverse range of impacts. Some of these effects are experienced across international boundaries—examples include climate change, acid rain, oil spills and radioactive fallout from nuclear accidents. Others are local concerns such as ambient air quality, land use and solid waste disposal. Some of these effects are immediate while others will be experienced by future generations. Some impacts will not be felt locally (e.g. in Nova Scotia) even though they result from energy consumption in the Province. For instance, most fossil fuels used in Nova Scotia are extracted in other countries (e.g. coal from Colombia, oil from Venezuela) and transported to the Province. In such cases the environmental and social consequences resulting from resource extraction are felt at the point of origin. However, the costs of these impacts are always borne by somebody, somewhere. Consequently, effects both at home and abroad must be considered when deciding how to move towards greater energy sustainability.

In this chapter a wide range of major known social and environmental impacts that result from energy use in Nova Scotia are briefly presented. The intent is to show the wide-reaching consequences that result from energy production and consumption in this Province, as elsewhere. Quantifying the full costs of each of these impacts is a huge undertaking—one that can not be completed in this project since it requires a full life cycle analysis of all fuels and energy sources used in the Province and since adequate quantitative data are not available on most impacts. Yet, not to mention these impacts may suggest that they do not exist or have no importance. Therefore, in this chapter, **GPI***Atlantic* attempts to provide as comprehensive an overview as possible of a wide range of major known impacts before turning to a smaller list of health and environmental indicators, which are analysed quantitatively in Chapter 6. In this later chapter seven indicators that affect human health and the environment in Nova Scotia are presented, and trends for each are tracked over time. These indicators are all related to emissions: carbon monoxide (CO); particulate matter (PM); sulphur oxides (SO_x); nitrogen oxide (NO_x); volatile organic compounds (VOCs); mercury (Hg); and greenhouse gases (GHG). These were chosen on the basis of their relative importance as well as the availability of data for each one.

Other impacts, although not always quantified for Nova Scotia, are briefly presented in this chapter. A more thorough assessment of these impacts will require substantial data collection and analysis, initially by central agencies (e.g. Statistics Canada, Environment Canada and Provincial departments) before these impacts can be fully quantified for Nova Scotia.

Included in the discussion here are the health and environmental implications of the following energy sources: coal; oil; natural gas; liquefied natural gas; nuclear energy; hydro power; biomass; wind; and solar energy. In addition, the following energy processes are examined: electricity generation, wood combustion and some industrial treatments.

Although Nova Scotia does not have its own nuclear power stations, the Province does receive some electricity (a few percent of its supply mix) from New Brunswick, where 25% of the electricity mix comes from the Point LePreau nuclear generating facility (NBPower, 2003). Given the anticipated supply crunch of oil, and the environmental concerns surrounding coal, debates about new power sources often lead to considerations of nuclear energy (Homer-Dixon and Friedman 2005; Economist 2005). Such discussions are incomplete if they do not fully address the potential risks and catastrophic effects of nuclear meltdown and of long-term storage of wastes, hence a presentation of some nuclear impacts is included in this chapter (European Commission, 1995; Joyce and Port, 1991).

Another major concern that is discussed in this chapter is the future availability of fossil fuels, especially oil and natural gas, and the consequences a shortfall in these resources might have for social wellbeing. Details about better known problems such as climate change, acid rain and air quality, for which quantifiable data are available, are briefly mentioned here, but are discussed in greater depth in Chapter 6. Other impacts beyond the social and environmental externalities mentioned above are not examined in the present chapter. For example, when considering employment in the energy sector it is common to think only about job creation. However, energy activities, or the consequences of these activities, can also result in loss of livelihood if, for example, capital-intensive activities replace labour-intensive activities, or if an oil spill ruins a fishery. Energy affordability and reliability are important considerations, too, and will be discussed in Chapter 5 where socio-economic indicators of energy are presented.

The impacts of energy on human health and the environment, and the relationship between energy and climate change, are discussed in turn in this chapter. This is followed by a brief discussion of the resource depletion implications of excessive energy use.

3.2 Human Health Concerns

The energy sector is both a risk factor and a known cause of a range of health concerns. Pollution is widely recognised as a significant detriment to public health. Air pollution, for instance, exacerbates respiratory illnesses and is connected to cardiovascular diseases and some cancers. It also “causes between 5,000 and 16,000 premature deaths in Canada annually. Even the low end of this range is higher than the annual death toll from breast cancer, prostate cancer, or motor vehicle accidents” (Boyd, 2003:94).

Pollutants of course, are not restricted to the air; they also can be directly emitted into or indirectly enter water and soil, often travelling far from their original source. Inevitably, concentrations of these contaminants—ingested through a variety of pathways—may cause a range of acute or chronic reactions, the form and severity of which depend on the dosage and concentration (CECNA, 2004; European Commission, 1999).

Another major concern is occupational health and the risk of accidents within the energy sector. Energy is a large employer in a field of work that includes dangerous occupations like coal mining, working in offshore oil rigs, and dealing with radioactive materials. To ensure stringent safety measures are upheld both for workers and the public, most energy industries are highly regulated. However, workers in the offshore industry in Nova Scotia are still not covered by the same safety standards as other workers in the Province (Hughes, L., 2005). While the energy sector in Nova Scotia has spent millions of dollars over the years upgrading technologies and meeting safety standards, it still remains a high-risk industry for occupational accidents, injuries and fatalities (Inhaber, 2004; McNamara, 2004). The 1992 coal mine explosion at the Westray mine in Nova Scotia serves as a reminder of the continuation of such occurrences even in countries with comparatively high safety standards such as Canada (Richard, 1997). Therefore eliminating, where possible, risks to life and health by investing in more benign energy systems is an important step towards more effectively protecting human health and safety. Together, the public and occupational health problems from pollution and industrial accidents attributable to energy production and use are a significant social cost both to individuals and to the public health care system.

Risk of accident

Extraction, transportation, processing and use of energy all involve human labour. Because these processes are not perfect, accidents can occur at all stages of the energy supply and demand chain. Many of the substances used in the fossil fuel or nuclear industries deal with toxic and dangerous substances that require diligent care (Inhaber, 2004). When accidents happen, and/or substances have been mishandled, the effects can be detrimental to both workers and the public at large. In order to minimize the likelihood of accidents, risk assessments are conducted to monitor and measure the likelihood of problems, and safety standards are developed by which industry is expected to abide (Inhaber, 2004). Although safety, regulatory and monitoring measures have produced a huge improvement in energy safety, accidents still occur, particularly in countries where labour and safety standards are low (Leowenson, 2001).

Since Nova Scotia relies mostly on energy imports, including oil from Venezuela and coal from Colombia, we need to take partial responsibility for the social costs that our energy decisions impose on others. The choice to support well-regulated and safe energy production abroad is essential to live up to our commitment of sustainability at home. While it is beyond our ability to calculate the full social costs of energy production incurred in other countries, it is important that we expect high quality labour and safety standards that diminish risks to human health and safety as much as possible. Even with proper safety standards in place, however, accidents can still occur, particularly in energy systems that deal with hazardous fuels. What follows is a brief overview of some of the major safety concerns relating to potential accidents in the energy sector.

Coal mining

Coal mining has a long history of fatal accidents from cave-ins to explosions. The most recent large accident in Nova Scotia was the 1992 Westray mine explosion that killed 26 miners (Richard, 1997). The explosion was not the result of one mistake but of a series of problems. The apathy and mismanagement at the mine led the Westray Public Inquiry to conclude that safety measures trailed behind production goals (Richard, 1997). The lesson from the inquiry was that there is a definite need to strike a balance between safety assurances and production if a preventable disaster like Westray is to be avoided in the future.

However, most of the coal burned in Nova Scotia today comes from outside the Province. This means the risk of accident on our soil is sharply reduced, but the shift does not exclude accidents from happening elsewhere, which they do—particularly in places where safety standards (and coal prices) are low. Nova Scotia Power, for instance, imports steam coal from China, as a cheap source of fuel for its power stations (ISIS, 2004). What is not considered in this economic transaction is the social cost of China's mining industry, which has had a disproportionately high number of accidents and deaths (Levine and Sinton, 2004; Stephens and Ahern, 2001). It is estimated that as many as 6,000 coal miners die each year in mining accidents in China (Levine and Sinton, 2004). Small-scale private mines are the main culprits in mining accidents, and increasing government pressure is beginning to close some of these more hazardous operations.

Other social costs of Nova Scotia energy are also felt elsewhere. In Colombia, the source of 17% of NSPI's coal, union workers are trying to negotiate better wages, as well as improved safety and environmental regulations. These negotiations are with Drummond, the third largest coal mining company in the world (ARSN, 2004). In response to this union activity, two Colombian union leaders were targeted and assassinated, and other workers have been killed, threatened, detained or "disappeared"—allegedly at the hands of paramilitaries working for Drummond (Amnesty International, 2005; ARSN, 2004).

In an attempt to bring awareness to and action on this issue, Francisco Ramirez, president of the National Coal Miners Union of Colombia, came to Nova Scotia in March, 2005, and tried to meet with NSPI to discuss the influential role that NSPI could play in demanding fair coal mining practices. NSPI declined to speak with Ramirez and argued that there would be a sharp increase in Provincial electricity prices if the company stopped purchasing coal from Colombia. According to Ramirez, however, there are existing coal cooperatives in Colombia that provide a viable alternative source, meeting Nova Scotia's energy demands at the same price as the coal produced by Drummond (ARSN, 2004).

These and other social problems in the coal mining industry need to be taken into account in assessing the true costs of energy production and use in Nova Scotia, and alternatives to the present system should be explored from a full-cost accounting perspective. Part of a commitment to sustainable energy in Nova Scotia is supporting efforts abroad that take social and environmental protections seriously, in order to minimize the cost in human life, health and safety. Any allegations that seriously question whether these rights are being upheld at least need to be properly investigated to ensure that the "cheapness" of the coal does not override safety and respect for human life, which in turn constitutes part of a sustainable energy strategy. At the very least, the question must be asked whether our unwillingness to intervene to improve the conditions and safety of the workers in Colombia who produce the coal we consume constitutes complicity in the serious human rights violations documented by Amnesty International. Beyond that, the social costs of that coal production should be included in our assessment of the true costs of energy in Nova Scotia.

Oil and gas

Work in the oil and gas industry can be dangerous, in particular to those workers producing oil in offshore development projects (Gardner, 2003). Toxic exposures from leaks or spills; explosions; the handling of heavy machinery; the stress of working long hours away from home—these factors have all contributed to injury, health effects and sometimes death (Gardner, 2003). Even weather events, such as the strong waves that dismantled the *Ocean Ranger* oil rig off the Newfoundland coast in 1982, can be devastating: in that particular incident, 84 men were killed (CBC, 2005).

Shipping accidents also cause oil spills which can have devastating effects on local ecosystems, as well as impacts on the livelihoods of people who rely on those ecosystems. For further information on the environmental impacts of oil spills see "Water pollution and aquatic impacts" in Section 3.3 below.

According to the Canadian International Development Agency (2005): "Working on an offshore oil rig is one of the world's most dangerous jobs. The threat of high winds, fire, exposure to hydrogen sulfide and other hazardous materials, and slips and falls are all part of a day's work on oil rigs from Newfoundland to Brazil." In Brazil, for example, industry experts recorded 92 accidental deaths related to petroleum exploitation over a three-year period from 1998 to 2001 (Osava, 2001). To improve this record, CIDA funded a Nova Scotia company, Frontline Safety Limited, to provide the Brazilian oil industry with the rental and operation of safety equipment, safety audits, and training in handling hazardous materials, fire prevention, electrical safety and fast rescues in emergencies. These defensive expenditures, paid in this case by Canadian taxpayers, along with accidents and lost lives may be classified as a cost of energy production (CIDA, 2005).

Liquefied natural gas

Liquefied natural gas (LNG) is an energy source that is expected to pass through Nova Scotia if current plans to build a LNG terminal at Bear Head in Cape Breton are realized. As discussed in Chapter 2, Bear Head and several other Nova Scotia communities are exploring the development of LNG terminals where natural gas in its liquid form can be docked and converted to gaseous form before being transported to U.S. and Canadian markets. The fuel is brought in by ship from areas rich in supply, including Trinidad, Tobago, Qatar, Algeria, Nigeria, Australia and Indonesia (TCLNG, 2005). Because the Province has limited infrastructure to distribute natural gas, and because the costs of LNG production and processing are higher than other available energy sources, the amount of liquefied natural gas used in this Province can be expected to remain very low in the foreseeable future. However, since these LNG terminals represent a potential new energy supply system located in the Province, the implications of its use should be explored.

The main concern with LNG is the risk of accidents or targeted attacks causing explosions in the storage terminals. Severe explosions in Cleveland, Ohio, in 1994, and at Staten Island, New York, (1973), led to the development of safer storage and transport infrastructure, which has significantly lowered the risk of LNG accidents (CH-IV International, 2005). In fact, many regard LNG as very safe and point to the relatively clean record of transporting LNG at sea (CH-IV International, 2005; Fagin, 2005).

Yet accidents do still occur—particularly in storage terminals, as shown by the 2004 explosion at a terminal in Skikida, Algeria (Fagin, 2005). Such accidents can have significant effects on the lives of nearby residents. In the Algerian incident, 75 residents were injured, and the blast shattered windows more than a mile away (Fagin, 2005). Incidents like this often cause fear and opposition among people living in the vicinity of LNG terminals, despite the relative safety of such facilities (Hoover et al, 2004).

The purported increased threat of sabotage by terrorists at LNG terminals is another key reason for residential opposition. A report by the U.S. Energy Department Laboratory says that "terrorists could use rocket-propelled grenades, missiles, planes or boats to break open the tankers," causing fires or explosions that could inflict "major injury and significant structural damage" (Blum, 2004). So while the risk of an LNG accident is low, the repercussions, if an incident does occur, are large. These concerns at least need to be addressed publicly, especially in the communities in which the terminals are being developed.

Nuclear

Arguably among the most worrisome of all energy accidents are those that occur at nuclear generating stations. Though nuclear energy is not produced in Nova Scotia at present, the previously outlined link with New Brunswick, which does generate nuclear power and export energy to Nova Scotia, requires that its risks be considered here. High level radiation exposure from nuclear accidents can cause severe burns, cataracts, spontaneous bleeding, cancer, neurological and genetic damage, lost fertility, development deformities, and death (Richardson, 2004).

Radiation exposure not only affects people within a specific geographical range, but also the health of future generations because of its persistence in the environment. Health problems can be immediate, while others may take years to appear (Richardson, 2004). This has been shown in the aftermath of the Hiroshima and Nagasaki atomic explosions, and more recently in Chernobyl in the Ukraine, where a nuclear power plant exploded in 1986 after an operational error (Richardson, 2004; Ramage, 1997). Although the total impact from Chernobyl will not be known for many years since radiation sickness can take a long time to develop, it is estimated that "thousands of children—perhaps as many as 10,000—contracted thyroid cancer as a result of exposure to high levels of radiation. And more than 350,000 people were permanently evacuated from surrounding areas" (Heintzman and Solomon, 2003:129). Although the risk of a major nuclear accident occurring is considered small, the impact is potentially enormous with repercussions lasting many generations and affecting a wide area, since nuclear fallout can travel long distances and settle indiscriminately across regions (Ramage, 1997).

Nuclear energy also results in the production of the highly toxic element plutonium as well as other radioactive substances. Plutonium is used in nuclear warheads and remains dangerous to humans for a quarter of a million years. The production of electricity by nuclear fission creates very little pollution compared to the conventional type of pollution generated by the use of fossil fuels. The difficult trade-off occurs because of the severe damage that can be caused by even minute amounts of some radioactive materials such as plutonium. In the words of Maguire and Wren (1994) "a hardly visible amount is lethal to a human being. As little as 130,000,000th of an ounce can cause cancer. One evenly distributed pound could kill everyone in the U.S." Consequently nuclear waste needs to be stored extremely carefully and—due to its persistent radioactivity (measured in millions of years)—in remote sites that will not be disturbed by human or geological activities. Whether this is even possible over enormous time horizons is not known. The waste storage problem is very costly in economic terms, and remains an unresolved problem in nuclear energy generation (WNA, 2001). In addition, the process of de-commissioning ageing and retired nuclear power plants also requires a storage solution, raises health and safety concerns and is very costly.

In a post-9/11 world there is also increased concern about the threat of terrorist attacks on nuclear generating facilities which could create the same effect as above, only by deliberate intent rather than accident.

Electricity generation

Electrical generation is also directly responsible for numerous accidents and the related social costs. Working with faulty wiring and contact with live wires carries some risk of accidents including fires, shocks and burns. These can injure—sometimes fatally—either industry workers or the general public (UKDTI, 2002). Dams used to produce hydroelectricity pose the risk of flooding, which has often affected nearby settlements, particularly those of aboriginal peoples (Health Canada, 2003). The small scale of hydroelectric developments in Nova Scotia substantially reduces or eliminates this risk.

Even with safety measures in place, accidents in the energy sector can and do still occur. Even relatively benign energy systems such as wind, bring with them the possibility for accidents during construction and maintenance of wind turbines (European Commission, 1999). While the attainment of a "risk free" energy system is impossible, it is important to understand the relative risk of each energy option. This allows for investment in energy sources that minimize the possibility of accidents occurring and that require fewer resources for protectionist measures. The purpose of this section, therefore, is by no means to be negative or alarmist or to exaggerate the likelihood of energy-related accidents, but simply to note that safety and comparison of safety records in different energy fields are among the many social considerations that must be taken into account in assessing full energy costs and alternative energy options and futures.

Illness and other health impacts

The chronic externalities of energy that workers and the public are exposed to on a routine basis are not often highlighted in the media because the effects (unlike accidents) are usually not sudden or dramatic occurrences, but they are nonetheless significant. Most studies have also focused on occupational impacts rather than the health problems experienced by people living near energy sites, because of the obvious challenges of proving cause and effect relationships in environmental illnesses (Stephens and Ahern, 2001). However, this is an important area of study that needs further research if the full costs of energy impacts are to be known (Stephens and Ahern, 2001). The following discussion provides an overview of some of the health impacts of routine practices in the energy industry.

Coal mining

Coal mining is among “the most hazardous occupations in the world” with a high risk both of on-the-job injuries and fatalities and of long-term impacts such as cancers and lung ailments (Stephens and Ahern, 2001). Respiratory illnesses range from chronic bronchitis to more fatal pulmonary conditions such as silicosis and pneumoconiosis, which are experienced by 12% of miners (Jennings, 2001; Stephens and Ahern, 2001; WHO, 2000; Castranova and Vallyathan, 2000). In addition, workers in the industry are subject to common occupational hazards including “musculoskeletal problems, stress and mental problems, asthmatic and other allergic reactions, and problems caused by exposure to hazardous agents” (Jennings, 2001). Other illnesses, such as cancer, are also more prevalent in workers at coal conversion and burning facilities (Gehrs, 1978).

Oil and gas

Human health problems in the oil and gas sector result from exposure to intense heat, noise and mechanical vibrations that can lead to hearing loss, musculoskeletal and repetitive strain injuries, and psychological stress (Gardner, 2003; Jennings, 2001). Long-term exposure to diesel fumes and other chemicals handled during oil processing are additional concerns (Luginaah, 2000; European Commission, 1999). The fuel additive benzene, for example, is one of many chemicals studied for carcinogenicity and other debilitating impacts on industry workers and the public. One study found an excess of mesothelioma in oil refinery workers and an excess of leukaemia in petroleum distribution workers 30 years after they were first employed in the industry (Sorahan et al, 2002). Other studies have found an excess of leukemia and malignant melanoma in upstream oil and gas workers, and cases have also been diagnosed among drilling and pipeline workers (Gardner, 2003). Another issue is the health impact of routine waste disposal in oil fields. In one of the few studies addressing this concern, an Amazonian community living in close proximity to oil fields was found to have higher rates of cancer than did outlying communities (Hurtig and Sebastian, 2002; San Sebastian et al, 2001).

Nuclear

Some evidence from the nuclear industry suggests that cancer, particularly leukemia, can develop from chronic, low-level radiation exposure. However, there is no agreement on what dose and concentration are thought to cause the disease (Wilson, 2004).

The many chemicals in our environment engender extensive health concerns. However, this is still a relatively new area of health research and data are difficult to obtain. This makes it hard to quantify releases and identify pathways to particular individuals and communities. Establishing clearer cause and effect relationships between energy externalities and health outcomes needs to be a priority of future research if the actual full costs of energy production are to be determined. As a necessary first step in assessing the health impacts of the energy industry this report aims to focus on those pollutants that are already well-documented, and to assemble the evidence that exists for these pollutant emissions from energy production and use.

3.3 Environmental Impacts

The environment sustains human life, providing a number of vital life-support services that ensure a hospitable habitat. Consequently, damage to the environment often results in longer-term harm to people. For example, the destruction of forests means a decreased ability to purify air, replenish oxygen, sequester carbon from the atmosphere and provide habitat for a wide range of species on which humans rely. Deforestation also exacerbates erosion and soil loss, affecting fisheries and water quality, altering local water levels and compromising future timber productivity. These changes, in turn, bring about a variety of health and economic effects. The environment is also the basis of the agricultural and fishing industries that provide our most basic necessities: these nurture us if healthy, and may harm us if compromised.

As well, the natural environment is the repository of genetic diversity, an incalculable legacy that may some day be the source of new medicines, crops and knowledge (UNDPI, 1997). For many people the environment is a source of spiritual and physical peace. Moreover, the environment also has intrinsic worth which is often overlooked due to the prevalence of utilitarian values.

Like all human activity, energy production and use affects the natural environment, the functioning of ecosystems, and the provision of ecosystem services on which humans depend. This occurs through acidic and toxic emissions, from the environmental impacts of mines and landfills, or simply from the use of land for transmission lines. Theses impacts have been studied to varying degrees, and our knowledge and quantification of their effects is increasing though still limited. Many of the key environmental impacts of energy production and use have become clear in the last two decades, even if solutions are expensive or not readily available. Likewise, different energy systems contribute to these environmental problems in different ways and to varying degrees and these differences must be carefully considered in the study of future options and energy alternatives.

Air, land, and water are interconnected through natural cycles and flows of energy and materials. Toxic pollutants and industrial emissions from the energy sector are often first released to the air.

These settle onto land and water—and from the land move into waterways where they may accumulate in marine organisms. Mercury, a toxic by-product of coal combustion, is one such pollutant where the toxin accumulates in animal tissue and thereby is able to move up the food chain until it is ingested by humans who eat fish and other aquatic species containing mercury. The levels of mercury in some fish species are so high that vulnerable members of the human population, especially pregnant women and children, are advised not to eat them. For example, in March, 2004, the U.S. Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) advised women who may become pregnant, pregnant women, nursing mothers, and young children not to eat shark, swordfish, king mackerel, or tilefish because they contain high levels of mercury (U.S. Department of Health and Human Services and USEPA, 2004).

This is just one example of the interconnectedness of the energy system and the natural environment. Similar chains of effect like that of mercury can be described for many other pollutants and emissions released by the energy sector. The air, land and water are all important carriers of these pollutants, so some of the key effects of the energy industry on these systems are described in this section. Since we return to the main air pollutants and toxins in more detail in Chapter 6 this section provides only a preliminary overview of these pollutant sources and focuses on those pollutants that are not quantified in Chapter 6.

Air pollution

The presence of substances in the air that are potentially harmful to human health and the environment is known as atmospheric or air pollution (Ramage, 1997). The main energy-related air pollutants that affect the environment are: sulphur dioxide (SO_x); nitrogen oxides (NO_x); fine particles or particulate matter (PM); and volatile organic compounds (VOCs) (Ramage, 1997). Excessively high levels of these pollutants can adversely affect soil, water, wildlife, crops, forests and buildings, and can harm human health. For more detail on these pollutants, see Chapter 6 and the **GPI***Atlantic* Air Quality Accounts (Monette and Colman, 2004).

Although carbon dioxide (CO_2) and other greenhouse gases (GHGs) are atmospheric emissions of particular concern, they are not strictly speaking “pollutants” in the traditional sense, and the nature of their impacts is significantly different from that of the pollutants noted above. For this reason, GHGs warrant a separate discussion (see 3.4 below). What is similar is that the air pollutants noted here and the greenhouse gas emissions discussed in the next section both result mainly from the combustion of fossil fuels.

Not all energy-related pollutant releases are due to fossil fuel combustion however. For example, fine dust (i.e. particulate matter) is released during coal processing and transport. Likewise wood burning results in air pollution, particularly when combustion occurs in inefficient, uncertified wood stoves and when wood is improperly burned (British Columbia Ministry of Environment, 2002). Residential fuel wood combustion is responsible for about 25 per cent of fine particulates found in Canada's air pollution, 15 per cent of volatile organic compounds, and 10 per cent of carbon monoxide (Environment Canada, 1999). In these cases strict standards are needed to protect local air quality (UKDTI, 2002).

Even hydro projects can cause emissions: methane is produced by the decomposition of vegetation killed by flooding from hydro dams (Dorcey, 1997). Old mine sites can be sources of air pollution as shown by the Springhill works in Nova Scotia: slag piles at this mine continue to smoke (due to internal heat from organic content) decades after the closure of the facility. Methane is also released during coal mining (UKDTI, 2002). Some of the gas is used for on-site energy needs but the majority escapes to the atmosphere and contributes to climate change. Methane is also a major safety concern because it is explosive.

Acid rain, smog and ozone

The effects of these air pollutants vary significantly. Acid rain is a major problem that results when sulphur dioxide and nitrogen oxides combine with water in the atmosphere, forming sulphuric acid and nitric acid respectively. Acid rain causes acidification of water and soil, which can cause serious damage to plants and aquatic life, and it can erode buildings and corrode metal objects. Elevated acidity in the environment due to anthropogenic releases over the last half century has caused materials damage (old buildings and historic sites); damage to crops; changes in forest productivity (damage to foliage and changes to soil nutrient regimes); and acidification of water (causing changes in fish species and production), which has culminated in changes to biodiversity (Monette and Colman, 2004; Environment Canada, 2002, 1998). Acid rain often forms and falls hundreds or even thousands of kilometres from the source of the pollution (Boyle, 1996). Because of the nature of its soils and water systems, Nova Scotia is particularly sensitive to acid rain and has suffered severe damage from it.

Of particular concern for human health is the reaction of NO_x and VOCs with sunlight to create ground-level ozone. Ground level ozone is linked to foliar injury in plants resulting in reduced agricultural yields in many common crops (Monette and Colman, 2004). It has also been shown to have damaging effects on lung function (OMA, 1998). Ground-level ozone is a constituent of smog which also includes particulate matter and other pollutants. Smog has been shown to exacerbate respiratory problems and cause higher than normal hospital admissions on smog-warning days (Monette and Colman, 2004).

Transboundary air pollution

Nova Scotia is in the unfortunate position of lying downwind of the major industrial and population centres of eastern Canada and the north eastern United States. As a result, up to 80% of Nova Scotia’s air pollution originates outside the Province (NSDP and NSDNR, 2001). This includes nearly all of the air pollutants discussed above and is a particular concern for acid deposition, mercury, and ground-level ozone. Accordingly, reductions in pollutant emissions in Nova Scotia must be coupled with decreases in the rest of eastern North America in order for substantial gains to be realized in this Province. At the same time, pollution from Nova Scotia also affects other regions, and the Province’s heavy reliance on coal produces some of the world’s highest per capita pollutant emissions from energy (Monette and Colman, 2004). Dominant westerly winds combined with fluctuations in the jet stream mean that some of the transboundary atmospheric pollution from Nova Scotia along with pollution from the rest of north-eastern North America is eventually deposited in Newfoundland. Even after the reductions in emissions of acid rain-forming pollutants in the 1990s Newfoundland continues to receive acidic deposition in levels high enough to cause acidification of lands and water with the deposition rates highest in the south-west and decreasing towards the north and east (Newfoundland and Labrador Department of Environment, 2001).

Water pollution and aquatic impacts

Impacts on aquatic ecosystems come from oil spills, fossil fuel extraction and combustion, damming waterways for hydro and tidal power generation, using water for waste disposal, and from mining and other land use changes. The impacts of each of these activities are discussed in this section.

Oil spills

Oil spills are a significant source of water contamination. Transportation, storage, and use of oil all present risk of spills. Furthermore, ships discharge oily bilge water in many coastal areas. Currently, only rough numbers are available for oil spills in Nova Scotian waters because small spills often go unreported. According to rough figures compiled by the Nova Scotia Department of Environment and Labour, there were 470 reported oil spills in 2002 and 350 in 2003; most of these would have been spills of less than 100 litres (Baxter, 2004).

Globally, numerous individual spills during the 1970s released as much as millions barrels of oil into the ocean during each event (Mariner Group, 2004). Measures to reduce oil spills have helped decrease the number of accidents and the amounts spilled during any one incident. Consequently, most spills in the last decade have been in the order of hundreds of thousands of barrels. Of course, there are also many smaller releases such as the recent 1,000-barrel spill off the coast of Newfoundland in December, 2004. Often the oil cannot be recovered. In the case of the Newfoundland incident, less than 5% was recovered (OGM, 2005). Nova Scotia, thus far, has been fortunate not to have had any major spills near its coast.

Oil affects marine life in two basic ways: physical contamination and smothering; and chemical toxicity (ITOPF, 2005). Clean-up operations may also physically or chemically damage wildlife and habitat. Physical smothering by heavy oils is the most visible and usually most damaging aspect of an oil spill. Those animals and plants that come into contact with the sea surface (e.g. seabirds, turtles and tidal zone vegetation) are most at risk in this case. Birds typically die from drowning or starvation or from hypothermia when the insulating value of their plumage is compromised.

Oil spills are particularly damaging to marine aquaculture sites (ITOPF, 2005). Although the most toxic components in oil tend to be volatile, sub-lethal toxic effects can also occur especially in sedentary, shallow water animals such as mussels. Mussels are also more at risk because, as filter feeders, they process large volumes of water. Sub-lethal effects include impairment of an organism’s ability to grow, feed or reproduce. Coastal marshes and mangrove forests can be destroyed by oil spills if roots and soil are covered in oil (ITOPF, 2005).

The effects of oil spills can be long-lasting. Ten years after the Exxon Valdez ran aground in Prince William Sound on 24 March, 1989, spilling 11 million barrels of crude oil and fouling

2,400 miles of Alaska's coastline, it was reported that oil remained below the surface on the coast continuing to damage wildlife, and that only two out of 28 species injured by the spill had recovered, with population declines continuing for many affected species (Friends of the Earth U.K., 2001). And spills can be expensive. Exxon paid over $US2 billion in attempts to contain and clean up the spill, and was forced to pay nearly $US6 billion in punitive damages to third parties, including $US4.5 billion in punitive damages for commercial fishermen, Alaska Natives and property owners imposed by an Alaskan court. Litigation continued into this year (Beale, 2005).

Exploration and extraction of fossil fuels

The extraction and processing of coal, uranium, and natural gas also have direct impacts on the aquatic environment (Azcue, 1999). Coal and uranium mine tailings, which is the waste rock produced in the mining process, negatively affect ground and surface water (UKDTI, 2002). Often water must be pumped from working mines to prevent flooding. This water is mineral-rich and acidic—and, in the case of uranium mines, radioactive—and should not be allowed to enter natural water bodies without treatment; yet this is not always prevented. For instance, elevated radiation levels have been found in water, sediments and fish around abandoned uranium mines in northern Saskatchewan (Laird, 2002). In either case, acidic or radioactive mine drainage severely reduces species diversity and population levels in affected areas (Gehrs, 1978; Thorp and Whitfield Gibbons, 1978).

Offshore oil and natural gas exploration and extraction also have effects on local habitat, including marine fisheries. Patin (1999), in his extensive review of the environmental impact of the offshore oil and gas industry, describes a series of impacts related to the four main stages of oil and gas development. The four stages are: geological and geophysical survey (seismosurveys, test drilling, etc.); exploration (rig emplacement, exploratory drilling, etc.); development and production (platform placement, pipe laying, drilling, extraction, separation, transportation, well and pipeline maintenance, etc.); and decommissioning (disassembling, structure removal, well plugging, etc.).

Impacts from these activities involve a range of physical, chemical and biological disturbances in the air and water, and on the ocean bottom. The physical impacts include seismic signals (water guns have been shown to kill fish fry up to 7 metres away) and explosions to remove fixed structures (Patin, 1999). Considering that a two-to-three week seismic survey by one ship entails seven to eight million seismic impulses, the impacts on fish, especially in the early stages, can be substantial.

According to Patin (1999), the most serious consequence of offshore production is chemical pollution. The drilling spoils (i.e. rock, mud, drill lubricants, etc.) from a single well can amount to 5,000 m^3. Meanwhile, thousands of cubic metres of production and ballast waters are also released each day. These materials typically contain considerable amounts of relatively stable and toxic hydrocarbon compounds, and a wide spectrum of other substances. These discharges are of particular concern in shallow coastal areas. It may take several years for benthic communities to recover after the termination of discharges of oil-containing wastes, and chronic effects may continue for 20-30 years after an actual oil spill.

Atmospheric pollution results primarily from the burning of oil and gas for on-site energy requirements or to dispose of waste gases (Patin, 1999). There is also the risk of accidents including slow leakage from pipes; explosions; and oil leaks from platforms, service ships and tankers. Major blowouts of a natural gas pipeline can have serious consequences for the surrounding ecosystems as well as for the fishing industry. Besides the effects on fish stocks, there can be direct interference with commercial fisheries due to the placement of platforms in fishing areas, ship traffic, and pipelines limiting trawling. When oil fields are abandoned, hazards typically remain including pipelines, moorings, and rigs.

The most important concern with the ecological impacts of offshore oil and gas is the possibility of long-term effects due to low levels of chemical pollutants (Patin, 1999). These effects are difficult to measure, monitor, and understand. However, an increasing number of studies have shown subtle long-term shifts including potential changes to species diversity, symptoms of chronic stress, and mutagenic and carcinogenic effects. The effect of offshore oil and gas activity on the Nova Scotia environment is an area that needs consistent monitoring and assessment. A report prepared by **GPI***Atlantic* researchers for the 2002 Public Review Commission into the effects of potential oil and gas exploration and drilling activities off the coast of Cape Breton, Nova Scotia, demonstrated the extraordinary sensitivity and potential environmental impacts and costs of this activity (Landon and Pannozzo, 2001).

Hydro generation

Certain forms of power generation also have direct effects upon aquatic flora and fauna. The two most obvious concerns are hydroelectric dams and thermal pollution. Hydroelectric dams can affect flow regimes, water temperature and terrestrial habitat. These dams generally have localized effects, affecting habitats, especially above the dam. They can also be extremely damaging to migratory fish. Fluctuating flow rates can have significant effects on habitat stability and species populations (Covich et al, 1978). Elevated temperatures in hydro reservoirs can lead to thermal stress as well (Esch and Hazen, 1978). Large hydro projects can also bring about substantial releases of mercury through increased micro-bacterial activity in newly flooded areas. This has led to fish consumption advisories at dams in parts of Canada (Pollution Probe, 2003; UNEP, 2003).

Nova Scotia Power currently has 12 fish ladders distributed among its 34 hydroelectric dams on 17 Provincial river systems. NSPI has improved some ladders recently and states that it assesses the need for fish ladders at each site (Vokey, 2004). However, it does not appear that NSPI intends to build fish ladders at all locations. It is unclear from existing information whether all rivers that have or have had migratory fish populations presently have fish ladders or similar structures and what the full effects have been on migratory fish species.

Thermal pollution

Thermal generating stations (including fossil-fuel, biomass and nuclear) require significant amounts of water to absorb waste heat produced during electricity generation, since only a portion of the energy embodied in the primary fuel can be converted to electricity. Large volumes of water, usually from local bodies of surface water, are used to absorb the waste heat that results from the process. The un-evaporated water that remains is then dumped back into the local water body, sometimes significantly altering local temperature regimes and reducing flow levels (Turnpenny and Coughlan, 2003).

Increased water temperature affects physiological processes in individual organisms such that basic elements (both toxic—e.g. heavy metals and radioactive substances—and beneficial) are incorporated faster into biological matter. Behavioural changes can also result for affected species, such as avoidance of warmer areas (e.g. changed migration routes), and the increased water temperatures can also lead to critical changes in oxygen levels (Grimås and Ehlin, 1975). These effects vary based on the receiving water body's physical factors (e.g. volume, currents, tides), biological factors (existing species, biological productivity, etc.) and the temperature and volume of waste water. Furthermore, pollutants within the thermal discharge, especially chlorine releases from condenser cleaning, can have damaging environmental effects (Schultz et al, 1978; Lanza et al, 1975). Organisms can also be affected by being impinged on the intake screens and passing through the cooling system.

As an isthmus, Nova Scotian geography facilitates the siting of thermal power plants directly on the coast. The extraction of water for cooling processes and the return of heated water to the ocean are expected to have considerably less impact than in a more finite freshwater body. However research for this study found no aquatic impact studies specific to thermal generation in Nova Scotia, so the actual impacts of thermal generation on water bodies and aquatic ecosystems in Nova Scotia remain unknown. Also, most plants use water from surface water bodies or ground water sources for process water (NSPI, 2005b). The amount of water withdrawn is not available and the effects on the environment are not known. The independently owned Brooklyn Power plant in Liverpool systemically reduces the environmental impact of higher temperature waste water. This is a combined heat and power facility that generates power and supplies steam to the nearby Bowater-Mersey Pulp and Paper Mill. In this case the high temperature steam by-product is actually used commercially to generate heat, thereby preventing the direct release of high temperature waste waster into the natural environment.

Improvements in technology, such as cooling towers, have reduced the environmental impact of thermal plants. Also, NSPI facilities must meet environmental standards. However little scientific information is publicly available as to the local effects of thermal pollution. For this reason, this study recommends that thermal pollution in Nova Scotia should be investigated further.

Toxic pollutants

Toxic pollutants can be released to land, air or water. According to the 2002 environment report of Emera (NSPI's parent company), NSPI's thermal generating stations released 26 toxic substances as listed by Environment Canada's National Pollutant Release Inventory. These include:

- Arsenic and its compounds
- Asbestos

- Chromium and its compounds
- Copper and it compounds
- Dioxins and furans
- Hexachlorobenzene
- Hydrochloric acid
- Lead
- Manganese and its compounds
- Mercury
- Nickel and its compounds
- Polycyclic aromatic hydrocarbons
- Sulphur hexafluoride
- Sulphuric acid
- Vanadium
- Zinc and its compounds

Most of these pollutants are the direct result of coal combustion. Many of them remain as ash after combustion. This ash is then stored in on-site landfills, transported to off-site landfills, or sold for other uses (Emera, 2002a). As such these pollutants have effects on land and, if not carefully contained in landfills, they can also affect ground and surface water. A number of these toxins are also emitted to the atmosphere in gaseous form (Emera, 2002a). These include sulphuric acid, hexachlorobenzene, mercury, arsenic, and various organic compounds. Many of these pollutants (for example, arsenic, cadmium, dioxins and furans, and hexachlorobenzene) are known or suspected carcinogens (Environment Canada, 2005a). Some pollutants, such as mercury and arsenic, are so toxic that they have been deemed non-threshold toxicants (i.e. a substance for which, at *any* level of exposure, there is believed to be some chance of adverse health effects). Furthermore, many of these pollutants are known to persist in the environment and bio-accumulate in the food chain. Other repercussions include neurological effects (from hexachlorobenzene and mercury), dermal effects (from hexachlorobenzene), and renal tubular dysfunction (from cadmium).

Mercury is of particular concern in the case of the energy sector both because it is emitted in significant amounts and because it is highly toxic. Mercury can affect both human and animal health (Environment Canada, 2005a). Mercury levels in fish are an increasing concern for the health of humans and other fish-eating species. Mercury has been shown to act as a neuro-toxin in loons in Kejimkujik National Park, where blood mercury concentrations have been found to be the highest of any loon population in North America (Nocera and Taylor, 1998). The energy sector, specifically coal-fired power plants, in Nova Scotia is the principal source of mercury emissions in the Province (Environment Canada, 2004b). We will return to the discussion of mercury in Chapter 7.

Coal-based thermal generation is not the only energy source that results in the release of toxins. Biomass combustion (e.g. wood for home heating) releases some 200 different chemical pollutants which include 14 known carcinogens (Pimental et al, 2002). Natural gas, though much cleaner than coal, also contains impurities, some of which are toxic, such as hydrogen sulfide (Patin, 1999).

Solar technologies and batteries are another potential source of toxic emissions. For example a common technique for producing photovoltaic (PV) cells results in the release of fluorine and chlorine air emissions. However, compared with coal combustion on a per megawatt generated basis, these releases are orders of magnitude smaller (Phylipsen and Alsema, 1995). Depending on the process, PV cell production can involve cadmium, arsenic, lead, nitrate, isopropanol, and respirable silica particles. However, these substances are present in small quantities compared to the main materials used in solar PV production: glass and aluminium. Batteries can use acids, lead, and nickel. The risk of these toxins entering the environment occurs during production and processing, which can be controlled through industrial regulations, and during disposal, which can be controlled through proper waste management, as discussed in the waste disposal section below (Fthenakis and Bulawka, 2004).

The amount of toxins released in energy production and their effect on human health and the environment are areas of continuing study. Of particular concern are those toxins that are released to the atmosphere, though impacts on water bodies also require further research. Other toxins produced through thermal generation and that are stored in landfills are also of concern and require investigation. More information is needed for this Province to better determine the links between energy production, water contamination, and consequent health and environmental effects in Nova Scotia. These issues need to be explored further and should be considered in future iterations of this report.

Land use concerns

The issue of land use is different from the concerns engendered by pollutants. The consignment of large tracts for energy purposes inevitably has some impact on habitats and biodiversity, and changes nutrient and water flows. Other less obvious effects include the opportunity costs of competing land uses. Transmission corridors and pipelines may also act as a barrier for the movement of small animals while offering easy access for hunters and people disturbing remote populations. Invasive species can also use such corridors for movement (Sawyer et al, 1997). The effect of energy projects on land use can vary greatly, depending on the territory in question. Here we present only some of the general concerns that can result from land use related to energy. A site-by-site assessment would be needed to provide more specific information related to the Nova Scotia energy sector.

Electricity generation

Traditional thermal power generation requires relatively little physical space (compared to other energy processes discussed below) because large amounts of power can be generated from energy rich fossil fuels. However, the land and sea area used or permanently contaminated or altered by hydrocarbon extraction should also be attributed to thermal power (see below). However, energy from wind, biomass, the sun and hydro power requires significant amounts of land to provide a similar power output (Pimental et al, 2002).

Pimental et al (2002) estimate that current renewable technology could meet 50% of U.S. energy needs but would require the use of 17% of U.S. land resources, though not all of this area would be used exclusively for energy production. Table 1 shows the land use figures as presented by

Pimental et al (2002) for various electricity producing technologies. Biomass, hydro and wind power are the three most land-intensive modes, but even the most land-efficient renewable technologies require an order of magnitude more land to produce the same amount of electricity as a fossil fuel or nuclear facility. The only exception is geothermal power, which can be very efficient in terms of land.

Table 1. Land resource requirements and total energy inputs for construction of electricity facilities

Electrical Energy Technology	Land Required (hectares)	Energy (Input-output ratio)
Biomass	200,000	1:7
Hydroelectric	75,000	1:24
Wind	13,700	1:5
Solar ponds	5200	1:4
Photovoltaics	2800	1:7
Parabolic troughs	1100	1:5
Coal	166	1:8
Natural Gas	134	1:8
Nuclear	31	1:5
Geothermal	30	1:48
Biogas	NA	1:2.5

Note: The input/output ratio applies to electric facilities that produce one billion kWh of electricity per year.

Source: Pimental et al, 2002.

The energy input/output ratio in the table above shows the number of units of energy output produced for each unit of energy input. This comparison was done on the basis of power plants that can produce one billion kWh of electricity per year.

Fossil fuel extraction

Extraction of oil, coal, natural gas and uranium raises concerns about land use as well as land and water contamination. Coal mining and oil and gas exploration cause disruption to terrestrial and marine ecosystems, often releasing toxic substances in the process. Deep coal mines have been known to cause land subsidence and often leave behind unwanted minerals that can leach into groundwater sources (Ramage, 1997). In Britain, where deep coal mining has occurred for centuries, subsidence occurs throughout the country, resulting in expensive reclamation and damage claims (UKDTI, 2002). Open cast mining, which is the most common type in Canada, has a greater visual impact than deep mines and disturbs substantial amounts of wildlife habitat. Reclamation is expensive and, historically, rarely done. Former coal mine lands often become derelict due to chemical wastes and physical hazards (UKDTI, 2002).

Coal has been mined in Nova Scotia since the 1720s. There are over 300 underground mines and many more bootleg (small scale) mines in the Province. There is subsidence at many of these sites as well as a number of large slag piles. Many large abandoned mines have been reclaimed over the last 20 years in Nova Scotia through private/public partnerships. Generally the pattern of reclamation has been to allow companies to mine remaining coal reserves at the surface while requiring the company to rehabilitate the site as the mining progresses. This has led to successful reclamation at mines in Stellarton, Westville, Thornburn and Sydney (Jones, 2005). Efforts continue in this manner although public groups have raised opposition to the process in a number of areas because of the potentially adverse effects of further mining activity.

Hydro generation

Hydroelectric projects also raise concerns about land use since large hydro dams cause extensive flooding, frequently drowning entire ecosystems, and in some cases displacing large numbers of people in the process (Boyle, 1996). For instance, once completed, the Three Gorges Dam in China will inundate 632 square kilometres of land, creating a 560 km long reservoir and displacing as many as one and a half million people (Kennedy, 2001). This is an extreme example but it is important to note that almost any hydro dam proposed today is likely to raise land use concerns. All hydro power stations will also have some impact on the hydrology of an area because they divert water in various ways. From an environmental and land use perspective, small scale, run-of-the-river schemes—i.e. where no damming takes place—are generally considered preferable to stoppage operations. As with any infrastructure project, consideration for energy projects has to be made on a case by case basis since the impacts are usually site-specific (Boyle, 1996).

Land use trends in Nova Scotia

At present, wind and solar power supply insignificant portions of Nova Scotia's energy. According to Nova Scotia Power, renewable energy sources (mainly hydro and tidal power) provide about 8-10% of Nova Scotia's electricity (NSPI, 2004). Natural Resources Canada's (1999) energy demand data for 1997 for Nova Scotia show that renewables (mainly wood), at 23.1 PJ, and hydro/tidal (3.5 PJ) account for approximately 10% of the Province's total primary energy demand of 262.1 PJ (Hughes, 2001).[16]

Equating these figures with land use statistics is very difficult. Most fuel wood sales in the Province are transacted between individuals and are not recorded, which means that figures for fuel wood use are rough estimates, at best. Next, a set volume of wood cannot be directly equated with an area of a given size because of varying productivities, multiple uses of harvested wood and different removal methods. For example, clear cutting strips all wood from a parcel of land while selection harvesting removes only a portion, while both methods are likely to involve use of wood for other commercial and industrial purposes, with only a portion diverted to fuel wood use.

Province-wide summaries of land use are not consistent and do not provide the information needed for this analysis. Though GIS makes accessing and analysing information easier, it still requires significant time and expertise, and has not been used to produce reliable estimates of

[16] *Primary energy* incorporates all energy used in the province including transportation, heating and electricity.

land use for fuel wood consumption and other forms of energy production.[17] The Nova Scotia Department of Natural Resources (formerly the Department of Lands and Forests) took a land use inventory in the 1960s and again some thirty years later (NSDNR, 1995; NSDLF, 1973). The 1965-1971 and the 1995 surveys both contain figures for the extent of high-voltage transmission lines in the Province, but do not include regular power lines and power plant sites. The two inventories indicate that in the 1960s high-voltage transmission lines covered approximately 6,950 ha, or about 0.1% of the Province; by 1995 the figure had doubled to 13,454 ha (around 0.24% of the Province's land).

Waste disposal

Burning solid fuels, such as coal and wood, results in unwanted by-products, such as ash. In Nova Scotia some of this ash is used as fertilizer on agricultural land or for construction material, but usually more is produced in generating energy than is required for these purposes. At the Point Aconi generating station alone more than 100,000 tonnes of ash are produced each year. This ash is disposed of in landfills that are specially lined to prevent leaching of mercury and other toxins contained in the ash (Joseph, 2000). However, at least some ash from other sites is deposited in unlined sites (Richards, 2004).

In 2002, ash from Nova Scotia Power facilities contained 26 tonnes of arsenic and 10.3 tonnes of lead (Environment Canada, 2005a). A further 135 kg of lead was recycled off-site. These chemicals, along with other trace and minor elements, have been shown to be highly toxic to aquatic organisms (Birge, 1978). Therefore proper disposal and monitoring at these sites is critical.

Another waste disposal problem—one to which no long-term solution has yet been found—is that of spent uranium, which is a by-product of nuclear power generation (Ramage, 1997). Due to its high radioactivity and long life, storage and transportation of spent nuclear fuel is a significant problem. In New Brunswick, as elsewhere, no satisfactory storage solution has been found. According to the NB Energy White Paper, "The need for safe, permanent storage of spent nuclear fuel and radioactive waste is a continuing environmental concern. Fuel at Point LePreau is stored in temporary, on-site facilities [until a permanent site is found]" (NBDOE, 2001: 67). The broader implications of this waste problem were presented in Section 3.2 above.

Widespread use of renewable technologies may also lead to waste problems, albeit of a very different kind. Well-developed recycling programs will be needed to reuse metal, glass, and electrical components, particularly from photovoltaics and wind turbines. An efficient recycling system should provide important benefits. One such benefit, in the case of major structural components like aluminium and steel, is the reduced energy required to produce recycled materials compared to materials from virgin ore. A major concern surrounding wastes from renewable technologies is that of toxic components in photovoltaics and batteries. The focus in development of these technologies must therefore be on developing and requiring the use of less toxic and non-toxic alternatives and on closed-looped systems in which all materials, especially toxic materials, are safely recycled.

[17] Geographic Information Systems (GIS) is a mapping and database technology that is used to view and analyse geographical data.

Other environmental impacts

Noise and visual intrusion

Wind turbine generators are frequently criticized for being noisy and unsightly. Residents may experience noise and visual intrusion if wind turbines are located close to settled areas. Some people feel that siting large wind farms along the coast, on top of hills and in other picturesque areas blights the landscape (Dohmen and Hornig, 2004). Similar concerns could (and do) apply to the visual aesthetics of power stations and power lines that run through the countryside. Because visual aesthetics is a personal perception issue it is difficult to measure and address these concerns in a way that satisfies everyone. Noise pollution is measurable and both concerns should receive attention when siting wind projects and any intrusive infrastructure projects.

Avian collisions

A further concern with wind energy is that birds may collide with the turbines. This problem is generally related to the choice of location. A report reviewing existing studies of avian collision mortality in the U.S. showed that vehicles, cats, buildings, windows, power lines and communication towers combined cause from 436 to 1,384 million bird deaths per year while wind generation is responsible for no more than 40 thousand bird deaths—less than one-hundredth of a percent of the lower-end figure of 436 million deaths attributable to other sources (Erickson et al, 2001). The authors show that even if there were orders of magnitude more wind towers erected they would still only represent a very small percentage of avian deaths. Sagrillo (2003) points out that loss of habitat due to human infringement and environmental despoliation are much larger contributors to bird loss than wind turbines.

Avian collisions are worth addressing but they must be put into proper context. For example, studies have shown that bird mortality from wind turbines that are properly sited to avoid migration paths is negligible compared to bird deaths caused from collision with motor vehicles (NWCC, 2001). In all cases, siting of turbines (and, indeed, of any significant infrastructure) can help reduce these risks. Proper assessment of bird migration paths is essential prior to approval being granted to large wind developments. Given the increased wind developments expected in Nova Scotia, it is important that this issue be considered at the planning stage in order to reduce avian collisions.

3.4 Climate Change

The production of greenhouse gases—now a well-accepted cause of climate change according to the United Nations Intergovernmental Panel on Climate Change and the world's most reputable scientific and meteorological institutes and academies—is possibly the most widespread, serious, and lasting impact of the global economy's current dependence on fossil fuels. Due to the enormous scale of the problem and its potentially catastrophic consequences, and in view of the high-level and high-profile national and international political discussions about how to tackle it, climate change has arguably become the most publicised environmental problem in the world today. The overwhelming reliance on oil, coal and natural gas for electricity generation, powering transportation, and as feed stocks for other industries such as fertilizers and plastics, has therefore come to have profound implications for the environment, the economy, health and safety, world politics, and the legacy left to future generations.

There are numerous gases, from both anthropogenic (human-made) and natural sources, that contribute to climate change. These gases retard the rate at which the earth loses heat to space by reflecting energy back to earth, thereby warming the planet (Environment Canada, 2000b). Also known as *global warming* or the *enhanced greenhouse effect*, climate change is a global phenomenon, in which the temperature balance of the earth is disrupted through rising concentrations of carbon dioxide and other gases in the earth's atmosphere—a balance that has maintained the temperature of the earth for a very long time (IPPC, 2001; Houghton, 1997).

Carbon dioxide (CO_2) and six other gases—methane (CH_4), nitrous oxide (N_2O), sulphur hexafluoride (SF_6), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and tropospheric ozone (O_3)—are referred to as the greenhouse gases (GHG) because they act as heat traps, affecting the natural equilibrium of the atmosphere which sustains a steady temperature on earth (IPCC, 2001). The greenhouse effect is a natural process but, through human activity, this effect has been enhanced, causing global climatic changes (Houghton, 1997).

The main source of GHG emissions is the burning of fossil fuels, the most important of which is CO_2. Combustion of fuel produces 95 per cent of anthropogenic carbon dioxide emissions. In fact, when all GHGs are considered, fossil fuel combustion is responsible for "around 85 per cent of the potential global warming effect of anthropocentric emissions of greenhouse gases" (UKDTI, 2003; IPCC, 2001a).

Impacts of climate change

According to the Intergovernmental Panel on Climate Change (IPCC) consisting of 2,000 scientists worldwide—the largest and most authoritative international group of climate change researchers ever assembled—climate change is expected to produce numerous impacts, varying from region to region, that will include sea-level rise, flooding, droughts, and changes in storm intensities (IPCC, 2001a).[18] Sea-level rise and increased storm intensity are of particular concern in Nova Scotia, particularly in the wake of the devastating impacts of Hurricane Juan. However, changes in the growing season, water shortages, and new diseases for plants, animals, and humans may prove to be the most significant long-term impacts. These predictions indicate that climate change will likely exact a significant toll in both the near and the more distant future. As the non-transportation energy sector is a key source of greenhouse gases, any discussion about the health and environmental impacts of the energy sector must address climate change.

The implications of a changing climate are potentially enormous, though the effects will differ from one place to another. The potential impact of climate change on the Maritimes has been studied by Environment Canada. It is projected to include elevated sea levels which could cause more flooding, coastal erosion, coastal sedimentation, and reductions in sea and river ice

[18] The IPCC was jointly established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988.

(Environment Canada, 1997). Other projected consequences of a changing climate in this region include: loss of fish habitat; changes in ice-free days which could affect marine transportation and offshore oil and gas activities; and changes in the range, distribution and breeding success rates of seabirds. Many of these changes would have a direct effect on the economy, including the energy sector itself. An increase in the intensity of storms, for instance, would likely increase power grid failures, while stronger sea-surges could jeopardize the stability of gas exploration platforms (IPCC, 2001a). There would also be economic costs associated with protecting coastal property and keeping people safe from these new weather patterns.

Evidence of climate change

When the concept of global warming was first discussed during the 1970s and 1980s there was substantial debate as to the validity of the science and the extent of the effect. Over time, and allowing for the fact that some scientific uncertainty will always exist, theories, measurements and models have confirmed as definitively as is possible in light of the available evidence, that climate change is a reality. For instance, all of the hottest 15 years on record have been since 1980 (Connor, 2005). In the words of the IPCC, "Detection and attribution studies consistently find evidence for an anthropogenic signal in the climate record of the last 35 to 50 years…. Emissions of CO_2 due to fossil fuel burning are virtually certain to be the dominant influence on the trends in atmospheric CO_2 concentrations during the 21st century" (IPCC, 2001:5). It should be noted that the IPCC only uses the term "virtually certain" when there is a greater than 99% chance that a result is true.

While it is impossible to establish direct and simplistic relationships, it is possible—given the evidence and IPCC analysis that global warming has already begun—that Hurricane Juan, White Juan, the 2004 November ice storm and other severe weather events of recent years, and the three consecutive years of severe drought conditions in Nova Scotia (1997-99) are early foretastes of the eventual costs of climate change in this Province. One article noted that Hurricane Katrina which devastated the U.S. Gulf Coast, the two-foot snowfall in Los Angeles, the unprecedented 37" of rain in a single day that flooded Mumbai, the record-breaking drought in Spain, Portugal and France and its accompanying wildfires and water shortages, the severe drought in the U.S. Midwest and the recent lethal heat wave in Arizona – all in 2005 – are consistent with the predictions of climate change scientists that a warming climate will trigger longer droughts, more intense downpours, more frequent heat waves and more severe storms. The analysis noted that although Katrina began as a relatively small hurricane that glanced off southern Florida, it was supercharged with extraordinary intensity by the high sea surface temperatures in the Gulf of Mexico (Gelbspan, 2005).

There remains uncertainty as to the full impacts of climate change, especially on a regional basis. The largest climate change model ever completed, the results of which were released in January, 2005, show that the Earth's climate is far more sensitive to increases in man-made greenhouse gases than previously thought (Connor, 2005). The study shows global temperature increases of between 2 and 11°C, double the rise predicted by the Intergovernmental Panel on Climate Change. Such increases are predicted to be catastrophic.

Munich RE, the largest re-insurance company in the world, estimates that economic and insured losses from natural catastrophes in the last 10 years have increased 7.7 (from U.S.$ 75.5bn to U.S.$ 550.9bn) and 13.9 (from U.S.$ 6.1bn to U.S.$ 84.5bn) times respectively since the 1960s (in constant dollar terms)—an increase that the company argues can only be explained by climatic factors linked to global warming (Munich RE, 2002).

Climate change and ozone links

Recent observations have raised questions about the links between climate change and ozone depletion (Allen, 2004). The relationship between the two is complex and may vary from place to place, and as yet is not completely understood.

Increased temperatures in the lower atmosphere (the troposphere) are likely to lead to greater ozone levels. However, expanded cloud cover due to enhanced evaporation rates may mitigate this increase. Climate, climate change, and ozone are also closely linked in the upper atmosphere (the stratosphere) where the "ozone hole" has formed (Allen, 2004).

The ozone layer is important for blocking harmful radiation from the sun. Increasing ozone concentration raises temperature by retaining heat from the sun's ultraviolet radiation and from infrared radiation from the lower atmosphere. The release of ozone-depleting substances over the last half century has led to "holes" (i.e. areas where there is no ozone) forming in the stratosphere, which has caused lower temperatures in this upper level of the atmosphere. The international reduction in the use of ozone-depleting substances was expected to allow the ozone layer to recover by 2050. However, lower stratospheric temperatures have led to increasing ozone destruction during the winters at both the south and north poles. At the same time, GHGs in the lower atmosphere are trapping extra infrared radiation in the troposphere, thereby possibly lowering the stratospheric temperatures even further and leading to slower ozone recovery (Allen, 2004). In other words, climate change may possibly reinforce ozone depletion.

The political process

In 1992, an initiative known as the United Nations Framework Convention on Climate Change (UNFCCC) was launched to address rising GHG emissions and to establish an international approach to their reduction. The process resulted in the establishment of the Kyoto Protocol in 1997. By ratifying this instrument, signatory countries commit to a combined reduction of at least 5% of GHG equivalents below 1990 levels. This target is to be achieved between 2008 and 2012. Canada pledged and is required by the Protocol to achieve a 6% reduction (Coward and Weaver, 2004; UNFCCC, 1997).

The pertinence of the Kyoto targets was highlighted recently when Russia ratified the protocol (CBC, 2004b). A condition of the accord was that it would only become binding when ratified by industrialized states that collectively accounted for emissions equal to 55 per cent of total emissions. The 2001 withdrawal of the United States, which accounts for nearly one-quarter of global greenhouse gas emissions, from the Kyoto agreement, had imperilled the protocol. With Russia's accession, this hurdle was passed and the protocol was officially brought into force on February 16, 2005. This reduces the uncertainty of global and regional negotiations and will likely increase international and national pressure on Canada to reduce its GHG emissions in accord with its commitments under the agreement. Canada ratified the Kyoto Protocol in 2002, but how the responsibility for reductions is to be shared among Canadian jurisdictions and economic sectors is still hotly debated (Coward and Weaver, 2004). In fact, Canada's emissions of greenhouse gases have increased steadily since 1990 and continue to increase, with a projected increase of 26% between 1990 and 2010 – the Kyoto target period (NRCan, 1999b).[19]

For a comprehensive discussion of the science and politics of climate change and its potential impacts in Canada and around the world, see documents produced by the Intergovernmental Panel on Climate Change (IPCC, 2001 and 2001a), Coward and Weaver (2004), Houghton (1997), Leggett (2001) and the **GPI***Atlantic* Greenhouse Gas Accounts (Walker et al, 2001), among many others. The potential impacts of climate change on Nova Scotia are discussed in Chapter 6 of the present volume. Indicators developed for tracking greenhouse gas emission trends are also presented in Chapter 6, but since the implications of climate change are so great and the energy sector plays such a central role in the climate change debate, this background discussion is presented here.

3.5 Fossil Fuel Depletion

Fossil fuels— oil, natural gas and coal, and their derivatives—were formed from the remains of dead plants and animals through a long, slow process involving decay, compression, chemical alteration and extreme temperatures (Ramage, 1997). While the process continues to this day, enormous amounts of time are required to generate large quantities of fossil fuels. The supplies we use today will not be replenished for millions of years. Consequently the consumption of fossil fuels results in an irreversible reduction of the available stock—in the case of oil and natural gas, reserves are almost certain to run out by the end of this century (Goodstein, 2004). Thus fossil fuels are considered non-renewable.

Peak oil production and its consequences

Before the end of oil and natural gas are reached, however, another important milestone will need to be addressed: the production peak of these energy sources. The "peak" is reached when production levels no longer increase. Once output ceases to rise, we begin to slide down the arc of steady depletion (Kunstler, 2005). The peaking date is far more important than the depletion date in the short term, for from that moment on, energy supply will no longer keep pace with demand, the consequences of which we have already seen in previous oil crises. The difference between the coming peak oil crisis and previous oil crises is the irreversibility of the situation, since the supply crunch will be forced upon us by nature rather than as a result of political disputation or temporary circumstances (Hirsch et al, 2005).

[19] The trends are depicted in graphic form in Natural Resources Canada's *Atlas of Canada,* "Trends in Greenhouse Gas Emissions, 1990-2010." Available at: http://atlas.gc.ca/site/english/maps/climatechange/atmospherestress/trendsgreenhousegasemission. Accessed 6 September, 2005.

There is much debate as to when global production of oil will peak. Some estimates offer a date prior to 2007 (Pfeiffer, 2004). Some authorities, such as petroleum geologist Colin Campbell, predict a peak in world oil production by 2010 (CBC, 2004a). There are also long range estimates: for example, the U.S. Energy Department predicts that peak production will occur in 2037 (CBC, 2004a). However, the consensus estimate for peak oil of 20 major studies conducted since 1995 including illogically high U.S. Energy Department figures is 2010 (Hughes, D., 2004), that is, in less then five years. Global natural gas production is expected to peak within the next two decades and may have already peaked in North America (Bentley, 2002).

The consequences of a shortfall in oil, in a society that depends on this resource for more than 80% of energy production, are enormous, and the transition to other energy sources is not moving nearly quickly enough to maintain current economic output when the shortfall occurs. This means that we are very unlikely to be prepared for the economic and social impact of the rising prices and reduced supply of fossil fuels. The impact of hitting the oil supply peak will be severe, by most predictions. The results of soaring energy prices may include: economic hardship; fuel shortages; inflation; increased potential for international terrorism; radically constrained transportation options; reduced food production; and the potential for large scale social disruptions (Hirsch et al, 2005; Bentley, 2002). These changes will be felt disproportionately by the poor and will have the greatest impact in countries that do not have the means to make a quick shift to other energy sources (Hirsch et al, 2005).[20]

Although alternatives—such as hydrogen and renewable energy sources—are being explored and implemented to some degree, current developments are a long way from permitting a smooth transition if the peak is reached within the next five (or even ten) years, as many analysts predict. Although electricity can be produced from other energy sources, there are many applications which depend directly on oil, including almost all transportation, many industrial processes, and numerous products such as fertilizers, plastics, detergents, paints, and artificial fibres. These are items that modern industrialized societies depend on daily.

Some analysts propose that non-conventional sources of oil such as Alberta's oil-sands will fill the gap greatly extending the time horizon before the onset of peak oil. Though Canada's oil-sand reserves are vast there needs to be a massive investment in infrastructure if projected shortfalls in supply are to be met from this source. Unlike conventional crude oil oil-sands are extremely energy intensive to extract as they must be mined rather than pumped. Huge volumes of water are needed in this process along with large amounts of energy (Hughes, D., 2004). It is projected that large scale development of Alberta's tar-sands would require all the natural gas expected from the Mackenzie Valley pipe-line for processing of the oil sands (Hughes, D., 2004). The destruction to land, the massive volumes of water usage, and the energy intensity of processing make the oil-sands an undesirable source of energy even before conventional emissions and climate change.

[20] There is much speculation about the impact of peak oil production and the subsequent end of oil and natural gas. Given the vast uncertainties related to this problem, it is beyond the scope of this project to explore the matter in depth here. For insightful readings on this important topic see: Heinberg, 2005; Goodstein, 2004; Heinberg, 2004; Deffryes, 2003; and http://www.hubbertpeak.com/.

The end of oil (and other fossil fuels)

Crossing the point of peak production of fossil fuels will result in an imbalance between supply and demand. The most likely impact of this will be an escalation in energy prices, the effect of which will reverberate throughout the economy and society, given our heavy dependence on these energy sources. These events will force greater energy substitution and conservation, which could curtail demand for certain products. How society will respond in the period following peak fossil fuel production is difficult to determine with certainty, so it is impossible to predict the exact time when we will actually have used up all the accessible oil, gas, and coal reserves in the world, because these numbers depend on the rates of consumption, among several other factors. Despite the difficulties, predictions are still made by analysts based on the best available knowledge.

Looking at the reserve to production ratio for fossil fuels provides a picture of the seriousness of depletion rates. For example, assuming no drastic declines in oil use due to scarcity, oil is expected to be depleted in about 40 years (Hughes, D., 2004).[21] In the case of gas (including natural gas, coal bed methane, and other gases), the reserve to production ratio is slightly better at about 70 years. Coal is by far the largest remaining fossil fuel with a reserve to production ratio of around 200 to 300 years (Hughes, D., 2004).

As with the likely date for peak production, depletion rate estimates vary, with some shorter and others longer than those given above. The estimates cited are based on current information about available resources, extraction technology and consumption rates and will need to be modified to account for conservation measures that will likely follow peak oil and gas production, and which may also result in greater reliance on remaining coal reserves. However, most estimates reveal that fossil fuel depletion is an issue facing the present generation. As yet, we have not begun to deal with this problem effectively – Provincially, Nationally, or globally. In order to address the depletion of the world's largest and most essential energy resource, serious changes to the way our economies are run will need to occur. While fuel substitution options do exist, the necessary infrastructure and end use changes also need to be implemented to facilitate a smooth transition to those alternatives (Lovins et al, 2005).

3.6 Impacts Summary

This chapter has outlined a wide range of impacts that the energy sector can have on human health, the environment and society. This was demonstrated through a brief review of the human health concerns related to energy production, and the potential for energy related accidents. The association between energy production and human illness was also noted. Furthermore, the environmental impacts of the various energy sources were outlined, and the effects on air, land and water were briefly reviewed. The effects of energy on our landscape and global climate were also noted. Lastly, the longer-term impacts of relying for our energy on non-renewable resources that are approaching peak production were summarized, along with some of the potential social

[21] This includes oil sands and what are likely inflated estimates for reserves held by the Organisation of Petroleum Exporting Countries (OPEC).

and economic repercussions that are likely to occur when demand exceeds the supply that our current energy system can provide.

Regardless of energy source, there will always be health and environmental impacts to consider. Table 2 provides a summary of some of the impacts of the primary energy sources that were addressed in this chapter. These represent the main energy sources produced and/or used in Nova Scotia in some way. Further discussion as well as quantitative analysis of many of these issues is provided in Chapters 6 and 8. Here it can simply be noted that a realistic analysis and comparison of the differential social, economic, environmental and health impacts of different energy sources is essential in considering alternative energy options and futures, so that least-cost paths may be pursued for the larger benefit of society.

Table 2. Summary of key impacts of primary energy sources

Source	Emissions and other by-products released	Health and environmental concerns	Specific health and safety concerns
Oil (and oil products)	CO_2, SO_X, NO_X, CO, VOCs, waste heat	Climate change, air pollution, acid rain, oil spills, oil rig accidents	Respiratory illnesses, accidents, hearing loss, musculoskeletal and repetitive strain injuries
Natural gas	CO_2, methane, waste heat	Climate change, pipe leakage, methane explosions	Respiratory conditions, accidents
Liquefied natural gas	Same as natural gas though higher CO_2 per unit energy	Same as natural gas but with potentially more damaging explosions and spills	Same as natural gas but with potentially more damaging accidents
Coal	CO_2 , SO_2 , NO_X, Ash (PM), Hg, waste heat	Climate change, smog, mercury contamination	Accidents, silicosis, pneumoconiosis, cancer
Nuclear	Radon, radioactive release, waste heat	Disposal of radioactive waste, risk of accidents, routine release of radioactive substances, terrorist attack, spread of nuclear weapons	Cancer, burns, cataracts, spontaneous bleeding, neurological and genetic damage, lost fertility, deformities, death from accidents
Biomass	VOCs, PM	Land use, incomplete combustion	Respiratory conditions, cancer from indoor inhalation of fumes
Hydro	Methane from rotting material in large dams (under study)	Displacement of people, ecosystem flooding, hydrological disruptions	Displacement of people, noise, accidents
Wind		Noise, visual intrusion, bird mortality	Noise, visual intrusion (though not necessarily more than for other energy systems), accidents during construction
Tidal bore		Flooding/disruption of ecosystems, fish mortality or disruption of migration routes	Flooding accidents
Solar		Use of toxic materials in manufacturing process (especially photovoltaics), battery disposal (if off-grid), possible land use issues and visual intrusion with large scale development	Exposure to toxic materials, work place accidents

Source: Adapted from Ramage, 1997, p. 303.

4. Indicators and Indicator Criteria

4.1 Introduction: Types of Indicators

The goals of a sustainable energy system were described in Chapter 1. The review of the Nova Scotia energy sector in Chapter 2 and its impacts in Chapter 3 made it clear that movement towards greater sustainability is both necessary to ensure future economic and social prosperity, and desirable to reduce the substantial costs and impacts of the current system. *Nova Scotia's Energy Strategy* (see Chapter 2) also supports this direction.[22] Effective measurement is needed to determine if our energy system is moving us towards or away from a healthier society, a cleaner environment, and a more robust economy. Measurements are also required to identify which institutional decisions in the sector help achieve or hinder the attainment of these objectives, and which programs are most effective in realizing established targets.

The need for better indicators to measure such progress was formally recognized at the international level by *Agenda 21*, which argued that:

> Commonly used indicators such as the gross national product (GNP) and measurements of individual resource or pollution flows do not provide adequate indications of sustainability. Methods for assessing interactions between different sectoral environmental, demographic, social and developmental parameters are not sufficiently developed or applied. Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems (UNEP, 1993).

The need for good indicators of long-term sustainability is frequently noted, for example a 2001 report of the National Round Table on the Environment and the Economy states:

> Determining whether society is on a desired course requires both a clear goal and a system that supplies decision-makers with the signals they need to make realistic choices. Indicators represent an important part of such a measurement system since they summarise key information about complex systems. There is

[22] The goal of the Nova Scotia energy sector, as stated in the NS Energy Strategy 2001 is to create "*an energy industry balancing economic growth, social goals and respect for the environment for generations of today and tomorrow, [this] is essential for Nova Scotia to achieve its vision of becoming one of the best places in the world to live and work"* (NSPD and NSDNR, 2001). It should be noted here that GPI*Atlantic* attempts to be very careful with its definitions and therefore distinguishes between "growth" (a purely quantitative concept that may or may not contribute to *quality* of life), and "development," which includes qualitative considerations and connotes an "improvement" rather than simply an "expansion". Some analysts have also argued that, in a world of limited resources and finite waste-absorption capacity in which we are already exceeding the earth's carrying capacity, the notion of "sustainable growth" may be an oxymoron, and that true long-term prosperity can better be assured through a steady-state economy rather than one based on growth. For both these reasons, GPI*Atlantic* uses the term "sustainable development" rather than growth and would amend the wording and objectives of the NS Energy Strategy statement to balance economic "development" (or "prosperity") rather than "growth" with social and environmental goals.

widespread agreement that most of the measures society uses to judge success do not take into account the long term implications of our current actions (NRTEE, 2001:2).

Indicators, therefore, are one way of assessing the efficacy of societal efforts to achieve its objectives. In the case of sustainable energy, they can show: the efficiency of energy systems; the quantity of energy supplies consumed; the environmental impacts of that energy use; the levels of emissions resulting from energy combustion; the effects of government decision-making; and more. Indicators can provide information to help make decisions between competing choices and to measure progress towards society's aims. Given the overarching goals of sustainability—long-term economic prosperity, environmental health, and social equity—the **GPI***Atlantic* Energy Accounts have compiled and suggested indicators to measure progress in three key areas:

- ***Socio-economic:*** These indicators consider energy supply, demand and use, efficiency, employment, and affordability of energy supplies;
- ***Health and Environment:*** Indicators that address energy-related air emissions, land use issues, climate change and waste disposal; and
- ***Institutional:*** Indicators that focus on decision-making, target-setting, policy formulation, enforcement, government spending, leadership and reporting in the energy sector.

The list of indicators explored in the **GPI***Atlantic* Energy Accounts is presented Table 3 at the end of this chapter. However, before moving to the individual energy indicators selected for this project, a general discussion outlines the rationale for the specific criteria used to select the indicators in this study. Several indicator frameworks were explored and these are discussed below in the context of the energy indicators selected for this report.

Sustainability indicators and their uses

Generally speaking, indicators are intended to provide useful policy-relevant information about physical, social or economic systems. "Indicators can be used to describe the state of the system, or to detect changes in it, and to show cause-and-effect relationships" (Farrell and Hart, 1998:7). Indicators are usually numerical and generally provide statistical information on significant trends in the system being explored. Which indicators are selected for this purpose will depend on the information that is required and on what questions must be answered (Farrell and Hart, 1998; Schipper and Hass, 1997).

The notion of sustainability indicators emerged from the need to measure progress towards the goals of sustainable development. These indicators are characterized by two key characteristics. First, sustainability, as we have seen in Chapter 1, defines the relationship between four systems: the encompassing physical environment, and the social, economic, and institutional systems required by all human societies. These four domains are often referred to as the four dimensions (or components) of sustainability. Thus sustainability indicators need to be chosen on the basis of what they can reveal of the interaction between these systems as well as about the systems themselves. However, this interaction in and of itself might simply describe current "wellbeing" in its various dimensions. Sustainability indicators can be identified by a second key characteristic – that they go beyond current wellbeing to assess whether present trends are likely to provide for the wellbeing of future generations. As noted in Chapter 1, one of the key elements of the definition of sustainability is inter-generational equity, and the understanding that we cannot deplete or degrade resources in a way that will imperil the wellbeing of future generations. Sustainability indicators, by definition, must also have this longer-term perspective.

The ultimate goal of identifying and tracking indicators of sustainability, therefore is two-fold. It is both to provide decision-makers and society at large with information that better reflects the relationship between environment, society, and economy, identifying trade-offs among these elements, and also to highlight trade-offs between current behaviours and consumption patterns on the one hand and future wellbeing on the other. Thus, it is possible that a jurisdiction registers a high current standard of living in material terms. But if this apparent prosperity is bought at the expense of future generations and is characterized by lifestyles and behaviours that are environmentally unsustainable, then good sustainability indicators should demonstrate that this jurisdiction is living beyond its means and depleting the resources required to sustain future generations.

Sustainability indicators therefore often describe a complex network of relationships that can only be adequately represented by a balanced and reasonably comprehensive set of indicators (Farrell and Hart, 1998). Which indicators are chosen for sustainability analysis also depends on the particular questions that need to be addressed. Many argue that sustainability indicators must communicate complex relationships that allow one to see progress towards particular goals and provide decision-makers with guidance towards the achievement of these goals. According to Shields and colleagues, "indicators of sustainability will only be effective if they support social learning by providing users with information they need in a form they can understand and relate to" (Shields et al, 2002). This means that these indicators need to reflect, adequately but simply, the particular concept or issue that is being measured. Because indicators—especially those used for tracking sustainability—often have to measure elaborate systems, they can take many different forms. It is important that each indicator highlights the rate of progress on the particular issue being measured (Farrell and Hart, 1998).

In keeping with the principles of sustainable development, sustainability indicators should focus on a range of concerns, including:

- furthering inter- and intra-generational equity;
- not exceeding the carrying capacity of natural resources and ecosystems;
- reducing the impact of human activities on the natural environment (particularly the rates at which renewable and non-renewable resources are used);
- integrating long-term economic, social and environmental goals; and
- preserving biological, cultural and economic diversity (Farrell and Hart, 1998).

As noted in Chapter 1, progress towards sustainability has both a relative and an absolute (i.e. threshold) dimension. Movement towards sustainability can appear significant when compared to previous inaction but it does not mean we are living within the carrying and absorptive capacity of the earth, ensuring equity or preserving diversity. Therefore it is important that indicators are chosen that help identify achievement toward (or away) from the threshold dimension or absolute sustainability rather than just movement on a relative scale.

4.2 The Development of Sustainability Indicators

The effort to create sustainable development goals and indicators gained momentum at the United Nations Conference on Environment and Development (the Earth Summit) held in Rio de Janeiro in 1992. This effort was formalized with the adoption of *Agenda 21*. Chapter 40 of *Agenda 21* called on countries and international governmental and non-governmental organizations to:

> …develop the concept of indicators of sustainable development in order to identify such indicators (*sic*). In order to promote the increasing use of some of those indicators in satellite accounts, and eventually in national accounts, the development of indicators needs to be pursued by the Statistical Office of the United Nations Secretariat, as it draws upon evolving experience in this regard (UNEP, 1993).

This call reflects the recognition that GDP and measurements of individual resource or pollution flows are not adequate indicators for assessing progress towards sustainability. Methods for assessing interactions between different sectoral, environmental, demographic, social and developmental parameters are needed as a step towards creating a more accurate and comprehensive accounting system than presently exists. Such an expanded capital accounting system will include measures of human, social and natural capital in addition to the produced and financial capital currently measured. Indicators are the first step towards such an expanded accounting framework, since identifying what needs to be measured has to happen before a valuation system is established. To this end *Agenda 21* requested that all countries undertake the following activities:

- Development of indicators of sustainable development;
- Promotion of global use of indicators of sustainable development;
- Improvement of data collection and use;
- Improvement of methods of data assessment and analysis;
- Establishment of a comprehensive information framework;
- Strengthening of the capacity for traditional information (UNEP, 1993).

4.3 Indicator Frameworks

On the basis of *Agenda 21*—to which most of the world's nations are signatories—many countries initiated projects to identify relevant indicators for measuring sustainability at both national and regional levels, as did international bodies at the global level. Canada was one of the first countries to attempt to measure sustainability through the use of indicators, and many sustainability indicator frameworks have since been developed here at the national and regional levels. To achieve the goals of sustainable development, Canada started developing a national set of environmental indicators over ten years ago. Led by Environment Canada, the Indicators Task Force was set up "to establish a framework for developing indicators, conduct a broad survey of key opinion leaders and potential users and define criteria by which indicators would be selected" (Environment Canada, 2005d: 1). This led to the establishment of 43 indicators in 18 issue areas and has culminated today into the National Environmental Indicator Series.[23] Another important Canadian project in this field is the Environment and Sustainable Development Indicators Initiative of the National Round Table on the Environment and the Economy (NRTEE), which identified a small suite of key sustainability indicators to guide Canadian policy makers (NRTEE, 2003).

Groups within provinces and regions have also undertaken sustainability indicator studies (NRTEE, 2003). In Nova Scotia, much of the work on sustainability indicators has been undertaken by **GPI***Atlantic*, but others, including the Nova Scotia Department of Environment and Labour in *The State of the Nova Scotia Environment 1998* (NSDE, 1998), have also sought to develop sustainability indicators for the Province. Unfortunately, there has been no systematic provincial state of the environment reporting in Nova Scotia since 1998; and the provincial Round Table on the Environment and the Economy, which also recommended the development of such indicators in the mid-1990s, was dissolved at that time and never reconstituted. The last Atlantic region state of the environment report published by Environment Canada was also issued a decade ago. Other regions of the country have reported on sustainability trends more recently. The Government of Manitoba, for example, issued a provincial sustainability report this year (GoM, 2005).

Almost every major multi-lateral organisation has undertaken some indicator work related to sustainability issues. These include, among others, the United Nations Environment Programme (UNEP), the European Union (EU), the Organisation for Economic Co-operation and Development (OECD), the World Bank (WB) and the World Economic Council (WEC). The International Energy Agency (IEA), the EU, UNEP and others have developed specific energy sector indicators at the international level. A review of these studies provided the starting point for the **GPI***Atlantic* Energy Accounts. One such Canadian initiative that was reviewed for this study is the sustainable energy indicator work of Natural Resources Canada (NRCan). In its first Sustainable Development Strategy, Natural Resources Canada undertook to develop objective means to assess progress towards sustainability in energy and to this end developed a set of energy indicators for sustainable development.

The NRCan approach, like that of many other groups including **GPI***Atlantic*, was to focus on "monitoring a suite of economic, environmental and social indicators that taken together highlight progress towards sustainability in energy, and serve as guideposts to the issues that will likely require attention from decision makers as energy policy is developed" (NRCan, 2003a). The NRCan framework uses the 'three-legged stool' framework to cover some of the domains also identified in this report: economic development, environmental stewardship, and social wellbeing. The institutional domain is not included in the NRCan approach, nor does it appear in most other frameworks for sustainable energy indicators.

[23] Canada's National Environmental Indicator Series: http://www.ec.gc.ca/soer-ree/English/Indicator_series

The NRCan work, like the work of other established bodies, helped to inform the indicator selection in this study, but the NRCan framework and indicators were not considered the most comprehensive or suitable sustainable energy indicators for Nova Scotia. In some cases, it was felt that the NRCan indicator choices did not reflect the most precise information that should be tracked to measure sustainability. For instance, the employment indicator identified in the NRCan framework tracks the weekly earnings of employees in energy industries compared to industrial aggregate earnings. As discussed in Chapter 5 (Employment indicator section) there are several considerations concerning sustainable employment in the energy sector that need to be tracked, including direct and indirect job gains in energy industries, job losses resulting from energy-related activities, and the potential for job creation through equivalent investments in energy conservation, efficiency improvements, and renewables. Job quality and duration are also important factors in a sustainability analysis, as will be explained in Chapter 5. Other indicators that were deemed more appropriate to the definition of sustainability and the questions addressed in this report, were adapted from NRCan and other frameworks, and are duly noted as such in this report. GPI Energy Accounts approach

GPI*Atlantic* has used a hybrid of all these approaches in this report, since no one framework was deemed suitable in its entirety and by itself for meeting the objectives of this study. Since this is a sectoral analysis, i.e. the interest is in indicators for the energy sector, we confined our analysis to indicators that apply to the energy sector only; in this way it is inherently a topic-based approach. However, to overcome the problem of one-sidedness and lack of linkages inherent in most topic-based frameworks, the interaction between energy and the four dimensions of sustainability is emphasized at each step. Energy gives rise to dynamic interconnections between social, economic and environmental factors by the very nature of how it is produced and consumed. The relationships between economy, society, environment and institutions cannot be separated, so indicator selection must address these connections in ways that may not be as obvious in other sectors. The ubiquity of energy in all forms of life and economic activity also makes it a very vast and complex sector with influence on all other sectors. It is also so central to the larger sustainability question that it deserves particular attention, and is therefore amenable to a topic-based approach that does not fall into the usual trap of ignoring vital inter-sectoral linkages.

Principles of the pressure-state-response approach were explored and used to help identify the environmental and health-related indicators used in this study. For instance, **GPI***Atlantic* started the project by asking, what concerns should society have about the impacts of current energy production and use on the environment and human health (the pressure)? What must be measured in order to understand the impacts of these energy-related activities on the state of the environment and human health (the state)? And, in which direction does the indicator need to move (i.e. what actions are required) to address and alleviate the pressure and thereby improve the state of the environment and human health (response)?

This method, and the pressure-state-response framework in general, worked well for identifying health and environmental indicators for this study, but was not so effective in identifying key economic and social indicators for the energy sector, although similar questions were asked for these factors as well. The questions asked included: What are the key social and economic concerns related to current energy production and use? What must be measured in order to understand the impacts of energy-related activities on the economy and society? In which direction do the indicators need to be moving to reduce the economic and social pressures of current energy-related activities and to improve long-term economic prosperity and social equity? However, the pressure-state-response model had limited utility in answering these questions effectively and identifying appropriate social and economic indicators. Instead, the goals-based indicator approach provided a better framework for identifying economic and social indicators for this study.

Returning to the goals of a sustainable energy system identified in Chapter 1, indicators were identified that would allow progress to be measured towards each of these goals and several more. For instance, one goal of a sustainable energy system is to increase the use of renewable energy sources. Progress towards this goal requires measurement of the amount of renewable energy in use in the system and/or a concomitant reduction in the use of non-renewable energy sources. Each goal therefore may have multiple indicators. Both the economic and institutional indicators were chosen on the basis of this goal-based framework.

Although the indicators were arrived at through different means based on all three frameworks outlined above, the guiding principle was always the same: What is it that needs to be measured in order to determine if there is progress towards the goals of a sustainable energy system? The indicators for this project were established with a view to answering this question, as well as by considering the requirements of an effective indicator (below).

Topic of interest approach

According to Farrell and Hart (1998), "[a] topic-based framework groups indicators by specific topic areas, such as the economy, the environment, transportation, pollution and so forth" (p.8). Although topic-based frameworks allow one to see the detail of a particular sector or issue, they tend to obscure important relationships and interactions among different sectors, and often include traditional indicators like measures of economic growth that may actually conflict with the measurement of sustainability. This makes it difficult to discern the linkages between areas and "provide[s] no impetus for the development of better indicator sets" (Farrell and Hart, 1998:8). For instance, NRTEE's Environment and Sustainable Development Indicators Initiative used a topic-based approach and focused on the economy as the object of sustainability rather than on all dimensions of sustainability (in contrast to this study). As the authors of the NRTEE report point out, the adoption of the four dimension approach, based on assessments of natural, human, social and produced capital, would result in conclusions that are "substantially different" from those arising from an exclusively economistic perspective (Smith et al, 2001). To its credit, the National Round Table did advocate moving beyond its rather narrow initial focus to an eventual broader accounting framework based on the four forms of capital.

The pressure-state-response framework

The pressure-state-response (PSR) framework focuses on those human activities (pressures) that lead to particular environmental conditions (states) and ultimately to remedial actions (responses). Also known as the Driving Forces State Response framework (a modification of the original PSR framework in attempting to identify the root causes or driving forces underlying patterns of human activity) , this approach is useful for describing the *causes* of problems and for understanding linkages between the economy, society and environment. But the approach can be difficult to apply to social and economic indicators, and has been criticized as being more appropriate for analytical and policy purposes than for indicators and measurement. For indicator and measurement purposes, it is important to be clear how each indicator is used in any specific case and "whether an increase or decrease is preferred" (Farrell and Hart, 1998:8) – which the PSR approach is frequently not able to accomplish with clarity. This PSR framework was first developed by Statistics Canada and later adopted by the OECD and many other organizations. A good example can be seen in Environment Canada's National Environmental Indicator Series (Environment Canada, 2003).

Goal-based framework

The goal-based framework requires the identification of a desired outcome (the goals), as well as what is needed in order to measure progress toward that end (the indicators).

> [It] organizes indicators into a matrix showing how each indicator relates to all the different sustainability goals of a particular group, community or other entity. As long as the goals adequately represent the desires of the community, this framework ensures that the indicator set reflects the full range of desires (Farrell and Hart, 1998:8).

The goals-based approach allows one to show linkages between goals and to measure progress towards multiple goals. The difficulty in this approach is the need for explicit and representative goal setting, because only if the goals are representative (of society's objectives) can the indicators be so too (Farrell and Hart, 1998). With a large, complex domain, such as sustainable development, it may be difficult to present the linkages that exist between the many (sometimes conflicting) goals and indicators and furthermore society's goals need to be broad and encompassing to ensure that all aspects of sustainable development are addressed.

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4.4 Criteria for Choosing Indicators

The determination of which indicators to use, at what level of aggregation, with what frequency of reporting, and over what period of time, must be decided on the basis of what questions about a particular issue require answers (Schipper and Hass, 1997). For instance, understanding the link between energy production and air quality requires tracking of those pollutants affecting air quality that arise from energy production. If the intention is to establish trends over time then air emissions over a number of years has to be collected and compared against energy production activities during that period. Furthermore, certain types of energy production may produce different levels of each pollutant; therefore, the data may need to be collected based on energy source or production method such as residential fuelwood or utility electricity generation. However, it is also important that indicators have certain common characteristics. If the main purpose of sustainability indicators is to serve as communication tools that simplify complex issues to help inform policy and guide it towards sustainability, then the indicators chosen should be easy to understand, reliable, and limited in number (Spangenberg et al, 2000; Farrell and Hart 1998).

In the work carried out by the Indicators Task Force led by Environment Canada, a broad survey of key opinion leaders and potential users was conducted. The interviewees surveyed stated that:

> Indicators would be useful for day-to-day decision-making if they were perceived as catalysts that could 'spark behavioural and ethical changes' among Canadians and answer to 'intelligent public concern' for the environment. They also commented that indicators buried in government reports are of little use to the public and that results must be communicated clearly and understandably to the users. The indicators needed to relate to things that people value or identify with, be directed to something requiring attention or action, illustrate changes in a reasonable time frame, and be flexible enough to respond to changing scientific data and public opinion (Environment Canada, 2003).

Much consideration has been given to criteria for effective indicators and to the characteristics of sustainability indicators. The following represent the most common features of effective indicators:

- general (i.e. not dependent on a specific situation, culture or society);
- indicative (i.e. truly representative of the phenomena they are intended to characterise);
- sensitive (i.e. react to changes in what they are monitoring);
- robust (i.e. directionally safe with no significant changes in case of minor alterations in the methodology or improvements in the database);
- relevant (i.e. applicable to the issue that needs to be monitored);
- practical to collect;
- clear and easy to understand;
- reliable and verifiable; and
- meaningful; (Barrera-Roldán and Saldívar-Valdés, 2002; Spangenberg, 2002; UNEP, 1993).

Of course, meeting all of these criteria is not always possible and a failure to do so should not automatically exclude an indicator from consideration. For instance, although the availability and reliability of source information is important, as is the inclusion of the most current statistical data, the lack of available data is not a sufficient condition for the exclusion of an indicator. It is precisely because there has been a failure to measure some key factors that they are conventionally assigned a null value and frequently excluded from adequate consideration in the policy arena. If an indicator is justifiable on the basis of the importance and relevance of the factor being tracked, and if it is potentially capable of providing clear, reliable information on which to measure progress towards sustainability, then efforts should be made to measure and track it. The lack of data for that indicator should be understood as the identification of an important data gap and as a recommendation for future data gathering in this area. Simple exclusion of the indicator due to lack of data would undermine the possibility of creating pressure or a constituency for future data collection in that field. Thus, an important function of indicator work is the identification of data needed to populate key indicators.

The energy indicators for the **GPI***Atlantic* Energy Accounts were selected with these criteria and considerations in mind, but above all they were chosen with a policy focus – to provide important and necessary information for making decisions on how to achieve a sustainable energy system.

Agenda 21, in particular, emphasises the production of information that can be used to make informed choices:

> Countries and international organisations should review and strengthen information systems and services in sectors related to sustainable development, at the local, provincial, national and international levels. Special emphasis should be placed on the transformation of existing information into forms more useful for decision-making and on targeting information at different user groups (UNEP, 1993).

This project tries to speak to this final point in particular. Despite a proliferation of information about energy collected by Statistics Canada and other agencies, the ways in which those data are currently presented are not always meaningful for tracking sustainability. Problems with transparency, consistency, and data availability and access were also discovered in the course of this research. This is much more often the case with data at the provincial, rather than National, level, as will become apparent. In order to be effective, indicators need to be consistent, transparent and accessible. Major data gaps and confidentiality clauses are problems that prevent the drawing of a complete picture of Nova Scotia's current energy status. **GPI***Atlantic* has tried to highlight data gaps and problems with transparency and accessibility in each of the following chapters. This was done with the hope of improving the information available to Nova Scotians about their energy options and futures, and to enable them to measure progress in the energy sector in Nova Scotia more accurately than is presently possible.

4.5 Indicators for Energy

Indicators were initially identified for each of the four dimensions of sustainability, but it quickly became evident that in some cases the connections between the four dimensions are too deeply entrenched to permit separation of the indicators under the four headings (environment, society, economy and institutions). Conjunctions are particularly evident between environment and health (society), and between society and the economy.

Rather than stick to the strict delineation of the four dimensions, therefore, the key indicators that have been analyzed in this study are presented under the three broad headings shown in Table 3, with the socio-economic and environment/health indicators quantified to the extent possible. These three subject areas— socio-economic, health and environment, and institutional—are presented in Chapters 5 through 7. There are other important areas of concern identified as important for measuring energy sustainability that could not be included as indicators at this time because even basic data and general information was limited. These are discussed briefly elsewhere in the report, particularly in Chapter 3. These additional areas, although not included as explicit indicators, are thereby not excluded from this study, and will hopefully be quantified and analyzed in future updates of this report as data become available.

Table 3. List of indicators explored in the GPI*Atlantic* Energy Accounts

Area of interest/concern	Indicators
Socio-Economic	
Energy production and supply	• Current energy mix - total units per year by primary fuel type • Units of primary energy produced in the Province vs. units of imported energy by fuel type • Percent of electricity generated from renewable sources, natural gas, and other fuels
Energy consumption	• Total energy consumption by fuel type • Total energy consumption by end use
Energy efficiency	• Equipment efficiency • Building efficiency • Process efficiency (in industry) • Efficiency of electricity generation and transmission
Employment	• Number of person months employed on energy-related jobs (by industry) • Number of person months lost due to energy industry accidents
Affordability	• Percentage of households living in fuel poverty
Reliability	• Number of household hours per year without power • Business hours lost due to power failure
Health and Environment	
Air pollutants	• Sulphur oxides (SO_x) • Nitrogen oxides (NO_x) • Volatile organic compounds (VOC) • Mercury (Hg) • Carbon monoxide (CO) • Particulate matter (PM)
Climate Change	• GHG emissions (CO_2 equivalents)
Institutional	
Leading by example	Internal government efforts to promote sustainable energy: • Procurement of energy from sustainable/renewable sources • Energy- efficiency of government buildings

Creating societal change	Regulatory, educational and fiscal measures: • Incentives/disincentives for sustainable energy use • Efforts to educate the public about energy options • Enforcement of regulations and standards
Reporting	Overseeing energy sector activities while ensuring transparency and fairness: • Target setting and progress reporting • Developing and adopting provincial-level indicators and measures of progress for energy sustainability
Evaluation	Efforts to monitor and improve how government addresses energy concerns: • Integration of energy policy (within and among levels of government)

Presentation of indicators

For each of the indicator groupings— socio-economic, health and environment, and institutional—a similar reporting framework has been used where possible to present both the indicator group and the individual indicators. First, some brief background is given about the indicator group in general and its linkages with energy, addressing concerns about energy impacts in each of the four key areas (environment, social wellbeing, the economy and institutions). This is followed by an overview of the indicators included for that section (group) presented in a summary table. For each indicator the following description is provided:

- What the indicator is and what it means in the context of energy.
- How or why this indicator can be used as a measure of sustainability.
- Whether an increase or decrease demonstrates sustainability.
- What the data tell us about where this indicator is heading—towards or away from sustainability, and whether sustainability targets are being met[24] (evidence of indicator trends).

The trends are presented graphically over time where data are available. Whenever possible the reporting period used is 1970-2003. In some cases shorter time spans had to be used where complete statistics were unavailable; these instances are duly noted. Any problems with data access or other data limitations are described at the beginning of each chapter or within the individual indicator sections to which they apply. Some common problems that were found include limitations of geographic scope for some data sets, time for which data are available, and confidentiality issues.

Trends in other regions of Canada and the world are presented where possible to provide the means for assessing Nova Scotia's performance on a comparative basis. This is followed by a short discussion of the goals and targets for the specific indicator – in other words, consideration of which direction ***and*** by what magnitude the indicator needs to be moving to approach (relative and absolute) sustainability. Short, medium, and long-term targets are also discussed. Wherever possible, existing targets set by Nova Scotia and/or Canada are presented. In cases where Nova

[24] Keeping in mind that progress towards sustainability has both a relative (directional) and an absolute (threshold) dimension, as discussed previously.

Scotian or Canadian targets do not exist, international targets are presented to show the scale of action required.

Short-term targets are defined as actions to be taken and targets to be achieved by 2015. Medium-term targets cover the period 2016-2049 (i.e. 30-40 years from now). Long-term targets refer to 2050 and beyond (i.e. more than 40 years away). There are many factors that have to be considered when setting targets and all may not be appropriate for Nova Scotia. The "goals and targets" section is intended as a starting point, in order to initiate discussion about what levels of improvement are necessary to move towards sustainability—but by no means do they represent the final word on adequate or accurate target levels.

It should be recalled that targets set by governments may be purely relative and refer to what is judged achievable and feasible by political, economic or social standards, and they may not refer to what the environment will bear. For example, the Kyoto targets are widely accepted nationally and internationally, but will not stop the accumulation of greenhouse gases in the atmosphere or reverse global warming trends. Far more ambitious targets are needed than those set by governments if global warming trends are to be reversed. Thus, the relative targets set by governments should always be viewed in the context of the more absolute standards set by nature itself, which assess the carrying capacity of the natural environment and its resource flows and waste absorption capacity.

Suggestions are made at the end of each of the indicators chapters about other areas of concern for which indicators should be developed in the future but that were not included at this time due to data shortages or other constraints.

5. Socio-Economic Indicators

5.1 Energy, Society and Economy

Energy and the economy are inextricably linked. Energy provides the means to produce goods, and is used to provide and maintain a whole range of services that sustain humanity and keep the economy running. As a result, energy is a major driver of development and social wellbeing (Geller, 2003). Without access to abundant, reliable and affordable energy, Nova Scotia's economy, like any other, would quickly grind to a halt. The vulnerability of all modern economies to disruptions in energy access is demonstrated regularly in different parts of the world. Here in Canada it was probably best illustrated by the oil crises of the 1970s. During the crisis periods (1972-73 and 1979-80) shortages ensued and oil prices increased as much as four-fold. This resulted in a downturn in the global economy, and around the world forced serious reconsideration of energy production, consumption and pricing (Doern and Toner, 1985). More recently, the spike in oil prices in the wake of Hurricane Katrina again demonstrated the vulnerability that can result from even a temporary disruption in production.

In Canada the main problem has not been one of overall scarcity, since oil is produced in the country, but rather one of equitably balancing the disparity between producing and consuming regions. Those regions that are dependent on imported petroleum products have suffered from oil price hikes while oil producing regions like Alberta have profited (Toombs, 2004). There were several responses to the crises of the 1970s; the promotion of energy self-sufficiency in order to circumvent international market volatility was one major strategy. This included switching to local fuel sources (EMR, 1977). As an oil importing region, Nova Scotia responded to the 1970s oil price hikes by, among others things, switching from imported oil to local coal for use in electricity generation. It is the legacy of the 1970s oil crises that, to a large extent, determine the electricity supply mix in the Province today.

Although initially economies were negatively affected by the oil crises, the events did spark a major move towards energy conservation, efficiency, and the use of alternative sources such as renewable energy. In Nova Scotia, not only oil consumption but the Province's entire energy footprint declined dramatically in the early 1980s. In fact, Nova Scotia's energy footprint (which measures human impact on the environment) declined by one-third from an all-time high of six hectares per person in 1979 at the time of the second oil crisis to just four hectares per person in 1985, and has not increased much since that time (Wilson and Colman, 2001).[25] These efforts demonstrated that economic development and prosperity do not have to be coupled to energy consumption on a one to one basis, as previously believed. With increasing concern about the health and environmental implications of our energy choices, combined with questions about the

[25] Canada's per capita energy footprint has always been considerably smaller than Nova Scotia's due greater reliance on hydro power and less on oil and coal. This, however, does not necessarily mean that the average Canadian uses less energy than the average Nova Scotian. In reality greater economic prosperity in the rest of Canada means that average energy use across Canada is significantly higher than in Nova Scotia but because of the different sources of energy used (i.e. hydro and natural gas which are less damaging to the environment on average) the footprint is smaller (Wilson and Colman 2001).

continued availability of cheap, abundant, conventional energy sources (in particular, oil and natural gas supplies), it is now widely recognised that the relationship between energy and the economy needs to be re-evaluated.

Approaches to energy service delivery must also allow economic activities to continue without harming human health or the environment. The types of energy used and produced, where it comes from, its costs, the jobs created, and the reliability and affordability of supply, are all important factors to consider when examining the relationship between energy and economy. What is needed for sustainable development is the de-coupling of economic development and energy consumption, with due consideration given to the wide range of options that can affect each of the factors noted above. As pointed out in a recent study by the Organisation for Economic Co-operation and Development (OECD), "the main challenge [to sustainability] is to further de-couple energy use and related air emissions from economic growth, through improvements in energy efficiency and through the development and use of cleaner fuels" (OECD, 2004:28).

Fortunately there is already a lot of experience and knowledge available on how this can be achieved. Countries and regions in many parts of the world have demonstrated that economies can be maintained and can thrive despite reduced energy consumption and greater reliance on renewable energy (Sawin, 2004; Geller, 2003). Although no country can claim full sustainability in its energy or economy, different examples in various areas show that the knowledge and experience to greatly increase sustainability are available. However, it is important to remember that energy demand and economic development and prosperity can never be completely decoupled as limits to efficiency, conservation and renewable energy exist and some energy will always be needed to produce goods and services.

Canada, as one of the most energy intensive countries in the world, has much room for improvement. Although considerable progress has already been made, particularly in the wake of the 1970s oil price shocks and shortages, there are still many opportunities for reducing energy use and developing renewable sources while continuing to fuel the economy and enhance prosperity. These opportunities need to be explored and implemented in Nova Scotia if there is to be significant progress towards sustainability.

Nova Scotia's Energy Strategy provides a starting point for defining the goals of the Province's energy sector. Using this as the basis, and then elaborating further with the aid of Canadian and international goals for energy sustainability, the **GPI***Atlantic* Energy Accounts have developed a set of socio-economic indicators for the energy sector in Nova Scotia. Using the goal-based indicator framework discussed in Chapter 4, the project considered what aspects of the economy are most affected by energy availability and supply, and which sectors particularly require change. The following broad energy sustainability goals have been identified as having major socio-economic implications:

- reduce the overall demand for energy, especially fossil fuels;
- reduce dependency on imported fuels by switching to indigenous sources, especially renewable energy;
- increase energy efficiency;

- increase long-term employment that matches skills with needs;
- avoid energy activities that lead to avoidable job losses, industrial accidents, oil spills, etc.;
- ensure that energy sufficient to meet the basic needs of *all* citizens is available *and* affordable;
- ensure reliable energy services.

Indicators to address each of these goals were identified in order to determine whether or not these goals are being achieved, and to measure progress towards or away from each one. Fourteen indicators were identified for this sector. Several of the indicators address multiple goals and most goals have multiple indicators. The indicators chosen are summarized in Table 4 and are discussed in detail below. The information provided includes the rationale for the inclusion of each indicator, a summary of trends, and a discussion of goals and targets for achieving sustainability.

The indicators in the table represent an ideal of the type of information that should be tracked in order to assess progress towards sustainability. However, it was not always possible to provide a complete picture of trends since not all indicators are currently collected and presented in the way suggested in this report. Employment and reliability are the least developed as indicators. In the case of employment there is a tension between more direct jobs in the energy sector and energy-related jobs that have health and environmental implications. There is no one indicator that can encapsulate both concerns. For example, coal mining is an energy-related job that may have adverse health and environmental consequences and costs, so it is not clear whether each additional coal-mining job is necessarily a sign of genuine progress, even though job creation is generally taken as a positive indicator. Similarly, interest in the reliability of the electricity grid applies to both the duration of power outages and their effect on society (as discussed below), so a single reliability indicator is unlikely to capture both concerns.

Table 4. Summary of socio-economic indicators for the Nova Scotia energy sector

Area of Concern	Goals (What do we want to achieve?)	Indicators (Means of measuring progress)
Energy production and supply	Increase the supply of energy from renewable and cleaner energy sources. (Conversely, reduce the supply from fossils fuels). Reduce dependence on imported fuels by switching to indigenous sources, especially renewable energy.	1. Current energy mix - total units per year by primary fuel type 2. Units of primary energy produced in the Province vs. units of imported energy by fuel type 3. Percent of electricity generated from renewable sources, natural gas, and other fuels
Energy consumption (by end use and fuel type)	Reduce the overall demand for energy, especially fossil fuels. Reduce dependence on imported fuels by switching to indigenous sources, especially renewable energy (same goal as above but examined here from a demand perspective as opposed to a supply perspective).	4. Total energy consumption by fuel type 5. Total energy consumption by end use
Energy efficiency	Improve the efficient use of energy, i.e. decrease the amount of energy needed per energy service or output required.	6. Equipment efficiency 7. Building efficiency 8. Process efficiency (in industry) 9. Electricity generation and transmission efficiency (I.e. Improve the input:output ratio in energy production and use in all these areas.)
Employment	Create long-term, higher skilled employment opportunities in the energy sector. Avoid energy activities that lead to job losses and industrial accidents.	10. Number of person months employed on energy-related jobs (by industry – direct and indirect employment) 11. Number of person months lost due to energy industry accidents
Affordability	Ensure energy to meet basic needs is available and affordable to all citizens.	12. Percentage of households living in fuel poverty
Reliability	Ensure reliable energy services, e.g. reduce electricity blackout periods.	13. Number of household hours per year without power 14. Business hours lost due to power failure

5.2 Energy Data Issues

Statistics Canada is the major compiler of energy information in Canada. Most data are collected from surveys of major energy users, suppliers, and producers (oil refineries, utilities, heavy industry, etc) (StatsCan, 2004b). Tracking the movement of energy down the supply chain to the end user is not an easy process. For example, a large supplier usually provides fuel to a variety of different users, including brokers and distributors, and therefore does not always know who the end user is. For this reason it is not possible to obtain perfectly accurate data.

The complexity of energy data makes it difficult to develop a clear picture of energy production, supply and demand. Normally, production is thought of as the amount of energy produced domestically (or Provincially in the case of Nova Scotia in this report) for example, tonnes of coal or barrels of oil extracted from the ground. Demand statistics generally consider all uses of fuel stocks including final consumer use (e.g. oil in a home furnace); producer use (e.g. burning coal to produce electricity), and non-energy use (e.g. non-energy petroleum products like plastics).

To further complicate matters energy may be exported and imported, both as electricity (normally secondary energy), and as a raw resource such as natural gas and oil (primary energy). Some fuel, whether imported from outside the Province or produced within it, is then converted to secondary forms of energy. Consumers then use either secondary forms of energy (i.e. converted forms such as electricity), or primary forms of energy such as oil and wood, for a variety of end uses such as heating and industrial production. Considering the overlap between these different categories, it is often difficult and sometimes impossible to determine exact numbers for each. Consequently, the supply and demand sides only equate if all these factors are considered. In order to deal with the complexities of energy data Statistics Canada separates data in a complex multistage process in order to track these various energy and non-energy uses of fuel stocks.

Another data limitation applies to fuel wood information. Wood is a major fuel source in Canada both for residential heating and for industrial steam and electricity generation. However, energy balance statistics for wood production and consumption are unreliable for all parts of the country. Some wood use is captured in electricity generation numbers where biomass plants are in operation, but residential use is not included at all in the energy balance statistics (Angers, 2005). Records are kept for industrial use of wood wastes and spent pulp liquor but these values are reported separately and are not included in other composite calculations and tables (StatsCan, 2004b). It is difficult to determine the extent of residential wood use for heating because wood cut on private lots is often used personally or sold in the informal economy, and therefore not recorded. Statistics Canada is currently working on improving figures for wood.

However, a greater constraint is confidentiality, which prevents Statistics Canada from disclosing certain information. Statistics Canada is bound by a number of agreements and laws that limit the release of data that may hurt the competitive position of a company. This is a particular problem for energy statistics in the Atlantic region. In small provinces such as Nova Scotia there are often only one or two major companies involved in the energy sector so fundamental data cannot be disclosed.

The indicators outlined in Table 4 for energy production and supply, and energy consumption require a number of different breakdowns of energy data to be available. Possibly the most important statistic of all is the total amount of primary energy demanded annually in the Province. This statistic, if carefully collected, reveals the total amount of natural energy resources used each year. However, recent primary energy data (both Provincial production and demand) are not available for Nova Scotia from Statistics Canada due to confidentiality restrictions. Even if primary energy statistics were available, wood energy data would not be included for the reasons noted above. Consequently, it is not possible to present either of the two production or supply indicators recommended in Table 4. The following section presents the available information on production in the Province as collected from a variety of sources. Secondary data sources on energy imports for Nova Scotia (indicator #2 in Table 4) are rare and unreliable and therefore this indicator could also not be operationalized.

In the case of energy consumption or demand, the merits of the different statistics were considered and a decision made to use “total primary and secondary energy [i.e. all energy] use, final demand” figures from Statistics Canada because it can be analyzed by both fuel type and end use (i.e. commercial, residential, transportation, institution, industrial and agricultural). Total primary and secondary energy is used here to indicate that the figures include both primary and secondary forms of energy consumed by end users. For example, a home owner uses electricity to light their home (a secondary source) and oil (a primary source) for heating. “Total primary and secondary energy use, final demand” only includes consumer use of energy and does not include the energy lost in producing electricity, powering refineries, producing coke, etc. Energy consumption data is presented in Section 5.4.

Energy use, final demand data are available through Statistics Canada’s CANSIM Table 128-0002. Statistics Canada also produces a detailed summary *Report on Energy Supply and Demand in Canada*. The CANSIM tables currently available provide data for 1978 through 2002. The latest energy report available covers statistics for 2003. Between 2003 and previous reports some changes have occurred that make comparison difficult. The 2003 report combines the residential and agricultural sectors, and the public administration and commercial sectors. Because of the important differences between these sectors, especially between the agricultural and residential sectors, **GPI***Atlantic* has kept them separate in this report. In many instances this has meant that data could be presented only up to 2002.

If all the various data collected by Statistics Canada were available (i.e. not suppressed) it would provide critical information needed to ascertain the sustainability of the Nova Scotia’s energy system. This would allow all of the indicators suggested in Table 4 for energy production and supply, and energy consumption to be developed. Furthermore the relationship between various indicators can give insights as to the level of energy resources used to produce non-energy goods (e.g. plastics). It would also provide an indication of electricity generation efficiency as well as the efficiency of other energy conversion processes. Unfortunately there are serious data limitations that require the following results to be interpreted with some caution.

5.3 Energy Production and Supply

In this report, *energy production* includes fossil fuel exploration, extraction, processing, and the manufacture of usable energy for electricity, heating and other purposes. In many places domestic production, both from non-renewable reserves and renewable resources, does not meet the full demand for different fuels or energy sources. Therefore, fuel is imported to *"supply"* the full demand. This is currently the case Provincially in Nova Scotia. Canada as a whole, however, produces more energy than is demanded nationally and exports the surplus. In fact, energy markets are global with nearly all countries involved to some extent in the exportation and/or importation of energy.

Energy demand drives the energy industry (i.e. production and supply), and thus represents the other side of the energy equation. Although supply and demand are connected in this way it is necessary to track developments in each area in order to understand their individual nuances. The energy demand indicators are therefore presented in Section 5.4 below.

Indicators for energy production and supply

Different energy sources and their production methods cause varying social and environmental impacts. For example, renewable energy sources are inherently more sustainable than fossil fuels and nuclear energy, both because supplies should last indefinitely and because renewables have less social and environmental burden due to reduced wastes and by-products. Therefore it is important to track not only energy consumption (demand), but also the sources and production systems used to supply this energy in Nova Scotia. Likewise it is worthwhile examining where these energy supplies originate (imported both from other provinces and other countries vs. Provincial), as well as how much Provincial energy is exported. Evaluating energy production systems helps assess progress toward energy security (i.e. reduced dependence on imported sources and increased production of renewables). To this end the following indicators of energy production are suggested:

- Current Provincial energy mix - total units per year by primary fuel type
- Units of primary energy produced in the Province vs. units of imported energy by fuel type

The current numbers and temporal trends for the first two indicators are shown below. There is some overlap here with the discussion in Chapter 2, since data to show trends were not always available. The third indicator for energy production and supply relates to electricity and is presented in a separate section below.

Trends

Nova Scotia has indigenous energy sources including natural gas, coal, biomass, hydro power, wind, solar power and geothermal energy. In 2001 Nova Scotia became a net energy exporter of energy (i.e. Provincial production surpassed Provincial demand) through the production of natural gas at the Sable Offshore Energy Project (NSPD and NSDNR, 2001). Since then production levels have declined and the Province is again a net importer (StatsCan, 2005). Even with substantial natural gas production, the majority of energy used in the Province comes from non-Canadian imported fuels (coal and oil) while most of the Provincially produced natural gas is exported to New Brunswick and the eastern United States.

According to NRCan 1997 estimates, somewhere in excess of 10% of total primary energy use in Nova Scotia was fuelled by Provincial sources (i.e. biomass and hydro are 10% plus unspecified amount of coal) (NRCan, 1999). Since that time the Province has started to use some natural gas and wind, however, these still provide a very small proportion of primary energy demand and the amount of coal mined in the Province has declined substantially. Consequently, it is anticipated that the 10% figure still holds despite no updated total primary energy data. The bulk of demand is currently for oil and oil-based products, and for coal (to generate electricity). Almost all of these are imported. The Province has its own coal resources but no longer mines sufficient supplies to meet the Provincial demand. A switch was made to imported coal sources because of its lower economic costs (Emera, 2001).

As discussed in Chapter 2 between 1992 and 1999 Nova Scotia produced more than 44 million barrels of crude oil at the offshore Cohasset-Panuke site, but currently there is no Provincial production of crude oil.

Natural gas was first produced in Nova Scotia by the Sable Offshore Energy Project in 1999. In 2004, production averaged 418 MMcf/d (CNSOPB, 2005). Annual production peaked in 2002 at 529 MMcf/d with the highest monthly production levels occurring in 2001(CNSOPB, 2005; Hughes, L., 2005). As noted this gas is largely exported. Known natural gas discoveries amount to 3.4 trillion cubic feet (tcf) with estimates of additional gas resources ranging from 12 to 40 tcf (Hughes, L., 2004; Kumagai, 2004; NSPD and NSDNR, 2001).

Nova Scotian coal production declined substantially in the 1990s, amounting to only 32 kilotonnes by 2003, down from a recent high of 4,488 kt in 1992 (StatsCan, 2004b).[26] What coal is produced is mainly used by NSPI. Total Nova Scotian coal reserves are estimated at over 2 billion tonnes, and recoverable reserves at one billion tonnes. Proven reserves amount to about 20% of the estimated resource (Calder, 1985).

Wood from Nova Scotia's forests provides heat energy for an estimated 100,000 homes in Nova Scotia, while a number of large industrial and institutional facilities also use wood for heating and energy needs (Dobbelsteyn, 2005). Natural Resource Canada's 1997 energy demand data for Nova Scotia show that wood accounted for approximately 8.8% (23.1 PJ) of the Province's total primary energy demand of 262.1 PJ (NRCan, 1999).

Currently about 9% of electricity in the Province is generated from hydro and tidal power (Emera, 2004). Hydro power is not expected to expand significantly because the best river sites have already been used. Although there may be some future potential to harness more energy from tidal currents and waves in the Province, the technology to do so is not yet commercially available. Tidal barrage power is unlikely to be expanded since it is not considered economic and has great environmental repercussions. Nova Scotia's geography and climate do however create a favourable wind regime. As yet though, only 19 large scale wind turbines are operating in

[26] The highest production levels occurred in the middle of the 20th Century.

Nova Scotia, collectively producing only a fraction of one per cent of the Province's primary energy (i.e. about 34 MW combined capacity). When Nova Scotia's hydro, tidal and electricity are combined with wood energy supply, renewable energy provided about 10% of total primary energy demand in 1997 (NRCan, 1999).

There is limited use of geo-thermal energy in the Province with about a dozen mine-water systems in the Springhill area and some residential heat-pumps operating throughout the Province (NSPD and NSDNR, 2001a).

The status of current production and estimated reserves for Nova Scotia, by fuel type, is presented in Table 5. To place this table in perspective, total energy use, final demand in Nova Scotia in 2002 was 174,000 TJ. This table shows the important contribution natural gas could make to energy self-sufficiency in Nova Scotia if natural gas was used on a larger scale in the Province.

Table 5. Nova Scotia energy production and estimated reserves in 2003/2004

Energy resource	Annual energy production (Terajoules)	Projected reserves / potential (Terajoules)[4]	Proven reserves / resource potential (Terajoules)
Oil	(0)	Unknown reserves	Unknown reserves
Natural gas[1]	165,000 (152,840 MMcf)	16,226,000 to 43,268,000 reserves (15-41 tcf)	4,868,000 reserves (4.5 tcf)
Coal[2]	912 (32 kt)	57,000,000 reserves (2 billion t)	11,400,000 reserves (400 million t)
Hydro, Tidal and Wind[3]	3,888 (1,080 GWh)	Unknown potential	Unknown potential

Note: Conversion to terajoules was done using the energy conversion factors provided in StatsCan, 2004b. Original physical units are provided in brackets. 1. Data for natural gas production is for 2004 and is from CNSOPB, 2005. Reserve figures for natural gas are less clear although discoveries amounted to 4.5-5.0 tcf in the late 1990s. However, reserve figures for SOEP, the major natural gas project, have been down graded from 3.6 tcf to 1.35 tcf (Kumagai, 2004; CNSOPB, 2002). 2. Data on coal production is for 2003 and is from StatsCan, 2004b. Coal reserve estimates are from Calder, 1985. Proven reserves for coal amount to about 20% of the estimated resource. 3. Data on electricity production from hydro, tidal and wind is for 2003 and is from Emera, 2004. With renewable resources energy is discussed in terms of potential and not reserves. A reserve is a finite value that decreases when the material is extracted. 'Potential' implies an infinite amount since there is constant renewal. 4. Projected reserves are aptly described as an optimistic or best case scenario. Actual recovered amounts are unlikely to ever match these figures.

Often proven reserves are presented as a ratio with annual production or demand to calculate reserve life. These ratios can provide interesting information with regards to resource depletion. However, calculating reserve life with the information in Table 5 can be misleading as reserve figures are not precise and the Province imports much of its energy. The natural gas proven reserve to production ratio indicates a reserve life of 29 years. However, proven reserves at SOEP, the only active natural gas project, are only 1.35 tcf which gives a reserve life of only 8 years for this project. Coal figures can be misleading as Nova Scotian production only fulfills a small portion of Provincial demand; however, Provincial demand figures for coal are not available. It is safe to say though that coal reserve life is much larger than any other Provincial fossil fuel resource. Most importantly this table points out a large knowledge gap in terms of the potential to generate electricity and other usable forms of energy from renewable sources.

The data available from Statistics Canada and other agencies are not sufficiently complete to provide trends lines (i.e. to present data over time) for the various fuel reserves or for energy production. In order to assess the level of energy security and self-sufficiency in Nova Scotia this important and basic information needs to be tracked more closely, and made publicly available. In addition, significant research is needed on the resource potential of different renewable energy sources in the Province.

Electricity

The information presented for energy production and supply is quite limited because of data restrictions. As discussed previously, these limitations are due to data confidentiality issues at Statistics Canada. One way to explore production and supply further is to look at electricity generation information based on data from NSPI. This reveals information about fuels such as coal, which is now preponderantly used for utility electricity generation. Only a small portion of coal is used by end users, as shown in the data presented in Section 5.4 on *Energy Consumption*. Theoretically a discussion about electricity can be approached from either a supply/production or demand perspective. From the demand perspective, electricity is used to meet residential and commercial energy needs. From the supply perspective, producing electricity consumes energy stocks such as coal and natural gas.

In many jurisdictions, including Nova Scotia, plans have been developed to increase the amount of electricity generated from renewable sources, such as wind and biomass. In this case a renewable primary energy source is being used to generate a very useful energy carrier (electricity) which in turn is used to meet people's needs for energy services. This section emphasizes the need to generate this highly useful form of energy from renewable sources and cleaner fuels (i.e. natural gas verses coal). The following indicator is thus suggested:

- Percent of electricity generated from renewable sources, natural gas, and other fuels

Electricity accounts for 21% of end use energy in Nova Scotia, and 33% when transportation is excluded. As discussed in Chapter 2, electricity generation is dominated by coal combustion. The fuel mix for electricity has been fairly stable since 1980, but until then oil was the dominant fuel source. The switch from oil to coal was spurred by the oil crises and dramatic price hikes of the 1970s. Initially, the coal used for electricity generation in the Province was indigenous, but cost factors and the closing of the Cape Breton coal mines have led to foreign coal being used almost exclusively (Emera, 2002).

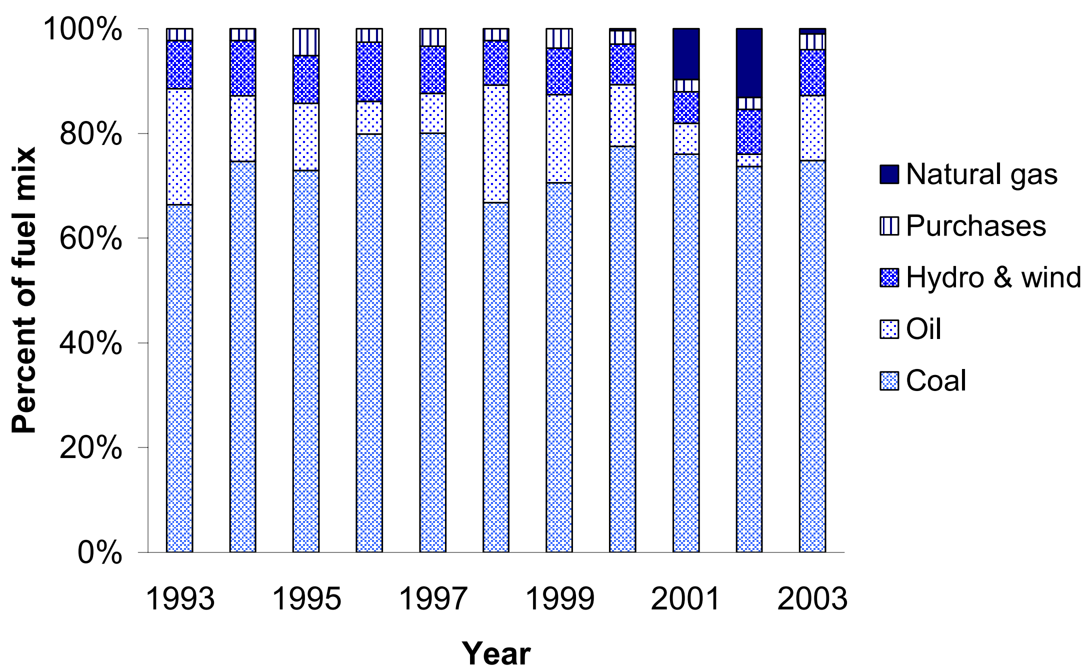
Figure 7 shows the fuel mix used by Nova Scotia Power from 1993 to 2003.[27] Coal has been the dominant source for electricity generation throughout this period. Differences from year to year are largely due to price changes in fuels or, in the case of hydro power, to varying climatic

[27] There are a handful of small independent power producers in Nova Scotia. Lack of data prevented the inclusion of the fuels used by these other producers.

conditions. A key point of interest in this figure, from a sustainability perspective, is the brief use of natural gas for fuel in electricity generation in 2001 and 2002. The conversion of one plant, Tufts Cove, to allow the use of natural gas or bunker C oil, allowed for a substantial change in the fuel mix. As noted, price increases for natural gas led to a steep decline in its use in 2003 (Emera, 2004).

Of greatest concern, however, from a sustainability perspective, is that the proportion of total electricity generation derived from renewable energy sources has not increased during the ten-year period indicated in Figure 7. Although annual variations in generation make it difficult to determine precise changes in the amount of electricity generated from each energy source, it appears that the amount of electricity generated from renewable sources has actually decreased slightly from 1994 to 2003. At best, the fuel mix in electricity use in 2003 is not substantially different from the profile in 1994. This stands in sharp contrast to the Danish, German and other European initiatives outlined below, where the proportion of electricity derived from renewable sources has increased sharply. In Nova Scotia, wind energy represents only a small portion even of renewable energy, which comes predominantly the same hydro power sources as ten years ago.

Figure 7. Power generation fuel mix for Nova Scotia Power, 1993-2003



Source: Emera, 2004, 2003, 2002, 2001; NSPI 2000, 1999.

Fuel mix figures for electricity generation are not readily available for the 1970s and 1980s, making it difficult to determine the longer-term trend in which coal was used to replace oil as the primary fuel source in the 1980s or the long term trend in renewable generation. However, figures for generating capacity are available for 1979. A comparison of generating capacity in

2003 with that in 1979 shows a significant change (Figure 8 and 9). In 1979, the installed electric generating capacity in Nova Scotia sharply favoured oil and gasoline, which combined to represent 58% of the total (note data in graph are rounded).[28] Hydro contributed 22% and coal provided only 19% of generating capacity. In the late 1970s and 1980s, a major shift was made to coal-fired power generation, due to the oil price hikes and shortages of the 1970s, resulting in the mix shown in Figure 9, where coal now dominates with 55% of electric generating capacity, followed by oil and gas (27%), and hydro and wind (18%). *Again*, from a sustainability perspective, it is of major concern that the proportion of electric generating capacity attributable to renewable energy sources has actually declined rather than increased in the last quarter century.

Generating capacity is not to be confused with actual electricity generation. The former refers to the total plant capacity that is available to generate electricity, whereas the latter is the amount of electricity that is actually generated (Section 2.4). A graph of the generation fuel mix in 2003 (Figure 7) shows that 75% of actual electric generation was supplied by coal; 12% by oil; 9% by hydro; and just 1% by natural gas (the remaining three per cent came from purchases). Thus, the proportion of actual electricity generation derived from renewable sources is even smaller than the capacity figures indicate, and that attributable to wind power remains negligible.

Several factors affect the actual generation of electricity, including the price of primary fuel sources (in the case of fossil fuels) and responses to peak demand. Thus, the large gap between coal and oil generating capacity on the one hand (55% and 27% respectively) and actual generation on the other (75% and 12% respectively) is partly due to the fact that it is cheaper for NSPI to use coal than oil. Variations in natural gas use from 2000 to 2003 illustrate how the actual generation mix can change quite rapidly from one year to the next in response to price fluctuations, even in the absence of shifts in generating capacity. The generation capacity mix is much slower to change since it is only affected when new power plants are built or old plants are retired.

Figure 8. Nova Scotia Power Corporation (NSPC) installed generating capacity, 1979

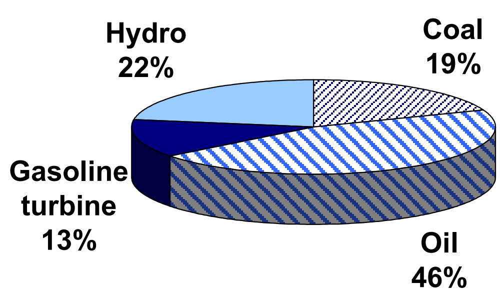
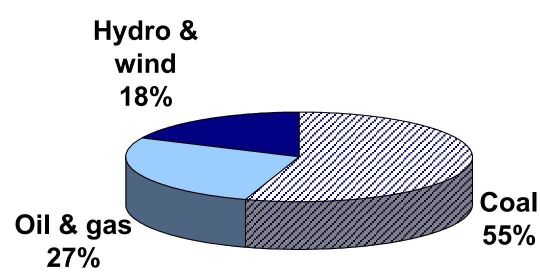


Figure 9. Nova Scotia Power Inc. (NSPI) installed generation capacity, 2003



Note: Nova Scotia Power Corporation (a publicly owned utility) became Nova Scotia Power Incorporated (a privately owned company) in 1992 when the Province sold the utility.

Source Figure 8: Nova Scotia Energy Planning Organization, 1979.

Source Figure 9: Emera, 2004.

[28] Due to rounding the values for oil and gasoline shown in Figure 8 total 59%.

Goals and targets for energy production and supply

With about 90% of the Province's energy derived from imported sources, almost all in the form of fossil fuels, it is clear that there is a need to become more reliant on cleaner, indigenous energy sources. This can be achieved in two ways: reducing overall demand (see the next two sections) and increasing the use of indigenous renewable energy sources.

Establishing long-term goals and targets requires careful exploration of the potential for energy substitution to indigenous sources. This is an area that has not received much attention in the Province and so it is difficult to say with certainty just how much of our energy could be produced locally. However, it is known that we are endowed with substantial untapped wind, biomass and solar energy, which could provide a useful starting point. Although the Province has established some goals and targets, they address only the electricity sector and do not move beyond short term (2010) considerations.

The Province has adopted a Renewable Portfolio Standard (RPS) for electricity, which requires Nova Scotia Power to obtain a certain proportion of its electricity from new generation of renewable sources. The target is to increase the proportion of total electricity generated from renewable sources by 5 percentage points by 2010 through the addition of new renewable generation (EMGC, 2003). If this goal were achieved, about 15% of electricity would be from renewable sources by 2010. With regard to other energy sectors (e.g. transportation and heating), no goals and targets have been set.

While the full potential for renewable energy production in Nova Scotia cannot be stated with certainty, it is safe to say that we have the resources and capacity to move well beyond the 2010 target, and should be discussing what further improvements are realistic and how they can be achieved. The experience of other countries and regions offers useful examples. Prince Edward Island, for instance, has set a target of having 15% of electricity coming from renewables (mainly wind) by 2010, with a goal of 100% by 2015 (PEIDEE, 2004). Currently, renewable energy generation accounts for about 5% of electricity on PEI. The Province has introduced a number of policies to encourage and support the achievement of this ambitious target and hopes to work with other provinces in the region to reach this goal (Ballem, 2005).

Germany aims to double the portion of electricity generated by renewable energies from 5 percent to 10 percent by 2010. A further goal is to increase that share to fully 50% by the year 2050. The capacity of wind energy facilities in Germany grew more than five-fold between 1995 and 2000. In 2000, there were approximately 10,000 such facilities in Germany which has created more than 25,000 jobs (GoG, 2005). Germany's Renewable Energy Sources Act (2000) establishes a mechanism to assist renewable energy sources to penetrate the electricity marketplace. Among other measures, it ensures that the price paid for electricity generated by solar power, wind power, biomass, pit gas (i.e. methane), and geothermal heat is high enough to allow the systems to operate on an economically viable basis (GoG, 2005). Germany leads the global wind energy sector, accounting in 2001 for 8,750 megawatts (MW) of the total world installed capacity of 24,000 MW (Planet Ark, 2002).

In Denmark, which provides another leading international example of commitment to renewable energy development, renewable wind electricity generation grew from 2% of electricity generation in 1990 to 18.5% in 2003. Under normal wind conditions production would have been over 20% in 2003 (GoDK, 2005). Two giant offshore wind farms are currently being developed that will push renewable electricity production in Denmark up to 29% (DEA, 2004). The efforts in Denmark will help to achieve the target established by the European Union to generate 22% of electricity from renewables by 2010 (Europa, 2004).

Establishing targets for electricity addresses only a small portion of overall energy use. Renewable energy use also needs to be increased in other applications, especially in heating and transportation. To date the government of Nova Scotia has not introduced policies to promote a move to renewables in other sectors aside from electricity generation. Here, Denmark again serves as a useful example. The use of biomass and waste for heating has grown in Denmark due to focussed policies promoting co-generation and district heating. Between 1980 and 2000 renewable energy use in Denmark nearly quadrupled, increasing from 3% to over 11% of total energy use (GoDK, 2005). The European Union has also set renewable energy targets beyond electricity. The goal is to have bio-fuels provide 5.75% of total energy by 2010 and 20% by 2020 (Europa, 2004).

Like the Europeans, Nova Scotia must also recognize that renewable electricity is only a portion of the total energy picture. A comprehensive assessment is needed in this Province of opportunities to produce bio-fuels and geothermal and other renewable energy sources; to increase the use of biomass and solar energy for heating; and to explore hydrogen for transportation and other applications. Meanwhile, goals must be established to limit and reverse the growth in primary energy consumption.

5.4 Energy Consumption (Demand)

Energy demand is one of the most powerful indicators for understanding the energy sector. Energy demand tells us how much energy is actually being used. Breaking demand down by sectors of the economy—typically into residential, commercial, industrial, transportation, institutional and agriculture uses—allows more careful tracking of who uses how much energy. If fuel types are distinguished, the key energy sources used by the different sectors can also be identified. Two indicators are thus suggested for understanding energy demand:

- Total energy consumption (in the Province) by fuel type.
- Total energy consumption (in the Province) by end use.

As discussed in the *Energy Data Issues* section, primary energy statistics for Nova Scotia are not available from Statistics Canada because of confidentiality. Therefore these indicators are based on “total primary and secondary energy use, final demand”, which does not include all primary energy used in the Province but only primary and secondary used by end consumers. Where other sources of data were available, for example from Natural Resources Canada and the National Energy Board, these have been used to fill in some of the gaps surrounding wood use.

Energy demand by fuel type

In this section, demand is broken down by fuel type. The next section presents demand using total primary and secondary energy use, final demand, by sector (i.e. end use).

Trends for energy use, final demand by fuel type

As described in Chapter 2 final demand for energy in Nova Scotia consists mostly of oil products and electricity. In 2001 oil products met 69% of energy use, final demand in the Province, and electricity met 21% (See Figure 2, Section 2.3).[29] About 50% of oil products are used for transportation which if removed make refined petroleum products less dominant as a fuel source, though they still constitute the largest energy source (Figure 3). Wood and waste wood constitute the third most important end use fuel in the Province, accounting for 7% of the total used mostly for residential heating and industrial energy needs. Provincial natural gas is largely exported. The main user of natural gas is NSPI but utility use of natural gas is not a "final demand". Only natural gas used by homes, businesses, and industry (non-utility) are shown in the figures in this chapter. Other minor sources of energy are described in Chapter 2.

The wood values discussed above and in Chapter 2 were developed by the National Energy Board (NEB) using the wood/pulp numbers reported by Statistics Canada in conjunction with the NEB's own estimate of wood use in the residential and commercial sectors (NEB, 2003). The residential/commercial estimate was derived by the NEB from Provincial estimates of wood use and converted to energy units (Mah, 2005). These calculations were not done for all Canadian provinces, so provincial comparisons must be made based on Statistics Canada data which exclude wood. Likewise it is impossible to develop supply and demand trends over time that account for wood. Unless noted, the rest of the figures in the chapter generally do not include wood use because of these data limitations.

Energy use, final demand by fuel type for the Province has not changed much since the 1980s (Figure 10). In the 1970s some industries still used coal, coke or coke oven gas for some energy needs, but this decreased substantially in the early 1980s. The use of refined petroleum products also decreased after the oil crises of the 1970s. Unlike other forms of energy, however, in which demand decreased substantially in the early 1980s and has grown relatively slowly since that time, electricity energy use has increased by more than 80% since 1978.

Overall, by 2002, total energy demand had increased by 14% from a low in 1986; but it continues to remain below levels in the late 1970s.[30] By contrast, electricity use is now well above 1970s levels. The spike in overall energy demand in the late 1990s may have been due in part to the construction of the Sable Offshore Energy Project natural gas pipeline and related economic activities. Figure 11 presents the same data on a per capita basis.

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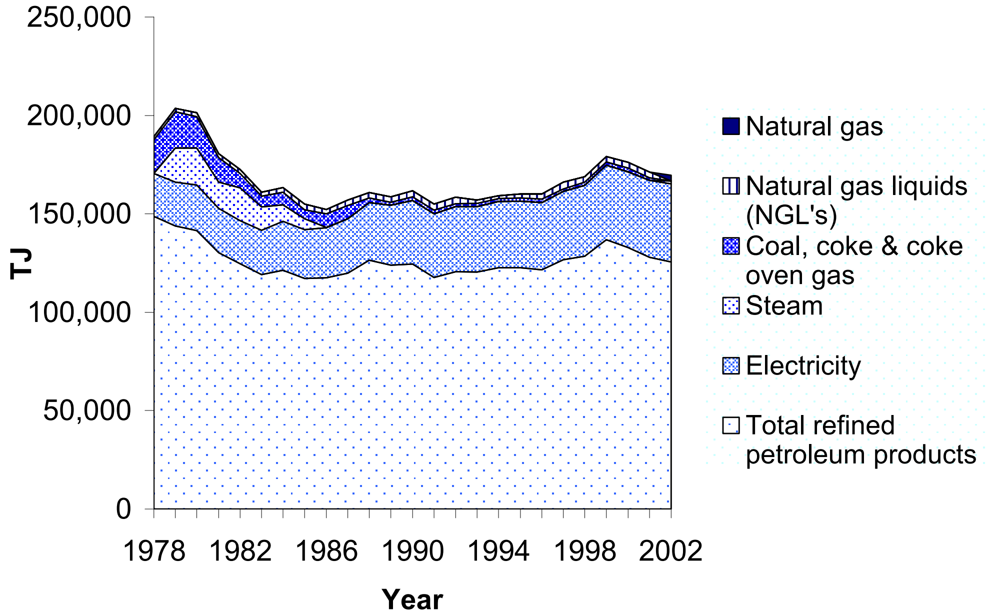
[29] 2001 was used because wood energy estimates were available for that year.

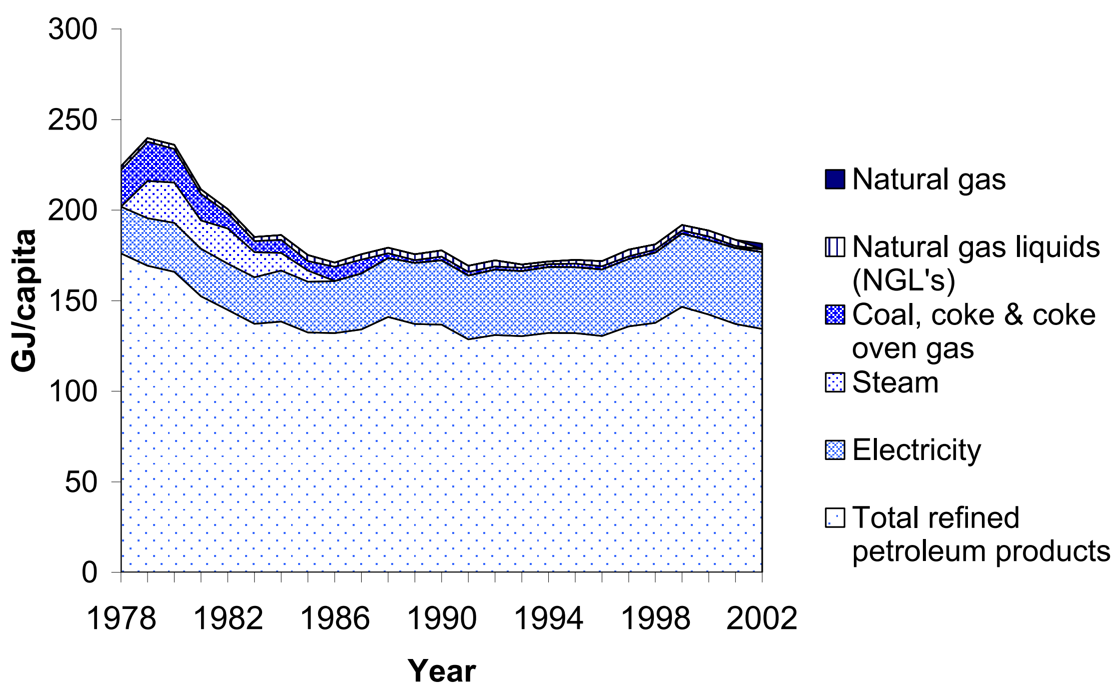
[30] This 14% increase is based on data for final demand by end use as shown in Figure 12. Based on final demand by fuel type the increase is only 11%. The reason for this difference is assumed to be because of the way that Statistics Canada processes and presents the data.

Figure 10. Energy use, final demand, in Nova Scotia (including transportation), by fuel type, 1978-2002



Source: StatsCan, 2005.

Figure 11. Energy use, final demand, in Nova Scotia (including transportation) per capita, by fuel type, 1978-2002



Source: StatsCan, 2005.

In terms of energy demand Nova Scotia is quite similar to that in the Atlantic region as a whole, although energy use in Nova Scotia fell more dramatically after the second oil crisis and has not increased as rapidly since. The end use fuel mix for Atlantic Canada, like Nova Scotia, is dominated by refined petroleum products and electricity which meet fully 98% of demand when wood is excluded (Appendix A), compared to 97% in Nova Scotia. Canada's energy use, final demand, in 2001 (including transportation, excluding wood), amounted to 7,175 PJ, but this represents a very different fuel mix than that in the Atlantic Provinces. Canadian demand was met by the following fuel mix: refined petroleum products, 41%; natural gas, 30%; and primary electricity - essentially hydro and nuclear, 25%. Natural gas is used far more extensively in Ontario and western Canada than in the Atlantic region (StatsCan, 2005).

Final demand for energy by end use

Energy demand is the driving force for the entire energy supply chain. Therefore it is important that we measure final demand accurately, and that we aim as a society to move towards greater sustainability by using less energy and by balancing demand with the amount of socially acceptable renewable energy that can be generated.[31] This section addresses the second indicator of energy consumption—energy demand by end use.

Energy use, final demand is normally broken down into six sectors, with further sub-sectors specified within these. The six main sectors are: industrial; transportation; agricultural; residential; public administration; and commercial. Again, records for wood use are missing from the trend figures due to the data limitations and difficulties specified above.

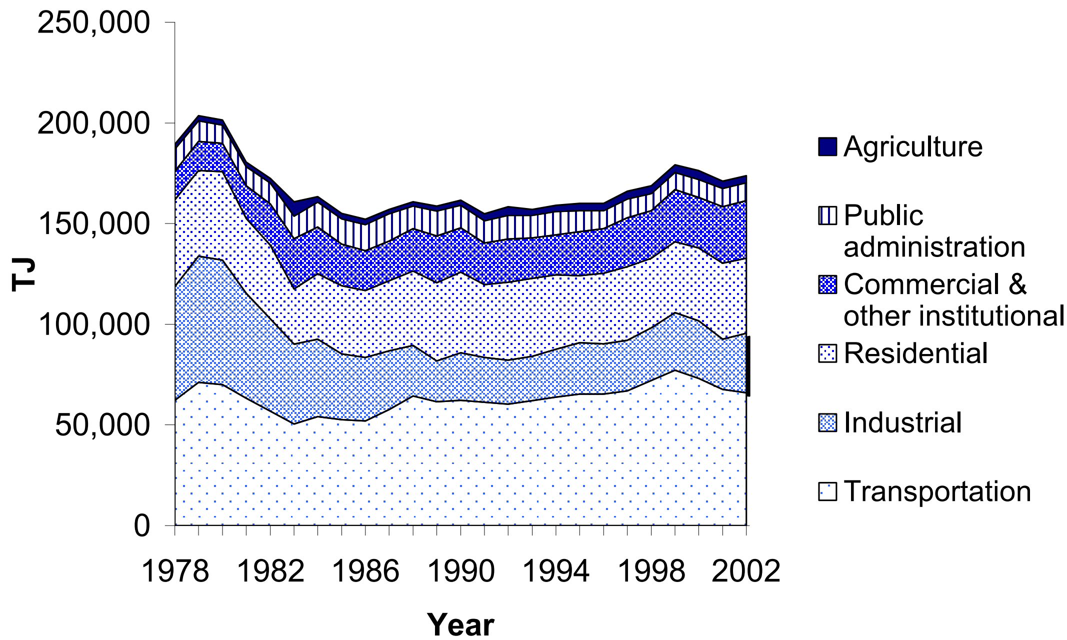
Demand trends by end use

In Chapter 2 a brief discussion of energy use, final demand was presented based on National Energy Board data for 2001 which included wood. Here energy use, final demand is presented using only Statistic Canada data which excludes wood. Therefore the values are slightly different; however, Statistics Canada data are the only sources that are available to create a historical trend. Total primary and secondary energy use, final demand, in Nova Scotia was 174 PJ in 2002 and 181 PJ in 2003 (StatsCan, 2005, 2004). At 39% of end use demand, the transportation sector accounts for the largest share of energy consumption in the Province, almost entirely in the form of petroleum products (see Figure 12). The commercial, residential and industrial sectors account respectively for about 16%, 21% and 17% of final consumption.

Energy use, final demand, by sector, over time is shown in Figure 12. Total demand for all sectors has increased 14% from the low in 1986; and increased 12% since 1991.

[31] "Socially acceptable" in this case seeks to highlight that although the potential to generate renewable energy may be very large there are social and environment effects. Therefore a society may choose not to dam every river, estuary and bay, put solar panels on every roof, or site wind turbines in every park, and along all coastlines.

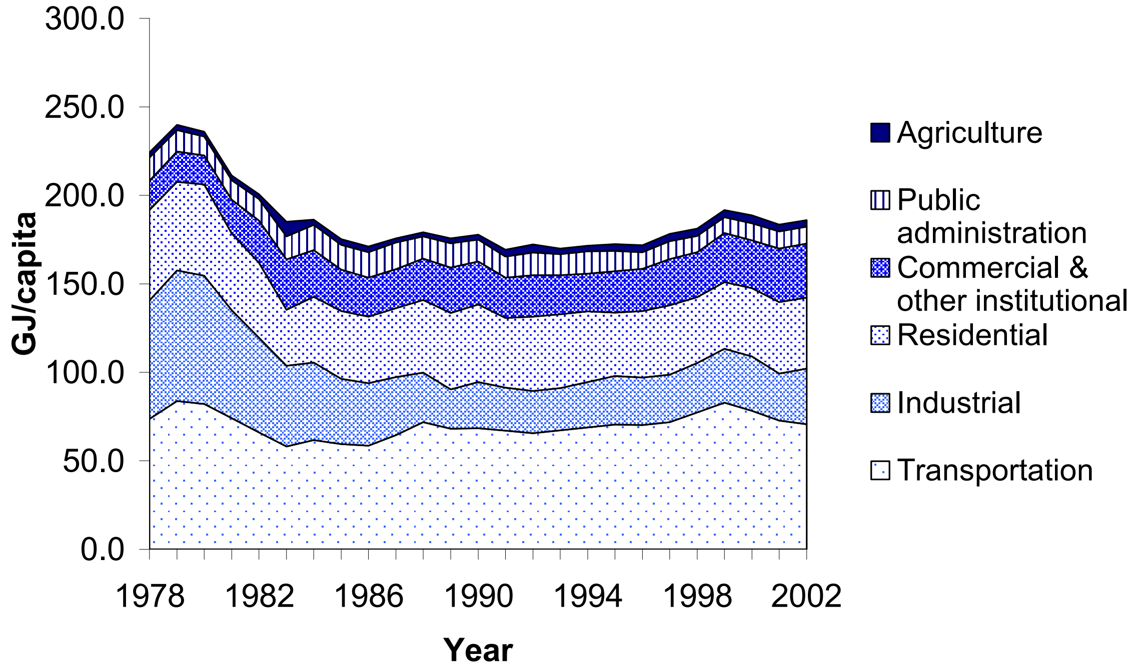
Figure 12. Energy use, final demand, in Nova Scotia, by sector, 1978 to 2002



Source: StatsCan, 2005.

Figure 13 shows Nova Scotia's energy use, final demand *per capita*, by end use, from 1978 to 2002. Including transportation, per capita final demand in Nova Scotia in 2002 was 186 GJ; and 115.2 GJ with transportation excluded. Non-transportation energy use per capita decreased by 35% from its high point in 1979 to a low in 1996. Total final demand decreased 25% from its high point in 1979 to a low point in 1986 with per capita final demand lowest in 1991 at 169 GJ. Per capita demand increased 10% between 1991 and 2002.

Figure 13. Energy use, final demand, in Nova Scotia per capita, by sector, 1978 to 2002



Source: StatsCan, 2005.

Although there is not a dramatic difference between the trends in per capita and total energy growth, the fact that total energy demand has increased by 2 percentage points more than per capita demand between 1991 and 2002 shows the importance of looking at both measures (Table 6). From a sustainability perspective both per capita and total impacts must be addressed. A singular focus on per capita energy use may suggest improving trends while masking worsening trends in energy use because of population increases.

Understanding the exact reasons for the changes in energy use in each sector would require an extensive economic analysis, which is not possible for this study. Furthermore, few efforts have been made to analyze energy in Nova Scotia at all, hence the importance of this report as a starting point. However, by analyzing the information in Figures 12-16 and other statistical data combined with a basic knowledge of recent economic history in Nova Scotia and Canada, some rudimentary interpretation is possible. This has been provided below but explanations cannot be confirmed without further analysis and should be viewed with some caution.

Critical events and other factors that have influenced energy demand over the 25 year period include the oil crises, economic growth rates, fuel switching, conservation and efficiency, and population growth. Nova Scotia, like the Nation as a whole, experienced an economic recession in between 1979 and 1981 after the second oil crisis. This is reflected in a substantial decline in energy use in the early 1980s (StatsCan, 2005b). Improvements in energy efficiency, an economic shift from energy-intensive industries to a larger commercial sector, and a generally slower rate of economic growth than in the previous decade all helped to keep energy demand below 1970s levels even after the economy recovered in the 1980s. Nova Scotia experienced another economic recession in 1990-1991 and very slow economic growth until 1996 (StatsCan, 2005b). The declining industrial energy use over time reflects a fundamental shift away from energy intensive production in the Province, like steel manufacturing, towards less energy intensive businesses like call centres and other service industries. The fact that per capita energy use in all sectors has increased from a low point in the 1980s suggests that once oil prices dropped after the oil shocks of the 1970s, the perceived need for conservation and efficiency also declined.

Using the data from Figure 13, Table 6 shows the calculated change in energy use per capita, by sector, between 1991 and 2002 and between 1978 and 2002. These two periods were chosen because they illustrate how energy demand has decreased over the longer term but has increased in the last 10 years.

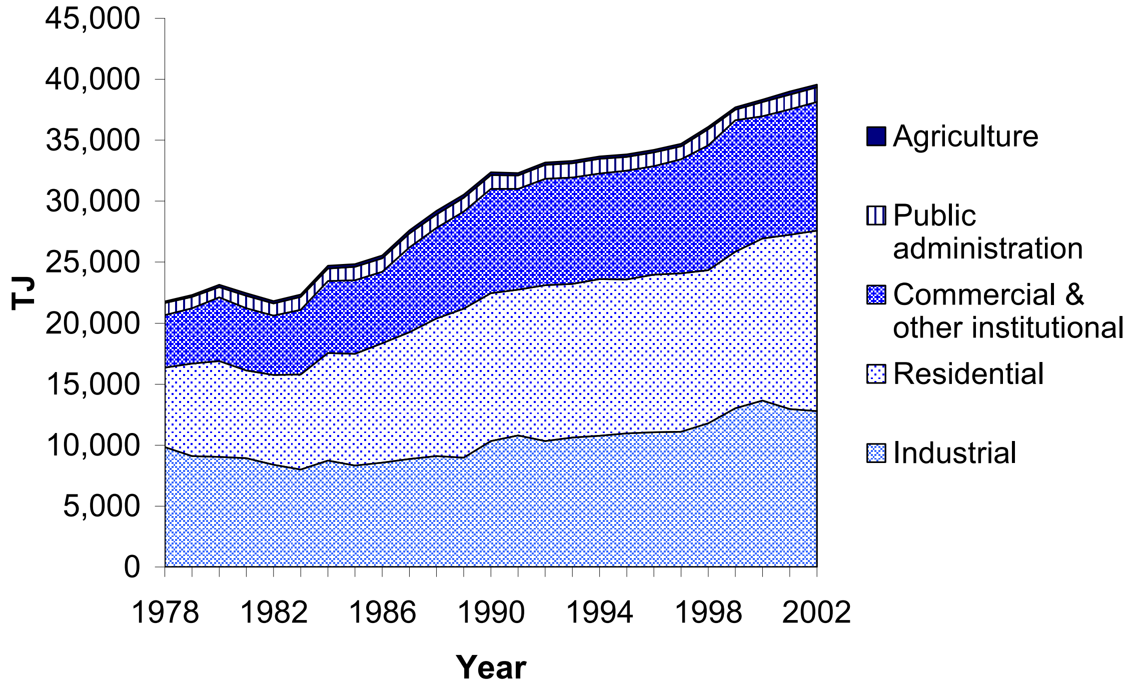
Table 6. Change in energy use per capita in Nova Scotia, by sector

Sector	1991-2002 % Change	1978-2002 % Change
Industry	30	-53
Transportation	5	-4
Agriculture	-8	20
Residential	-1	-22
Public administration	-20	-26
Commercial	35	84
Final demand per capita	10	-17
Final demand (not per capita)	12	-8

The commercial sector is the only one in which per capita energy use has consistently increased over the last quarter century, and it is the only major sector in which energy use, total and per capita, in 2002 was higher than in the late 1970s. Sectoral differences are likely functions of changes in the economic structure more so than indicators of energy efficiency and conservation. Thus, the commercial sector itself has grown substantially, while cuts to public services and government downsizing in the mid-1990s, a major restructuring away from energy-intensive industry in the 1980s and a major reduction in residential energy use and transportation following the second 1970s energy crises most likely explain the declines in per capita energy use in these sectors.

Using Statistics Canada data, it is also possible to analyse the final demand for electricity and refined petroleum products by sector (Figure 14 and Figure 15). These help provide further insight into the energy trends shown in Table 6. Electricity use, which is divided fairly evenly between the residential, industrial and commercial sectors – 37%, 32% and 27% respectively – increased steadily from 1978-2002. Of the major users the increases in electricity usage have been proportionately largest in the commercial sector and smallest in the industrial sector. The increased demand for electricity is a trend seen globally and is caused in large part by a proliferation in the ownership and use of electronics and electrical equipment, especially in the residential, commercial and institutional sectors (Owen, 2000).

Figure 14. Electricity use by sector, Nova Scotia 1978 to 2002

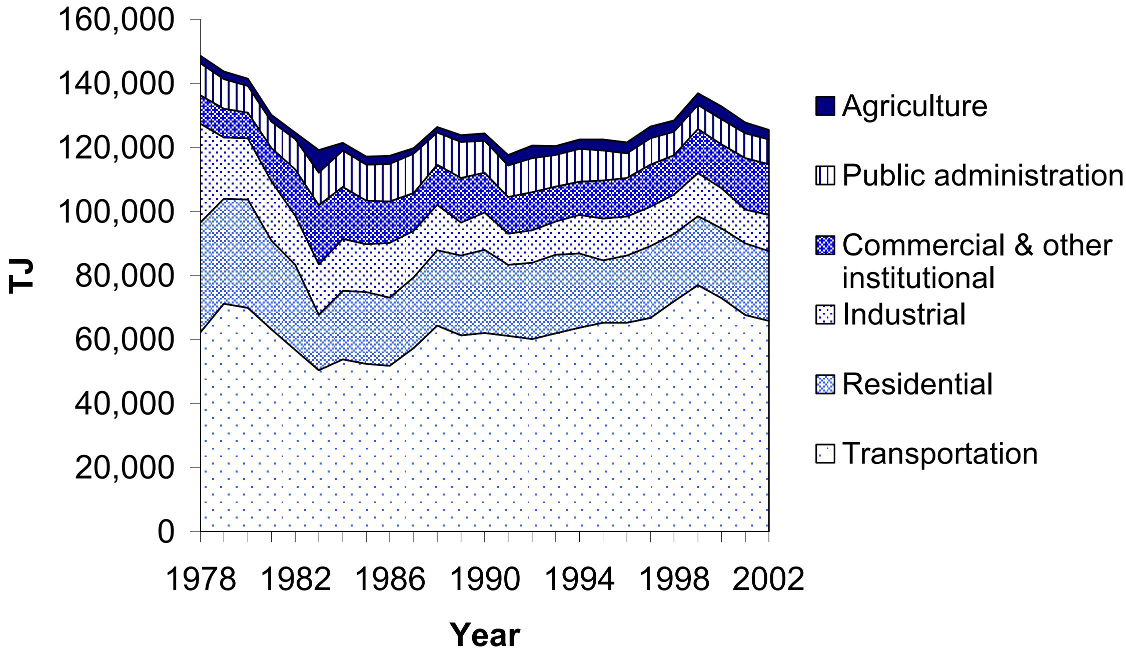


Source: StatsCan, 2005.

The use of petroleum products declined substantially after the second oil crisis in 1979-80 and since then has not increased as rapidly as the use of electricity (Figure 15). The decrease in use of petroleum products is likely due to a combination of three factors: a large improvement in the fuel efficiency of vehicles in the 1980s; the switch from using oil and gasoline to using coal as the dominant fuel for generating electricity in Nova Scotia; and a decreased use by industry and the residential sectors of petroleum products. For both the residential and industrial sectors electricity has obviously become a more important source of energy. Also these sectors may have switched in part to increased reliance on wood for heating needs.

Transportation accounts for about half of refined petroleum product usage in the Province. The expansion in petroleum products use since the 1980s is due mostly to increased transportation and commercial use although overall petroleum use in the Province still remains below the high levels of the late 1970s. Due to the changes in the structure of transportation including the number of vehicles (higher vehicle ownership and increased population); the types of vehicles (more inefficient vehicles such as SUVs); increased commuting and a shift from rail to truck cargo transport, use of petroleum products in transportation exceeds 1978 levels despite fuel efficiency improvements in vehicles since that time (Walker et al, 2005). Largely for the economic reasons noted above, the commercial sector has seen the largest percentage increase in petroleum product use since the late 1970s (Figure 19).

Figure 15. Refined petroleum product use in Nova Scotia, by sector, 1978 to 2002

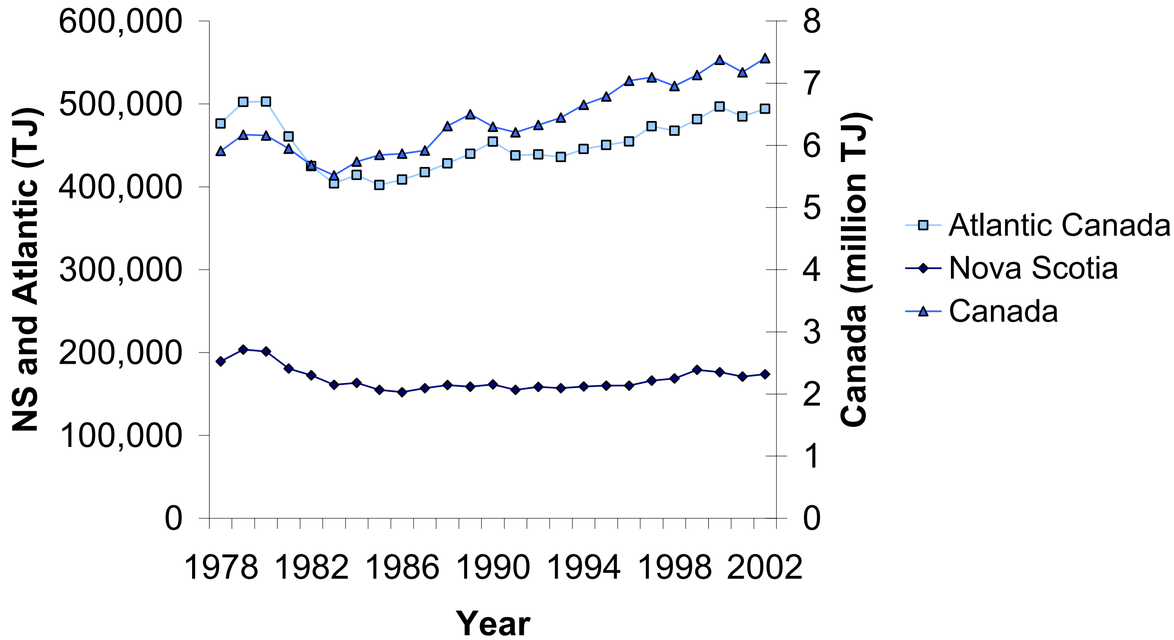


Source: StatsCan, 2005.

Though there have been changes within sectors, Nova Scotia's total final demand for energy remained fairly stable from the mid 1980s through to 2002 increasing gradually but remaining below the highs of the late 1970s (Figure 16). Meanwhile, final demand steadily increased in the rest of Canada since the 1980s and in 2002 was 20% above demand in 1979. Final demand in the Atlantic region has increased less sharply, but demand in 2002 was about equal to the all time peak of 1980.

According to the statistics available it appears that the most important factor explaining the large increase in demand for Canada as a whole is that population grew 44% over the last 25 years in Canada but increased only 13% in the Atlantic Provinces and 17% in Nova Scotia. This larger increase in population levels is also reflected in a higher economic growth rate for Canada than Nova Scotia over the 25 year period (StatsCan, 2005b). Also in the 1980's and 1990's, fuel prices declined in real terms, leading to a decreased emphasis on conservation and alternative energy development which contributed to the increasing energy use across Canada.

Figure 16. Comparison of energy use, final demand, 1978 to 2002



Source: StatsCan, 2005.

In 2002, Nova Scotians used 12% less energy than the rest of the Atlantic Provinces and 21% less than the rest of Canada on a per capita final demand basis (based on per capita final demand by sector or end use). Interestingly, Nova Scotia has seen only a small increase in per capita demand since the early 80s, as is true for Canada overall, whereas the Atlantic Provinces in the aggregate experienced a large increase in per capita demand (though per capita Atlantic demand levels remain below the Canadian average) (See Figure 46 and Figure 47 in Appendix A). The reason for the large increase in per capita energy demand in Atlantic Canada is unclear.

On a per capita basis, Nova Scotia uses on average 186 GJ/person, Atlantic Canada uses 211 GJ/person and Canada uses 236 GJ/person. In all three areas per capita final demand remains below the all time highs of the late 1970s. In 2002, demand, compared to the peak per capita demand for each region was 78% in Nova Scotia, 94% in the Atlantic region and 92% in Canada. The higher per capita use in Canada is attributable almost entirely to higher industrial and commercial energy use (i.e. more economic activity). Nova Scotia continues to have substantially lower per capita use than the rest of the Atlantic region because of lower industrial energy use, indicating either a smaller industrial sector or a less energy intensive energy sector.

An international comparison shows that Canada's total primary per capita energy use is nearly twice as high as the OECD average (Table 7) (USDOE, 2004). Assuming Nova Scotia and Canada experience similar rates of energy loss between total primary energy and final demand energy use, it can then be extrapolated that Nova Scotians use about 352 GJ of primary energy per person (i.e. 22% less than the Canadian per capita average).[32] As such, primary energy use in Nova Scotia is about 50% higher than the OECD average and 20% lower than the Canadian average. The cold climate, long distances, and resource-based industrial activities are often used as explanations for Canada's high energy consumption. But a comparison with Finland and Sweden, which have comparable climates and levels of industrialization, shows that these Scandinavian countries use much less energy than Canada at 248 and 265 GJ/capita respectively compared to 440.6 GJ/capita in Canada.

Table 7. International comparison of primary energy use per capita (gigajoules)

	2000	2001	2002
Canada	442.9	434.2	440.6
Finland	248.0	251.2	249.2
Sweden	264.7	270.8	264.5
Western Europe	235.4	238.0	238.4
OECD Average	225.4	227.2	228.8

Note: Energy values converted based on 1 BTU = 1054.615 J.

Source: USDOE, 2004.

Goals and targets for energy consumption

Final demand for energy has been examined here by end use and by fuel type. The options for a shift in fuel sources were discussed in the previous section. The goal from a sustainability perspective is to reduce demand at the point of use. By curtailing consumption at the point of use all of the upstream energy losses due to conversion, transportation, refining, etc are reduced, similarly all of the negative environmental and social impacts are lowered back through the energy chain. Although the Province's overall energy demand has been relatively stable since the late 1970s, comparison of Nova Scotian energy consumption to countries and regions with similar climates, like Scandinavia for example, indicate that further reductions in demand are possible without decreasing the quality of life.

A recent European Union Green Paper on Energy Efficiency found that the European member states (which already use energy far more efficiently than North Americans) could save at least 20 percent of their present energy consumption for a net savings of 60 billion euros per year, by enacting further energy conservation programs across European society - in homes, commercial buildings, factories, and transport (European Commission Directorate-General for Energy and Transport, 2005). The EU report says the United States could save far more with widespread

[32] This calculation is based on the U.S. Department of Energy figure for Canada of 446 GJ/capita of primary energy consumption. USDOE (2004) provides worldwide figures on primary energy consumption, per capita consumption, and energy consumption per unit of GDP. Compared to NRCan (1999) data for Nova Scotia for 1997 this figure appears high. NRCan figures indicate a per capita total primary energy consumption of about 280 GJ. Also, data from Statistics Canada for 2002 would put Canada per capita total primary energy consumption at 353 GJ. However, the comparison with other countries is likely still valid, as all figures in Table 9 are from the USDOE, and similar methodologies should therefore have been used to create the comparative estimates of primary energy use.

adoption of energy conservation practices since the United States currently wastes approximately 50 percent more energy than the European Union to produce one unit of GDP. Considering energy use in Nova Scotia is more comparable with the U.S. than with Europe it is certain that vaste improvements in energy use are possible, on the order of 50% or more, while maintaining and improving the competiveness of our economy.

In order to move more forthrightly towards a sustainable energy system, the Province should consider setting targets for an absolute reduction in energy end use in the order of 10-15% in the short term, with growing reductions over time in order to meet the current OECD average in the medium term. These targets can realistically be achieved through improved conservation and efficiency that reduce production and running costs and thereby strengthen rather than undermine economic prosperity. The practical ways in which demand can be decreased can be determined through a careful examination of the particular activities and processes that demand energy. The next section will focus on options for energy efficiency and will present more specific goals and targets in that context. The end consequence of greater efficiency should be reduced energy consumption which is one of the key goals of a sustainable energy system.

In talking about energy demand, we cannot only talk about reducing ***aggregate*** or *average* ***per capita*** demand. It must be acknowledged that higher-income households consume considerably more energy than low-income households. For example, the richest 20% of Nova Scotians spend an average of $3,135 a year on energy, while the poorest 20% spend $2,175 (or about 30% less) (see Section 5.7 on Affordability below). In electricity use, the richest 20% spend an average of $1,723 a year, or about 80% more than the poorest 20% who spend just $952 a year. In other words, higher-income groups are responsible for a larger percentage of energy use on a per capita basis and therefore a larger percentage of the damage costs attributable to energy-related pollutant and greenhouse gas emissions than are lower-income groups, and they are correspondingly responsible for a larger proportion of the reduction in demand required for the energy system to become more sustainable. Efforts to reduce energy demand must recognize this fact and take account of equitable access to energy services and proportional responsibility.

5.5 Energy Efficiency

A unit of energy saved is one that never has to be generated in the first place, thus eliminating all possible impacts that accompany energy production and use. Energy efficiency measures the relationship between the level of energy service (output) provided by a device or system and the energy put into it (input). Improving efficiency means that the same level of output is provided with less energy input. This ensures conservation of energy resources and the minimization of wastes and harmful emissions. This is also often the least cost approach to energy management and should be considered before any supply technology is implemented, whether the supply comes from renewable, nuclear, or fossil fuel sources. As pointed out by Lovins and King (2003) "Efficiency and human behaviour have always been a better answer to our energy problems than any new supply" (p.181).

Unfortunately, efficiency and its consequent savings are not properly valued in standard GDP-based accounting methods, which value only the quantity of production and consumption without consideration of their attendant costs. By contrast, the full-cost accounting methods used in the Genuine Progress Index give full value to savings and efficiencies that reduce costs. In measures of progress based on the GDP, "more" is therefore always "better," while the GPI recognizes that "less" can be "better" if it enhances efficiency and thereby reduces costs.

Because of its multiple benefits, energy efficiency addresses all four components of sustainability: environmental, social, economic and institutional, as well as the connections between them. We can reduce our energy expenditures because we require less energy for the same level of service. The pollution resulting from our energy use is lowered, and we can reduce dependence on finite and often imported supplies of energy. Together these benefits will lead to a more competitive economy and result in environmental and health improvements.

Efficiency can be applied at most levels of economic activity: equipment that uses energy, the building envelope, major and minor industrial processes, energy supply, energy delivery and the planning and design of urban forms and infrastructure (MK Jaccard and Associates, 2004). At the national level, Natural Resources Canada has developed several objectives that relate to energy efficiency:

- increasing the efficiency of new and existing buildings, equipment, systems and vehicles;
- persuading individuals and organizations to choose buildings, equipment systems, and vehicles that are more energy efficient;
- ensuring that energy-consuming equipment is used in the most energy-efficient way possible;
- influencing the energy-use practices of individuals and organisations; and
- developing technologies that provide consumers, industry, and communities with new opportunities to improve energy efficiency (NRCan, 2004a).

Using urban forms and infrastructure changes to affect energy demand refers to how we plan our communities. Through building orientation and styles (e.g. passive solar); integrated land use and transportation planning that minimizes the necessity for automobile use and maximizes walking, bicycling and mass transit options; commercial activity locations within easy access of housing; and use of waste energy in district heating systems, we can achieve greater energy efficiencies and reduce demand.

Efficiency vs. conservation

The distinction between energy efficiency and energy conservation needs to be made clear. In both cases the aim is to reduce the amount of energy used. In the case of efficiency, the energy service provided is not altered. Efficiency is usually brought about through technical measures and upgrades to a device or system. This includes, for instance, the replacement of an incandescent light bulb with a compact fluorescent light bulb (CFL). Replacing a 60 Watt incandescent bulb with a 15 Watt CFL will provide the same level of lumens (light quality) but will typically result in a 75% reduction in energy use. In the case of energy conservation, energy is used more conscientiously and the reduction in demand occurs because of behavioural changes. In the case of the light bulb, a conservation measure would be to consistently switch off the light after use. Efficiency and conservation can be combined; in the previous example this would involve consistently switching off a CFL.

The terms *conservation* and *efficiency* are often used interchangeably but are not the same thing and should not be confused (Owen, 2000); nor can they be measured by the same indicator. Because either can lead to significant energy savings they are both important components of a strategy to reduce energy and enhance sustainability. However, the behavioural requirements of conservation are more difficult to control as they depend on individual, business and societal awareness and compliance, whereas efficiency improvements can be built into the appliance or system and thus become automatic. The relationship between conservation and efficiency is very important and the two strategies have acted both to complement and offset each other over the years, especially at the residential level. For instance, despite efficiency improvements in home appliances and automobile fuel efficiency, behavioural factors, such as owning and using more appliances, buying larger vehicles like SUVs, and commuting longer distances have resulted in increased energy use (Owen, 2000).

Indicators of efficiency

To track progress towards energy reduction through the more efficient use of energy is challenging. Two aggregate measures are typically used, but neither fully assesses efficiency improvements or the role of improved efficiency in reducing energy consumption. First, to understand overall consumption trends for a nation or region, end use energy demand must be measured. This is usually tabulated for society as a whole and also broken down by sector (e.g. residential, commercial, industrial, etc.), as described in Section 5.4 above. Tracking total consumption may indicate the combined effects of efficiency and conservation, but provides no distinction between the two, and may also be caused by other factors like an economic downturn or a milder winter. As well, because the effects of conservation are brought about by behavioural changes, conservation is nearly impossible to monitor in isolation (Schipper and Haas, 1997).

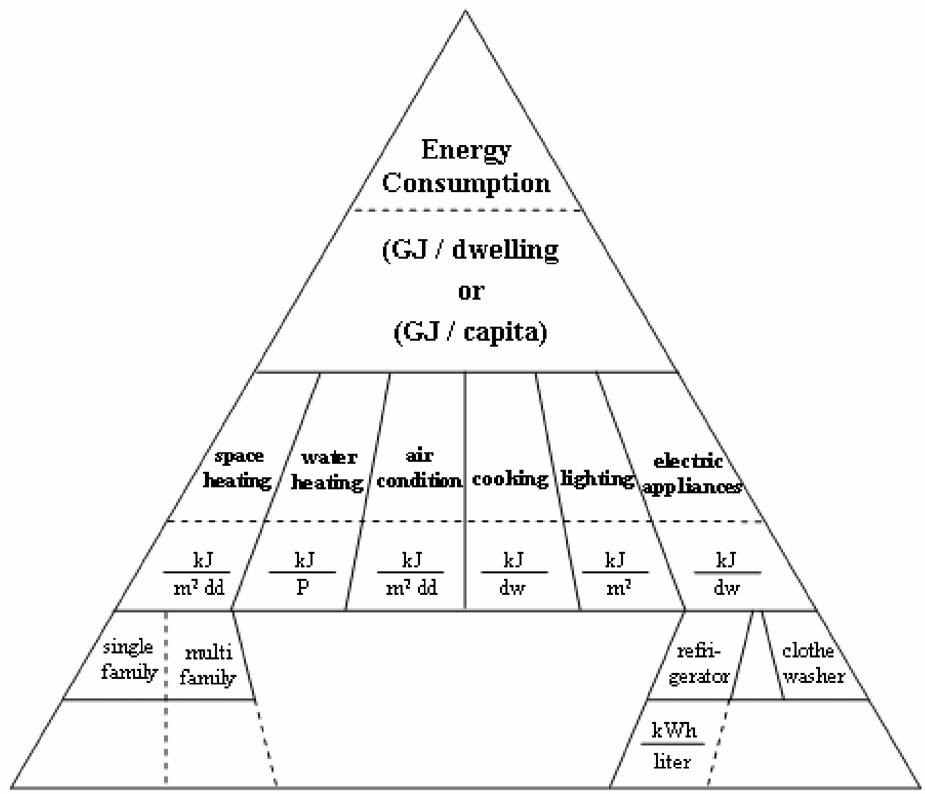
Measuring energy efficiency at an aggregate level can only be done by calculating energy intensity—defined as energy use per unit of activity or output. Although an easy number to generate (done by dividing total energy consumption by GDP or population at the aggregate level—i.e. national or regional), it is not a very meaningful measure since all it tells us is how much energy we are using per person or per unit of economic activity. It is insufficient to explain the reasons for the intensity, including the role of improved efficiencies (Schipper et al, 2001).

Four key factors influence changes in energy use: activity (variations in levels of activity within sectors); structure (shifts towards more or less energy-intensive activities); weather (the annual fluctuations in temperature and precipitation); and energy efficiency (changes in the level of energy consumption of equipment and processes) (NRCan, 2004a). So although energy intensity statistics can tell us if Nova Scotians are more or less energy-intense per person than, for instance, the Japanese, they do not provide insight into why and how that may be. To this end they also provide little guidance as to what action needs to be taken or where efficiency improvements could be made. Some even suggest that energy use per GDP, despite being one of the most common indicators of energy intensity in the world, is essentially a meaningless measure. Schipper et al (2000) argue that “since the denominator [GDP] represents many diverse activities, the ratio cannot really measure efficiency [and because] the numerator aggregates many fuels and stirs electricity into the mix as well, even the notion of 'energy' is confused." Still others assert that energy/GDP is an indicator of economic efficiency rather than energy efficiency (Bosseboeuf et al, 1997).

Despite their limitations, energy intensity statistics (both per capita and per GDP) are currently the principal means of comparing efficiency spatially and temporally. As a result, long-term trend data across many countries and regions are available. For example, comparative statistics on primary energy use per capita for several countries were provided in the previous section (Table 7). Given the reservations about intensity indicators outlined here, **GPI***Atlantic* advocates the inclusion of additional efficiency indicators to assess progress towards sustainability in this area – in particular, measures which track the efficiency and uptake of efficient equipment in use in the economy. These measures are generally referred to as ***disaggregated*** efficiency indicators, because they attempt to pinpoint exactly where efficiencies occur.

A useful way to think about aggregated and disaggregated efficiency indicators is in the pyramid form presented in Figure 17. The pyramid shows energy consumption by end use in the residential sector, but the same model can be applied to other sectors too. At the top of the hierarchy is total energy consumption, followed by energy per capita or, in the case of the residential sector, energy use per household or dwelling. These are the aggregate indicators of overall energy efficiency for the sector. However, to understand the activities and processes that affect the aggregate number, it is necessary to dissect (or "disaggregate") the components that make up the whole. In the case of the residential sector, household energy demand is influenced by dwelling and household size, which in turn affects the need for heating, cooking, lighting, and other energy services usually provided through a variety of appliances. "Once the services for various end uses have been specified, they can be aggregated to form a picture of energy services for the residential sector as a whole. This aggregation takes place by multiplying the population of users by the market penetration of each end use product (dish washers, water heaters, etc.) and multiplying this figure by the fuel share consumed." The intensity of consumption is simply the product of the usage, efficiency and service level (Haas, 1997:793-794).

Figure 17. Residential energy consumption pyramid by end uses



Note: The abbreviations in each disaggregated component are simply the units in which the energy intensity can be measured. For example lighting is measured in kilojoules of energy used per square meter of floor space illuminated. For a full description of all the units see Hass, 1997.

Source: Haas, 1997, p.794.

To capture trends in efficiency at the disaggregated level fully and to track progress at the end use stage, efficiency indicators need to be developed at the component level. For each sector of society—industrial, commercial, residential and so on—individual process and appliance efficiency indicators need to be developed and tracked. Only at this level of disaggregation can we understand how the overall energy demand figures are derived and what has influenced a change in trends over time – including the extent to which efficiency improvements have reduced demand.

In this section suggestions are made for the development of disaggregated energy efficiency indicators for Nova Scotia. Given the vital importance of energy to our wellbeing and prosperity, and the instability and insecurity of our current system, many more such indicators could and should be developed, and tracked over time in order to track progress in this important area. Some of the main indicators for which data are already collected at the National level (and, to a lesser extent, Provincially) are presented here. To understand disaggregated indicators, it is necessary to identify the many ways in which efficiency improvements are possible in the economy. The indicators are presented in the context of these options.

All indicators included in the efficiency section are presented briefly in Table 8 and discussed in more detail below, addressing a rationale for each indicator, and trends for each one (where available). Goals and targets are discussed for the section as whole.

Table 8. Summary of efficiency indicators

Sector	Indicator
Appliances, equipment and other electrical devices	
	• Average efficiency (ratio of energy input per unit of desired output) of individual appliances, office equipment, boilers, etc., available on the market • Average stock efficiency of these items at the residential and commercial levels
Building efficiency	
	• Percentage of homes built to R-2000 housing standards • Percentage of commercial buildings built to Canadian Commercial Buildings Incentive Program (CBIP) standards • Percentage of homes retrofitted under the Energuide for Homes program • Percent reduction in energy use achieved through the Energuide for Homes program
Industrial processes (engines, etc.)	
	• Not available (too many different processes)
Electricity generation and transmission	
Energy transformation and transportation (i.e. transmission and distribution) efficiency	• Average efficiency of electricity production by type of fuel (percentage of fuel energy converted to electricity) • Percentage of electricity (and heat) from combined heat and power plants • Percentage of total energy provided by distributed generation (DG) • Percentage of energy from generating units lost in transmission and distribution
Load management	• Percentage of customers on time of use rates • Percentage of customers with smart meters • Amount of energy savings achieved through load management measures by individual user

Measurements of all the indicators suggested here are not always available for Nova Scotia due to data limitations. Many of these indicators are only tracked at the National level, or the information is confidential, or there have been no activities on which to report (e.g. district heating has not yet been introduced in N.S.). The discussion on trends below - under each of the above headings – represents the best available data on these indicators that could be collected within the scope of this project.

Measuring the effectiveness or total energy savings from an energy efficiency and/or conservation program is difficult or impossible if an accurate baseline does not exist. The baseline allows decision-makers to determine if the improvement would have occurred in the absence of any program, and it helps to avoid counting the same energy savings more than once as can occur when a given result is attributed to multiple government programs (Gillingham et al, 2004). Only with an accurate baseline, therefore, can we measure whether efforts to reduce energy consumption (through efficiency and behavioural change) have been effective. In short, even where trends cannot be assessed, an effort is made below to produce a present-day snapshot, so that these baseline data can be used in the future to construct trends.

Equipment, appliances and electrical devices

Most equipment that uses energy has become more efficient over time. A new refrigerator (2004 model), for instance, uses, on average, about half the electricity of a model produced 10 years ago (Environment Canada, 2005b). Through the *Energy Efficiency Act* the Federal Government sets efficiency standards for a wide range of products and provides consumer information to encourage the use of this equipment.

> [These regulations] incorporate national consensus performance standards that include testing procedures to determine the energy performance of the equipment. They prohibit imports of, or inter-provincial trade in, prescribed products that fail to meet minimum energy-performance levels and labelling requirements (NRCan, 2004a).

The *Energy Efficiency Act* "cover[s] products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial-institutional sector" (NRCan, 2004a). This includes household appliances; office equipment; heating, cooling and ventilation equipment; windows and doors; lighting and signage; commercial and industrial products; and consumer electronics. More than 25 different product categories are subject to efficiency standards in Canada (NRCan, 2005).

The task of tracking the efficiency of individual appliance types and assessing progress towards efficiency targets is also undertaken by the Federal Government with information compiled for the country as a whole. Unfortunately, there are no short-cuts. To understand and track progress towards greater efficiency in this area requires looking separately at developments for each individual appliance and device. The information can then potentially be aggregated to assess overall progress towards greater efficiency in this field. One way to track progress through time is to calculate both the average efficiency of the current stock of an appliance, and the market penetration of the most efficient models. To this end, the following two indicators are suggested:

- Average efficiency (ratio of energy input per unit of desired output) of individual appliances, office equipment, space and water heating boilers, etc., available on the market.
- Average stock efficiency of these items at the residential and commercial levels (e.g. average efficiency of refrigerators in all homes in Nova Scotia).

Together these indicators allow us to understand both the current levels of efficiency that have reached the commercialisation stage and the levels of efficiency that can actually be found in people's homes and businesses. In order to regulate compliance with these standards and negotiate increasing efficiency for various goods, we need to track the present state of efficiency and compile accurate data on a wide range of appliances and equipment. A stock model is further important for understanding the actual age and levels of efficiency of all appliances and devices currently in use in the country. In sum, there are two questions that these indicators attempt to answer – are efficient models available on the market, and are these models being widely used? This information allows us to calculate more accurately the amount of energy that our appliances and devices are currently using in the aggregate, and the impact that switching to more efficient models will have on overall energy consumption. That information is important for designing incentive schemes (like rebates on highly efficient items) in order to promote the use of energy efficient products, and programs to measure their effectiveness in reducing energy consumption and producing cost savings.

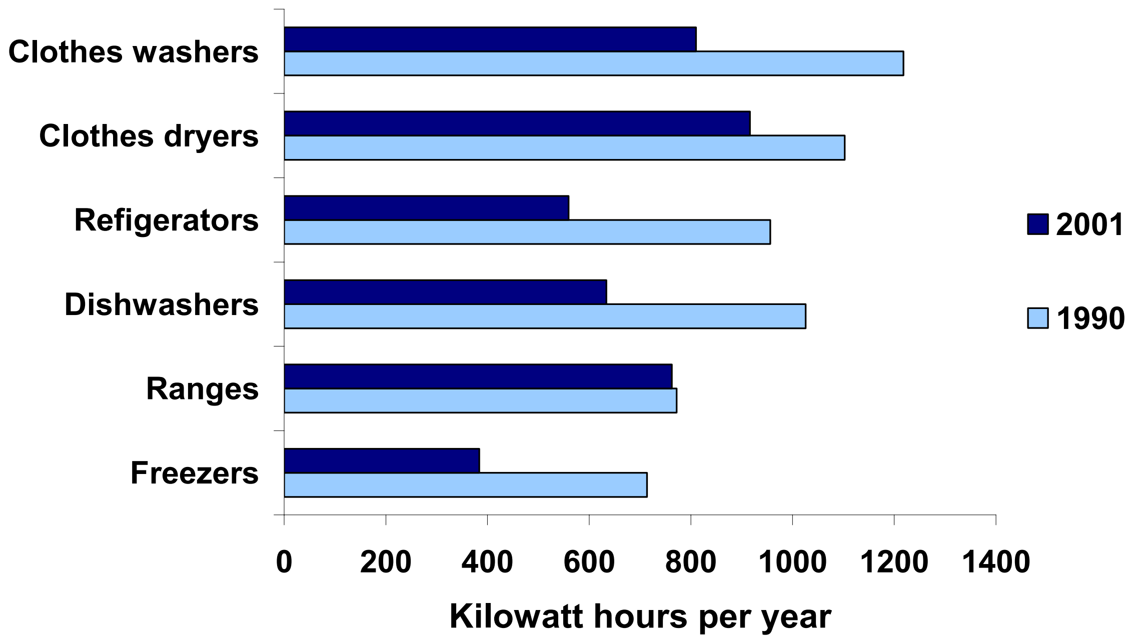
Trends of appliance and equipment efficiency

To assess energy efficiency trends accurately and comprehensively, each type of appliance, office equipment and other device used in this country must be tracked individually. This is a task undertaken for Canada as a whole by the Federal Government's Office of Energy Efficiency (OEE), and does not need to be presented in detail in this report, as the OEE website provides abundant information on the energy efficiency of a wide range of appliances, heating and cooling equipment, electronics, home fixtures, office equipment, and vehicles. [33] Instead, the general national efficiency trends of a few selected appliances are presented here simply to illustrate the energy savings that are possible.

The average energy consumption of new appliances for six product types that were available on the market in 1990 and in 2001 is shown in Figure 18. The improvements in efficiency displayed here are evident for many other appliances as well, including office equipment, space and water heating devices, and more. It is shown that the average consumption of new refrigerators, freezers and dishwashers decreased by 38-46% between 1990 and 2001. Efficiency improvements of clothes dryers and clothes washers have not been quite as significant but progress has also been made (NRCan, 2005a; NRCan 2003).

[33] See http://oee.nrcan.gc.ca/energuide/home.cfm for energy efficiency information on a wide range of appliances, heating and cooling equipment, house fixtures, office equipment, electronics, and vehicles.

Figure 18. Average energy consumption of new appliances in Canada, 1990 and 2001 models



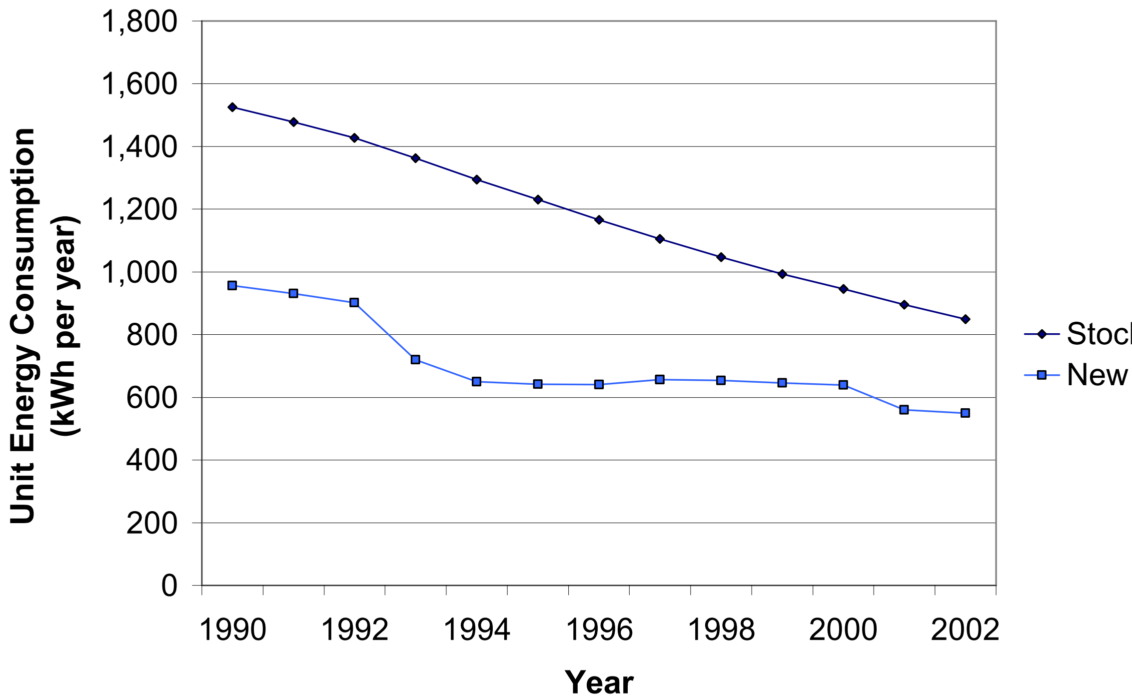
Note: The 2001 value for refrigerators was provided by Trudeau, 2005.

Source: NRCan, 2005a; Trudeau, 2005.

The case of refrigerator efficiency will be used to explore efficiency developments and trends in more detail. Figure 19 shows the average energy efficiency of refrigerators in Canada both for the appliance stock actually present in Canadian homes and for newly manufactured fridges coming on to the market. Trends are tracked from 1990 to 2001. Both the stock and new refrigerators have seen improved energy efficiencies over time. The energy used by the average refrigerator in Canadian homes fell from 1,525 kWh per year in 1990 to 849 kWh per year in 2000, an improvement of more than 44%. A similar decline of over 42% occurred in new refrigerators coming on to the market, falling from 956 kWh per year in 1990 to 550 in 2002. The difference between the stock estimates and the new appliance estimates reflects the fact that homes still retain an inventory of older, less efficient refrigerators that have not yet been retired. The sharply reduced energy consumption of new refrigerators coming on to the market in 2002 (about one-third the stock average 12 years earlier, and one-third less than the 2002 stock average), signifies that the energy consumption of the actual stock of Canadian refrigerators in Canadian homes will continue to decline in coming years as older refrigerators continue to be retired.

Canada is regarded as a world leader in setting energy efficiency standards for refrigerators. A 1999 study conducted by the Australian Federal Government assessed global energy efficiency standards and found that the 2001 standards for the United States were the most stringent in the world in setting minimum energy performance standards for refrigerators (Harrington, 2002). Given that the Mexican and Canadian standards are harmonized with the American standards the results shown in Figure 19 reflect some of the most stringent refrigerator standards in the world (Harrington, 2002).

Figure 19. Energy efficiency of Canadian refrigerators, 1990-2002



Source: Trudeau, 2005.

Appliance efficiency information is available at the National level but is not tracked consistently at the Provincial level. Without this information it is difficult to determine the efficiency of the stock of appliances currently in use in Nova Scotia, to compare it to the Canadian average, or to analyse the effects of or need for policy changes at the Provincial level.

Building efficiency

By incorporating certain measures and techniques in the construction phase, building methods can also produce significant energy savings. These include reducing the embodied energy of materials used in the building and reducing the energy used to heat and light the building by applying better insulation, installing double- or triple-glazed windows, and orienting buildings strategically to capture heat and light from the sun, to name but a few options.

Standards designed to assist the adoption of these measures have been developed at the federal level for both commercial and residential buildings. R-2000 is a technical performance standard for building and certifying new homes to a higher level of energy efficiency than the requirements for energy efficiency and environmental responsibility in current Canadian building codes. It encourages Canadian builders to construct, and Canadian consumers to purchase, more energy-efficient houses that are environmentally friendly and healthy to live in (NRCan, 2004a).

Meeting R-2000 standards results in a 30% reduction in energy use over a conventional new home (NRCan, 2004).

The Federal Government also has a program that operates at the commercial, institutional and multi-unit residential levels to improve the energy efficiency of buildings in these categories. "The Commercial Building Incentive Program (CBIP) provides financial incentives to builders and developers who incorporate energy-efficient features into the design and construction of new commercial, institutional and multi-unit residential buildings" (NRCan, 2005b). To qualify for the incentive, buildings must be at least 25% more energy efficient than similar structures constructed to the Model National Energy Code for Buildings – MNECB (NRCan, 2005b).

LEED—Leadership in Energy and Environmental Design—is another environmental standard towards which commercial and institutional buildings can strive to achieve greater energy efficiency. LEED is a "voluntary, consensus-based national standard for developing high-performance, sustainable buildings" (USGBC, 2005).

Efficiency improvements can also be made to existing buildings through retrofit programs. Among the many measures that can be taken are replacing single paned windows with double or triple glazing and installing more insulation. The Federal Energuide for Homes program aims to improve the efficiency of existing buildings in Canada by helping people pay for energy audits of their homes and subsidizing certain retrofit measures that reduce a building's energy consumption. This is a program developed by the Office of Energy Efficiency at Natural Resources Canada in partnership with the Canadian Mortgage and Housing Corporation. A trained and approved energy auditor conducts an initial inspection of a home to help identify the energy saving options that are available. If changes or retrofits occur, the homeowner can then request a follow-up inspection to assess the improvements (NRCan, 2005c).

To keep track of building efficiency, indicators are needed for both new buildings and retrofits. The following indicators are suggested for measuring building efficiency in Nova Scotia.

Building Efficiency Indicators:

- Percentage of new homes built to R-2000 housing standards.
- Percentage of new commercial buildings built to Canadian Commercial Buildings Incentive Program standards.
- Percentage of homes retrofitted under the Energuide for Homes program.
- Percent reduction in energy use achieved through the Energuide for Homes retrofit program

Trends in the energy-efficiency of buildings

At the Provincial level there is a need for better tracking and public communication of the number and percentage of homes and commercial structures built to R-2000 and CBIP standards. Targets need to be set for increasing their construction and perhaps additional incentives provided to ensure their achievement at the Provincial level. The National and Provincial data that are available demonstrate that efforts to make buildings more energy efficient have been somewhat limited. Since the fiscal year 1982/1983, approximately 11,000 homes in Canada have been certified to the R-2000 standard, of which 1,300 were in Nova Scotia. According to the latest update from Natural Resources Canada's Office of Energy Efficiency (OEE) of the commercial buildings built to CBIP standards in Canada, only 550 have been completed nationally. Of these, 24 are in Nova Scotia (Trudeau, 2005).

Some provincial statistics are also available regarding the Energuide for Homes program. Thus far 158,968 Canadian houses have had an initial evaluation at the national level, with 24,332 (15%) having undergone a follow-up assessment after the retrofit. In Nova Scotia, just 4,173 (1.0%) homes have been evaluated, with only 353 houses (8.5% of those evaluated) receiving the follow-up evaluation after the retrofit representing only 0.0009% of all homes (Trudeau, 2005).[34]

As shown here, the number of houses inspected or meeting the R-2000 standard represents only a very small portion of newly built homes and an even smaller portion of the housing stock in Canada. R-2000 buildings represent less than one-tenth of one percent of Canada's housing stock; the number of homes with an initial Energuide inspection represents just 1.3% of the total; and the number with a follow-up assessment after retrofit represents just 0.2% of the stock.[35] This suggests that there is a need for increased institutional involvement to encourage and support energy-efficient buildings at the federal and Provincial levels.

Industrial processes

Energy efficiency in industry can be understood in terms of both generic energy services and unique processes. The former refer to energy services that are not specific to a particular industry and include the following categories: steam-generation systems (boilers and co-generators); lighting, heating, ventilating and air conditioning (HVAC); and electric motor systems (pumps, fans, compressors and conveyors). Although many energy efficiency improvements have been made in these areas, there is still great potential to bolster the efficiency of all of these generic processes. Speaking collectively about unique processes is far more difficult since these can vary significantly from one industry to the next, depending on the nature of each industry's particular operations. Some industries use great quantities of heat, while others depend on large amounts of electricity to drive massive motors (MK Jaccard and Associates, 2004). Motivated by the cost saving potential, efficiency improvements in the industrial sector have seen far more progress than in the residential and commercial sectors, but there are still more actions that can be taken to improve efficiencies further (MK Jaccard and Associates, 2004).

Given the heterogeneous nature of the demand for energy services at the industrial level, it is very difficult to establish a single indicator to track progress towards greater efficiency in industrial processes, though there are efforts underway to develop a simple aggregate indicator. One approach to the aggregation challenge associated with heterogeneous sectors of the economy is the Composite Indicator Approach (Nanduri et al, 2002). The development of such an indicator is an elaborate process that requires the inclusion of a wide range of sub-sector activities. Elaborating on the methodology for such a proposed indicator is beyond the scope of

[34] The 2001 Census recorded more than 403,819 private dwellings in Nova Scotia (StatsCan, 2002).
[35] The 2001 Census recorded more than 12.5 million residential dwellings in Canada (CMHC, 2004).

this study, so no indicators for energy efficiency in industrial processes in Nova Scotia can be suggested at this time. This is an area that should be revisited in future iterations of this report.

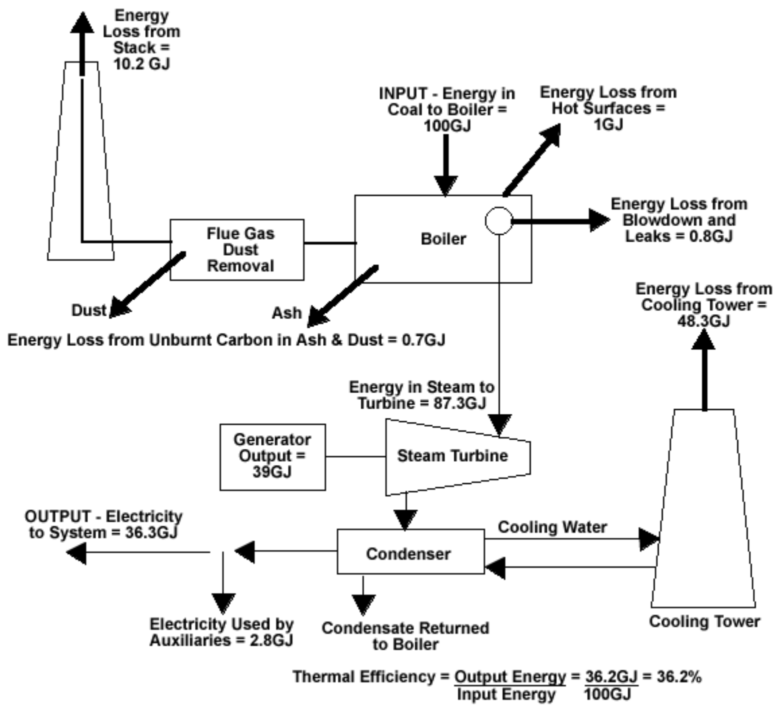
Although a large per capita energy consumer, Nova Scotia has relatively few large industries. Tracking their efficiency is probably best done by measuring the energy intensity of each one and assessing how that intensity has changed over time. Initially indicators will need to be established on an industry-by-industry basis. Given the diversity of this sector and the lack of data presently available, no trends have been tracked at this time, but this is an area that requires attention to ensure that the industries operating in this Province are using energy as efficiently as possible.

Electricity generation and transmission

Electricity is one of the most convenient forms of energy available for human use, but it is also one of the most inefficient energy transformation processes. For every unit of energy that enters a typical thermal power plant, only about 30% is available at the electrical socket in homes and buildings (GoQL, 2005; Ramage, 1997). Depending on what the electricity is used for, the overall efficiency may decrease even further. Most of the energy embodied in the fuel source is lost as waste heat during the transformation process or used for production processes in the generation plant. Just where energy losses occur in a typical power station can be seen in Figure 20.

The energy efficiency of a power station is usually called *thermal efficiency* and may be defined as the electrical energy leaving the station divided by the fuel energy entering the station. It is essentially a measure of the overall fuel conversion efficiency for the electricity generation process (GoQL, 2005).

Figure 20. Energy balance in a typical coal-fired power plant (for an input energy of 100 GJ)



Note: The above diagram and the assessment of losses are based on a single generating unit. In reality, common items in the power station will also use energy and will detract further from the net energy sent out to the transmission grid. This reduction in net available energy further decreases the overall thermal efficiency of the power station beyond what is shown in the diagram above. These common items include the receiving and storing of fuels, water supply and treatment, waste treatment and disposal, operation and maintenance of workshop and administration buildings, and station lighting.

Source: GoQL, 2005.

After the electricity leaves the power station, there are further losses in the transmission and distribution networks as the electricity flows to consumers. Most of the decrement is attributable to the heating of the power lines by the electrical current flowing through them. The heat is then lost to the power lines' surroundings. Losses in the transmission and distribution networks are influenced by a number of factors including: the location of generating plant and load connection points and the energy associated with each; types of connected loads; network configuration; voltage levels and voltage imbalance; length of the lines (which is almost a linear relationship in which doubling the line length would double the line loss); the design of lines, particularly the size, material composition, and type of cables; and the types of transformers and their loadings. The annual, weighted average transmission and distribution loss factors for regions in which electricity is transported over long distances add up to between 4% and 6% of the total electricity that is generated by the power plant (GoQL, 2005).

Inefficiencies in power generation can also result from start-up and shut-down processes because energy is required for these processes. According to the Government of Queensland primer on power stations:

These reductions in available energy are not shown in the diagram. This additional energy usage is normally not considered unless the generating unit has a significant number of start/stop cycles. For generating units which come on line several times a week, this energy can become a significant part of the total energy usage and can reduce the average thermal efficiency of the generating unit. The generating unit and its auxiliary equipment can be optimized in the design stages to reduce, to some extent, the energy used for starting and stopping. Another way of reducing the energy needs in these phases is to reduce the number of stops and starts by controlling the power load (GoQL, 2005).

Some of the losses and inefficiencies described here are inevitable due to physical laws, but there are ways to make energy transformation and transportation (including transmission and distribution) more efficient, and to capture some of the lost heat for useful purposes. The main options available are listed here and discussed in more detail below:

- Improving the efficiency of power plants especially through the use of co-generation (combined heat and power)
- Reducing losses in transmission and distribution especially through the use of distributed generation
- Ensuring better power load management

Improving the efficiency of power plants

Newer generations of power plants can achieve greater efficiency than the average efficiency noted above. The greatest recorded efficiency achieved by a commercially operating coal fired plant has been 45% in a Danish plant. However, this was an exceptional and expensive case, and 37% is a more common and realistic efficiency when normal economic constraints are considered.[36] The latest designs of large combined-cycle gas turbines (CCGTs) achieve some of the highest efficiencies, reaching around 50%. This figure represents the maximum efficiency possible but will be affected by how the plant is operated and maintained, and how frequently it is turned on and off.

Given that the majority of energy lost from a power station is in the form of heat, capturing that heat for useful purposes can improve efficiency significantly. Co-generation plants—also known as combined heat and power (CHP)—produce both electricity and steam for industrial processes and for district heating (i.e. heat for homes and commercial buildings). Rather than allowing the waste heat from the electricity generation process to escape, CHP plants capture this energy for useful purposes. CHP plants can achieve efficiencies approaching 90%, if almost all of the process heat is utilised (GoQL, 2005).[37] The following indicators are suggested for measuring power plant efficiency:

[36] This refers to a supercritical, sea water cooled design in Denmark which achieved its high efficiency because it used exceptionally high steam temperature and pressure with two stages of reheating, and used very cold water for condenser cooling. It was only economically justifiable because of high coal costs.
[37] The overall efficiency of a CHP plant is the sum of the energy generated as electricity and the process heat that is utilized all divided by the energy content of the fuel burned. If one compares only the amount of electricity

- Average efficiency of electricity production plants by type of fuel
- Percentage of electricity (and heat) from combined heat and power plants

A single tracking tool for plant efficiency in the Province – either for thermal electricity generation plants or for CHP – is problematic because of the distinctive nature of individual plants. However, separate measures should be developed of the efficiencies of major energy conversion processes in the Province, along with an assessment of average efficiency when all major plants are considered, and goals for loss reduction in these facilities should be established. Only when the current situation is measured accurately, and a reliable baseline established, can movement towards sustainability be determined in this area.

Reducing losses in transmission and distribution

Nova Scotia has a long transmission system with some power stations located significant distances from major load centres. This network configuration produces higher network losses than a denser configuration of power stations and loads. These network losses can be reduced by augmenting existing lines and through optimal design of new lines (GoQL, 2005). The reason that Nova Scotia's generating system is distributed in this way is that the coal-fired power plants that make up most of the base load were located near the Province's major coal fields (McCoombs, 2005). However, now that coal is imported, this configuration is no longer beneficial from an efficiency perspective. Furthermore it reduces opportunities to modify existing plants for CHP, as the Cape Breton plants are located too far from the residential and industry concentrations in the Halifax metro area that would benefit most from the capture of the waste heat.

Another way to reduce line losses is by locating power generation much closer to the power load, thereby reducing the length of transmission lines. Distributed generation (DG) refers to the use of small-scale power generation technologies (including use of renewables) located close to the load being served. This reduces the loss of energy that results from transmission of energy over long distances. DG is a more flexible approach to electricity generation which can also help improve reliability, reduce emissions, and expand energy options (ISE, 2005). Distributed generation also increases the opportunity for CHP in smaller demand areas. Although centralized power generation is expected to remain the principal form of electrical supply for years to come, DG can complement central power by providing incremental capacity to the utility grid or to an end user. "Installing [DG] at or near the end user can also in some cases benefit the electric utility by avoiding or reducing the cost of transmission and distribution system upgrades" (CEC, 2005). The following indicator is suggested for tracking developments transmission losses and distributed generation:

- Percentage of total energy provided by DG
- Percentage of energy from generating units lost in transmission and distribution

generated a CHP plant is usually less efficient than a power station specifically designed for electricity generation only (GoQL, 2005).

Ensuring better power load management

Load management (LM) programs are generally initiated by electricity utilities to reduce the need to install and run expensive generation plants during peak demand times. These programs can either reduce the load at peak times or shift electricity use to off-peak times. They sometimes require a change in lifestyle or business practice for the customer (i.e. taking conservation measures or changing the timing of energy use). These actions can produce significant reductions in electricity requirements during peak periods and play a major role in delaying the need to add new generation. LM activities can include installation of electrical thermal storage units for residential customers, automated ("smart") metering to allow consumers to better track and regulate their energy usage, and time-of-use rates for large energy consumers. The following indicators could be used to track activities for better LM but may have to be modified according to the load management options made available by the utility to its users:

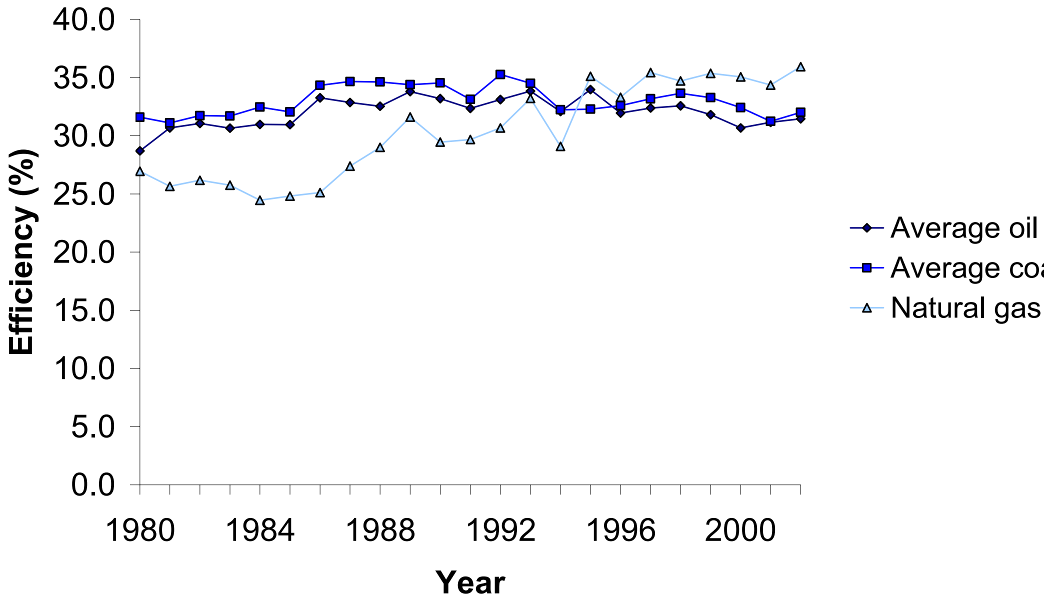
- Percentage of customers on time of use rates
- Percentage of customers with smart meters
- Amount of energy savings achieved through load management measures by individual users (e.g. residential, commercial and large user)

Each of the measures described above can help reduce wasteful energy losses in electricity generation and transmission, thereby reducing the impacts that electricity production has on the environment, society, and economy. These measures should therefore be encouraged for all electricity production in the Province. Currently in Nova Scotia, some actions have been taken in these areas as described in the trends section below. For example, there are several independent co-generation plants in the Province. Indicators should be developed for each of the DM processes pursued in Nova Scotia and progress tracked over time.

Trends in electricity generation and transmission

Data on actual operating thermal efficiency for Nova Scotia Power are not publicly available nor do there appear to be data for optimal efficiency ratings for NSPI's five thermal plants. Rough estimates for thermal efficiency in NSPI generating plants are 35-37% optimal efficiency for its base coal-fired plants (McCoombs, 2005). Figure 21 shows the average optimal thermal-electric power efficiency by fuel type across Canada. Efficiency trends for oil and coal combustion have shown no real improvement over time. Only natural gas conversion, which has benefited from CCGT technology, has shown any improvement over a 20-year period.

Figure 21. Efficiency of thermal-electric power stations in Canada, by fuel type, 1980 to 2002



Source: StatsCan, 2004a.

Records of NSPI transmission and distribution losses are equally scarce. Emera's annual report for 2003 states that the transmission system was 97.1% efficient. However, further losses also occur in the distribution system. It is estimated that 3% of energy is lost in the high voltage transmission system, and an additional 4% is lost in the local distribution systems (McCoombs, 2005).

According to the co-generation database of the Canadian Industrial Energy Efficiency Data and Analysis Centre (CIEEDAC, 2004), there are eight co-generation facilities in Nova Scotia.[38] The inception dates for these projects range from 1960 to 1998. Brooklyn Power and Taylor Lumber, which both use biomass as fuel, are the only co-generation facilities currently producing heat and selling electricity to the grid (Hayes, 2005). Comeau Lumber, which has a biomass co-generation plant, uses the electricity to reduce its own requirements from the grid (McCoombs, 2005). The exact status of the other facilities listed by CIEEDAC is not clear. It does appear that Stora Forest Industries (pulp and paper mill in Port Hawkesbury), the Canadian Salt Company (in Pugwash), and the Minas Basin pulp and paper mill are actively co-generating heat and electricity. There is renewed interest in looking at NSPI's Tufts Cove power plant for potential co-generation in Dartmouth and Halifax (Hayes, 2005). The Halifax Regional Municipality is also exploring options with several partners for the development of CHP in downtown Halifax (O'Toole, 2005a). Data is not available to determine the percent of electricity generated in Nova Scotia from co-generation plants. The largest of the co-generation facilities is Brooklyn Power at a name plate capacity of 30MW of electricity. This represents between 1 and 2% of the generation capacity in the Province.

[38] The database is at http://www.cieedac.sfu.ca/CIEEDACweb/mod.php?mod=cogeneration.

There are only a few distributed generation facilities operating in the Province. These include the CHP plants mentioned above that produce power for their own needs. In addition to the few industrial sites that produce their own power there are also several households around the Province that produce power for their own needs. This includes a few off-grid households that serve as primary residences and a larger number of cottage systems. There is limited activity and very little information on DG in the Province and not enough data to operationalise the indicator.

Load management at Nova Scotia Power has focussed on two approaches: *interruptible load* and *demand time switching*. NSPI has two tiers of interruptible industrial customers who pay a lower rate but can be requested to lower their demand on 10 minutes' notice. The first tier is the large industrial interruptible rate. This group currently has only two customers: StoraEnso and Bowater pulp and paper mills: They represent a total power demand of 250 MW. They can be put off-grid for either economic (fuel cost reasons) or peak demand problems. The other rate is the regular industrial interruptible rate, which currently includes another 150 MW of demand that can be shut off only when capacity problems occur (McCoombs, 2005). Because demand fluctuates daily and seasonally it is not possible to specify the exact portion of demand that these 400 MW represent. However, based on NSPI's all-time peak demand of 2,238 MW in January, 2004 this 400 MW is 18% of demand although it represents a higher percentage of annual average demand.

NSPI has pursued various options for switching load from peak to off-peak periods – "demand time switching." Efforts in the last few years have resulted in 3,000 customers switching to 'Time of Use' residential, commercial and industrial rates (Emera, 2004).[39] Since 2000, this has resulted in 50 MW of demand being moved from peak to non-peak times (about 2% of demand based on all-time peak of 2,238 MW). In the Utility and Review Board rate case hearings of 2004, NSPI indicated plans to pursue another 75 MW of peak time switching by 2010 (McCoombs, 2005).

Goals and targets for greater energy efficiency

A reduction in energy use can be achieved at many levels. Energy efficiency is an aggregate measure of society's use of energy. Goals and targets can be set at this level that aim to minimize overall energy consumption (in other words, to use energy as efficiently as possible at the societal level). In Nova Scotia this may mean setting a per capita energy consumption target 20% below current levels in the short term (10 years), and then aiming for a 50%—or larger—reduction target in the medium to long term (20 to 50 years). The technical capacity exists to achieve these levels of efficiency, as experience in other countries has already shown. However, aggregate targets such as these are hard to achieve and essentially meaningless unless activities at the disaggregated level are also measured in order to indicate precisely ***how*** the aggregate target is to be achieved. Ideally, targets are set and monitored at the disaggregated level for each of the indicators identified. Some targets and actions are described for each of the efficiency areas discussed above.

[39] Time of Use rates provide differential pricing based on the time period the electricity is used. Typically prices are lowest from late evening to early morning when demand on the grid is lowest. This encourages individuals and businesses to use less energy during peak periods.

Appliances, office equipment and other electrical devices

Efficiency standards for new appliances and equipment in Canada are high in many cases. In order to maximize the benefits of these efficiency improvements, old and inefficient equipment must be replaced with newer machines. Active encouragement of replacement may require more than just an information campaign. Appliance efficiency rebate programs and other incentives to encourage the replacement of old, energy-hungry equipment are common policy in many parts of the world, including some Canadian provinces and help make the transition affordable for householders and businesses.

The potential for more far-reaching rebate and incentive programs should be explored jointly by the Provincial and Federal Governments so as to speed the uptake of more efficient equipment in Nova Scotia and the rest of Canada. One example of such a program currently in operation is the rebate on natural gas furnaces rated by Energy Star.[40] This program, of course, only applies to consumers who have access to natural gas, which in Nova Scotia is only about 400 residential and commercial customers to date. Due to the very large numbers of appliances and devices to which such rebate and incentive policies could apply, no single goal or standard can be recommended. But it is suggested that this area be given more attention and investigated further.

Building efficiency

Homes in Nova Scotia also need to be built to higher efficiency standards, and more emphasis must be placed on capturing passive solar heat to reduce heating and lighting costs. Goals should include increasing the number of homes built to R-2000 (and higher) standards, and increasing the number of commercial buildings meeting the energy thresholds outlined in the Canadian CBIP. LEED certification should also be encouraged and eventually made mandatory for all new commercial and institutional buildings in the Province. Although many of these standards are set Nationally, they need to be encouraged and supported at the Provincial level if significant progress is to be made.

Electricity generation and transmission

There are several actions that can be taken in this area, depending on whether the focus is on improving efficiency at the generation plant level, reducing line losses, or making the whole electricity system more efficient. Further efforts should be made towards improving and maintaining the efficiency of all existing thermal power stations in the Province, and new plants should be required to be built as co-generation facilities to allow use of the waste heat. Transmission and distribution losses should be addressed through the encouragement of distributed generation (DG). More research is needed to set specific targets for all of these undertakings which together represent important actions that can significantly improve the sustainability of Nova Scotia's energy system.

[40] Energy Star is a U.S. government-backed program that sets standards, tests, and labels business and residential devices for superior energy efficiency.

5.6 Employment

Meaningful and gainful employment is an important indicator of social wellbeing, household stability, and economic development, all of which are important considerations for sustainability. Paid work fulfills an important role in both social and economic wellbeing by not only providing households with income to meet their basic needs, but also expanding individual options and lifestyle choices. As noted in the GPI report on working time and employment, substantial research has indicated that paid work is also important for the social contact, sense of self-worth, and satisfaction it can give individuals (Pannozzo and Colman 2004). The types of jobs that people can find at given skill levels, the stability of those jobs, the work conditions, and the pay received are all important considerations in assessing the ***quality*** of employment. Ideally, work should be not only materially rewarding but contribute to other non-material aspects of wellbeing. Consequently, job creation and retention, including government policies aimed at attracting new businesses and providing support and training to prepare people for the labour market, should focus on the quality of employment as much as on its quantity, and on the types of jobs created as well as their number.

Unfortunately most conventional employment statistics are strictly quantitative, so the GPI working time report introduces a number of indicators designed to assess quality of employment (Pannozzo and Colman 2004). Data limitations, as indicated below, as well as time and resource constraints, did not permit a full application of the GPI employment indicators to the energy sector, and only a very limited assessment of energy-related employment factors can be included here. Future updates of this report may expand on this section.

Data limitations

The total number of people employed in the energy sector is difficult to ascertain for two reasons: 1) the way in which labour statistics are reported, and 2) the difficulty in identifying the indirect jobs that are created by the energy sector.

Relying only on the information that Statistics Canada makes publicly available, it is impossible to distinguish between types of energy employment within larger, aggregated categories. For instance, jobs related to oil and gas exploration are reported together with jobs in mining, forestry and fishing under the heading "resource extraction jobs." Similarly for the category "utilities," there is no way to distinguish between jobs in electricity utilities and those in water utilities for instance. Furthermore, employment related to the retail distribution of gasoline is considered a part of general retail employment (Newcomb, 2005).

The employment data provided by Statistics Canada are also complicated by the fact that in some provinces there are only one or two major firms operating within a specific energy industry. Due to confidentiality issues that do not allow release of information on particular companies, Statistics Canada is therefore not permitted to disclose specific figures on energy sector employment in Nova Scotia (Newcomb, 2005). This is an issue that affects smaller provinces in Canada, and is not specific to the energy sector. This problem is exacerbated by the growing number of mergers and acquisitions that are occurring in a wide range of industries, including the oil and gas sector, which further limit the data released by Statistics Canada in order to protect those companies.

Other major problems with the data are the difficulty in distinguishing between direct and indirect jobs related to the oil and gas industry, and the lack of information on the duration of these jobs. This is problematic because many service jobs that supply the energy industry are not necessarily counted as energy-related jobs. This creates difficulties in tracking job creation specific to the energy sector (Newcomb, 2005). This, in addition to the other more general data issues listed above, have severely limited **GPI***Atlantic*'s ability to establish a reliable total for energy sector employment in Nova Scotia. Accordingly, **GPI***Atlantic* has supplemented the Statistics Canada data with information in corporate annual reports and other sources to create at least a rough estimate for energy sector employment. It is important to work towards overcoming some of the current shortcomings in the data and to collect and monitor this information, since the kind of energy system we have can affect the types and duration of jobs created.

Indicators for employment

Employment is included as an indicator in the energy accounts because the energy sector can be a significant potential area of job creation, but can also produce job losses under certain circumstances. The key conventional employment indicators used at the societal level are, of course, employment and unemployment rates. The interest in this study is in jobs created from or through the energy sector, as well as in livelihoods lost as a result of energy sector activities. Qualitative issues are also important in the energy sector, as, for example, some jobs may be associated with adverse health and environmental impacts. It is therefore difficult to determine a single indicator that captures all key employment-related concerns.

One possible approach to assessing basic employment figures in the energy sector would be to include two indicators - one that estimates (to the extent possible) the number of jobs in the energy sector, and the other that measures the number of jobs lost due to energy-related activities. But, as noted above, the issue with employment is not only limited to the ***number*** of jobs (quantitative assessment) but also the ***types*** of occupations and the matching of skills with job functions (qualitative assessment). As a result, identifying a single composite indicator for employment concerns in the energy sector is impossible. In order to understand the employment impact of the energy sector in Nova Scotia, much better tracking of trends is required than presently exists. As a very simple starting point in this endeavour, the following two indicators are suggested for this report, though the limitations of both indicators must be emphasized, and a further breakdown of each indicator over time is eventually needed.

Suggested energy-sector employment indicators:

- Number of person months employed on energy-related tasks (e.g. oil and gas, electric utility, oil refining, oil delivery and service), by industry, (direct and indirect employment).
- Number of person months lost due to energy industry accidents.

Direct and indirect energy-related jobs could be a sub-set of both these indicators, although these currently need to be compiled and extrapolated from various sources, as explained below. Other important indicators for tracking progress in this area, which could potentially provide information on job ***quality***, would be energy-job duration and occupation/skills matching, but there are currently no specific data available for these variables.

Trends in energy-related jobs in Nova Scotia

The importance of jobs in Nova Scotia's energy sector is particularly evident in the attention currently being given to employment in the oil and gas industry. Companies bidding for drilling rights off Nova Scotia's shores must provide initial and successive benefit reports to the Canada Nova Scotia Offshore Petroleum Board (CNSOPB). Among other things, these filings show the number of jobs each project creates. Reporting must be provided for three categories: jobs for Nova Scotians; for other Canadians; and for foreigners (CNSOPB, 2003).

Other new energy industries also hold promise of job creation. For instance, the construction of liquid natural gas (LNG) terminals—one is currently planned for Bear Head, Richmond County—is often promoted on the basis of potential job creation, among other criteria (NSDEL, 2004). Other major energy sector employers in Nova Scotia include the electricity utility (Nova Scotia Power) and its suppliers, the oil refinery, heating fuel companies, and those sub-sectors that provide regular service and maintenance of energy infrastructure.

When considering employment in the energy industry, it is common to think only about actual and potential job creation in this sector. However, energy activities, or the consequences of these activities, can also result in losses of livelihood. Coastal communities are particularly vulnerable to offshore energy activities. Oil spills, for example, can have significant short and long-term impacts on the livelihood of fishing communities. For example, the *Prestige* oil tanker spill off the coast of Spain in 2003 resulted in the closure of local fisheries for four months (WWF, 2003). The spill and fishery closure occurred in an area considered to be the main fishing region in Europe—one that is responsible for 40% of the total Spanish catch (Negro & Garcia, 2002). While such catastrophic environmental, economic, and employment impacts have not yet afflicted Nova Scotian coastal communities as a result of energy-related activities, their potential must be considered in any full benefit-cost analysis.

Measuring employment trends in the energy sector is a difficult task given the data and definition problems noted above. As a result the numbers presented here are not always as comprehensive as is desirable. Nonetheless, they do represent the best available data that could be gathered in the circumstances and within the scope of this project. The unclear distinction between some sub-sectors prevents a clear overview, but certain general trends can still be discerned. The most important issue raised here is in fact the delineation of the information gaps that currently exist due to reporting protocols or lack of data collection. In order to track the extent to which our energy system is contributing to employment (or job loss), better record keeping is essential, recognizing that some of the limitations highlighted here may only be resolved in the medium to long term.

Job creation and losses

Some energy industries, especially those connected with the boom and bust tendencies of mineral exploration, lead to front-end job creation, but much less long-term employment. In such cases many jobs may be created at the start of a project, during the construction, for example, of a drilling platform or in the laying of pipelines. This was the case during the development phase of the Sable Offshore Energy Project (SOEP). According to a study conducted for Nova Scotia's Department of Energy, it was estimated that 14,460 person years of direct and indirect work were created during the development phase of SOEP (1999-2000). However, during the 1999-2000 production period (no later data was included in the study) only 1,670 person years of direct and indirect employment were created in the two year production period assessed (Table 9) (Gardner-Pinfold, 2002).

Other industries, such as the electricity sector, with several generation plants and a vast distribution system to maintain over time, tend to have a more stable job profile. Some employment fluctuations may occur during the construction or refurbishment of a new generation plant, but these do not significantly affect the overall profile. Jobs in energy-related manufacturing and production, as well as in sectors where regular maintenance and service of energy-related facilities and equipment are required, also tend to be more stable. The discussion here is based on periods of economic robustness and may not apply to periods of general recession, or when individual enterprises experience financial difficulties, when substantial layoffs can occur.

Oil and gas

Data for this sector are incomplete because public records are only available for direct employment in offshore operations. According to the CNSOPB, oil and gas related activities that take place on shore are not included in the Board's annual update of industry benefits. One study, covering the period 1991-2000, does provide some statistical separation of direct and spin-off jobs for Nova Scotia's offshore oil and gas industry (Table 9).

Table 9. Estimated employment in Nova Scotia's offshore oil and gas industry, 1991 to 2000 (in person years)

Offshore activities			Direct	Spin-off	Total
Cohassett-Panuke*	All activities	1991-1999	1,080	2,000	3,080
SOEP (Tier 1)	Development	1997-2000	3,440	11,020	14,460
	Production	1999-2000**	310	1,360	1,670

*This is a completed project and so the numbers given are the total for the duration of the project.
**Production in some wells overlapped with development of others, hence the overlap of these two activities.

Source: Gardner-Pinfold, 2002.

The oil and gas industry's employment impact on Nova Scotia is not well documented, yet many believe the Province has benefited greatly from the industry. The Greater Halifax Partnership, in association with the Halifax Chamber of Commerce and NovaKnowledge, suggested that approximately 40,000 people in Nova Scotia obtain at least part of their household income from the oil and gas sector (reported in Landon & Pannozzo, 2001, page 108). A study by the Conference Board of Canada (2002) evaluated the economic impact of offshore developments in Nova Scotia. The paper considered three scenarios based on differing estimates of the available natural gas reserves. One scenario, based on what was deemed a modest estimate of reserves, projected that the Provincial unemployment rate would drop to a low of 4.5 per cent by 2020 due to oil and gas exploration and production. This would drop Nova Scotia's unemployment rate below that of all Canadian Provinces other than Alberta (Conference Board of Canada, 2002). More recent estimates indicate that the actual amount of natural gas is much lower than suggested in any scenario in this study, and that the Conference Board's employment projections therefore require quite drastic revision.

The oil and gas industry can potentially have negative effects on other employment sectors of Nova Scotia's economy, such as the fishery (Landon and Pannozzo, 2001). Offshore oil and gas development can:

- directly affect fish habitat through exploratory seismic testing;
- cause physical disruption of marine habitat due to drilling sediment and increased marine traffic; and
- lead to potentially damaging industrial accidents during drilling and general operation (It was already noted in Chapter 3 that industrial accidents can be a cause of job loss).

In sum, it is possible that activities which generate jobs in the oil and gas sector can potentially be detrimental to employment opportunities in the fishing and tourism industries. In considering energy industry employment impacts, it is therefore important to be aware of the trade-offs that may occur in other sectors of the economy. Better tracking of jobs created and lost due to activity in the energy sector is therefore necessary to understand whether developments in the industry are moving us closer to or further away from sustainability.

Energy-related Mining

The number of jobs in the energy-related mining sector in Nova Scotia has declined significantly in recent years. Table 10 illustrates this decrease, presenting 1999-2002 employment figures for the Province's coal mining industry. This dramatic decline was caused by the closure of the Phalen mine in 1999, and the closure of the Prince mine in 2001.

Table 10. Nova Scotia mining employment, 1999 to 2002

	1999	2000	2001	2002
Coal Mining Jobs	1,010	625	588	68

Source: NSDNR, 2004.

Although the operations are fairly small, there were four active surface coal mines and a coal recovery project operating in Nova Scotia in 2002.[41] The number of coal mining jobs could grow as a result of new developments, such as the possible reopening of the Donkin coal fields in Cape Breton (CBC, 2004). Whether this kind of job creation is desirable from an environmental and health perspective is open to debate and illustrates the difficulty of using employment as an indicator of energy sustainability. Mining is a dangerous activity with serious consequences for human health and the environment (see Risk of Accidents in Section 3.2 and Section 3.3 Environmental Impacts). For these reasons, job creation in the mining sector cannot simple-mindedly be counted as a contribution to wellbeing and sustainability unless its consequences are also considered and factored into the equation.

Electricity

The electricity sector has a more stable level of employment, as shown in Table 11, than either the oil and gas industry or the mining sector. The figures used in the table were taken from Emera's *2004 Annual Financial Report*. These numbers can be considered roughly representative of the electricity industry as a whole in the Province, as Nova Scotia Power, Emera's subsidiary, is the only electric utility company operating in the Province. However, as noted above, some small suppliers do provide electricity to the grid from sources like biomass and wind power, and these jobs are not included in Table 11. The jobs total listed also includes energy-related employment outside the electricity sector, as Emera's satellite firms are involved in pipeline projects as well as the operation of a fuel oil company in Nova Scotia. While most jobs presented in Table 11 are in Nova Scotia, a portion of these are also outside the Province since Emera owns and operates smaller facilities in other jurisdictions, most notably Bangor Hydro-Electric in Maine.

Table 11. Estimate of Nova Scotia electricity employment, 2000-2004, based on total Emera employment figures

	2000	2001	2002	2003	2004
Emera Jobs	2,134	2,666	2,476	2,359	2,249

Source: Emera, 2005.

Emera also reports the number of safety incidents that have occurred each year at Nova Scotia Power. Although these numbers only reflect a small portion of energy-related accidents in the Province, as they represent only the electricity sector, they do highlight some of the employment risks that inhere in the energy industry. There were 16 reportable safety incidents at Nova Scotia Power in 2004 and 25 in 2003 (Emera, 2005a).

[41] A coal recovery project involves returning to a former coal mine and extracting additional coal either from the mine or from waste materials. In Nova Scotia coal recovery often takes the form of open pit mining. While open pit mining has environmental impacts, a potential benefit of this process is that land that has become unusable due to subsidence and other physical dangers can be rehabilitated if the work is done properly.

Oil refining

The Imperial Oil refinery in Dartmouth also provides jobs to Nova Scotians. This is the only refinery operating in the Province and employs some 200 people (Imperial Oil, 2004a). The refinery distributes more than 50 refined petroleum products in Atlantic Canada and eastern Quebec through a network of agents and distributors.

The numbers presented here for Emera and Imperial Oil only represent a small portion of energy-related employment in Nova Scotia. There are likely a significant number of spin-off jobs that are not reflected in these estimates. A higher number would also result if statistics were available in their entirety for the home heating, fuel distribution, and fuel wood industries. The inclusion of employment generated from these industries, along with their indirect spin-off jobs, would substantially increase the total. Any further work in this field should consider the inadequacies of the data presented above and seek to improve data collection so that it is eventually possible to derive accurate aggregate employment estimates for the energy industry as a whole.

Employment in energy efficiency and renewable energy

It is important to recognise that employment is not created only through energy production, but also through energy conservation activities. As well, it is necessary to compare existing employment in the energy field (largely reliant on oil and coal in Nova Scotia) with potential employment in renewable energy enterprises. It has been shown in numerous studies that the renewable energy and energy efficiency sectors generate more jobs than the fossil fuel-based energy sector per unit of energy delivered (i.e., per average megawatt) (Kammen et al, 2004; U.S. PIRG, 2004). It has also been found that "the employment rate in fossil fuel-related industries has been declining steadily for reasons that have little to do with environmental regulation" (Kammen et al, 2004:4).

Although there has been no comprehensive assessment of the employment potential for these activities in Nova Scotia, studies in other regions highlight some of the possible employment advantages to pursuing a sustainable energy strategy. A recent report prepared by the Apollo Alliance in the United States calculated that "energy efficiency is far more labour intensive than generation, creating 21.5 jobs for every $1 million invested, compared to 11.5 jobs for new natural gas generation" (Apollo Alliance, 2004:8). The employment benefits of pursuing renewable energy are even greater: "four times as many jobs are created [with renewable energy] per megawatt of installed capacity as natural gas and 40% more jobs per dollar invested than coal" (*ibid*). These industries create jobs in the manufacturing, building and construction trades, in installation and in maintenance and operation. Maximising on this potential depends on the level of activity and support for these industries but the benefits for employment and skills development could be substantial.

Given these findings it is essential to place the discussion on employment in a larger context: What employment could a new sustainable energy strategy generate? And might those employment numbers exceed those in the present centralised fossil fuel dependent system to which we are now accustomed? A thorough investigation of that potential for Nova Scotia is needed before these questions can be answered but results in other areas suggest this could be a worthwhile investigation.

Goals and targets

Unlike other indicators, the trends in this section do not allow a comparison with other regions or countries because there are significant variations in the numbers of people employed in different sectors of the energy industry, and because current data availability does not provide adequate information for aggregate comparisons. The types of energy-related resources available, variations in population and population density, and differences in commercial and industrial activity all affect the number and types of energy-related jobs that exist in different jurisdictions. As a result such aggregate comparisons may be quite meaningless even if data allowed their compilation. It is more important to consider how the energy-related jobs that are created within a jurisdiction compare with other industrial sectors in terms of numbers of jobs created or lost; wages earned; skills required; and the match between skills and jobs. Since not all the data in these areas are currently tracked in a systematic way, the first step is to improve monitoring and reporting protocols.

The overarching goal of achieving sustainability requires the creation of long-term, stable, and decently paid employment opportunities that match the skills in the Province (so that the jobs are given to Nova Scotians), and a reduction in occupations that are detrimental to human health and the environment. It is also important that – to the extent possible – work is available in the areas in which people seeking employment live, in order to prevent excessive disruption of communities. The type of energy system we have can influence these factors. For example, an efficient, decentralized system with reliance on small-scale distributed renewable generation is more likely to spread long-term stable employment among many communities in a diversified mix of jobs than larger, more centralized operations like an offshore oil project or the construction of an LNG facility that may produce a more temporary, localized boom. From a sustainability perspective, the goal should therefore be to create the types of jobs in the energy sector that are most likely to lead to a more sustainable energy system.

5.7 Affordability

Affordable access to energy is widely recognized as a basic human right and standard of development (UNHCHR, 1991). To exercise this basic right, however, depends on people's actual ability to pay for energy services. Given the inequalities in income among Canadians, the affordability of energy services is questionable for some individuals and households in this country.

Not surprisingly, energy burdens are disproportionately high among low-income energy users (CHRA, 2005). There are a number of reasons for this beyond direct financial limitations, including the fact that, low-income households are often subjected to higher energy costs. People with lower incomes are, for instance, more likely to own or rent poorer quality homes that are poorly insulated, and to use older, less energy-efficient appliances, and they are therefore more likely to have a higher demand for energy for equal or less energy service. Home-owners of limited means may also not be able to afford to make energy-efficient upgrades to their properties, while renters can only lower costs by convincing their landlords to renovate and retrofit properties – an unlikely proposition where tenants rather than landlords foot the power bills (CHRA, 2005).

According to the Canadian Housing and Renewal Association, low-income consumers are also "more likely to heat with electricity – the most expensive heating source" (CHRA, 2005). In addition, they are the most vulnerable to price hikes, market fluctuations, and price changes during cold spells, all of which make affordability of energy uncertain and inconsistent from month to month. Researchers of energy affordability assert that energy burdens are not simply a budgeting issue but rather a systemic problem stemming from a number of structural and underlying socio-economic factors (CHRA, 2005; Colton, 2004; UKDTI, 2001).

When the cost of energy exceeds people's ability to pay for it, a number of social problems ensue. For one, having to make choices between competing household necessities—food, rent, clothing, or heat—causes insecurities about how to make ends meet. In order to save on energy costs or, in the case of shutoffs that ensue from a failure to pay bills, people have been known to resort to dangerous heating alternatives. Examples include the burning of clothes, coal, or other combustible material in a fireplace, heating from open ovens, and the use of space heaters. Such practices have been the cause of fires that imperil the lives of occupants and their neighbours. For example, each year in the United States 12,000 residential fires (22% of the total) are caused by the use of supplementary heaters, resulting in the deaths of 600 people (CHRA, 2005). There are also health concerns from chronic household exposure to cold and damp conditions, which have been recognized to cause respiratory problems among other ailments. In sum, the costs of fuel poverty are considerable, and pose a heavy burden on health and social institutions (CHRA, 2005; Colton, 2004; UKDTI, 2001).

Indicator of affordability

Energy prices produce varying burdens depending on individual or family income. One well-known indicator of energy affordability is the percentage of households that spend more than a defined percentage of their income on energy. This is calculated by dividing a household's energy (i.e. heating fuel and electricity) bill by its income, in order to determine the percentage of income spent on energy, defining a threshold of affordability, and determining the proportion of households in a defined population that exceed that threshold (Colton, 2004). In the United Kingdom, where energy affordability has attracted both public and government attention, the government has determined that households spending more than 10% of their income for energy for the home are considered to be suffering from "fuel poverty"—a state in which they "cannot afford to keep warm at reasonable costs" (UKDTI, 2001).

Fuel poverty is a problem that is socially and economically costly, and needs to be addressed as a matter of priority. This must be stressed here, as the issue has not yet captured the same public and policy attention in North America as it has in Europe. The first step to raise the policy profile of the issue is to determine the extent of the problem, for which indicators are essential. Given the multi-faceted nature of the problem, the aggregate indicator quantifying the extent of fuel poverty, as suggested here, is unlikely to capture many of the nuances of the circumstances leading to fuel poverty or its consequences, but it does provide a good general indication of the direction of the trend, i.e. whether the number (and proportion) of people living in fuel poverty is increasing, shrinking, or remaining static. To track this basic movement the following indicator of affordability is suggested:

- Percentage of households living in fuel poverty (where fuel poverty is determined by an agreed threshold based on the percentage of household expenditures devoted to energy needs).

The level of expenditure on energy needs that is considered excessive is not universal and needs to be determined from one jurisdiction to another. The U.K. uses 10% of income as the defining threshold. In Nova Scotia it may be determined that the level should be higher or lower depending on local circumstances such as energy prices, income levels, and energy needs (i.e. climate, housing quality, etc.) Until that threshold level is agreed, and until data are publicly available to determine the percentage of households spending more than a given threshold (which is not the case at present), it is necessary to track affordability by other means.

Measuring energy expenditure by quintile has been recognised as another important indicator for tracking energy affordability. Natural Resources Canada's *Energy Indicators for Sustainable Development,* discussed in Chapter 4, identified as an indicator to monitor this issue 'household energy expenditures as a share of disposable income by income quintile' (NRCan, 2003a). [42] This information is collected by Statistics Canada in its annual Survey of Household Spending and is recommended here as the second affordability indicator:

- Household energy expenditure as a share of disposable income by quintile

Statistics Canada collects information on energy expenditures according to three categories – fuel (gas, oil, etc.) for shelter needs, electricity for shelter needs, and fuel for transportation needs. The NRCan report includes all three of these line items in its display of indicator trends for Canada. Given the exclusion of transportation in this report, the focus here is only on fuel and electricity needs within the home (shelter).

The data for these indicators at the provincial level are not freely available. **GPI***Atlantic* was only able to obtain the 2003 figures for Nova Scotia because of the generosity of Green Communities Canada, which kindly shared the data it had purchased from Statistics Canada. It is also important to note that the Survey of Household Spending, in its present form, has only been conducted since 1997. Although household expenditure surveys do exist for many years prior to 1997, Statistics Canada personnel indicated that the compatibility of the data sets is unclear, and therefore pre-1997 data were not used for this report. [43]

The data challenges noted above illustrate the difficulty of tracking energy affordability at the provincial level in Canada. It is particularly paradoxical that data elucidating issues of affordability are only available at a cost. This is a serious barrier to understanding and addressing

[42] The term "quintile" refers to the division of households into fifths by income, from the highest one-fifth of income earners (top quintile) to the lowest fifth (bottom quintile).
[43] Harold Rennie, Statistics Canada, personal communication, 29 September, 2005.

the very important and highly topical problem. Indeed, if this information were available, the current fuel rebates to low-income Canadians and Nova Scotians, instituted by both the federal and provincial governments at considerable cost, could be targeted far more effectively and cost-effectively.

Fuel poverty trends in Nova Scotia

There is substantial evidence to suggest that fuel poverty exists in Nova Scotia. According to the Nova Scotia Department of Finance's 2003 statistical review: "13.4% percent of all 'economic families' were low-income (34,845) in 2000, while 38.5% of all 'unattached individuals 15+ years' were low-income (44,760) that year" (Colton 2004:6; NSDF, 2003). Of Nova Scotia's 930,000 residents, 147,020 (or 15.8%) are in the low-income bracket, and in September, 2004, 32,097 households were receiving social assistance (NSDF, 2004; Colton, 2004).[44] Given that fuel poverty particularly affects those on low incomes, there is reason to believe that a significant portion of the population bears high energy burdens (Colton, 2004).

The 2003 Survey of Household Spending shows that the lowest-income quintile in Nova Scotia spent an average of 14.2% ($2,175) of annual pre-tax income on home energy needs for fuel and electricity. This is broken into 8% of total expenditure on fuel and 6.2% on electricity (Table 12). This compares to a total fuel and electricity expenditure of 4.7% ($2,555) of income by all households and only 2.8% ($3,135) of income by the highest income quintile (StatsCan, 2004d).

Table 12: Average Nova Scotia household expenditure on energy as a percent of pre-tax income, 2003

	Nova Scotia					
	Lowest Quintile	Second Quintile	Third Quintile	Fourth Quintile	Highest Quintile	All Households
Pre-tax income	$15,331	$29,741	$46,359	$66,435	$113,745	$54,322
Fuel & electricity (amount spent)	14.2% ($2,175)	7.5% ($2,234)	5.2% ($2,427)	4.0% ($2,672)	2.8% ($3,135)	4.7% ($2,555)
Fuel (amount spent)	8.0% ($1,223)	3.9% ($1153)	2.8% ($1288)	2.0% ($1321)	1.2% ($1412)	2.4% ($1,291)
Electricity (amount spent)	6.2% ($952)	3.6% ($1081)	2.5% ($1139)	2.0% ($1351)	1.5% ($1723)	2.3% ($1,264)

Source: StatsCan, 2004d.

For these figures, Nova Scotia falls between the expenditure averages in the Atlantic Provinces and those in Canada. The Atlantic Canadian average expenditure for the lowest income quintile for electricity and fuel is 15% ($2,171) of income, and for Canada it is 13% ($1,977). For all

[44] The low-income bracket has been determined using Statistics Canada's Low-Income Cut-Off. This is determined according to the proportion of annual family income spent on food, shelter and clothing. It is linked to a base year and updated annually for inflation using the consumer price index. The low-income cut-off varies based on family and community size (StatsCan, 2004c)

households the average is 5.1% ($2,583) for Atlantic Canada and 4% ($2,483) for all Canada (Table 13).

Table 13: Average Atlantic Canada and Canada household expenditure on energy as a percent of pre-tax income, 2003

	Atlantic Provinces		Canada	
	Lowest Quintile	**All Households**	**Lowest Quintile**	**All Households**
Pre-tax income	$14,469	$50,619	$15,199	$61,782
Fuel & electricity (amount spent)	15.0% ($2,171)	5.1% ($2,583)	13.0% ($1,977)	4.0% ($2,483)
Fuel (amount spent)	7.6% ($1,101)	2.3% ($1,162)	7.0% ($1,067)	2.0% ($1,250)
Electricity (amount spent)	7.5% ($1,070)	2.8% ($1,421)	6.0% ($910)	2.0% ($1,233)

Source: StatsCan, 2004d.

By comparison, in the U.S., the U.S. Department of Energy's 2001 Residential Energy Consumption Survey (RECS) found that in fiscal year 2002, the average U.S. household had a mean individual energy burden of 5.9 percent of income. Low-income households had an energy burden of 12.6 percent, more than twice the energy burden of all households, while Low Income Home Energy Assistance Program (LIHEAP) recipient households had an energy burden of 17.0 percent, more than 11 percentage points higher than for all households and more than 4 percentage points higher than for low-income households (USDHHS, 2005a).

The above statistics provide information on income expenditures by quintile, which is one of the two suggested affordability indicators. Because financial resources did not allow the purchase of provincial data for prior years, it was not possible here to assess trends over time for energy expenditures by quintile. The second indicator would provide information on the proportion of households that spend more than a defined threshold percentage of income on home energy needs, but this indicator could not presently be operationalised for two reasons. One is the lack of agreement on what proportion of income defines the threshold of fuel poverty, and the other is the lack of availability of that data even if a threshold were defined.

Fuel poverty figures that correspond to the U.K. definition and data (percentage of the households spending more than 10% of their income on fuel) are not publicly available in Canada. Statistics Canada was uncertain whether such statistics could be extracted from existing data sources in a special custom tabulation and indicated that it would charge **GPI***Atlantic* just to investigate whether such numbers could even be calculated, without a guarantee whether this is possible. If its investigation proved possible, Statistics Canada indicated that additional charges would then be levied to produce the numbers. Financial constraints did not permit this investigation for this report. In any case, Statistics Canada's response indicates that fuel poverty figures are not easily available in Canada, if they can be deduced at all. In light of the major health costs and productivity losses attributable to fuel poverty assessed by U.K. studies (which could amount to nearly $50 million annually in Nova Scotia if comparable rates and conditions existed here as in the U.K.), this data gap is unfortunate, and it is a key recommendation of this report that fuel poverty statistics be collected regularly and made publicly available. As Natural Resources Canada has recognised fuel poverty as a key indicator of sustainable development in the energy sector, it is clear that federal government departments, in addition to independent research institutions like **GPI***Atlantic*, require those statistics. As well, the current public focus on fuel rebates for low-income Canadians and Nova Scotians indicates that policy makers require such data to target their programs effectively.

Discussions with and queries made to other groups working on energy and low-income issues – both government departments and non-governmental organisations – reinforced the problem of data scarcity and inaccessibility. For example, Dalhousie Legal Aid also emphasized the lack of specific current data on energy burdens and energy affordability in the Province during the last NSPI rate case hearings (Colton, 2004).

Actions to address fuel poverty

Addressing fuel poverty first requires that consistent methodologies for data collection on energy burdens be established. The United Kingdom is currently in the process of establishing protocols to calculate the energy burdens carried by its citizens more accurately (UKDTI, 2004). The resulting methodology will offer a valuable model for data collection in Nova Scotia and Canada. Once information needs are met, the possibility of creating a comprehensive strategy to alleviate fuel poverty becomes more likely.

Currently Canada uses a patchwork of strategies to help alleviate energy burdens and to improve energy efficiencies and savings for low-income households. The most common programs are temporary price caps, rebates, and energy assistance programs. Such instruments do provide immediate relief from high energy costs, but they are not adequate long-term solutions. Energy caps, for instance, are expensive and have been criticized for not offering direct relief to low-income consumers. They also misrepresent the real price of energy, making it appear cheap, and thereby serving to promote consumption rather than conservation (CHRA, 2005). Rebates and assistance programs are also expensive and do not provide long-term solutions. Energy efficiency programs are also commonly used to address fuel poverty. By providing retrofits and new standards for buildings, these programs help ensure future energy savings. Energy efficiency programs are thought to be the best strategy for alleviating long-term fuel poverty, but are limited in their ability to provide immediate relief (CHRA, 2005).

A comprehensive strategy that addresses both immediate and long-term needs is required to tackle fuel poverty adequately in Nova Scotia. The Province's Keep the Heat program is making small steps towards integrating short and long-term solutions by offering modest retrofit assistance and a chance to win an energy savings kit, in addition to one-time rebates (CHRA, 2005).

The ultimate goal of effective policies to alleviate fuel poverty, according to research and advocacy groups in the field, is to create a national strategy for energy efficiency and affordability, particularly for people with limited financial means (CHRA, 2005). A co-ordinated government strategy that involves multiple partners in the public and private sectors has been recommended by many of these groups. Various national programs in other countries could be used as models for Canada. The U.S. Weatherization Assistance Program, for example, is a publicly funded initiative in which community groups deliver free energy audits and retrofitting services to low-income families (USDOE, 2005). The Low Income Home Energy Assistance Program (LIHEAP) is another U.S. initiative to help low-income families pay their energy bills during the winter months (USDHHS, 2005). In the U.K., a fuel poverty relief strategy called Affordable Warmth was developed to provide assistance to people experiencing energy burdens that are higher than 10% of income. Affordable Warmth takes a preventative approach to fuel poverty by encouraging the construction of energy-efficient homes, providing upgrades to inefficient ones, and overall trying to reduce fuel costs and improve income levels (UKDTI, 2001).

Addressing fuel poverty is an important component of any sustainable energy strategy. As noted, alleviating fuel poverty has also been recognised as a national priority in other countries. As a first step, it is recognized here that proper research and data collection are needed to identify the actual social, economic and environmental costs of energy burdens and fuel poverty, both to give the issue the attention and priority it requires and to monitor progress over time.

5.8 Reliability

The functioning of our society is highly dependent on a reliable and constant flow of energy. When power outages and shortages occur, they not only disrupt the activities of individuals, households and businesses, but they may impede people's ability to meet basic needs. Similarly a disruption in fuel supplies—whether oil for heating, natural gas for cooking, or petroleum for automobiles and trucks—disrupts the smooth functioning of our society and can affect basic human survival. Patients who rely on electrically powered medical instruments for their health, understand that a power failure may mean the difference between life and death.

As described in the previous section, a loss of power may force people to seek other means to meet their energy needs that can lead to risky practices, with consequences for human health and safety. Hazards that sometimes result from outages include carbon monoxide poisoning caused by the operation of gas generators; house fires started by electrical devices coming back on after power is restored; and even car accidents caused by traffic lights that are not operating (Lipscombe, 2004; Nicoll, 2004).

Less serious, but nonetheless adverse, consequences of energy disruptions, are interruptions in production processes, business operations, and other economic activities that can lead to loss of income. In this age of electronic dependence, a lack of power means we can no longer engage in most commercial transactions. A survey conducted by the Canadian Federation of Independent Businesses identified the following impacts of power outages: employees not being able to work; loss of orders or customer patronage; lost production of goods or services; lost revenue due to lack of electronic payment capabilities; and damaged, spoiled or lost inventory (Hache, 2005).

Indicators for reliability

In light of the extensive impacts caused by a loss of energy delivery, a consistent and reliable source of power is a vital indicator of energy sustainability. The question of how best to secure dependable energy entails consideration of the kind of fuels we choose to use, where they come from, the robustness of the delivery system, and the efficiency of their use.

Nova Scotia, as a net importer of fossil fuels, is vulnerable to challenges relating to the reliability of supply. The first obstacle is the insecurity of energy sources that originate externally – often in politically unstable parts of the world. The cost of external sources of energy is also contingent on price fluctuations in the international market and on changes in the buying power of the Canadian dollar. This can make it difficult for power companies to offer a consistent and predictable price for electricity. The major fluctuations and price spikes at gas pumps in recent months indicate the volatility of prices for imported oil. Unless a firm has negotiated a long-term fuel purchasing agreement to buffer against price fluctuations and irregular contract deals, fuel supply may be inconsistent and subject to fluctuating prices (ISIS, 2004). The 2004/2005 NSPI rate increase application was made on the basis of just such price increases and uncertainties.

However, ensuring the security of fuel supplies and the stability of prices are only two elements of energy reliability. Delivering that energy from fuel storage facilities and/or electricity generation stations to individual homes and businesses is another key factor in reliability. Several power outages between 2003 and 2005, including two for extended periods affecting large numbers of customers, have reminded Nova Scotians that energy availability cannot be taken for granted, and that the transmission system itself is vulnerable to unexpected weather events and disruptions. Although an independent review for the Utility and Review Board found that, on the whole, the Nova Scotia electricity grid meets the standards expected by the Canadian Electricity Association, extreme weather events (which are predicted to increase in frequency and intensity as a result of global warming) can impede NSPI's ability to ensure a consistent power supply (Liberty Consulting Group, 2005).

Indicators that address fuel security are covered indirectly in the section on energy supply. Identifying a single indicator for fuel reliability (i.e. security) is not practical due to the different types and sources of fuel and the different vulnerabilities and types of disruption and insecurity outlined above. Here only indicators of electricity reliability are presented, though future updates of this report may expand the analysis to other types of fuel security. Capturing the reliability even of the electricity supply in a single indicator is impossible since power failure affects different people in different ways. Here two indicators are suggested, though these too may be expanded in future updates of this report.

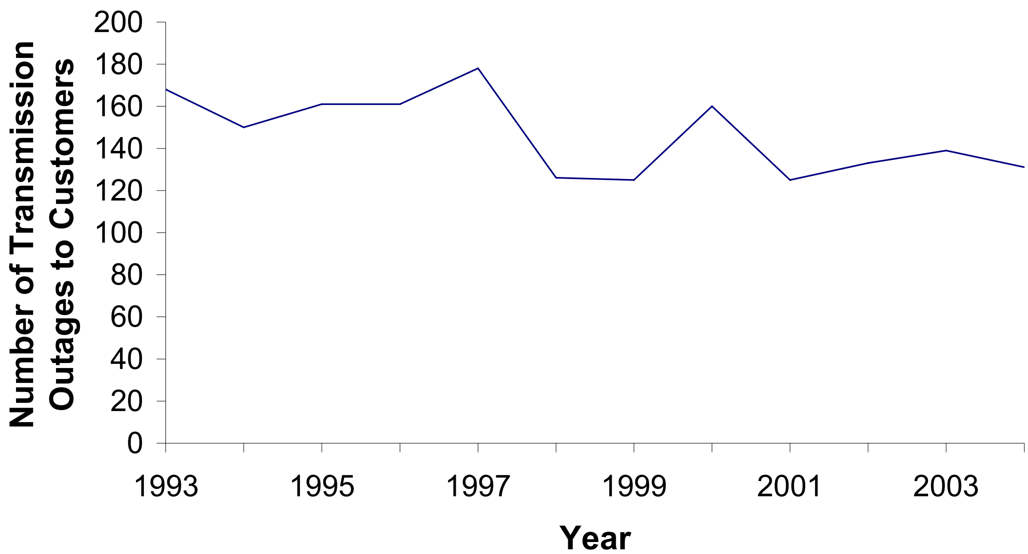
- Number of household hours per year without power.
- Business hours lost due to power failure.

The difficulty is in encapsulating both the duration and impact of a power outage in the suggested indicators, since a disruption can affect various sectors of society quite differently. For example, a power outage may be catastrophic for one business, resulting in major inventory losses for perishable goods, and barely affect another that is less dependent on electric power for its operations. Thus, "business hours lost" assesses only duration and does not effectively capture the actual impacts and costs of power outages.

Reliability trends

Data limitations do not presently allow an assessment of trends for the indicators suggested above. However, Nova Scotia Power and the Canadian Electricity Association do track electricity reliability according to a different (and rather flawed) indicator – the number of transmission outages, and these numbers were included in a 2005 report to the UARB. Transmission outage trends for Nova Scotia between 1993 and 2004 are shown in Figure 22, which at first glance appear to indicate a declining (and therefore improving) trend for the reliability of electricity in Nova Scotia. The key flaw in this indicator is that it does not account for the duration of outages or the numbers of customers affected (as our suggested indicators above do), and so it gives no indication of the severity of the disruptions. If duration of outages and numbers of customers affected are taken into account, the trend lines may not appear so positive. Although not represented in the chart, the trends for electricity reliability in Nova Scotia closely resemble the reliability data tracked nationally by the Canadian Electricity Association (UARB, 2005).

Figure 22. Number of transmission outages in Nova Scotia, 1993 to 2004



Note: This does not display the number of customers who experienced outages each year. Each outage here is a single event in which a line or transformer was damaged and a portion of the grid lost power irregardless of the number of customers affected or the duration of the outage.

Source: UARB, 2005: 65.

The numbers in Figure 22 do not reflect the duration of the outages and the number of people affected. The only source of information about the latter that **GPI***Atlantic* could find was reports from newspapers, which have covered some of the most recent, major power outages in the

Province. Table 14 lists power outages in Nova Scotia from 1999 to 2004 that were reported by the media. While this is not an exhaustive list of the Province's power outages, it is indicative of grid reliability problems caused by extreme weather and other events. Table 14 indicates that when duration and number of customers is taken into account, a very different picture emerges from that presented by NSPI and the Canadian Electricity Association above. Clearly, the more recent disruptions in 2003 and 2004 were far more serious and of much longer duration than those in earlier years.

Table 14. Power outages in Nova Scotia, March 1999 – March 2005, reported by media

Date	Affected[1]	Area	Cause	Duration[2]
Dec. 2004	4,800 customers	Dartmouth	Snow storm	2 days
Dec. 2004	4,000 customers	Cape Breton	Fallen tree, downed line	1 day
Nov. 2004	181,000 customers	Province-wide	Ice storm - Transmission towers damaged	6-7 days
June 2004		Two areas in Halifax		<1 day
Feb. 2004	14,000 homes	Halifax	Snow storm	
Oct. 2003	300,000 people	Province-wide	Hurricane Juan	7-8 days
Nov. 2002	440,000 customers	Halifax, Western NS	Storm	< 1 day
Oct. 2002	4,000 people	Halifax	Hurricane Gustav	
	900 customers	Broad Cove	Hurricane Gustav	
July 2001	18,000 homes	Halifax	Lightning storm	
Dec. 2000	2,500 homes	Millwood, Beaverbank, Lucasville	High winds	
Nov. 2000	1,500 homes	Dartmouth	Downed wire	<1 day
	220 businesses	Dartmouth	Downed wire	<1 day
Sept. 2000	N/A	Downtown Halifax	N/A	<1 day

1. This column contains a variety of terms used to represent those affected by power outages. While a consistent measurement would be ideal, the nature of the media reports was such that a wide range of terms was used, and are therefore employed in this table.

2. The times listed in this column represent the maximum duration that a significant number of customers remained without power. During the longer outages (October 2003 and November 2004), not all of the customers specified in column 2 were without power for a week, some had their power restored much sooner and others even later.

Note: <*1 day* indicates a time period of 30 minutes to 24 hours.

Severe weather events, which meteorologists predict will increase in frequency and intensity due to global warming, are a challenge to NSPI in improving its reliability performance. Powerful storms are the primary reason for unusual hikes in the average system interruption, the duration of system interruptions, and the average customer interruption since 1999 (UARB, 2005). These storms have caused both direct and indirect damage to grid infrastructure. Again, it must be noted that none of these factors are accounted for in Figure 26, which demonstrates the inadequacy of an indicator measuring only the number of transmission outages.

To take one instance, the ice storm that hit Nova Scotia in November, 2004, put tremendous pressure on transmission lines from the weight of heavy ice, snow and slush, causing major transmission failures. More than 100,000 homes and businesses were left without power, leading some communities to declare a state of emergency (Myrden, 2005). According to the Liberty Consulting Group, which evaluated NSPI's performance during the storm, transmission failure might have occurred even if infrastructure upgrades had been in place (Liberty Consulting Group, 2005). Thus, even enhanced infrastructure may still be vulnerable to heavy storms.

At times, storm debris can obstruct the transmission of electricity by damaging power lines, as spectacularly demonstrated by Hurricane Juan in October, 2003. In fact, according to Nova Scotia Power, "trees falling on power lines are the single largest cause of outages in severe weather" (Taylor, 2005). This has prompted NSPI to propose a $7 million plan to cut down trees in order to double the width of the power-line corridor from three to six metres (Myrden, 2005; Taylor, 2005). NSPI has deemed this an "inexpensive" and effective response to the problem, and estimated that it will improve the Province's electricity reliability by 20% (Myrden, 2005; Taylor, 2005). Other alternatives, such as investing in underground transmission lines, are considered too costly (Pugsley Fraser, 2005).[45]

Public response to the tree-cutting proposal has not been positive. Given the aesthetic and practical value of trees, many people in the Province are opposed to this plan. Trees are important for many reasons including their role in reducing greenhouse gases, reducing the heat island effect in urban settings, providing shade, reducing wind impacts, reducing soil erosion, and serving as a dependable habitat for birds and insects. In addition, trees beautify the city and have a positive affect on mental health (O'Toole, 2005). Social and environmental benefits and costs therefore need to be considered when assessing the economic advantages of greater reliability.

Goals and targets

Increases in the frequency and severity of storms are predicted to continue as a consequence of climate change. Wind, ice and rain storms, tornadoes, hurricanes, and floods will further challenge the reliability of electrical grid systems worldwide (UNFCCC, 2005), and this Province will be no exception as the events of recent years have demonstrated. Since upgrading infrastructure or even cutting down trees may not be enough to ensure electricity reliability in future, serious consideration needs to be given to the robustness of the grid system as a whole.

[45] This solution is only "inexpensive" in terms of the direct cost to NSPI for the destruction of trees. Considering the value of the many services provided by trees, especially in urban settings, the solution may not be at all "inexpensive" from a full-cost accounting perspective. Trees moderate climate, slow wind, purify air, and combat climate change by sequestering carbon, amongst other services. Cutting down trees to facilitate uninterrupted energy consumption (the primary cause of climate change) can therefore be termed inexpensive in only a narrow economic sense.

Concern about the reliability of our energy imports and the durability of our energy infrastructure has begun to prompt exploration of systemic and structural alternatives to and improvements in the Province's energy system. This more far-reaching exploration of systemic alternatives is happening globally, and the conclusions and actions of other jurisdictions are highly relevant to this Province. A study for the United Kingdom Department of Trade and Industry, for example, concluded that improving reliability in the longer term requires moving away from heavy dependence on imports, diversification of the fuel mix, and investment in local energy production and generation (UKDTI, 2005). Such a strategy would reduce vulnerability to distant markets and also provide immediate backup sources in cases where there may be one fuel shortage after another.

Diversifying the fuel mix necessarily raises the question of which types of fuels are likely to provide the greatest reliability. Given that fossil fuels are a limited resource whose reliable supply will certainly diminish – likely in the near future, and given that they also cause the most severe environmental and social impacts among all fuel types, it would be irresponsible to continue to rely solely on fossil fuels. Hence a concerted effort to make locally available renewable energy a greater component of the energy mix is a key goal in securing energy reliability. Of course, investment in renewable energies, such as wind and solar power, also prompts questions about consistency of supply and the potential to meet energy demands. The problem here is not the availability of the fuel but the ability to store and distribute an intermittent source of power. Thus investment in research and development in the renewable energy sector is paramount if renewables are to provide an efficient, reliable and competitive alternative. Successful European models of increased reliance on renewable energy sources, as in Denmark and Germany, should quickly become the focus of our attention if we are to make genuine progress in this field.

5.9 Chapter Summary

Energy is a major determinant of economic development and social wellbeing. Without access to abundant, reliable and affordable energy, Nova Scotia's economy, like any other, would quickly grind to a halt. But there are also negative consequences to producing and delivering energy, as outlined in Chapter 3, and so energy demand and supply must be approached from the perspective of long-term sustainability. This chapter began by outlining the following economic and social goals of a more sustainable energy system:

- reduce the overall demand for energy, especially fossil fuels;
- reduce dependency on imported fuels by switching to indigenous sources, especially renewable energy;
- increase energy efficiency;
- increase long-term employment that matches skills with needs in the energy sector;
- avoid energy activities that lead to avoidable job losses, industrial accidents, oil spills, etc.;
- ensure that energy sufficient to meet the basic needs of all citizens is available and affordable;
- ensure reliable energy services.

Unfortunately, energy demand is increasing and reliance on imported fossil fuels remains extremely high. So the current system cannot be classified as sustainable, and progress in moving towards sustainability has thus far been very limited. Use of indigenous energy is low, with coal mining at an historic low, natural gas produced primarily for export, and renewable sources (hydro, tidal, biomass, wind, etc.) still below 10% of total primary energy supply. Wind power, which has the greatest potential for significant expansion, remains a negligible proportion of the total energy supply, though recent statements and actions indicate this may be changing. By the end of 2005, NSPI will have contracts in place to increase the supply of renewable energy in Nova Scotia by 25% (approximately 100 megawatts)..." (NSPI, 2005e). With the exception of the dramatic oil price fluctuations in September/October of this year, fossil fuel prices have been relatively stable and reliability has been reasonable, reducing immediate economic incentives for change. However, the system remains so dependent on foreign supplies and fossil fuels that when petroleum production peaks, a drastic economic re-organization may occur. There may only be a narrow window of opportunity at the present time to prepare effectively for what experts regard as an inevitable transition.

End use, final demand, in Nova Scotia fell substantially in the late 70s and early 80s in the wake of the oil shocks, shortages, and quadrupling of prices in the 1970s. Since then demand has begun to rise slowly but has not yet reached the high level of the l970s. The increase in demand and the continued dominance (~90%) of largely imported, polluting, non-renewable fossil fuels shows the continued lack of sustainability in the Province's energy sector. Gains have been realized through efficiency, conservation, and recent expansion of wind power, but there have been losses in sustainability as well through expansion of energy-intensive activities (e.g. increased use of appliances and motor vehicles, larger homes, continued ex-urban development that requires longer commutes, etc.) New ways of conserving energy, and of using it efficiently, and more systemic and structural approaches to energy sustainability, must be adopted.

Due to the difficulty of representing efficiency through a single indicator or number, a series of indicators have been suggested (summarised in Table 8). Many of these indicators are currently not tracked at the Provincial level and therefore cannot be measured accurately. This however, should not exclude the recommended indicators, which are all important for determining progress towards making the Nova Scotia energy system more efficient. The benefits of reduced energy demand (which is the basic goal of efficiency) affect all four components of sustainability and hence are an essential area on which to focus. Moreover, it is much faster to implement efficiency programs than it is to develop new forms of energy supply. Efficiency reduces demand, drives prices down, and ameliorates vulnerability.

Improved data collection and monitoring are needed to assess the sustainability of the energy system accurately in the socio-economic context. More information is needed on the use of wood, total primary energy use, energy efficiency, the affordability and reliability of energy, and the number of people employed in the energy sector. Employment figures remain elusive, preventing Nova Scotians from assessing the full impact certain industries have had on the Province's society and economy. The indicators suggested in this chapter, as well as the data gaps identified, demonstrate where data collection and reporting must be improved to assess progress towards sustainability more effectively from a socio-economic perspective.

6. Human Health and Environmental Indicators

6.1 Introduction

Like all human activity, the production and use of energy has consequences for the environment and human health. As discussed in Chapter 3, these include acidic and toxic emissions; the sending of wastes to landfills; and the use of land for resource extraction and energy distribution (e.g. mining, transmissions lines, etc.). Though these phenomena have been studied to varying degrees, full knowledge and quantification of their effects is limited. Where impacts are clear, options to remedy these problems are often expensive or, in some cases, not readily available. Different energy systems contribute to these environmental problems to various degrees and these differences must be considered in planning for a sustainable energy future.

Protecting human health and the environment are at the core of sustainable development. Although often discussed as separate components of sustainability, environmental and health concerns are presented together in this section because of the strong connection between them in the field of energy impacts. Many of the energy-related indicators that reveal information about the state of the environment are the same ones that need to be tracked for addressing human health concerns. Damage to the processes and resources produced by the natural environment may also jeopardize human health. For example, the release of mercury from power stations can enter ecosystems and hence the local food chain. Mercury accumulates in species at the top of the food chain. Humans are often the final link in this chain, ingesting mercury that has built up in animals, especially certain fish species. Mercury accumulation in humans is detrimental to health, leading to neurological and developmental damage (Environment Canada, 2004b). Neurotoxin effects due to mercury have also been found in wildlife, and many species may be subject to similar effects as those experienced by humans. Other indicators, too, demonstrate a strong connection between environmental and health concerns.

This chapter builds on the discussion in Chapter 3 by identifying specific indicators for measuring environmental and human health effects. Indicators cannot be presented for all impacts because of data gaps and problems in assigning clear directional goals. For example, land use for energy production can be considered both desirable and undesirable depending on the type of fuel involved and the nature of impacts, therefore no clear statement about goals can be made. The indicators included here were identified using the pressure-state-response framework. In each case the analysis shows where the problem originates (pressure), what the impacts on human health and the environment are (state), and what policy actions can be taken to address the problem (response) in order to adjust the direction of the trends and move towards sustainability.

6.2 Overview of Indicators

Human health impacts

Health is arguably the most important factor determining the quality of life in both our personal lives and our contributions to society. Fostering an environment that helps to achieve healthy lives and to protect against illness is not only a development priority worldwide but also an important component of sustainable development (UNDP, 2003). Addressing the issue of how the energy system can best promote good health should therefore be among the top priorities of the energy sector in Nova Scotia.

Two significant and widely recognized indicators of health are mortality and morbidity rates (WHO, 2005; European Commission, 1999). Decreasing the incidence of premature death and disease is currently the most widely accepted indication of improving health in a given population. While physical and material factors like income, toxic emissions, and rates of smoking, obesity and physical inactivity are recognized as key determinants of human health, it is also acknowledged that psychological, social and spiritual factors are important determinants of health. Here, only a limited number of physical health determinants are considered. Because it is often difficult to trace death or illness to one specific cause—especially in the case of environmental illnesses—the indicators used in this report are not mortality and morbidity rates per se, but rather the main energy-related pollutants that affect them. The following six pollutants were selected as key indicators for the energy sector that should be rigorously monitored because of the consequences each can have for human health:

- Carbon Monoxide (CO);
- Particulate Matter (PM);
- Sulphur Oxides (SO_x);
- Nitrogen Oxides (NO_x);
- Volatile Organic Compounds (VOCs); and
- Mercury (Hg).

These substances are recognized as common primary energy pollutants in Nova Scotia. They are widely recognized for their direct or indirect role in causing or exacerbating a range of illnesses, and thereby of diminishing longevity. All except mercury are considered “criteria air contaminants” by Environment Canada (Environment Canada, 2000). The impacts of all these six pollutants (including mercury) are also assessed by Health Canada’s Priority Assessment Program (Department of Justice, 1999).

As primary pollutants, these six substances are also precursors to the creation of secondary pollutants, which can be equally if not more damaging to health. Ground level ozone, for example, is a secondary pollutant which forms when nitrogen oxides and volatile organic compounds react in sunlight, and has been shown to have damaging effects on lung function (OMA, 1998). Likewise smog, which has been shown to exacerbate respiratory problems and cause higher than normal hospital admissions on smog-warning days, consists of ground level ozone, particulate matter and other pollutants. For this reason, smog alert days in major Canadian urban centres is used by Natural Resources Canada as an additional indicator of environmental stewardship in the energy sector as part of its core energy indicators for sustainable development (NRCan, 2003a). Because ground-level ozone and smog are based on the primary pollutants listed above, only the latter are used in this report. However, the secondary pollutant consequences of the six substances considered here are acknowledged as a key reason to monitor these six pollutants carefully for their role in directly **or** indirectly causing or contributing to adverse health effects (Monette and Colman, 2004).

By no means are the six pollutants above the only ones that are damaging to health. Other serious but less widely recognized energy-related pollutants can pose a host of health risks and have been studied both in Europe and in North America (Environment Canada, 2005a; European Commission, 1999). Poly-aromatic hydrocarbons, dioxins and furans, radioactive wastes, heavy metals (lead, arsenic, cadmium, chromium, nickel), as well as occupational effects like noise – all of which are related to energy production and supply of different kinds – have been shown to have quantifiable impacts on health (European Commission, 1999; Department of Justice, 1999).

In this Province, 26 substances listed in the National Pollutant Release Inventory (NPRI) are emitted by Nova Scotia Power's thermal generating stations (Emera, 2002). To add some of these additional substances to the six indicators chosen for this study, further epidemiological studies and research into their effects are needed to encourage mandatory reporting and emission standards and reduction targets.

Environmental impacts

With the exception of carbon monoxide, all of the six pollutants listed above also have demonstrated impacts on the environment. For example, mercury has been shown to produce neurotoxic effects in loons in Kejimkujik National Park (Nocera and Taylor, 1998). The energy sector, specifically coal-fired power plants, is the principal source of mercury emissions in Nova Scotia (Environment Canada, 2005a). Because of its known environmental impacts, mercury is included among the indicators used here, even though it is not classified by Environment Canada as a criteria air contaminant.

The other pollutants listed above – all criteria air contaminants - also have known impacts on the natural environment. Particulate matter leads to reduced visibility and the soiling of materials and plants. Soiling of natural and cultivated vegetation reduces gas and light flow into plants, usually reducing yields (Monette and Colman, 2004). Volatile organic compounds, when combined with NO_x in sunlight, form ground level ozone. Ground level ozone has been linked to material damage, and crop and forest damage through foliar damage, forest dieback, and reduced biomass. NO_x has also been linked to eutrophication of waterways and damage to forests through changes in the nutrient balance (MacKenzie and El- Ashry, 1989).

Sulphur oxides (particularly sulphur dioxide) and nitrogen oxides, though commonly part of smog and important precursors to secondary pollutants, are possibly most damaging to the environment because they become acidic in the atmosphere and fall as some form of acid deposition. Elevated acidity in the environment due to anthropogenic releases (i.e. those caused by humans) over the last half century has induced materials damage (to old buildings and historic sites for example), damage to crops, changes in forest productivity (damage to foliage and changes to soil nutrient regimes), and acidification of water (causing changes in fish species and aquatic productivity), which in turn produces adverse impacts on biodiversity (Monette and Colman, 2004; Environment Canada, 2002, 1998a).

Climate change

Possibly the most widespread and lasting impact of the current fossil fuel dependent energy system is the production of greenhouse gases, which have been strongly linked to climate change. The preponderance of oil, coal, and natural gas for electricity generation, powering transportation, and as feed stocks for other industries such as fertilizers and plastics, therefore has profound implications for the environment, the economy, health and safety, world politics, and the legacy left to future generations. A brief overview of the causes and consequences of climate change was presented in Chapter 3. These impacts are expanded upon in this chapter.

6.3 Clarification of Data Issues

Most of the physical indicators presented in this chapter come from a common data source, Environment Canada's reports on criteria air contaminants. Because of their importance and commonality, issues with the data used for CO, SO_x, NO_x, PM and VOCs are jointly outlined in this section, and the approach used for establishing reduction targets is also discussed. Data sources for Hg and GHGs are dealt with in their separate sections as they are not classified as criteria air contaminants by Environment Canada.

Data for criteria air contaminants

Environment Canada has collected and synthesized information about emission levels for CO, SO_x, NO_x, PM, and VOCs since the 1970s, and published these data in a series of reports. Results are released about once every five years, with the most recent monograph published in 2005 with records for 2000. The data are presented in six categories – industrial processes, non-industrial fuel combustion (formerly described simply as fuel combustion for 1985 and earlier results), transportation, incineration, miscellaneous, and open sources (a category added in 1995). These categories are further broken down into sectors. For example marine transportation and motorcycles are sub-sectors in the transportation category. **GPI***Atlantic*'s ambient air quality accounts include a thorough description and analysis of these Environment Canada reports and results on criteria air contaminants (Monette and Colman, 2004). A short summary of the data limitations is provided here.

Limitations to emissions estimates data include:

- Data cannot be used to assess trends over time because different methodologies were used to collect data at different times.
- The data are estimates using the best information available, including self-reported industry surveys, but are not actual physical inventories of emissions.

- Where firsthand information was not available in the form of survey responses, emission factors and engineering estimates were used (Monette and Colman, 2004).
- Emissions from residential combustion of wood for home heating have been based on annual surveys of residential wood use conducted by Statistics Canada. Values varied widely from year to year producing unreliable wood emission estimates. An extensive study was conducted in 1997 to determine more accurate wood usage figures. The 2000 data reflect this improved data and are therefore much more reliable.

To create the indicators for criteria air contaminants in this report, **GPI***Atlantic* used the "Fuel Combustion" category until 1985 and the "Non-industrial Fuel Combustion" category since then, as the classifications were re-organized with the presentation of 1990 results. Since 1990, fuel combustion emissions in the industrial sector have been reported as emissions under the "Industrial Processes" category. Unfortunately, it is impossible to recreate an industrial fuel combustion sector for 1990, 1995 and 2000, as fuel combustion for the industrial sector is not reported separately anywhere. Environment Canada breaks down the industrial sector into sub-categories by industry, but not by industrial processes. Non-industrial fuel combustion – the primary focus of this chapter – includes electric power generation (utilities), residential fuel and fuelwood combustion, and commercial fuel combustion.

Confining the present analysis to the fuel combustion category also excludes emissions from transportation, which are reported in the **GPI***Atlantic* Transportation Accounts. As such, the emissions estimates in this report do not reflect the full environmental impact of fossil fuel combustion and energy production in this Province, but only those impacts deriving from non-transportation energy production.

Included in the classifications used in this report is "upstream fuel processing." This label includes emissions from coal mining. Emissions from other industrial sectors directly linked to the oil and gas industry are rightly attributable to the energy sector. However, because the oil and gas industry produce fuels for both transportation and stationary combustion only a portion of these emissions are attributable to stationary combustion and therefore these categories were not included in this report. As Nova Scotia uses a large amount of oil and coal from other parts of the world, a significant amount of upstream processing emissions that are attributable to fossil fuel consumption in Nova Scotia are not included in the emissions results presented here. Accordingly, **GPI***Atlantic* considers these emissions estimates an underestimation of the true impacts of energy use in Nova Scotia.

Goals and targets for criteria air contaminants

Ambient air quality objectives are target levels that afford a specified amount of protection for humans, other life forms, and/or habitats (such as soil and water) from pollutants occurring in outside air. Air quality objectives are generally set at a national level to cover both short- and long-term exposure to pollutants. Pollution control agencies (e.g., Environment Canada, Nova Scotia Department of Environment and Labour) routinely monitor the levels of air pollutants and compare them with the air quality objectives in order to assess progress in achieving and maintaining the best possible air quality for the public and for the environment.

In the 1970s the Canadian Federal Government set national ambient air quality objectives (NAAQOs) based on recommendations from the Federal-Provincial Advisory Committee on Air Quality (FPACAQ). The NAAQOs are not standards but "objectives," which means that they are not legally binding. NAAQOs were designed to meet the following objectives:

- assist in establishing priorities for reducing contaminant levels and determining the extent of pollution control needed;
- provide a uniform measure for assessing air quality in all parts of Canada; and
- indicate the need for and extent of monitoring programs.

NAAQOs were established as a three-tiered system: 'desirable', 'acceptable', and 'tolerable' levels of pollutants in the atmosphere.:

- The *maximum desirable concentration (MDC)* is the long-term goal for air quality and also provides a basis for an anti-degradation policy for unpolluted parts of the country (i.e. of not allowing the quality of unpolluted air to deteriorate even though there might be apparent leeway to do so without demonstrable effect). It also provides a guideline for the continuing development of control technology.
- The *maximum acceptable concentration (MAC)* is intended to provide adequate protection against the potential effects of air pollution on soil, water, vegetation, materials, animals, visibility, and personal comfort and wellbeing.
- The *maximum tolerable concentration (MTC)* denotes time-based concentrations of air contaminants beyond which, due to a diminishing margin of safety, appropriate and immediate action is required to protect the health of the general population.

Pollutant levels below the maximum desirable objective are classified as being within a desirable or "good" range. Levels between the maximum desirable and maximum acceptable objectives are classified as acceptable or "fair." Levels between the maximum acceptable and maximum tolerable levels are classified as "poor," and levels higher than the maximum tolerable are in the "very poor" range.

These ranges are intended to reflect the reality of different levels of air quality in Canada. That is, certain parts of the country have extremely low levels of the common air pollutants, and a reasonable goal for these areas is to maintain air quality within the good or desirable range and to prevent any deterioration in quality. However, in other areas of the country – particularly in some major urban centres – there are significant emissions of the common air pollutants, and air quality usually falls within the fair or acceptable range. Under these circumstances a reasonable short-term goal might be to maintain air quality within the acceptable range, avert any trends toward more polluted air, and work to improve air quality over the long term.

There are several arguments to support the goal of achieving desirable rather than merely acceptable levels of air quality in Nova Scotia:

- MDCs are intended to represent a long-term management goal and to ensure that the quality of unpolluted air is not permitted to deteriorate;

- MACs may not provide long-term assurance that the health of more sensitive individuals and ecosystems will be protected adequately;
- there is uncertainty about exact threshold levels for pollutants (an exposure below which health effects do not occur), and whether a threshold even exists; and
- meeting MDC objectives will help to promote tourism and other economic opportunities in Nova Scotia if the Province gains a reputation for excellent environmental quality.

Based on these arguments, achieving the MDC for each criteria air contaminant has been seen as the ultimate goal. Depending on the current status of a specific pollutant, the short-term goal may be to meet MAC or MTC targets. Meeting these targets is a broad societal goal, and the energy sector is clearly not the only source of these pollutants in Nova Scotia or in any other jurisdiction. Both transportation and industry are often significant sources of emissions. Therefore reductions may be required in several sectors to meet air quality objectives. It may also be found that the cheapest and most cost-effective solution to meet a target is to focus, at least temporarily, on one sector.

Complicating the whole matter greatly is the fact that trans-boundary pollution is a very important factor determining air quality in Nova Scotia and must be factored into the policy and planning process. Thus, even the best and most rigorous emissions controls within Nova Scotia will have only a partial effect on ambient air quality in the Province, since air quality is largely influenced by prevailing wind patterns that carry air-borne pollutants from major population and industrial centres in central Canada, the mid-western United States, and the north-eastern seaboard. For a more detailed discussion on trans-boundary pollution and its impacts in Nova Scotia, see the GPI Air Quality report (Monette and Colman, 2004). Because the focus of this report is the Provincial energy sector and its impact, this study considers only pollutant emissions within Nova Scotia, not overall air quality in the Province.

The NAAQOs, established in the 1970s, are no longer entirely consistent with current scientific knowledge. Therefore, it should be noted that there may in fact be health risks at pollutant levels in the good and fair ranges, even though few or no effects are indicated in the literature (now 12-16 years old). In order to develop more current and binding objectives Federal, Provincial, and Territorial Environment Ministers have been involved with an ongoing process to develop common environmental standards, including quantitative standards, for protecting the environment and human health from pollutants in ambient air. These are known as the Canada-Wide Standards (CWSs). To date, CWSs exist for only a few of the criteria air contaminants therefore it was felt that the NAAQOs provided a better basis for establishing targets for air pollutants. However, for those CWSs that do exist to which Nova Scotia is a participant it must fulfill its legal obligations.

Under the Nova Scotia Environment Act, the Nova Scotia Air Quality Regulations established criteria for ambient air quality throughout the Province. These criteria are expressed as maximum permissible ground-level concentrations. The maximum permissible concentrations in parts per million and parts per billion are also presented, for comparison to NAAQOs. With the exception of the maximum permissible concentrations for ozone and TSP, each of the Nova Scotia concentrations are slightly lower than the NAAQO maximum acceptable concentrations, ranging from 1-2ppm lower for CO, and 3-5ppb lower for SO_2 and NO_2. The concentrations for TSP and ozone are equal to the NAAQO MACs for those contaminants. Both the Provincial standards and the NAAQOs are presented for each of the criteria air contaminants presented in this Chapter. The discussion of goals, however, focuses only on the NAAQOs as these have the advantage of multiple levels and are more widely recognized in Canada.

6.4 Presentation of Indicators

Indicators of pollutants that affect human health and the environment are presented in the following order: carbon monoxide, particulate matter, sulphur oxides, nitrogen oxides, volatile organic compounds, mercury, and greenhouse gases (GHG).

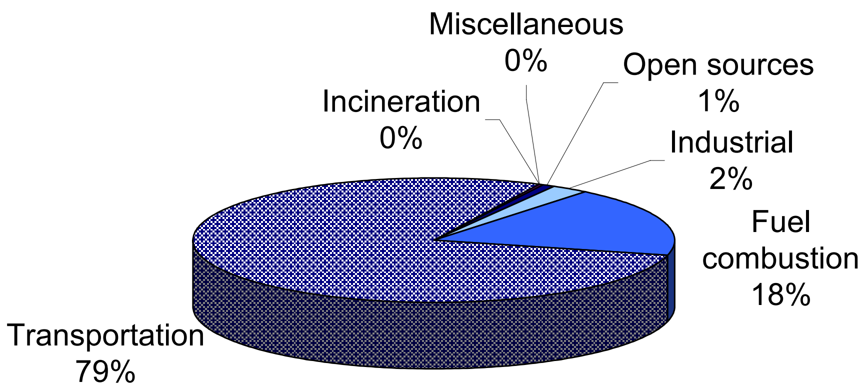
Carbon monoxide

Carbon monoxide is a colourless, odourless, and tasteless gas which is toxic to humans in sufficient concentrations. It is a product of incomplete combustion of fossil fuels and wood (i.e. any combustion process where organic material that contains carbon is burned without sufficient oxygen).

Sources

The major anthropogenic sources of CO in Canada are transportation and fuel combustion (including electricity generated from fossil fuels and residential heating such as fires, wood or gas stoves, etc.). Figure 23 illustrates the fraction of CO emissions in Nova Scotia that are attributable to each sector, and indicates that nearly 80% of CO emissions in the Province come from transportation. Total CO emissions for Nova Scotia in 2000 were 293 kilotonnes.

Figure 23. Nova Scotia CO emissions by category, 2000



Source: Environment Canada, 2005

Non-industrial fuel combustion (listed simply as 'fuel combustion' in Figure 23), includes emissions from commercial power generation, electrical utilities, and residential fuel combustion (wood, oil, natural gas, etc.). In this category, the burning of residential fuel wood contributes about 90% of emissions.

Prior to 1990, *industrial fuel combustion* was also included in the fuel combustion category, but it is now incorporated in the *industrial* category. The industrial category includes emissions resulting from a wide range of activities. In Nova Scotia, the main industrial CO emitters are the Province's three pulp and paper mills. A number of other industries contribute more marginally to CO emissions, including iron works; mines and quarries; and other wood processing facilities. *Incineration* includes a range of incineration facilities, some of which produce usable energy as a by product (i.e. heat or electricity from waste combustion).

Human health effects of carbon monoxide

The toxic effects of CO are due to its preferential combination with the heme component of red blood cells to form carboxyhemoglobin, which reduces the capacity of red blood cells to carry oxygen to tissues. Tissues with high oxygen demand are the most sensitive to the effects of CO: heart, brain, and exercising skeletal muscle.

Exposure to CO is considered most harmful to people with severe anemia, chronic lung disease (such as chronic obstructive pulmonary disease), coronary artery disease, arteriosclerosis, chronic angina, and ischemic heart disease (Health Canada, 1998; Environment Canada & Health Canada, 1994). Other risk groups include pregnant women, fetuses, newborn infants, young children and the elderly.

High levels of CO (usually occurring indoors) can result in headaches, drowsiness, and cardiac arrhythmias (any irregularity in the natural rhythm of the heart). At sufficiently high levels, CO can lead to coma and death. Studies have shown that healthy adults exposed to increased levels of CO can exhibit decreased aerobic capacity; impaired work capacity; and reduced visual perception, manual dexterity, and performance of complex sensory-motor tasks (Health Canada, 1998).

Health effects associated with relatively low-level, short-term exposure to CO include decreased athletic performance and aggravated cardiac symptoms. Small increases in CO exposure could adversely affect myocardial function and produce ischemia (a local loss of blood flow), and these effects may lack a safe threshold (Environment Canada & Health Canada, 1994). In other words, exposure to any amount of carbon monoxide may be dangerous. At the levels typically found in large cities, CO may increase hospital admissions for cardiac diseases, and there is also evidence of an association with premature death (Health Canada, 2001; Environment Canada & Health Canada, 1994).

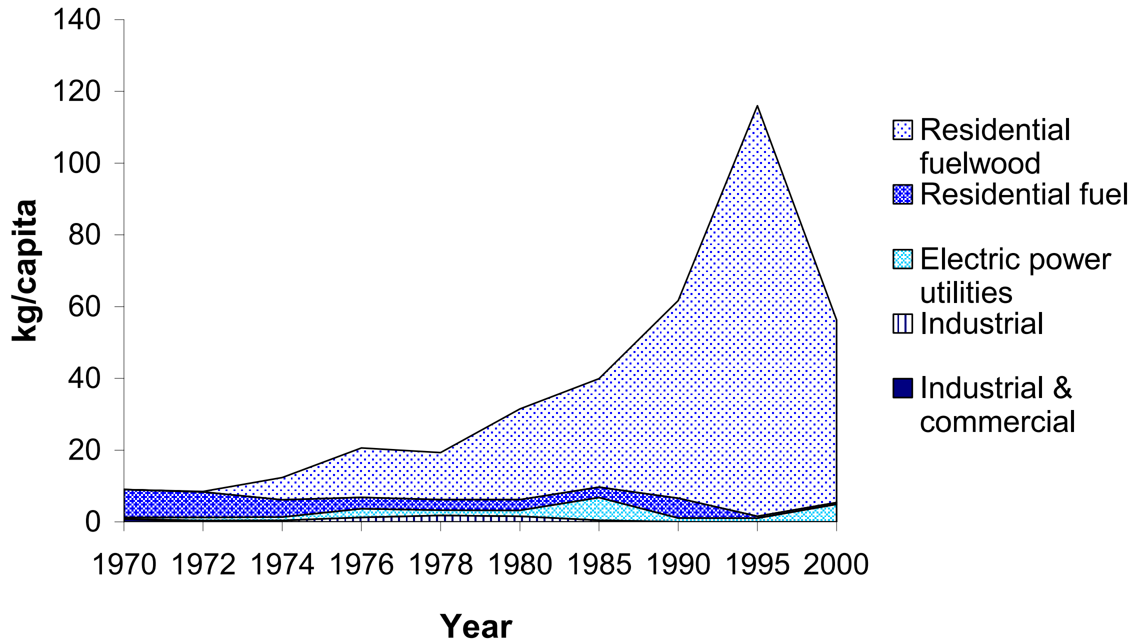
Environmental effects of carbon monoxide

Although carbon monoxide may have similar effects on wildlife (especially mammals) there has been little study of this subject. It should be noted that ambient concentrations of CO at levels likely to have health effects would most often be found in urban areas. No other significant environmental effects of CO are known.

Carbon monoxide emission trends

At first glance, it appears that carbon monoxide emissions per capita from stationary energy sources in Nova Scotia rose dramatically from 1970 to 1995 (by nearly 1,300%), but have since declined substantially. This has resulted in an apparent overall increase of 630% between 1970 and 2000 (See Figure 24).[46] Within the energy or fuel combustion category, residential fuel wood is responsible for the vast majority of these emissions, though, as noted earlier, transportation is responsible for nearly 80% of overall CO emissions. However**,** most of the apparent increase in CO emissions is really due to variability in wood usage estimates produced by Statistics Canada. 2000 figures are the most accurate for wood emission in the Province. Hopefully, current estimates are now relatively reliable and future changes in emissions will become obvious in the data.

Figure 24. Per Capita CO emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000



Note: Industrial fuel combustion emissions were only captured up to 1985. The 1990-2000 figures only represent non-industrial fuel combustion, while industrial fuel combustion is now captured in the overall emissions figures for the industrial sector (not presented in this report). Industrial fuel combustion is therefore no longer separately reported.

Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000, 2005.

[46] As in all other sections of this chapter, "energy-related emissions" and "emissions from energy sources" are here defined to exclude transportation and, after 1990, also to exclude fuel combustion in the industrial sector. Pollutant emissions attributable to transportation are separately considered in the **GPI***Atlantic* Transportation Accounts. Emissions from energy sources refer, in this report, to be those in Environment Canada's "non-industrial fuel combustion" category.

Carbon monoxide releases in Nova Scotia's stationary energy sector approximate emission levels in the rest of Atlantic Canada. However, Nova Scotia's per capita CO emissions from stationary energy sources are more than double those in the rest of Canada. This can be linked to the higher number of people using wood for heat in Atlantic Canada (See Appendix B). At 57 kg per capita, CO emissions from Nova Scotia's stationary energy sector *alone* are about half the average *total* per capita CO emissions in countries of the Organisation for Economic Co-operation and Development (OECD). If transportation emissions are included, Nova Scotia's per capita CO emissions are more than double the OECD average (Monette and Colman, 2004).

Goals and targets

Table 15. National ambient air quality objectives for CO

Pollutant	Averaging Time	Maximum desirable concentration	Maximum acceptable concentration	Maximum tolerable concentration
Carbon monoxide in parts per million (ppm)	8-hour	5	13	17
	1-hour	13	31	

Note: Blank cells indicate that there is no established objective.

Source: Health Canada, 2004.

Table 16. Health impacts of CO exposure at NAAQO concentrations

Amount	Good range (0 – maximum desirable)	Fair range (maximum desirable – maximum acceptable)	Poor range (maximum acceptable – maximum tolerable)	Very poor range (over the maximum tolerable)
Impact	No effects.	Changes in blood chemistry.	Increasing cardiovascular symptoms in smokers with heart disease.	Increasing cardiovascular symptoms in non-smokers with heart disease. Physiological stress on individuals with cardiovascular and respiratory disease. Some visual impairment. Subtle behavioural effects (central nervous system hypoxia). Possible increased mortality.

Sources: Government of Canada, 1991; Environment Canada, 1990; and FPACAQ, 1987.

Table 17. Nova Scotia standards for CO

Contaminant	Averaging Period	Maximum Permissible Ground Level Concentration		
		Micrograms per cubic meter ($\mu g/m^3$)	Parts per hundred million by volume (pphm)	ppm
Carbon Monoxide	8-hour	12,700	1,100	11
	1-hour	34,600	3,000	30

Source: GoNS, 2005b.

The Canadian and Nova Scotian standards for most pollutants, including CO, are not as stringent as those of the U.S. and Europe, as well as those of the World Health Organization (Monette and Colman, 2004). Based on the analysis by Monette and Colman (2004), it appears that the 1-hour MAC (Canadian standard of 31ppm) was not exceeded in Nova Scotia at any sampling stations during the periods for which data are available. However, the MDC was exceeded.

Based on the earlier discussion of goals and the fact that CO concentrations were below the 1-hour MAC at all Nova Scotia sampling stations, this study proposes that lowering levels to not exceed the MDC should be the medium-term goal of the next 10-15 years. The short-term goal should be to ensure adequate ambient air quality monitoring throughout the Province, reversing a decade of decline in monitoring. For the long term, the Province should stay abreast of new international standards that are more rigorous than those currently used here, ensuring that ambient air quality standards reflect the best knowledge available. This applies to all forms of pollutants.

For CO in particular, the evidence indicates that particular attention needs to be paid in Nova Scotia to regulating residential wood heating (which produces 90% of energy-related CO emissions in the Province) to ensure that wood combustion occurs only in the most efficient and least polluting stoves that are certified to operate according to the highest standards. Rebate and incentive programs can be introduced to encourage shifts to state of the art woodstoves with advanced emission control technologies. Because most air pollution from wood-burning appliances results from incomplete burning of the wood and smoke, both of which waste energy, advanced combustion stoves with catalytic combustors not only burn combustible gases and particulates before they leave the chimney, thereby reducing pollution, but they also increase energy efficiency and save on wood use. For fireplaces, high efficiency inserts can also improve efficiency and reduce pollution (USDOE, 2004b). Realistic interim targets for Nova Scotia are to reduce energy-related per capita CO emissions first to the Canadian level (less than half present NS levels) and then to the OECD level.

Particulate matter

Airborne particulate matter (PM) is any aerosol that is released to the atmosphere in either solid or liquid form and that can be inhaled into the respiratory system. This includes particles such as dust, soot, ash, fibre, and pollen. PM can be relatively larger or smaller, and is generally classified in three categories according to diameter: less than 2.5 micrometres (µm); greater than

2.5 µm but less than 10µm; and total particulate matter (denoted as $PM_{2.5}$, PM_{10}, and TPM, respectively). The largest particles, with diameters larger than about 10µm, settle soon after being emitted from a source (Health Canada, 1998). Smaller particles—less than or equal to 10µm—can remain suspended in the air for long periods of time, and are now believed to cause much more serious health problems than the larger particles.

Sources

The principal sources of anthropogenic PM emissions are open sources, industrial processes, fuel combustion, transportation, and solid wastes in that order. The sources of Nova Scotia particulate matter in 2000 are presented in Figure 25 and Figure 26. Excluding open sources PM emissions were 38 kilotonnes in 2000; with open sources included they amounted to 392 kilotonnes.[47]

Figure 25. Nova Scotia TPM emissions, 2000, by category (excluding open sources)

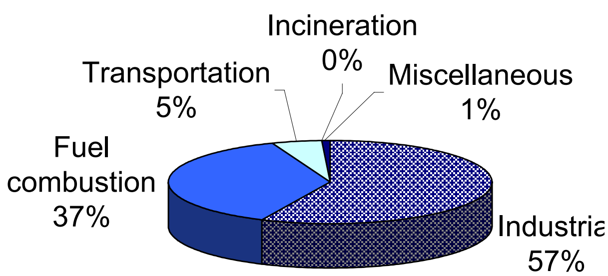
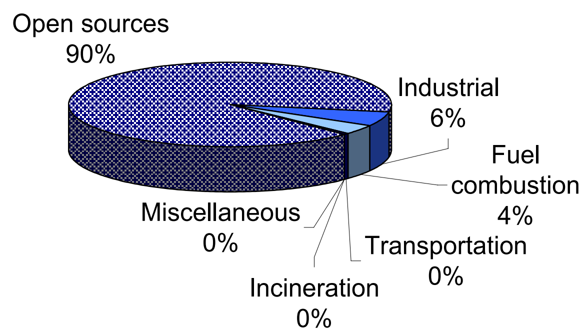


Figure 26. Total Nova Scotia TPM emissions, 2000, by category (including open sources)



Note: Fuel combustion above refers to non-industrial fuel combustion, which includes electric power generation (utilities), residential fuel and fuel wood combustion, and commercial fuel combustion. It excludes industrial fuel combustion, which is included in the "industrial" category but not separately reported.

Source: Environment Canada, 2005.

The main industrial sources of particulate matter in Nova Scotia are mining and quarrying; road paving; and the pulp and paper industry. TPM from vehicles and braking is a fairly minor source, with heavy-duty diesel vehicles responsible for the largest portion. The largest source of PM in the fuel combustion category is residential fuel wood (56%).

[47] Open sources include agriculture, roads, forest fires, landfills, and mine tailings. Prior to 1995, open sources were not included in emissions estimates. Dust from paved and unpaved roads is, by far, the largest source of PM. If included, open sources account for 90% of PM emissions in Nova Scotia. Road impacts are included in **GPI***Atlantic*'s transportation report and PM from roads is therefore covered in that study (see Walker et al, 2005). Figure 25 excludes open sources to give a better picture of the other sources of PM. Fuel combustion—in particular, home heating—is a priority source because it is linked to indoor air quality, an important determinant of health.

Human health effects of particulate matter

There are several mechanisms by which inhaled PM can exert a toxic effect on humans (Health Canada, 1998; Smith and Sloss, 1998; NSDE, 1987):

- Particles may be intrinsically toxic due to inherent chemical and/or physical characteristics.
- Particles may interfere with one or more of the clearance mechanisms in the respiratory tract, which can lead to other pollutants having a greater than normal effect.
- Particles may act as carriers of an absorbed (attached) toxic substance.
- Free radical activity on the surface of particles causes an increase in surface area, which may compromise epithelial integrity and lead to uptake of particles into the interstitium.
- PM is associated with strong aerosol acidity (the number of acid or acid-coated particles, and the total acid dose to a cell).
- Particles may interact with other pollutants in the air and act synergistically (i.e., the effect of two or more contaminants acting together may be greater than the sum of the effects attributable to each contaminant separately).

The finer the particulate matter, the greater the health risk. In fact, PM_{10} and $PM_{2.5}$ are considered to be "toxic" under the 1999 *Canadian Environmental Protection Act* (CEPA) (Environment Canada and Health Canada, 2000). This is because finer particles can travel deep into the lungs causing increases in chronic cough and bronchitis and restrictions during respiratory-related activity (Environment Canada and Health Canada, 1999a). PM has also been correlated with elevated mortality rates from cardiovascular and respiratory diseases. Long-term $PM_{2.5}$ exposure has been significantly associated with cardiopulmonary and lung cancer mortality. These health problems also inevitably increase the numbers of lost work days and school absences, leading to a depreciation of human capital and declines in economic productivity. They also lead to more visits to doctors' offices and emergency rooms, increase hospital admissions of people with cardiac and respiratory disease, and shorten the lifespan of some individuals (Health Canada, 2001; OMA, 2000; Environment Canada and Health Canada, 1999a).

Groups that are particularly susceptible to the effects of PM include the elderly, those with chronic pulmonary or cardiovascular disease, the very young, asthmatics, smokers, and people with respiratory infections or bronchitis.

Short-term exposure to airborne PM is associated with a variety of adverse effects, including eye, nose and throat irritation, breathing difficulties, reduced lung function, and worsening of asthma symptoms. PM may cause a wide spectrum of immunological disorders, and can aggravate lung infections, possibly by reducing the body's ability to fight infection (OMA, 1998).

Long-term exposure to PM is associated with decreased lung function and increased mortality rates. Longer term, sub-chronic, or chronic exposures have been associated with increases in mortality, respiratory disease symptoms, and a decline in lung function (Environment Canada and Health Canada, 1999a). The risk of developing respiratory tract cancers may increase with long-term exposure. Particulates may contain mutagenic and carcinogenic compounds, or these compounds may be attached to the particulate surfaces. Particles containing polycyclic aromatic hydrocarbons, nitrosamines, and nitroaromatics have been linked to respiratory cancer (Health Canada, 1998).

Environmental effects of particulate matter

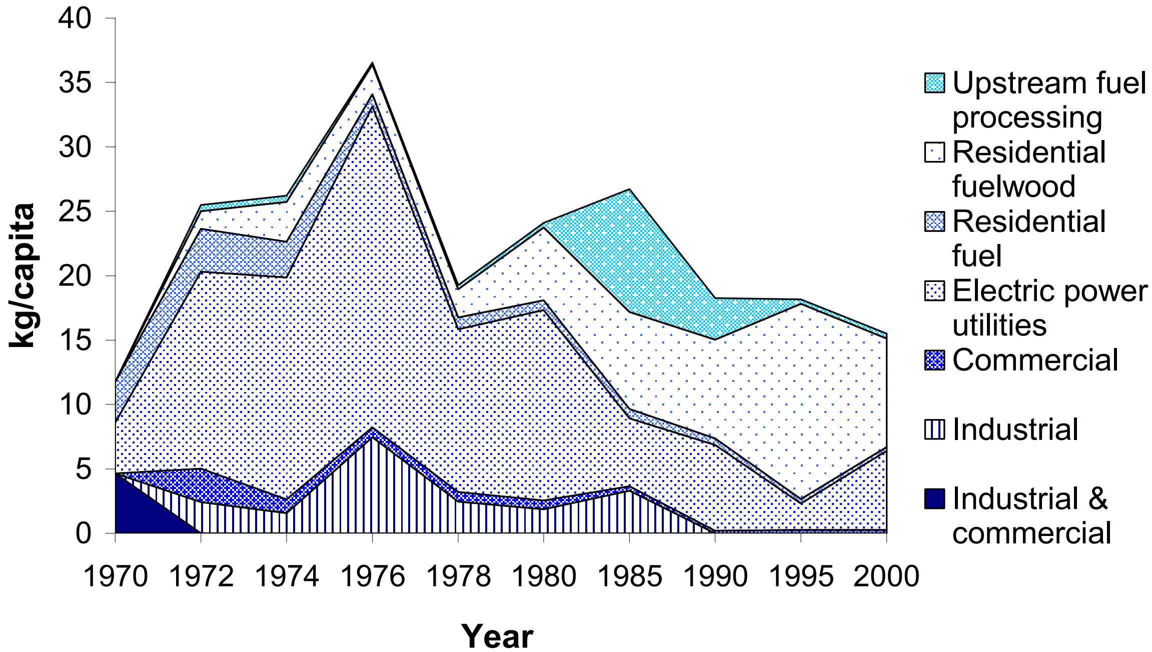
PM can affect vegetation by physical smothering of the leaf surface, physical blocking of stomata, and inducing a chemical effect due to particle composition. Indirect effects include disturbances of soil pH and ionic composition; nutrient imbalances through particle deposition to soils; and reduced light intensity due to particle loads in air (USEPA, 2002). Particle accumulation on the leaf surface causes reduced light transmission, affecting photosynthesis, and may increase the plant's susceptibility to disease (Environment Canada and Health Canada, 1999a).

The effects of PM on materials have been investigated for metals, wood, stone, painted surfaces, electronics, and fabrics. The deposition of PM on these materials may cause soiling and discoloration, thus reducing their aesthetic appeal and necessitating cleaning and repainting. The presence of PM has been linked to enhanced speed of corrosion on metal surfaces; altered paint durability; accelerated stone corrosion; and corrosion and failure of electronics (Environment Canada and Health Canada, 1999a).

Particulate matter emission trends

Total particulate matter emissions from Nova Scotia's stationary energy sector have been decreasing. From a 1976 peak of 37 kg per capita, emissions have decreased since then by 60%. Electric power generation appeared to be the main source of stationary energy-related PM emissions from the 1970s to early 1980s, but, as technology in the industry improved, emissions decreased substantially. The proportions and total PM emissions from stationary energy sources shown in Figure 27 below are also likely to be somewhat distorted for the 1970s and 80s due to poor estimates of residential fuelwood emissions. As better estimates of fuel wood combustion emissions have been developed (2000 figures), it is now clear that the primary source of stationary energy-related PM emissions in the Province is actually wood burning, with electricity a close second.

Figure 27. Per Capita TPM emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000



Note: Industrial fuel combustion emissions were only captured up to 1985. The 1990-2000 figures only represent non-industrial fuel combustion, while industrial fuel combustion is now captured in the overall emissions figures for the industrial sector (not presented in this report). Industrial fuel combustion is therefore no longer separately reported.

Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000, 2005.

Nova Scotia's stationary energy-related PM emission rate is comparable to those in the rest of the Atlantic Provinces. Fuel wood combustion is the main stationary energy source of PM emissions in Atlantic Canada overall, even more so than in Nova Scotia specifically. Nova Scotia's PM emissions levels from stationary energy use, however, are considerably higher than those elsewhere in Canada (See Appendix B). Nova Scotia's per capita PM releases from stationary energy sources *alone* exceed the per capita PM emissions from *all sources* in most OECD countries (Monette and Colman, 2004).

Goals and targets

Table 18. National ambient air quality objectives for PM

Pollutant	Averaging Time	Maximum desirable concentration	Maximum acceptable concentration	Maximum tolerable concentration
Suspended particulates (μg/m^3)	annual	60	70	
	24-hour		120	400

Note: Blank cells indicate that there is no established objective.

Source: Health Canada, 2004

The Canada-wide Standards for PM was agreed to by the Canadian Council of Ministers of the Environment in 2000. The standard for $PM_{2.5}$ is a maximum average concentration of 30 micrometers per cubic meter per 24-hour period, to be achieved by 2010. $PM_{2.5}$ is the smallest and most health damaging size of particulate matter. However, it is only a portion of the emissions.

Table 19. Health impacts of PM exposure at NAAQO concentrations

Amount	Good range (0 – maximum desirable)	Fair range (maximum desirable – maximum acceptable)	Poor range (maximum acceptable – maximum tolerable)	Very poor range (over the maximum tolerable)
Impact	No effects.	Decreased visibility.	Increased frequency and severity of lower respiratory disease in children; soiling evident.	Increasing sensitivity in patients with asthma and bronchitis.

Sources: Government of Canada, 1991; Environment Canada, 1990; and FPACAQ, 1987.

Table 20. Nova Scotia standards for PM

Contaminant	Averaging Period	Maximum Permissible Ground Level Concentration		
		μg/m^3	pphm	ppm
Total Suspended Particulate	Annual	70		
	24-hour	120		

Note: Blank cells indicate that there is no established objective.

Source: GoNS, 2005b.

Based on Monette and Colman's work (which covers 1984-1995), it is apparent that there were numerous instances when the MAC objective for PM in Nova Scotia was exceeded. The number of exceedances has declined in recent years, although it should be noted that the number of monitoring stations is also decreasing, so that some records may be less reliable. Moreover the PM standards for Nova Scotia and for Canada are below that of the U.K., U.S., and the World Health Organization (Monette and Colman, 2004:53).

Based on the earlier discussion of objectives and the fact that PM concentrations did exceed MAC objectives on a number of occasions, it is recommended that keeping PM levels below the MAC should be a minimum short-term target. Furthermore the Province needs to keep it's commitment to achieve the CWS standard for $PM_{2.5}$ of a maximum average concentration of 30 micrometers per cubic meter per 24-hour period, to be achieved by 2010. Current $PM_{2.5}$ monitoring indicates that the Province is meeting this objective in all areas of the Province except over Sable Island where ambient levels exceeded this target in 2002 (Environment Canada, 2005e). The medium-term goal should be to meet MDC objectives throughout the Province, although it must be acknowledged that even the most rigorous and effective Nova Scotian actions will not ameliorate the impact of transboundary pollution, and that achievement of MDC objectives is not up to Nova Scotia alone. Nevertheless, to do its part, in the long term the Province should seek to stay abreast of new emissions and ambient air quality standards and of research on the health and environmental impacts of PM and other pollutants, to help ensure that ambient air quality standards and practices in the Province reflect the best knowledge available.

Because residential fuelwood combustion is the primary source of energy-related PM emissions, the specific recommendations in the previous section on improving wood stove and fireplace combustion efficiency are equally relevant here, and constitute the primary means by which the Province can reduce energy-related PM emissions. In addition to the regulations, incentives and rebates that can hasten the adoption of more efficient and less polluting woodstoves and fireplaces, there is also a real need for education and public awareness campaigns to reach the large portion of Nova Scotians who use wood for heat. As above, realistic interim targets for Nova Scotia are to reduce energy-related per capita PM emissions first to the Canadian level and then to the OECD level.

In order to ensure that Provincial PM emissions as a whole continue to decline, and in order to track progress towards this goal, monitoring of both ambient air quality and emissions in the Province, including PM, must be improved to establish a representative database for the Province. As noted, monitoring has declined in recent years as a result of budget cuts. An interim goal is to restore earlier levels of monitoring, and a longer-term goal is to exceed previous reporting standards, always with a view to both temporal and spatial comparability.

Sulphur oxides

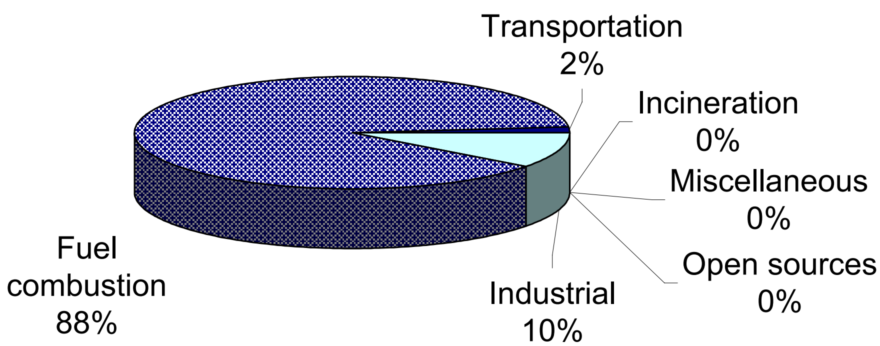
Sulphur dioxide (SO_2) is a colourless gas with a pungent odour that combines easily with water vapour in air to form sulphurous acid (H_2SO_3). It will unite with oxygen in the air to form the more corrosive sulphuric acid (H_2SO_4). Sulphur forms a number of oxides but only SO_2 and sulphur trioxide (SO_3) are important as gaseous air pollutants. Usually, only a small amount of

SO_3 accompanies SO_2, and together the two are designated as sulphur oxides (SO_x). Sulphate aerosols (SO_4), which are an important pollutant affecting people's health, are reported by Environment Canada as particulate matter (Environment Canada, 2005; Venema and Barg, 2003).

Sources

SO_2 is generally a by-product of the burning of fossil fuels and of industrial processes. Ore smelting, coal-fired electricity generation, petroleum refining, pulp and paper mills, incineration, and natural gas processing are the main sources of SO_2 emissions in Canada (Health Canada, 1998; Environment Canada, 2002a). Sources of Nova Scotia's SO_x emissions in 2000 are presented by category in Figure 28. Electricity generation (mostly coal-fired) is the main source in the Province (84% of all emissions). Nova Scotian SO_x emissions totalled 166 kt. Because of Nova Scotia's heavy reliance on coal-fired electricity, the Province's per capita SO_x emissions are among the highest in the world.

Figure 28. Nova Scotia SO_x Emissions by Category, 2000



Note: Fuel combustion above refers to non-industrial fuel combustion, which includes electric power generation (utilities), residential fuel and fuel wood combustion, and commercial fuel combustion. It excludes industrial fuel combustion, which is included in the "industrial" category but not separately reported.

Source: Environment Canada, 2005.

The Province's pulp and paper mills are the main sources of SO_x in the industrial category while marine transport (very low grade fuel) and heavy-duty diesel vehicles are the dominant transportation sources.

Human health effects of sulphur oxides & acid deposition

It is currently believed that SO_2 in ambient air will not produce adverse effects in healthy individuals. However, there is some evidence that exposure to elevated SO_2 levels may increase the incidence of premature death in susceptible populations (Health Canada, 2001a, 1998). At lower levels of exposure, hypersensitive individuals, particularly asthmatics and persons with lung disease, may also experience breathing difficulties. Eye irritation, shortness of breath, and reduction of lung function can also result from SO_2 exposure. Groups that are particularly sensitive to SO_2 exposure include people with asthma who are active outdoors, children, the elderly, and people with heart or lung disease (USEPA, 2002a).

Sulphur dioxide is best known for the role it plays in secondary air pollution, like acid rain and smog. Acid rain, a product of SO_x and NO_x emissions, has been deemed a health hazard. Sulphur dioxide is very soluble in water and when inhaled it will rapidly dissolve in the secretions covering the cells of the upper respiratory tract (nose, mouth, throat, trachea, and bronchi). At relatively high levels of exposure this causes tissue irritation and congestion (FPACAQ, 1987). Sulphur dioxide is important in sulphate formation, a key element of urban smog. Significant associations have been found between elevated sulphate levels and an increase in the number of acute care respiratory hospital admissions (Health Canada, 1998). Exposure to sulphate particles is also associated with a higher incidence of premature death (USEPA, 2002a).

Environmental effects of sulphur oxides

As mentioned, the acidifying effects of sulphur oxides have numerous consequences. Elevated acidity in the environment due to anthropogenic releases of sulphur oxides over the last half century has caused materials damage (to old buildings and historic sites for example); damage to crops; changes in forest productivity (damage to foliage and changes to soil nutrient regimes); and acidification of water, which causes changes in fish species and aquatic productivity, and in the species that prey upon them, culminating in changes to biodiversity (Monette and Colman, 2004). Wilson (2000) summarizes numerous studies that show significant changes to water chemistry in the Maritimes and substantial declines in Atlantic salmon populations that may be due in large part to acidification.

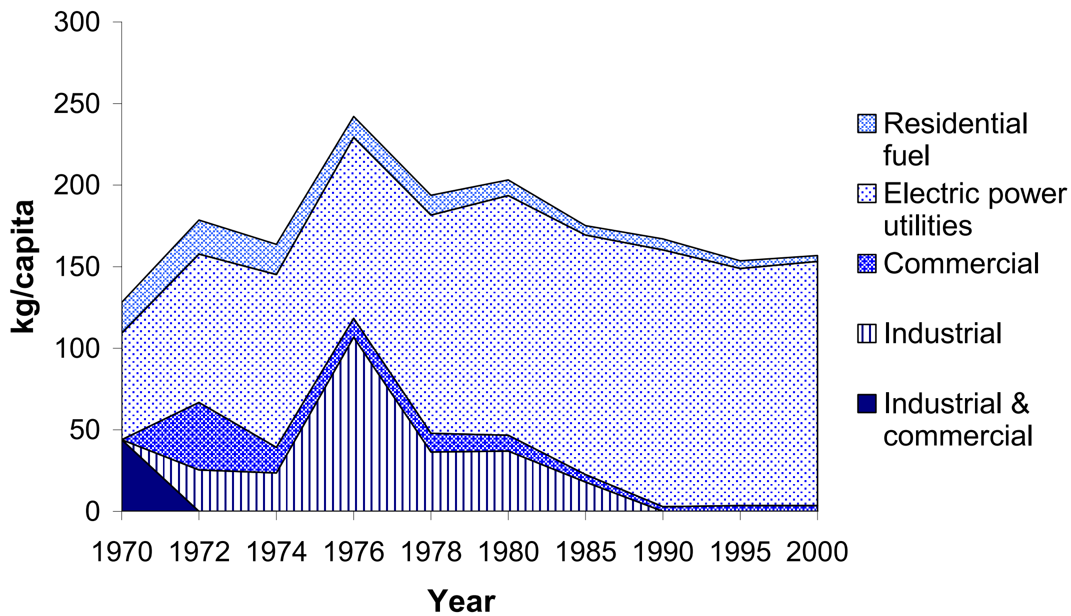
Acid rain is a generic term used for precipitation that contains a high concentration of sulphuric and nitric acids (H_2SO_4 and HNO_3). These acids form in the atmosphere when SO_x and NO_x emissions combine with water in air (Environment Canada, 2002b). When the environment cannot neutralize the acid being deposited, damage can occur. Unfortunately, eastern Canada, and the South Shore of Nova Scotia in particular, are highly sensitive to acid rain (Environment Canada, 2002a, 1998). In these areas, water and soil systems lack natural alkalinity—such as an adequate lime base—and therefore cannot neutralize or "buffer" against acid rain naturally. Though substantial reductions in SO_x and NO_x emissions have been achieved in both the U.S. and Canada, partly as a result of bilateral agreements between the two countries, many areas of the Atlantic Provinces and of Nova Scotia in particular (both aquatic and terrestrial environments) continue to receive more acid deposition than they can buffer (NEIS, 1999). This is referred to as critical load exceedance.

Sulphur oxide emission trends

The overall trend for Provincial sulphur oxide emissions from stationary energy use since the mid 1970s has been positive (with a 35% decline since 1976). However, stationary energy-related SO_x emissions have increased slightly since 1995 (Figure 29). Electric power generation in Nova Scotia, the major source of SO_x emissions, relies heavily on coal, which is the main reason why Provincial sulphur oxide emissions remain so high. Power generation has also been increasing in the Province to meet higher demands, which makes steps to decrease SO_x emission more challenging. In recent years some NSPI facilities have been retrofitted to meet proposed targets for reduced SO_x emissions. This goal is part of Nova Scotia's 2001 energy strategy to reduce SO_x emissions by 25% from "current" levels by 2005 (NSPD and NSDNR, 2001:35).[48] The 25% reduction stipulated is to be achieved using legislated caps for certain large emitters (mainly NSPI). These new limits became effective in 2005. Results in the third quarter of 2005 show that emissions were 71% compared to the third quarter in 2004 (Atwell, 2005).

Nova Scotia per capita SO_x emissions from stationary energy sources are ***seven times*** the level of the rest of the country (See Appendix B). Per capita SO_x emissions from *stationary energy* sources alone in Nova Scotia are ***four times*** higher than the OECD average *total* SO_x emissions from all sources.

Figure 29. Per Capita SO_x emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000



Note: Industrial fuel combustion emissions were only captured up to 1985. The 1990-2000 figures only represent non-industrial fuel combustion, while industrial fuel combustion is now captured in the overall emissions figures for the industrial sector (not presented in this report). Industrial fuel combustion is therefore no longer separately reported.

Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000, 2005.

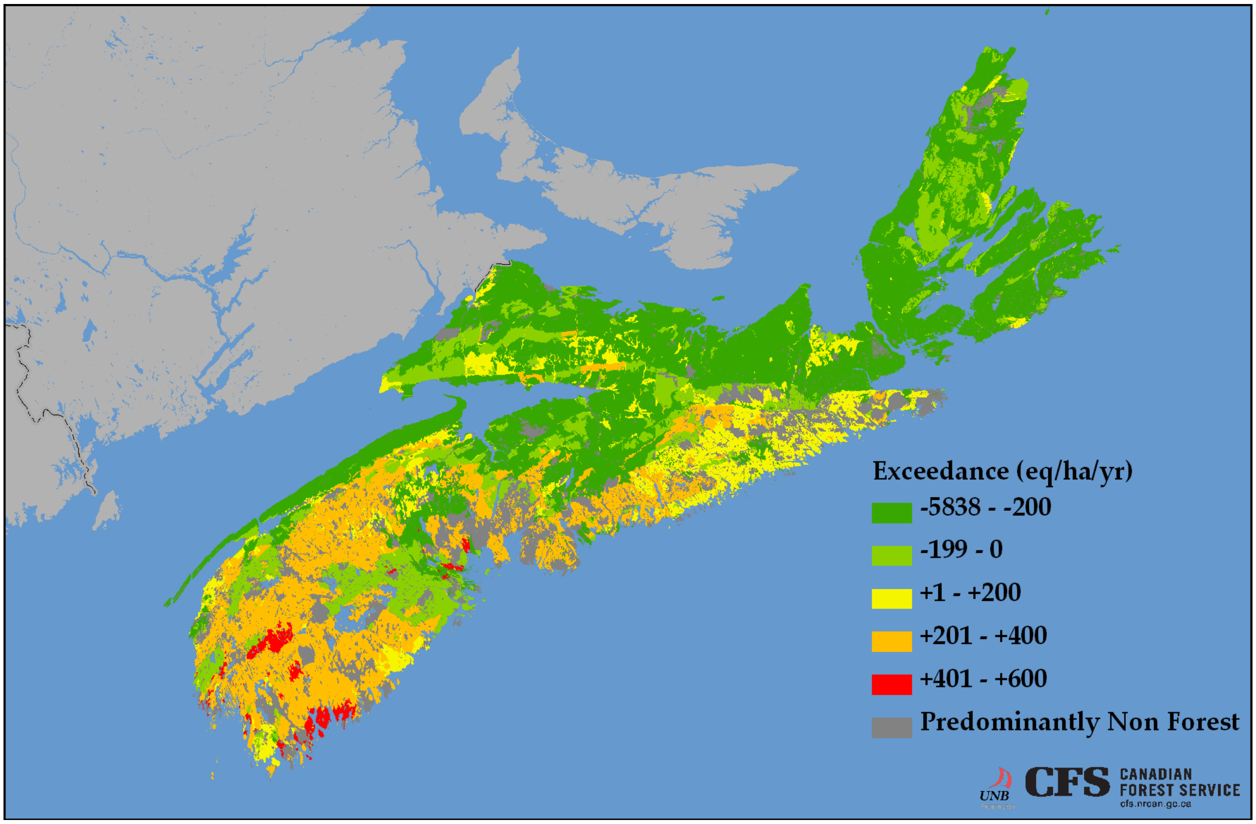
Critical load exceedance

A key consideration when setting targets for reduced acid precipitation is to limit the amount of land and water where critical loads are exceeded. According to Beattie and Keddy (1996), the critical load for much of the Atlantic region is less than 8 kg of acidic deposition per hectare per year (kg/hectare/year), while the critical load target for reductions is set at less than 20

[48] "Current" is understood to mean the year the Nova Scotia Energy Strategy was released, 2001.

kg/ha/year (Environment Canada, 2003a).[49] Projections indicate that the Atlantic region will continue to receive deposition greater than 8 kg/ha/year even after legislated emission reductions come into effect. Although further reductions have occurred in many parts of North America, recent work by Arp and DeMerchant (2005) on critical loads in eastern Canada indicates that large areas are still acidifying. Despite reductions in acid raid depositions in the 1980s and 1990s, the critical load is still exceeded in a large portion of Nova Scotia. This is shown in Figure 30, where the colors yellow to orange indicate exceedance. This information is to be included in Environment Canada's upcoming National Acid Rain Assessment.

Figure 30. Critical load exceedance in the Maritimes, late 1990s



Note: Positive values indicate that a location is receiving more acid deposition than it can buffer, or the critical load is being exceeded and therefore the location is being damaged.

Source: Arp and DeMerchant, 2005.

[49] Acid deposition is measured in similar fashion as fertilizer applications to agricultural land. 20kg/ha/yr means that each hectare of area (be it forested, agricultural, urban or water) is receiving 20 kilograms of acidifying substances each year. Land can naturally buffer some acidic deposition; however, this ability is limited. In the Atlantic region the ability of land to buffer acid deposition is low, in many places the land can only buffer 8 kg/ha/yr. If the land receives more acid deposition than 8kg/ha/yr the soil acidifies.

Goals and targets

Table 21. National ambient air quality objectives for sulphur dioxide

Pollutant	Averaging Time	Maximum desirable concentration	Maximum acceptable concentration	Maximum tolerable concentration
Sulphur dioxide (ppb)	annual	11	23	
	24-hour	57	115	306
	1-hour	172	334	

Note: Blank cells indicate that there is no established objective.

Source: Health Canada, 2004

Table 22. Health impacts of sulphur dioxide exposure at NAAQO concentrations

Amount	Good range (0 – maximum desirable)	Fair range (maximum desirable – maximum acceptable)	Poor range (maximum acceptable – maximum tolerable)	Very poor range (over the maximum tolerable)
Impact	No effects.	Increasing injury to some species of vegetation. Worsening of respiratory disease with combined exposure to smoke.	Odorous. Increasing sensitivity in patients with asthma and bronchitis. Increased mortality in elderly with combined exposure to smoke.	Hypertensive and asthmatic individuals may experience breathing difficulties. Increased morbidity.

Sources: Government of Canada, 1991; Environment Canada, 1990; and FPACAQ, 1987.

Table 23. Nova Scotia standards for sulphur dioxide

Contaminant	Averaging Period	Maximum Permissible Ground Level Concentration		
		$\mu g/m^3$	pphm	Parts per billion (ppb)
Sulphur Dioxide	Annual	60	2	20
	24-hour	300	11	110
	1-hour	900	34	340

Source: GoNS, 2005b.

The 24-hour MAC (344ppb) was exceeded twice at CFB Shearwater, in 1993, and eight times at South Street, Glace Bay, in 1988 (Monette and Colman, 2004). Environment Canada (2003a) reports that between the early 1980s and the early 90s, “the area of eastern Canada receiving more than 20 kg/ha/yr of sulphate in rain and snow had declined by 61%." Despite such progress, critical load exceedances continue to occur in large areas of eastern Canada, and particularly in Nova Scotia.

Therefore, further sulphur oxide emissions reductions are clearly needed – both in Nova Scotia, and in Canada as a whole, as well as in the United States. Although Nova Scotia has extraordinarily high levels of sulphur oxide emissions due to its heavy reliance on coal-fired electricity generation, acid rain depositions in Nova Scotia are largely the result of transboundary pollution, so emission reductions must occur far more widely than in this Province alone if acid rain damage is to be reduced.

In the mid-1990s scientists estimated that a further 75% drop in sulphur dioxide emissions would be needed in targeted regions of eastern Canada and the U.S. in order to protect all areas currently vulnerable to acid rain damage. In response to this, Nova Scotia agreed to bring SO_x emissions to 25% below 2001 levels by 2005 (which appears will happen); and to 50% below 2001 levels by 2010. In order to address acid deposition issues, NO_x must also be considered. Nova Scotia has therefore also committed to reducing NO_x emissions by 20% below 2000 levels by 2009. These decreases will be achieved largely by alterations to industrial and commercial boilers, more stringent fuel standards, and through changes at Nova Scotia Power facilities. In the longer term, possibly the only way to reduce Nova Scotia's own excessive energy-related SO_x and NO_x emissions and to bring per capita emissions down to Canadian and then OECD levels is to reduce the current reliance on coal-fired electricity generation.

These goals cover the short to medium term. In the long term, emission targets for both NO_x and SO_x – in Nova Scotia as in the rest of Canada and the U.S. – should be set so that there are no critical load exceedances on land or water in eastern Canada. This may seem like an ambitious target, but it should be noted that damaged ecosystems will only have a chance to recover (albeit perhaps never to their historic state) when critical loads are no longer exceeded. Even with no exceedances, areas will still continue to receive acidic deposition that will retard recovery.

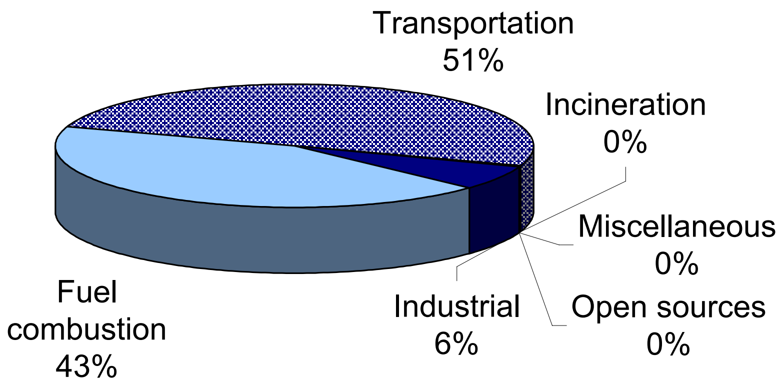
Nitrogen oxides

Nitrogen oxides (NO_x) is a generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying amounts. Many of the nitrogen oxides are colourless and odourless. Nitric oxide (NO) and nitrogen dioxide (NO_2) are the most significant air pollutants in this class of compounds (Health Canada, 1998). Nitrogen dioxide is a reddish brown gas with a characteristic pungent odour. In the presence of sunlight these substances can transform into acidic air pollutants such as nitrate (NO_3^-) and nitric acid (HNO_3) particles. Nitrogen oxides play a key role in the formation of ground level ozone and smog.

Sources of nitrogen oxide emissions

In Nova Scotia—as in Canada generally—the main anthropogenic sources of NO_x are the combustion of fuels in motor vehicles and in industrial and electrical-utility boilers (Environment Canada, 2002a). Figure 31 shows the contribution of emissions by category. Various industrial processes and residential and commercial furnaces also produce NO_x emissions. Nova Scotia nitrogen oxide emissions in 2000 totalled 71 kilotonnes.

Figure 31. Nova Scotia NO_x Emissions by Category, 2000



Note: Fuel combustion above refers to non-industrial fuel combustion, which includes electric power generation (utilities), residential fuel and fuel wood combustion, and commercial fuel combustion. It excludes industrial fuel combustion, which is included in the "industrial" category but not separately reported.

Source: Environment Canada, 2005.

Human health effects of nitrogen oxides

Of the nitrogen oxides, NO and NO_2 have the most direct impact on human health, with NO_2 the more significant of the two (Health Canada, 1998). Prolonged exposure to high concentrations of NO_x can affect the body's ability to defend itself against bacterial and viral infection, and is associated with an increased incidence of respiratory illness (Health Canada, 1997). Nitric acid and related particles can affect the human respiratory system, making breathing difficult, damaging lung tissue, and causing premature death (USEPA, 2002b). These small particles can also penetrate deeply into sensitive parts of the lungs and cause or worsen respiratory diseases such as asthma, emphysema, and bronchitis. They may also aggravate existing heart disease. Children, the elderly, and people with asthma and chronic obstructive pulmonary disease may be at increased risk of suffering the adverse health effects of NO_x (USEPA, 2002b; Health Canada, 2001).

In air, NO_x react with common organic chemicals to form a variety of toxic products (e.g., the nitrate radical, nitroarenes, and nitrosamines), some of which may cause biological mutations (USEPA, 2002b). However, the greatest concern with NO_x emissions is the role they play in the formation of ground-level ozone and smog. These two secondary pollutants have been linked to more serious health concerns relating to respiratory and cardiovascular illnesses and premature death (OMA, 2000).

Environmental effects of nitrogen oxides

The principal environmental effect of nitrogen oxides is their role in producing acid rain. The impacts of acid deposition are described in the section on the *Environmental Effects of Sulphur Oxides* above.

NO and NO_2 both contribute to the formation of acidic precipitation, which can damage water bodies and affect the growth and health of forests (see Section 3.3 and Sulphur Oxides above). Excessive nitrogen deposition can also harm forests in other ways: vigorous growth, stimulated by nitrogen fertilization, may result in nutrient deficiency; nitrogen compounds can alter physiological and anatomical development; and excessive nitrogen can increase the susceptibility of trees to freezing or dessication in winter. Increased nitrogen loading in water bodies also accelerates "eutrophication," which leads to oxygen depletion, and reduces fish and shellfish populations. (MacKenzie & El- Ashry, 1989).

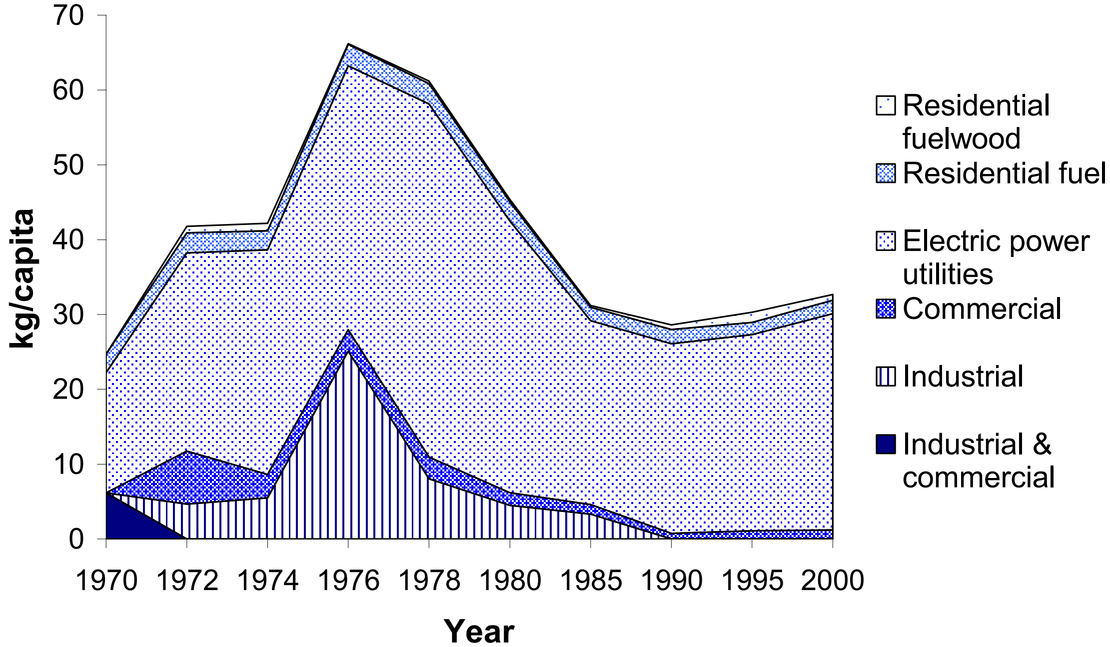
NO_2 can affect visibility since it is an intensely-coloured gas, and absorbs light over the entire visible spectrum. Nitrate particles can also block the transmission of light, reducing visibility (USEPA, 2002b). NO_x exposure can cause the corrosion of metals, fading of fabric dyes, and degradation of textile fibres, rubber products, and polyurethanes.

Nitrous oxide (N_2O) is a greenhouse gas (GHG) and can accumulate in the atmosphere with other GHGs, such as carbon dioxide (CO_2), affecting the global climate system. N_2O has 310 times the ability of an equivalent amount of CO_2 to trap heat and thus has a correspondingly greater potential, on a per unit basis, to enhance the greenhouse effect (Monette and Colman, 2004).

Nitrogen oxides emissions trends

Between 1976 and 1990, per capita NO_x emissions from stationary energy sources in Nova Scotia decreased 56% (Figure 32). Since 1990, stationary energy-related NO_x emissions have risen 14%. Reductions in the late 1970s were due to large decreases in industrial fuel combustion sources (which were included in the fuel combustion category up to 1985) and due also to reductions in utility emissions. In the 1980s and 1990s stationary energy-related NO_x emissions stabilized and then slowly began to increase due to increased power generation rates and the continuing use of coal to generate electricity. The 2001 Provincial energy strategy has committed Nova Scotia Power to a 20% reduction in NO_x emissions below 2000 levels by 2009 (NSPI, 2004). As Figure 31 demonstrates, electric power generation accounts for almost all nitrogen oxide emissions from stationary energy sources in Nova Scotia.

Figure 32. Per capita NO_x emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000



Note: Industrial fuel combustion emissions were only captured up to 1985. The 1990-2000 figures only represent non-industrial fuel combustion, while industrial fuel combustion is now captured in the overall emissions figures for the industrial sector (not presented in this report). Industrial fuel combustion is therefore no longer separately reported.

Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000, 2005.

Nitrogen oxide emissions from stationary energy sources in the Province continue to be higher than in the rest of Canada. Per capita emissions in Nova Scotia are 20% greater than for the Atlantic region as a whole, and about three times the Canadian average (Appendix B). This is due to the heavy reliance on coal for electric power generation. At 33 kg per capita, emissions of nitrogen oxides in Nova Scotia from stationary energy sources alone nearly match the average per capita nitrogen oxide emissions for OECD countries from all sources including transportation (the largest source of NO_x emissions) (Monette and Colman, 2004).

Goals and targets

Table 24. National ambient air quality objectives for nitrogen dioxide

Pollutant	Averaging Time	Maximum desirable concentration	Maximum acceptable concentration	Maximum tolerable concentration
Nitrogen dioxide (ppb)	annual	32	53	
	24-hour		106	160
	1-hour		213	532

Note: Blank cells indicate that there is no established objective.

Source: Health Canada, 2004

Table 25. Health impacts of nitrogen dioxide exposure at NAAQO concentrations

Amount	Good range (0 – maximum desirable)	Fair range (maximum desirable – maximum acceptable)	Poor range (maximum acceptable – maximum tolerable)	Very poor range (over the maximum tolerable)
Impact	No effects.	Odorous. No known human health effects.	Increased rate of respiratory illness from long-term exposure. Increasing bronchial reactivity in asthmatics. Atmospheric discoloration.	Increasing sensitivity in patients with asthma and bronchitis.

Sources: Government of Canada, 1991; Environment Canada, 1990; and FPACAQ, 1987.

Table 26. Nova Scotia's standards for nitrogen dioxide

NO_2	Averaging Period	Maximum Permissible Ground Level Concentration		
		$\mu g/m^3$	pphm	ppb
	annual	100	5	50
	1-hour	400	21	210

Source: GoNS, 2005b.

The 24-hour MAC (213ppb) was not exceeded at any Nova Scotian sampling sites during the periods for which data were available (Monette and Colman, 2004). However, acid deposition continues to be excessive (see SO_x Section) and smog and ground-level ozone are still problematic within the Province.

As mentioned, the Province aims to reduce NO_x emissions by 20% below 2000 levels by 2009. In the medium term the goal should be to maintain NO_x levels in the Province below the MAC, although again, it must be acknowledged that even the best efforts to reduce NO_x emissions in the Province will have only a partial impact on ambient NO_x levels, which are influenced in large part by transboundary pollution. In the long term there should ideally be no areas where critical load is exceeded and the Province should stay abreast of new and more rigorous international standards and research on health and environmental impacts, ensuring that ambient air quality standards and emissions controls reflect the best knowledge available.

The declining trend of NO_x emissions since the 1970s suggests some modest progress towards greater sustainability. However, recent increases in emissions, and the fact that Nova Scotia's per capita energy-related NO_x emissions remain much higher than Canadian and OECD averages, show that much more effort must be made to ensure that NO_x emissions from the energy sector (especially electricity production) continue to decline. In the longer term, possibly the only way to reduce Nova Scotia's own excessive energy-related SO_x and NO_x emissions and to bring per capita emissions down to Canadian and then OECD levels is to reduce the current reliance on coal-fired electricity generation. If coal is to continue being used a major investment is needed in pollution control technology in order to reduce emission levels.

Volatile organic compounds

The term volatile organic compounds (VOCs) refers to photochemically reactive hydrocarbon gases and vapours that tend to evaporate quickly at ordinary temperatures. Volatile organic compounds contain at least one carbon atom. There are many thousands of organic compounds in the troposphere that meet the definition of a VOC, but CO_2 and CO are *not* classified as VOCs. Volatile organic compounds are also called reactive organic gases or non-methane volatile organic compounds. Total hydrocarbons (THCs) is a broader term for organic gases and vapours, which include methane. VOCs are a sub-set of THCs.

Volatile organic compounds can react with nitrogen oxides in the presence of sunlight to form ground-level ozone. The categories of VOCs most relevant to ground-level ozone formation include:

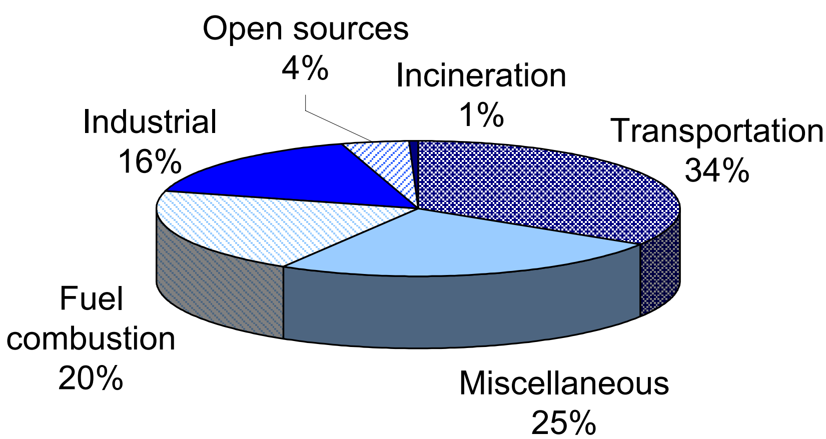
- Alcohols – e.g., methanol, ethanol
- Alkanes – e.g., ethane, propane
- Alkenes – e.g., ethylene, propylene
- Biogenic alkenes – e.g., isoprene
- Alkynes – e.g., acetylene
- Aromatics – e.g., benzene, toluene
- Aldehydes – e.g., formaldehyde, acetaldehyde
- Ketones – e.g., acetone
- Ethers – e.g., methyl tertiary-butyl ether (Environment Canada and Health Canada, 1999a).

Thousands of natural and synthetic chemicals are VOCs, including benzene, which is a natural component of crude oil and petroleum products. Other examples of VOCs include trichloroethylene, tetrachloroethylene, and methylene chloride. Some VOCs are carcinogenic, such as formaldehyde and benzene (Health Canada, 2001).

Sources of volatile organic compounds emissions

The main sources of VOC emissions are: stationary fuel combustion; industrial processes (particularly in petroleum refineries, petrochemical plants, plastics manufacturing, etc.); and transportation (Environment Canada, 1996). Benzene is a VOC that occurs naturally in crude oil and in many petroleum products. It is also a by-product of the incomplete combustion of organic substances. Trichloroethylene and tetrachloroethylene are synthetic compounds used primarily as solvents in metal-degreasing, the dry cleaning industry, and in various manufacturing processes. Methylene chloride is a colourless commercial chemical used primarily in paint removers, as a foam-blowing agent, and as a component of aerosols. Total VOC emissions in Nova Scotia were estimated at 56 kt and are presented by category in Figure 33.

Figure 33. Nova Scotia VOC emissions by category, 2000



Note: Fuel combustion above refers to non-industrial fuel combustion, which includes electric power generation (utilities), residential fuel and fuel wood combustion, and commercial fuel combustion. It excludes industrial fuel combustion, which is included in the "industrial" category but not separately reported.

Source: Environment Canada, 2005.

Residential fuel wood combustion accounts for virtually all VOC emissions from energy sector sources and therefore alone accounts for 21% of total VOC emissions.[50] Other stationary fuel combustion sources are currently insignificant. "Miscellaneous" VOC emissions in Nova Scotia come from numerous sources, the most significant of which are general solvent use, surface

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[50] As in all other sections of this chapter, energy-related emissions here are defined to exclude transportation, and include only those emissions classified by Environment Canada as deriving from its "non-industrial fuel combustion" category (which includes electric power generation, residential fuel and fuel wood combustion, and commercial fuel combustion.) Pollutant emissions (including VOCs) attributable to transportation are separately considered in the **GPI***Atlantic* Transportation Accounts.

coatings, and fuel marketing. Dry cleaning, printing, and structural fires also contribute VOC emissions. The upstream oil and gas sector and pulp and paper mills are the major industrial sources of VOC emissions.

Human health effects of volatile organic compounds

Volatile organic compounds can be classified according to whether they are a direct human health concern, promote ground-level ozone formation, or both. Among the potentially toxic VOCs are known human carcinogens such as benzene. Health Canada has also classified methylene chloride as a probable human carcinogen. Trichloroethylene and tetrachloroethylene have been shown to cause cancer in laboratory animals but the health risk to humans is not known (Health Canada, 1997).

Numerous studies have demonstrated an association between occupational exposure to benzene and adverse health effects. Occupational benzene exposure has been shown to cause hematotoxic reactions; effects on the immune system (such as decreases in T lymphocytes, alterations in serum immunoglobulins, and benzene-induced autoimmunity and allergy effects); neurotoxic effects; and incidences of leukemia. Workers in the chemical, petrochemical, graphics, rubber, and oil refining industries are among those most likely to be exposed to benzene (GoC et al, 1993). Gas station attendants have been found to have blood levels of benzene more than twice as high as those in the general population (Brugnone, 1997).

However, the health effects of exposure to environmental levels of benzene are unknown. The level at which adverse effects have been observed in laboratory mammals is over 100,000 times greater than the highest reported concentration of benzene in urban air in Canada (Health Canada, 1997). The lowest concentration reported to be lethal to plants, terrestrial invertebrates, and mammals, following acute laboratory exposure to benzene in air, is almost 240,000 times more (GoC et al, 1993).

Long-term exposure to high levels of trichloroethylene in the workplace is associated with adverse liver and cardiovascular effects, kidney damage, and other problems. Short-term exposure to high levels of tetrachloroethylene is associated with symptoms ranging from eye, throat, and nasal irritation to dizziness and nausea. At very high concentrations, and after long-term exposure, tetrachloroethylene can cause cancer in some laboratory animals, although it is unclear whether these results are applicable to humans. Short-term exposure to elevated concentrations of methylene chloride vapours can cause sluggishness, irritability, light-headedness, nausea, and headaches (Health Canada, 1997).

Human health effects of ground-level ozone & smog

Another major concern with VOCs is their contribution to ground-level ozone and smog. Ground-level ozone, even at low concentrations for short periods, has been linked to a broad spectrum of human health effects. These secondary pollutants have been linked to lung damage, respiratory problems and cardiovascular disease, leading to increased hospital admissions and emergency department visits as well as premature death (USEPA, 2002c; Environment Canada and Health Canada, 1999a; OMA 1998).

Environmental effects of volatile organic compounds, ground-level ozone, & smog

The primary environmental effects associated with VOCs are those deriving from secondary pollutants - smog and ground-level ozone – to which VOCs contribute. The following summary of the effects of ground-level ozone is abstracted from **GPI***Atlantic*'s Air Quality Accounts, which provide a more detailed description.

Plant response to ground-level ozone exposure is a sequence of biochemical and physiological events. Possible results include: visible foliar injury; altered carbohydrate allocation which compromises growth, reproduction, and overall plant health; and impacts on the competitive relationships within plant communities and ecosystems (Environment Canada and Health Canada, 1999a). The foliage is the primary site of plant response to ozone exposure. Ozone exposure can also make plants more susceptible to disease, pests, and environmental stresses (USEPA, 1997).

Ground-level ozone has been shown to reduce agricultural yields for many economically important crops: soybeans, kidney beans, wheat, cotton, corn, peanuts, potatoes, sorghum, and turnips (Environment Canada and Health Canada, 1999a; USEPA, 1997). Foliar injuries to sensitive crops in response to ozone exposure have been demonstrated in New Brunswick (potato); Quebec (dry bean, soybean, tobacco); Ontario (dry bean, soybean, potato, tomato, onion, tobacco, cucumber, grape, peanut, radish); and British Columbia (pea, potato) (Environment Canada and Health Canada, 1999a). Assessment of the precise impacts of ground-level ozone on agricultural yield is difficult because of the ubiquity of ozone exposure, the effect of meteorological variables on ozone distribution within crop canopies, and the effect of other factors that can alter plant response.

The effects of ground-level ozone on trees are believed to accumulate over many years, so that whole forests or ecosystems can be affected (USEPA, 1997). Many factors affect the overall health and growth of trees, including natural determinants such as competition among species, changes in precipitation, temperature fluctuations, insects, and disease. Human activities such as pesticide use, logging, and air pollution can also influence tree health and growth. It is difficult to isolate which of these stressors is to blame when trees die in large numbers, are unhealthy, experience less than optimal growth, or when biomass is reduced.

It has been clearly demonstrated that ozone concentrations common in several areas of Canada are sufficient to retard tree growth significantly (Environment Canada and Health Canada, 1999a). Ozone damage may be reducing forest growth and timber yield particularly of sensitive species such as maple, ash, white spruce, white pine, poplar, white birch and red oak, and contributing to forest decline in some parts of Canada (CESD, 2000).

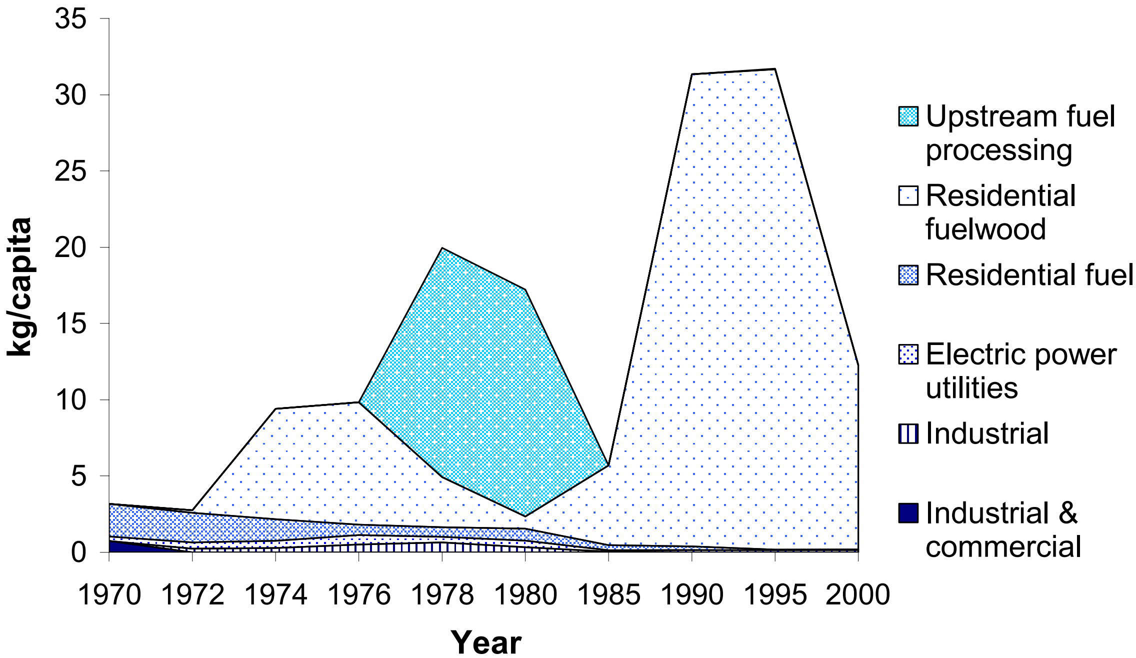
Based on a review of the literature, Environment Canada & Health Canada (1999a) have also summarized the potential ozone damages to many different types of materials. Ground-level ozone mars materials both functionally and aesthetically, alone or synergistically in the presence of SO_2 and NO_x. Factors such as sunlight, heat and moisture can influence the harm to materials caused by ground-level ozone. Observed effects of ground-level ozone on materials include: hardening and cracking of rubbers; strength reduction in cotton and silk; fading; erosion of paint; and corrosion of metals and stone (Monette and Colman, 2004, 38-40). In sum, the contribution of VOCs to ground-level ozone is associated with significant potential adverse health and environmental effects.

Volatile organic compounds – emissions trends

Through 1980, only total hydrocarbon (THC) emission estimates are available. In the 1985 inventory, for the first time, estimates for both THCs and VOCs are given, whereas in the 1990, 1995, and 2000 inventories, only VOC estimates are given. Volatile organic compounds represent a subset of THCs that excludes photochemically non-reactive compounds such as methane and ethane. Therefore, when compiling VOC emissions data for this report, estimates of THC emissions were used for 1970 through 1980 as a proxy for data on VOC emissions that were not separately available for those years. Accordingly, changes in estimated emissions totals between reporting years cannot solely be attributed to changes in actual emissions, and may slightly overstate emissions estimates for 1970-1980 that included photochemically non-reactive compounds.

Historically, the two major sources of THC emissions in Nova Scotia from the stationary energy sector have been coal mining and processing, and fuel wood combustion (Figure 34). Coal mining produces methane emissions, which is a hydrocarbon (also a greenhouse gas) but not a VOC (it is photochemically non-reactive). Once separate totals for VOC and THC emissions were computed, coal mining was shown to be a very small source of VOCs. This difference explains the apparent substantial contribution of upstream fuel processing to VOC emissions in the late 1970s with a dramatic decline in the mid 1980s (the rapid rise is explained by the increase in Provincial coal mining following the oil crises of the 1970s). There are several reasons for the apparent substantial rise in VOC emissions indicated in Figure 34 below, including unreliable estimates of fuel wood use. As noted above, 2000 estimates for fuel wood emissions are much more reliable than earlier estimates and the apparent trends may be largely an artefact of improved data sources than reflective of actual dramatic changes, as the graph would seem to indicate.

Figure 34. Per capita VOC emissions from stationary energy-related sources, Nova Scotia, 1970-2000



Note: Industrial fuel combustion emissions were only captured up to 1985. The 1990-2000 figures only represent non-industrial fuel combustion, while industrial fuel combustion is now captured in the overall emissions figures for the industrial sector (not presented in this report). Industrial fuel combustion is therefore no longer separately reported. Prior to 1990 emissions shown are THC of which VOC are a subset.

Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000, 2005.

Per capita volatile organic carbon emissions from stationary energy sources in Nova Scotia are 22% less than in the Atlantic region as a whole, but are more than double those of Canada (Appendix B). The disparity can be explained largely by the fact that a larger proportion of homeowners in Nova Scotia and the Atlantic region continue to use fuel wood for home heating, whereas the vast majority of Canadians use electricity, oil, and natural gas.

Goals and targets

There are no targets for VOCs, however, because VOCs are one of two chemical precursors (along with NO_x) for ground-level ozone formation targets for ground-level ozone have been presented here.

Table 27. National ambient air quality objectives for ground-level ozone

Secondary Pollutant	Averaging Time	Maximum desirable concentration	Maximum acceptable concentration	Maximum tolerable concentration
Ground-level Ozone (ppb)	annual		15	
	24-hour	15	25	
	1-hour	51	82	153

Note: Blank cells indicate that there is no established objective. Ground-level ozone is included here as VOCs are a major precursor for the formation of ground-level ozone.

Source: Health Canada, 2004

The Canada-wide Standard for ground-level ozone is a maximum concentration of 65 parts per billion in an 8-hour period, to be achieved by 2010.

Table 28. Health impacts of ground-level ozone exposure at NAAQO concentrations

Amount	Good range (0 – maximum desirable)	Fair range (maximum desirable – maximum acceptable)	Poor range (maximum acceptable – maximum tolerable)	Very poor range (over the maximum tolerable)
Impact	No effects.	Increasing injury to some species of vegetation.	Decreasing performance by some athletes exercising heavily.	Impairment of respiratory function. Increased respiratory symptoms. Increasing sensitivity of patients with chronic pulmonary disease.

Sources: Government of Canada, 1991; Environment Canada, 1990; and FPACAQ, 1987.

Table 29. Nova Scotia's standards for ground-level ozone

Ground-level Ozone	Averaging Period	Maximum Permissible Ground Level Concentration		
		µg/m^3	pphm	Ppb
	1-hour	160	8.2	82

Source: GoNS, 2005b.

Both the National and Provincial objectives for ground-level ozone are more rigorous than those of the U.K. and the World Health Organization (Monette and Colman, 2004). Monette and Colman (2004) report that, Nationally and Provincially, ground-level ozone was one of the few criteria air contaminants that did not decline substantially during the 1980s and 1990s. Although, ground-level ozone is a secondary pollutant, energy production and use is a major source of both NO_x and VOCs, the chief precursors of ground-level ozone. The MAC objectives for ground-level ozone have been exceeded at numerous locations throughout Nova Scotia over the last two decades.

In the short term (by 2010), a reasonable target is that MAC objectives not be exceeded anywhere in the Province and that the CWS for ground-level ozone be achieved by 2010. However, achieving these goals, particularly in the western regions of Nova Scotia, can only happen if significant reductions in precursor emissions are achieved in the U.S. and eastern Canada, which are major sources of precursor emissions affecting Nova Scotia. In fact, current monitoring indicates that the CWS has been met in all areas of the Province except the western region (Environment Canada, 2005e). In the medium to long term, further bilateral negotiations and agreements between Canada and the U.S. are needed to reduce VOC and NO_x emissions to the point where the MDC objectives are reached in all areas.

But, given the very high per capita emissions of VOCs in Nova Scotia and the other Atlantic Provinces, action can also be taken in this region without waiting for the rest of Canada and the U.S. to act. As noted, volatile organic compound emissions are not presently moving rapidly enough towards sustainable levels in this region. In order to ensure that VOC emissions decline in Nova Scotia and throughout Atlantic Canada, home fuel wood consumption needs to be addressed in a far more dedicated way than at present. Efficiency and emissions standards for wood-burning home heating devices need to be implemented, and households must receive active encouragement, education, and incentives to upgrade old devices. Action in other sectors like transportation is not addressed here, but is considered in the GPI Transportation Accounts.

Because residential fuelwood combustion is the only source of (non-transportation) energy-related VOC emissions, the specific recommendations in the earlier sections (on CO and PM) on improving wood stove and fireplace combustion efficiency are equally relevant here, and constitute the primary means by which Nova Scotia can reduce energy-related VOC emissions. In addition to the regulations, incentives and rebates that can hasten the adoption of more efficient and less polluting woodstoves and fireplaces, there is also a real need for education and public awareness campaigns to reach the large portion of Nova Scotians who use wood for heat. As noted above, realistic interim targets for Nova Scotia are to reduce energy-related per capita VOC emissions first to the Canadian level and then to the OECD level.

Mercury

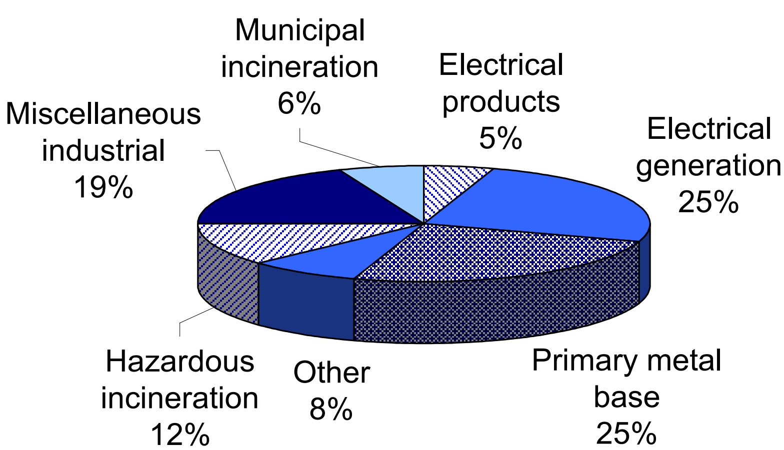
Mercury (Hg) is a dense heavy metal. It is a liquid at room temperature and, when heated, changes to an odourless, colourless gas, and becomes more volatile. There are different forms of mercury; the most bioactive of which is inorganic or methylmercury, which is stored up in organisms for long periods without being broken down through natural processes (i.e. it bioaccumulates), and is transmitted through the food chain (UNEP, 2003).

Sources

The major anthropogenic sources of mercury are coal-fired power plants, metal smelting, incineration, fuel combustion, and intentional use in products such as light bulbs, hospital and dental equipment, and thermostats. Also, hydroelectric dams often release mercury to the environment as increased bacterial activities associated with the decomposition of plant life in flooded areas promote mercury leaching from rock and soil (UNEP, 2003). Figure 35 shows the percentage of atmospheric mercury deriving from various anthropogenic sources in Canada.

Nova Scotia Power is the largest emitter of mercury in Nova Scotia. Other Provincial sources include the Department of National Defence, Imperial Oil, Lafarge (a concrete producer), and some waste water treatment facilities. Until recently, most products containing mercury were not recovered in Nova Scotia. Now one company collects a variety of materials containing mercury and sends them out of Province for recycling.

Figure 35. Sources of atmospheric mercury in Canada, 2000



Source: Environment Canada, 2004b.

Health effects of mercury

Mercury is considered toxic under the *Canadian Environmental Protection Act* (CEPA) (Environment Canada, 2005a). There is no safe threshold for mercury, as very low concentrations can be toxic to the environment and human health (Environment Canada, 2004b). Pregnant women, fetuses and children are most at risk from mercury poisoning. The main pathway to mercury poisoning in human beings is through low-level “background” exposure from mercury vapours, while the most common form of ingestion is through the consumption of contaminated fish and other meats (Pollution Probe, 2003; Health Canada, 2002).

The toxic effects have the gravest impact on the central nervous system, and have been linked to neurological and developmental damage (Environment Canada, 2005a, 2004b). Acute exposures have been linked to “permanent brain damage, central nervous system disorders, memory loss, heart disease, kidney failure, liver damage, loss of vision, loss of sensation and tremors” (Pollution Probe, 2003, p. 35). Mercury may also be an endocrine disruptor (Environment Canada, 2005a; Pollution Probe, 2003). Exposures that are low-level but chronic can cause neurological, reproductive, behavioural, and learning problems (Pollution Probe, 2003).

Environmental effects of mercury

Pollution Probe (2003) reports that mercury in aquatic ecosystems is a particular concern. Though mercury concentrations in terrestrial environments have been elevated by human activity, levels are usually not high enough to threaten wildlife. However, certain aquatic environments promote the transformation of mercury into methylmercury, a more toxic substance, which then bioaccumulates in fish, marine mammals, and fish-eating species (e.g. otters, loons, mink, and osprey). Although there has been more research on the human health effects or mercury and on the dangers to human health of ingesting fish with high levels of mercury, neurotoxin reactions have also been found in wildlife and similar health effects to those experienced by humans are considered likely in many species. High levels of mercury have also been found in predatory saltwater species such as tuna (UNEP, 2003).

Mercury emission trends

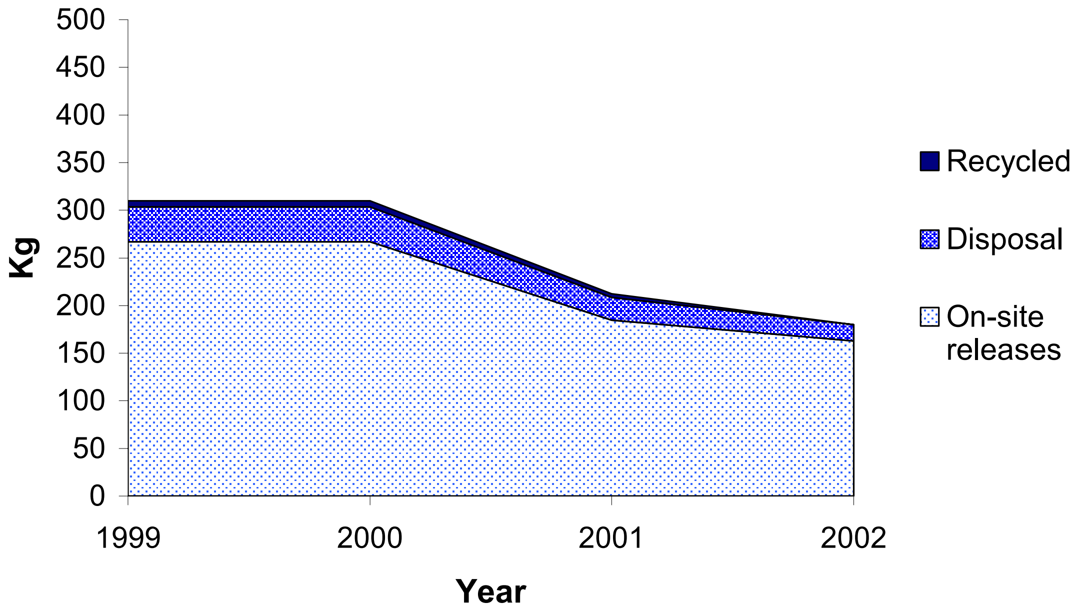
Like other pollutants, much of the mercury deposited in Nova Scotia is released in Quebec, Ontario or the U.S. Unlike other important air pollutants, however, mercury is not included among Environment Canada’s criteria air contaminants because it is not released to the environment only as a gas. Data for mercury emissions were therefore obtained from the National Pollutant Release Inventory (NPRI).[51]

The NPRI includes releases from stationary, point source emitters that meet reporting requirements. The reporting requirements for mercury (and its compounds) used to be that any “manufacture, process, or otherwise” emitting more than 10 tonnes per year had to file a brief stating the amount released to air, water, or land, or sent for final disposal or recycling. In 2000, the NPRI reporting threshold for mercury was lowered to five kilograms, thereby increasing the number of groups that had to report (Environment Canada, 2005a).

Mercury emissions have been slowly declining in Nova Scotia, though the continued use of coal for electricity generation means that mercury is still emitted by the energy sector (Figure 36). The vast majority of mercury emissions in the Province still come directly from on-site pollutant releases. Coal-fired power generation accounts for more than 90% of recorded mercury emissions in Nova Scotia.

[51] The NPRI is “the only legislated, nation-wide, publicly-accessible inventory of its type in Canada. It is a database of information on annual releases to air, water, land and disposal or recycling from all sectors - industrial, government, commercial and others” (Environment Canada, 2005a).

Figure 36. Nova Scotia Power's mercury releases and transfers, 1999 to 2002



Source: Environment Canada, 2005a.

Goals and targets

Given that there is no safe threshold for mercury emissions, the long-term goal should be the complete elimination of anthropogenic mercury emissions (Pollution Probe, 2003). In the short term the Provincial Government has set a target for reducing mercury emissions to 30% below 1995 levels by 2005. Nova Scotia Power achieved this target in 2002. Canada has made several international commitments to decrease mercury use and emissions. The Canadian Council of Ministers of the Environment has agreed to standards for products containing mercury, and is currently drawing up Canada-wide standards for mercury emissions at coal-fired electric plants (Pollution Probe, 2003). Environment Canada (2004b) reports that the new Canada-wide standard will prevent the atmospheric release of 60-90% of the mercury in coal by 2010.

Under the new Canada-wide standard, Nova Scotia and NSPI have been assigned a specific emission cap of 65 kg of mercury per year for the existing coal-fired power plants at Lingan, Point Tupper, Trenton, and Point Aconi – a significant reduction of 57% from the present estimated emissions of 150 kg/year, based on 2002-04 utility monitoring program results (Canadian Council of Ministers of the Environment, 2005). If the new standards are accepted and approved, Nova Scotia will need to adopt this target in the short-term. In the longer-term, the complete elimination of energy-related mercury emissions in the Province, as recommended by Pollution Probe, will probably only occur if coal is completely phased out as a source of electric power generation. Certainly major investment is needed in pollution control technology for coal plants in order to reduce emission levels. It is important to pursue reduction agreements with other parts of Canada and the U.S. because much of the mercury deposited in Nova Scotia comes from outside the Province's borders.

Greenhouse gas emissions

There are numerous gases, both natural and anthropogenic, that contribute to climate change. The most important anthropogenic gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_20) (Environment Canada, 2004). Four others contribute to climate change to a lesser degree: sulphur hexafluoride (SF_6); perfluorocarbons (PFCs); hydrofluorocarbons (HFCs); and tropospheric ozone (O_3) (IPCC, 2001). Together these seven are referred to as the primary greenhouse gases (GHGs) since they slow the rate at which the earth loses heat to space by reflecting energy back to the planet (Environment Canada, 2000b). These gases are tracked and presented collectively as "CO_2 equivalent" measures, which equates the non-CO_2 GHGs to CO_2 based on atmospheric lifetime and global warming potential.

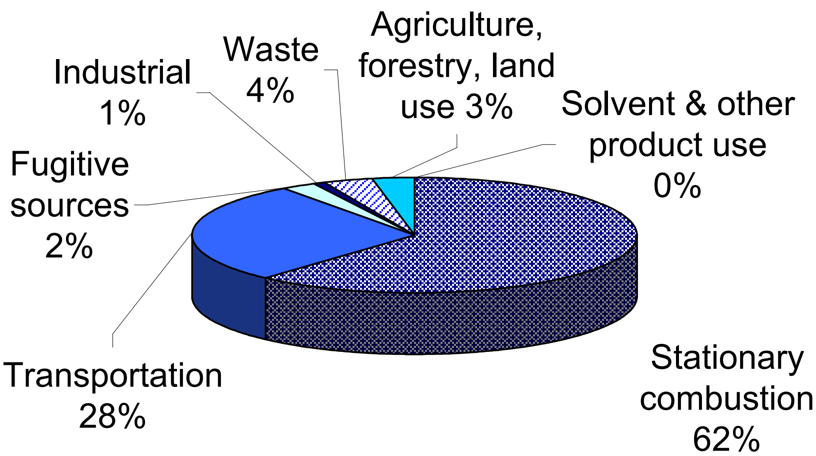
The United Nations Framework Convention on Climate Change (UNFCCC) has also identified indirect GHGs. These substances do not themselves trap heat but are either chemically modified in the atmosphere to become direct GHGs or influence the atmospheric lifetime of other gases (Environment Canada, 2002d). This set includes SO_x, NO_x, CO, and non-methane VOCs.

Climate change in Nova Scotia will likely trigger extensive and varied effects, some of which are predicted by Environment Canada and summarized in the **GPI***Atlantic* Greenhouse Gas Accounts (Walker et al, 2001). These include impacts on temperature, precipitation, frequency and intensity of extreme weather events, changes in sea level at various locations, coastal erosion, health of crops and forests, and fish catch levels. Sharply reducing the quantity of anthropogenic GHG emissions is widely accepted as the best method globally to avoid compounding the serious anticipated future problems and costs of climate change worldwide. Even with major reductions in GHG emission the climate will continue to change for some time but major reductions can reduce the rate of future climate change and thereby limit the impacts. Therefore, this report uses anthropogenic GHG emissions from the provincial energy sector as the indicator for climate change. Clearly the impacts of climate change in Nova Scotia are related to greenhouse gas emissions globally, while the costs and consequences of Nova Scotia emissions are experienced worldwide. In order to provide additional information on the impacts of climate change in Nova Scotia specifically, future iterations of this report may want to consider adding indicators on the potential effects of climate change in this Province, including measures on the frequency and intensity of storms, droughts and floods, and sea-level.

Sources of greenhouse gas emissions

According to Environment Canada, "energy" accounted for almost 92% of Nova Scotia's total GHG emissions in 2002 (Environment Canada, 2004). In this case, however, the definition of energy includes transportation; electricity and heat; and fossil fuel production (e.g. methane from coal mines and CO_2 releases from refineries). In Canada, and generally around the world, the main source of GHGs is the combustion of fossil fuels (Environment Canada, 2002d). Other GHG sources include changes in land use and forestry (including deforestation), which globally account for approximately 25% of GHG emissions, but are less significant in Nova Scotia today, since most dramatic land conversions and logging of old-growth forests occurred in the past (Environment Canada, 2004; Walker et al, 2001). Figure 37 shows the proportions of greenhouse gas emissions attributable to different anthropogenic sources in Nova Scotia. Stationary combustion accounts for 62% of emissions in the Province.

Figure 37. Nova Scotia's GHG emissions by category, 2002



Source: Environment Canada, 2004.

Health, environmental and economic effects of climate change

Climate change has serious implications for the environment, and for human health and safety. According to the Intergovernmental Panel on Climate Change (IPCC), climate change is expected to have numerous impacts that will vary from region to region. These include but are not limited to:

- Sea-level rise;
- Melting of glaciers and polar icecaps;
- Floods;
- Droughts;
- Changes in storm intensities;
- Changes in biological variables and biodiversity, including species extinctions (IPCC, 2001).

Canada's Third National Report on Climate Change states:

> Climate change has the potential to have wide ranging impacts on human health and safety. These impacts would arise by both direct pathways (e.g., exposure to changes in thermal stress and extreme events) and indirect pathways (e.g., increases in some atmospheric pollutants, pollens, and mould spores; malnutrition; increases in the potential transmission of vector-borne and water-borne diseases; stresses on the general public health infrastructure) (GoC, 2001:101).

Environment Canada's *Canada Country Study* outlined six major areas of climate change sensitivity in the Atlantic region: fisheries; coastal zone; ecosystems and water resources; agriculture; forestry; and socio-economic dimensions (Environment Canada, 1997). The study predicted that certain areas of Atlantic Canada may become unsuitable for native species due to changes in ice and snow regimes, loss of wetlands, disease and insect incidence, and forest fires (Walker et al, 2001). Depending on the rate of change, many of these species may not be able to migrate to new regions, a failure that would lead to significant losses of biodiversity.

Higher ambient temperatures, thermal expansion of ocean waters, subsidence of coastal lands and increased melting of sea ice are all predicted to contribute to a rise in sea levels and to increasing storm intensity in Atlantic Canada. Drawing on the *Canada Country Study* **GPI***Atlantic*'s greenhouse gas accounts note that:

> …the potential impacts of climate change on the Atlantic coastal zone include effects of accelerated sea level rise and variable storminess. Increased flood risk in some areas, coastal erosion in others, sediment redistribution, and coastal sedimentation are likely effects of the rise…. Both types of effects [sea-level rise and increased storm intensity] would have serious socio-economic impacts. (Walker et al, 2001:22)

Global sea level has risen by 10 to 25cm over the past 100 years and much of the rise may be related to the increase in global mean temperature. The predictions from the IPCC (1996) are for a further rise of 20 to 86cm by 2100. Relative sea level is now rising in most parts of Atlantic Canada. Low-lying regions around Yarmouth, the Bay of Fundy and Halifax Harbour have been identified as particularly vulnerable to a combination of sea level rise, higher tides and changes in storm intensity and frequency (Shaw et al, 1998). The construction of new dykes and the raising of existing ones to counteract some of these impacts will be costly. A sea level rise of 75cm has been predicted for Halifax over the next 100 years (Shaw et al, 1998). Recent studies indicate that in Chezzetcook, Nova Scotia, sea level has risen 35 cm since 1900 (Gehrels et al, 2004, 2001). This rate of change is without precedent in the last millennium and corresponds with scientific predictions on the impacts of hemispheric (and global) climatic warming.

The probable impact of climate change on the Atlantic fisheries is uncertain. Climate change is expected to have an effect on the distribution of fish species and on their migration patterns, arrival times, recruitment success, and growth rates (through physiological effects). It is also likely that there will be changes in disease patterns, food availability, and predator abundance. However, extremely limited knowledge of ocean response, fish life-cycles, and environmental influences on fish abundance, productivity and health, prohibits definitive predictions of the effects of climate change on regional fisheries. The importance of the fisheries both to the Nova Scotia economy and to the viability of coastal communities makes further research in this area imperative (Walker et al, 2001).

GHG emission trends

Emissions of GHGs in Canada are tracked by the Greenhouse Gas Division of Environment Canada. The Greenhouse Gas Division keeps records of CO_2, CH_4, N_2O, SF_6, PFC, and HFC emissions, as required by the UNFCCC, following the methodologies recommended by the IPCC (Environment Canada, 2004). Underlying data come from a variety of federal government departments including Statistics Canada, Natural Resources Canada, and Agriculture and Agri-Food Canada, and from various provincial agencies. It is important to note that Figure 38 and Figure 39 include both GHG emissions from stationary combustion (i.e. non-transportation energy use) and fugitive emissions from coal mining.

As with the criteria air contaminant reports, there have been improvements over the past decade in the protocols for compiling data on greenhouse gases.[52] For example, with each new assessment, the previous years' totals are now recalculated using updated methodologies, thereby making the data more indicative of actual emissions and trends, and ensuring comparability over time. Nonetheless there continue to be challenges pertaining to data availability. Of particular concern in Nova Scotia are changes to federal privacy laws, so that records of certain categories of emitters—which, in this Province, may include only a single corporation for a particular industry—are no longer made public (Environment Canada, 2004).[53] For example, stationary combustion emissions from electrical utilities, mining, and agriculture and forestry are not given values after 2000. This is a particularly serious omission for electrical utilities, since it was noted in Figure 37 above that stationary combustion accounts for 62% of greenhouse gas emissions in the Province.

Fortunately, Environment Canada presents a provincial analysis in Annex 9 of *Canada's Greenhouse Gas Inventory, 1990-2002* in which it is stated that between 1990 and 2002, GHG emissions from stationary combustion in the electricity and heat sector (residential heating is a separate sector) rose 10%, with a decline of 11.6% between 2001 and 2002 (i.e. GHG emissions from electricity production increased between 1990-2002 even though there was a large decrease between 2001 and 2002) (Environment Canada, 2004).[54] Based on these percentage changes the GHG emissions from electricity and heat for Nova Scotia were calculated by the authors of this study to be 8,499 kt CO_2 equivalents in 2001 and 7,513 kt in 2002. It appears that Environment Canada has calculated these percentage changes for electricity and heat emissions based on data in 2001 and 2002 that were suppressed in the data tables for Nova Scotia that are available to the public as presented in Annex 10. Similar percentage change estimates were not available for stationary combustion emissions from mining, agriculture and forestry. However, two figures in Environment Canada's provincial analysis (Figures A9-5 and A9-6 in Annex 9) were used to estimate stationary combustion GHG emissions from agriculture and forestry in 2001 and 2002 at 140 kt CO_2 equivalents in 2001 and 120 kt in 2002 (Environment Canada, 2004). Once stationary combustion figures for electricity and heat, and agriculture and forestry were calculated, stationary combustion mining emissions (the remaining suppressed data) were simply assumed to be equal to the remaining unaccounted for emissions in the stationary combustion

[52] It should be noted that earlier critiques of air quality reporting are related mostly to declining monitoring and not to the quality of the protocols and methodologies used in the monitoring, except in the case of wood combustion emissions and underlying wood usage data which have not been consistent and accurate enough to develop accurate assessments of changes in emissions.

[53] Environment Canada's GHG emissions data for 1990-2002 are part of *Canada's Greenhouse Gas Inventory, 1990-2002*. National and provincial data are contained in Annex 10 and can be accessed at http://www.ec.gc.ca/pdb/ghg/1990_02_report/ann10_e.cfm/.

[54] Provincial and territorial trend analyses are contained in Annex 9 of *Canada's Greenhouse Gas Inventory, 1990-2002*. This can be accessed at http://www.ec.gc.ca/pdb/ghg/1990_02_report/ann9_e.cfm.

category. This would give a value of 40 and 62 kt CO_2 equivalents for stationary combustion emissions from mining in 2001 and 2002 respectively.[55] It must be emphasized that these are derived estimates, and it would be much more satisfactory to receive the direct estimates, as they were released to the public up to 2000.

In light of the growing importance of monitoring trends in GHG emissions, particularly in the power generation sector that accounts for such a large portion of all emissions in the Province, it is recommended here that privacy concerns for particular corporations – in this case NSPI – be properly balanced against the need to protect the public good. Climate change has such potentially catastrophic consequences for future generations that this is decidedly not the time to diminish the availability and specificity of key data that are essential in monitoring progress towards sustainability.

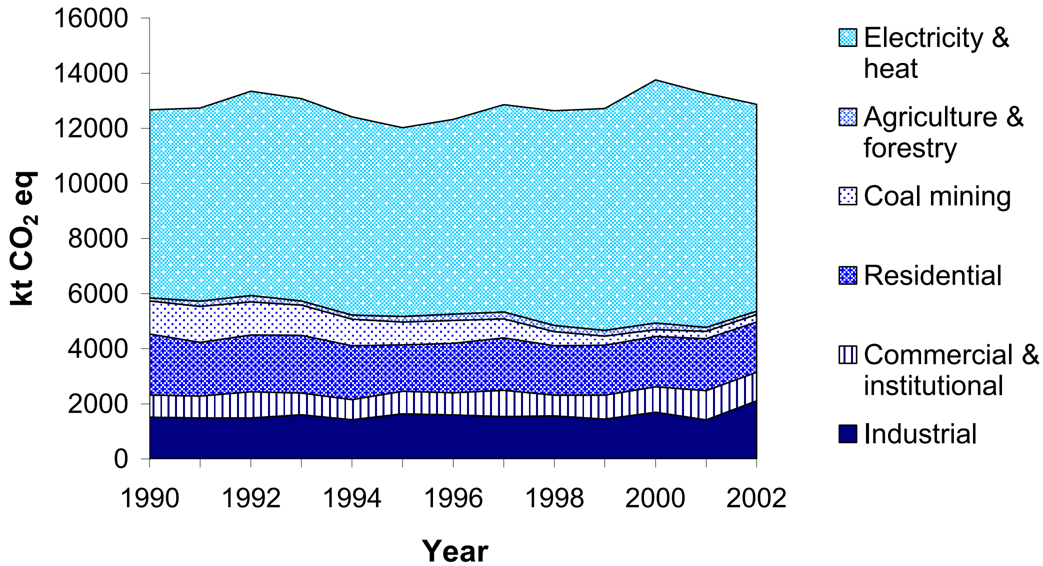
Environment Canada's analysis shows that total energy emissions including transportation increased 5.6% between 1990 and 2002 (17,800 to 18,800 kt); emissions from stationary combustion sources increased 9.6% (11,500 to 12,600 kt); and emissions from the electricity and heat sub-sector increased 10% (data not provided). Fugitive emissions from coal mining declined by 77.5% (due to mine closures) between 1990 and 2002 (from 1,200 to 270 kt).[56] When all non-transportation energy sources (stationary combustion plus fugitive coal mining) are considered, emissions increased 1.3% (12,700 to 12,870 kt) (Figure 38). On a per capita basis, non-transportation energy source emissions increased by 1.4% between 1990 and 2002, from 13.9 t CO_2 equivalent per capita to 14.1 t/capita.

Figure 38 shows that GHG stationary energy-related emissions (stationary combustion plus fugitive mining emissions) have varied somewhat over time. There were slight decreases during the recession of the early to mid-1990s and an increasing trend in the late 1990s. It is likely that emissions from the electricity and heat sector decreased briefly in 2001 and 2002 due to greater use of natural gas in the Tufts Cove generating plant (Figure 7 in Chapter 5). This analysis is supported by the fact that the amount of electricity generated at NSPI has increased in each of the past five years while the amount of power generated from non-GHG emitting hydro and wind sources did not change significantly over the same period. The only remaining explanation is the use of natural gas. Prior to the use of natural gas by NSPI in 2001, GHG stationary energy-related emissions (stationary combustion plus fugitive mining emissions) had increased by 8.4% from 12,700 kt in 1990 to 13,761 kt in 2000. This includes a 29% increase in GHG emissions from the electricity and heat sector from 6,830 kt to 8,830 kt. Since 2002, it is probable that GHG emissions from electricity generation have increased again, because NSPI sharply decreased the use of natural gas in 2003 in response to price increases (Figure 7 in Chapter 5).

[55] Environment Canada data on GHG emissions has two categories that relate to mining. The first is emissions that result from stationary combustion of fuels in mining operations. The second is fugitive emissions of methane (i.e. naturally occurring methane trapped underground) that are released during coal extraction. Data on fugitive coal mining emissions are available for the entire reporting period (1990-2002); however, stationary combustion emissions data from mining operations are suppressed after 2000.

[56] See footnote number 55.

Figure 38. Nova Scotia's stationary energy-related GHG emissions by source, 1990 to 2002

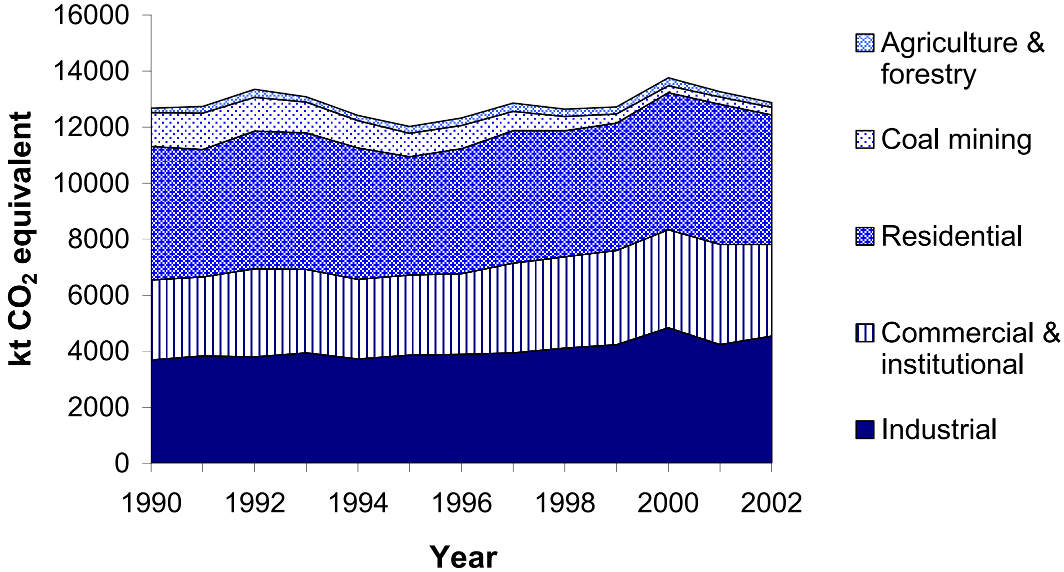


Note: Since 2001 data for electricity and heat, mining (within the industrial stationary combustion category), and agriculture and forestry, have been suppressed for confidentiality reasons. Data for these sectors were therefore estimated using Environment Canada's Provincial/Territorial Analysis.

Source: Environment Canada, 2004.

If GHG emissions from electricity generation are attributed to end users rather than producers, it is possible to understand more clearly the effects of energy demand on GHG emissions. This also shifts the lens towards consumers (i.e. the demand side) instead of assigning responsibility preponderantly to producers (i.e. NSPI, the major supplier). This perspective is shown in Figure 39. These estimates show that GHG emissions from the industrial sector have increased by 23% since 1990 from 3,687 kt to 4,534 kt; emissions from the commercial and institutional sector have increased by 15% from 2,856 kt to 3,275 kt; and emissions from the residential sector have decreased by 3% from 4,767 kt to 4,623 kt during this time period. However, the residential sector remains the largest source of GHG emissions when electricity emissions are attributed to end users, even without considering the fact that consumer demand also ultimately drives industrial and commercial activity as well.

Figure 39. Nova Scotia stationary energy-related GHG emissions by source with electricity emissions attributed to end use, 1990 to 2002



Note: Data were suppressed for a number of categories within the stationary combustion sector (including electricity, agriculture and forestry, and mining) after 2000 due to new privacy legislation. See above discussion on estimating the levels for these sectors for 2001 and 2002. Statistics Canada data from CANSIM Table 128-0002 were used to determine the end use of electricity from 1990 to 2002 (Figure 14, Chapter 5). These values were then used to apportion and apply the GHG emissions from electricity and heat to the various sectors shown in Figure 38. Due to the fact that estimates had to be indirectly derived for the 2001 and 2002 suppressed data, total energy emissions shown in Figure 39 for 2001 and 2002 do not exactly equal those published by Environment Canada. The electricity usage from the Statistics Canada categories "Public Administration" and "Commercial and Other Institutional" were added together to determine the electricity usage for the "Commercial and Institutional" category shown above.

Source: StatsCan, 2005, and Environment Canada, 2004.

Per capita GHG emissions in Atlantic Canada as a whole have grown much faster than in Nova Scotia alone, having increased by 23% from 12.0 t per capita in 1990 to 14.8 t per capita in 2002. However, per capita emissions in Nova Scotia were much higher than the Atlantic Canadian average in 1990, and in 2002 were quite similar (14.1 t per capita in Nova Scotia compared to 14.8 t per capita in Atlantic Canada as a whole). Also the brief use of natural gas in 2001-2002 creates a misleading impression of lower current emissions (2002 having the latest available data), since emissions are likely to have climbed since 2002 due to the discontinuation of natural gas at Tufts Cove. So it is probably unwise to read too much into the apparent difference between per capita emissions increases in Nova Scotia and Atlantic Canada as a whole.

In any case, GHG emissions per capita from the energy sector in Nova Scotia and Atlantic Canada are about 50% higher than in the rest of the country, with the sharp difference largely attributable to the type of energy used for electricity generation (Appendix B). Two key factors account for most of this difference. First, hydro-electric power, which contributes virtually no GHG emissions, is a major source of energy in Canada as a whole, accounting for about two-thirds of total electricity production nationwide, whereas in Nova Scotia hydro-electricity is only a minor component (about 9%) (NRCan, 2000). Second, in Nova Scotia, 75% of energy production is from coal, the highest source of GHG emissions per unit of energy.

At 14 t per capita, Nova Scotia's GHG emissions from the non-transportation energy sector ***alone*** are just below average GHG emissions for OECD nations from ***all*** sources (16 t per capita) (OECD, 2004).

Goals and targets

Although Canada's climate, geography and resource-based economy mean that we will inevitably tend towards a more energy-intensive society than more densely populated countries with warmer climates and fewer resource industries, Canada's current energy use and per capita GHG emissions nevertheless indicate energy practices that are extremely inefficient and overly dependent on fossil fuels. This profile is even truer in Nova Scotia and Atlantic Canada than in the country as a whole. In ratifying the Kyoto Protocol, Canada committed to a reduction in GHG emissions of 6% below 1990 levels by 2008-2012 (Environment Canada, 2004). Although the details for achieving this goal, including provincial targets and responsibilities, have yet to be determined and implemented, this short-term target should be challenging for Nova Scotia in light of its heavy reliance on fossil fuels for energy and lack of progress to date.

For Canada, as for Nova Scotia and the other Atlantic Provinces, GHG emissions have continued to increase since 1990, therefore, a much larger reduction from present levels is now needed to achieve the Kyoto goal. In Nova Scotia, total GHG emissions (from all sources) increased by nearly 6% between 1990 and 2002. In the Atlantic Provinces emissions increased by 19%, from 46,600 kt in 1990, to 55,470 kt in 2002. In Canada the increase was 20% from 609,000 kt in 1990 to 731,000 kt in 2002. Emissions from the energy sector (excluding transportation and refineries) rose by just 1.3% between 1990 and 2002, due in large part to the use of natural gas in the Tufts Cove generating plant in 2001 and 2002. But both stationary energy-related and total GHG emissions in 2003 and 2004 were probably higher due to the discontinuation of natural gas use in response to price.

It is recognized that even achievement of the Kyoto targets is an interim measure that will not in itself stop the continued accumulation of greenhouses in the atmosphere or reverse global warming trends. It is accepted that further emissions reductions will be required after Kyoto. For the medium term the IPCC, the European Union and the David Suzuki Foundation have therefore discussed such goals as a 50-60% reduction in GHG emissions (David Suzuki Foundation, 2002). Based on these targets, a suitable medium-term goal of a 50% reduction in GHG emissions by 2030 is recommended.

In the long term, acceptable levels of GHG emissions should be determined based on the best scientific evidence of globally sustainable per capita emission levels that will not produce further atmospheric accumulation of greenhouse gases. Meeting these emission levels will require an inevitable and major restructuring of the global economy and energy system based on substantial reductions in energy demand, dramatic gains in efficiency, major investments in development of renewable energy sources, sharp cuts in fossil fuel consumption, and changes in lifestyle.

Scientists have identified climate change as the most challenging environmental issue we face, and perhaps the greatest global challenge of the next century. As such, continued and improved monitoring and reporting are needed to provide the necessary information base for informed decision-making and action. Future research should look carefully at the full costs of different kinds of emissions, the costs and benefits of GHG reductions and the role of alternative energy futures for achieving reduction targets. Region-specific research is also required to assess with greater specificity the possible effects of climate change on the people and environment of Nova Scotia. Efforts thus far in the Province have not matched Canada's international obligations, with greenhouse gas emissions moving away from rather than towards sustainable levels.

6.5 Chapter Summary

This chapter has presented a series of key indicators of the impacts of energy production and use in Nova Scotia on human health and the environment. Efforts by Environment Canada and other agencies to monitor and report on these indicators have greatly expanded the information available in this vital area. Over the last 30 years there has been a decrease in emissions of most of the pollutants discussed above. A summary of the indicators presented and of associated trends is shown in Table 30.

The following results must be qualified by the major caveat that such a summary can only demonstrate ***relative*** progress towards sustainability, and may in fact send quite misleading messages to policy makers, especially when emissions levels are unacceptably high and baseline levels so poor that a change in course is almost inevitable. Thus, a jurisdiction with a much better and more environmentally responsible historical record may show less relative progress towards sustainability, according to the criteria used in Table 30, than one with a very poor record, because its baseline is higher. The trends summarized below and the accompanying assessments of "movement towards sustainability" must, therefore, be understood in a very limited and relative sense that does not convey the full meaning of sustainability or the underlying purpose of this report, and that may allow the danger of possible misinterpretation without such qualifiers.

Table 30. Summary of health and environment indicators for the energy sector

Indicator	30-Year Trend	10-Year Trend	Movement Towards Sustainability
CO emissions per capita[a]	Unknown	Unknown	?
CO emissions total[a]	Unknown	Unknown	?
TPM emissions per capita	Decreasing	Decreasing	Yes
TPM emissions total	Decreasing	Decreasing	Yes
SO_x emissions per capita	Decreasing	Increasing	No
SO_x emissions total	Decreasing	Increasing	No
NO_x emissions per capita[b]	Decreasing	Increasing	No
NO_x emissions total[b]	Decreasing	Increasing	No
VOCs emissions per capita[a]	Unknown	Unknown	?
VOCs emissions total[a]	Unknown	Unknown	?
Mercury emissions total	Unknown	Decreasing	Yes
GHG emissions per capita	Unknown	Increasing	No
GHG emissions total	Unknown	Increasing	No

Notes: a) Changes in emissions estimates attributable to data reliability make actual trends unclear. b) Recent emission increases following historical declines indicate new measures are needed to ensure continuing improvement.

In light of the fact that Nova Scotia's per capita pollutant emissions levels are generally much higher than Canadian and OECD levels, modest improvements cannot be taken as signs of sufficient movement towards sustainability. As well, for an indicator like mercury that shows some positive movement towards sustainability in Table 30 above, the caveats must be added that there are no accepted safe levels of exposure, that the new Canada-wide standards will likely require a further 57% reduction in NSPI emissions, and that Pollution Probe (2003) has recommended the complete elimination of anthropogenic mercury emissions. From that perspective, Nova Scotia is still a considerable distance from sustainability and the modest progress made to date may be deemed inadequate at best.

Due to changes in data collection methods and consequent adjustments in emissions estimates, it is impossible to determine even a general trend for CO emissions. Hopefully the next round of criteria air contaminant reporting will show a more sustainable decreasing trend than is possible to discern at this stage. Considering the important local effects of fireplaces and wood furnaces both for indoor and outdoor air quality, this chapter has pointed to the importance of encouraging and ultimately enforcing the highest efficiency and emissions standards for wood-burning home heating devices and of providing incentives and rebates to encourage households to upgrade from older, inefficient models. Similarly, improvements in building standards would reduce heating needs, overall energy demand, and consequent pollutant emissions.

Medium-term goals for Nova Scotia that can reasonably be accomplished in the next 10-15 years include lowering per capita emissions of all pollutants and greenhouse gases first to Canadian and then to OECD levels. In the longer-term, reductions in transboundary pollution will also be essential if Nova Scotia is to attain the goal of not exceeding MDC levels for all criteria air contaminants and if the Province is to reverse the legacy of damage caused by high levels of acid rain, ground-level ozone, and smog.

Interpreting trends in TPM and VOC emissions entails difficulties similar to those encountered with CO, as techniques for estimating emissions from residential fuel wood combustion have improved. As such it is impossible to assess longer-term trends with certainty. As with CO, wood fireplaces and furnaces are a primary source of these pollutants.

Realistic short to medium-term goals for TPM and VOC emission reductions in Nova Scotia, to be accomplished in the next 10 years, should be to reduce emission levels first to Canadian and then to OECD levels. In the longer term, the capacity to meet MDC objectives is tied to reductions in transboundary pollution and emission reductions in central Canada and the U.S. Reducing and eliminating exceedances of MAC for ground-level ozone throughout Nova Scotia is clearly a high priority for health and environmental reasons. As both VOCs and NO_x are precursors of ground-level ozone, it is essential to reduce emissions of these pollutants both in Nova Scotia and beyond. In the energy sector, speeding the transition from coal-fired electric power generation and improving the efficiency of residential wood stoves and fireplaces are important steps for this Province.

SO_x and NO_x are similar in their effects, particularly as contributors to acid rain, and also in their emission trends. Energy-related pollutant emissions of both SO_x and NO_x in Nova Scotia have declined since peaking in the mid 1970s, but started to increase again in the 1990s due to rising energy use. New reductions for both pollutants are scheduled as part of Nova Scotia's 2001 Energy Strategy, with a 25% reduction in SO_x from 2001 levels by 2005, and a 20% reduction in NO_x emissions below 2000 levels by 2009. These decreases will help reduce the health and environmental effects that are linked to acid rain, ground-level ozone, and smog. Even with these projected reductions, however, Nova Scotia will continue to have among the higher emissions rates of SO_x and NO_x in Canada and the OECD. Furthermore these Provincial emissions reductions, unless matched in the rest of eastern North America, will not be enough to halt the effects of acidification in all parts of the Province. In addition to curbing its own very high emissions, therefore, the Province will need to be pro-active in encouraging continued bilateral negotiations and agreements on emission reductions in Canada and the U.S.

The extreme toxicity and harmful health effects of mercury in humans are now well-known, but understanding of the effects of mercury on species other than humans and on ecosystems continues to be weak. Also, there are very few data on current and historical ambient mercury levels in the natural environment in Nova Scotia, both aquatic and terrestrial. These issues deserve continued study and are vital in setting effective long-term targets. Based on the evidence that is available and on the persistent nature of mercury, Pollution Probe (2003) has recommended the complete elimination of mercury emissions. Recent emissions decreases, and particularly the planned future reductions in mercury emissions from the energy sector outlined in the new draft Canada-wide standards, are a positive indication of improving sustainability. But a sharp reduction in reliance on coal to produce electricity in Nova Scotia is possibly the only long-term way to move towards the complete elimination of mercury emissions. Reductions in transboundary sources of mercury are also needed. At a minimum, sources of cleaner coal are required along with a major investment in pollution control technology to reduce the emission of a number of pollutants from coal-generated electricity.

The importance of reducing pollution from coal-fired electricity generation in Nova Scotia has been highlighted in a number of recent reports. Based on 2003 data available through the NPRI, PollutionWatch (2005) reports that NSPI is the 4th largest emitter of air pollutants in all of Canada. Analysis of the North American Commission for Environmental Cooperation's 2005 report *North American Power Plant Air Emissions*, shows that NSPI has three of the top four most polluting coal-fired power plants in Canada in terms of acid gas emissions (i.e. SO_x and NO_x) on a per MWh basis (Energy Probe, 2005). Out of North America's 409 coal-fired power plants NSPI's Point Tupper plant ranked 356, Lingan ranked 399, and Trenton ranked 402. The Energy Probe comparison showed that NSPI facilities are also large emitters of mercury with facilities ranking 82, 193, and 231 out 409. The only NSPI facility to score relatively favourably was Point Aconi, the sole facility in which advanced pollution control technology is used. Point Aconi ranked 101 in terms of acid gas emissions and 5th for mercury.

Nova Scotia's total GHG emission levels increased almost 6% between 1990 and 2002, with emissions from the energy sector rising about 1.3% - with the anomalously high use of natural gas by Nova Scotia Power in 2001 and 2002 ameliorating the increase. GHG emission levels in Nova Scotia continue to be among the worst in the world on a per capita basis, due to the Province's heavy reliance on coal and oil for energy, and are not sustainable. The short-term goal is clearly to meet Kyoto obligations (6% reduction of GHG emissions below 1990 levels by 2008-2012). In the medium term, the goal should be to achieve a 50-60% reduction, as recommended by the David Suzuki Foundation, and as currently under consideration by the IPCC and European Union. Thus far the Province's efforts have not matched Canada's international obligations and the trend has been away from keeping those commitments.

A number of data problems were mentioned in this chapter, including the fact that the number of monitoring stations for ambient air quality in Nova Scotia has decreased substantially. A concerted effort is needed to ensure an adequate and representative monitoring network in the Province. Second, unreliable data for wood use have made it difficult to determine trends for VOCs, PM, and CO. Fortunately, the quality of data used in estimates of emissions from residential fuel wood combustion has improved in the 2000 data. Hopefully future reports will contain reliable wood data. Data restrictions due to privacy and confidentiality protection were also noted namely GHG emissions data for certain sectors since 2001. As well, Environment Canada has ceased to report industrial fuel combustion figures separately from those for other industrial emissions. This information is important for evaluating the full effects of energy use.

Despite some data limitations, it is clear that emissions levels and ambient concentrations of many air pollutants have declined, and therefore improved, since the 1970s, due in large part to improvements in technological pollution controls. It is equally clear that current per capita emissions of most air pollutants and of greenhouse gas emissions in Nova Scotia remain inordinately high, both by Canadian, and particularly by, OECD standards. As well, energy demand has been increasing rather than declining. Progress towards energy sustainability in Nova Scotia can by no means be classified as adequate in the present circumstances.

Yet the evidence indicates that awareness of the issues is growing, and that, with continued and more dedicated attention, monitoring, education, and policy efforts, the energy sector can indeed become far more sustainable in all the aspects outlined in this chapter. The most substantial benefits can very quickly be realized through improved efficiency and conservation, as outlined in the previous chapter. Such measures will not only reduce the substantial energy-related emissions of criteria air contaminants, mercury, and GHGs and other air pollutants emissions but will also address problems associated with security and reliability, as discussed Chapter 5. Substantial benefits are also likely to be realized through new pollution control technologies for coal and wood based energy processes.

7. Institutional Indicators for the Energy Sector

7.1 The Role of Institutions in Energy Sustainability

There are many factors that slow or prevent progress towards achieving sustainability in the energy sector, including economic, social, cultural, technological and political barriers. Separating these factors is not always possible, but it is clear that institutional policy has a significant role to play in addressing many of these hurdles (ICRE Secretariat, 2004).
Figure 1 of Chapter 1 displays the relationship between the environment, society, the economy and institutions. Institutions oversee and manage interactions between the other components: they establish the rules for interactions between society and the economy; they regulate the impacts of society on the environment; and they attempt to facilitate the flow of natural resources and services from the environment to the economy. Institutional indicators therefore provide a means for institutions to assess how well they are managing these interactions and how they themselves measure up against the sustainability goals and targets that they propose for society as a whole. Institutional indicators provide the ***enabling framework*** for sustainable development, because they assess the effectiveness of the underlying rules and organizational structures that direct society in a sustainable direction.

Several concrete and practical actions can be taken at the institutional level to accelerate progress towards sustainable energy systems, namely:

- Promote research and development that supports a shift towards use of energy efficient and renewable energy technologies.
- Formulate clear goals and targets for implementation of energy efficiency and renewable energy. This includes setting appropriate and enforceable standards for energy efficiency, targets for renewable energy generation as a growing proportion of total energy production, and targets for pollutant emission reductions.
- Develop institutional, scientific, planning and management capacities and processes to produce and use more efficient and less polluting forms of energy.
- Promote the development and application of methodologies to integrate energy, environment and economic policy decisions for sustainable development.
- Establish transparent and consistent market conditions that encourage investment in energy efficiency, renewable energy and other clean energy technologies.
- Encourage education and awareness-raising programs at the local, regional and national levels concerning the social and environmental impacts of energy production and use, and the means to mitigate these impacts through consumer behaviour and technology choices (e.g. energy efficiency, renewable energy) (ICRE Secretariat, 2004; Geller, 2003; UN, 1993).

As with the other components of sustainability discussed in the previous chapters, these institutional activities need to be carefully and regularly documented and tracked, which in turn requires the development of institutional indicators of sustainability. To this end, some institutional indicators for the energy sector have been suggested in this chapter. The chapter begins by clearly defining what is meant by *institutions* and *institutional indicators*. The indicators presented here focus on ***Provincial*** Government responsibilities, and the rationale for this emphasis is provided. Indicator selection for the energy sector is then discussed, and a set of institutional indicators for Nova Scotia's energy sector is suggested. **GPI***Atlantic* then presents evidence of progress or lack thereof for the individual institutional indicators, including a discussion of the policies that influence the rules that currently regulate the energy sector. The chapter concludes with a review of all the indicators developed and recommended in this report, showing which institutions have responsibilities regarding these indicators, and whether or not the indicators are being tracked and publicly reported.

7.2 Clarification of Terms

Institutions

For any society to shift to a more sustainable path, it is important to be mindful of the key role of institutions because "institutional change shapes the way societies evolve through time and hence is the key to understanding historical change" (North, 1990:1). To assess and measure the role of institutions in promoting sustainability, the term "institutions" must first be defined and the institutional influences on societal change identified.

The following definition is adapted from a report on institutional indicators and sustainable development commissioned by Germany's Federal Environment Agency (Spangenberg et al, 2000).

Institutions are organizations, mechanisms and systems of orientation that structure how individual or collective actors behave within society. This includes institutions that influence all actors (or groups of actors) in a society as well as institutions that apply to specific actors. Organizations, mechanisms and orientations can all be described as systems of rules (Spangenberg et al, 2000:89).

With institutions defined as the overseers of how "actors behave within society," it is a small step to the question: Who oversees the institutions? In a democratic system the electorate (voting public) is empowered to ensure that institutions are performing as desired and to hold them accountable for their actions. In the case of a publicly traded business it is the shareholders who perform that role. If these institutions are not performing in the interests of most voters or shareholders, then they can, at least in principle, be changed. Because institutions are modifiable in these ways, institutional indicators are necessary, since they can demonstrate the degree to which existing institutions are successful in promoting sustainability, and can point to areas in need of attention.

To assess whether or not particular goals and objectives within the mandates of existing institutions are being achieved, a monitoring system of institutional indicators must therefore be developed. As indicated in the above list of practical actions that institutions can take to promote a sustainable energy system, these indicators should not only measure the activities institutions undertake to meet societal goals, but they should also attempt to quantify the results or responses that are attributable to the institution's activities.

Institutional indicators

To assess progress towards sustainable development properly and accurately, the effectiveness of institutional oversight and management must be measured. If human development is to be "sustainable" at the societal level, then the institutions that oversee that development must themselves first meet certain sustainability requirements. In other words, a first requirement of effective institutional oversight is that the institutions lead by example, and an initial set of institutional indicators can simply apply many of the indicators from the previous sections to the institutions themselves – to assess the degree to which they are energy-efficient, use renewable sources, reduce demand, and minimize the environmental and social impacts of energy use in their own operations.

Beyond that leadership role, institutions can be thought of as the enabling framework that allows society and the economy to function smoothly and effectively. In that regard, institutional indicators are also the means by which that framework is assessed. The following description of institutional indicators, adapted from a previous **GPI***Atlantic* report, describes that assessment of the enabling framework:

Institutional indicators measure how well we maintain suitable financial, administrative and organizational capability over the long term, as a prerequisite for measuring overall wellbeing and sustainability. Ideally institutional indicators of sustainability would measure the manageability and enforceability of resource use and pollution control regulations; and the effectiveness of the organizations that implement management approaches—i.e. the bodies and agencies that manage the energy sector and protect the environment and society from damages caused by the energy sector. These bodies and agencies can be governmental, private stakeholders in the energy sector, or communities, and can either be formal (e.g. the legal system) or informal (e.g. coal mine workers lobbying for the re-opening of a Cape Breton coal mine, and environmentalists concerned about the environmental impacts of coal use) (adapted from Charles et al, 2002:2).

7.3 Selection of Institutional Responsibilities and Activities

Most analyses of sustainable development produced in the past two decades focus on the links between three key domains—the environment, the economy and society—without mentioning the role of institutions. This is done when indicators are entirely concerned with measuring sustainability ***outcomes*** (e.g. the amount of air pollution over time) at the societal level without assessing ***processes*** (e.g. why air pollution levels have changed or how to make them decrease in the future). But some prominent reports—most notably the United Nation's *Agenda 21*—have identified the need to add an institutional dimension to the concept of sustainability to assess the mechanisms and process by which progress towards sustainability can be made.

That said, the institutional indicators of *Agenda 21* are intended to be globally relevant and its general sustainability recommendations are aimed at the national level. This is a much broader focus than is required for this **GPI***Atlantic* energy report, which is confined to a provincial-level sustainability analysis of Nova Scotia's energy sector. The indicators provided by *Agenda 21* and related documents are less relevant to provincial institutions (Spangenberg, 2002; UN, 2001).

To address the need for a more detailed set of institutional indicators than is provided in *Agenda 21*, Spangenberg's team developed an expanded, hierarchical set of institutional indicators (Spangenberg, 2002; Spangenberg et al, 2000). This hierarchy of indicators ranges from a few general, overarching indicators that facilitate communication of broad trends to more numerous, institution-specific indicators for use by specialists and local analysts (Spangenberg et al, 2000). A similar process has been used here, and institution-specific indicators have been categorized according to the specific activities for which a given institution is responsible.

Institutional responsibilities

A set of institutional indicators has been developed in this chapter by analysing and combining criteria for local institutions' responsibilities as outlined in two policy papers that do address sub-national institutional responsibilities: 1) *The Report of the Secretary-General on Information for Decision-Making and Participation*;[57] and 2) the *Renewables 2004 Conference Report*[58] (ICRE Secretariat, 2004; UN, 2001; Spangenberg et al, 2000).

These documents were used together to identify locally relevant areas of responsibility because neither one specifically addresses the local institutional aspects of the *entire* energy sector. The *Renewables 2004* paper outlines specific responsibilities for local institutions, but only with respect to renewable energy development. Institutional responsibilities for energy conservation, conventional energy regulation, reliability of infrastructure, and emissions reductions are not addressed in the *Renewables* report. Thus – by itself – the scope of this paper is too narrow for the purposes of this more wide-ranging study. Conversely the Commission on Sustainable Development (CSD) report on information for decision-making and participation looks at broad institutional themes of sustainable development in general—many of which are relevant to sub-national institutions, but without special reference to the energy sector—and therefore the CSD list of institutional activities is too broad for the purposes of this report.

Combining the insights and approaches of both these reports, however, it is possible to develop a framework and set of indicators for institutional activities and responsibilities that are relevant to the energy sector at the provincial level of analysis. Analysis of these two reports identified four main categories of institutional responsibility, each covering specific sets of activities (UN, 2001):

[57] The Commission on Sustainable Development (CSD) Work Programme on Indicators of Sustainable Development, which is from the ninth session of the United Nations CSD held in New York in April, 2001.
[58] From the International Conference for Renewable Energies (ICRE) held in Bonn in June, 2004.

1. Leading by example;
2. Creating societal change;
3. Reporting; and
4. Self-evaluation.

Each of these responsibilities is described further in Section 7.4 below.

Institutional activities

The two reviewed reports noted above identified a wide range of institutional activities that are directly relevant to the fulfilment of the four types of institutional responsibility. These institutional activities are listed below, with notes added to indicate the particular categories of responsibility in the energy field to which the activities are most relevant.

The institutional activities presented in the *Report of the Secretary-General on Information for Decision-Making and Participation* are:

1. Strategic implementation of sustainable development (relates to #1 - leading by example, #2 - creating societal change, #3 – reporting, and #4 – self-evaluation).
2. International cooperation (relates to #2 - creating societal change, and #3 - reporting).
3. Information access (relates to #2 - creating societal change, and #3 - reporting).
4. Communication infrastructure (relates to no local, energy-relevant theme).
5. Science and technology (relates to #2 - creating societal change).
6. Disaster preparedness and response (relates to #2 - creating societal change).

Institutional activities presented under the heading "the Role of Local Authorities" in the *Renewables 2004 Conference Report* (ICRE Secretariat, 2004) are:

7. Establish local building codes (relates to #2 - creating societal change).
8. Strengthen stakeholder involvement in licensing and in prioritising siting of facilities (relates to #2 - creating societal change, and #3 - reporting).
9. Increase awareness and capacities (relates to #2 - creating societal change, and #3 - reporting).
10. Use the power of public procurement (relates to #1 - leading by example).
11. Establish public-private investment funds to be used to develop renewable energy, efficient technologies, etc. (relates to #1 - leading by example, and #2 - creating societal change).
12. Address energy issues in other areas of local action (relates to #4 - self-evaluation, and (thereby) to #1 – leading by example and #2 - creating societal change).

These 12 areas of institutional activity recommended by the two reports, provide a suitable foundation for developing institutional indicators that can denote progress towards sustainability in Nova Scotia's energy sector. Because of the dynamic nature of institutions, many institutional activities cause changes in two or more areas of responsibility. The far-reaching nature of institutional activity and its impact on all aspects of sustainability means that mainstream, reactive frameworks like the pressure-state-response model (discussed in Chapter 4) are poorly suited for identifying institutional indicators, as they only recognise the role of institutions at one stage of the process – the response stage. Although the pressure-state-response model was used to develop the *Agenda 21* indicators, it has since been abandoned because it was deemed too unwieldy and unsuitable (UN, 2001, 2001b; Spangenberg et al 2000).

The linkages between institutional activities and responses to those activities reflect the complex and unpredictable nature of societal dynamics. For example, the Federal Government's 1980 National Energy Program provoked such a sharp backlash at the provincial level that, 25 years later, it still impedes national-provincial cooperation in moving towards a sustainable energy regime (Doern and Gattinger, 2003). Despite the difficulty this complexity and unpredictability creates for planning, it has been recognized that an effective set of rules, usually created by governments, and a good set of institutional indicators capable of monitoring the implementation of these rules and trends in the impacts of institutional activities, can render the large and uncertain task of creating societal change more manageable.

Following the recommendations in the study on institutional indicators prepared by Spangenberg's team, the institutional indicators for this report have been developed to provide specialists and policy-makers in Nova Scotia's energy sector with appropriate feedback on how effectively the activities they embark upon address their responsibilities in moving the Province towards greater sustainability.

7.4 Institutional Indicators for the Nova Scotia Energy Sector

In Canada, provincial governments are the principal institutions charged with overseeing the "development, conservation and management of non-renewable natural resources" and the "development, conservation and management of sites and facilities in the province for the generation and production of electrical energy" (GoUK, 1867; s. 92a[1]). According to the *Constitution Act,* the Federal Government retains jurisdiction over inter-provincial and international transfers of resources (see also Chapter 2, Section 5 on Nova Scotia's Energy Policy).

The powers vested in the Provincial Government do not cover every aspect of the institutional influences on energy sustainability. In addition to the effects of other levels of government, contributions are also made by various non-government organizations that are also defined as institutions in the definition above. These include social bodies (e.g. religious groups and clubs); economic bodies (e.g. firms, trade unions); and educational bodies (e.g. schools, universities) (North, 1990). However, the terms of the *Constitution Act* do put the overarching responsibility for the management of the energy sector in the hands of provincial legislatures, which also have an influence on the role of other institutions through their capacity to set educational policy, provide incentives and rebates to industry, and other activities. Therefore the following set of recommended indicators concentrates on Provincial Governmental activities that enhance (or inhibit) sustainable development in Nova Scotia's energy sector.

By focusing attention on the Provincial Government, this study aims to identify an initial set of institutional indicators that can be considered for adoption and implementation in Nova Scotia.

This set of recommended provincial-level indicators is not intended to be definitive, nor is it meant to preclude development of institutional indicators for other relevant institutions that play a role in the energy sector. Indeed, both the federal and municipal levels of government retain authority over various aspects of energy use, management, and planning, as do other, non-governmental, institutions.

The indicators identified in this section are therefore simply intended to provide a starting point in the effort to identify a suitable set of institutional indicators. In the future, a multi-stakeholder, consensus-based process could be initiated to further develop and expand the institutional indicators for Nova Scotia's energy sector, both for the Provincial Government and for other institutions.

Two sets of indicators have been assigned for each identified institutional activity: one to track the implementation of each activity (activity indicator); and another to measure the results of the activity—i.e., the response of the economy, society, and the environment to each institutional activity (response indicator). The activity indicator is intended to chart the extent to which each intended activity is carried out in practice, while the response indicator evaluates the activity's effectiveness in fulfilling the institution's responsibility. Table 31 outlines the relationship between institutional responsibilities, activities that help address these responsibilities, and the activity and response indicators that gauge the institution's success in achieving progress in sustainable development in the energy sector.

Table 31. Nova Scotia Provincial Government responsibilities for sustainable energy, possible activities to fulfill those responsibilities, and proposed institutional indicators of implementation and success.

Institutional Responsibility	Activity	Proposed Institutional Indicators	
		For the Activity	For the Response
***Leading By Example*:** Internal govt. efforts to promote sustainable energy use within Provincial Government institutions.	Procurement of energy from sustainable/renew-able sources ("green" energy).	Percentage of all departments, agencies and services with green energy procurement policies.	Percentage of total government energy purchases classified as green (electricity, heating fuel, fleet transportation fuel, etc.).
	Energy-efficiency of government buildings.	Percentage of annual retrofits and new construction projects that meet model energy use thresholds.	Percentage of total floor area in government buildings that exceeds current high-efficiency standards.

Creating Societal Change: Fiscal, educational, and regulatory measures.	Government incentives/ disincentives to promote a more sustainable energy supply and demand (i.e. use of economic instruments to reduce demand, and promote efficiency and use of renewables).	(1) Ratios of public monies spent on different energy sources and processes to support change (e.g. to help develop renewable energy based industries).	Ratio of non-renewable energy generator's tax rate to renewable energy generator's tax rate.
		(2) Dollar value of public monies spent on programs designed to improve energy efficiency and conservation (e.g. Provincial contribution to the Energuide program for energy savings in residential housing).	Energy savings attributable to conservation and efficiency programs.
		(3) Dollar value of Provincial Government efforts to eliminate fuel poverty through (a) investment to improve energy efficiency and (b) rebates to elevate immediate economic hardship due to fuel costs.	Percentage of Nova Scotians living in fuel poverty.
	Government efforts to inform people about energy options.	Percentage of all energy-related promotional material focusing mainly on renewable energy, energy efficiency and conservation.	Percentage of survey respondents who retain knowledge from promotions of renewables, efficiency, and conservation.
	Enforcement of regulations and standards (patrolling).	(1) Percentage of pollutant emissions covered by existing regulatory regime.	Percentage of recognized pollutants with emission standards and reduction targets.

		(2) Percentage of pollutant emission standards that meet or exceed highest comparable international standards.	Percentage of emission reductions per pollutant.
		(3) Percentage of polluters inspected for compliance with existing standards	Percentage of identified polluters that comply with existing emission target regulations.
		(4) Percentage of buildings surveyed for energy efficiency in (a) the residential sector and (b) the commercial and institutional sector	Percentage of buildings that meet highest building efficiency standards in: (a) the residential sector meeting the R-2000 standard; and (b) the commercial and institutional sector meeting the Commercial Building Incentive Program standard.
		(5) Rate of increase in Provincial Renewable Portfolio Standard and comparison of target with leading international standards.	Percentage of electricity supply generated from renewable sources and complying with Renewable Portfolio Standard definition of renewable.
Reporting: Overseeing, monitoring, and reporting on energy sector activities while ensuring transparency and fairness.	Target setting and progress reporting.	Number of recommended energy-related targets set, and percentage of these that match best practices globally.	Percentage of recommended energy-related targets met.
	Developing and adopting provincial-level indicators and measures of progress for energy sustainability.	Percentage of indicators recommended in this report that are actually tracked by the Provincial Government.	Percentage of indicators showing adequate progress towards designated targets.

Evaluation: Efforts to monitor and improve how government addresses energy concerns.	Integration of energy policy (within and among levels of government).	Percentage of government departments (a) audited for energy use and procurement and (b) assessed for energy policy contradictions.	(a) Percentage of government departments adhering to best practices in energy use and procurement and (b) number of identifiable regulatory and policy actions that perpetuate energy waste and promote unsustainable practices.

Other indicators could certainly be included in each area, and could correspond to potential government interventions in all the spheres of action identified in the previous two chapters, but the above list of indicators provides a reasonable beginning to the process of developing institutional indicators for sustainability in the energy sector. These initial indicators are elaborated on below.

Leading by example

This responsibility refers to government's role as a trendsetter, or more directly, to its role in popularizing and publicizing beneficial trends due to the high public profile of its activities and the fact that democratic government, in name at least, represents the interests of society at large. If it is desirable for Nova Scotians to undertake a certain course of activity, such as reducing energy demand, then the Government can lead by example to demonstrate in practice that reducing demand is possible without sacrificing performance or comfort. If sacrifice *is* required, such as turning down the thermostat and wearing sweaters in workplaces or using smaller vehicles to convey officials, then Government actions and willingness to bear those sacrifices can inspire those who are governed to follow suit.

The Provincial Government accepts its responsibility as a role model for change in its 2001 energy strategy, stating that "government is challenged to demonstrate leadership in efficient and wise use of energy" (NSPD and NSDNR, 2001:10). To this end, indicators for two activities have been identified that can measure how effective the Provincial Government is in its attempts to use energy wisely and efficiently.

The first activity is green energy procurement, which has been undertaken in other jurisdictions. Canada's Federal Government has plans to purchase 20% of its electricity from renewable sources (GoC, 2000), while the Government of Nevada plans to obtain 15% of its electricity from renewables by 2013 (Sterzinger, 2002:2). A comparable target could be set for the Nova Scotia Government's electricity purchases. Potentially, this policy could extend to other energy acquisitions as well. For example, a small number of Nova Scotia's Government buildings are partially heated with bio-diesel, a fish oil derivative. The indicators suggested here for green energy procurement activities would quantify such activities and their impact.

Activity – Green Energy Procurement:

> Activity Indicator: Percentage of all departments, agencies and services with green energy procurement policies.
> Response Indicator: Percentage of total government energy purchases (electricity, heating fuel, fleet transportation fuel, etc.) classified as "green" (i.e., that meets sanctioned renewable energy certification guidelines such as Ecologo).[59]

Charting the energy-efficiency of buildings used by the Nova Scotia Government is another activity that could aid in efforts to lead by example. One pertinent benchmark is the Canadian Commercial Buildings Incentive Program target for overall energy use in a building. Many Government buildings are currently being assessed for energy efficiency, and the indicators provided here can help track the progress of this activity.

Activity – Energy-Efficiency of Government Buildings:

> Activity Indicator: Percentage of annual retrofits and new construction projects that meet model energy use thresholds.
> Response Indicator: Percentage of total floor area in government buildings that exceeds current high-efficiency standards.

Both of the activities identified above are part of the Provincial Government's current energy use strategy (NSDOE, 2004f). These "Leading by Example" indicators relate to the *Renewables 2004* recommendation #4 - Use the power of public procurement, and to CSD 2001 recommendation #1 - Strategic implementation of sustainable development.

Creating societal change

The responsibility of Nova Scotia's Government to lead by example is closely linked to the second responsibility of creating societal change: both pertain to the leadership role of government. All but three of the 12 recommendations for institutional activities contained in the CSD and *Renewables 2004* reports deal with creating societal change, and one of the remaining three has no particular applicability to the energy sector in Nova Scotia. So this key responsibility, not surprisingly, produces the most extensive list of suggested indicators in Table 31 above.

The activities identified here include those that government agencies have already been working on through existing initiatives, such as the Keep the Heat fuel rebate program, the Natural Resources Canada Energuide for Houses program, and the sulphur dioxide emissions reductions mandated by the Provincial Government (NSDOE, 2004f). [60]

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[59] Details of Ecologo certification in a Nova Scotia policy context are given in the Electricity Marketplace Governance Committee final report (EMGC, 2003).

[60] The Keep the Heat Program fuel rebate program is a quasi-annual program that provides a rebate to low income people who heat with propane or oil and is used to offset the effects of high prices during the winter heating season. The Energuide for houses program is a program of Natural Resources Canada that offers unbiased, third-party home

The first set of indicators for tracking institutional activity to create societal change deals with government use of economic instruments to bring about change. Economic incentives and disincentives offered and legislated by governments can have a large impact on the energy sector, either promoting sustainability or adversely affecting society and the environment. Most of the negative consequences of so-called "perverse" subsidies in the energy sector (those that promote increased energy demand and fossil fuel use) are not accounted for in conventional economic accounts and remain hidden (Myers and Kent, 2001). Chapter 8 presents a more detailed discussion on the role that such subsidies play in the energy sector.

Three sets of indicators have been proposed here for measuring the economic incentives and disincentives provided to the energy sector by the Provincial Government. The first pair of indicators measures the balance between the tax regimes for renewable and non-renewable energy service providers. This indicator set would compare taxation of property and corporate income, as well as other taxes and fees that governments impose on different energy sector participants.

Activity – Government incentives/disincentives to promote a more sustainable energy supply and demand (i.e. use of economic instruments to reduce demand, and promote efficiency and use of renewables):

> Activity Indicator: Ratios of public monies spent on different energy sources and processes to support change (e.g. to help develop renewable energy based industries).
> Response Indicator: Ratio of non-renewable energy generator's tax rate to renewable energy generator's tax rate.

The second pair of indicators for government incentives and disincentives looks at programs aimed to reduce energy demand through programs addressing energy efficiency and conservation in all sectors. Financial support for the R-2000 building program or the Energuide for Houses programs as well as a host of other existing and potential programs can serve to lower the cost of these programs for users and thereby provide an incentive for increased uptake of efficiency and conservation measures.

> Activity Indicator: Dollar value of public monies spent on programs designed to improve energy efficiency and conservation (e.g. Provincial contribution to the Energuide program for energy savings in residential housing).
> Response Indicator: Energy savings attributable to conservation and efficiency programs.

The third set of indicators seeks to address the serious social problem of fuel poverty. In the last few years, the Nova Scotia Government has offered home heating fuel rebates to low-income households in the Province, while it also generally supported the federal Energuide for Houses program offered by Natural Resources Canada. However a comprehensive strategy to address fuel poverty must address immediate hardships for low-income households while enabling these households to become more self-sufficient by developing programs to improve the efficiency of

energy evaluations. Advisors model each home and provide a report to help the homeowner plan for energy efficiency renovations. Grants are provided to homeowners who complete the recommended energy retrofits.

energy use in these households thereby permanently lowering the amount of energy used and hence the amount of money spent on energy. For example many low-income households cannot afford to participate in the Energuide for Houses program and therefore need a similar program where the costs of the audit and upgrades are more heavily subsidized or covered completely.

> Activity Indicator: (3) Dollar value of Provincial Government efforts to eliminate fuel poverty through (a) investments to improve energy efficiency and (b) rebates to elevate immediate economic hardship due to fuel costs.
> Response Indicator: Percentage of Nova Scotians living in fuel poverty.

As discussed in Chapter 5, it is difficult to isolate individual activities that create energy demand increases or decreases, but it is important to attempt to do so if we are to understand what leads to change and which actions have the greatest potential to enhance sustainability in the energy sector. At the institutional level, what needs to be understood is the impact a particular policy or program has had or may potentially have (in reducing energy demand, for instance, or for increasing renewable energy use in the Province). Targets should be set at the inception of government programs and progress measured over time to assess the effectiveness of the programs in achieving their stated goals.

One of the Nova Scotia Government's aims is to "bundle existing and future business incentives into a Nova Scotia Energy Industry Growth Program, and develop a communication and marketing plan to introduce this program aggressively to energy-related businesses on a global scale" (NSDOE, 2004f). Part of this process could be the inclusion of indicators that show the level of relative support offered to renewable energy industries compared to fossil fuel based industries.

Another key aspect of creating societal change is increasing public awareness and understanding of energy issues and options that affect Nova Scotia and the global environment. The Provincial Government has undertaken some activities to inform Nova Scotians about *Nova Scotia's Energy Strategy* through public consultations and an energy forum held in 2004. The Province also provides energy conservation information on its website; has sent out information packages with its Keep the Heat program; and has surveyed Nova Scotians on the issues facing Nova Scotia's energy sector (NSDOE, 2004f). The following set of indicators would measure the effectiveness of these activities, and provide a baseline against which to assess future survey results.

Activity – Government efforts to inform the public and stakeholders about energy options:

> Activity Indicator: Percentage of all energy-related promotional material focusing mainly on renewable energy, energy efficiency and conservation.
> Response Indicator: Percentage of survey respondents who retain knowledge from promotions of renewables, efficiency, and conservation.

Another way that governments affect societal change is by creating standards and enforcing regulations that govern actions in the energy sector. These methods range from pollutant emissions standards and efficiency standards for buildings to setting electricity prices and regulating electricity generation sources.

If regulations are to be effectively enforced, compliance rates must be measured. Some of the indicators proposed in this report are already currently measured by governments while others could be measured in the future. The following three sets of activity/response indicators address some of the main regulated aspects of Nova Scotia's energy sector.

Activity – Enforcement of regulations and standards (patrolling):

Emissions of most air pollutants are tracked in Nova Scotia, although some energy-related pollutants are not adequately monitored or have no associated standards (e.g. arsenic as discussed in Chapter 3). Emissions resulting from the generation of electricity are generally tracked relatively carefully, and new regulations that aim to reduce many of these emissions further have been enacted (SOx and NOx for example) or proposed (mercury). But other emissions—notably those from the home heating sector—are not closely tracked and remain largely unregulated. The following group of indicators would quantify the adequacy of existing pollutant emission standards and of the current regulatory regime, and they could also serve to assess the enforcement of existing regulations, compliance with those standards, and the degree to which these standards are exceeded.

> Activity Indicator: Percentage of pollutant emissions covered by existing regulatory regime.
> Response Indicator: Percentage of recognized pollutants with emission standards and reduction targets.
>
> Activity Indicator: Percentage of pollutant emission standards that meet or exceed highest comparable international standards.
> Response Indicator: Percentage of emission reductions per pollutant.
>
> Activity Indicator: Percentage of polluters inspected for compliance with existing standards.
> Response Indicator: Percentage of identified polluters that comply with existing emission target regulations.

Another aim of the Nova Scotia Government is to "promote the use of energy service companies (ESCOs) as a means of achieving energy savings by large energy users, including government" (NSPD and NSDNR, 2001). This measure has been *suggested* for large energy users, but there is no legislation that compels Nova Scotian energy users to strive for energy-efficiency gains in buildings or in industrial and commercial processes. Such legislation could convert existing voluntary programs, like the 1997 Model National Energy Code of Canada for Houses and the Model National Energy Code for Buildings, into enforceable Provincial building codes. Such action would contribute to meeting recommendation #7 from the *Renewables 2004* report mentioned above.

> Activity Indicator: Percentage of buildings surveyed for energy efficiency in (a) the residential sector and (b) the commercial and institutional sector.

Response Indicator: Percentage of buildings that meet highest building efficiency standards in: (a) the residential sector meeting the R-2000 standard; and (b) the commercial and institutional sector meeting the Commercial Building Incentive Program standard.

Nova Scotia created the legal means to develop a Renewable Portfolio Standard (RPS) in the *Electricity Act* of 2004 with the intention of increasing the share of renewable energy in the Province's electricity mix. The Nova Scotia Electricity Act states that an RPS will be set, but the penalties for non-compliance have not yet been determined, nor has the rate of increase in renewable energy been formally disclosed. The next pair of indicators is intended to measure the government's actions in promoting renewable energy using the RPS approach, and the level of compliance with the Provincial RPS. In order to ensure that the bar is not set too low and that expectations of renewable energy uptake are not too modest, the RPS target and rate of increase in renewable energy uptake should also be compared with "best practices" nationally and globally.

Activity Indicator: Rate of increase in Provincial Renewable Portfolio Standard and comparison of target with leading international standards.
Response Indicator: Percentage of electricity supply generated from renewable sources and complying with Renewable Portfolio Standard definition of renewable.

Reporting

Part of government's role is to communicate the effectiveness of its efforts to meet established goals and targets in demand reduction, energy efficiency, renewable energy uptake and other key areas. This is particularly important, because progress in these areas depends not only on the suppliers of energy and the producers of electricity but on the willing compliance of its consumers. For this reason, effective communication and reporting are particularly important functions of government and other institutions such as Nova Scotia Power. Indeed, highlighting the responsibility and importance of institutional reporting is one of the key aims of the **GPI***Atlantic* energy accounts, and the indicators recommended in this report are intended to facilitate that function.

The two reporting activities identified here are essentially second order indicators or "indicators of indicator development" and use. They are designed to ensure that oversight of government activities is effective. They focus on establishing goals and targets and on measuring progress towards achieving those goals, rather than on the specific activities taken to meet those goals (which are the focus of the previous section).

The first activity for institutional reporting by the Nova Scotia Government is measuring the commitments made by government itself. There are three key purposes of the indicators proposed for this activity:

- First, to monitor the *intentions* of government to move towards a sustainable energy system by assessing whether or not it is setting appropriate targets in all key fields (e.g. demand reduction, energy efficiency, etc.);

- Secondly, to ensure that government is not simply setting targets that are too easy to meet without substantive change; and that it is setting the bar sufficiently high by comparing its targets to the intentions and actions of governments with ambitious targets and proven records in moving rapidly towards a more sustainable energy system; and
- Thirdly, to monitor the actual efforts made to meet government commitments and targets for developing a more sustainable energy sector.

Activity – Target setting and progress reports:

> Activity Indicator: Number of recommended energy-related targets set, and percentage of these that match best practices globally.
> Response Indicator: Percentage of recommended energy-related targets met.

Having basic indicators on targets setting and progress reporting can facilitate the early development of strategies to meet energy-related commitments with graduated targeting and monitoring as a priority. In particular, clear targets can help mobilize Nova Scotians behind a common vision and facilitate reporting and transparency. By contrast, the absence of clear targets may blunt commitments and stymie essential action. For example, Nova Scotia's greenhouse gas emissions in 2002 were 5.7% above 1990 levels despite Canada's commitment to reduce GHG emissions to 6% below 1990 levels by 2008-2012, and despite the Province's commitments under the New England Governors and Eastern Canadian Premiers Climate Change Action Plan of 2001 (NEG/ECP, 2001). That document calls for a return to 1990 emissions by 2010. However the key issue from the reporting perspective under discussion here is that there have not yet been any step-wise targets set in Nova Scotia to monitor the Province's progress towards either of these goals and no comprehensive reporting has been undertaken by the Province to inform citizens, businesses or policy makers of the situation. Government and the general public will more easily keep track of progress if the Province sets clear targets for sustainable energy-related development and if these commitments are tracked by indicators such as those recommended in this report.

The second key reporting activity, which follows directly from the target setting activity described above, is indicator development itself. Once targets are set, the next step is to develop clear and effective indicators that measure progress towards achieving those targets. To strengthen governmental accountability and self-assessment, therefore, the number and quality of measurements for energy sector activities should also be monitored. In short, this is an indicator of indicator development. The aim is to develop and adopt provincial-level indicators and measures of progress for sustainability.

Activity – Developing and adopting provincial-level indicators and measures of progress for energy sustainability:

> Activity Indicator: Percentage of indicators recommended in this report that are actually tracked by the Provincial Government.
> Response Indicator: Percentage of indicators showing adequate progress towards designated targets.

While this chapter suggests some key indicators for institutional consideration, this indicator selection procedure can continue more systematically by means of a multi-stakeholder process that draws up a manageable and rigorously formulated list of energy sustainability indicators.

Evaluation

The rationale for including this area of institutional responsibility comes mainly from recommendation #12 above, namely to "address energy issues in other areas of local action." The *Renewables 2004* report recommends that other government activities not directly related to energy should be screened to identify multiple areas of opportunity for adoption and implementation of renewable energy. This concept was expanded to include a careful consideration and evaluation of countervailing policies and of intersecting areas to ensure that policies are not in place in various sectors that may potentially undermine efforts towards sustainability. This evaluation activity, and the indicators that measure it, aim to reduce inconsistencies in departmental policies and regulations as they relate to energy use, by uncovering potential conflicts so they can be properly addressed and resolved.

Activity – Integration of energy policy within and among levels of government:

> Activity Indicator: Percentage of government departments (a) audited for energy use and procurement and (b) assessed for energy policy contradictions.
> Response Indicator: (a) Percentage of government departments adhering to best practices in energy use and procurement and (b) number of identifiable regulatory and policy actions that perpetuate energy waste and promote unsustainable practices.

The paired activity and response indicators described above all aim to assess institutional activities that are designed to fulfil institutional responsibilities in moving towards a more sustainable energy system. Though often neglected in assessments of sustainable development, these institutional indicators are here seen as essential complements to the social, economic and environmental indicators described in Chapters 5 and 6. They are just as important as these other indicators because they link the social, economic and environmental dimensions and they track the effectiveness of the institutions that oversee energy sector behaviours and impacts. The following section outlines some of the specific current government activities relating to the energy sector (mostly at the provincial level) that would be monitored by the indicators described in this chapter.

7.5 Government Policy

To this point, institutional indicators have been described fairly broadly and conceptually. This section presents a brief description of some relevant actions on energy by government (Provincial and Federal) that are indicative of the types of specific activity that can be monitored through use of the institutional indicators outlined in this chapter. These activities include: regulating the efficiency of household appliances; purchasing "green" power; reducing pollutant and greenhouse gas emissions; expanding use of renewable energy; enhancing conservation and efficiency; regulating the impacts of energy on water and land; etc.

This review is not comprehensive and does not analyse the methods, implementation, and effectiveness of the various policies. Such an effort is well beyond the scope of this brief introduction. The primary focus in the following examples is on Provincial policy. However, Provincial efforts are sometimes linked directly to Federal and international agreements. The development of institutional indicators for Nova Scotia's energy sector is still at too early a stage to quantify progress definitively. Therefore, the following description simply illustrates the wide range of actions, including target setting, available to governments to enhance sustainability, and the importance of institutional indicators to monitor and promote government action. Nevertheless, even this brief qualitative review reveals areas of relative strength in institutional activity (e.g. setting explicit targets for pollutant emission reductions) and areas of relative weakness (e.g. lack of enforcement mechanisms, and absence of a coherent strategy for greenhouse gas emission reductions).

Air pollution

Increasing evidence of the effects of air pollution (in particular acid rain) led to the 1991 Canada-U.S. Air Quality Agreement. Under this accord Canada agreed to reduce annual SO_2 emissions in the seven easternmost provinces to 2.3 million tonnes by 1994, a 40% decrease from 1980 levels (Environment Canada, 1992). The Federal Government also set a permanent national cap of 3.2 million tonnes per year by 2000. In addition Canada promised to reduce nitrogen oxide emissions from stationary sources by 100,000 tonnes (from a forecasted emission level of 970,000 tonnes in 2000). Canada also began tightening automobile NO_x emissions standards in conjunction with U.S. efforts.

Canada's promised reductions were also a product of the country's earlier commitment under the 1979 Convention on Long-Range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE) (Environment Canada, 1992). In signing, Canada had agreed to cut SO_2 emissions by at least 30%. Therefore, by 1992, Canada had already achieved about 80% of the reductions required in the 1991 Canada-U.S. Air Quality Agreement. In the 1980s and 1990s Canada made further UNECE commitments for SO_2 and NO_x emission reductions (Environment Canada, 2004a).

In order to achieve these reductions, the cooperation of the Provincial Governments was needed. This was achieved in the Eastern Canada Acid Rain Control Program which was initiated in 1985 and subsequently formalized in seven federal-provincial compacts. In the Canada-Nova Scotia agreement, signed in 1993, the Province agreed to a 1994 target of 189 kilotonnes of SO_2 (Environment Canada, 2002a).

In order to address this target, the Point Aconi generating station was commissioned. At that time it was the world's largest circulating fluidized-bed, coal-burning power plant, designed to capture 90% of the sulphur in the fuel and simultaneously to reduce nitrogen oxide emissions.

Nova Scotia Power was, and remains, the major source of SO_2 emissions in Nova Scotia. With the privatization of the utility, the Nova Scotia *Environment Act*'s Air Quality Regulations stipulated that NSPI would have an SO_2 emissions cap of 145,000 tonnes by 1995 (GoNS, 2005).

In the mid-1990s, work began on the Canada-wide Acid Rain Strategy for Post-2000 and on the Canada-wide Standards for PM and ground-level ozone (Environment Canada, 2000a). The Canada-wide Standards for PM and ozone were agreed to by the Canadian Council of Ministers of the Environment in 2000. The standard for $PM_{2.5}$ is a maximum average concentration of 30 micrometers per cubic meter per 24-hour period, to be achieved by 2010. The standard for ground-level ozone is a maximum concentration of 65 parts per billion in an 8-hour period, to be achieved by 2010.

In 1998 Federal and Provincial energy and environment ministers signed *The Canada-wide Acid Rain Strategy for Post-2000*. Nova Scotia committed to a 25% reduction in SO2 by 2005 (which data confirm is likely to occur in 2005), and a 50% reduction by 2010 (Environment Canada, 2004a). These undertakings have been reiterated by the Province in *The Acid Rain Action Plan* of the Conference of New England Governors and Eastern Canadian Premiers (CNEG/ECP)—which calls for a 50% reduction in SO2 emissions by 2010—and in Nova Scotia's own *Energy Strategy*, which repeats these commitments (NSPD and NSDNR, 2001; CNEG/ECP, 1998;). The CNEG/ECP *Acid Rain Action Plan* also looked at NOx emissions and established a target of a 20-30% reduction by 2007. Nova Scotia has committed to a 20% reduction by 2009 (NSPD and NSDNR, 2001). Efforts to reduce both NOx and SOx should simultaneously help the Province reach the Canada-wide Standards for PM and ozone by 2010, since NOx is a precursor of ground-level ozone and since many pollution controls effectively reduce emissions from several pollutants (NSPD and NSDNR, 2001).

The NEG/ECP has also developed a *Mercury Action Plan* (CNEG/ECP, 1998a). The target was to achieve a 50% reduction in mercury emissions by 2003 and the virtual elimination of mercury releases in the long term. In Nova Scotia's 2001 *Energy Strategy,* the Province promised, by 2005, to achieve mercury emissions that are 30% lower than in 1995 (NSPD and NSDNR, 2001). As noted in the previous chapter, the Canadian Council of Ministers of the Environment has released new draft Canada-wide Standards that will require further mercury emission reductions to 57% below 2002-2004 emissions, with a total emissions cap of 65 kg of mercury per year by 2010 for the existing coal-fired power plants at Lingan, Point Tupper, Trenton, and Point Aconi.

Meeting these new targets is dependent on various changes to federal fuel and vehicle standards and to Provincial regulations for heavy fuel, and will require operational changes at Nova Scotia Power facilities. Currently NSPI is on tract to have a 25% in 2005. To meet the new NO_x targets, it is also crucial that Nova Scotia continue to require all utility and industrial boilers to install low-NO_x technology during upgrades and stock turnover (NSPD and NSDNR, 2001).

Under the Nova Scotia *Environment Act*, the Province has developed fees for industrial stationary emissions of SO_2, PM, and VOCs, as shown in Table 32 (GoNS, 2005). The air quality regulations, as updated in 2005, also contain a number of steps for achieving these targets including:

- Reducing the Province's annual SO_2 emissions cap to 141,750 tonnes from 189,000 (effective March 1, 2005).

- Each facility that released more than 90 tonnes of SO_2 in 2001 must submit an emission reduction plan to achieve SO_2 emission reductions of 25% from 2001 levels by 2010.
- Effective July 1, 2005, the sulphur content of heavy fuel oil consumed in a facility must not exceed 2.2% by mass and 2.0% on an annual basis.
- Effective July 1, 2005, the sulphur content of the total fuel consumed in a petroleum refinery must not exceed 2.2% by mass and 2.0% on an annual basis.
- Effective March 1, 2005, NSPI's SO_2 emissions must not exceed 108,750 tonnes annually.
- By 2010, NSPI's SO_2 emissions must not exceed 72,500 tonnes annually.
- By 2010, NSPI's NO_x emissions must not exceed 21,365 tonnes annually.
- Effective March 1, 2005, NSPI's mercury emissions must not exceed 168 kg annually.

Table 32. Provincial fees for industrial stationary air pollutant emissions

Pollutant	Threshold (tonnes/year)	Rate
Sulphur Dioxide	> or = 500	$2.70/tonne
	> or = 50 and < 500	$350.00 flat fee
Particulate Matter	> or = 100	$2.70/tonne
	> or = 10 and < 100	$350.00 flat fee
VOCs	> or = 100	$2.70/tonne
	> or = 10 and < 250	$350.00 flat fee

The analysis of criteria air contaminants in Chapter 6 shows that residential use of wood for heating is a major source of VOCs, PM, and (to a lesser extent) CO. Currently there are no National or Provincial standards for wood-burning heating devices that specifically address air pollution and energy efficiency, even though highly efficient woodstoves and fireplaces are now available that sharply reduce pollutant emissions (Dobbelsteyn, 2004; NRCan, 2004). National standards are expected in 2005 and Provincial standards are being developed.

This brief review of standards, targets, pollution fees, and agreements on pollutant emissions, illustrates the critical role of government institutions in moving towards a more sustainable energy system, and the importance of institutional indicators in monitoring government actions to promote necessary changes and report on progress.

Other environmental impacts

Unfortunately, the environmental focus of Nova Scotia's *Energy Strategy* is only on air pollution. The Province's pollution reduction targets and strategies are important steps towards improving air quality in Nova Scotia and providing the Province with the moral suasion to request reductions from the up-stream polluters who are responsible for the transboundary pollution that is responsible for so much of the Province's ground-level ozone, smog, and acid rain. What is not clear from the brief review of targets, standards and agreements above is how these targets are going to be enforced, nor what the penalties will be for violations or failures to meet specified targets. With no explicit enforcement plans in place for many of the agreements, standards and targets described above, there is a risk of non-compliance and of targets being missed or only tardily achieved.

In addition, there are many other environmental impacts resulting from energy sector activities, as discussed in Chapters 3 and 6, but only targets for air pollution are fully developed in the Province's energy strategy. A few of these other energy-related environmental concerns are discussed below with a view to illustrating the type of governmental policies, targets, regulations, and agreements that can be monitored through institutional indicators like those suggested in this chapter.

Climate change

Greenhouse gases and climate change are briefly mentioned in the main volume of the Province's energy strategy. Climate change is a global issue and the principal framework for addressing it, the Kyoto Protocol, is an international agreement to which Canada is a signatory. The Kyoto Protocol was developed in 1997 and came into effect in 2004. Canada's commitment is to reduce GHG emissions to 6% below 1990 levels by 2008-2012 (NRCan, 2004a).

Canada was slow to ratify the accord, and to develop a full implementation plan. Canada's strategy for reducing greenhouse gas emissions was finally released in 2005 as *Moving Forward on Climate Change: A Plan for Honouring Our Kyoto Commitment* (GoC, 2005). The likely effectiveness and cost of the plan are contentious and will not be analysed here. Suffice it to say that the strategy is based largely on voluntary reductions, education, and "partnerships." Federal-provincial agreements, akin to those developed in the 1980s and 1990s for acid rain, have yet to be developed.

The Provincial Government has also been slow to respond to climate change and to the necessity of reducing greenhouse gas emissions. Volume 1 of Nova Scotia's *Energy Strategy* briefly outlines the government's plan:

> The document that resulted from the climate change consultations, *Creating a Nova Scotia Climate Change Strategy Framework*, forms part of the Energy Strategy. It includes a series of low-cost first steps to reduce GHG emissions that focus on public awareness and education; government's leading by example through reducing emissions from government-owned buildings and vehicles; transportation and land use planning; the promotion and sponsorship of research and development on new technologies; and practices to increase energy efficiency and generate clean energy (NSPD and NSDNR, 2001:35).

However, the consultations to which the *Energy Strategy* refers fall far short of a coherent strategy for reducing greenhouse gas emissions. There are no reduction targets for any individual sector, nor for the Province as a whole. Furthermore, *Creating a Nova Scotia Climate Change Strategy Framework* is exactly that: a discussion pointing towards a potential framework, not an action plan or a strategy (NSPD and NSDNR, 2001a).

The closest the Province has come to developing a strategy with the potential for achieving progress is through the New England Governors and East Coast Premiers' 2001 Climate Change Action Plan (CNEG/ECP, 2001). This document outlines a set of overarching goals for the region. They are:

- Short-term goal: Reduce GHG emissions to 1990 levels by 2010.
- Mid-term goal: Reduce GHG emissions to at least 10% below 1990 levels by 2020, and establish an iterative five-year planning process, commencing in 2005, to adjust the goals if necessary and set future emissions reduction goals.
- Long-term goal: Reduce GHG emissions sufficiently to eliminate any dangerous threat to the climate; current science suggests this will require reductions of 75–85% below current levels.

In order to meet these targets there are also several sub-goals:

- Reduce end use GHG emissions within the public sector by 25% by 2012.
- Reduce the amount of CO2 emitted per megawatt hour of electricity use by 20% by 2025.
- Increase the amount of energy saved through conservation by 20% by 2025, thereby reducing GHG emissions.

At best, this NEG/ECP plan seems to be out of favour with the Provincial Government, which has not seriously referenced or implemented its provisions. Instead, the Province appears to be relying on the 2001 *Energy Strategy* as its primary climate change mitigation plan, and on the Federal Government as Canada's signatory to the Kyoto Protocol. From the perspective of assessing institutional activity as described in this chapter, an initial qualitative review does not indicate adequate concerted action, target-setting, incentives/disincentives, or enforcement mechanisms designed to reduce the Province's energy-related greenhouse gas emissions.

Less CO_2-intensive energy

In order to achieve significant carbon dioxide reductions that meet the NEG/ECP targets, the Province must switch to energy sources that produce less CO_2 and/or reduce overall energy use. The Province has officially promoted the use of natural gas—which is less carbon intensive than other fossil fuels—as well as renewable energy (namely, wind power), but the actions still remain very modest within the larger context of total energy use and the dominant reliance on coal and oil. In referring to natural gas, Nova Scotia's *Energy Strategy* states, "we export only those resources surplus to our needs" (NSPD and NSDNR, 2001:22), and advocates "using our energy resources in Nova Scotia" (NSPD and NSDNR, 2001:20). However in actual fact, as outlined in Chapter 2, the vast majority of natural gas continues to be exported to New England and New Brunswick. There are only about 400 customers in the Province, and Nova Scotia Power—which could burn natural gas at Tufts Cove—uses very little, due to price. Efforts to promote natural gas in the Province include a small Provincial fund to help extend pipelines, and rebates on efficient natural gas appliances (a program partially funded by Natural Resources Canada) (Heritage Gas, 2004).

On development of renewable energy, there has been some policy progress. Specific actions to promote electricity generation from renewable sources are outlined in the *Energy Strategy* and in the report of the Electricity Marketplace Governance Committee (EMGC). These include net metering for small-scale renewable generation; a forced opening of the distribution system for both independent renewable and co-generation power producers through an open access transmission tariff and the ability to sell directly to large users; the development of renewable energy standards (i.e. defining what constitutes renewable electricity); and a Provincial renewable portfolio standard or RPS (EMGC, 2003; NSPD and NSDNR, 2001). The energy strategy set a voluntary RPS of a 2.5 percentage point increase in new renewable generation. The EMGC further recommended setting a mandatory RPS of a 5 percentage point increase in new renewable generation starting in 2006. Although not yet legislated, the Province has informally accepted the proposed target of a 5% RPS starting in 2010 (EMGC, 2003). The *Electricity Act* of 2004[61] provides the legislative authority for many of these new changes, although some have already been implemented by the Utility and Review Board and others remain to be implemented in the yet to be passed new Energy Act. The Federal Government has also been promoting wind energy through the Wind Power Production Incentive program, which pays eligible wind producers $0.012 per kWh. This ensures a certain level of return to wind power producers, thereby making it a safer investment (NRCan, 2002a).

There seems to be no policy progress at the Provincial level in promoting development and use of biofuels, hydrogen and other renewable alternatives. Policies to require or encourage passive and active solar energy also seem to be lacking. Although it is not yet possible to apply the suggested institutional indicators outlined in this chapter in a systematic and quantitative way, this brief qualitative overview does point towards areas of relative strength and weakness in institutional activity. The importance of this activity in moving towards a sustainable energy system points clearly to the need for further systematic development and application of the type of institutional indicators suggested above.

Efficiency and conservation

Efficiency and conservation are the other key tools for reducing GHG emissions and achieving self-sufficiency. A wide variety of technologies that produce, process, and use energy—vehicles, appliances, homes, buildings, and industrial processing— could be improved through institutional policy efforts, incentives and regulations.

Nova Scotia addressed residential and commercial efficiency through the *Energy-efficient Appliances Act and Regulations*, which were last amended in 1994, and through the *Building Code Act and Regulations*, which were last amended in 2003 (GoNS, 2005). The building code regulations use the *National Building Code of Canada 1995* standard along with subsequent revisions up to 2002. This is a reasonable basis for building standards but is deficient in terms of efficiency standards. Instead, the model national building codes and the R-2000 standards enjoin greater energy efficiency, but these have been used in only a tiny proportion of new buildings, have not been incorporated into legislation, and lack any enforcement apparatus.

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[61] The 2004 *Electricity Act* is available at: http://www.gov.ns.ca/legislature/legc/bills/59th_1st/3rd_read/b087.htm. Accessed September 26, 2005.

This example illustrates the importance of institutional indicators being sensitive enough to distinguish general goals, targets, and statements of intent (e.g. promotion of building efficiency, use of natural gas, GHG emission reductions, and other noble intentions), from legislated actions, fiscal incentives, and enforcement mechanisms. The latter have the capacity to realize these targets on a widespread scale, to bring them into the mainstream, and to transform the current unsustainable system practically and effectively into a sustainable one.

Federally, the *Energy Efficiency Act* is the enabling legislation for developing a wide variety of efficiency standards and programs for appliances and buildings. A primary purpose of the Act is to eliminate the least energy-efficient products from the Canadian market (NRCan, 2005). The Federal Government has the authority to regulate any good that is imported to the country or traded between provinces, which gives considerable potential scope to the *Energy Efficiency Act* to enhance appliance efficiency and energy savings. Less promisingly, the federal regulations have not been updated since 1998 despite considerable improvements in technology and efficiency in many appliances since then.

It is currently difficult to compare Provincial and Federal standards for energy efficiency, as efficiencies are reported in different formats. A thorough understanding of other markets and of available technologies is also needed in order to establish institutional indicators that have meaningful targets. At a minimum, based on this initial overview, it appears that both Federal and Provincial regulations could use substantial updating to promote enhanced efficiency, considering the technological advances of the last decade. As noted earlier, the lack of standards for wood-burning heating devices remains a significant problem, especially in provinces such as Nova Scotia, where wood use is prevalent. This is particularly unfortunate in light of the vastly improved technologies now available that have substantially increased woodstove efficiency and that have significant potential to reduce harmful energy-related pollutant emissions in the Province.

Water and land issues

Legislative authority over the use and protection of water is outlined in the Nova Scotia *Environment Act* and associated regulations (GoNS, 2005). Approval is needed and fees are mandated for dam construction, water withdrawals, water storage, and discharges to water. Approval is likewise needed for application of herbicides for vegetation control in transmission corridors. The *Environment Act* also requires environmental assessments for operations such as power plants, including thermal and wind power and offshore exploration. The Act and accompanying regulations also prescribe punitive measures for offences such as intentionally discharging oil. Nova Scotia's *Energy Strategy* contains very little discussion of these types of energy-related environmental issues, and makes only passing references to the potential effects of offshore oil and gas on marine life and the fisheries. Institutional progress in this area would be signified by more explicit links between the Province's *Energy Strategy* and the provisions of the *Environment Act.*

Other legislation of interest

The following is a brief list of some other legislation (a form of institutional activity as described above) that affects the Nova Scotia energy sector:

- Mining (including coal) and access to geothermal resources is controlled by the Department of Natural Resources under the *Mineral Act* (among others).
- A number of pieces of legislation guide the actions of Nova Scotia Power including the 1992 *Nova Scotia Power Privatization Act* (which created NSPI from the crown Nova Scotia Power Corporation) (GoNS, 1992); Bill 87 (the Nova Scotia Power Reorganization Act) of 1998 which paved the way for Emera to be created as the holding company for NSPI (GoNS, 1998); and the *Electricity Act* of 2004 (GoNS, 2004). Of note is that the *Privatization Act* forbids NSPI to build a nuclear plant.
- The *Petroleum Resources Removal Permit Act* allows the NS Department of Energy to compel petroleum and gas resources extracted in the Province to be used to meet Provincial energy needs and to promote other industries in the Province (e.g. chemicals).
- The *Environment Act* allows the use of a wide range of regulatory and economic tools to protect the environment, though it promotes the use of non-regulatory means such as cooperation, communication, education, incentives and partnerships, rather than punitive measures. It also requires the province to report on the state of the environment "periodically" (GoNS, 2005a).[62] The last Nova Scotia State of the Environment Report was released in 1998.

It is noteworthy that Part One, Section 2 (b) (ii) of the Nova Scotia *Environment Act* enshrines the precautionary principle in these words:

> The precautionary principle will be used in decision-making so that where there are threats of serious or irreversible damage, the lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation.

Despite this legislative authority, the principle has not been invoked to take forthright action on climate change, energy conservation, clear-cutting, and other key energy and environmental issues in the Province.

These last two examples further illustrate the need for effective institutional indicators of sustainability to assess not only whether intentions are expressed, targets set, legislation passed, and regulations promulgated (though all such actions are vitally important), but also whether actions are implemented in practice, encouraged through the use of financial instruments, and enforced through punitive means if necessary. For this reason, the recommended indicators above include both an "activity" component and a "response" component.

[62] The requirement is to report "periodically" on the state of the environment. Since 1995 this has only been done once in the 1998 State of the Environment Report.

Other policy areas including renewable energy

The policies discussed above do not cover all the issues and impacts of energy use in which government and other institutional activity can have a profound impact. Other areas of interest are worker safety, energy security, subsidies, and affordability.

Affordability is an area where there seems to be a lack of Federal and Provincial legislation attending to the needs of the fuel-poor. Some scattered actions have been taken at different times, but there is no systemic or structural proposal on the horizon to alleviate fuel poverty which, as we saw in Chapter 5, may affect about 20% of low-income households in Canada. The Nova Scotia Government in 2003 offered modest rebates to low-income Nova Scotians to help offset the high price of home heating fuel, and in 2000 the Federal Government sent about 10 million cheques averaging $250 per household to those eligible for GST rebates because they met the low-income test on their previous year's income tax return. But both programs were strongly criticized as being ineffective and doing nothing to improve the efficient use of energy, which, it was argued, could save more money than the despatch of rebate cheques. Even the Federal Finance Minister, Mr Goodale, recently acknowledged that the administration of the 2000 rebate program was "awful" (Cordon, 2006).

It may be argued that relevant institutional activity is not confined to specific energy policy alone, but that the latter penetrates all other spheres of government activity. For example, in an economy dependent on imported fossil fuels, energy security is linked, in part, to foreign and military policy, although Canada remains fortunate in this regard because it has substantial domestic sources of energy. It is clearly not possible to develop specific institutional indicators for every energy-related policy, but these examples illustrate the importance of institutional factors, including policy-making, in moving the current energy system towards greater sustainability.

Existing energy subsidies, incentives, and disincentives, unfortunately, are not covered in this report, apart from the brief descriptive discussion in Chapter 8. These subsidies are completely intertwined with policies on taxation, on research and development funding, and with other forms of preferential treatment that foster and promote specific types of economic activity. One difficulty in assessing the differential impacts of subsidies on the energy sector is that these subsidies take many different forms, and are sometimes hidden, rarely publicized, and in some cases not properly accounted for or reported. To assess the impact of these subsidies on sustainability in the energy sector, governments will need to become more transparent in these areas and provide fuller public reporting.

From a sustainability perspective, the goal of any subsidy program should be to promote more sustainable forms of energy, including research and development into renewable energy sources and applications. There is reason to suspect that current subsidies are heavily weighted to promote fossil fuel exploration and extraction over renewable energy development, and are thus "perverse" subsidies from a sustainability perspective. This is a subject that requires much deeper exploration than is possible here, but it is flagged here again to illustrate the vital importance of institutional interventions in creating a sustainable energy system. At a minimum, subsidy programs should not be preferential towards non-renewable energy. They should, at least, provide equal opportunities for all forms of energy production.

A 2005 study comparing taxation rates for wind energy projects in Canada showed that Nova Scotia has the highest taxes for wind energy of all the provinces. Based on existing and proposed projects a standardized 20MW facility will pay on average $679,810 (2005 $CDN) annually in Nova Scotia verses $42,785 in Ontario, the province with the lowest tax rate (Current Generation Inc., 2005). The study also provided a comparison of taxation of wind projects to taxes paid by NSPI per MWh of electricity generated. The taxation figures for NSPI were developed by the Renewable Energy Association of Nova Scotia in a 2005 position paper. The tax per MWh for NSPI was $1.45 and for wind $10.32, a sevenfold difference. These figures indicate wind energy developers in Nova Scotia are at a strong competitive disadvantage to wind developers in other parts of the country and to conventional generation (largely thermal plus some hydro) in Nova Scotia. Such conditions are unlikely to lead wide-scale free-market development of wind energy in Nova Scotia without the use of incentives and regulations (e.g. future renewable portfolio standards).

Table 33 presents some of the main policy initiatives on energy efficiency, conservation, renewables, and the environmental impacts of energy, along with links to the institutional themes covered in this chapter. This approach is suggested here as the basis for further investigation that can reveal areas where improvement is needed. However, even at this very preliminary level of analysis, certain gaps have become apparent, such as outdated efficiency standards, inadequate standards and regulations for wood stoves, and the lack of policies aimed at addressing problems that stem from transportation fuels. This approach is useful to identify areas where policy interventions can help move the energy system to greater sustainability. In particular, it is suggested that the framework recommended here may help with the development of a more systematic approach to energy policy that will facilitate the deeper, structural changes necessary to create a genuinely sustainable energy regime for Nova Scotia. Above all, Table 33 indicates the extraordinarily important role that governments can play in this process, and the necessity for including institutional indicators in this analysis.

Table 33. Summary of policy initiatives on energy efficiency, conservation, renewable energy and environmental impacts of energy in Nova Scotia

Issue	Government Action	Links to Institutional Themes
REGULATION		
Renewable portfolio standard	5 percentage point increase in renewable electricity generation as portion of total generation through new capacity by 2010 (currently voluntary target for NSPI but expected to become mandatory)	Creating societal change
Co-generation	No targets. Regulations only require new co-generators to have access to grid	Creating societal change
Efficiency standards	Efficiency standards set in 1994 (no standards for wood-burning heating devices, some expected).	Creating societal change
Emissions caps	Emission reductions: SO_2: 25% by 2005; 50% by 2010. NO_x: 20% by 2009. Mercury: 30% by 2005.	Creating societal change
FISCAL MEASURES		
Net-metering	Yes, for small-scale renewable generators under 100 kW	Creating societal change
Financial incentives	Rebates on efficient natural gas appliances (boilers and water heaters)	Creating societal change
	Unspecified fiscal support for R-2000 homes	Creating societal change
Financial dis-incentives	Fees for SO_2, NO_x, and VOCs	Creating societal change
INFORMATION / EDUCATION		
Information and awareness	Some energy efficiency information is available from NSDOE. Uncertainty on degree of societal knowledge.	Creating societal change
	Endorsement of home energy audits	Creating societal change
Research, development and training (skills development)	None mentioned for renewable energy (only oil, gas and "clean" coal). For example, Cape Breton University has a Centre of Excellence in Petroleum Development but none for renewable energy. (Centres of learning also have an institutional role in the energy field in addition to governments.)	Creating societal change
Green Power Program	Yes (NSPI)	Creating societal change
IN HOUSE GOVERNMENT CHANGE		
Procurement	Not mentioned	Leading by example
Building and vehicle efficiency improvement	No targets	Leading by example

7.6 Institutional Tracking of Proposed Energy Sector Indicators

Part of **GPI***Atlantic*'s core mandate is to examine the effects of human actions on the environment, communities, families, and human health, in this and future generations—effects that often are not accounted for in the market place or in conventional measures of progress. In order to measure progress accurately and comprehensively, these effects need to be accounted for, valued, assessed, and quantified to the extent possible. Various institutions may be involved in the development of quantitative indicators that demonstrate trends over time. Governments, businesses, universities, and other non-governmental organizations all have a role to play in the development and use of energy indicators. Table 34 provides a snapshot of institutional reporting and use of some of the energy indicators discussed and presented in this report.

Table 34. Reporting on energy indicators by Nova Scotian institutions

Indicator (Nova Scotia Level)	Current (C) / Possible (P)[1] Collecting Institutions	Is the Indicator Tracked / Publicly Available?
CO emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
TPM emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
SO_x emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
NO_x emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
VOC emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
Mercury emissions – total and per capita	(C) Environment Canada (P) NSDEL	Yes / Yes
GHG emissions – total and per capita	(C) Environment Canada (P) NSDEL, NSDOE	Yes / Yes
Current energy mix - total primary units per year by primary fuel type.	(C) Statistics Canada (P) NSDOE	Partially (wood data missing) / Partially
Units of primary energy produced in the Province vs. units of imported energy by fuel type.	(C) Statistics Canada (P) NSDOE	Yes / Partially (confidentiality)
Total energy consumption by fuel type	(C) Statistics Canada (P) NSDOE	Yes / No (Primary energy data is suppressed)
Total energy consumption by end use	(C) Statistics Canada (P) NSDOE	Yes / No (Primary energy data is suppressed)

Equipment efficiency	(C) NRCan—OEE (P) NSDOE	Partially / Partially (some data only at Atlantic level)
Building efficiency	(C) NRCan—OEE (P) NSDOE	Partially / Partially (some data only at Atlantic level)
Process efficiency (in industry)	(C) NRCan—OEE (P) NSDOE	Partially / Partially (data only at Atlantic level)
Electricity generation and transmission efficiency	(C) NSPI (P) NSDOE, NRCan—OEE	Partially / Partially (some data only at Atlantic level)
Number of person months employed on energy-related jobs (by industry) (direct and indirect)	(C) Statistics Canada (P) NSDOE, CNSOPB	Partially / Partially (incomplete picture presented because of aggregation and lack of information on indirect jobs)
Number of person months lost due to energy-industry accidents	(C) Workers Compensation Board (P) NSDEL	Partially / Partially
Percentage of households living in fuel poverty	(P) NSDOE, NSDH, Nova Scotia Advisory Council on the Status of Women	No / No
Number of days per year grid is down	(C) NSPI (P) NSDOE	Yes / No
Proportion of the population affected by grid failure	(C) NSPI (P) NSDOE	Yes / No

Note: NRCan—OEE: Natural Resources Canada— Office of Energy Efficiency. NSCOPB: Nova Scotia-Canada Offshore Petroleum Board. NSDEL: Nova Scotia Department of Environment and Labour. NSDH: Nova Scotia Department of Health. NSDOE: Nova Scotia Department of Energy. NSPI: Nova Scotia Power Incorporated.

1. Current or (C) means that the institution or agency collects data for the specified indicator. Possible (P) means that the institution or agency has responsibilities surrounding an area and therefore could be involved with collecting data and reporting on the specified indicator.

7.7 Chapter Summary

Indicators of sustainable energy development have been identified by numerous groups including Natural Resources Canada, but often the institutional aspect of sustainability has not been included. Building on the framework for sustainable development introduced in the UN's *Agenda 21*, a set of indicators for the institutional aspects of Nova Scotia's sustainable energy development has been suggested in this chapter.

The indicators identified in this analysis are meant to be a starting point. A multi-stakeholder, consensus-based process can potentially be initiated to develop and expand the institutional indicators for Nova Scotia's energy sector, both for the Provincial Government and for other institutions.

While many policies exist for the energy sector in Nova Scotia, some of which address the impacts of energy production and use on the larger economy, on society, and on the natural environment, many policies are also outdated and require reassessment. A coherent set of institutional indicators that link government activities to its responsibilities would help keep legislation current and relevant.

The need for institutional indicators of sustainable energy development has been identified. The subset presented here is intended to highlight the institutional dimension of sustainable development. It is hoped that the development of these institutional indicators will strengthen the role of the Nova Scotia Government both in setting the rules and targets for a sustainable energy system and in ensuring that these rules and targets are implemented, supported by financial instruments, and enforced when necessary.

8. Assessing the Full Cost of Energy in Nova Scotia

8.1 The Importance of Full-Cost Accounting

The extraction, production, transportation, marketing, and use of energy have effects on people's health, the environment, and society. As discussed in Chapter 1, few of these effects are reflected in the market price of energy. For instance, air pollution from the burning of wood and fossil fuels has measurable impacts on human health, increasing medical expenditures. Greenhouse gas emissions from burning coal and oil are virtually certain to be causing and will continue to cause climate change, which will have costly and even deadly impacts throughout the world for generations to come. Yet these costs are not included in the current price of the fuels used.

To give just one example: The costs of Hurricane Katrina are predicted to add up to more than $US200 billion – *not* counting the value of more than a thousand lost lives. While it cannot be proved with certainty that global warming is the culprit, the damages are consistent with scientific predictions that climate change will produce more intense and frequent storms, which pick up strength from higher sea temperatures. The United Nations' Intergovernmental Panel on Climate Change (IPCC), consisting of 2,000 top meteorologists and scientists worldwide, has stated:

> Emissions of CO_2 due to fossil fuel burning are virtually certain to be the dominant influence on the trends in atmospheric CO_2 concentrations during the 21st century…. Emissions of long-lived greenhouse gases have a lasting effect on atmospheric composition, radiative forcing and climate…. Global mean surface temperature increases and rising sea level from thermal expansion of the ocean are projected to continue for hundreds of years after stabilisation of greenhouse gas concentrations (even at present levels)…. More intense precipitation events – very likely…. Increase in tropical cyclone peak wind – likely…. (IPCC, 2001)

The IPCC is careful only to use the term "virtually certain" when there is a "greater than 99% chance that a result is true." If then, there is a likely link between fossil fuel combustion and extreme climate change damage costs, it is valid to ask: "What is the true cost of coal and oil?" Paradoxically, Hurricane Katrina repair and clean-up costs will be counted as contributions to the U.S. GDP and to economic growth rather than as costs that should be reflected in the true price of energy.

The production of energy also has social benefits in that it creates jobs and economic wealth. These gains are more accurately reflected and monitored in the market economy than are societal costs, which often are not considered, or are not associated directly with the energy sector. For example, the massive movement of labour for temporary, large-scale energy products, like oil and gas exploration and the construction of generating plants, dams, and refineries, and the resulting impacts on society and on communities remain uncounted in conventional market statistics. The military and political costs of securing and maintaining foreign sources of oil and coal are likewise not added directly to the price of energy, so those who consume such fuels do not pay directly for these services at the gas pump or in their heating bills. For example, the huge costs of the war in Iraq, which at least to some extent may be related to securing the continued flow of oil from that country, are counted in conventional market statistics as contributions to GDP and economic growth rather than as costs of oil.

Borrowing from the work of other researchers worldwide, in this chapter **GPI***Atlantic* begins to monetize the true costs of energy choices in Nova Scotia through a Full-Cost Accounting (FCA) approach. The aim is to assign a price tag that more accurately reflects the economic burden our energy choices impose on the environment and society. Although much has been written on this topic, the methodologies for assigning economic benefits and costs in this young, complex, and contentious field of study are still being developed. Moreover, costs will vary from place to place because there are many national and regional variations that affect the full value of energy choices. Because of these and other challenges, a ***"full"*** cost accounting of energy production and use is simply not possible at this preliminary stage, and this chapter is only able to point to a few key costs of energy that are not considered in conventional accounting mechanisms.

Despite the uncertainties and the preliminary nature of the data in this chapter, this is a vitally important exercise, since not assigning a value to non-market goods and services implies that they have zero monetary worth (which is highly inaccurate). Hawken et al (1999) point out that "Whatever value one may choose to assign natural capital, zero is surely the wrong answer." It is therefore essential to begin to point towards the true economic benefits and costs of energy and of its impacts on the natural environment, human health, and society. Until energy price signals begin to reflect these impacts, and so long as we continue to assume that coal and oil are "cheap," the deeper, systemic changes needed to move towards a sustainable energy regime are unlikely to be embraced by governments, businesses, or ordinary households. Indeed, the Nova Scotia Round Table on the Environment and the Economy recognized that full-cost accounting was an essential prerequisite for its 1992 Sustainable Development Strategy. This chapter is therefore a small step in the direction of assigning a more accurate economic value to energy production and use.

The most comprehensive FCA work to date has been on the economic costs of emissions of air pollutants and greenhouse gases. Using information from other studies, the costs of the effects of Nova Scotian emissions of these substances are estimated in this chapter. The dollar value of impacts of other energy-related activities cannot be tabulated as systematically as the costs of air pollutant emissions and GHGs because of information scarcity and methodological challenges. However, reference is made to economic values that have been assigned to these impacts in research on other regions.

8.2 Methods and Approach

This chapter of the **GPI***Atlantic* energy accounts looks at ways of pricing the unaccounted negative costs of energy production and use. Clearly there are also many benefits attributable to the energy sector, but given most of these are already well accounted for the focus here is on assessing negative impacts which are often ignored or overlooked in the decision-making process. Dollar value estimates are developed for the costs of air pollutants and GHG emissions in Nova Scotia in 2000. The year 2000 was used as it is the most recent for which *both* air pollutant *and* GHG emissions data are available.

There are many other economic consequences and implications of energy production and consumption that are not fully acknowledged in conventional accounting schemas. These include affordability, reliability, energy security, subsidies, resource consumption and depletion, employment, land use, and land and water contamination. These and other impacts are not assigned dollar values in this chapter, either because the valuation methodology is not fully developed, there are no reliable data at the Provincial level, or the links to the energy system are not delineated with sufficient precision to attribute economic value.

Table 35 provides an overview of some of the key impacts that energy can have on human lives and the environment, which have been discussed in previous chapters, especially Chapter 3. The table summarizes the level of detail at which each energy-related health and environmental issue is addressed in this report. Some are covered only by a general discussion in Chapter 3, others are partially quantified in this chapter (using cost estimates or examples from elsewhere), and two are quantified as fully as possible on the basis of available costing data and methodologies.

Table 35. Summary of topics assessed in this report

Topic	**Impacts Discussed** (Chapter 3)	**Partial Cost Assessment** (Chapter 8)	**Costs Quantified** (Chapter 8)
Human Health Concerns			
Risk of Accident	X		
Illness and other health impacts	X		
Environmental Impacts			
Toxic pollutants – other than Criteria Air Contaminants	X		
Waste disposal	X		
Noise and visual intrusion	X		
Avian collisions	X		
Fossil fuel depletion	X		
Affordability		X	
Reliability		X	
Energy security		X	
Resource consumption		X	
Resource depletion		X	
Energy subsidies		X	
Employment		X	
Land use costs		X	
Land and water contamination		X	
Criteria Air Contaminant emissions			X
Greenhouse gas emissions			X

Unless otherwise specified, all comparative monetary values in this report are in year 2000 Canadian dollars (2000 $CDN). However, first citations of monetary estimates from the literature generally state the year and the currency used by the author, before the figures converted to 2000 Canadian dollars. In some instances, the year was not specified in the studies examined. In such cases, the dollar year was assumed to be that previous to the publication date for the purpose of converting estimates to 2000 dollars.

Conversion values were calculated using the Bank of Canada's DataBANK Statistics Look-up, which provides an historical record of inflation in Canada as well as foreign currency conversion rates.[63] The noon exchange rate monthly means were averaged in order to establish a yearly rate. Exchange rates for years prior to 1995 were converted using an on-line currency converter.[64] Values given in foreign currencies were first converted to Canadian dollars in the same year (e.g. 1996 U.S. dollars were first converted to 1996 Canadian dollars) and then adjusted for inflation to express a value in 2000 Canadian dollars.

Estimating the monetary value of externalities

"Externalities" are the effects of a market transaction on individuals or firms other than those involved in the transaction.[65] Industrial pollution that affects a nearby population centre is an example of an externality. Such environmental, social, or health effects are said to be "uncompensated"—i.e. the costs are not borne by the causal agent. As a consequence of negative externalities, the private costs of production may be lower than the social costs (Monette and Colman, 2004).

Environmental or "full-cost" accounting attempts to provide a more accurate and comprehensive picture of the full or true benefits and costs of economic activity by assigning explicit value to externalities. For example, some of the effects of pollutant emissions on health and on changes in environmental quality can be assessed in pecuniary terms if there are demonstrated impacts on health care expenditures, productivity losses, pollution cleanup expenses, lost recreational opportunities, and other such costs. Other environmental externalities include oil spills that contaminate water and cause wildlife destruction; degradation of habitat and soil erosion due to poor forestry practices; and acid drainage from coal mines. When such costs and benefits are fully incorporated into accounting mechanisms, then these "externalities" are said to be "internalized," which in turn should greatly enhance efficiency in the market economy by ensuring that prices reflect the true costs of production and consumption. This internalization of externalities is not yet the case in practice in any jurisdiction, but it is a core goal of full-cost accounting and of any comprehensive sustainable development strategy.

[63] For inflation rates see: www.bankofcanada.ca/en/inflation_calc.htm. For currency conversion see: www.bankofcanada.ca/en/exchange-avg.htm.
[64] The currency converter can be found at www.x-rates.com.
[65] Externalities can be positive or negative. Negative externalities include water and air pollution for example. Positive externalities in the area of energy may include the sequestration of carbon by biomass crops, or the improvement of agricultural yields due to nitrogen deposition. In some cases the same externality can be either positive or negative depending on the situation or degree of impact. For example, nitrogen that has been converted in the atmosphere to an acidic form will fall as acid rain thereby decreasing crop productivity. However nitrogen that is deposited in a non-acidic form can act to fertilize plants.

Estimating monetary values for externalities will never be an exact science because money is a poor tool for assessing the value of goods and services that are not regularly traded in the market economy. Results often depend on the judgment and the assumptions of the analyst and on the physical models underlying the economic valuations. For example, estimates of the costs of greenhouse gas emissions are entirely dependent on the underlying climate change models that are used and their assumptions about likely physical interactions and long-term estimates of projected damages attributable to climate change. It is not surprising then that widely differing results are frequently obtained in full-cost accounting exercises, and that the literature reveals a broad range of estimates for any particular cost element. However, these externalities do have economic impacts, and therefore require valuation. Failing to do so implies that these impacts have a zero cost which is likely far less accurate than honest attempts to trace their economic effects. In the absence of such assessment, policy attention to the prevention and alleviation of impacts is apt to be insufficient.

There are several methods for "monetizing" (estimating the monetary value of) environmental externalities. Damage cost and control cost methods are discussed here. There is considerable controversy in the literature over whether externality values should be calculated on the basis of damage done, or in terms of the cost of actions required to limit or control the externality. The argument for using damage costs is that these represent the actual costs of the impacts of the activity. The argument against their use is that these damage costs are very difficult to determine and to project, may occur far into the future, and are subject to many uncertainties. The argument for using control costs, calculated as the amount spent to reduce or eliminate the externality, is that these represent the sum that society is apparently willing to pay to reduce the impacts of the externalities.

However, it has also been argued that the cost-effectiveness of policy interventions and reduction measures cannot be gauged without assessing the value of the damages they are designed to avoid. For example, the debate in Canada on ratifying the Kyoto Protocol has been centred almost entirely on varying control cost estimates—i.e. the costs of reducing greenhouse gas emissions—without reference to the damage costs of not reducing GHG emissions. For this reason, **GPI***Atlantic* recognizes that both damage cost and control cost estimates are necessary, and that they constitute two sides of the same equation. From **GPI***Atlantic*'s perspective the critical question is: What level of investment is required to reduce an impact or externality to avoid a given quantity of damage costs?

Unfortunately, time and financial resources did not allow, in this report, for the inclusion of control cost estimates for reducing different air pollutant and GHG emissions in Nova Scotia. Policy makers should seek to develop control cost estimates as part of the policy process. For example, any comprehensive greenhouse gas reduction strategy for the Province should include comparative estimates of the costs of different emission reduction options. Once those estimates are developed, future iterations of this report should include an analysis of the cost effectiveness of pollution and GHG control efforts in relation to the damage costs described in this chapter.

Estimating damage costs

There are three major stages or levels of environmental impacts leading to damages: initial loadings; intermediate effects; and ultimate impacts. In principle, all three should be measured and valued appropriately (Tellus Institute, 1994). It is most important to monitor the ultimate impacts of energy production and use on human health, the environment, and the economy (for example, the incidence of premature mortality or reduced crop yields attributable to a pollutant). These must then be linked to the initial pollutant loading (e.g. tonnes of SO_x emissions) often through an understanding of the intermediate stage (e.g. ambient concentration of SO_x). In the case of air pollutants this is a highly complex process because the ambient pollutant concentrations in Nova Scotia are largely the result of emissions elsewhere. In order to link air pollutant emissions from one plant, city, or province with the ultimate impacts of those emissions, complex dispersion modeling is needed. Without such modelling it is not possible to link Nova Scotian pollutant emissions directly with ultimate impacts within Nova Scotia or elsewhere. Without such modeling, it is only possible *either* to develop damage costs estimates for Nova Scotia (i.e. costs *to* Nova Scotia) based on ambient concentrations measured within the Province regardless of their place of origin *or* to assess the *regional* and *global* damages of Nova Scotian emissions based on universal per tonne estimates of damages from the ecological economics literature.

Damage cost calculations are based on the estimated or projected cost of the damage that the externality causes to society and the environment. This method involves the monetization of various social effects (on human health, land use, visibility, agricultural and forest productivity, etc.). Once monetized and linked to initial pollutant loadings or actions through the development of models or projected per tonne damage costs for each pollutant emission, policy makers can then address these externalities effectively and prioritize actions based both on the extent of projected damages and on current domestic emissions levels. As noted above, monitoring and calculating all the damage costs to Nova Scotian society of the ultimate impacts of activities in Nova Scotia's energy sector, while theoretically desirable from a policy perspective, is scientifically impossible. At best modelling can provide a working estimate of the damage costs caused by emissions. Even estimating Nova Scotia-specific damage costs based on ambient pollutant concentrations is very challenging and would have to account for the Province's particular circumstances (e.g. climate, soil quality, agricultural and forest productivity, etc.). For this exercise, **GPI***Atlantic* uses studies from a variety of locations that have linked ultimate damages on a regional or global scale with initial actions to develop a per tonne cost of emissions for each pollutant and for greenhouse gases.

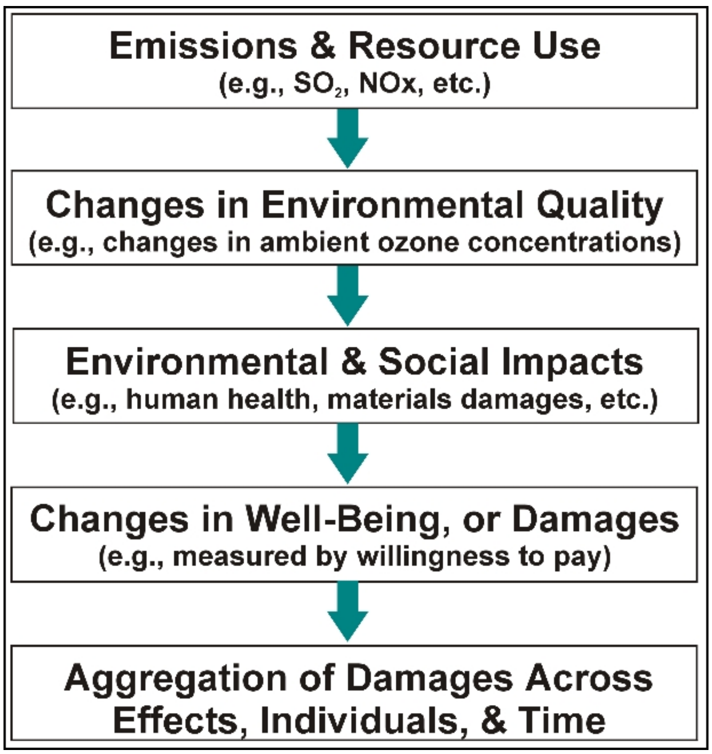
The "impact pathway approach" (IPA) is a commonly used method for linking pollutant loadings to ultimate impacts. The procedure for estimating the damage costs is as follows:

1. Estimate emissions by source for each pollutant.
2. Model atmospheric concentrations.
3. Estimate exposure of receptors (humans, buildings, crops, forests, etc.) to these concentrations.
4. Model the physical effects of these concentrations on receptors.
5. Determine the economic value of such effects.

6. Translate this estimate into a dollar per tonne value for each pollutant (IBI Group, 1995).

The impact pathway approach (also called damage function approach) is a "bottom-up" method in which environmental costs are estimated by following the pathways: first from source emissions to physical changes in air, soil, and water quality, then to the health, productivity and other consequences of those changes, and finally to the monetary damages associated with the consequences of the pollutant emissions (IER, 1999). The phrase "impact pathway" simply refers to the sequence of events linking emissions to an impact and to the subsequent cost of that impact. The IPA provides a logical and transparent way of quantifying the costs of some types of externalities (Figure 40).

Figure 40. Overview of the Impact Pathway Approach



Source: Adapted from Stinson O'Gorman, 2002.

Rigorous application of the impact pathway approach is difficult because of two major hurdles:

(1) the complexity of modelling the interactions between emissions levels and health and environmental effects, which are mediated by a wide range of intervening variables such as topographical conditions (dispersion and effects modelling); and
(2) the inherent challenge in capturing the full range of damage effects.

The challenges in application, and the differing assumptions underlying alternative models of health and environmental effects, give rise to a wide range of uncertainty associated with estimates of each type of external cost, as presented in the literature. As well, cost estimates are dependent first on the capacity to assign economic value to ecosystem services and to life itself. There are many difficulties involved in establishing reliable figures for the economic value of ecological services, and some non-market phenomena are essentially impossible to estimate in monetary terms (e.g. spiritual values or the social and cultural value of a resource to a community). Many ecological services are irreplaceable and have multiple functions that are not always discernible, let alone amenable to accurate economic valuation. Because of the extraordinary difficulty in assigning quantitative values in these cases, there is an implicit tendency to *undervalue* ecological services even in the most rigorous valuation exercises.

In light both of the case for economic valuation and of these important caveats, we may conclude that estimating the damage costs of air pollutant emissions, for example, can be a highly useful tool – and indeed essential to secure appropriate policy attention – provided it is used with proper caution. It is unreasonable to assume that it is possible to place a precise dollar value on every social, health, economic, and environmental impact, and economic valuation exercises cannot be judged by that standard. Nevertheless, in many cases monetization *can* assist decision-makers by providing estimates of some key environmental and social impacts of policy decisions, when these specific impacts might otherwise be ignored, remain hidden, or receive insufficient attention.

The overall method used in this study is referred to as *environmental value transfer*. This term denotes the use of estimated valuations from one study location in another location, in this case the Province of Nova Scotia (Brouwer and Spaninks, 1999). While this approach is not without controversy due to different mediating and intervening variables in different locations, it is frequently used; often, as in this case, due to the overall cost effectiveness of this approach (Brouwer, 2000). Through the use of other, more direct (and expensive) research, general comparisons can be made with regions outside of the initial study area, taking into account the particular conditions and circumstances of these secondary locations. Because the limitations of this method are recognised and acknowledged, every attempt is made to highlight concerns about the applicability of the cost estimates to Nova Scotia.

Discounting

One assumption that strongly affects results in the economic valuation of ecological services is the choice of a discount rate. The discount rate reflects the change in the anticipated value of a dollar from a given date to some later point.[66] Discounting is a process that allows total social costs and benefits in different years (particularly as projected into the future in a case like projected climate change damage costs) to be converted to a common "present net value" measurement so that these benefits and costs accruing in different years can be compared both to one another and to control cost estimates. Based on the assumption that a dollar now is worth more to people than a dollar received in the future, economists generally apply a discount rate to future values. This allows for an estimate of the costs of environmental degradation over time in present day dollars.

[66] A thorough discussion of the concept and effects of discounting are provided in earlier **GPI***Atlantic* reports; see Monette and Colman, 2004, p.160 and Walker et al, 2001, p.36.

The question of discount rates is controversial and depends on how the future is valued by decision-makers in the present. The discount rate is effectively an expression of society's willingness to trade the future for the present. If the needs of the present generation are considered paramount, then the future value of costs and benefits is correspondingly low and the discount rate is high. If a high value is placed on costs and benefits for future generations, the discount rate is low.

The discount rate chosen can have an enormous impact on the outcome of economic valuation studies, particularly those with a long time range (50 years or more). The Treasury Board of Canada recommends a 10% discount rate for economic studies that involve future projections based on present-day costs or benefits. This 10% figure is highly questionable when applied to environmental resources. From the perspective of a measure of sustainable development like the Genuine Progress Index, the future is worth as much as the present. The GPI (or any sustainable development) assumption is, by definition, that we will live and consume resources in such a way that the next generation will not be worse off than the present one. Because the choice of a discount rate reflects the value we place on the future compared to the present, the **GPI***Atlantic* approach inherently supports a 0% discount rate in assessing natural capital values, and environmental costs and benefits. This also supports a "strong sustainability" approach that assumes that most forms of natural capital are not substitutable (i.e. cannot readily be replaced by produced, financial or other forms of capital) and must therefore be preserved in order to protect the interests of future generations. In that approach, a "sustainable" society is one that lives off the interest produced by natural capital stocks, as reflected for example in the natural productivity rates of timber, soils or fish stocks, or in the natural capacity of land, water and air to absorb waste, but it does not deplete or degrade the capital stock that produces those services. That perspective lends strong support to a 0% discount rate. Nevertheless, most **GPI***Atlantic* studies, including this one, do present results based on a range of discount rates, because these are so widely used in the literature and by economists, and because they are necessary for comparative purposes and to create a meaningful dialogue with policy makers and conventional economists.

In this report the discount rate has relatively little effect on estimates for damage costs for air pollutants because much of the damage caused by air pollutants (like respiratory irritation and reduced visibility) occurs relatively soon after emission, although impacts like acid rain can have very long-lasting effects. A key exception is mercury, which accumulates and persists in the environment and cycles between soils, water systems and the atmosphere for long periods of time. While a discount rate might be applicable to the costs associated with the release of mercury, the studies used in this report to establish estimates of costs attributable to mercury emissions made no mention of discount rates.

The emission of greenhouse gases is the primary focus of discount rates in this report. This is because GHGs, like mercury, can result in damages that occur decades and even centuries later. The discount rates used to assess the damage costs of GHG emissions are discussed in further detail in the GHG section below.

8.3 Calculating Externalities with Dollar Cost Estimates

Air pollutants

The sources and impacts of air pollution from the energy sector in Nova Scotia have been reviewed in various sections of this document. This chapter takes the analysis of energy-related air pollution one step further by attempting to identify the dollar costs associated with the release of air pollutants in the energy sector. While a number of costing methodologies can be used, this section focuses specifically on damage costs.[67] The damage cost estimate includes consideration of factors such as increased medical expenditures due to the health consequences of pollutant exposure as well as the costs associated with general environmental degradation (e.g., reduced crop yields, forest defoliation, acidification of lakes, etc.). Varied assumptions about the nature and extent of these health and environmental effects, as well the general characteristics of the valuation study itself with its methodological and data challenges and uncertainties as noted above, help to explain the wide range of cost estimates that can be found in the literature.

This section relies heavily on the estimates, methods, and data sources in *The Ambient Air Quality Accounts for the Nova Scotia Genuine Progress Index* (Monette and Colman, 2004). After a thorough review of recent literature, it was recognised that the per tonne cost estimates presented in this earlier **GPI***Atlantic* study adequately represent the current state of knowledge on this subject. The earlier report's extensive literature review and focus on Nova Scotia still appear to provide the basis for accurate cost estimates for energy-related air pollutant emissions. A recent study by Venema and Barg (2003) examined the costs of air pollutant and GHG externalities from thermal power generation in Eastern Canada. A comparison with this highly relevant work is provided; however, Venema and Barg used a dispersion modelling approach that could not be replicated in this study because of the cost and time associated with such modelling.

Monetized estimates of projected damages per tonne attributable to particular air pollutant emissions are presented in Table 36. Figures for carbon monoxide (CO), total particulate matter (TPM), sulphur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), and mercury (Hg) are provided. Both a low and high estimate is included in order to represent the often significant variability of the cost estimates in the literature. The substantial gap between the high and low figures reflects the different assumptions made in each of the studies. Each of these estimates is described in more detail in the paragraphs below.

[67] Other costs, such as those for pollution control, can also be calculated, but could not be included in this report due to time and resource constraints.

Table 36. Damage costs of air pollutant emissions

Pollutant	$C2000/tonne	
	Low	High
CO	$2	$6
TPM	$2,120	$5,180
SO_x	$1,380	$10,500
NO_x	$1,410	$12,450
VOCs	$2,000	$8,240
Hg	$8,180,400	$11,521,500

Note: Dollar values for damage costs taken from the *GPI Air Quality Accounts* were converted from foreign currencies and adjusted for inflation as required (Monette and Colman, 2004:151).

Source: CO, TPM, SO_x, NO_x, and VOCs from Monette and Colman, 2004. Low mercury estimate Tellus Institute, 1992. High mercury estimate from from Nolan-ITU et al, 2001.

With the exception of mercury, the estimates in Table 36 were taken directly from the **GPI***Atlantic Air Quality Accounts*. These numbers were selected from an extensive literature review as most representative of the likely damage costs of air pollutants in Nova Scotia. These cost estimates are based largely on Canadian data. Where Canadian data were not available, American studies were used. European research was also reviewed and referenced for comparative purposes. The results of Monette and Colman's (2004) substantive review of literature on air pollution damage cost estimates are shown in Table 37.

Table 37. Range of damage costs in the literature ($CDN 2000)

Study	Cost per tonne emitted[a]				
	CO	PM	SO_x	NO_x	VOCs
Canadian Studies					
Klein, 1997, 1997a		$2,120	$1,060[c]	$1,060	
Klein, 1999		$5,180			
Ken Church Engineering, 1997			$1,380 – $5,560	$2,970 – $12,450	
MacRae, 1997		$2,120	$1,060[c]	$2,120	
Concord Scientific Corporation & VHB Research and Consulting, 1990			$850 – $2,180		
BC Hydro, 1993	$51	$2,450	$5,740	$1,410	
BC Hydro, 1993 cited in Alchemy Consulting Inc., 2001		$4,500	$10,500	$2,570	
Alchemy Consulting Inc., 2001		$45,000[b]	$5,750[c]	$2,000	$2,000
Studies from the United States					
CEC, 1993 – SCAQMD	$6	$81,125[b]	$14,780	$25,700	$12,100
CEC, 1993 – other district minimums and maximums	$0 – $2	$178 – $36,760[b]		$140 – $11,830	$49 – $8,240
CEC, 1993 – out-of-state Southwest		$2,270[b]		$1,330	$9
CEC, 1993 – out-of-state Northwest		$2,230[b]		$1,270	
Un-weighted mean for seventeen U.S. regions (Wang & Santini, 1995)		$10,001[b]		$7,417	$3,718
Levy et al, 1999		$17,480[b]	$1,165[c]	$1,165	
Matthews and Lave, 2000	$2 – $1,594	$1,443 – $24,600[b]	$1,169 – $7,137[c]	$334 – $14,426	$243 – $6,681
European Study					
Krewitt et al, 1999 – former FRG, base year 1990		$25,530[b]	$12,180[c]	$7,190	
Krewitt et al, 1999 – former FRG, base year 1996		$25,530[b]	$12,030[c]	$7,920	
Krewitt et al, 1999 – former GDR, base year 1990		$18,780[b]	$9,390[c]	$4,990	
Krewitt et al, 1999 – former GDR, base year 1996		$18,780[b]	$10,420[c]	$6,310	
Krewitt et al, 1999 – EU-15, base year 1990		$19,100[b]	$8,800[c]	$7,340	

Notes: FRG = Federal Republic of Germany (West Germany). GDR = German Democratic Republic (East Germany). (a) Where applicable, values have been converted and adjusted for inflation from the original references to $CDN 2000. Values have been rounded. (b) These particulate matter values are specifically for PM_{10}. (c) These values are specifically for SO_2.

Source: Monette and Colman, 2004:156.

The CO estimate of $2-6 per tonne comes from studies by the California Energy Commission (CEC). These figures include damages from acute health effects but do not include the costs associated with chronic health effects. This may mean that the costs are underestimated. On the other hand, peak daily ambient concentrations were assumed to occur for the entire day, which may overestimate damages. Estimates that include the damages due to CO converting to CO_2 and thereby contributing to climate change were much higher but were excluded here, as the climate change effects of CO_2 are separately included in the greenhouse gas cost estimates below.

The damage cost estimates used here for total particulate matter (TPM) are based on Canadian studies by Klein (1997 and 1999). The value given by Klein in the 1999 study was significantly higher than that in the earlier study, as a result of new research in the intervening years that had shown particulate matter to be more damaging to health than previously thought. Other studies gave damage costs specifically for PM_{10}, a physically smaller and more damaging form of particulate matter. However, PM_{10} is only a portion of TPM.

There are a number of Canadian studies that look at damage costs attributable to SO_x emissions. Many of these investigated only one form of sulphur oxide, such as SO_2 or SO_4, however, only studies that examined multiple forms of SO_x were considered for use in this study. The lowest Canadian estimates ($850-$1,060/tonne) were for sparsely populated, well buffered areas of central and western Canada. As soils and water in Nova Scotia are more sensitive to acidification, the somewhat higher low-end estimate of $1,380/tonne by Ken Church Engineering (1997) was selected as the low value for the purposes of this study. This estimate is still considered to be conservative and transferable to other parts of eastern Canada. The high estimate of $10,500/tonne is from a BC Hydro study (cited in Alchemy Consulting Inc., 2001). This estimate is based on each tonne of emissions affecting a population about double that of Nova Scotia. However, the estimates of environmental effects in the BC Hydro study are likely too low for Nova Scotia due to this Province's greater environmental sensitivity to acid rain. Balancing these population and environmental considerations, the BC Hydro high estimate is considered reasonable as a high-end estimate for Nova Scotia conditions and circumstances. The same consideration of environmental sensitivity to acid rain applies to the selection of low and high values for NO_x except in this case the low value is taken from a BC Hydro (1993) and the high estimate from Ken Church Engineering (1997).

The only available Canadian estimate for VOC damage costs is that used by Alchemy Consulting (2001). This value ($2,000/tonne [2000 $CDN]) was selected as the low estimate for this study. The CEC (1993) value of $10,964/tonne (1995 $CDN), which is equivalent to $12,100 (2000 $CDN), was not selected for this report since the estimate reflects the unusually poor air quality in urban southern California, which is partly influenced by that region's population density and unique topographical qualities that are not applicable to Nova Scotia. The more conservative value of $8,240/tonne (2000 $CDN) from other California Air Quality Management Districts was selected for the high value instead.

The mercury damage cost estimates are a new addition to the **GPI***Atlantic* full-cost accounting effort to quantify the costs of air pollutant emissions, and are therefore not included in Table 37. A number of air pollution costing studies exclude a damage cost estimate for mercury stating that the appropriate methodology and basic research for such an estimate are lacking (Venema and Barg, 2003). However, two credible damage costs estimates were found in the literature for atmospheric mercury emissions. The Washington State Department of Ecology, in a review of the costs of solid waste, cites a number of studies on the impacts of trace elements, including two damage cost estimates for mercury.

The high estimate for mercury comes from a 2001 Australian study of curbside recycling which gives a value of $14,388.85/tonne (2000 $AUS) (Nolan-ITU et al, 2001). This mercury cost estimate is based on a series of government reports that attempted to apply existing life cycle assessment data and economic valuations for pollutant and resource impacts. In the case of mercury, no damage cost studies were available that used an impact pathway approach. Instead, values were assigned to pollutants such as mercury by applying established pollutant load weights to a base valuation for fine particulates. A critical volume approach was used based on established concentration goals. For example, if pollutant A is known to have adverse effects at 1 mg per litre and pollutant B at 10 mg/L, then pollutant A is 10 times more harmful and would have a proportionately higher pollutant load weight. Since mercury is toxic at very low concentrations, it has a high pollutant load weight.

The Australian estimates are reported to be conservative because in the case of all pollutants many impacts are excluded. In the following list of impacts that were included and excluded logically not all of the impacts apply to mercury. However, because the methodology involved comparison of many pollutants to a base valuation for particulate matter it is worth noting all the factors considered in the study. The Australian valuation includes:

- human toxicity (air and water) impacts
- aquatic ecotoxicity potential
- nutrification potential
- acidification potential
- photochemical oxidant formation potential and
- utility and nuisance

The valuation excludes:

- global warming
- abiotic depletion
- biotic depletion
- ozone depletion
- terrestrial ecotoxicity
- human toxicity (soil)
- noise (Nolan-ITU et al, 2001:A-9)

The low damage estimate chosen for our study for mercury is from a 1992 Tellus Institute study. This research used a methodology very similar to that of the Australian study. The Tellus study established a health damage ranking system for a variety of pollutants. Then, using an extrapolation based on the damage costs associated with lead, estimates were established for the entire list of pollutants, including mercury. The study assumed that the control costs for each pollutant were proportional to the damage costs that result from that pollutant (Tellus Institute, 1992). While **GPI***Atlantic*'s focus in this chapter is on damage costs, the Tellus estimate was included in light of the assumption relating control to damage costs and because very few estimates exist for mercury, necessitating the inclusion of this relational (rather than direct) estimate.

Once per tonne damage cost estimates have been determined, they must be multiplied by the emission amounts of various pollutants to assess the total global damages caused by emissions from a particular jurisdiction. Table 38 presents the tonnes of energy-related emissions for Nova Scotia in 2000. Note that Table 38 excludes emissions from transportation and from oil and gas refineries.[68] These values and the key sources of each pollutant emission are discussed in detail in Chapter 6.

Table 38. Tonnes of stationary energy-related air pollutant emissions for Nova Scotia, 2000

Pollutant	Emissions (tonnes)
CO	52,782
TPM	14,467
SO_x	146,621
NO_x	30,547
VOCs	11,474
Hg	0.267

Source: Environment Canada, 2005.

Table 39 is a result of multiplying the information in Table 36 and Table 38 to arrive at a damage cost estimate for stationary energy-related air pollutant emissions.

Table 39. Nova Scotia stationary energy-related air pollutant damage cost estimate, 2000

Pollutant	Low	Damage Costs	High	Damage Costs
CO	$2	$105,560	$6	$316,690
TPM	$2,120	$30,670,040	$5,180	$74,939,060
SO_x	$1,380	$202,336,980	$10,500	$1,539,520,500
NO_x	$1,410	$43,071,270	$12,450	$380,310,150
VOCs	$2,000	$22,948,000	$8,240	$94,545,760
Hg	$8,180,400	$2,184,160	$11,521,500	$3,076,240
Total		**$301,316,000**		**$2,092,708,000**

Although the air pollutant emissions from transportation are separately analyzed in the **GPI***Atlantic* transportation accounts, we present a brief summary here of the air pollution externalities from all energy use, including transportation. The same methods and data sources as those discussed in Chapter 6 are used here to assess pollutant emissions from both transportation

[68] The emissions from oil and gas production cannot solely be attributed to the energy sector because a large portion of the fuel is used for transportation. However upstream coal production emissions are included.

and refineries, and then to calculate the total combined damage costs attributable to energy-related pollutant emissions, including those from transportation. The "total" must be slightly qualified here to note that the results actually exclude pollutant emissions from stationary fuel combustion by industry, as these values can no longer be separated from total industrial pollutant emissions as presented in the Environment Canada data.[69] With that caveat, the results for damage costs from energy-related pollutant emissions including transportation are shown in Table 40 and Table 41.

Table 40. Tonnes of stationary and transportation energy-related air pollutant emissions for Nova Scotia, 2000

Pollutant	Emissions (tonnes)
CO	282,486
TPM	16,346
SO_x	149,217
NO_x	66,263
VOCs	33,487
Hg	0.267

Note: Emission values include 'fuel combustion' (stationary combustion), 'transportation' and upstream processing of fuels including 'coal mining', the 'upstream oil and gas industry' and 'other petroleum and coal products industry'.

Source: Environment Canada, 2005.

Table 41. Nova Scotia stationary and transportation energy-related air pollutant damage cost estimate, 2000

Pollutant	Low	Damage Costs	High	Damage Costs
CO	$2	$564,970	$6	$1,694,910
TPM	$2,120	$34,653,520	$5,180	$84,672,280
SO_x	$1,380	$205,919,460	$10,500	$1,566,778,500
NO_x	$1,410	$93,430,830	$12,450	$824,974,350
VOCs	$2,000	$66,974,000	$8,240	$275,932,880
Hg	$8,180,400	$2,184,160	$11,521,500	$3,076,240
Total		**$403,726,000**		**$2,757,129,000**

By contrast to **GPI***Atlantic*'s *Air Quality Accounts,* which included damage cost estimates for all criteria air contaminant emissions from all sectors in the Province, the cost estimates above only represent Nova Scotia's energy sector emissions (including transportation). Thus, the cost estimates here do not represent or include the damage costs associated with air pollutants that are generated from other industries and activities within the Province.

[69] See Chapter 6 for a discussion of this data limitation and the changes in reporting since 1990.

Pollutant emissions outside Nova Scotia that affect ambient air quality levels in the Province through transboundary pollution are also not included in the estimates provided here or in the GPI *Air Quality Accounts*. It would not be accurate to add the cost of externalities from transboundary sources without first deducting the externalities cause by emissions in Nova Scotia that happen in other jurisdictions. Damage costs to Nova Scotia itself, attributable to ambient pollutant concentrations within the Province, may be considerably larger than the estimates given here, because prevailing wind patterns carry more pollution (including acid rain, ground-level ozone, and smog) into Nova Scotia than is generated here or transported from this Province to other jurisdictions. However, these outcomes are only surmised here, as there has been no definitive dispersion modelling of pollution releases in eastern North America. Due to Nova Scotia's geography some Provincial emissions will certainly be transferred to other jurisdictions, such as Newfoundland, or deposited at sea. But while the net effect of this exchange of transboundary pollution is not fully understood or quantified, it is highly probable that the costs of incoming pollution from central Canada and the northeast United States vastly outweigh the damage costs of Nova Scotian emissions on other jurisdictions.

Other damage cost estimates for Nova Scotian air pollution

Research conducted by the International Institute for Sustainable Development (IISD) provides an estimate of the costs of the air pollutant externalities resulting from thermal power production in Nova Scotia. The study valued the damage costs of the SOx, NOx, and VOCs emission externalities attributable to thermal power generation in Nova Scotia at $16,169,000 (2000 $CDN).[70] The study attributed 90% of this externality cost in Nova Scotia to SO_4. Ground-level ozone (a secondary pollutant formed from NOx and VOCs) was found to represent 8.6%, while SO_2 was found to represent only 1.3% of the externality costs of thermal power generation in the Province (Venema and Barg, 2003). The findings from the IISD study for Nova Scotia are substantially lower than the low cost estimate for air pollution externalities developed in this study. To understand this difference the methods and limitations of both approaches must be compared.

Using an impact pathway approach, which is common to many valuation studies, the IISD research analysed the isolated pollution from thermal power generation. The study used census information and geographic distribution modelling of air pollution to estimate impacts on human health. They adapted emission-dispersion modelling "from earlier studies done for the AMG [Analysis and Modelling Group (AMG) as part of the National Climate Change Process] and calculated the average SO4 and SO2 concentrations in individual Census divisions in Eastern Canada" and "isolated the increment of air pollution attributable to the power sector by using linear proportionality principles previously applied by the AMG." They "also developed an impact-pathway model to calculate the ozone concentrations attributable to the power sector within individual Census divisions" using data from the National Air Pollution System. Once the ambient concentrations of these pollutants were modelled for each Census division, a model developed by Environment Canada and Health Canada, called the *Air Quality Valuation Model*

[70] Estimate in 2000 Canadian dollars is based on the estimate of $15,144,000 (1996 CDN) from Venema and Barg, 2003.

(AQVM), was used to estimate the human health and material damage costs in each division. This model relates ambient concentrations of pollutants to health care and other damage costs.

In comparison, the approach used to develop the **GPI***Atlantic* damage cost estimate for air pollutants was *environmental value transfer*. As described previously, this approach involves using existing studies, normally developed in another jurisdiction, and applying the results to a new area. The differences between areas can be significant, whether in terms of population densities, climate, or environmental and biological factors. We have used damage cost estimates that also use the impact-pathway approach, such as those of the IISD, and applied these to emissions in Nova Scotia. Unfortunately, the results of the IISD study could not be used directly in our study because the results could not be easily calculated on a per tonne emission basis (e.g. the damage costs per tonne of SO_x emitted).

The IISD only includes emissions from thermal power generation and then only a limited number of pollutants. The IISD study does not include any cost estimates for particulate matter, mercury, or carbon monoxide. Furthermore it only includes emissions from power plants, unlike the **GPI***Atlantic* energy sector estimates in Table 39 and Table 41 above, which include emissions from home and commercial fuel consumption and upstream processing of coal. However, even with the damage costs estimates limited to utility emissions (i.e. thermal power) of only SO_x, NO_x, and VOCs our estimate of damage costs is still much higher (Table 42).

Table 42. Nova Scotia electrical utility air pollutant emissions damage cost estimate, 2000

Pollutant	Utility Emissions (t)	Low Estimate (2000 $CDN/t)	Damage Costs
SO_x	139,745	$1,380	$192,848,100
NO_x	26,999	$1,410	$38,068,590
VOCs	134	$2,000	$268,000
Total			**$231,184,000**

Another difference between the IISD study and this one is that the former was based on the 1995 criteria air contaminant emission information provided by Environment Canada whereas 2000 data were used in this study. In terms of thermal power generation, emissions in 2000 compared to 1995, were higher for SOx, NOx, and VOCs by 3%, 11%, and 6% respectively. However, the levels of increase are not high enough to explain the large difference in results between the two studies.

The IISD study does state that its damage costs are a “conservative under-estimate”, explicitly acknowledging a number of factors which influence their results, including some of the factors already mentioned such as the exclusion of a number of air pollutants. Some of the key uncertainties noted in the IISD study are summarised here with the directional impact of the bias noted in brackets:

"**Fundamental Uncertainties** (damage functions known to exist but data not available)

- Carbon Monoxide causing cardiac hospital admissions (bias downward)[71]
- Acid Deposition impacting fishing yields (bias downward)
- Air toxins and risks of cancers, neurological disorders (bias downward)
- Ozone damages on forests and agricultural crops (bias downward)

Fundamental Uncertainties (damage functions unknown but believed to exist)

- NOx emissions impacts on agriculture and ecosystems (bias downward)
- Air toxics impacts on terrestrial wildlife (bias downward)
- Acid deposition impacts on ecosystems (bias downward)

Systematic Analytical Biases

- No air quality externalities from Eastern Canadian sources with U.S. receptors (bias downward)
- Atmospheric transport mechanisms (bias unknown)
- No upstream source-receptor model for gas (bias downward)
- Mortality valuation methodology (bias unknown, possibly upward)" (Venema and Barg, 2003: 57).

Of note in this list of uncertainties is that the acidic effects of SO_x and NO_x on ecosystems are not included. Poor soils in Nova Scotia mean that acidic deposition has significant impacts on forest productivity and fisheries, hence the logic for our choice of somewhat higher low damage cost estimates for SO_x and NO_x even though lower estimates were available in the literature. There are further uncertainties surrounding the models of atmospheric transport of pollutants. The main issue in the IISD study for Nova Scotia is whether pollutants emitted in Nova Scotia, which were transported to other jurisdictions, such as Prince Edward Island and Newfoundland, are included in the total damage costs estimates for air pollutant externalities from thermal power generation in Nova Scotia. From Venema and Barg's description of surrounding transboundary pollution, it appears that any impacts outside the Province –e.g. on Newfoundland, Prince Edward Island and impacts on marine ecosystems – are not included in the cost estimates. These are significant limitations especially considering the location of many of Nova Scotia's thermal generating units, in eastern and north eastern areas of the Province. Considering the dominant westerly winds in the region, pollutant emissions from these sources are likely to have greater impacts in other areas than within the Province of Nova Scotia itself.

In short, the IISD study authors list a variety of uncertainties and biases, which, with the exception of one, all produced a lower damage cost estimate than would have been the case had the uncertainties and biases been interpreted less conservatively or been addressed through more thorough dispersion modelling. This IISD study is referenced here for comparative purposes because it is a thorough Canadian study on the externality costs of power generation and the only study available for Nova Scotia.

[71] A downward bias indicates that the uncertainty caused the IISD externality cost estimate to be lower.

One possible way to further compare the results of the IISD study and this study is to present damage costs on a per kWh basis. As shown in Table 43, the per kWh damage costs of SOx, NOx and VOCs for thermal power generation as extrapolated in this report is within the range presented in other studies. If the externality costs of mercury, carbon monoxide, and particulate matter are included as estimated in this report the value dollar costs rises to $0.0239/kWh. This is based on the low-end estimates chosen in this study.

Table 43. Comparison of air pollutant damage cost externalities in $CDN/kWh

	IISD		ExternE	GPIAtlantic
	Eastern Canada[1]	**NS**	**U.K.**[2]	**NS**
Thermal generation	0.0127	0.00168[3]	n/a	0.0225[4]
Coal fired generation	0.0171	n/a	0.035	n/a

Note: IISD and ExternE results in 1996 dollars. GPIAtlantic results in 2000 dollars.

1. Eastern Canada includes Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island.

2. As reported in Venema and Barg, 2003.

3. Calculated using IISD's thermal power air pollutant externality value of $15,144,000 (1996 $CDN) by the total amount of electricity produced from thermal power production in Nova Scotia in 1997 or 9029 GWh (Venema and Barg, 2003).

4. Based on SOx, NOx, and VOC emissions from utilities (Environment Canada, 2005), damage cost estimates as shown in Table 42, and NSPI's total thermal power generation in 2000 of 10255.3 GWh (Emera, 2001).

The results from the U.K. are the highest, which are explained by the fact that population densities are significantly higher. While damage costs should be lower in Nova Scotia in comparison with the U.K. because of significantly lower population densities, the IISD results for Nova Scotia are thought to be too low due to the modelling limitations and the exclusion of ecological impacts as discussed above. Meanwhile, our estimate is likely high for a conservative value because of lower population densities across the Atlantic Provinces and because much of Nova Scotia's emissions are deposited at sea. Considering the limitations of our methods and those of the IISD study it appears that a reasonable conservative working value for the dollar cost of air pollutant externalities from thermal power generation in Nova Scotia is between $0.00168/kWh and $0.0239/kWh. In order to make this estimate more precise a wider range of pollutants must be modelled, point source atmospheric dispersion modelling of pollutants is needed, and a wider range of impacts, namely ecological impacts, must be included.

Our high estimate of damage costs from thermal power air pollutant externalities (all pollutants valuated) gives a per kWh value of $0.179. This is an extremely high value in comparison with existing studies. Therefore, this level of damage costs is not considered likely to occur. It can be thought of as an upper limit or a precautionary type value as it indicates that costs can be much higher than mainstream analysis indicates. As noted all values are based upon a limited understanding of the effects of pollution on human health and the environment.

Another example of comprehensive research on the damage costs of air pollution is the Ontario Medical Association's *Illness Costs of Air Pollution* report (OMA, 2000). This study provides detailed estimates of the economic and human costs of air pollution in Ontario (including only human health and productivity, and excluding environmental impacts). The impacts of particulate matter and ground-level ozone on cardio-respiratory illnesses were reviewed. The health impacts and costs that were examined included minor illnesses, doctor's office visits, emergency room visits, hospital admissions, and premature mortality. This information was determined by modelling current and future air quality conditions in Ontario; outlining the distribution, size, and composition of the population exposed to pollution; establishing exposure response functions for the particular air pollutants studied; and finally, estimating the economic impacts of illnesses related to air pollution (OMA, 2000).

The results of the study found that the costs of air pollution in Ontario were more than $1 billion a year, due primarily to absenteeism and medical expenses attributable to illnesses caused by pollutant exposure (OMA, 2000). The $1 billion figure was based on estimates of $560 million in economic losses to employees and employers, and $600 million in health care expenditures. The study forecast that in the year 2000, Ontario would experience roughly 1,900 premature deaths, 9,800 hospital admissions, 13,000 emergency room visits, and 47 million minor illness days due to air pollution. These numbers were expected to grow significantly by 2015. The $1 billion estimate grows to $10 billion if loss of life and the value of pain and suffering are included (OMA, 2000).

By comparison, Venema and Barg (2003) estimate the damage costs for SO_2, SO_4, and O_3 attributable to the power sector in Ontario to be $439 million. Considering the overwhelming dominance of SO_2 and SO_4 in Venema and Barg's estimates, and the fact that the OMA study focussed on particulate matter, ground-level ozone, and human health impacts (not on sulphur oxides or environmental impacts), it is reasonable to combine the results of these two studies for illustrative purposes to give a more complete picture. Together the two studies indicate that air pollution in Ontario would account for $1.5-$10.5 billion in damage costs annually.[72] It should be noted that even this is far from a comprehensive figure, considering the exclusion of some pollutants, the exclusion of environmental impacts in the OMA study, and the exclusion of all other sectors beyond power generation in the IISD study.

When this partial Ontario figure is compared to our value for energy-related pollutant emissions in Nova Scotia—which has a much smaller population but much higher per capita emissions—our estimate ($400 million - $2.7 billion) appears to be in the right order of magnitude although possibly a little high. As Tables 24 and 26 indicate, sulphur oxide emissions account for more than half the damage costs attributable to energy-related air pollution in Nova Scotia. As well, Nova Scotia's total per capita sulphur oxide emissions are more than double the Canadian average (Monette and Colman, 2004, Figure 55), due in large part due to the Province's heavy reliance on coal to generate electricity. The high damage costs attributable to sulphur oxide emissions may help explain why energy-related pollutant damage costs seem to be higher on a per capita basis in Nova Scotia than in Ontario. Nova Scotia also has very high per capita emissions of other pollutants including NOx and VOCs. However, as became obvious with the

[72] Note that the OMA study includes all sources of ozone and particulate matter, whereas Venema and Barg focus on sulphur oxides and ozone from power plants only.

comparison of thermal power externalities it may be that our estimates do not adequately address the dispersion of pollutants to areas with low population densities (i.e. the ocean and the Atlantic Provinces). This comparison to the OMA and the IISD indicates again that damage cost estimates should be applied with caution and a full understanding of the studies limitations. The comparison also indicates that our high estimate should be viewed as an upper limit until a better analysis, specific to the Province, is available.

In 2005, economic estimates that accompanied the introduction of the new Clean Air Interstate Rule of the United States Environmental Protection Agency (USEPA) demonstrated the importance and relevance of full-cost accounting for the energy sector. The Rule requires an overall reduction in the air pollution that individual states are permitted to generate. The legislation requires a 61% reduction in NO_x emissions and a 73% reduction in SO_x emissions (Associated Press, 2005). The reductions are based on 2003 levels and are expected to be realized by 2015. These results are expected to come largely from the addition of scrubbers to power plants. To demonstrate the benefits of the new regulations, the USEPA released important information regarding the projected economic value of the health and environmental impacts of the reduction in air emissions.

The USEPA estimated that each year this legislation will prevent 22,000 non-fatal heart attacks, 17,000 premature deaths, and 700,000 respiratory ailments from asthma and bronchitis. In addition, the declining air pollution will reduce haze that has a direct and adverse impact on forests and parks. The USEPA noted that by 2015, the annual benefits would be worth up to $100 billion. This greatly overshadows the $4 billion price tag of the legislation itself (Associated Press, 2005). This contemporary example demonstrates that full-cost accounting can be a valuable tool for policy makers who have to weigh the costs and benefits of decisions about energy.

Future full-cost accounting work on the Nova Scotia energy sector should consider whether the fines incurred by Nova Scotia Power for air pollutant emissions from its thermal power plants cover the actual damage costs of those emissions. Between 2002 and 2004, Nova Scotia Power was charged over $700,000 for air pollutant emissions (see Section 7.5) (Hoare, 2005). A preliminary comparison with the damage costs demonstrated here reveals that these fines only partially internalize the actual costs of the energy externalities. This type of comparison can be very important for legislative and policy efforts, and can help set the appropriate level of fines. As the USEPA study demonstrates, efforts that produce a reduction in pollutant emissions can produce very significant savings. Sharp pollutant emission reductions in the energy sector would enable Nova Scotia Power to reduce or eliminate the money currently spent on pollution fines, while the Province and taxpayers would also benefit from a reduction in expenditures on health care.

Greenhouse gas emissions

Assessing the cost of energy-related greenhouse gas emissions typifies the complexities and challenges of full-cost accounting. Though produced locally, these emissions have global impacts; so damage cost assessments reflect costs in other jurisdictions due to Nova Scotian emissions, just as climate change impacts within Nova Scotia are due to GHG emissions globally. Additionally, emissions released today will have uncertain effects that reach well into the future – indeed for centuries to come, as noted by the IPCC. These and other elements combine to make the establishment of a single per tonne dollar value for GHG emissions a significant challenge—but not an impossible one. Indeed, the greenhouse gas emissions trading schemes authorized by the Kyoto Protocol require such dollar values to be established, and the economic valuation exercise itself draws attention to climate change impacts previously neglected.

This section draws heavily on previous work done by **GPI***Atlantic* in *The Nova Scotia Greenhouse Gas Accounts for the Genuine Progress Index* (Walker et al, 2001) as well as on an extensive review of the literature that has emerged since the publication of that report. Only the damage costs of GHG emissions are presented in this report. Assessment and analysis of prevention, mitigation, and control costs associated with energy-related GHG emissions were not possible for this study but should be included in future updates of this report.[73] As noted in the earlier discussion on pollutant cost estimates, it is the ratio between different types of control costs and mitigation expenditures on the one hand and damage costs on the other that establishes the cost-effectiveness of alternative emission reduction measures and enables policy-makers to identify and prioritize actions.

Greenhouse gas emissions from Nova Scotia's energy sector are described in Chapter 6 of this report. To estimate the damage costs associated with the release of these GHGs, the future impacts of climate change on ecological and terrestrial systems; human society; health and disease; agriculture; coastlines; and global weather systems including the frequency and intensity of droughts, floods, storms and hurricane activity, must all be modelled. As well the particular and different vulnerabilities of developing and developed nations must be assessed, along with the potential for human adaptation to climate change. These considerations all involve assumptions that have a major impact on estimating damage costs attributable to GHG emissions.

The underlying assumptions and premises that determine damage cost estimates will typically include predictions of future population, economic growth and GHG emissions levels, of the resulting environmental, social and economic impacts, the estimated costs of these impacts; the overall timeline selected; the discount rate chosen; and the capacity to adapt. Cost estimates are also very sensitive to the capacity of climate change models (a) to incorporate the potential for catastrophic shocks and extreme events (like sudden shifts in average global temperatures and unexpected feedbacks such as massive methane releases from melting permafrost) that may occur when certain thresholds are passed, and (b) to assess a wide range of natural, climatic and human intervening variables that may modify predicted trends. For example, most climate change models do not yet adequately account for feedbacks in response to global warming from the global cloud regime and the oceans; and they do not fully incorporate the effects of stratospheric ozone depletion and the generation and impacts of atmospheric aerosols.

Subtle alterations to any one of these predictions can dramatically change damage cost estimates. For a summary of some of the key scientific factors that influence these estimates, see Appendix B of the *GPI Greenhouse Gas Accounts,* titled "The Science of Climate Change: A GPI Primer

[73] For a brief discussion of the prevention costs see Walker et al, 2001.

for Nova Scotians." The challenge for climate change economists, then, is to make reasonable assumptions with respect to each of these factors. Despite the uncertainties, the potential for serious and potentially irreversible damage due to climate change requires damage cost estimates to be assessed on the basis of the best available evidence and the precautionary principle to be invoked to reduce greenhouse gas emissions without delay.

GPI*Atlantic's* previous work on GHG emissions used a range of damage cost estimates to reflect the varied numbers that are found in the climate change economics literature. They included a low marginal damage cost estimate of $40/tonne of carbon dioxide (2000 $CDN), and a high cost estimate of $1,086/tonne of carbon dioxide (2000 $CDN).[74] The huge difference between the two values reflects the vastly different assumptions behind the cost estimates. The low number represents a cost estimate that reflects a conservative approach to damage costs. The high estimate, from Bein and Rintoul, 1999, factors in the potential for more severe and irreversible consequences due to global climate change. A summary of Bein and Rintoul's critique of lower-end estimates and their rationale for a much higher estimate is provided in the *GPI Greenhouse Gas Accounts* (Walker et al, 2001, pages 40-42).

The enormity of potential damage costs stems from the fact that climate-induced damage, from extreme weather events that are predicted to accompany global warming for example, could in a very short time destroy capital assets that represent both the embodied accumulation of many years of production and the future loss of goods and services that would have contributed to GDP for many years to come. Interestingly, since the time of Bein and Rintoul's estimate (which may have seemed excessive at the time), the massive costs that may potentially be associated with global warming have taken on greater reality in the public eye with recent estimates that the costs of Hurricane Katrina alone may exceed $US200 billion (not counting losses in human life and natural resources) and imperil the fiscal stability of the United States of America. When capital asset losses are considered, it is possible for projected higher-end GHG damage cost estimates to exceed the value of a jurisdiction's total annual output of goods and services, as accumulated natural, human, social, and produced/material assets and wealth may be diminished.

The original intention of the present study was to apply the range of damage cost estimates from the *GPI Greenhouse Gas Accounts* to energy-specific greenhouse gas emissions. This approach was reconsidered in light of a more recent article by Tol (2004) which reviewed 28 independent studies covering 103 estimates of marginal damage costs for carbon dioxide equivalent GHG emissions. In light of Tol's extensive review of the past 15 years of research in this field, the earlier GPI range of damage cost estimates was re-evaluated. Those earlier estimates (described above) are therefore used here for discussion and comparison purposes only, while a new set of estimates has been adopted for this report, based on the rigorous, recent work of Richard Tol.[75]

[74] Original estimates in the **GPI***Atlantic Greenhouse Gas Accounts* for Nova Scotia (in Canadian 1997 dollars) were $38 and $1,040.

[75] Tol's own expertise in this area includes extensive experience with the Intergovernmental Panel on Climate Change, and as an author and editor of the *Handbook on Methods for Climate Change Impact Assessment and Adaptation Strategies*, UNEP (1998). Dr. Tol, Professor and Director of the Research Unit on Sustainability and Global Change at Hamburg University, Germany, has also authored or co-authored more than 25 publications on the damage costs of climate change and is regarded as one of the world's leading experts in this field.

The new range of estimates, which also include high and low values, was adopted after extensive discussions among the GPI research team, and after direct communication with Dr. Tol (2005), and represents a significant shift from the values used in the 2001 GPI report.

As with **GPI***Atlantic*'s own literature review in 2000-01, Tol's extensive and more recent review of the research also demonstrates the very wide range of the cost estimates. The lowest estimates begin at values less than zero while the highest estimate he found is $2,472/tonne of carbon (2000 CDN).[76] Tol carefully analysed, organised, and categorised all 103 estimates based on a number of factors, including the size of the cost estimates, the range of uncertainty in the results, the discount rate, the time horizon studied, and whether or not the work was peer reviewed. This allows each of the cost estimates to be carefully scrutinized based on the merits of the research and assumptions on which each estimate is based.

After extensive statistical analysis and review of all of the estimates in the literature, Tol concludes that the marginal damage costs of carbon dioxide equivalent greenhouse gas emissions are unlikely to exceed a value of $74/tonne of carbon (2004 $CDN), [77,78] which represents the mean of all of the peer-reviewed studies, and that the costs are very likely to be significantly lower. The previous GPI damage cost estimate range was therefore reconsidered given that Tol's conclusion was based on a nearly complete assessment of the available literature in this field of study. Tol (2004) found that the peer-reviewed estimates are the result of more rigorous methods and produce cost estimates with fewer uncertainties.

The low estimate for the marginal damage cost of greenhouse gas emissions, determined to be the most representative of the low-end estimates reviewed by Tol and the most suitable for the purposes of this study, was $23/tonne of carbon (2000 $CDN). This was the mean of all of the estimates reviewed by Tol that used a "pure rate of time preference" (i.e. discount rate) of 3%. Tol notes that this number corresponds to a "social discount rate of 4-5%, close to what most western governments use for longer term investments." The authors of this study felt that this figure would be an adequate and conservative representation of lower-end estimates, based on a commonly used assumption regarding the discount rate. This lower-end estimate also corresponds to the conclusions drawn by Tol himself, who favours an estimate well below the $74/tonne that represents the mean of the peer-reviewed studies. Indeed, Tol uses that $74/tonne mean as his own upper limit (Tol, 2005). However, it is recognized that using a discount rate above 0 implies that costs and benefits incurred by future generations are not as important as those incurred by the current generation.

The high-end estimate for the marginal damage costs of greenhouse gas emissions selected for this study is $137/tonne of carbon (2000 $CDN). This figure represents the mean of all 103 cost estimates reviewed by Tol. It is important to highlight that the "mean" is a number that more adequately represents, and gives weight to, the complete range of cost estimates. The use of the

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[76] Based on converting the highest estimate of $1666.70 (1995 U.S.) to 2000 Canadian dollars.
[77] Based on the conversion of the $50 (1995 $U.S.) estimate.
[78] The GPIAtlantic greenhouse gas accounts discusses damage cost estimates for climate change in dollars per tonne of carbon dioxide equivalents. Tol's damage costs are cited in dollars per tonne of carbon. To convert from tonnes of carbon to tonnes of carbon dioxide, you need to correct for the molecular weight of carbon (12) relative to the weight of CO_2 (12 + 2*16), that is 12/44.

mean of all studies reflects both the highest and lowest of all of the estimates, and does not distinguish based on the varied assumptions. This decision was taken as it was thought to be important to adequately reflect the broader range of estimates found within the literature unlike the low estimate which uses only a subset of estimates and a fairly high rate of time preference.

The selection of an estimate above Tol's own upper limit reflects two considerations. First, **GPI***Atlantic's* commitment to the precautionary principle demands that a higher estimate for the marginal damage costs of greenhouse gas emissions be considered because higher damage cost estimates are generally the result of more pessimistic forecasts of the consequences of climate change. This means that some consideration is given here to the possibility of extreme damage scenarios, and of impacts that would be permanent or irreversible.

Secondly, Tol (2005) has suggested that a reason that the peer-reviewed studies have produced more conservative cost estimates is not only that they used better methods and therefore produced more certain results, but also that these results may have been influenced in part by the views of the journal referees. Tol notes that referees may be unwilling to publish cost estimates that are outside the range on which there is a general consensus.[79] For both these reasons, and because Tol's own upper-end estimate of $74/tonne of carbon itself reflects the ***mean*** of only the peer-reviewed studies, it was considered reasonable to adopt the $137/tonne carbon mean of all the 103 reviewed studies as the high-end estimate for the purposes of these GPI energy accounts.

The decision to adopt a considerably lower high-end estimate in this study than the $1,086/tonne of carbon dioxide (2000 $CDN) high-end estimate used in the original *GPI Greenhouse Gas Accounts* was not made without some trepidation. While climate change modelling is vastly improving in sophistication, it is still strongly influenced by assumptions that can be challenged. For example, the nature of changes induced by global warming may not be linear or incremental, and the sudden shocks or resource collapses that may occur when certain thresholds are exceeded may not be amenable to modelling. Much like the compound interest accumulated in a bank account, the increasing concentration of greenhouse gases in the atmosphere may have compound and much more severe effects than commonly predicted.

For these reasons, some analysts argue for inclusion of higher-end estimates than those considered in this present study. Bein and Rintoul (1999), who produced the $1,086/tonne of carbon dioxide (2000 $CDN) high-end estimate used in the *GPI Greenhouse Gas Accounts* (Walker et al, 2001) have demonstrated that even small changes in the assumptions used to establish the costs of greenhouse gas emissions can greatly alter final estimates by orders of magnitude. The decision not to use the Bein and Rintoul (1999) high-end estimate in this study is no reflection on the power and cogency of their argument or rationale – with which we have found no major fault since reporting it in the 2001 *GPI Greenhouse Gas Accounts*. Indeed, as noted above, Tol found studies with damage cost estimates considerably higher (and in one case

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[79] Interesting in this regard is a survey conducted by William Nordhaus of Yale University (Nordhaus, W. "Expert Opinion on Climate Change." *American Scientist*, Vol. 82, January-February, 1994, 45-51). Nordhaus polled a small sample of climate change experts, some of whom were economists and some of whom worked in the natural sciences. Nordhaus found that the economists consistently provided lower estimates for damages attributable to climate change than did the natural scientists. The economists also consistently offered lower estimations of the rate at which climate change could be expected to occur. Richard Tol and William Nordhaus are both economists.

more than twice as high) as the Bein and Rintoul estimate. In this study, however, we have made a considered decision to err on the side of conservatism, to narrow and lower the range of damage cost estimates substantially, and to use Tol's peer-reviewed studies to establish a range of estimates that can be very widely accepted.

Using the $23 - $137 per tonne of carbon range (or $6.27 - $36.55 per tonne of carbon dioxide)[80], the damage cost estimates for energy-related greenhouse gas emissions in Nova Scotia are shown in Table 44. The results are obtained by multiplying the low and high per tonne marginal cost estimates by the tonnes of greenhouse gas emissions generated from the Nova Scotia energy sector (as outlined in Chapter 6). The resulting low estimate is $86 million for year 2000 emissions alone, and the high estimate is $502 million dollars (2000 $CDN).

Table 44. Nova Scotia stationary energy-related GHG damage cost estimate, 2000

	Low	High
Cost Estimates (per tonne of carbon)	$6.27	$36.55
Emissions (tonnes CO_2 eq.)	13,750,000	13,750,000
Total	**$86,212,000**	**$502,562,000**

Note: Emissions from stationary sources includes stationary combustion and fugitive coal mining sources from Environment Canada, 2004. Using the Environment Canada data two different totals are possible. This is because the total for the stationary combustion category as shown in Environment Canada's data tables is slightly less then the sum of the individual sectors within the stationary combustion category. To be conservative we have used Environment Canada's stated total for 2000 and added coal mining fugitive emissions.

The total projected damage costs when emissions from transportation are included are presented in Table 45. This increases the low cost estimate to $124 million and the high estimate to more than $723 million (2000 $CDN). Even using the highly conservative range of estimates described above, the damage costs attributable to greenhouse gas emissions in Nova Scotia are potentially enormous, and demonstrate that energy conservation and efficiency and energy production methods that generate fewer emissions can potentially be highly cost-effective.

Table 45. Nova Scotia stationary and transportation energy-related GHG damage cost estimate, 2000

	Low	High
Cost Estimates (per tonne of carbon)	$6.27	$36.55
Emissions (tonnes CO_2 eq.)	19,800,000	19,800,000
Total	**$124,146,000**	**$723,690,000**

Note: We have used Environment Canada's (2004) stated total emissions for energy sources in Annex 10.

[80] See footnote 78 on converting between tonnes of carbon and tonnes of carbon dioxide.

8.4 Discussion of Externalities without Dollar Cost Estimates

This section considers the potential costs of other energy impacts and externalities for which dollar-cost estimates for Nova Scotia could not credibly be provided at this stage, due either to data limitations or to methodological challenges. Nevertheless, a brief qualitative overview of these issues here can serve to illustrate the importance of these energy-related impacts on Nova Scotian society. Included here are: affordability, reliability, security, subsidies, employment, land and water contamination, and land use. The discussion that follows references important new research that has begun to explore the cost of these impacts. The fact that these costs can be identified reinforces the earlier argument that it is incorrect to assign them an implicit value of zero, as generally occurs when the costs are not quantified or fully acknowledged. Rather this brief preliminary overview of the potential social and economic costs associated with key energy-related impacts indicates the need for further research and data development that will allow more effective quantification in the future.

Affordability

When the cost of energy exceeds the ability of people to pay for it, a number of social problems ensue. For example, having to make choices over competing household necessities, like food, rent, clothing, or heat, may cause great insecurity and distress in trying to make ends meet – a stress that can affect all members of a household. More directly, fuel poverty can cause some low-income people to live in cold conditions which in turn may be associated with excessive dampness, growth of mould, and health problems. There are also the direct and measurable costs of fires and deaths due to makeshift heating in fuel-poor homes.

Fuel poverty has been researched extensively in the United Kingdom (U.K.), which has high fuel-poverty levels. The annual cost to the British national health system of treating cold-related illnesses was estimated at around £1 billion in the early 1990s (Boardman, 1991, in Friends of the Earth Scotland, 2000). This is considered an underestimate, as it excludes treatment for asthma and other allergic conditions that have been linked with cold living conditions and fuel poverty. However, the British health cost estimate does include the costs of illness due to cold conditions outside the home (e.g. waiting for buses) which are not attributable to fuel poverty. A damage cost estimate for fuel poverty in Edinburgh, a city of 400,000 people, was £10 million a year in 2001 (Director of Public Health, 2004). In both cases, costs such as decreased productivity, mental health costs, and accelerated deterioration of buildings due to mould and rot, are not included in the estimates.

The U.K. has the highest incidence of fuel poverty in Europe due to its poor housing stock. However, many people live in sub-standard housing in Nova Scotia as well, so the health costs stemming from fuel poverty could potentially be in the tens of millions of dollars. Although considerably more work is required to assess comparative fuel poverty rates and the costs of fuel poverty in the particular conditions and circumstances of Nova Scotia, the following extrapolation is offered for illustrative purposes. The £10 million cost estimate for a population of 400,000 amounts to more than $50 per person (2000 $CDN). Extrapolated to Nova Scotia's population, and assuming that fuel poverty rates, health care costs, and other conditions in Nova Scotia were identical to those in Edinburgh, this would yield annual costs of more than $47 million attributable to fuel poverty in this Province. This indirect extrapolation is not intended to describe the particular reality of this Province, but it does serve to illustrate that health and other social costs attributable to fuel poverty are potentially large, and it makes a strong case for collecting data and tracking this important variable with the same concern and determination as in Britain.

Addressing fuel poverty and other energy externalities related to affordability is possible through improved housing and targeted subsidies. A study of public housing stock improvement in London showed a seven-fold reduction in illness days and health costs per household (Ambrose, 2002). Successfully combating fuel poverty will result in other benefits, as income is made available for food and other necessities. A full-cost assessment of the effects of fuel poverty, and concomitant studies on the social and economic benefits of its alleviation would provide extremely valuable information for policy makers to design provincial and national strategies to reduce and eliminate fuel poverty and to ensure basic energy affordability.

Reliability

Energy reliability and the costs of energy disruptions are highly relevant in Nova Scotia given recent extreme weather events (e.g. Hurricane Juan in 2003 and the "White Juan" blizzard and the ice storm of 2004) that interrupted power to large numbers of customers, sometimes for significant periods of time. As noted in Chapter 5, residents and businesses in Nova Scotia are becoming aware that they cannot always rely on a continuous source of electricity. This section attempts to identify the potential costs of disruptions to Nova Scotia's electricity supply. It does not address the issue of responsibility for recent events. Although not addressed in this section, there are also other issues related to energy reliability, including uncertainties inherent in dependence on foreign fuels (oil and coal) often from unstable regions of the world. This aspect of energy reliability is noted in more detail below in the discussion on energy security and resource depletion.

Figure 22 (Chapter 5) showed that there is a declining trend in the number and frequency of power outages and therefore, apparently, an improving trend for the reliability of electricity in Nova Scotia. Despite these seeming improvements in the reliability of the electricity system, Nova Scotians are well aware that extreme weather events can interrupt service. Indeed a review of media reports in Chapter 5 (Table 14) indicated that the *duration* of electricity disruptions and the *number of customers* affected for long periods of time has increased substantially in the last two years due to these extreme weather events. From that perspective, it is clear why Nova Scotians doubt Nova Scotia Power's assurances of improved reliability, and (combined with the recent sharp fuel price hikes that followed Hurricane Katrina) why they are becoming increasingly concerned about the reliability of the energy supply.

Energy supply disruptions and electricity outages may produce a wide range of social consequences. As outlined in Chapter 5, power outages give rise to health and safety concerns. There are also economic costs incurred as the result of an unreliable power system. Power outages can have a wide range of detrimental impacts on businesses. A survey by the Canadian Federation of Independent Businesses found that, of more than 500 Nova Scotian proprietors and business owners polled, 40% indicated that their business had been interrupted by more than three power outages in 2004 (Hache, 2005). The impacts and associated economic costs of these outages included employees not being able to work (73% of respondents); loss of orders or patronage (57%); lost production of goods or services (48%); lost revenue due to lack of electronic payment capabilities (37%); and damaged, spoiled or lost inventory (17%). Only 9% of respondents indicated that the power outages had had no impact on their business. Ninety per cent of the proprietors surveyed indicated that a reliable energy source for their business was extremely important (Hache, 2005).[81]

The costs associated with lack of energy reliability and lost economic revenue and the environmental benefits of concomitant reductions in pollutant emissions are perhaps best illustrated by data gathered on the blackout that affected parts of eastern Canada and the United States in August, 2003. As a result of the power outage, 26.4 million work hours were lost in Ontario and Quebec (CBC, 2003). The net impact, factoring for the increased overtime hours, resulted in a total of 18.9 million work hours lost.

Research conducted by the University of Maryland uncovered an unexpected benefit of the power outage. Aerial sampling over Pennsylvania 24 hours after the power outage revealed a 90% drop in sulphur dioxide levels and a 50% reduction in ground-level ozone (Associated Press, 2004). Visibility increased by more than 40 kilometres over normal conditions. The levels of carbon monoxide and soot related to automobile use remained the same, however.

This example well illustrates the complexities of the economic, social, and environmental costs and benefits associated with the reliability of energy supply. The outages listed in Table 14 (Chapter 5) show that Nova Scotia has encountered major reliability challenges on a regular basis in recent years. The establishment of a full cost estimate of the impacts of these disruptions on the economy, society and environment of Nova Scotia is not currently possible due to lack of accurate data. However, the examples above clearly demonstrate that lack of energy reliability and disruptions in supply do have major economic impacts and that the issue of reliability will eventually require serious consideration in future full-cost accounting assessments of Nova Scotia's energy sector. It should also be noted that Nova Scotia Power's proposed solution to improving the reliability of the electricity grid—namely expanding the right-of-way for power lines by cutting down more trees—also has serious environmental and social costs that need to be considered when making policy decisions.

Energy security

Energy security and energy reliability are closely linked in the current market structure due to the reliance on imported fuels from regions in the world that may be quite unstable. The structure of the existing global energy market, the reliability of imported fuel supplies, and the prices paid by oil consumers cannot be separated from military operations around the world designed to secure

[81] This is not to suggest that no economic benefits occur as a result of power outages. Some businesses may benefit from the sale of certain items (gasoline, generators, gas cookers, flashlights, candles, and the like) before, during, and after a power outage. Repair work can also create temporary jobs and increase overtime income. In conventional accounting mechanisms, such defensive expenditures dedicated to damage repair contribute to GDP and economic growth. In the Genuine Progress Index, such defensive expenditures are counted as costs, not gains, to the economy, as the money would otherwise be available for more productive uses.

and maintain fossil fuel supplies (Levin, 2003). Any consideration of the full cost of energy, no matter where in the world, must consider the associated security costs of maintaining energy supplies.

For example, the 1991 Gulf War cost the United States $7 billion net (2000 $U.S.) (Lovins, 2003), while the Iraq War that began in 2003 is estimated to have cost between $150-300 billion thus far (2003 $U.S.) (ICTA, 2005). Even peacetime disbursements for military forces prepared for interventions in the Persian Gulf are approximately $60 billion a year (2000 $U.S.). While the extent to which these military expenditures are related to U.S. efforts to secure a reliable supply of imported oil from the Middle East is highly controversial, there is no question that reliance on imported fuels carries significant security costs.

Attention to energy-related military and security expenditures often focuses specifically on the Middle East. But other areas of the world, particularly South America, are also becoming areas of security concern and even military involvement as a result of energy resources. Colombia is now the third largest recipient of U.S. military aid (behind Israel and Egypt) (ICTA, 2005). In 2002, 100 U.S. Special Forces were deployed to Colombia to train local Colombian military personnel specifically to provide protection for an American oil company pipeline (ICTA, 2005). These examples illustrate the financial and military expenditures that can be attributed to providing a secure and uninterrupted supply of energy.

While it would be extremely difficult to quantify the associated costs or benefits of ensuring a secure energy supply that are directly or indirectly linked to Nova Scotia, it would be misleading to exclude such costs from a full-cost accounting analysis of energy externalities in Nova Scotia. Small countries or provinces that do not directly spend money on energy security receive economic benefits from the countries that do and share the consequences of lapses in this security through higher fuel prices, oil shortages, and other adverse consequences. This is the reality of a global energy market in which all players are linked. Although the few illustrative examples provided above refer to American military expenditures, the security of energy resources is a global pursuit. One estimate, from an International Center for Technology Assessment study of security and protection service costs related to *Gasoline Cost Externalities,* suggests that approximately 25% of the world's military disbursements go towards securing oil (ICTA, 2005).

It should also be noted that there are energy security costs beyond direct military expenditures. Considerable human, environmental, and social costs are incurred while attempting to provide global energy security. The costs listed above do not include the lost lives of soldiers or civilians that occur in wars over petroleum. They also do not reflect the tremendous environmental degradation that has resulted from conflicts related to energy, such as the toxic air pollution caused by the massive oil well fires in Kuwait and the devastation of marine wildlife and seabirds in the Arabian Gulf due to intentional oil releases during the Gulf War. Such indirect security-related costs should also be reflected in any full-cost accounting exercise.

It is not presently possible to quantify the security costs associated with energy production and use in Nova Scotia. But it is clear that the inclusion of these costs would significantly increase the aggregate energy-related costs that are summed below. On the positive side, the recognition of such costs lends added weight to initiatives that have the potential to reduce the social and economic costs associated with energy security. Reducing consumption, improving energy efficiency, and fostering the use of indigenous energy sources—especially renewables—can significantly reduce the need for energy security expenditures and their associated social, economic and environmental costs, by reducing the current reliance on foreign energy resources.

Resource consumption

There are both intrinsic and external costs associated with the exploration, extraction and processing of energy resources. For discussion purposes these issues have been grouped under the heading of resource consumption. The issues discussed here will overlap somewhat with the earlier discussion in Chapter 3, and are intentionally reiterated here to ensure that they are considered within the context of a full-cost accounting analysis of Nova Scotia's energy sector.

The current global structure of the energy system links producing and consuming nations inextricably. The fact that Nova Scotia obtains 17% of the coal used for Provincial electricity production from Colombia (ARSN, 2004) provides just one example of these international connections. Such international associations greatly extend the reach of a true full-cost accounting endeavour and prompt consideration of impacts and events that are well beyond what most observers would consider to be consequences of energy use in Nova Scotia.

The international linkages of the energy system in Nova Scotia were highlighted in spring, 2005, by a speaking tour titled *Mining the Connections,* which featured Francisco Ramirez, president of Colombia's national mineworkers' union. The purpose of the tour was to bring attention to human rights violations connected to coal mining operations in Colombia (ARSN, 2005). Ramirez and other speakers provided a detailed account of abuses suffered by workers and union leaders in the coal mining districts of Colombia. A list of the recorded human rights violations in Colombian mining regions for the year 2000, as presented by Ramirez, is shown in Table 46.

Table 46. Human rights violations in Colombian mining districts, 2000

Year	Homicides	Disappearances	Injuries	Torture	Arbitrary Detentions	Threats	Massacres
2000	1294	283	119	96	171	337	98

Source: Ramirez, 2005.

ARSN argues that the human cost of importing coal from Colombia is immeasurable and requested NSPI executives to meet with Ramirez to discuss alternatives to NSPI's current Colombian coal supply (ARSN, 2004).[82] Although the numbers in Table 46 are hard to verify, it is undeniable that a link between Nova Scotia energy consumers and Colombian coal miners does exist; therefore some responsibility must be taken in Nova Scotia for the social costs and consequences of our consumption habits. Conversely, the issue raises questions as to what Nova Scotian producers and consumers can do to reduce the costs in suffering and human life that are

[82] Nova Scotia Power, which buys about 17% of its coal from Colombia, refused to meet with Ramirez during his visit to Nova Scotia.

linked to the current coal supply system. Not all coal burned by Nova Scotia Power is necessarily linked to human rights violations, and every supplier of coal should be assessed independently. But this example of Colombia effectively demonstrates that the estimation of costs related to energy production and use must extend beyond the borders of this Province.

At the same time, the impacts and costs associated with the exploration, extraction, and processing of energy resources are sometimes experienced much closer to home. This is certainly the case with Nova Scotia's offshore oil and gas industry. As noted in Chapter 3, there are environmental costs and concerns related to seismic testing during the exploration phase; there is potential for drilling accidents or oil spills from offshore operations, and activities may hurt the fisheries and tourism industries that operate within the region (Landon and Pannozzo, 2001).[83] The Provincial coal industry has historically also had significant impacts on the environment and on the health of miners, none of which have been fully monetized.

In short, the external costs of energy resource consumption are both near and far. While definitive data do not exist to allow inclusion of these costs in this study, these few examples illustrate that the estimated external costs of exploration, extraction, and processing can be considerable and would raise the aggregate costs in any comprehensive full-cost accounting analysis of Nova Scotia's energy sector. The examples also illustrate that changes to the existing energy system could help avert some of the related social and environmental costs of resource consumption. Certainly a reduction in energy demand in Nova Scotia could result in a corresponding decline in purchases from fuel vendors involved in human rights abuses, and a shift to renewable energy sources could reduce the environmental and social costs associated with fossil fuel exploration, extraction and processing.

Resource depletion

Separate but related to the issue of consumption is the cost of resource depletion. Depletion can be defined as the "progressive reduction of the overall stock (or volume in the instance of oil and natural gas [or coal]) of a resource over time as the resource is produced" (USDOE, 2000:ix). When the term is used in the oil and gas industry, it often refers to diminishing production from a specific field, reservoir or well (USDOE, 2000).

The impacts of fossil fuel depletion were outlined briefly in Chapter 3, which showed that the impending peak in oil production will have significant and extensive impacts. A study conducted by the U.S. Energy Information Administration (USDOE, 2000) identified some of the impacts and relationships associated with accelerated resource depletion. For example, higher oil prices caused by resource depletion are expected to boost natural gas prices and lead to increased exploration and production activities for gas resources (USDOE, 2000). The analysis also shows that the accelerated depletion of oil and gas will likely result in a greater dependence on coal in the U.S. (USDOE, 2000). The study shows that the impacts of resource depletion will have significant environmental and social costs.

[83] For a more complete examination of the potential impacts of offshore oil and gas exploration and extraction in Cape Breton, see: Landon and Pannozzo, 2001.

Resource depletion is also affected by technology development related to energy exploration, extraction, and consumption (USDOE, 2000). The more effective and efficient these activities become, the more the time frame for the use of non-renewable resources can be extended, thereby limiting (at least temporarily) and possibly reducing the impacts of resource depletion. Improved renewable energy technologies can reduce the need for the development of non-renewable energy in a more long-lasting way, and thereby reduce the related social and environmental costs of resource depletion.

A study conducted by the Australian Environmental Protection Authority (1998) attempted to establish a cost estimate for coal that included the costs associated with resource depletion. The cost estimate also reflected the more common environmental costs associated with the mining and extraction of coal, as described in Chapters 3. This study considered the cost of rehabilitating land, and used detailed predictions regarding the future demand for coal and the technologies that might be in use in the coming years. Based on all these factors, the Australian analysis resulted in a cost estimate of $26 ($U.S.) per tonne, which included resource depletion costs (NSWEPA, 1998).

Due to data limitations and methodological challenges, this study was not able to include the costs associated with resource depletion in the final estimate of energy costs. However, as the Australian example demonstrates, establishing a cost for resource depletion may become more feasible in the future and should be considered in future full-cost accounting efforts for Nova Scotia's energy sector.

Energy subsidies

Subsidies are a direct, taxpayer-borne cost associated with energy production and use that are often ignored or overlooked because they are hidden and can come in so many different forms. For example, a government budget announcement may be made to support energy-related activities (like research and development in the oil and gas sector), and then quickly forgotten by the public. More often than not, however, energy subsidies are a recurrent expense that is paid for with public tax dollars. Energy subsidies can result in market distortions that favour one form of energy over another, undermine efficiency, and prevent society from paying the direct or full costs of energy on a daily basis.

Subsidies are not an externality in the same way as the impacts of air pollutant emissions. Subsidies are more often a cost that is hidden in the price of energy or taxes and that essentially comes from the public purse. Because subsidies are often unknown or overlooked by the general public, but do represent a very real and direct cost associated with energy production and use, a brief overview of the issue is provided here.

The World Trade Organization definition of subsidy contains three elements:

1. a subsidy must be a financial contribution of some sort;
2. a government or public body must make this contribution; and
3. this contribution must result in a benefit of some kind (Pershing and Mackenzie, 2004).

There are a number of different kinds of energy subsidies that meet these criteria. Subsidies can take the form of direct financial transfers; preferential tax treatment; trade restrictions; and energy related services provided by the government at less than full cost (Pershing and Mackenzie, 2004). Though not necessarily a direct financial transfer, preferential regulation can also be considered a subsidy. These disparate actions or policy measures may be developed for a number of reasons. Some of the more common motivations for implementing or pursuing energy subsidies are:

- protecting provincial industry and promoting jobs at home;
- reducing imports and improving national security (i.e. reducing reliance on fuel from unstable regions);
- managing risk;
- making energy more affordable for specific social groups; and
- protecting the environment (Pershing and Mackenzie, 2004:6).

While energy subsidies are often well-intentioned, they may not achieve the desired results and may lead to unwanted consequences. According to Pershing and Mackenzie (2004), energy subsidies can:

- lower the price of energy and therefore increase consumption;
- reduce government income or increase government expenditures; and
- lead to investment in specific technologies, thereby discouraging and restricting the development of potentially promising new technologies.

This illustrates the often conflicting nature of energy subsidies. Subsidies can provide benefits to some sectors while injuring others. In some cases subsidies can be considered "perverse," because they have a negative impact on both the economy and the environment (Myers and Kent, 1998). Despite these complexities, energy subsidies are used extensively worldwide. One study estimated that the global cost of annual energy subsidies is $244 billion ($U.S.) (Pershing and Mackenzie, 2004). Examination of the technologies that receive the bulk of these subsidies is an important component of subsidy analysis. The majority of global energy subsidies are given to fossil fuels (an estimated $151 billion (U.S.) annually), while nuclear power obtains $16 billion, and renewable energy receives only $9 billion (Pershing and Mackenzie, 2004). Thus subsidies can and generally do support existing technologies and thereby limit the growth of new and more sustainable energy technologies.

The situation in Canada is similar. The Canadian oil and gas industry is heavily subsidised, as documented in a recent study commissioned by the Climate Action Network and conducted by the Pembina Institute (Taylor et al, 2005). The Pembina research focused on three types of Federal Government subsidies: grants and direct expenditures; the tax system; and program spending through government departments for oil sands development as well as conventional oil and gas exploration, extraction and processing . The results showed that subsidies to the Canadian oil and gas industry were over $1 billion (2000 CDN) in 1996, growing to nearly $1.5 billion in 2002. The total taxpayer-funded subsidies to the industry between 1996 and 2002 totalled more than $8.3 billion (Taylor et al, 2005). These energy subsidies are a significant contribution to an industry that is currently profiting from high energy prices and has significant adverse environmental impacts.

A 2000 report by the federal Auditor General concluded that:

> …with a few exceptions, federal government support today for energy investments, including support through the tax system, does not particularly favour the non-renewable sector over the renewable sector. The exceptions are investments in oil sands and coal mines, which receive a significant tax concession; nuclear technology investments, which receive substantial direct support; investments in alternative fuels, which receive more favourable excise tax treatment; and provincially owned energy companies, which pay no federal income tax. We also found that the income tax system does not give any preferential treatment to certain energy efficiency investments.

However, the Auditor General only included federal energy subsidies (not provincial investments) and did not examine subsidies through program spending that were also addressed by the Pembina Institute. The only subsidy clearly in the Auditor General's report was direct federal spending, which totalled more than $200 million in 1998-99; two-thirds of which went to non-renewables.

As noted in Chapter 7 Nova Scotia has the highest taxes for wind energy projects of all the provinces (Current Generation Inc., 2005). Furthermore per MWh of electricity generated NSPI pays $1.45 in taxes, while wind projects pay $10.32, a sevenfold difference. Such preferential treatment for NSPI in effect puts wind developers at a competitive disadvantage and will serve to discourage the widespread development of wind energy in the province. This example reinforces the notion that non-renewable energy forms are more heavily subsidized than renewable forms.

These reports show that the average citizen is paying, often unknowingly, to support the Canadian energy sector. The exact portion of these government subsidies that benefit the energy sector in Nova Scotia is not known. For this reason, subsidies could not be directly included in this full-cost accounting exercise. However the Pembina and Auditor-General reports show that if subsidies were considered in the full costs of energy, the final cost tally would be higher than in the aggregation below, which includes only pollution and greenhouse gas emission costs. Because subsidies represent allocation of taxpayer dollars, their direction is potentially open to public influence, which could help determine where energy subsidies are directed and which technologies and energy sources receive funding.

Recent polling by Nova Scotia Power found that a substantial majority of Nova Scotians prefer conservation and renewable energy developments (especially wind) over increasing energy use and fossil fuel generation (NSPI, 2004a). If Provincial and Federal support for energy developments were fully disclosed and transparent, and if public information and discussion on subsidies were actively facilitated, energy subsidies might be very different than they are today. In the context of the health and environmental costs outlined in this chapter, it is paradoxical that government subsidies for non-renewable forms of energy incur substantial long-term health and environmental costs that will also be borne by the public. This indicates the importance of a full-cost accounting approach when planning and implementing energy subsidies.

Employment

A complete valuation analysis of the energy sector would also account for the full benefits and costs of energy sector employment and layoffs. The inclusion of employment benefits in full-cost accounting analyses is particularly challenging because *net* societal benefits and costs must be considered after accounting for inter-sectoral employment shifts. Increased employment is typically seen as a benefit to society, but the quality of jobs, including job security, fringe benefits, work hours, and exposure to health risks, also affects wellbeing and produces a wide range of both positive and adverse benefits and costs. This section briefly considers energy-related employment issues that may affect a full-cost accounting analysis of the Nova Scotia energy sector.

Energy sector employment issues include the type of the jobs created, the skills required, the duration of the positions, the impact on other employment sectors, and whether or not the type of work being done generates local jobs. These factors vary according to the type of energy project that is creating jobs at any particular time. For example, comparisons are frequently made between the job creation potential of conventional oil and gas projects, emerging renewable technologies, and the field of energy efficiency (see Chapter 5, Section 6). As well, the duration of jobs can vary significantly in different phases of energy sector development. For example, the oil and gas industry in Nova Scotia is widely seen as a significant employer in the Province. However, Chapter 5 indicated that many oil and gas jobs are created during the construction phase of large energy infrastructure projects, such as drilling platforms and pipelines, but the number of jobs decline significantly as the project moves into the operational phase. Assessing the costs and benefits of energy sector employment must therefore weigh the type of and duration of employment as well as the type of energy activity in which employment is created.

There has been some important comparative research on the job creation potential of different types of energy development. The David Suzuki Foundation, for example, estimated that if Ontario shifted a substantial portion of its energy generation to renewable energy sources by 2010, $9 billion would be added to the economy and 25,000 new jobs would be created (DSF, 2004). One U.S. report estimated that increased support for renewable energy in that country through 2020 could result in the annual creation of 154,000 jobs (Nayak, 2005). These estimates show that changes in the energy supply mix can significantly affect opportunities for employment in the energy sector.

Too often, oil and gas sector employment is touted as an economic benefit meriting support for non-renewable energy development, without reference to the employment that could potentially be generated by equivalent investments in renewable energy development. Fortunately, evidence is now available that allows this type of comparison. A study by the Pembina Institute has compared the generation of jobs in the oil and gas sector with those in the renewable energy industry. The study found that that a $1 million investment in conventional oil and gas generates seven jobs while the same investment in alternative energy would generate 12 jobs (Campbell and Pape, 1999). A one million dollar investment in solar energy would create an estimated 28 jobs, while investment in energy conservation and efficiency would produce 37 jobs (Campbell and Pape, 1999). Thus a strong case can be made for the employment benefits of pursuing energy efficiency and conservation.

Although now somewhat dated, a 1994 energy strategy developed for British Columbia found that the skills required in the energy efficiency and conservation fields were a good match for the skills held by unemployed people in that Province (Askew, 1994). It is possible that a similar correspondence could exist in Nova Scotia, but no studies have yet been conducted to explore this. These pieces of evidence indicate the importance of Nova Scotia-specific research on the potential for investment in energy efficiency, conservation, and renewable energy to create jobs and reduce unemployment in the Province. As well, research should produce employment projections based on various energy technologies and consider the potential employment-related trade-offs between investments in different types of energy development.

Land use costs

Although time, resources, and data gaps did not permit the inclusion of land use indicators in this report, a brief discussion is necessary here to highlight potential costs in this area. Some costs of land use are already included in the price of energy in a competitive market structure. For example, most utility companies need to purchase land before building plants. They must also pay property taxes. Similarly, wind energy requires land to be purchased or leased for placement of wind turbines. Wood fuel prices also include land use costs, as companies pay stumpage fees and private land owners pay property taxes. These kinds of land use costs are generally transferred to the user, and therefore already "internalized" in energy prices. However, there may be cases where property taxes or purchasing prices do not accurately reflect land use costs due to either preferential or inflated taxes or other subsidies.

Different energy sources also have various land use impacts and costs that may be less transparent and obvious than land purchase costs and property taxes. For example, wind turbines and solar power systems can generally be incorporated into a variety of landscapes causing small impacts. The United States Department of Energy (2004a) estimates that 7% of the built-up area in the U.S., or 0.4% of the total land mass, would be needed to produce all the country's electricity through solar photovoltaics. However, these systems can often be placed on existing roofs, highway embankments, and walls of building that do not withdraw productive land from other uses. By contrast, although biomass energy can be incorporated into agricultural landscapes, it is likely to require significant amounts of dedicated land that would not then be available for other uses. Large hydro projects also have significant land use costs that may or may not be accurately reflected in the price of electricity depending on whether the flooded land is purchased or leased at competitive and accurate prices. These opportunity costs may be only partially incorporated into the price of energy. Other externalities due to land use include the costs of human resettlement, sedimentation of water, chemical or nutrient leaching, habitat loss, and opportunity costs due to the withdrawal of land from agricultural or other uses. If full-cost accounting practices were fully applied to energy prices, these costs would be incorporated in tax or regulatory structures either as general land use costs or based on the projected costs of specific impacts (e.g. the amount of annual erosion).

Possibly the most significant externality of energy land use is that life-sustaining services provided by undeveloped land are lost or impaired when converted to use for energy production. There is no market value for trees purifying the air and replenishing oxygen or for wetlands that purify water and limit flooding. Natural landscapes also provide recreational activities for humans and habitat for other animals (Carter et al, date unknown). Such costs should be considered in major energy policies and developments, so that adverse land use impacts can be minimized. Methods for costing these types of non-market services might include "replacement cost" valuations, such as the cost of purifying water in a filtration plant or purifying air through a filtration system. Other costing approaches and methodologies that may be applicable to valuing land converted to energy production (such as a coal mine) include the costs of restoring a developed area to a natural state, as sometimes happens when the productive life of a mine ends. The shift from normal procedures is that a full-cost accounting approach considers such costs at the front end rather than at the time of reclamation, and aims to build such costs into the actual price of production, purchase, and use.

A landmark study by Costanza et al (1997) estimated the economic value of the world's ecosystems.[84] Values included for forests were climate regulation, soil formation, waste treatment, biological control, food production, recreation, and cultural benefits. Their estimate does not include other vital forest ecosystem services such as the control of soil erosion, water supply and watershed protection, nutrient cycling, gas regulation, pollination, habitat regulation, and genetic resources.

According to Costanza et al (1997), the value of ecosystem services in boreal and temperate forests is at least $460 per hectare per year (2000 $CDN) ($302/ha/yr - 1994 $U.S.). Costanza et al (1997) estimate that wetlands contribute $22,500/ha/yr (2000 CDN) in ecosystem services.[85] The accuracy of estimates by Costanza and his associates are difficult to assess though they are stated to exclude many essential ecosystem services because of a lack of data and information sources.

Different energy sources produce varying degrees of impacts on ecosystems in terms of both costs and benefits. For example, an industrial power plant provides no ecosystem services whereas a high yield plantation for bio-energy would still provide ecosystem services like habitat (though at a reduced level compared to a natural forest). Data are not available to include land use valuations in this costing exercise for Nova Scotia's energy system. But it is clear even from this brief discussion that the inclusion of land use costs is an important component of a full-cost accounting exercise, and would certainly affect the final results, most likely increasing the full costs of energy.

Land and water contamination

Another cost of our current energy system is the contamination of land and water. As noted in Chapter 3, there are a number of ways that the current energy production system can adversely

[84] For further information on the economic valuation of the goods and services provided by the natural environment see de Groot et al, 2003. For a discussion regarding the materials-balance model and principle that is highly relevant to this exercise, see Pethig, 2004.
[85] $14,785 per hectare per year in 1994 $U.S..

affect land and water. Examples of these impacts include the discharge of hot water from thermal power plants and the tailings produced by mining coal. But the land and water contamination issue of greatest concern to Nova Scotians is oil spills. Chapter 3 presented the NS Department of Environment and Labour's (NSDEL) rough figures for reported oil spills in Nova Scotia – 470 in 2002 and 350 in 2003 (Baxter, 2004).

Because of the lack of detail available on this important issue, media sources were used in an attempt to identify to the scope of some oil spills in the Province. While it has its own clear limitations, this method at least allows a more descriptive analysis of some key incidents than is available from the summary, aggregate NSDEL figures, often revealing whether the spill occurred on land or in the water, how much oil was released, and occasionally the estimated or projected costs associated with the spill. Table 47 provides a list of the oil spills for both land and water that were reported in Halifax newspapers between 1999 and 2004.
The total reported oil spilled in these nineteen events was between 8,380 and 9,380 litres. If the total direct costs for each of the listed categories are combined for those cases where fines were levied and clean up costs estimated, the resulting aggregate cost for this time period is $865,000. It is important to emphasize that this total only represents the actual direct recorded economic costs for media-reported cases where fine were levied and clean-up costs estimated. It does not consider indirect and non-market costs, like the environmental or social damage attributable to these oil spills.

Table 47. Reported oil spills on land and in water in Nova Scotia, March, 1999 – March, 2005

Date	Location	Amount in Litres (L) and Type	Land (L) or Water (W)	Costs ($)		
				Clean- up	Fines	Other
Dec. 2004	Springfield Lake		W			
Nov. 2004	Cape Breton – Hwy. 105		L			
Oct. 2004	Truro	(Heating Oil)	L			
Aug. 2004	Eastern Passage		L	43,000		
Dec. 2003	Halifax	(Used Motor Oil)	L			
July 2003	Sydney Harbour	(Bunker C Oil)	L/W			
June 2003	Richmond County Harbour	800 L (Diesel Fuel)	W	14,000	5,000	23,000[a]
May 2003	Colchester County	1,410 L (Oil)	L	350,000		
Feb. 2002	Halifax Harbour[b]		W	80,000	100,000	
June 2002	Sydney[c]	380 L (Lube Oil)	W			
May 2002	Pugwash Harbour	180 L (Hydraulic Oil)	W			
Apr. 2002	Halifax Harbour		L/W			
Spring, 2002	Off coast of NS	92 L	W		125,000	
June, 2001	Lingan Bay	500 L (Bunker C Oil)	W			
Mar. 2001	Truro	670 L (Heating Oil)	L			

Nov. 2000	Off Cape Breton	1,500 L	W			
Oct. 2000	South of Yarmouth	2,000-3,000 L (Oily Bilge Water)	W			
Aug. 2000	Halifax		L			
Dec. 1999	Off coast of Nova Scotia	850 L	W		125,000	
Total		**8,382-9,382 L**		**$487,000**	**$355,000**	**$23,000**

Notes: a) The expenses here include $8,000 for compensation and a $15,000 corporate donation. b) Estimated that 150 seabirds died. c) Reported that 10 large water-birds were killed.

Source: Adapted from newspaper articles from the *Chronicle-Herald*, and the *Daily News* from March, 1999 to December, 2004.

The incidents listed in Table 47 represent only a small fraction of the hundreds of oil spills that occurred in the Province of Nova Scotia in the last six years, and (with one exception) do not include ships' dumping of oily bilge water and other incidents at sea. The World Wildlife Fund has estimated that less than 10% of oil spills are ever found or reported (Lambie, 2002). This estimate suggests that any reported measure of the number of oil spills in the Province would be a gross underestimation. In addition, the environmental impact of the oil spills is difficult to measure and quantify. The World Wildlife Fund states that oil spills in Atlantic Canadian waters kill roughly 300,000 birds a year (Lambie, 2002). This represents a considerable environmental consequence and cost attributable to the energy sector in Nova Scotia and Atlantic Canada that is difficult to quantify in monetary terms.

As noted, the costs in Table 47 and the simple quantitative aggregation of oil spills in the summary NSDEL figures do not reflect the significant environmental, human health, and social damage costs related to oil spills. These costs can be sizeable and should be considered in any full-cost accounting analysis. According to the Insurance Bureau of Canada (2002), it takes only one litre of spilled oil to contaminate one million litres of drinking water. While it was not possible to quantify or include the costs of oil spills and other water and land contamination attributable to Nova Scotia's energy industry in the present analysis, future research and full-cost accounting estimates related to the Nova Scotia energy sector should consider and reflect these associated damage costs to the extent possible.

While the majority of oil spills listed in Table 47 represent larger scale industrial incidents, there are a number of spills from much smaller sources like home oil tanks. The fact that there are approximately 200,000 Nova Scotian homes that rely on oil for heating creates substantial opportunities for smaller scale spills from leaky tanks, and other incidents (Harris, 2005).

The most widely reported costs associated with residential oil spills in Nova Scotia and Atlantic Canada relate to insurance and cleanup. The insurance industry is more aware than most of the costs associated with residential oil spills, since these costs now represent the third most expensive property insurance claim in Atlantic Canada, with only fire and water damages being higher (Harris, 2005). Between 1999 and 2002, New Brunswick, Prince Edward Island, Newfoundland, and Nova Scotia collectively had 1,239 insurance claims related to residential oil spills, costing insurance companies a total of $61.4 million (Harris, 2005).

On a per incident level, the costs of cleanups related to residential oil spills have also been rising. In 2002, the estimated cost for the cleanup of a residential oil spill in Atlantic Canada, as published by the Insurance Bureau of Canada, was between $5,000 and $150,000. An insurance adjuster in Dartmouth stated that the *average* claim is now about $150,000 (Harris, 2005). These are significant costs that Nova Scotians are paying through higher insurance premiums which stem directly from the energy use and from the types of fuels on which we currently depend. Bill Adams of the Insurance Bureau of Canada notes that Nova Scotia has resisted calls for regulation regarding oil tank installation and replacement choosing to rely on voluntary guidelines (Harris, 2005). However, the Insurance Bureau of Canada sees a strong role for government regulation regarding this issue.

8.5 Aggregated Damage Cost Estimates for Nova Scotia's Energy Sector

The aggregated damage costs attributable to the Nova Scotia energy sector for the year 2000 for GHG emissions and air pollutants only are shown in Table 48 and Table 49. The latter includes emissions from the transportation sector and the former does not. High and low estimates are included, as described earlier in this chapter, as well as costs per capita based on a population of 933,881 in 2000.[86] The other energy-related costs briefly described above – including costs of fuel poverty, supply disruptions, security, resource consumption and depletion, subsidies, foregone employment, land use impacts, and land and water contamination, could not be included in the aggregate estimates at this stage for the reasons described.

Table 48. Aggregated air pollution and greenhouse gas damage cost estimates attributable to Nova Scotia's stationary energy sector

	Low	High
Air Pollutant Damage Costs	$301,316,000	$2,092,708,000
GHG Damage Costs	$86,212,000	$502,562,000
Total	**$387,528,000**	**$2,595,270,000**
Per Capita	**$415**	**$2,779**

[86] Nova Scotia population estimate is from Statistics Canada CANSIM Table 051-0001.

Table 49. Aggregated air pollution and greenhouse gas damage cost estimates attributable to Nova Scotia energy and transportation sectors

	Low	High
Air Pollutant Damage Costs	$403,726,000	$2,757,129,000
GHG Damage Costs	$124,146,000	$723,690,000
Total	**$527,872,000**	**$3,480,819,000**
Per Capita	**$565**	**$3,727**

Each year the stationary energy sector alone accounts for between $387 million and $2.5 billion in externality costs attributable to air pollutant and greenhouse gas emission impacts, depending on the impact models and their assumptions. When transportation is included these figures grow to $527 million and $3.4 billion. At a minimum these costs amount to over $565 annually for every woman, man, and child in the Province. It should be reiterated that these costs are not incurred only in Nova Scotia but are experienced regionally (in the case of air pollution) and globally (in the case of GHGs). Similarly the pollution and climate change damage costs borne by this and future generations of Nova Scotians are partly the result of pollutant emissions elsewhere in North America and globally in the case of GHG emissions.

Furthermore it is critical to emphasize, as done in Chapter 5, that higher-income households consume considerably more energy than low-income households (see Section 5.7 on Affordability). In other words, higher-income groups are responsible for a larger percentage of energy use on a per capita basis and therefore a larger percentage of the damage costs attributable to energy-related pollutant and greenhouse gas emissions than are lower-income groups, and they are correspondingly responsible for a larger proportion of the reduction in demand required for the energy system to become more sustainable.

As indicated in Tables 48 and 49, damage costs for GHGs are comparable to those for the criteria air contaminants and mercury. If a higher damage cost estimate for GHGs had been used, as recommended by Bein and Rintoul (1999) and others (e.g. $1000/tonne vs $100/tonne), GHG damages would be an order of magnitude larger.

The costliest air pollutant is SO_x. This is due both to the severe environmental damages and concomitant costs caused by acid rain, the severe health effects of SO_4 and to the sheer amount of SO_x released in the Province due to its heavy reliance on coal-fired power generation. The quantity of SO_x emissions is also dependent on the type of coal burned and the state of a generating plant's pollution abatement technology which can either be included in the design of new plants or added to older ones. For example, the second largest electrical utility emitter of SO_x in Canada is Nova Scotia Power's Lingan generating plant in Cape Breton, a 23-24 year old, 606 MW facility. The largest emitter is Ontario Hydro's Nanticoke coal-fired plant, a 29-30 year old, 3920 MW facility (Energy Probe, 2005; NRCan, 2004c). The Lingan plant produces between four and five times more SO_x than Nanticoke per unit of electricity produced despite Nanticoke being the older facility (Energy Probe, 2005; Hoare, 2005). Nanticoke has benefited from significant investments in pollution control technology since it began operating. When compared to the annual externality costs of NSPI 's aged, inefficient and heavily polluting coal-fired plants, it becomes obvious that implementing new energy technology is an effective strategy for pollution reduction and, from a full-cost accounting perspective, a worthwhile and cost-effective investment that will produce a substantial rate of return to society in reduced pollutant damage costs. Of note is the fact that NSPI cleanest coal plant, Point Aconi, though the most costly to build, now has the lowest operating costs (NSPI, date unknown).

Air pollutant emissions can be reduced substantially by using existing pollution abatement technologies and/or by switching to cleaner fuels such as low-sulphur coal and natural gas, and to renewable sources like wind and solar power. Natural gas has the added benefit of reduced GHG emissions compared to coal. Though advanced technological solutions for coal can address air pollutant emissions to a considerable extent, they are costly to build and unfortunately only partially reduce emissions and have little effect on GHG emissions and dependency on foreign supplies. The best solution for addressing GHG emissions is through improved efficiency and conservation. Such measures could greatly reduce overall energy demand, resulting in the co-benefits of reduced air pollution emissions, and a reduction in all of the other impacts and associated costs discussed in this chapter. Improved efficiency and conservation must go hand in hand with an increase in renewable energy production, which produces little to no emission of GHGs and air pollutants. Greater reliance on local renewable energy sources should also help to reduce security costs, slow the rate of resource depletion, and address problems associated with resource extraction.

It should be emphasized again that the totals presented in Table 48 and Table 49 omit a wide range of costs related to reliability, security, subsidies, land use, contamination, and other impacts. If all these costs were included, the full cost of energy in Nova Scotia would be significantly higher than indicated in Table 48 and Table 49. Even the partial estimates above, are based on limited information and new methodologies both of which continue to improve and become more robust with new research. While the dollar amounts provided here are certainly not precise, they do point to the extent of the damages caused by our current unsustainable energy system and to the very considerable costs it generates. In that regard, even rudimentary efforts to assess these costs are more accurate than the implicit assumption of conventional accounting systems that the costs do not exist. As data sources and methodologies continue to improve over time, greater precision and more comprehensive cost valuations will gradually become possible.

Comparative externality costs

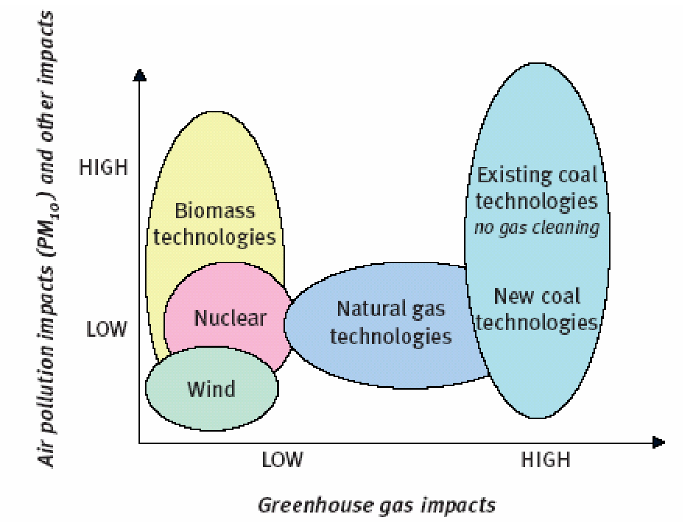
The partial cost estimate for the Nova Scotia energy sector above represents an overview of the pollutant and GHG emission damages attributable to one year's operations. This estimate represents a wide range of energy sector activities, including residential heating, commercial and institutional energy use, and electric power generation. There is, however, a great deal of literature that attempts to establish the externality costs associated just with the direct production of electricity alone. This shifts the basis of cost estimates from a tonne of emissions to a kilowatt-hour of electricity. This method then allows for a direct comparison of the differential costs that result from the various methods used to generate electricity (e.g. coal vs. natural gas vs. wind). An analysis of the costs at this level allows for an assessment of the value and full benefits and costs of investment, refurbishment, or conversion of electricity-producing capital stock. Similar analyses could be developed for other devices that use energy, including vehicles and wood stoves.

A European mega-project called ExternE has undertaken the most thorough research assessment in this field, and has produced highly useful costs per kilowatt-hour for different forms of electricity generation. The combined study is the result of more than 20 research projects over the past 14 years. The goal of the research consortium was to attach realistic financial cost estimates to the various methods of electricity production in the European Union (European Commission, 2004). ExternE's examination of the external costs of electricity considered:

- human health costs from:
  - PM_{10}, SO_2, NO_x, O_3 and CO exposure,
  - Exposure to heavy metals, dioxins, other atmospheric micro-pollutants,
  - radiological exposure, and
  - occupational health effects;
- building material damages from air pollution;
- noise pollution and visual amenity impairments;
- the economic cost of accidents associated with the fuel cycle;
- terrestrial ecosystem effects;
- water use and pollution and nutrification potential; and
- climate change damages from greenhouse gas emissions (Venema and Barg, 2003:18).

The research conducted by ExternE is extremely thorough, although it is difficult to apply directly to Canada and Nova Scotia. The main difficulty in transferring the values from the ExternE study is the contrast in population density. Europe is much smaller than Canada, but the population is many times larger, so pollutant emissions from stationary sources in Europe, for example, will affect larger numbers of people than in Canada. There are also differences in the power generating technology used in Europe and in Canada, as well as varying fuel grades, which result in differing emission levels and different climatic and environmental ecological conditions. All these factors make the European results difficult to extrapolate to Nova Scotia. However, the assumptions and conclusions of the ExternE study remain valid generally, and can be used fairly universally to compare the externalities associated with the various means of producing electricity, as presented in Figure 41. As shown, wind energy has the lowest externalities in terms of GHG, air pollutant and other impacts while most coal technologies scoring high in these categories.

Figure 41. Comparative externalities of electricity production methods



Source: Directorate-General for Research, 2003, p.12.

The IISD study, *The Full costs of Thermal Power Production in Eastern Canada*, referred to previously, also included a cost comparison by fuel type for electricity generation (Venema and Barg, 2003). The results of this research are shown in Table 50. The table includes the damage cost estimates both for air pollution and for climate change attributable to electricity generation in eastern Canada, as well as total aggregate values. Using a different basis for calculation than the earlier per tonne estimates, the IISD results again illustrate the high external costs associated with the use of fossil fuels for electricity generation, particularly coal which is nearly twice as high as for oil and three times higher than for natural gas. The externality costs of renewable electricity were not included in that study.

Table 50. Thermal power externality costs in Eastern Canada by fuel type (2000 $CDN/kWh)

	Coal	Natural Gas	Oil
Air pollution externalities	0.0183	0.0001	0.0041
Climate change externalities	0.0238	0.0108	0.0192
Aggregate externalities	**0.0421**	**0.0109**	**0.0233**

Note: While the air pollution externality value for natural gas is undoubtedly lower than for coal and oil, the value presented in this table only includes air pollution that occurs when natural gas is burned to produce electricity. Most of the impurities in natural gas are removed or escape when the gas is pumped from the ground and undergoes initial processing.

Source: Venema, and Barg, 2003, pp 5, 6 & 8.

As noted in the discussion on comparative employment estimates for different energy sources, these comparative externality costs can be used in long-term planning or capital venture cost/benefit analysis. They also can be used to assess and evaluate the full costs of investment, refurbishment, or conversion of power generating facilities.

8.6 Chapter Summary

Full-cost accounting is a challenging endeavour, and may yield results that are incomplete and that vary considerably depending on the assumptions employed. Extrapolating values from one location to another can be difficult, and the availability of data for assessing externality impacts, let alone for full-cost accounting analyses, is generally limited. These limitations are exemplified by the fact that the costs associated with air pollutants and greenhouse gases were the only two areas that were fully monetized both in this report and in the recent IISD study cited above. Most costs could only be discussed in general terms, using examples from other jurisdictions to highlight potential costs. While these additional costs could not be included in this full-cost accounting analysis, future work should consider and attempt to address an increasing number of these cost categories.

The assessment of air pollutant and greenhouse gas emissions resulted in a low estimate for the aggregate damage costs associated with Nova Scotia's stationary energy sector in 2000 of over $617 million, while the high estimate was almost $4 billion. These aggregate cost estimates represent only a fraction of the true costs of energy, as they exclude the costs associated with affordability, reliability, security, resource consumption and depletion, subsidies, employment, land use, and land and water contamination due to energy use in Nova Scotia. The inclusion of these costs would significantly increase the overall estimate of the total costs of energy in the Province.

Despite these exclusions, and the limitations and difficulties noted throughout this chapter, it is essential to consider and point to the full costs of energy to the extent possible in order to make considered and informed decisions on energy options and futures. Even this limited exercise of acknowledging and briefly outlining the true costs associated with energy production and use can help inform and improve policy making in Nova Scotia and beyond. The awareness that specific energy industries and technologies produce greater environmental and health costs than others should help guide investment decisions and choices on the basis of cost-effectiveness. As an example, as the time approaches to retire or refurbish some of the older coal-fired power-generating facilities in Nova Scotia, a more informed and sustainable approach can be used to guide the process of change and development in the energy sector.

When the full costs of energy production and use are not reflected in conventional accounting mechanisms, key factors like health and environmental impacts also do not get adequate attention in the policy arena and in decision-making processes. For these reasons, despite the very preliminary nature of the results, the information presented here can still be used both in Nova Scotia and beyond to create a more sustainable energy sector.

9. Conclusions & Recommendations

9.1 Putting It All Together

A sustainable energy system is one that provides adequate energy services to meet basic human needs, improves social welfare, and contributes to economic development without degrading the natural environment and without undermining or endangering the quality of life of current and future generations. It is therefore a system that is based on replenishable resources with a minimised waste stream that does not either deplete or degrade the stocks of those resources (i.e. that preserves natural capital) or overload or exhaust the capacity of the biosphere to absorb and process wastes effectively.

The analysis of energy production and use in Nova Scotia, its social and environmental impacts, and the resulting cost implications developed in this report, show that this Province is still a considerable distance from a sustainable energy system. Based on the ***principles of sustainability*** established at the beginning of this report, the evidence makes it clear that the Nova Scotia energy system does not:

- Achieve inter-generational equity since non-renewable resources are being depleted at faster rates than they can be replenished or replaced by other energy sources, thereby depriving future generations of 'cheap' energy sources;
- Respect the carrying and absorptive capacity of the earth since per capita air pollutant and greenhouse gas emissions and other wastes resulting from the energy sector in Nova Scotia are extremely high by OECD standards, and are causing serious and potentially irreversible damage to land, air, and water;
- Adhere to the precautionary principle since where there are threats of serious or irreversible damage, lack of full scientific certainty is often still used as a reason for postponing measures to prevent environmental degradation;
- Internalize negative externalities since polluters do not generally pay for the damage they create;
- Take both qualitative and quantitative integrity into consideration since the current system is not mindful of leaving both ample supplies and high quality forms of energy for future generations. Sustainability requires that energy sources are matched both in scale and in energy quality to end use needs so that both quantity and quality are ensured;
- Nor does the Nova Scotian energy system adequately address both the supply and demand side in energy management. Suggested and enacted regulatory measures are incomplete and fail to ensure that both producers *and* consumers of energy take responsibility for the consequences of their actions and of their consumption patterns by reducing overall energy demand and providing the remaining consumption needs through environmentally and socially benign processes.

The definition and principles of a sustainable energy system require action on two principle levels. First, there must be ample investment in renewable energy development and deployment in order to accelerate sharply the rate of its adoption and use. Equally importantly, is that the current rate of non-renewable energy consumption be drastically slowed to delay the advent of peak oil and the end of cheap non-renewable supplies, and to decelerate and then reverse the serious environmental consequences of fossil fuel combustion including climate change and air pollution. This is achieved by concerted conservation efforts and sharp efficiency improvements, both of which can also reduce costs or at least absorb gradual price increases.

Both strategies – major investment in renewable energy development and reducing current non-renewable energy demand through conservation and efficiency – are therefore essential and complementary components of a sustainable energy system and both intimately link the economic, social, and environmental elements of sustainability. Both the definition of a sustainable energy system adopted here and the practical strategy for achieving it, as well as the simple reality of peak oil and depletion of non-renewable supplies, join considerations of supply, demand, price, and affordability directly with environmental protection, concern for inter-generational equity, and the social change required to achieve these goals.

Too often, as in Nova Scotia, only one part of the equation is acknowledged. For example, Nova Scotia Power has committed to increasing its wind energy capacity somewhat, while aggregate energy production and demand continue to rise. Compared to other jurisdictions, the current investment in expansion of wind capacity in Nova Scotia is modest at best and nowhere near the rate that is essential to prepare for the onset of peak oil or to reverse the environmental degradation produced by fossil fuel combustion. But equally, Nova Scotia can make no claim to moving towards a sustainable energy system so long as it does not address conservation and efficiency in a concerted way, with clear and ambitious targets for aggregate demand reduction. These are the goals towards which Nova Scotia should, and does strive at least in intention, but far more concerted and dedicated action is needed to attain sustainability in the energy sector. In particular, the advent of peak oil and the dangers of climate change have dramatically narrowed the window of opportunity, shortened the time scale in which effective action is possible, and require – from both an economic and environmental perspective – a sense of far greater urgency than currently exists. Some essential actions to move Nova Scotia's energy system more rapidly towards sustainability are outlined in this chapter.

This final chapter begins with a summary of some of the key policy-relevant findings of this report, before making a number of recommendations about how Nova Scotia can more effectively measure progress towards a sustainable energy system. The chapter draws on examples of best practices in other jurisdictions to show what has been possible elsewhere and to provide inspiration for moving forward in this Province. In other words, Nova Scotia does not have to re-invent the wheel but can learn from and adopt effective sustainable energy strategies that have been tried and tested elsewhere.

Previous chapters have explored and assessed the current situation, including stated goals and targets for the future. But the evidence suggests that even the most laudable of these present goals and targets will not produce the deeper systemic and structural changes required, nor ensure progress towards sustainability at a rate that will adequately address present and future economic and environmental pressures and challenges. This chapter therefore offers suggestions that can move the Nova Scotia energy sector beyond the status quo far more decisively and accelerate progress towards sustainability. The recommendations are divided into several categories, including: data needs; goals and targets; energy supply and demand; institutional actions; and recommendations for further study.

9.2 Main Findings

All forms of energy production and use have side effects that can lead to environmental and social damage. In small quantities, many of these impacts are easily dissipated, but with societies around the world depending on ever increasing quantities of energy to run their economies, the cumulative effect of modern energy practices is taking its toll in serious ways that can no longer be ignored or dismissed simply as unfortunate externalities. The significant increase in global energy demand has resulted in a number of negative consequences for human and environmental health, social wellbeing, and economic prosperity. The broad range of impacts that result from energy production and consumption were outlined in Chapter 3. These impacts include threats to human health and mortality, which can be affected by energy industry accidents, as well as illnesses caused by exposure to pollutants and toxins released by the energy sector (at various stages). Environmental impacts noted include air pollution, water pollution and other aquatic impacts, toxic pollution, land use concerns, waste disposal, and noise pollution. The predicted consequences of climate change attributable to fossil fuel combustion were also discussed.

The problem of resource depletion of fossil fuel supplies, predictions regarding depletion rates, and the potential consequences of production peaks in oil and natural gas were also presented in the consideration of energy sector impacts in Chapter 3. An examination of key literature on resource depletion concluded that rising demand is rapidly outstripping the limited, accessible global supplies of fossil fuels, and that oil production is likely to peak within the next 10 to 20 years. This peak in oil production will have serious and widespread repercussions for all industrialized and developing societies. The general discussion on the impacts of energy production and use in Chapter 3 set the stage for the development of indicators of progress for Nova Scotia's energy sector in Chapters 4-7, and the full cost accounting analysis of the current Provincial energy system in Chapter 8.

This study identified 30 key indicators that can be used to assess progress in the energy sector in Nova Scotia. This is not an exclusive or final list, but represents key areas and activities that must be measured if the Province is to understand and keep track of genuine progress in the energy sector. The indicators were grouped into the following categories: socio-economic, health and environment, and institutional (Chapters 5, 6 and 7 respectively). Table 51 lists the indicators that were developed and the relative progress or lack of progress that has been made in each area, whether towards or away from sustainability. These are denoted by TS (towards sustainability), AS (away from sustainability), NC (no change) and NA (not available), which means there was insufficient information available to make a complete assessment of progress.

The following results must be qualified by the major caveat that such a summary can only demonstrate ***relative*** progress towards sustainability, and may in fact send quite misleading messages to policy makers. A very poor performance baseline for any indicator, for example, will more likely produce a positive trend than a higher baseline, because there may literally be "no direction but up" in the former case. Also, a simple relative trend towards greater sustainability reveals nothing about whether progress is sufficiently rapid to attain defined targets or whether thresholds of carrying capacity are being met or passed. The assessments of "progress towards sustainability" in Table 51 must, therefore, be understood in a very limited and relative sense that does not convey the full meaning of sustainability as defined above and in Chapter 1 of this report. It is particularly dangerous to interpret positive trends as reasons for complacency, when they may only signal the very beginning of needed progress in the right direction.

Table 51. (Relative) progress toward sustainability of GPI*Atlantic* energy indicators

Area of interest/concern	Indicators	Progress towards sustainability (denoted by AS,TS, or NA)
Socio-Economic		
Energy production and supply	• Current energy mix - total primary units per year by primary fuel type • Units of primary energy produced in the Province vs. units of imported energy by fuel type • Percent of electricity generated from renewable sources, natural gas, and other fuels.	• AS - Increasing use of fossil fuels (with limited renewable energy development). • AS / TS - Increasing dependence on imported fuels but some development of renewable resources and potential to use Provincial natural gas. • AS / TS – Decreased renewable generating capacity since 1978 but some development of renewable electricity in the last few years.
Energy consumption	• Total energy consumption by fuel type • Total energy consumption by end use	• AS - Increasing total use and increasing use of fossil fuels*. • AS - In all sectors energy use is increasing though the rate varies*. * Consumption data are based on final demand not total primary energy.
Energy efficiency	• Equipment efficiency • Building efficiency • Process efficiency (industry) • Efficiency of electricity generation and transmission (I.e. Improve the input:output ratio in energy production and use in all these areas.)	• NA - Tracking of progress for energy efficiency at the Provincial level is poor for all suggested efficiency indictors.
Employment	• Number of person-months employed on energy-related jobs (by industry). • Number of person-months lost due to energy industry accidents	• NA – There is insufficient information available to quantify all job gains and losses attributable to the energy sector. • NA – See previous note.

Affordability	• Percentage of households living in fuel poverty (i.e. spending more than 10% of income on home energy).	• NA – No agreed definition of fuel poverty nor the data available to calculate the % of households spending more than 10% of income. Data on expenditure by quintile was not freely available
Reliability	• Number of household hours per year without power • Business hours lost due to power failure	• NA – Trends not sufficiently tracked to assess progress for grid reliability. • NA – See previous note.
Health and Environment		
Air pollution	• Carbon monoxide (CO) emissions • Particulate matter (PM) emissions • Sulphur oxides (SO_x) emissions • Nitrogen oxides (NO_x) emissions • Volatile organic compounds (VOC) • Mercury (Hg)	• NA – Changes in data make it difficult to assess trend • TS – High but decreasing levels of emissions. • AS - 30 year trend is TS but 10 year trend is AS. Emissions remain very high (7x per capita CDN emissions.) • AS - 30 year trend is TS but 10 year trend is AS. Levels remain high. • NA – Improvements in fuel wood data make it difficult to assess trend. • TS – High but decreasing levels of emissions from coal-fired power plants.
Climate Change	• GHG emissions (CO_2 equivalents)	• AS - Emissions have been increasing. Levels high.
Institutional		
Leading by example (internal government efforts):	• Procurement of energy from sustainable / renewable sources • Energy- efficiency of government buildings	• AS - No green Provincial procurement. • NA - No clear data to indicate improvements. Some goals set.
Creating societal change (regulatory, educational and fiscal measures):	• Incentives/disincentives for sustainable energy use • Efforts to educate the public about energy options • Enforcement of regulations and standards	• NA - Some disincentives for emissions but lack of information on other efforts. • NA - Some basic educational efforts but no data on numbers of people reached and effectiveness • TS / AS – In 2005 there were changes in environmental regulations for air pollutant emissions. However, there are no standards yet for some pollutants (e.g. arsenic) and energy processes (e.g. wood stoves) and information on fines and enforcement is difficult to access.

Reporting (overseeing energy sector activities):	• Target setting and progress reporting • Level of indicator development	• TS / AS - Provincial Government has set targets for some aspect of energy system but reporting has been weak, lacking consistency and quantifiable indicators • AS – No substantive indicator development
Evaluation (monitoring and improving how government addresses energy concerns):	• Integration of energy policy (within and among levels of government)	• NA – No indication that this has occurred.

Note: AS=Away from sustainability; TS=Towards sustainability; NC=No change; and NA=Not available (i.e., there was insufficient data to assess progress).

Of the 30 indicators identified and explored as measures of progress for the Nova Scotia energy sector, only two are showing clear signs of progress towards sustainability based on the definition of sustainability presented in this report and the periods for which data are available. There has been mixed progress in some areas and movement away from sustainability in others, while some areas still have not been addressed at all. For nearly half the recommended indicators, inadequate data exist to assess trends, indicating that a first requirement is the improvement of monitoring and tracking mechanisms.

Even in the two cases that have shown clear progress, through reductions in particulate matter and mercury emissions, present levels of emissions still remain high. Per capita *energy-related* PM emissions in Nova Scotia are still considerably higher than the Canadian average and still exceed the per capita PM emissions from *all sources* in most OECD countries (Monette and Colman, 2004.)

Mercury emissions also remain high – 150 kg/year, based on 2002-04 utility monitoring program results.[87] The new Canada-wide standard proposed by the Canadian Council of Ministers of the Environment sets an emissions cap of 65 kg of mercury per year for Nova Scotia's existing coal-fired power plants – a significant reduction of 57% from present levels. It is not yet known whether the Province and Nova Scotia Power will commit to this standard.

In short, even in the three areas where definite progress has been made, there is certainly no room for complacency. Indeed, the real test of progress lies ahead. Progress on renewable electricity development should be continually monitored to ensure the 5 percentage point target for new renewable energy in the electricity sector is met by 2010 and that new, more aggressive targets are established and achieved. It also remains to be seen whether Nova Scotia can lower its

[87] Canadian Council of Ministers of the Environment, *Canada-wide Standards for Mercury Emissions from Coal-Fired Electric Power Generation Plants,* Draft accepted by the Federal and Provincial Ministers of the Environment in June, 2005. Available at: http://www.ccme.ca/assets/pdf/canada_wide_standards_hgepg.pdf. Accessed 19 September, 2005.

PM emissions first to Canadian and then to OECD levels, and whether it can meet the new Canada-wide standard for mercury emissions.

For other serious emissions, such as sulphur oxides, nitrogen oxides, and greenhouse gas emissions, the trend is away from sustainability in the short term (last 10 years), although SO_x and NO_x emissions have dropped over the longer term (last 30 years). New legislated reductions for SO_x came into effect in 2005, which should result in greater progress towards sustainability for this pollutant. For two of the seven health and environmental indicators (CO and VOCs) changes in wood fuel emissions data made it impossible to assess whether real progress is being made in reducing emissions. In those cases, dramatic changes in the trend lines, showing apparent massive increases in CO and VOC emissions between 1985 and 1995, are likely an artefact of changes in data collection and availability in this area.

Lack of data was also a serious impediment to assessing trends for many of the socio-economic indicators. Data for indicators of employment, affordability, and reliability were all incomplete, preventing adequate assessment of sustainability trends. Energy efficiency data were available at the national level but insufficient at the Provincial level to assess trends for Nova Scotia. The information that was available suggests the probability of some movement towards sustainability in improved appliance and building efficiency, but comprehensive data at the Provincial level were not available to confirm this. Information on the efficiency of the electricity transmission and distribution system is limited but what is available suggests little movement in any direction. Industrial process efficiency data were either not well enough developed or publicly available making an assessment impossible. Indicators to assess efficiency trends of electricity generation and transmission similarly lacked data, but based on the limited development of combined-heat and power plants and distributed generation it is unlikely that any significant gains have been made in this area.

Energy consumption indicators both by fuel type and end use suggest a movement away from sustainability since energy demand has been increasing in nearly all sectors, and this demand has been almost entirely for non-renewable fossil fuels and coal-generated electricity. The indicator for energy supply also suggests movement away from sustainability due to increasing reliance on imported fossil fuels. Nova Scotia continues to import coal and oil while exporting natural gas and using very little of this local source provincially. Although there are some renewable energy developments in the Province, particularly in the field of wind power, progress is slow and the preponderant reliance on imported fossil fuels will continue to cause fuel security problems. In fact, as a proportion of total generating capacity, renewables have actually declined from 22% of capacity in 1979 to 18% of capacity in 2003 (Figure 8 and Figure 9, Chapter 5).

Some progress has been made in the area of institutional indicators, but better tracking, reporting and goal setting needs to happen. The main focus of the institutional indicators in this report has been on actions taken by the Provincial Government. Efforts have been made to report on various aspects of Provincial policy that affect energy sector developments and public education efforts to promote conservation and efficiency. The development of institutional indicators of sustainability is an essential first step in an area of sustainability reporting that has received inadequate attention to date, and considerable work is still required to operationalise these indicators so that consistent, quantified time series are available. The institutional indicators identified in this analysis are therefore meant to be a starting point both for the Provincial Government and for other institutions to assess their own role in moving the energy system towards greater sustainability. A coherent set of institutional indicators that link government's activities to its responsibilities in leading by example, creating societal change, reporting, and evaluation, would help keep energy-related legislation current and relevant.

The indicators in this report represent only those for which at least some data are available in some jurisdictions (if not always for Nova Scotia) – to demonstrate that tracking in these areas is feasible. For example, although affordability and fuel poverty data are not freely available for Nova Scotia, the U.K. data on this subject indicate that appropriate data collection, standards, and reporting are certainly possible to track this important subject. For that reason (and also because it has been explicitly identified by Natural Resources Canada as a key energy indicator of sustainable development), fuel affordability and fuel poverty has been included in the indicator suite in this report. We have not included indicators where data limitations and methodological challenges appear to present an insuperable obstacle to better reporting in the future. The lack of complete data sets in the recommended indicator suite is demonstrated in Table 51 by the 12 indicators for which "not available" had to be entered as the conclusion.

No pretence or claim is made that the 30 indicators suggested in this report represent a complete profile or portrait of Nova Scotia's energy sector. In addition to those recommended here as a useful starting point, there are other impacts of the energy sector that should eventually also be measured and tracked to gain a more complete understanding of the full costs of energy production and use in Nova Scotia. Some of these additional impacts and potential indicators were explored in Chapters 3 and 8. Among the recommendations discussed below, therefore, is the need to revisit, expand, improve, and update this work, and to include additional indicators of energy sustainability for the Province. These should include at least some of the 25 additional toxic pollutants released by NSPI's thermal generating stations that are noted in Section 3.3 of Chapter 3 but not included in the health and environmental indicators in this study. Also needed is better tracking of land used for energy; water pollution and aquatic effects resulting from thermal power generation and hydro dams; and work place health and safety data for the energy sector. More work also needs to be done on efficiency indicators to obtain a better understanding of useful indicators and their associated data sources and analytical relevance, and to develop new data sources, where there is currently little material available.

The full cost accounting analysis in this report showed that Nova Scotia's stationary energy system cost between $387 million and $2.5 billion in 2000 in health, environmental and materials damage costs due to air pollutant and greenhouse gas emissions alone. The wide variation in the range is due primarily to different assumptions in air pollution and climate change impact models. Not only, therefore, does the evidence in this report indicate that current energy production and consumption habits are unsustainable from a health, environmental and resource perspective, but the full-cost accounting analysis further indicates that the existing energy system is extremely costly when the value of externalities is considered and the damages quantified in economic terms.

The above dollar sums represent only those costs that could be quantified for Nova Scotia, which included damages attributable to atmospheric emissions from six pollutants – carbon monoxide, particulate matter, sulphur oxides, nitrogen dioxide, volatile organic compounds, mercury – and from greenhouse gases. The other impacts discussed in this report could not be quantified for Nova Scotia due to a lack of data and methodological difficulties. In some instances costing studies of these additional impacts were found for other regions, but numbers specific to Nova Scotia could not be derived because physical data were incomplete. In one case, such an extrapolation was undertaken for illustrative purposes only to demonstrate that fuel poverty could cost the Province $47 million annually if fuel poverty rates and health impacts were analogous on a per capita basis to those in Edinburgh, Scotland, where such a costing study has been done. However, neither fuel poverty rates nor the health impacts of fuel poverty have been calculated for Nova Scotia, so it is not possible to assess the degree to which the Edinburgh results are truly applicable to this region. For this reason, these and other costs were excluded from the analysis in Chapter 8. The social, environmental and economic costs of the following impacts of energy production and use are therefore not included in the cost figures presented in Chapter 8: toxic pollutants; waste disposal; noise and visual intrusion; avian collisions; resource depletion; affordability; reliability; energy security; resource consumption; energy subsidies; employment; land use costs; land and water contamination; and work place accidents.

Given this long list of additional impacts, and the known (and frequently costly) problems associated with many of these impacts that could not presently be quantified, it is evident that the $387 million - $2.5 billion cost estimate for energy-related impacts given above is likely an under-representation of the full costs of the current energy system. Due to constraints on data availability, methodological challenges, and project resources, this range represents the best estimate possible at this time for externality costs attributable to energy production and use in Nova Scotia. Further research and resource commitments are strongly encouraged to address these shortcomings and limitations, and to produce a more accurate and comprehensive assessment of the full costs of the Province's energy system.

A recurrent theme in this study is that better measurement and reporting are necessary not only to track progress and inform policy, but also to help Nova Scotians understand the social and environmental implications inherent in different forms of energy use and production, and the trade-offs that exist between competing choices. This knowledge is essential to enable Nova Scotians to make more informed decisions about their energy system and about energy options for the future. To this end, and based on the evidence presented in this report, several recommendations for moving forward towards a more sustainable energy system are made in the next section.

9.3 Recommendations

The findings of this report lead to the formulation of a number of recommendations. These have been organized under the following headings: data issues, goals and targets, energy supply and demand, institutional actions, further study, and ways to improve this report. Together these recommendations represent our best current understanding both of the nature of Nova Scotia's current energy system and of the concrete ways in which it can become more sustainable. To ensure that this analysis remains practical, the path to greater sustainability is presented here in terms of very specific actions, which are supported, where applicable, by practical applications and examples of "best practices" which demonstrate that the proposed actions are not pipe dreams but eminently do-able.

Resolving data issues

As noted throughout this report, complete, accessible data on key aspects of Nova Scotia's energy system were often unavailable. These data gaps, in turn, prevented a comprehensive evaluation of trends for all of the recommended indicators. In many cases, the information needed to assess progress towards or away from sustainability had to be extrapolated from a combination of sources, resulting in varying levels of uncertainty. The consequence is that this study was not always able to assess progress adequately. As noted in Chapter 4, indicators should be clear, consistent, and easy to understand if they are to be meaningful for making decisions. The recommendations in this section are intended to help address key existing data gaps and limitations.

The following areas represent significant aspects of the energy system in which data are currently inadequate and require improvement. Each of these issues is addressed briefly below to highlight both the current problem and the type of information needed to improve the knowledge base for:

- Primary energy supply and demand
- Efficiency
- Affordability
- Reliability
- Wood use
- Air monitoring
- Mercury emissions
- Land use

Primary energy supply and demand

Painting a complete picture of primary and secondary energy supply in this Province is impossible under current Statistics Canada publication arrangements. Confidentiality issues prevent important information such as total primary energy demand from being released. The key reason for this confidentiality and data suppression in the energy sphere is that, in a number of cases, there are only one or two companies operating in a specific energy sector. The release of data might therefore effectively identify key information about specific company operations that might endanger its competitive advantage data. However, suppressing this information denies the public access to complete knowledge about the energy system on which it depends for its livelihood and wellbeing – information that is also essential to establish sustainability targets and to assess progress towards those targets.

The smallness of the energy market in Nova Scotia is said to necessitate confidentiality. However, we argue here that the desire of particular energy companies for confidentiality to protect their competitive advantage must be balanced against the public good. This is particularly true in a field like energy, on which all sectors of society depend for their basic needs and in which public policy plays such an essential role. The present confidentiality provisions that prevent Statistics Canada from releasing key information deny decision-makers full knowledge about the energy sector which they are required to guide and regulate and create a serious "disconnect" between policy formulation and the data required to ensure that such policies are informed and based on the best available knowledge.

Current data availability does not take into account the level at which policy is actually made. Thus, data *are* generally available for the Atlantic region as a whole, where more companies operate, but often not for individual provinces in which there are only one or two companies. If energy policy was formulated for the Maritime or Atlantic region as a whole, current data restrictions would be much less of a problem, and, in some cases, data access problems would be virtually eliminated. But each province has its own energy policy. In these circumstances, the authors recommend that confidentiality be balanced more reasonably against the public good, and that federal legislation qualify Statistics Canada's current confidentiality provisions to ensure the release of key information on such basic issues as Nova Scotia's primary and secondary energy supply.

Energy efficiency

Information about the level of efficiency of the stock of appliances, energy-using equipment, and buildings is not known for Nova Scotia. Penetration rates of efficient buildings are tracked for new buildings in the Province, but not other processes like retrofitting, so there is no information on the overall percentage of energy efficient buildings (residential, institutional, or commercial) as a proportion of the whole. These are important areas in all of which energy consumption could be sharply reduced, but the level of possible improvement cannot be known without complete baseline information. The discussion in Chapter 5 of energy consumption levels in OECD countries, which are much lower on average than in Nova Scotia, and the EU's plans to make a further 20% reduction in demand even though energy is already used far more efficiently, are both indicative of the possible gains that can be realized in Nova Scotia.

Accurate measuring and tracking would also help evaluate the effectiveness of any Provincially based efficiency program. To know whether existing programs are working or not, and whether they are cost-effective, good outcome indicators are essential. Developing effective new policy also depends on adequate information about the current situation, without which realistic targets and goals for new programs cannot be set. The information is particularly important from an economic point of view, as efficiency programs may involve financial incentives and rebates for efficiency improvements including the replacement of older, inefficient equipment with newer, less polluting and more efficient equipment. Without good outcome indicators on appliance, equipment and building efficiency indicators, it will remain unclear whether the investment of taxpayer dollars in incentives and rebates is justified by the results.

For all these reasons, it is strongly recommended that energy efficiency data be collected through household, business and other surveys at the provincial level. Statistics Canada and the Office of Energy Efficiency at Natural Resources Canada do track some of these data at the national level, so in many cases, it is a matter of expanding the sample size of existing surveys in order to collect meaningful information at the provincial level. Availability of such provincial-level efficiency information would also encourage healthy competition among the provinces to demonstrate efficiency gains, and it would reveal the relative disadvantages and challenges of provinces like Nova Scotia, which have a relatively older building stock and greater reliance on wood burning stoves. Such comparative information would therefore enable federal energy efficiency programs to be targeted to regions like Atlantic Canada, where the needs and potential gains are likely to be greatest. This would also make federal energy efficiency programs more effective programmatically *and* more cost-effective, by allowing more targeted application of resources.

Employment

It is widely assumed that the energy sector produces significant employment benefits to the Province. Yet no formal tracking of direct and indirect jobs created by the energy sector is undertaken for Nova Scotia, so critical information – like the percentage of new energy jobs that goes to Nova Scotians – is unavailable. As well, this key data gap makes it difficult to assess the job-creation potential of alternative energy investments in the Province. How many jobs, for example, would a million dollar investment in energy conservation, efficiency improvements, and demand management create in the Province compared to a million dollar investment in renewable energy development or a million dollar investment in the oil and gas industry? Such information is vital to assess the social and economic implications of alternative energy options and futures for Nova Scotia.

It is possible to piece together some employment figures for individual industries, but these numbers come from various sources and do not allow a complete or comparable assessment. Moreover, estimates that are currently made focus only on job creation with little to no analysis of job losses resulting from energy-related activities such as oil spills that may lead to job losses in other sectors such as the fisheries. The current partial evaluation of energy projects does not capture the negative side-effects that can result from some energy-related activities such as oil spills, LNG explosions, and other accidents.

In sum, the full costs and benefits of energy jobs need to be more carefully weighed than at present, along with the employment benefits and consequences of alternative development scenarios in the energy sector. The first step is better tracking of the number and types of energy-related jobs created, and the number of, and reasons for job losses. Additional questions and slight changes to existing Statistics Canada Labour Force Surveys could be one way to help capture some of the necessary information.

Affordability

There are insufficient data available to track the affordability of energy in Nova Scotia. This lack of information is a significant omission given the importance of energy in modern society to meet essential needs. Further reasons necessitating a better understanding of energy affordability in this Province include: the number of low-income households in Nova Scotia; recent and projected increases in fuel and electricity prices; Nova Scotia's climate which requires heating fuel for health and survival; and the fact that energy is often used inefficiently in low-income households due to aging housing stock, inadequate insulation, and older, poorly maintained heating devices are. Improved measurement and tracking of energy affordability in Nova Scotia would provide highly useful information to begin addressing the problem of fuel poverty in the Province. Indeed, without such information, the problem of fuel poverty and its attendant risks and costs, as outlined in this study, will remain hidden and out of the public eye, and will receive inadequate policy attention. Fortunately, a good model exists in the United Kingdom of the kind of tracking, reporting, and policy development that are possible, and indeed necessary, on this important issue (see Best Practice #1).

Best Practice #1: Tracking Fuel Poverty in the U.K.

In 1999, an Inter-Ministerial Group on Fuel Poverty was set up to examine the issue and develop a *UK Fuel Poverty Strategy*. One of the first tasks of the Inter-Ministerial Group was to look at existing data. Using statistical data collected through a variety of surveys by government departments in England, Wales, Scotland and Northern, estimates of fuel poverty levels were developed. Where possible these data were analyzed based on factors that contribute to fuel poverty.

Based on existing data, a fuel poverty strategy was developed. Along with solutions and policies for reducing fuel poverty, attention was given to monitoring and data needs. The Fuel Poverty Monitoring and Technical Group looked at data needs and developed recommendations. Currently each of the regional governments in the United Kingdom is using these recommendations to improve data collection. Each region of the country now conducts a major study of energy affordability and fuel poverty every 3 to 5 years and most provide an annual update. Collectively they report on a number of indicators of fuel poverty including income, energy prices, demographics, fuel types, and type of housing. The *UK Fuel Poverty Strategy* requires annual reporting both on outcome indicators (the number of households living in fuel poverty, etc.) and output indicators (government actions).

Source: UKDTI, 2001.

As discussed in Chapter 5 fuel poverty figures that correspond to the U.K. definition and data (percentage of households spending more than 10% of their income on fuel) are not publicly available in Canada. In response to queries from **GPI***Atlantic,* Statistics Canada was uncertain whether such statistics could be extracted from existing consumer finance and household survey data sources in a special custom tabulation. Statistics Canada indicated that it would have to charge **GPI***Atlantic* just to investigate whether such numbers could even be calculated, without any assurance whether this was possible. If its investigation proved the feasibility of extracting information on the percentage of households spending more than 10% of their income on fuel, Statistics Canada indicated that additional charges would then be levied to produce the numbers themselves. Financial constraints did not permit this investigation for this report. In any case, Statistics Canada's response indicates that fuel poverty figures are not easily available in Canada, if they can be deduced at all.

In light of the major health costs and productivity losses attributable to fuel poverty assessed by U.K. studies (which could amount to nearly $50 million annually in Nova Scotia if comparable rates and conditions existed here as in the U.K.), this data gap is unfortunate. It is therefore a key recommendation of this report that fuel poverty statistics be collected regularly and made available to the public at no charge. As with the data gaps noted above, it would not be costly or difficult to adjust existing survey instruments like the Survey of Consumer Finances, or existing Statistics Canada publications like *Income in Canada,* to ensure that the required data are collected and reported on a regular basis.

Wood use

Given the significant impact of wood burning on air quality, better information about this energy source and its uses in this Province (and in the rest of Canada) is needed. Further knowledge of the supply of and demand for fuel wood in the Province, as well as the efficiency of wood burning devices currently in use, would allow for a better assessment and understanding of the related pollutant emissions, most notably volatile organic compounds (VOCs), particulate matter (PM), and carbon monoxide (CO), and their links to local and indoor air quality problems and related health effects. Improved data collection on fuel wood use would also provide further knowledge about other areas of sustainability, such as the impacts of energy-related wood consumption on land use for forestry and on harvesting practices. This information is needed to create policies that will effectively mitigate the impacts that result from wood use, and manage and regulate the associated production processes and consumption patterns.

Air monitoring stations

The number of air quality monitoring stations decreased in the Province throughout the 1990s. The ability to track air quality must be maintained in a geographically representative manner. This is important for two reasons: first, to assess whether policy efforts and reduction targets have been effective; and second, because pollution impacts vary widely and must be assessed locally. Provincial averages provide limited information. For example, it is essential to track pollution from point sources like thermal power generating plants and to assess potential impacts on workers in the energy industry and on nearby residential communities.

An example of the decline in monitoring and data gathering capacity that particularly affects assessments of Nova Scotia’s energy sector is Nova Scotia Power’s Point Tupper power plant, where SO_2 levels exceeded the annual maximum acceptable concentration (MAC) in 1994 and 1995. Unfortunately, monitoring at this location ceased in 1995, and no data are available for the last ten years. An exception to the decline in air quality monitoring capacity is in Sydney, Cape Breton, were ambient air quality data are now collected more consistently, frequently, and in greater detail than previously by the Muggah Creek Remediation Project (i.e. the Sydney Tar Ponds).

GPI*Atlantic*'s *Ambient Air Quality Accounts* (Monette and Colman, 2004: 183-186) contain detailed recommendations on restoring and improving air quality monitoring capacity in the Province. Here we include one additional recommendation – the establishment and maintenance of air quality monitoring stations at all thermal generating plants and other major energy production facilities in Nova Scotia, and in nearby communities, and regular public reporting on results from these stations.

There has been one significant improvement in reporting that makes the establishment of these local ambient air quality monitoring stations even more important. Starting with the 2002 reporting year, facilities meeting National Pollutant Release Inventory (NPRI) reporting requirements, including Nova Scotia Power's thermal generating plants, must report all atmospheric releases of CO, total PM, PM_{10}, $PM_{2.5}$, SO_2, NOx, and VOCs along with other toxins. The availability of this important new emissions information through the NPRI makes it essential to match these emissions data with local and in situ ambient air quality levels. Improved monitoring of this kind will help, for the first time, to assess the degree to which specific local air quality problems are attributable to local sources (and therefore amenable to corrective action at the local, corporate, and provincial levels), and the degree to which the air quality problems are attributable to transboundary pollution (and therefore more difficult to alleviate through local action).

Mercury

While data collection and tracking of mercury emissions trends is becoming better, further improvements could be made. Given the very serious environmental and health concerns related to the release of mercury, an accurate measure of the total amount of mercury released Provincially is required. The change in the standards of the National Pollutant Release Inventory (NPRI) that requires a reporting threshold for mercury of five kilograms a year represents a significant improvement. However, considering the need to eliminate this toxin, an annual Provincial estimate of total and non-point source releases of mercury should also be developed to complement the NPRI's point source inventory.

Land and water impacts

The impacts of the energy sector on land and water represent another area that requires better data collection in order to measure progress towards or away from sustainability in the energy sector. There are currently no publicly available data on the removal of water from natural water bodies for use in thermal generation plants. Data on ash disposal resulting from the use of coal to generate electricity is also unavailable. The effects of hydroelectricity dams on fish and general habitat in the Province are also unknown due to lack of data availability. These three examples demonstrate the importance of adequate data collection in areas of energy production that have a potential for significant impacts on land and water that are currently not being measured.

In some cases, it is possible that information exists, but in such cases it is proprietary and not publicly available, and the authors of this report were unable to assess whether the problem is lack of monitoring or withholding of information. **GPI***Atlantic* has requested information on many of these and other subjects from Nova Scotia Power, but has received very limited information. From the perspective of this report and the evidence presented in the previous pages, it is clear that energy-production has health and environmental impacts that directly affect the public interest and which, in many cases, produce costs that are borne by the public purse. It is therefore a recommendation of this study that mandatory public reporting be required on the land and water impacts of energy production and use.

Government policy and action

As demonstrated in Chapter 7, government and other institutions have a vitally important role to play in helping the Province move towards a sustainable energy system. There are several important policies that need to be developed and actions that must be taken to ensure genuine and rapid progress towards sustainability. Only those relating to data collection and, therefore, to the government's reporting responsibilities, are mentioned briefly here. Additional recommendations for the institutional sector are noted below.

The first step to better reporting is to ensure that the data gaps identified above are adequately addressed, since data collection and the specific subject areas noted are spheres in which public institutions have particular responsibility. In addition to the data gaps and recommendations listed above, more information is also needed regarding the government's own actions, especially relating to energy subsidies. At present it is very difficult to determine the total amount of subsidies of different kinds received by the energy sector in Nova Scotia, and the degree to which these subsidies promote sustainability or are "perverse" incentives that create a disadvantage for more sustainable alternatives. Without such information it becomes impossible to assess whether or not the non-market costs and benefits of different energy choices are being accurately reflected in the price of energy. Furthermore, from a policy perspective, it is impossible to judge whether or not the proper incentives and disincentives exist to put the energy system on a more sustainable path. Subsidies are a key financial instrument that can be used for better or for worse. At a minimum, and before any judgement is made, it is first essential that such subsidies be clearly identified and transparently reported.

Goals and targets

Throughout this document, goals and targets have been suggested for most indicators. These are based on existing policy in the Province, on evidence in scientific studies, or on established targets in other jurisdictions. It is recognised that the latter two types of targets can only serve as a starting point for discussion on region-specific applications, and need further study in order to determine whether they represent appropriate goals and targets for this Province. Only 5 of the 30 suggested indicators in this report currently have specific, officially designated targets in the Province. Many more indicators have loosely stated goals but no clear indication as to how those goals are to be achieved or according to what timeline. In order to identify current trends and track progress more effectively and accurately, there first need to be clearly established goals, and thereafter specific, quantifiable targets for each of the indicators addressed in this document. Existing and recommended goals and targets for the indicators suggested in this report are reviewed briefly in this section.

Supply mix

The Nova Scotia Government has recognised that increasing the portion of energy coming from Provincial renewable sources is an important strategy for reducing the environmental impact of energy production as well as a way to improve security by diversifying energy supply. To that end, the Province has set a target of a 5 percentage point increase in the amount of electricity that comes from new renewable generation by 2010. This is an important start, but it is a modest target by comparison with those of other jurisdictions (e.g. Prince Edward Island) and given the potential of this resource, so further action is needed to move more rapidly to greater reliance on renewable energy sources. In view of the impending advent of peak oil production, and the growing political and price insecurity associated with reliance on imported oil, there is considerable urgency in moving towards more local and sustainable production methods with greater speed and determination.

Aside from setting a higher target for electricity generated from renewable sources, the Nova Scotian government must also recognise that electricity represents only a portion of the overall energy demand in the Province. In order to move more quickly towards sustainability, therefore, targets should also be set and met for renewable energy use in other sectors, especially oil-based heating and transportation, as has been done by Prince Edward Island (Best Practice # 2 below). For instance, the integration of active and passive solar power in all new buildings (where conditions allow) could be made a requirement in building permit regulations. Passive solar design is best integrated at the new building stage, but passive and active solar energy (e.g. solar hot water heating) can be integrated in existing buildings. For both these goals, specific short-term and medium-term targets could be set for the proportion of buildings using solar energy.

Geothermal, biogas and other renewable energy sources should also be encouraged. Many of these require further study in order to assess feasible target levels, but enough is known about the potential and use of many of these energy sources to begin the development process without delay.

Needless to say, targets must be accompanied by other actions in order to be meaningful and practical, but it is also true that without initially setting goals and targets little progress can be expected. By setting more ambitious targets, Nova Scotia could potentially mobilize its populace behind the concrete actions needed to expand renewable energy significantly. A first action towards encouraging renewable electricity generation in the province must be to reduce the inordinately high tax burden of wind energy producers. Tax levels for all renewables should be set at such a level to encourage their adoption. Full-cost accounting techniques should be applied so that the the high negative externalities associated with fossil-fuel generated energy result in higher taxation levels than for renewable sources. It is important to do this on a case by case basis in order to recognize the reduced emissions and damage costs of plants using advanced pollution control technology such as Point Aconi.

Best practice #2: 100% renewable electricity target in Prince Edward Island

Recognizing that the heavy dependence on imported fuels and lack of energy self-sufficiency is costly to the provincial economy, the PEI Government has proclaimed a bold plan to move the province from reliance on imported fuel sources to made-in PEI energy sources (Ballem, 2005). In its 2004 Energy Strategy, the PEI Department of Environment and Energy set a target of 15% renewable electricity by 2010 and 100% by 2015. Furthermore, the province, recognizing that electricity represents only a portion of energy use, is seeking to develop a hydrogen village, and is examining the use of biomass fuels for heating and transportation.

These are ambitious goals, but without such a vision for change and clear targets that define expectations to be achieved, it is difficult to make progress towards sustainability or to formulate appropriate policy actions to that end. Nova Scotia can emulate the PEI vision and now has the advantage of learning from PEI experiences and proposed actions, including the suite of incentives, standards, and programs that are recommended in the PEI Energy Strategy to reduce energy demand and achieve the Island's ambitious renewable energy targets.

Sources: Ballem, 2005; PEIDEE, 2004.

Energy efficiency

The evidence in this report demonstrates clearly that energy use can become much more efficient than it currently is in the Province. Various important efficiency standards and programs already exist, such as the Federal Government's Model National Energy Code for Buildings (MNECB), the R-2000 standard for homes, and the Energuide program. But some existing efficiency standards are outdated and do not reflect the best available technology on the market, and some key energy production units, like wood-burning devices, are not yet governed by regulatory standards for efficiency and emissions, despite the fact that highly efficient wood-burning technologies are now available that could sharply reduce CO, VOC, and PM emissions if they were to replace older, inefficient, and polluting equipment.

Of even greater concern, as indicated in Chapter 5, is that many of the efficiency standards that do exist are not effectively encouraged, publicized, or implemented, nor have many been accepted as universal standards and therefore they still have very modest penetration. For example, since 1982 only 1,300 Nova Scotian homes have been certified to the R-2000 standard, and only 24 commercial buildings in the Province have been built to Commercial Building Incentive Program standards (Trudeau, 2005). Nova Scotia's *Energy-efficient Appliances Act and Regulations* have not been updated since 1994.

Based on the evidence in this study, **GPI***Atlantic* recommends that the Provincial Government commit itself to making the model national building codes and most advanced building standards (like R-2000 and CBIP) the minimum norm for all new construction in the Province and to ensure that these standards are upheld through the building permit system. Targets should also be considered to ensure that the existing Provincial housing and building stock be upgraded to these advanced standards through retrofits. The 1994 Energy Appliances Regulations should also be updated without delay, and a commitment made to update appliance efficiency regulations on a regular basis to reflect the most energy-efficient technologies available in each field. Provincial standards should be established for high-efficiency natural gas furnaces and for wood-burning equipment, based on the most advanced Energy Star ratings. The current Federal/Provincial rebate program for Energy Star approved natural gas furnaces could continue but be targeted towards homes with limited incomes for purchasing more expensive Energy Star furnaces.

While the Federal and Provincial regulations addressing appliance efficiency cover a wide range of products, they should also be expanded to include products not included. It was noted that Federal regulations cover products that consume 80 percent of the energy used in the residential sector and 50 percent in the commercial-institutional sector (NRCan, 2004a). A deliberate effort is needed to identify and develop standards and uptake targets for the remaining products. Targets should also be set for expansion and increased penetration of combined heat and power generation, which can produce considerable efficiency gains through use of waste heat reduction, as well as for improved efficiency in new power generation and other industrial processes. Some standards and targets will have to be introduced incrementally to allow consumers and producers of energy adequate time to respond, but efficiency goals need to be set in all areas of energy production and use (heat and power generation, appliances, buildings, etc.) so that progress in reducing overall energy demand can begin to be made.

Targets and standards are, of course, only half the challenge. To facilitate movement towards a defined target, support measures are needed, generally through a combination of financial instruments and regulations, especially in the initial stages. Achievement of targets and adherence to standards for energy efficiency can be encouraged through incentives like rebates or tax breaks for home retrofits and other actions. Disincentives in the form of fees, regulations, and penalties that discourage adoption of energy-inefficient equipment and appliances can also be used. The U.K., for example, will begin to colour code new cars according to their energy efficiency, with SUVs required to display red stickers, while small, fuel-efficient models will sport labels in shades of green according to their degree of efficiency (Townsend, 2005). The U.K. also charges lower Vehicle Excise Duties on vehicles with good fuel economy (UKDT, date unknown). Such incentives and disincentives based on energy efficiency and demand reduction can be applied to buildings, appliances, and all other forms of energy production and use. These and other mechanisms for supporting or discouraging action will be discussed in more detail in the *Efficiency improvements* section in *Energy supply and demand*.

Air pollutant emissions

Short to medium term targets have been established and emissions levels and ambient air concentrations are being monitored for a number of the criteria air contaminants outlined in Chapter 6 – sulphur oxides, nitrous oxides, $PM_{2.5}$, and VOCs. The Provincial targets established by Nova Scotia's 2001 *Energy Strategy* call for the reduction of SO_x emissions to 25% below 2001 levels by 2005, and a 50% reduction by 2010; a reduction of NO_x emissions to 20% below 2000 levels by 2009. Although the 25% reduction in SO_x emissions by 2005 is likely going to be achieved through legislated reductions which took affect in 2005, data to confirm the reductions will not be available until 2006 or 2007. The longer term target recommended in this study should be to ensure that acid critical load levels are not exceeded in all areas of the Province, though this will require the cooperation of Canadian, provincial and U.S. authorities, as SO_x and NO_x levels and their consequences (acid rain, ground-level ozone, and smog) in Nova Scotia are greatly influenced by transboundary pollution.

Nova Scotia has agreed to the 2000 Canada-wide Standards for $PM_{2.5}$ and ground-level ozone which are to be achieved by 2010. The Canada-wide Standard for $PM_{2.5}$ is 30 µg/m3 averaged over 24 hours, to be achieved by 2010, and the Canada-wide Standard for ozone is 65 ppb averaged over 8 hours, also to be achieved by 2010 (CCME, 2005a). Ground-level ozone is a secondary pollutant, so achievement of the CWS for this pollutant will require reductions in its precursor primary pollutants – NO_x and VOCs. Based ambient air monitoring data from the National Air Pollution Surveillance (NAPS) Network the only areas of the Province in which the CWS for ozone was exceeded between 2001-2003 is in the western part of the Province (Kejimkujik and Annopolis Valley and nearly exceeded in Yarmouth) (Environment Canada, 2005e). Ambient levels of ground-level ozone in this part of the Province are almost entirely from transboundary pollution and therefore require reductions in emissions in other jurisdictions. Plans for reducing precursor emissions in Nova Scotia include the 20% reduction in NO_x emissions below 2000 levels by 2009. The CWS for $PM_{2.5}$ has only been exceeded in Sable Island from 2001-2003. Emissions of carbon monoxide and volatile organic compounds, though monitored, do not presently have specified Provincial reduction targets. It is recommended here that reduction targets be established for these pollutants.

As noted in Chapter 6, specific goals and targets have been established for mercury emissions, with the most recent being the proposed Canada-wide Standard which specify a 57% reduction in mercury emissions from Nova Scotia Power's coal-fired generating plants from the 2002-2004 level of 150 kg/year to a cap of 65 kg/year by 2010. NSPI achieved the target of a 30% reduction in mercury emissions below 1995 levels in 2002 even though the target date was 2005.

The new national and provincial mercury emissions targets and caps proposed by the Canadian Council of Ministers of the Environment will require far more drastic measures than have been taken to date. Nationwide, the proposed new Canadian-wide Standards for mercury established by the Canadian Council of Ministers of the Environment are intended to prevent the release into the environment of 60-90 per cent of the mercury in coal by 2010. The Nova Scotia Government has committed itself to "assess the state of technology options for mercury removal, and introduce appropriate regulations for mercury emissions that comply with Canada-wide Standards for mercury now under development, by 2010" (NSDEL, 2005).

These short and medium targets should be met with the intention of meeting a long-term goal of zero mercury emissions as there is no safe threshold for mercury emissions. Considering the large reductions in mercury emissions from the energy sector to which the Nova Scotia Government has committed itself to by 2010, a reasonable goal might be the complete elimination of mercury emissions by 2020. This long-term target of zero emissions may require a shift away from coal-fired power generation altogether, which could occur with the retirement of Nova Scotia Power's aging coal-fired thermal generation plants.

While this section refers specifically to recommendations on target setting, it is clear that the actual targets for all pollutant emission reductions will be achieved by the same three-fold strategy recommended throughout this report – improvements in conservation and energy efficiency that will reduce overall energy demand, the use of pollution control technology, and shifts away from reliance on fossil fuel combustion to renewable energy sources. Considering NSPI's status as the fourth largest emitter of air pollutants in Canada, with the three of the top four most polluting coal-fired power plants in Canada in terms of acid gas emissions, it is critical that these three actions be applied to the production and use of electricity (Energy Probe, 2005; PollutionWatch, 2005).

Greenhouse gas emissions

Although the Federal Government has made an international commitment to reduce Canada's GHG emissions to 6% below 1990 levels before 2012, provincial targets have not yet been negotiated between the Federal and Provincial Governments. Nova Scotia, has however, committed to GHG reductions at the regional level through the 2001 Climate Change Action Plan negotiated between the New England Governors and Eastern Canadian Premiers. The Plan calls for the reduction of regional GHG emissions to 1990 levels by 2010 and a 10 % reduction below 1990 levels by 2020. A long-term target of 75-80% reduction below 1990 emissions, recognised as necessary to stabilise atmospheric concentrations of greenhouse gases, is also mentioned in this document but no target date given. These are important goals, but recent updates from Environment Canada show that total greenhouse gas emissions are still on the increase in this Province, as are emissions from stationary energy sources. A clear recommendation emerging from this report is that Nova Scotia must develop a clear strategy and action plan to meet both the national and regional short and long-term GHG emission targets, which will include major reductions in emissions from the energy sector. As well, targets could be much more ambitious than they presently are, as indicated by the United Kingdom targets described in the Best Practice #3 below.[88]

[88] For a wide range of corporate and governmental case studies and best practices in GHG emissions reductions, including target setting and a broad array of strategies for achieving those targets, see The Climate Group website at: http://www.theclimategroup.org/index.php?pid=430.

BEST PRACTICE # 3: Ambitious targets for greenhouse gas reductions in the U.K.

Through the Kyoto Protocol the U.K. has committed to a 12.5% reduction in GHG emissions below 1990 levels between 2008 and 2012. The U.K. has also set an internal target of a 20% reduction by 2010. Not only is the U.K. Kyoto target more ambitious than Canada's, but the current per capita emissions level is already well below that of Canada. In 2003 emissions were already 15% lower than 1990 levels. This makes the U.K. one of only a few OECD nations to have reduced GHG emissions during the 1990s.

Unlike many nations, including Canada, which have wavered in their commitment to the Kyoto protocol and have delayed action, the U.K.'s first climate change action programme was developed in 1994 and has been implemented and updated ever since. Much of the reduction in GHG emissions in the U.K. has been the result of fuel switching to natural gas, a less carbon intensive fuel. Nova Scotia could follow suit and begin to use more of its offshore natural gas resources within the province. Other reductions in the U.K. have occurred because of greater energy efficiency and the introduction of pollution control measures.

The U.K. explicitly recognizes that the Kyoto Protocol is only a first step and has committed itself to a future reduction in GHG emissions to 60% below current levels by 2050, as first announced in the U.K.'s 2003 Energy White Paper and now incorporated into the country's Climate Change Programme. It has also begun a national discussion and policy development on future large scale emissions reductions that includes a £348 million investment in renewables over four years that is projected to create 35,000 new jobs, rigorous energy efficiency targets, and a tax on business use of energy with financial incentives for good performance.

The U.K. has explicitly recognized that a major continued effort at emissions reductions will be needed as transportation, urban sprawl, and increasing economic prosperity are projected to result in increased emissions following 2010. But the commitment to succeed in this effort has been made at the highest level, with recognition that its success will bring significant economic benefits to the country. According to Prime Minister Tony Blair, "I want Britain to be a leading player in this coming green industrial revolution."

Source: UKDEFRA, 2001, 2000; The Climate Group, 2005.

Energy supply and demand

Energy supply is driven by demand. Addressing only the supply side of the equation ignores the consumption that drives the need for energy and deflects attention from initiatives, like improved conservation and efficiency measures, that can be taken to reduce demand. At the same time, an exclusive focus on demand would fail to consider *how* those demands can best be met through different types of supplies. Tackling the two sides of the equation together, as this report attempts to do, can address the challenges presented in this report in a comprehensive way. A number of recommendations have emerged from the evidence in this report on how both energy supply and demand can be addressed. These recommendations can be divided into three practical categories:

- Decrease energy demand, both final demand and total demand.
- Increase the use of local resources, especially renewables and natural gas.
- Improve the processes that rely on non-renewable resources, making them more efficient and reducing emissions and waste products.

A change in thinking is essential to achieve societal change on the large scope and to the major extent necessary – a change that emphasizes energy services rather than energy products. What is ultimately needed to run society and the economy and to maintain basic needs are the services that energy provides, such as heat, light, and mobility, not tanks of gas, barrels of oil, and lumps of coal. When decisions are made about alternative energy options, they should therefore be based on how particular energy *services* can most effectively be provided by the most benign and efficient processes, rather than on the traditional equation of energy sufficiency with supplies of ample quantities of fossil fuels.

Reduce energy demand

To reduce energy demand effectively requires a wide range of actions by every sector of society in the areas of both conservation and efficiency. Conservation requires behavioural changes and is therefore more difficult to address through policy, although energy education and awareness is an important place to start, as noted below. Efficiency is achieved mainly through technical improvements in buildings, appliances, and industrial processes, and can therefore often be introduced without major behavioural changes on the part of consumers. There are many efficiency improvements that can be made in Nova Scotia, among which a few key actions are discussed below.

When considering reducing energy demand on an individual or household level we must be aware that higher-income households consume considerably more energy than low-income households and they are correspondingly responsible for a larger proportion of the reduction in demand required for the energy system to become more sustainable. Efforts to reduce energy demand must recognize this fact and ensure equitable access to energy services.

Efficiency improvements

A key strategy for promoting energy efficiency is the wider encouragement and more rigorous enforcement of efficiency standards for commercial and residential appliances, heating devices, and buildings, as discussed in Energy efficiency section above. As well, more ambitious efficiency objectives can be established, including the widespread use of passive solar techniques and solar hot water systems in new buildings wherever possible. These are proven technologies that can be integrated for little cost into new buildings. Recognising the benefits of solar thermal systems, the city of Barcelona, Spain, now requires all new buildings to integrate solar hot water systems wherever it is technically feasible (see Best Practice #4). Older homes too can be retrofitted with solar water heating systems and can be encouraged to do so through financial incentives like rebate programs or tax breaks. Other retrofit options to improve building efficiency include replacing and increasing insulation, replacing windows with double or triple-glazed windows, and adding air exchange systems with built-in heat recovery. Lower cost options applicable to virtually every home or commercial building include weather stripping, window coverings, and insulators for electric outlets on exterior walls. Low-income households could be given special support for such actions. Together these kinds of measures can reduce the energy demand in buildings between 10 and 50%, which translates into energy savings that can reduce both operating costs and the environmental burdens associated with energy use.

Best Practice #4: Solar water heaters on every roof – the story of Barcelona

In 1999, the city of Barcelona, Spain, established a solar ordinance requiring that all new or retrofitted buildings be equipped with solar water heaters. The city ordinance requires the solar thermal system to cover 60% of the buildings' sanitary hot water requirements. In the first 18 months of the ordinance alone, the total area of solar thermal collectors in Barcelona quadrupled. In 2002, 8000 m^2 of solar collectors in Barcelona offset the use of 780 tonnes of oil and eliminated 1000 tonnes of CO_2 emissions.

Despite preconceptions to the contrary, Halifax actually has a favourable solar climate – the third best in Canada. Victoria, B.C., a comparable city both in size and climate to Halifax, has a better solar climate than Barcelona suggesting that Halifax too could be suitable for large scale application of solar energy. When solar water heaters are combined with passive solar space heating, the majority of domestic energy needs can be met. The remaining needs can be supplied through renewable heating and electricity generating technologies, including heat pumps, wind energy, and biomass. Adoption of such a strategy has the potential to make Nova Scotia's residential energy sector self-sufficient. Barcelona's vision and determination has produced excellent success and results that may be replicable in Nova Scotia.

Sources: Sustainable Energy Authority Victoria, 2004; Irish Energy Centre, Renewable Energy Information Office, 2002.

Achieving greater efficiencies in the building stock is important not only to reduce overall energy demand but as a key strategy to address fuel poverty. Reducing energy needs helps low-income households reduce the amount they spend on heating and other energy requirements. Since people in the lowest-income brackets are most likely to live in older, less efficient homes, it is important that these households be targeted specifically in order to raise efficiency. Reducing reliance on electric heating is another key strategy to reduce energy costs and improve affordability.

While this brief overview has focussed on concrete actions to improve energy efficiency in buildings, a similar array of policy actions is available to improve appliance efficiency. For example, assisting with appliance replacement (e.g. through rebates) can not only reduce overall residential energy demand, but also assist those who struggle with energy affordability.

As noted in this report, wood heating devices are widely used in the Province but are not regulated either Federally or Provincially in terms of efficiency and emissions. Regulations are expected at both levels in the near future. The development and implementation of these standards at the earliest opportunity is essential both to improve efficiency and to reduce the high levels of pollutant emissions that currently result from lack of efficiency in wood burning processes in Nova Scotia.

Electricity generation and distribution

Thermal electricity generation is extremely inefficient, resulting in only about a third of the energy value of fuel reaching the end user at which point further losses may occur. Demand side management, combined heat and power generation ("cogeneration"), distributed generation, and upgraded technology can all reduced energy losses in electricity generation and distribution. For example load management, a form of demand side management, improves efficiency by switching demand from peak times to non-peak times, thereby decreasing energy losses due to starting and stopping of large plants. Nova Scotia Power Incorporated, recognizing the economic gains of demand side management (DSM), has achieved some progress in this area, but there is room for considerably greater efficiency gains. NSPI, the Utilities and Review Board, and the Nova Scotia Department of Energy should examine future utility-lead options for DSM.

The substantial efficiency gains from combined heat and power generation indicate that all future thermal generation should use this type of generation technology. It has been estimated that on-site cogeneration can be twice as cost-effective as traditional thermal power generation, while drastically cutting down the amount of carbon dioxide released (Cogeneration Technologies, 1999). Nova Scotia's current co-generation capacity represents only a tiny portion of electricity generation, but the potential for further development and efficiency gains in this field is enormous. In Sweden, fully 60% of total power generation is supplied by cogeneration plants (Cogeneration Technologies, 1999). By developing combined heat and power plants of various scales and in a variety of locations (i.e. distributed generation), NSPI should also be able to realize substantial reductions in transmission losses and improve the reliability of the grid.

The evidence in this report points to the need for active support for increasing co-generation, district heating, and distributed generation capacity in Nova Scotia, both in existing plants where possible, and for all new facilities that are built in the future.

Increase the use of local resources

A major increase in the use of renewable energy will sharply improve the overall sustainability and security of the energy sector in Nova Scotia by reducing the need for fossil fuel generation that causes proportionately higher environmental damage and leads to energy dependency on foreign fuels that often come from unstable regions. To achieve this shift, however, requires a better understanding of the renewable energy resources available in the Province and the options for tapping them. For instance, there is currently only a low-resolution wind resource map for the Province. A high-resolution map would guide government, industry, and individuals to identify optimal locations for development of wind energy in the most economic and energy-efficient way. Such resource studies should also be conducted for geothermal, hydro, and solar power. In order to encourage full development of these renewable sources, this information cannot be proprietary, but should be in the public domain.

At the same time, more ambitious targets for employing renewable energy should be introduced and should not be limited to the electricity sector. The use of renewable energy sources for heating, cooling, and transportation is being explored and pursued more actively in other areas than in this Province, and requires far greater attention and commitment here in order to realize its full potential. Other jurisdictions have set ambitious targets (like Germany's intention to derive 50% of its electricity from renewable sources by 2050 and Prince Edward Island's determination to generate 100% of its electricity from renewables by 2015), and have made significant investments in development of renewables (like the U.K.'s £348 million investment in renewables over four years).

Nova Scotia could emulate such ambitious targets and investments, particularly since other jurisdictions have been motivated in large part by projected gains to their economies. Investment in renewables is not only key to creating a more sustainable energy system, but can produce substantial economic stimulus, export opportunities, and job creation. (see Best Practice #5).

Best Practice #5: Wind energy for economic development

Since the mid-1970s, Denmark has invested more in wind energy than any other European country, initially for the purpose of reducing dependence on imported energy, and only later for environmental reasons. An investment subsidy introduced in 1979 to cover 30% of investment costs in wind turbines, was not only a stimulus for the construction of wind turbines but also a stimulus for market forces to develop a strong wind turbine industry. By 1989 government support was no longer necessary to make private investment in wind turbines attractive, and the subsidy was abolished. Small- and medium-sized wind turbines quickly became reliable and cost-effective, and Denmark is now the world's largest exporter of wind turbines.

Sources: IISD, date unknown.

The increased use of natural gas, another of Nova Scotia's indigenous resources, should also be encouraged in the Province. Natural gas is the 'cleanest' of the fossil fuels (i.e. the least polluting in terms of GHG, SO_x, NO_x, and mercury emissions). Based on data from the United States Department of Energy report, *Natural gas issues and trends 1998,* natural gas combustion emits 44% less GHGs and 80% less NO_x than coal combustion, and 29% less GHGs and 80% less NO_x than oil combustion, and virtually no SO_x (Natural Gas Supply Association, 2004). These rates vary based on the impurity levels of the fuels and the types of pollution controls used.

Natural gas could be extensively used in the Province for electricity generation, heating, and industrial applications. These applications are currently in very limited use, representing only about 1-2% of final energy demand in the Province, with the vast majority of natural gas produced in Nova Scotia now exported to New England and New Brunswick rather than used Provincially.

Natural gas can act primarily as a useful bridging fuel while the capacity of renewables is increased. Increasing natural gas use for power generation would also likely result in the displacement of electricity produced from coal. Although there is a concern regarding the economics (i.e. higher price) of natural gas for home heating and electricity production, the full cost accounting section of this document demonstrates that other costs, like those associated with pollutant exposure, climate change, and energy security, need to be considered when assessing different energy options.

From a conventional accounting perspective, coal is cheaper than natural gas in generating electricity. However, if the full costs (including environmental and health impacts) are considered, the total costs of natural gas are not only competitive with coal but indeed considerably lower. The extensive European ExternE study found that the external damage costs of coal were the highest of any energy source (wind power had the lowest costs). A detailed case study of the Spanish electricity system found that the external damage costs attributable to coal were 3.6 times higher for imported coal than for natural gas, and 7.6 times higher for domestic coal (European Commission, date unknown).

There are also other benefits that would be realized through increased Provincial use of Nova Scotia's own local resources, including both development of renewables and use of natural gas. These benefits include local employment gains, and improved energy security through reduced reliance on foreign resources. The latter advantage would help to reduce the global externalities associated with relying on energy resources from other countries.

Reduce the impacts of fossil fuel generation

For the foreseeable future the Province will continue to rely on non-renewable energy sources as its primary source of energy while renewable capacity is increased and conservation and efficiency efforts are pursued. For that reason, any movement towards sustainability must, in the short and medium-term, include recommendations and policy actions designed to reduce the considerable impacts and costs of fossil fuel combustion. Power plants and industrial facilities that use fossil fuels can reduce their environmental and social impacts by adopting the most efficient processes available, by using purer grades of fuels, and by the safe removal of some emissions and wastes at the end of pipe. These actions should be required of all industries and power generation in the Province, so that they are performing at peak efficiency and with the least possible impacts.

Switching to the most advanced and efficient boilers and the best available technology to reduce air emissions can lead to much cleaner electricity production in existing plants. Any additional non-renewable energy projects should also be required to invest in the cleanest and most efficient available technology (Best Practice #6).

Best Practice #6: Point Aconi Plant, Cape Breton, using cleaner coal technology

In 1994, the NSP Point Aconi coal-fired power plant began to generate electricity. At the time it was the largest circulating fluidized bed (CFB) boiler unit in the world. Between the circulating fluidized bed and additional emission control technology, sulphur dioxide and nitrous oxide emissions are reduced by up to 90% and 75% respectively compared to older, less efficient, and more polluting plants. Mercury emissions are very low. In terms of air pollutants this plant is superior to most existing facilities and it also has the lowest operating expenses of NSPI's coal-fired power plants.

Continuing technological research on coal plant emissions has produced a variety of pollution control technologies that exceed those of Point Aconi. A suite of options now exist to optimize pollution control while maintaining or improving plant efficiency. Some technologies can be added to existing plants and others are designed to be used in new facilities. These newer technologies address more than simply NO_x and SO_x: many also reduce particulate matter emissions and trace emissions of toxins, including mercury. Current research is also exploring the potential for capturing CO_2 emissions to reduce climate change impacts. However, this research has not yet been tested on a commercial scale, and its practical application remains uncertain.

While applauding NSPI's success at Point Aconi, further improvement is needed. The largest coal-fired plant in Nova Scotia, Lingan, is the second largest electrical ultility source of SO_x in Canada, and emits SO_x at five times the rate per unit of power generated as Canada's largest electrical utility source of SO_x emissions, Ontario Hydro's Nanticoke Plant. In fact NSPI has 3 of the top 4 most polluting coal-fired power plants in terms of acid gas emissions on a per MWh basis. Upgrading to cleaner fossil fuel technologies while pursuing new renewable power generation will put Nova Scotia onto a more sustainable path.

Sources: Energy Probe, 2005; NSPI, 2005b; USDOE, 2005a.

Institutional actions

The role of institutions (including but not restricted to government) is to manage and guide the relationships and interactions within and between society and the economy and to administer and regulate the interactions between human society and the natural environment. In order to make progress on many of the recommendations presented in this report and particularly in this chapter, there is a need for commitment and action by institutional bodies. This is not to suggest that individuals (whether in a personal or professional capacity), businesses, and industry do not have a responsibility to act, but many actions need to be facilitated. This is where institutions, especially local, regional and national governments, have a vital role to play. The recommendations in this section focus on some key actions that governments can take to encourage the achievement of the recommendations listed above. Other institutions, like universities and non-governmental organizations, also have a key role to play. But here we emphasize what governments can do.

1. Governments should, by example, ***lead citizens down the sustainability path*** – by reducing their overall energy demand and using renewable energy sources in their own operations. By taking action and using the very technology it wants citizens to adopt, governments send a strong message that these are important, feasible, and attainable goals. In short, by demonstrating that sustainable energy practices are practical and workable, governments can inspire and mobilize citizens and businesses to move towards sustainable practices themselves.

2. Governments can ***set and encourage the achievement of clear goals and targets*** to ensure movement towards sustainability. Through the use of incentives, disincentives and standards (including the use of financial instruments), governments should encourage greater energy efficiency, conservation, and renewable energy and natural gas use, and discourage the excess use of polluting and damaging sources of energy, particularly those resulting from fossil fuel extraction, production and use.

3. Governments should ***educate and inform the public on energy issues***. Greater energy literacy is needed to ensure the populace is fully aware of the impacts and implications of different energy sources, including the options for improvement on the individual and institutional level (e.g. efficiency and conservation). Without knowledge of impacts, the public will likely follow habitual patterns of excess energy use, unaware of the harm and damages caused. With knowledge of options, the public cannot make informed choices about energy futures or hold their leaders and institutions accountable for their performance. The value of information and awareness building exercises and the need for more education in the Province (both for the general public and for the power providers) was displayed in November, 2004, at an Energy Forum for electricity customers (Info Box).

Info Box: Nova Scotians support sustainable energy

Based on an Energy Forum held in the fall of 2004, NSPI reports that:
- "92% of customers want NSPI to educate them on energy efficiency (Demand Side Management)
- 73% want NSPI to aggressively control air emissions
- 82% said they would pay more on their bills to contribute to the global effort to control greenhouse gases
- Customers ranked limiting pollution and greenhouse gases as the top two factors to consider in electricity production. Reliability was ranked third.
- 75% strongly support the addition of renewable energy sources (especially wind) over fossil fuel sources
- 74% are willing to pay more to reduce demand for electricity"

Sources: NSPI, 2005c.

4. Until support for conventional energy sources (fossil fuels and nuclear power) and sustainable alternatives is more even and better reflects their costs and benefits, ***direct and indirect support through government law and policy*** is needed to encourage the latter.[89] These policies may include investment subsidies, tax breaks, capital grants, and other financial instruments to encourage development of renewables, as noted in examples and best practice given above. Best practice # 7, for instance, provides one example of government using the taxation system to support renewable energy.

Best Practice # 7: Commercial tax exemptions to renewable energy businesses

"San Francisco supervisor Jake McGoldrick has introduced legislation that would offer tax exemptions to companies that generate green power or manufacture renewable energy technology. The legislation would allow companies with more than ten employees to be exempt from municipal business tax for ten years, similar to the city's biotechnology industry tax credit that was approved last year. The tax credit would have a window of 15 years and is based on a report that estimates that investments by 2010 could create 52,000 to 114,000 new jobs in the state of California. In 2001, voters in San Francisco approved a U.S.$100 million bond to place solar panels, wind turbines and energy-conservation technology on civic property."

Sources: REFOCUS, 2005.

5. It is essential that governments track and report on energy indicators and progress towards or away from sustainability. As shown throughout this study, better information collection is needed as well as regular public reporting of findings. Examples of movement in this direction are Natural Resources Canada's Energy Sustainability Indicators and the United Kingdom's Energy Statistics.

6. Governments should incorporate full cost analysis into the decision-making process to account more accurately for the social and environmental costs associated with different energy options. The New Zealand carbon tax, for example, recognizes some of the costs associated with carbon emissions and will, once the law comes into force, begin to internalize the costs of GHG emissions by charging people for releasing GHG into the atmosphere (Best Practice #8).

[89] Experiences in Germany, Denmark, and Spain have shown that strong renewable energy growth in those countries is attributable to an active political commitment to fostering renewables. This has involved fostering public awareness through information campaigns and engaging the public in the development process, but above all, setting clear policies that send a strong message of support and encouragement to attract renewable energy developments (Etcheverry, 2005). Closer to home, the Prince Edward Island (PEI) government, recognising the importance of political commitment, is establishing a policy framework to help PEI become the Canadian leader in renewable energy development.

Best practice #8: New Zealand Carbon Tax

New Zealand recently introduced a universal carbon tax to take effect in 2007. The tax is set at NZ$11 a metric tonne of carbon emitted, which will translate into about an extra NZ$2.90 a week for electricity, petrol and natural gas for the average New Zealander. The tax will apply to producers and consumers alike, making it the first country to implement such a broad-based carbon tax. A few of the countries' most energy-intensive industries have been granted exemptions in return for commitments to reduce GHG emissions. This compromise will allow these industries to continue to operate. Impressively, the tax has been designed to be revenue neutral as other taxes will be reduced proportionately.

Former Energy Minister, Peter Hodgson, the minister responsible for climate change policy at the time, stated, "If we are going to tackle climate change, we need to start taking environmental costs into account in the economic choices we make." It is hoped that this tax will make oil and coal more expensive than wind, hydro, and solar power, and thereby spur development of these energy forms.

Sources: Vidal, 2005.

Areas for further study

Several limitations prevented this study from developing the indicators and full cost analysis to their full extent. Some constraints were imposed by data limitations and others by limited time and resources. In future iterations of this report and in other works of this nature, additional energy indicators for the Province should be tracked, and the costing analysis carried out quantitatively for as many additional indicators and cost variables as possible. This will help generate a more complete understanding of energy sustainability and the full costs of different energy options and futures in Nova Scotia. The costing analysis, one purpose of which is to allow a common basis for comparison of alternative energy development options in Nova Scotia, would also benefit from the application of one consistent costing framework using direct Nova Scotia data, rather than relying so heavily on work carried out in other regions and extrapolated to the Nova Scotia context. Using the full impact-pathway model for all indicators is the approach and method recommended at this time. In order to develop more robust estimates of damage costs of externalities a wider range of pollutants must be modelled, point source atmospheric dispersion modelling of pollutants is needed, and a wider range of impacts, namely ecological impacts, must be included.

To show the full cost implications of shifting from one energy choice to another, direct application of full-cost accounting (FCA) methods to major energy decisions taken in the Province would be extraordinarily useful and provide new insights to policy makers. The utility of the ExternE study of energy externality costs carried out for the European Commission, well demonstrates the type of comprehensive costing analysis that can help guide energy policy in Canada and all the Provinces. For example NSPI's Lingan power generating station (Canada's second most polluting electricity plant on a per kWh output) is its largest thermal plant. In only a few years, a choice will be made about the future of this plant and potential replacement options. Carrying out a full cost accounting analysis and comparison of the costs and benefits of upgrades to make the existing plant more efficient and less polluting versus the costs and benefits of replacing it with renewable sources, for instance, can help guide the decision-making process. Indeed this example well illustrates the value of full-cost accounting procedures in facilitating decisions between competing choices so that externality costs are taken fully into account. For each major energy decision that is made in the Province, a more complete costing analysis, which includes the value of non-market goods and services and goes beyond the short-term direct market cost assessment that dominates today, should rightly be conducted to identify and assess the most cost-effective options.

Indicators requiring better tracking

Indicators of progress for the areas of energy sustainability listed below need to be better understood and tracked in Nova Scotia. Although each of these indicators was discussed in this report, and while their identification represents a first step to understanding their role in energy sustainability, information to establish trend lines for those indicators is still lacking. Thus, it is not presently possible to confirm through direct evidence whether there is movement away from or towards sustainability in the following areas:

- Energy production
- Energy consumption
- Energy efficiency
- Employment
- Affordability
- Reliability
- Government building efficiency (leading by example)
- Regulatory, educational and fiscal measures used to encourage sustainable energy (creating societal change)
- Efforts to monitor and improve how government addresses energy concerns (evaluation)

In each of these areas, efforts have been made to marshal and present existing evidence, in order to give some indication of progress, or at least a snapshot of the current situation. But considerable new data collection and analysis are required before credible and accurate trends can be identified and established in these areas of concern.

Institutional indicators were not quantified at all in this report, but, in principle at least, they should be quantifiable. It is therefore recommended here that efforts be made to quantify and develop consistent and comparable measures over time for the institutional indicators suggested in this report, and that future updates of this report include data in this important area.

A host of other issues were discussed though potential indicators were not explicitly stated. Future reports should include more in-depth analysis of:

- impacts on ground-water and surface bodies from the withdrawal of water for thermal plants;
- thermal and chemical impacts on aquatic ecosystems from the discharge of thermal plant cooling and process water;
- impacts on fish and aquatic ecosystems from hydro dams;
- the extent of and the impacts resulting from the use of land for energy purposes (e.g. reduced habitat or invasive species in transmission line corridors);
- oil spills and their impacts on water and terrestrial ecosystems;
- offshore drilling and their impacts on marine ecosystems and fisheries;
- workplace accidents and their impacts;
- impacts experienced in other jurisdictions due to the importing of fuels;
- avian collisions with energy infrastructure;
- toxic ash storage from coal burning; and
- impacts from trace emissions of toxic chemicals (e.g. arsenic, etc).

Indicators requiring full-cost accounting (FCA)

The following indicators could not be developed fully in the FCA analysis due to data constraints. There is overlap between the development of the indicators and the capacity to undertake a credible and comprehensive FCA analysis, because economic valuations are always based on prior physical evidence. For example, in order to assess the damage costs of pollutant and GHG emissions, we first had to know emissions levels for each particular pollutant in physical terms (e.g. tonnes or kilotonnes.) Fortunately, this is one area, along with greenhouse gas emissions, where good, consistent, and comparable data exist over time. However, if an indicator is not properly tracked and reported in Nova Scotia, then it is also not possible to determine the externality costs associated with that indicator in the Province. In some cases, other studies were referenced and rough cost estimates were extrapolated to Nova Scotia from other jurisdictions, but direct evidence for the Province was not available and therefore did not permit inclusion in the full-cost accounting analysis in Chapter 8. Therefore the list of indicators below is additional to those listed above, and refers to areas that should included in future full-cost analyses as data become available.

- Energy security
- Energy subsidies
- Resource extraction
- Resource consumption

Updates and revisions of the current report should also happen periodically to track and keep abreast of new developments in the Province as well as to expand the full cost analysis.

Overview of recommendations

The key recommendations in this report are summarised in Table 52 under the heading to which they apply. As shown, there are several recommendations for most issues, with each recommendation listed under the appropriate headings: data needs, establishing goals and targets, supply and demand, and further study.

Table 52. Summary of recommendations

Issues to be addressed	Data Needs	Establishing goals & targets	Supply & Demand	Further study
Energy mix (energy, production, supply & demand)	Transparency needed	• Set additional renewable energy targets • Set targets for reducing demand through efficiency and conservation	• Reduce energy demand • Increase renewable energy use • Increase use of natural gas • Clean up fossil fuel use	Update if and when data access improves
Efficiency	Better collection of data needed	Set and enforce more stringent standards – requires collaboration between different levels of government	Reduce demand	Update when data improve
Employment	Better tracking – distinguish between quantity and quality		Examine employment creation potential of alternative energy investments	Update when data improve
Affordability	Better collection and reporting of data needed	Establish comprehensive fuel poverty strategy with targets	Reduce energy demand for low-income households through efficiency improvements	Update when data improve
Wood use	Better tracking	Establish and enforce emission and efficiency standards for wood heating devices	Reduce energy demand through efficiency improvements	Update when data improve
Air monitoring stations and air quality	More monitoring – especially at energy generation sources	Establish long term reduction targets for all emissions	Shift away from fossil fuel use; increase use of renewables; use natural gas a bridging fuel; apply advanced pollution control technology	Update when data improve
Mercury emissions	Non-point source estimates needed	Adopt and implement the new Canada-wide Standard. Establish long term reduction targets for all sources	Medium-term: Adopt mercury control technology in all coal-fired plants. Long-term: Shift away from coal	Update when data improve
Land and water impacts	Better tracking of impacts of cooling water, ash disposal, and dams on fish	Set goals and targets based on improved information		Update when data improve

Greenhouse gases	Need data on all major sectors' contribution especially utilities	Meet short term (2012) targets and set medium to long term targets	Shift away from coal & oil use; increase use of renewables, natural gas	
Government policy and action	• Data needed on level and types of subsidies • Better reporting of government action needed	• Set clear goals and targets and enforce standards • Track and report on energy indicators & progress towards or away from sustainability	• Educate and inform the public on energy issues, and need for action on all levels (supply and demand) • Develop incentives and disincentives, including use of financial instruments	• Incorporate full cost analysis into the decision-making process • Investigate effective policy support for renewable energy use for all energy not just electricity

9.4 Summing Up

Indicators are powerful tools that can be used on a regular basis to inform decision-making and influence policy. Indeed, they are the essential knowledge base for responsible policy formation, and the means to evaluate whether existing policies are achieving their goals and targets. To choose policy options that meet the goals of sustainability, explicit value must be given to key variables like health and environmental impacts that are vitally important but often ignored in decision-making processes. The **GPI***Atlantic* Accounts provide a comprehensive framework for considering, valuing, and assessing trends in basic areas that matter to Canadians today and that affect the wellbeing of future generations – including livelihood security, health, safety, environmental quality, educational attainment, equity, free time, and community vitality. It provides a system of measuring progress that does not exclude more than half the work performed on the planet (without pay) and the services provided by nature itself.

Although not complete by any means, the indicators identified and assessed in the **GPI***Atlantic* Energy Accounts provide such a framework and starting point for making better decisions regarding Nova Scotia's energy system. The indicators and full-cost accounting analysis can be used both to measure progress towards sustainability and to weigh the full costs and benefits of competing energy choices. As shown in this report, these choices can have serious long-term implications for the wellbeing of society, the economy, and the environment, and must therefore take account of all their key impacts. Until our decisions reflect the actual interconnectedness of human and natural systems and our dependency on ecosystem services, we will continue to degrade the quality of the land, water and air around us and deplete the resources on which we rely for survival. Because these Energy Accounts include such broader considerations, they provide a useful framework to bring the environmental and social impacts of energy production and use into the decision-making process. Further work is needed in many areas, like energy efficiency and affordability, in order to bring them fully and effectively into a comprehensive and integrated energy strategy. But, even at this early stage of development, there is adequate material in these Accounts to inform both existing policy processes and the general public.

The evidence presented in this document shows quite clearly that Nova Scotia is not making significant or adequate progress towards sustainability in its energy system, and that the production and use of energy are the leading cause of a number of serious environmental problems. But energy is also a vital component of a healthy society and vibrant economy.

Balancing the tradeoffs between environmental health, social wellbeing and economic development is not an easy task but one that must be undertaken if we are to protect the environment and the health of Nova Scotians. Fortunately, it is possible to identify several win-win scenarios, based particularly on effective actions that have been tried and tested in other jurisdictions. For example, investments in energy efficiency, conservation, and development of renewables have been shown to produce substantial economic savings, jobs, viable industries, and gains in security and self-sufficiency, while at the same time reducing adverse health and environmental impacts and reliance on imported fuels.

Fortunately, too, we have the technical, social, and economic know-how needed to achieve concerted and much more dramatic progress towards greater energy sustainability. Indeed, there is no reason that Nova Scotia cannot be a leader in this field. Although progress to date towards the goals outlined in this report has been very limited, there is ample scope for positive action in the days and years to come. Some important steps have already been taken. Others that need to be considered and implemented as soon as possible include:

- Decreasing energy consumption through behavioural changes (achieved through education and pricing policies);
- Increasing energy efficiency in all sectors through the adoption of innovative technologies as well as through simple techniques that are already known and well established;
- Increasing the use of indigenous energy supplies, especially renewable energy resources like wind power, and natural gas (primarily as a bridging fuel);
- Adoption of new, cleaner technologies for energy extraction, production, and use;
- Better integration between environmental, economic and social policy in the energy sector
- Financial carrots and sticks, including an end to perverse subsidies that encourage excessive resource use and reliance on fossil fuels, and the introduction of taxes, rebates, investments and other instruments that reward efficiency and conservation, encourage development of renewables, and reflect the true costs of energy use on the environment and human health. This includes changing the current playing field so that renewable energy development can compete effectively with fossil fuel energy exploration and extraction;
- Building non-market values into decision-making through use of full-cost accounting;
- Engaging Nova Scotians in the decision-making process, and providing the necessary education and information to allow informed decisions between competing energy choices. This includes the adoption and use of indicators such as those suggested in this report.

It is important to note that that these recommendations are not new or radical, but really only reiterate what many scientists, policy-makers, and energy analysts around the world have been saying since the first oil crisis in the 1970s. The difference is that the imperative for change has now grown dramatically given the impending peak in oil production, the rate of environmental degradation, and the dangers of climate change that were not as fully known or understood in the 1970s. But the message is old and the solutions are available today. Indeed, the knowledge and technologies required to make genuine progress towards energy sustainability are further developed today than they were in the 1970s, and Nova Scotia now has the advantage of learning from excellent models in other jurisdictions that have demonstrated dramatic success in energy conservation, efficiency, renewable energy production, and clean technologies since the 1970s.

The other positive change since the 1970s is that, despite the major data gaps still existing and highlighted in this report, there have also been vast improvements in data availability in many areas. For example, air quality monitoring was only in its infancy at the time of the oil crises of the 1970s, and no usable records were kept of greenhouse gas emissions. Indeed tracking GHG emissions was not even regarded as an issue worthy of consideration at that time. Thus, better tracking of progress towards sustainability and far better reporting on energy sector impacts is possible today than in the 1970s. Indeed, a report like this one is today able not only to apply genuine progress principles and concepts to the Nova Scotia energy sector, but also to begin tracking quantitatively at least some key trends and making preliminary assessments on progress or lack thereof towards sustainability. Much more work is clearly needed. But these Energy Accounts can certainly be a first step in tracking energy sustainability in this Province and providing us with a more accurate and comprehensive description of the energy sector that takes account of at least some of the impacts and full costs of current decisions and actions at the personal, corporate, institutional, and political levels.

Although positive change is taking place, in Nova Scotia as elsewhere, towards greater reliance on renewable energy sources, towards cleaning up fossil fuel energy processes, and towards using energy more efficiently, the pace of change needs to quicken sharply to respond to the impending advent of peak oil production, the urgency of environmental crises like global warming, and the growing insecurity of imported fossil fuel supplies that often originate in highly unstable regions. We have been warned by many experts that "the range of current responses are not commensurate with the nature, the extent or the urgency of the situation at hand" (Cropper in Amos, 2005).

In a globalized world, Nova Scotia cannot stand apart from the global political, environmental, economic, and resource trends that currently imperil future energy supplies, affordability, and the wellbeing of future generations. This Province must take full responsibility for its own role and actions towards a more sustainable and secure future. As well, within Nova Scotia, this responsibility is not confined to any one sector. Rather government, industry, energy producers, and each individual Nova Scotian must take full responsibility for their actions and decisions, and work together to affect needed changes.

The good news is that undertaking these essential changes in the areas of energy conservation, efficiency, clean technologies, and development of renewables will not only make an important contribution to a healthier global environment but will also produce substantial savings and economic gains that can make Nova Scotia a healthier, more vibrant, and more energy sustainable place. The very crisis we face is replete with opportunities for actions that can have highly positive consequences for the economy, society, and the environment. Nova Scotia has every reason and motivation (due to its heavy current reliance on imported fossil fuels) and the full potential and capacity to leap into the forefront of what must become a global movement towards energy demand reduction and greater reliance on renewable energy sources. Indeed, such a movement is essential if we are to secure a sustainable future for our children.

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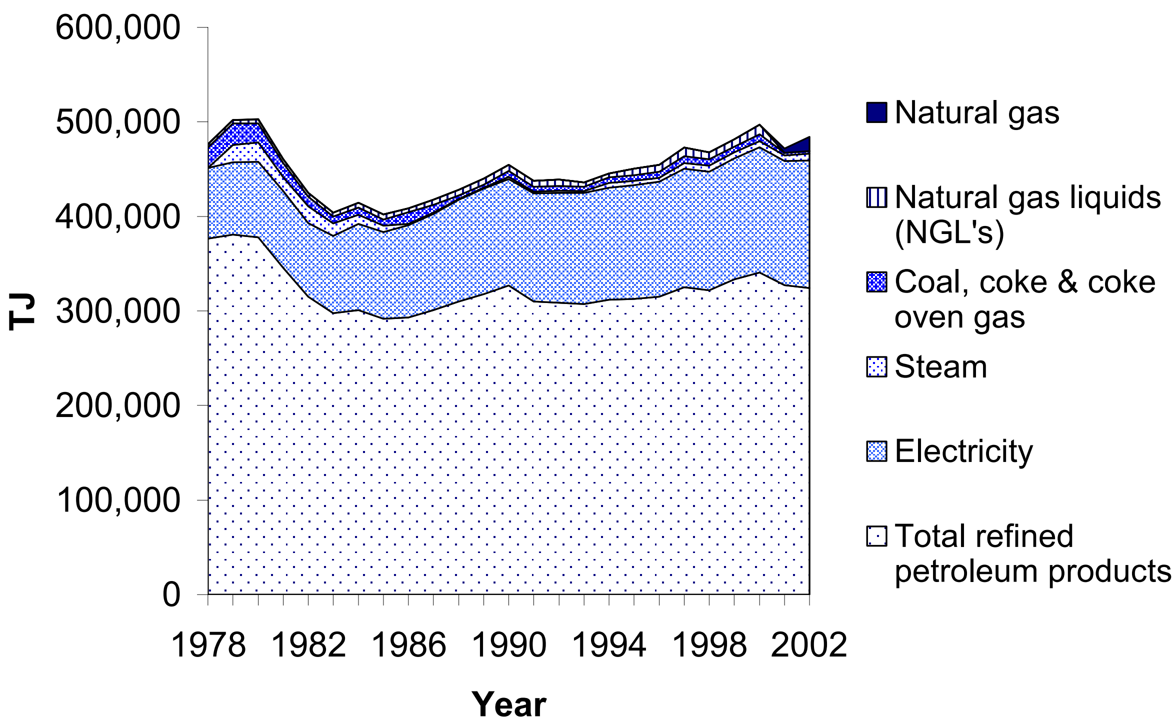
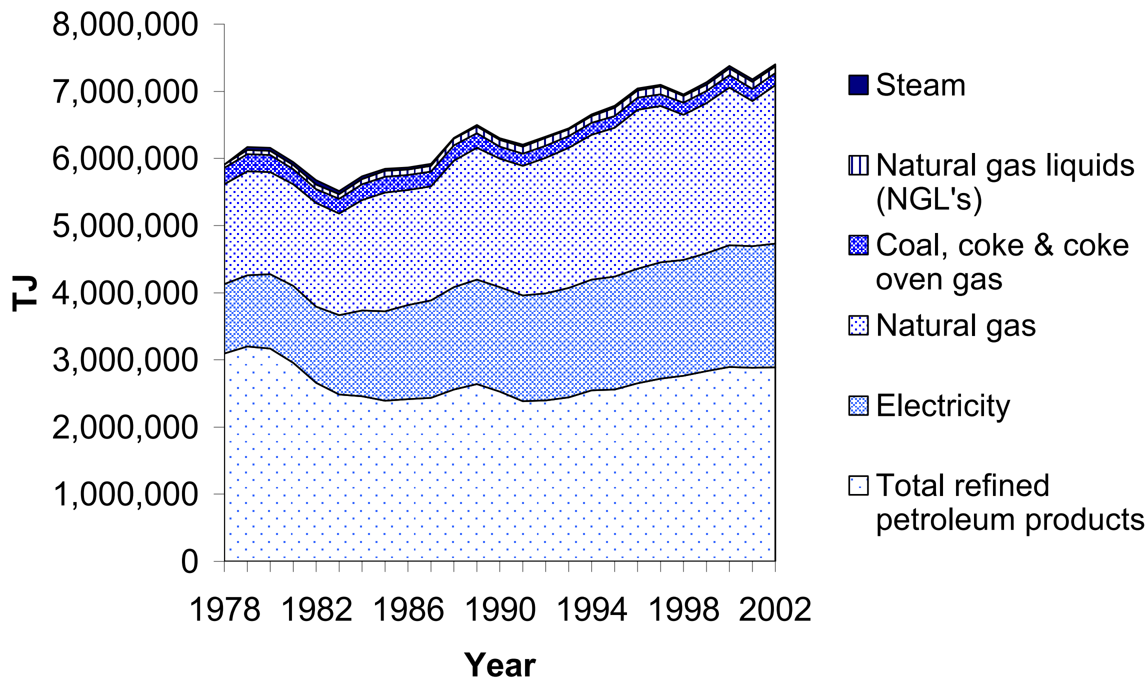
APPENDIX A
SUPPORTING ENERGY PRODUCTION AND USE INDICATORS

Figure 42. Energy use, final demand, by fuel including transportation, Atlantic Canada, 1978 to 2002



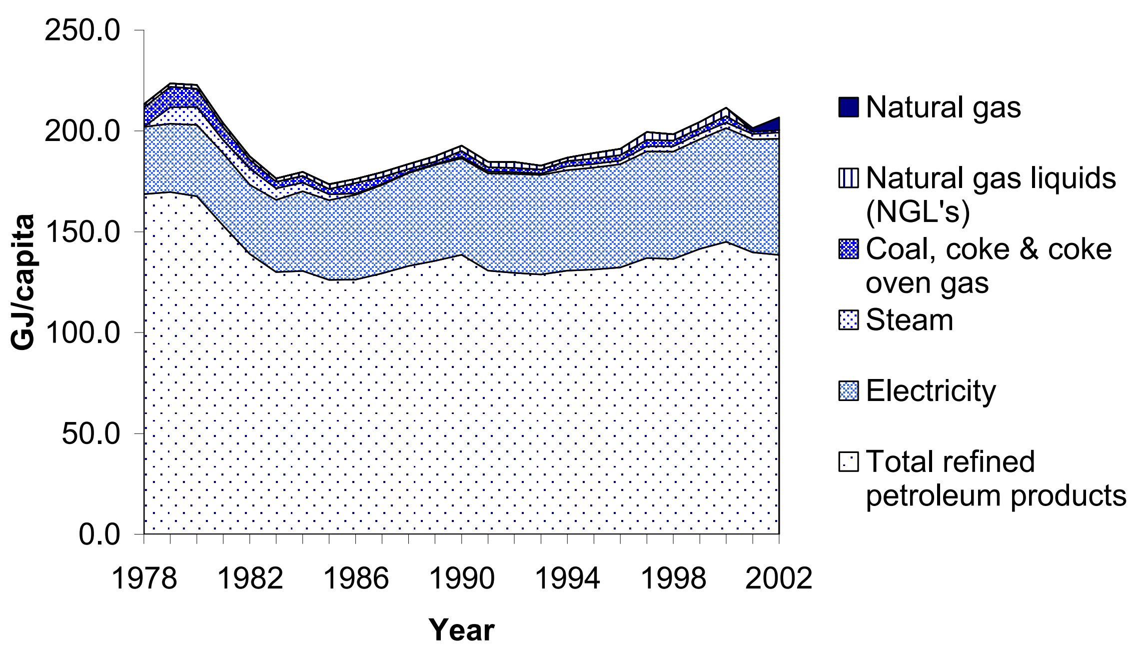
Source: StatsCan, 2005.

Figure 43. Energy use, final demand, by fuel including transportation, Canada, 1978 to 2002



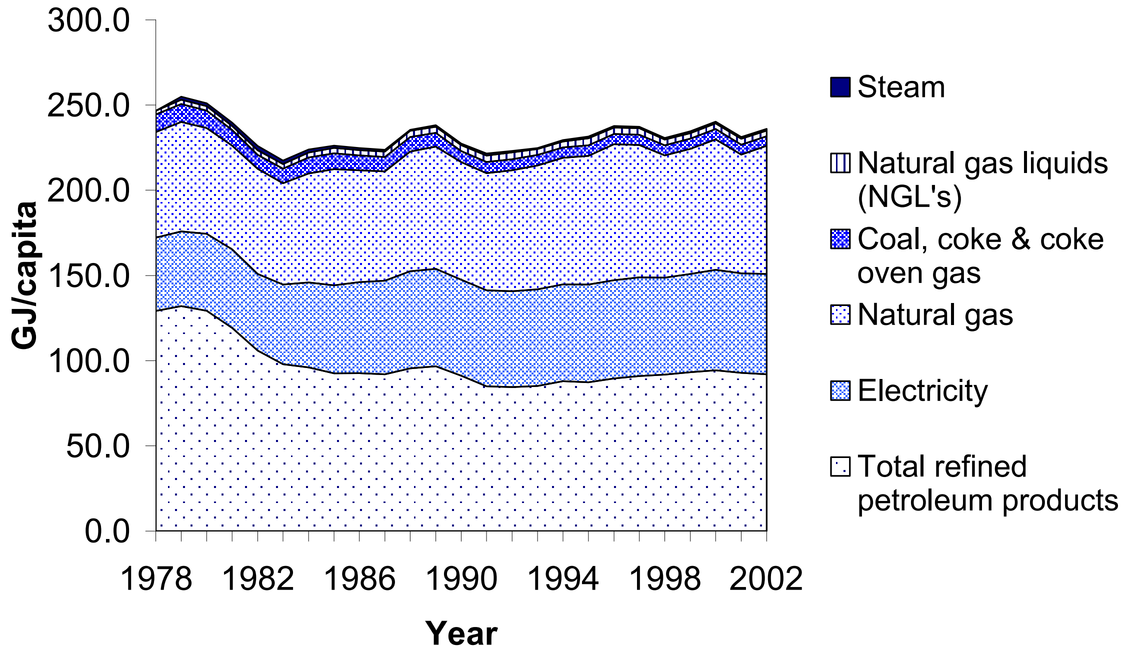
Source: StatsCan, 2005.

Figure 44. Energy use, final demand per capita, by fuel including transportation, Atlantic Canada, 1978 to 2002



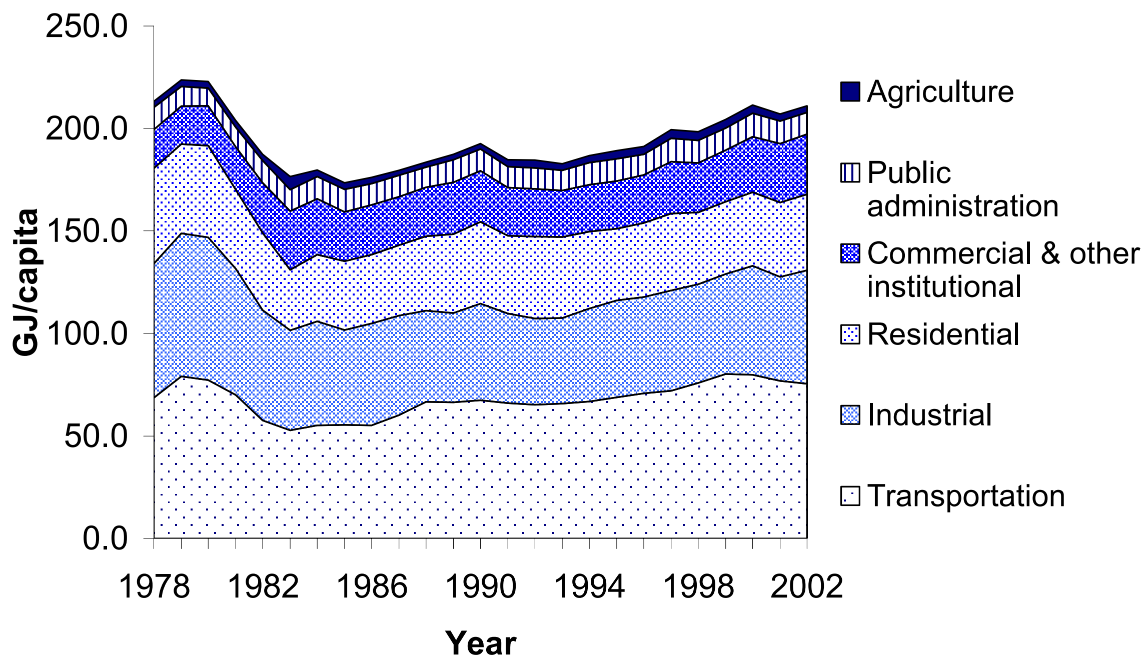
Source: StatsCan, 2005.

Figure 45. Energy use, final demand per capita by fuel including transportation, Canada, 1978 to 2002



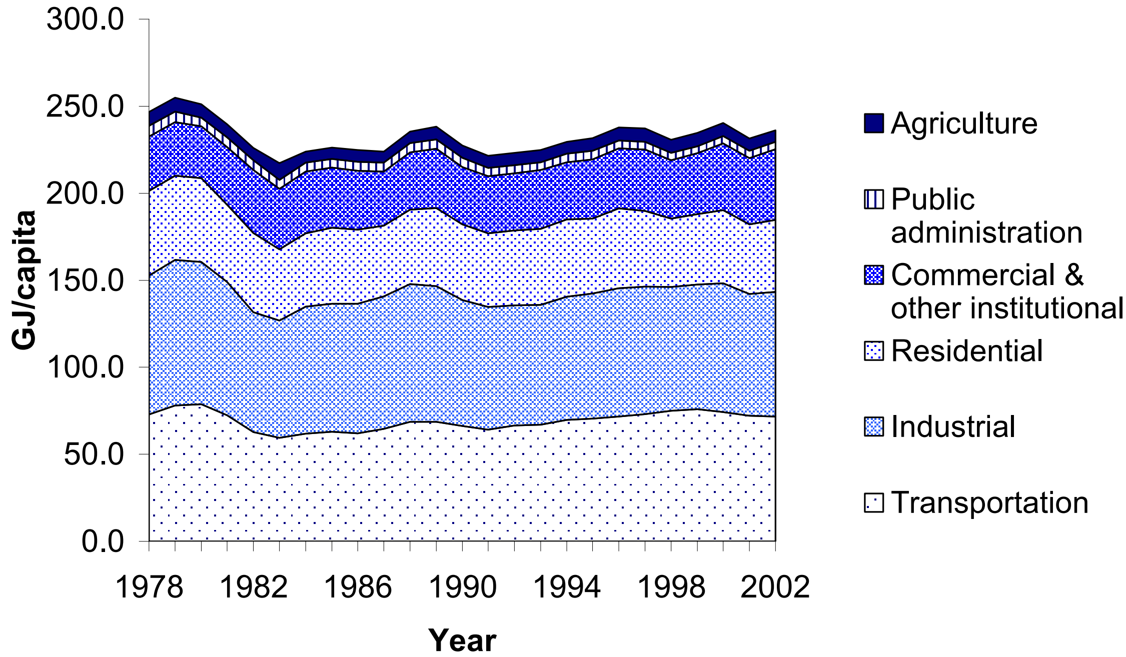
Source: StatsCan, 2005.

Figure 46. Energy use, final demand per capita, by sector, Atlantic Canada, 1978 to 2002



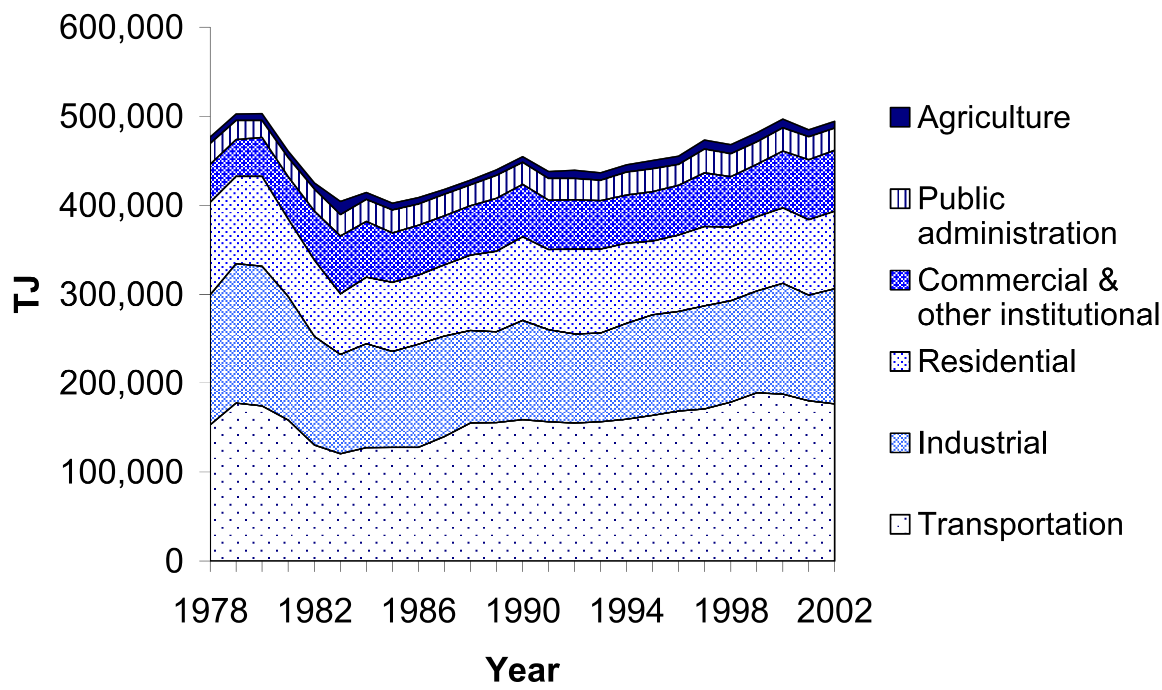
Source: StatsCan, 2005.

Figure 47. Energy use, final demand per capita by sector, Canada, 1978 to 2002



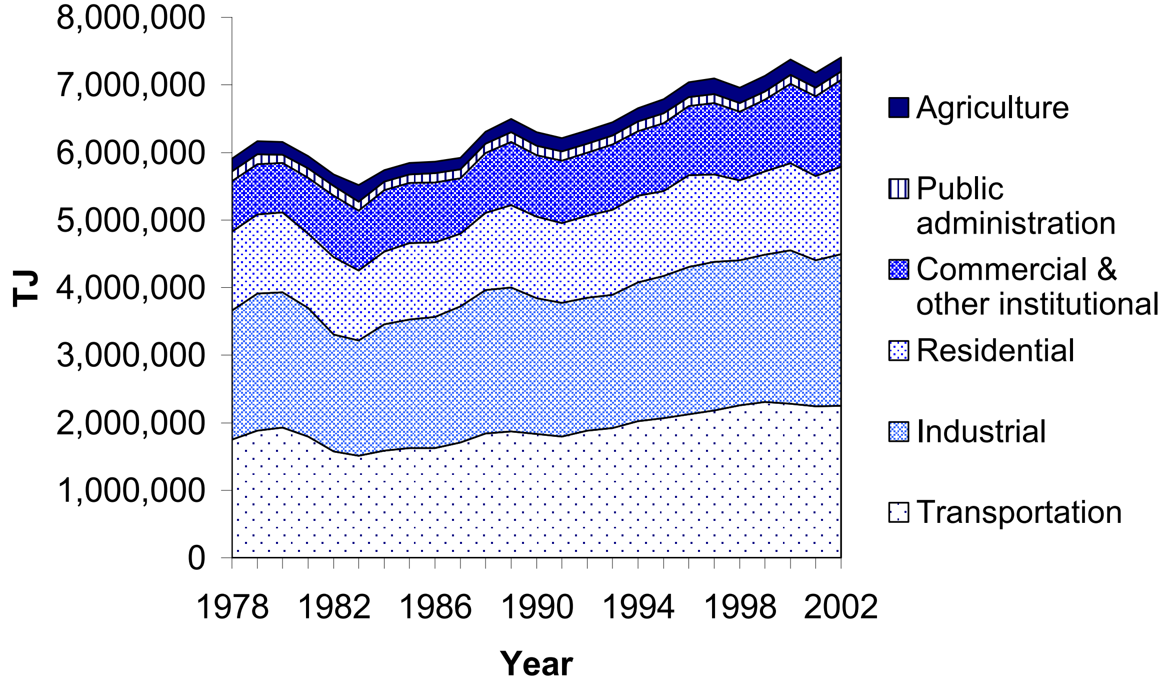
Source: StatsCan, 2005.

Figure 48. Energy use, final demand by sector, Atlantic Canada, 1978 to 2002



Source: StatsCan, 2005.

Figure 49. Energy use, final demand by sector, Canada, 1978 to 2002

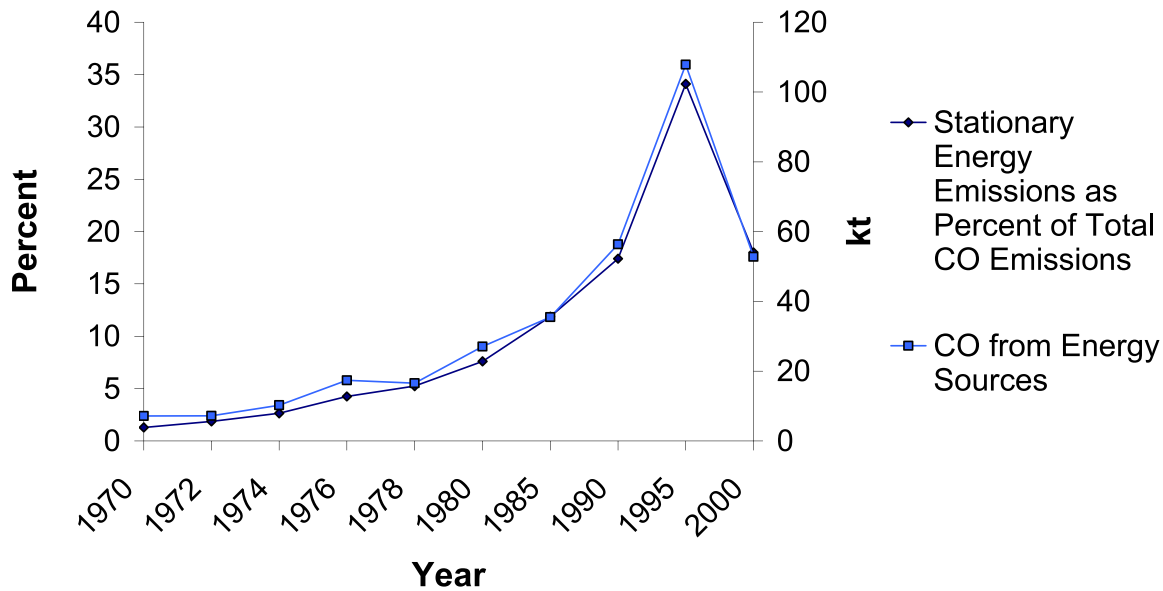


Source: StatsCan, 2005.

APPENDIX B
SUPPORTING HEALTH AND ENVIRONMENTAL INDICATORS

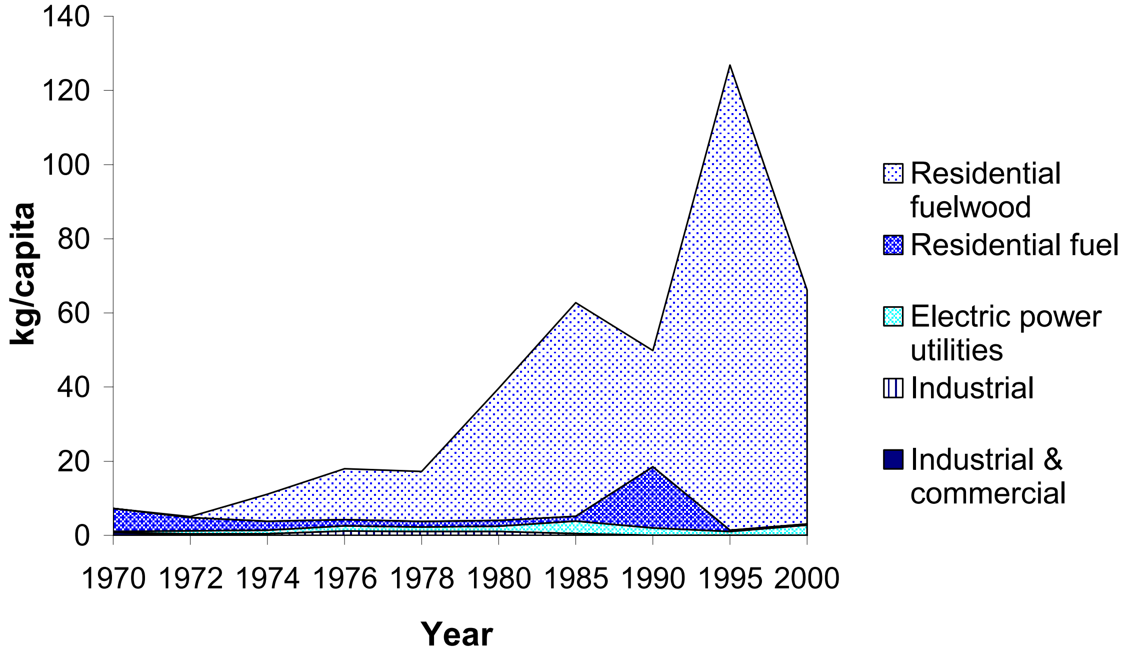
Carbon Monoxide

Figure 50. Relative and absolute levels for CO emissions from stationary energy sources (stationary combustion and coal mining) for Nova Scotia, 1970 to 2000



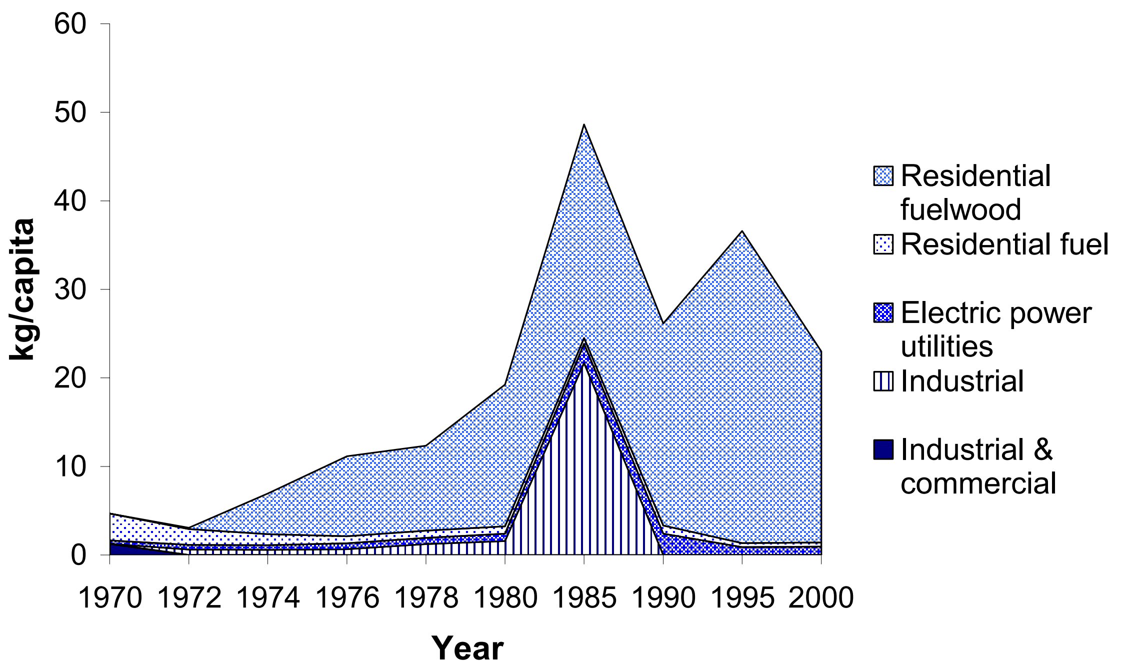
Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

Figure 51. Per capita CO emissions from stationary energy sources for Atlantic Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

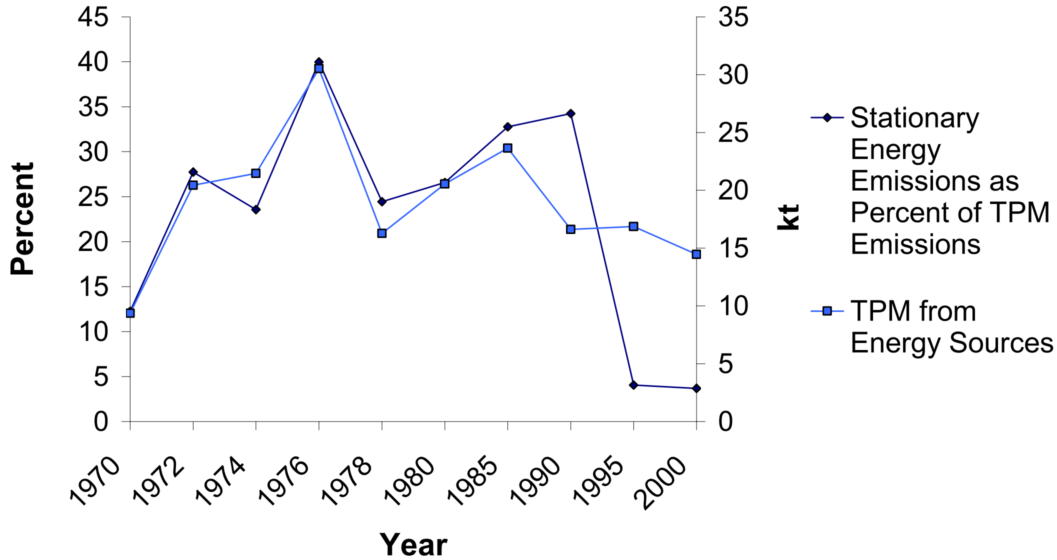
Figure 52. Per capita CO emissions from stationary energy sources for Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

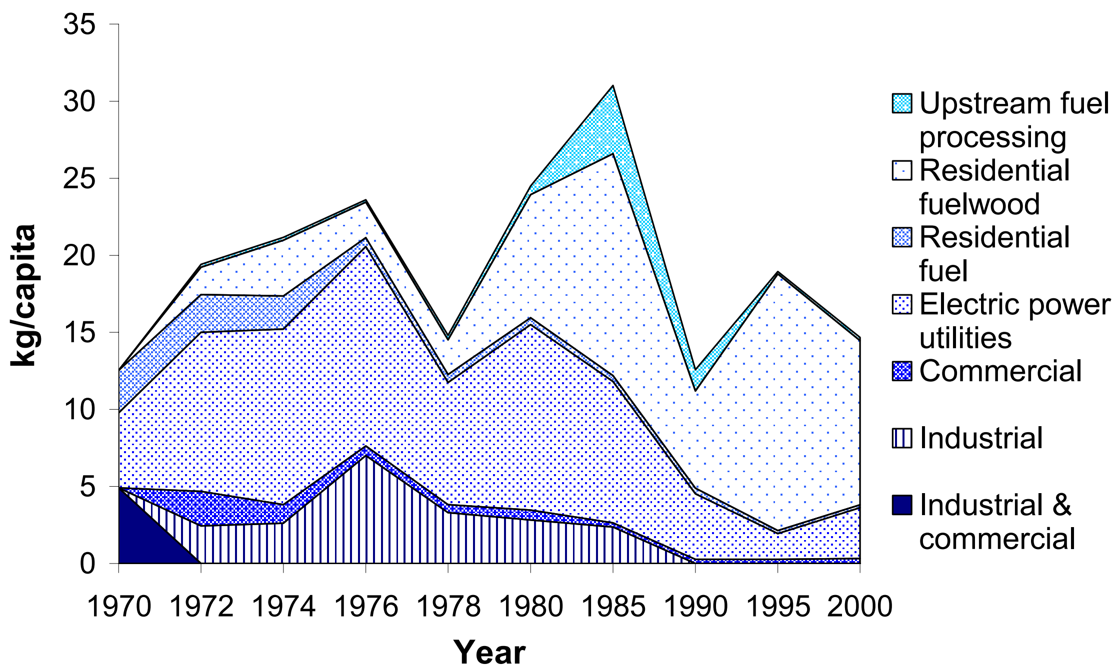
Particulate Matter

Figure 53. Relative and absolute levels for TPM emissions from stationary energy sources for Nova Scotia, 1970 to 2000



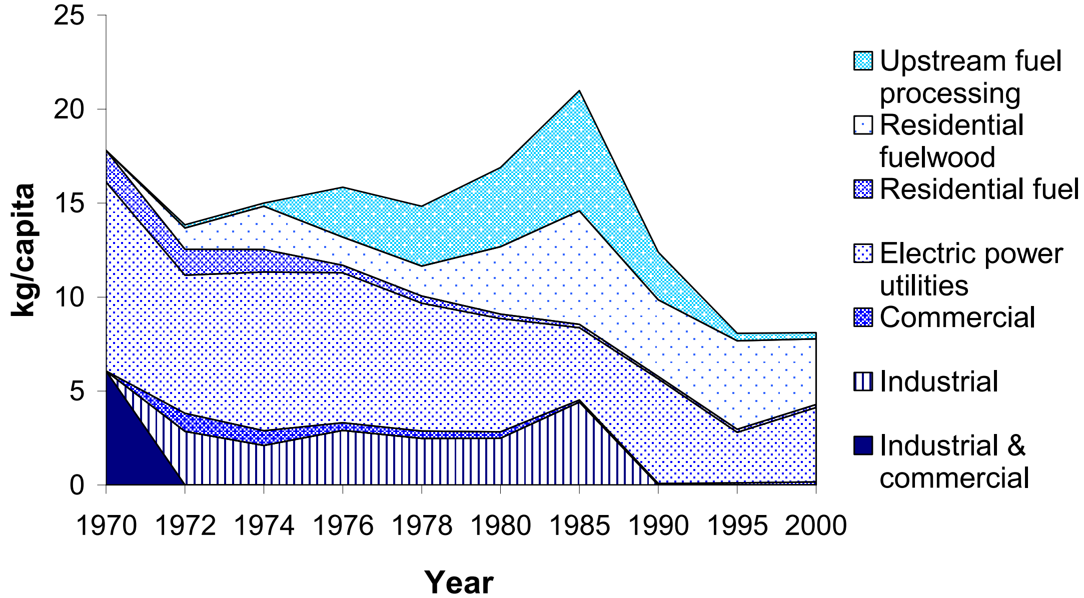
Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

Figure 54. Per capita TPM emissions of stationary energy sources for Atlantic Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

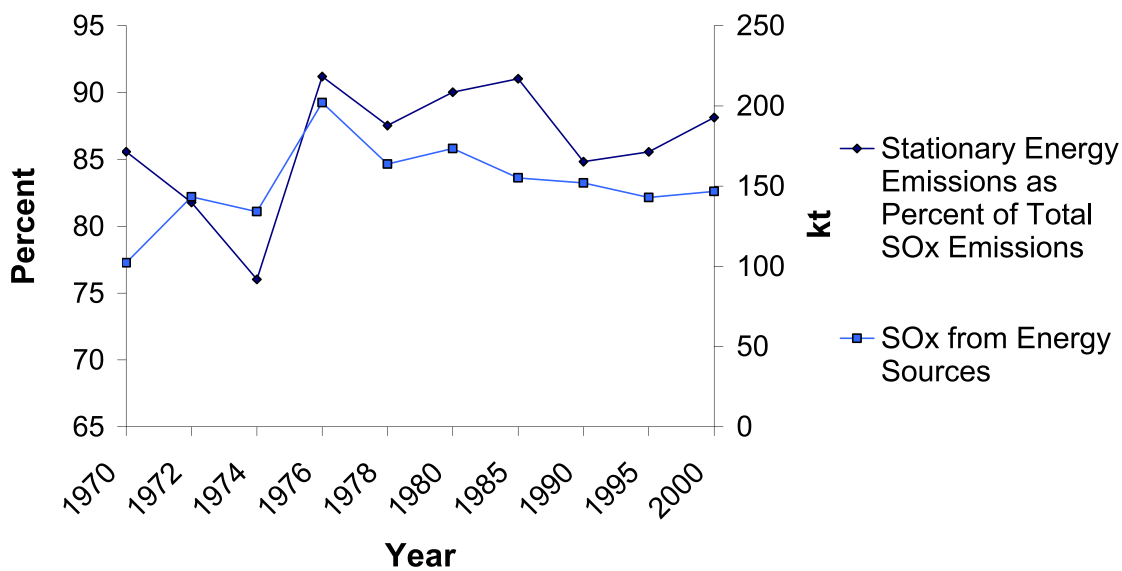
Figure 55. Per capita TPM emissions of stationary energy sources in Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

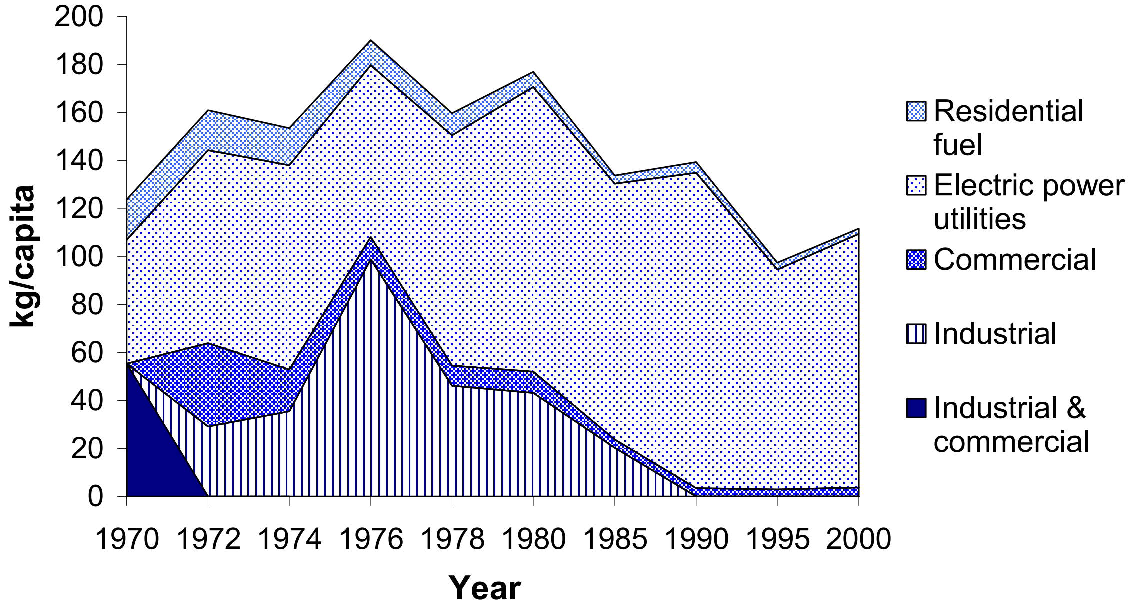
Sulphur Oxides

Figure 56. Relative and absolute levels for SO_x emissions from stationary energy sources for Nova Scotia, 1970 to 2000



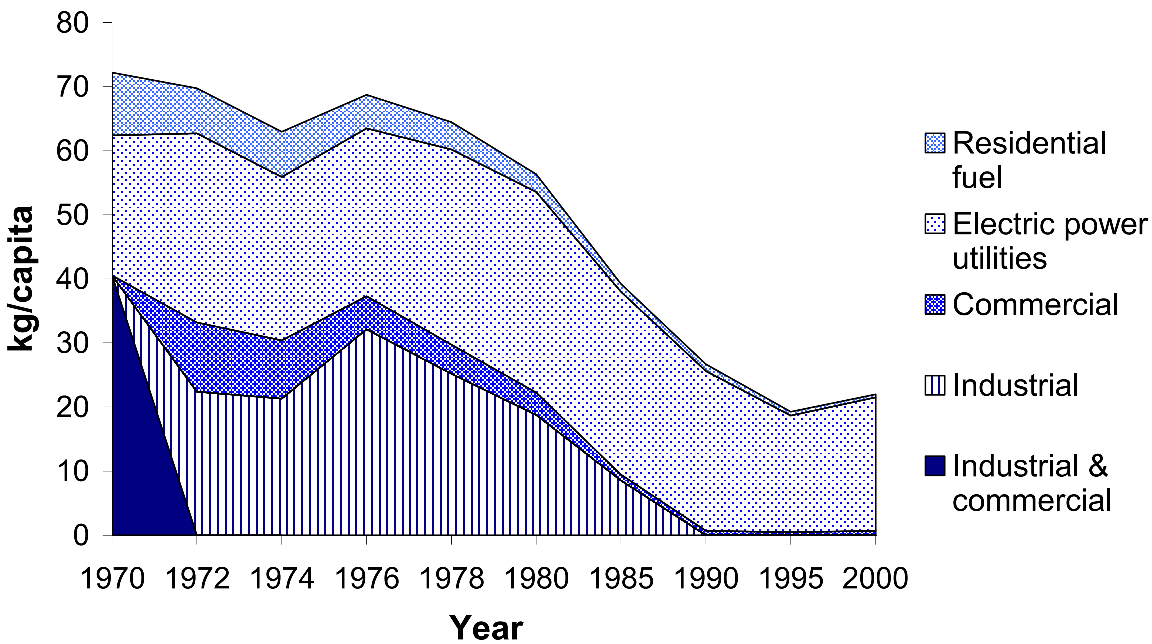
Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

Figure 57. Per capita SO_x emissions from stationary energy sources for Atlantic Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

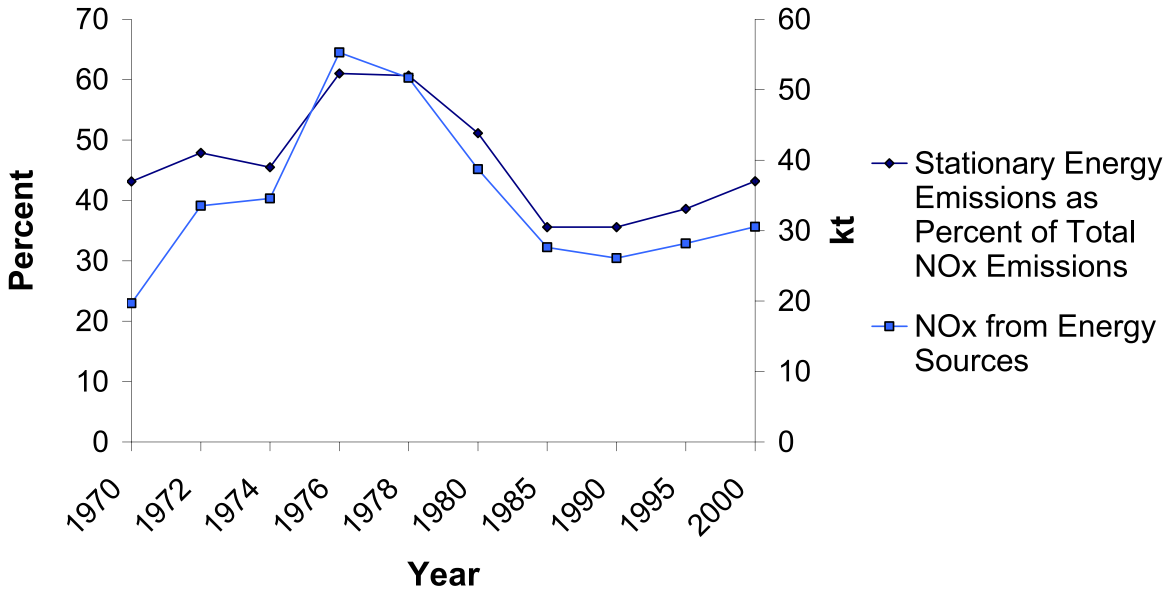
Figure 58. Per capita SO_x emissions from stationary energy sources for Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

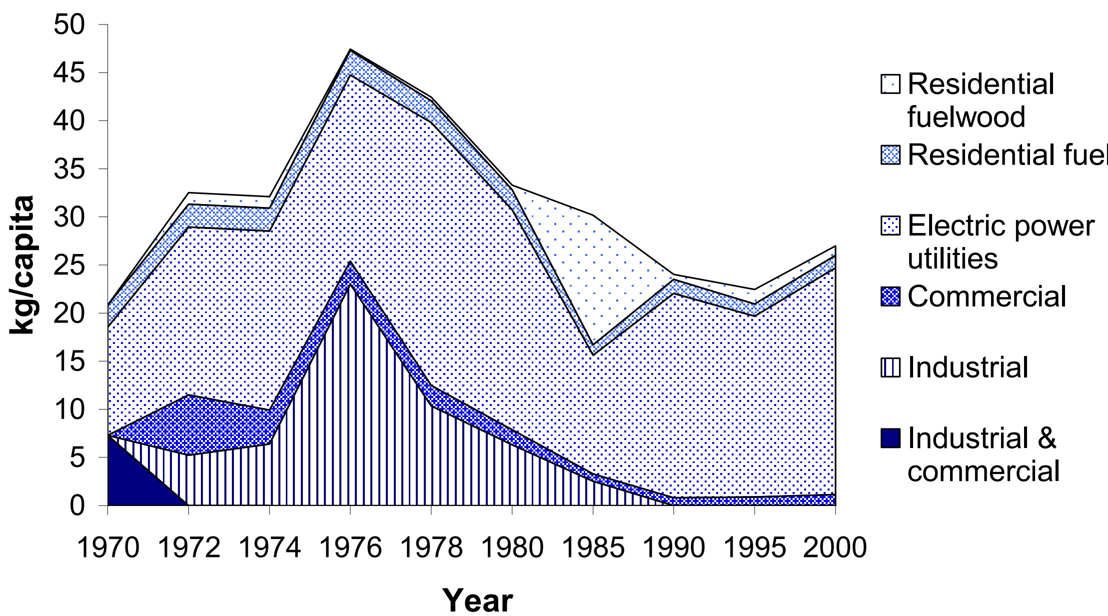
Nitrogen Oxides

Figure 59. Relative and absolute levels for NO_x emissions from stationary energy sources in Nova Scotia, 1970 to 2000



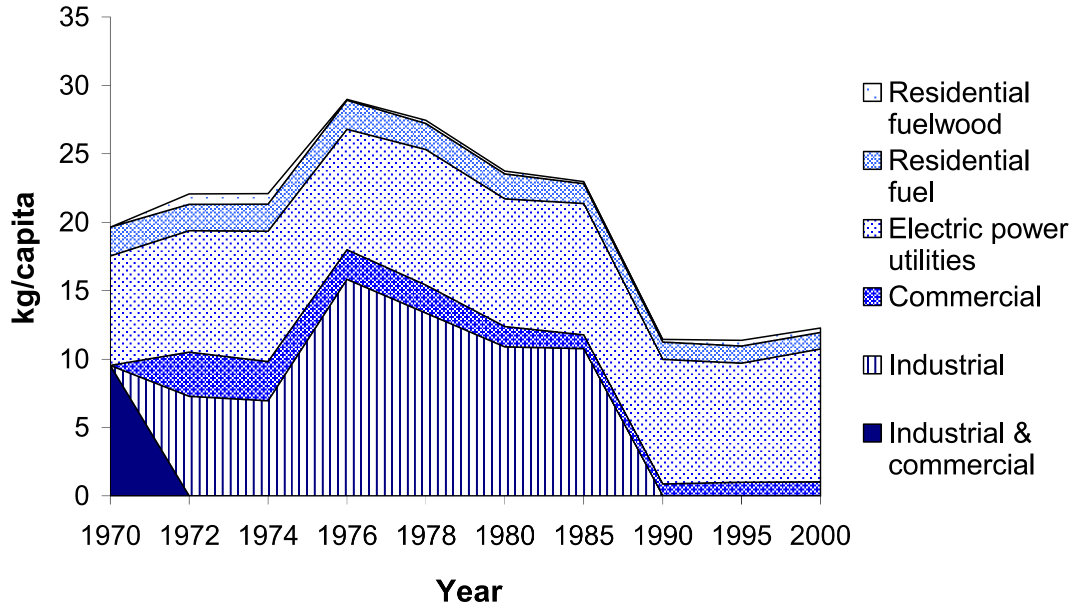
Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

Figure 60. Per capita NO_x emissions from stationary energy sources for Atlantic Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

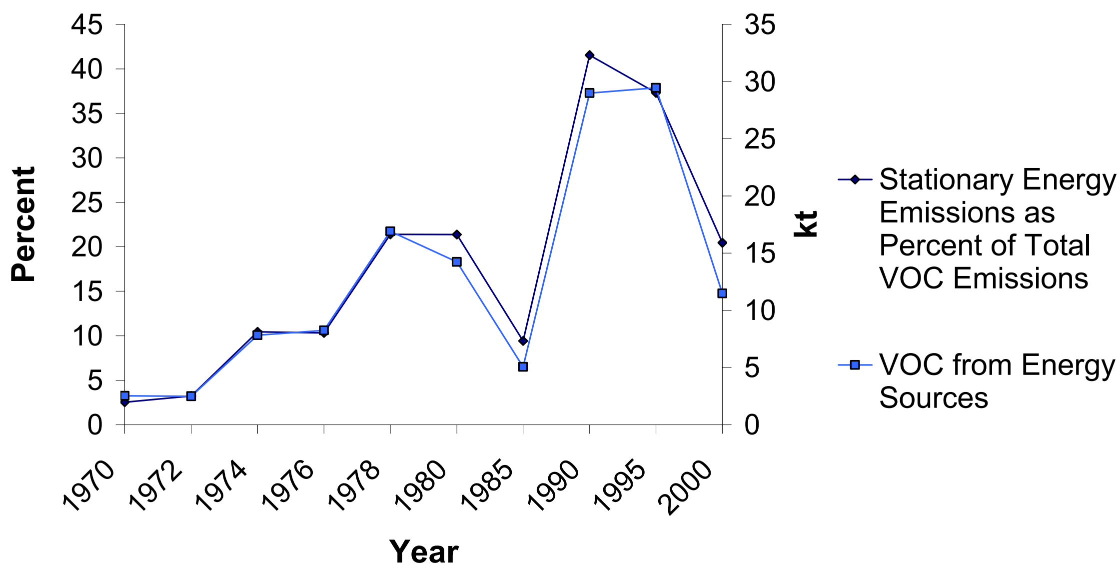
Figure 61. Per capita NO_x emissions from stationary energy sources for Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

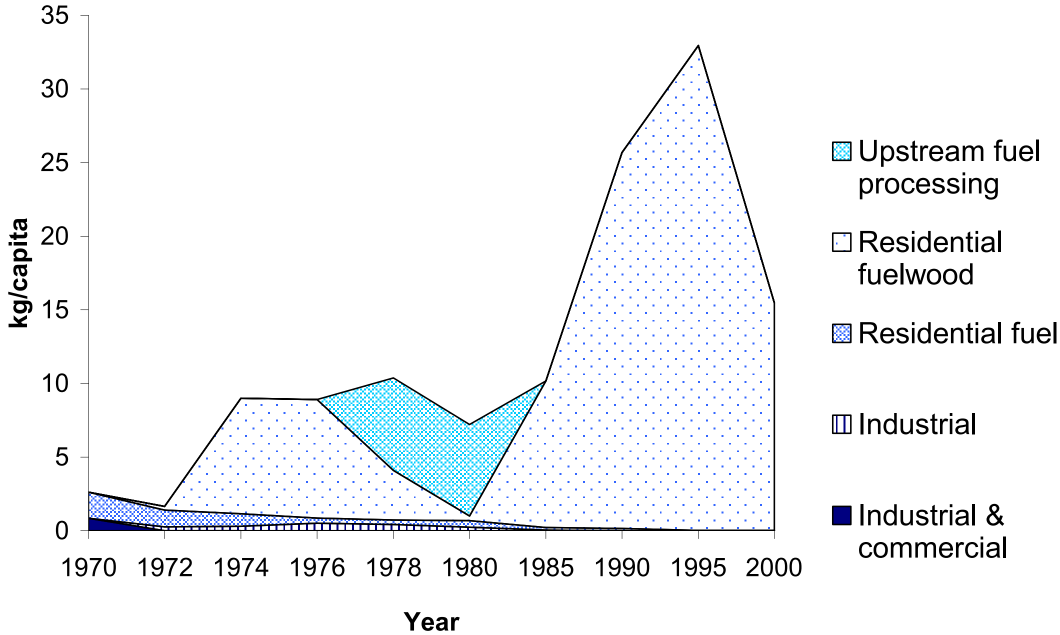
Volatile Organic Compounds

Figure 62. Relative and absolute levels for VOC emissions from stationary energy sources in Nova Scotia, 1970 to 2000



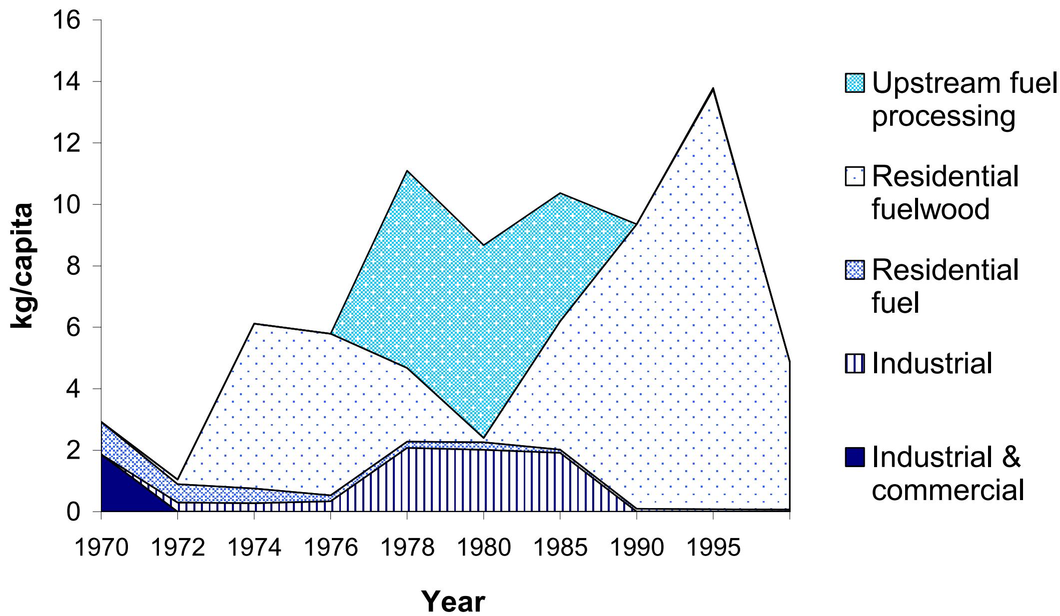
Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

Figure 63. Per capita VOC emissions from stationary energy sources for Atlantic Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

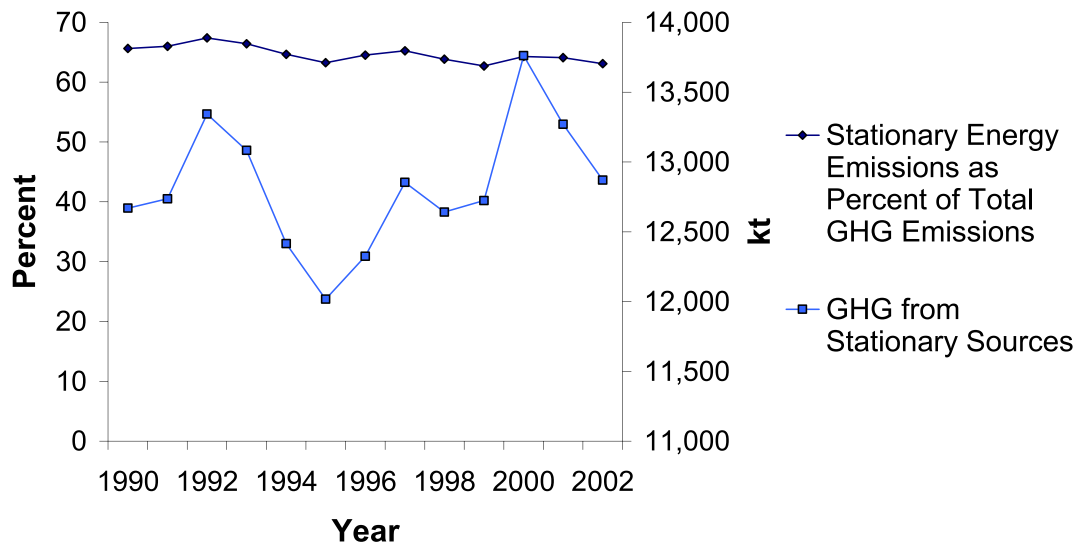
Figure 64. Per capita VOC emissions from energy sources for Canada, 1970 to 2000



Sources: Environment Canada 1973, 1977, 1978, 1981, 1983, 1986, 1990, 1996, 2000.

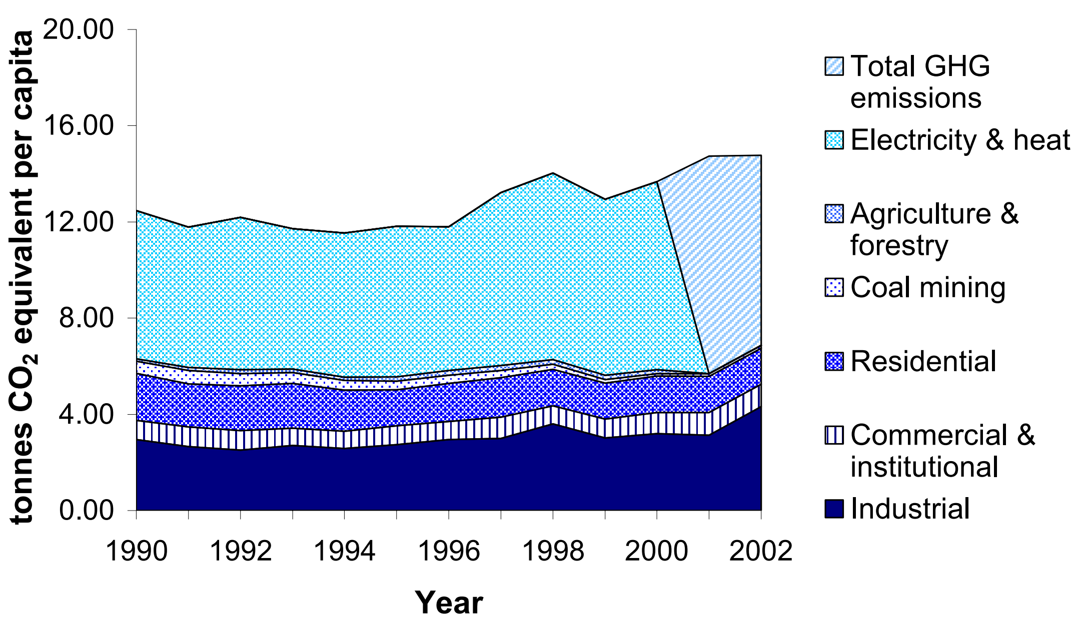
Greenhouse Gases

Figure 65. Relative and absolute levels for GHG emissions from stationary energy sources (stationary combustion and fugitive coal mining emissions) in Nova Scotia, 1990 to 2002



Sources: Environment Canada, 2004.

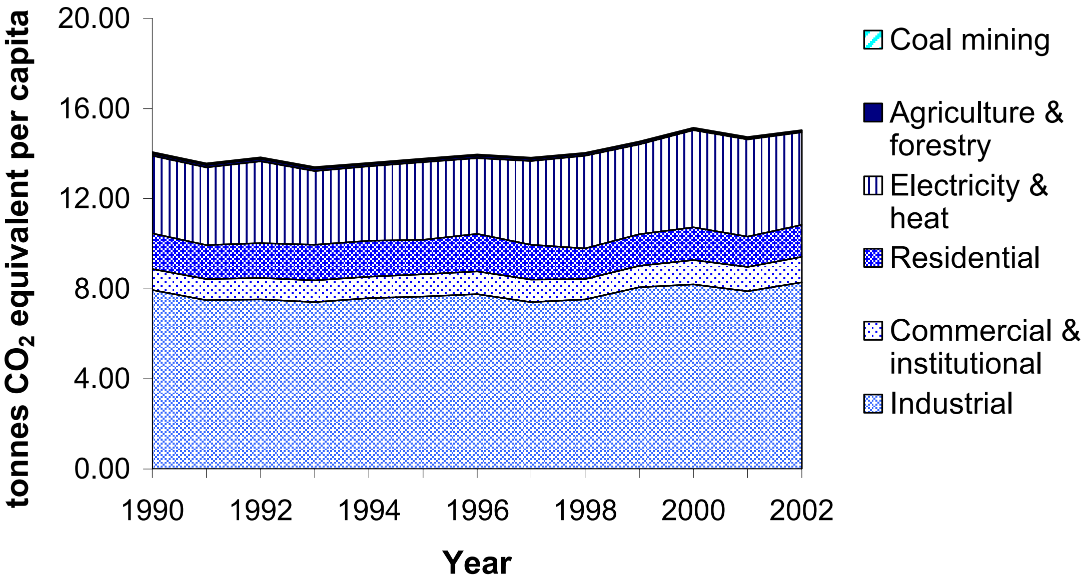
Figure 66. Per capita GHG emissions from energy sources for Atlantic Canada, 1990 to 2002



Note: Since 2001 data for electricity and heat, mining (within the industrial stationary combustion category), agriculture and forestry, have been suppressed for confidentiality reasons for all the Atlantic Provinces.

Sources: Environment Canada, 2004.

Figure 67. Per capita GHG emissions from energy sources for Canada, 1990 to 2002



Sources: Environment Canada, 2004.

APPENDIX C
DATA TABLES FOR FIGURES

Chapter 2

Figure 2. Energy use, final demand, Nova Scotia (including transportation and wood), by fuel, 2001 (184.5 PJ)

Fuel/Energy Carrier	Use (TJ)
Natural gas	109
Natural gas liquids (NGL's)	3,048
Electricity	39,151
Other	1,204
Refined petroleum products	127,876
Wood & pulp liquor	13,084
Total	184,472

Figure 3. Energy use, final demand, Nova Scotia (including wood, excluding transportation), by fuel, 2001 (116.1PJ)

Fuel/Energy Carrier	Use (TJ)
Natural gas	109
Natural gas liquids (NGL's)	3,048
Electricity	39,151
Other	1,204
Refined petroleum products	60,246
Wood & pulp liquor	13,084
Total	116,842

Figure 4. Nova Scotian energy use, final demand (including wood), by end use, 2001 (184.5 PJ)

End use	Use (TJ)
Industrial	33,884
Transportation	67,700
Residential	42,009
Agricultural	3,694
Commercial & public administration	37,200
Total	184,487

Figure 5. NSPI fuel generation mix, 2003 and Figure 6. NSPI generation mix, 2002

Fuel	2002 (GWh)	2003 (GWh)
Coal	8,862	9,219
Oil	288	1,536
Hydro & wind	1,025	1,080
Purchases	277	375
Natural gas	1,579	120

Chapter 5

Figure 7. Power generation fuel mix for Nova Scotia Power, 1993-2003

Year	Fuel Use in GWh				
	Natural gas	Purchases	Hydro & wind	Oil	Coal
1993	0	219	878	2,117	6,346
1994	0	216	1,012	1,206	7,160
1995	0	500	883	1,239	7,053
1996	0	255	1,112	609	7,850
1997	0	340	935	781	8,247
1998	0	242	891	2,358	7,015
1999	0	411	981	1,871	7,816
2000	44	295	881	1,348	8,864
2001	1,129	279	692	691	8,855
2002	1,579	277	1,025	288	8,862
2003	120	375	1,080	1,536	9,219

Figure 8. Nova Scotia Power Corporation (NSPC) installed generating capacity, 1979 and Figure 9. Nova Scotia Power Inc. (NSPI) installed generation capacity, 2003

<table>
<tr><th>Fuel</th><th>1979 (MW)</th><th>2003 (MW)</th></tr>
<tr><td>Coal</td><td>301</td><td>1,233</td></tr>
<tr><td>Oil</td><td>708</td><td rowspan="2">606</td></tr>
<tr><td>Gasoline turbine</td><td>205</td></tr>
<tr><td>Hydro</td><td>351</td><td>404</td></tr>
<tr><td>Total</td><td>1,565</td><td>2,243</td></tr>
</table>

Figure 10. Energy use, final demand, in Nova Scotia (including transportation), by fuel type, 1978-2002 (in TJ)

Year	Natural gas	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Steam	Electricity	Refined petroleum products	Total
1978	0	1,780	17,155	n/a	21,772	148,695	189,402
1979	0	1,775	18,345	17,471	22,313	143,759	203,663
1980	0	2,041	15,838	18,882	23,137	141,477	201,375
1981	0	2,092	12,483	13,312	22,454	130,283	180,624
1982	0	1,970	7,272	16,785	21,824	124,661	172,512
1983	0	1,965	5,408	12,024	22,352	119,208	160,957
1984	0	2,354	6,323	8,521	24,722	121,434	163,354
1985	0	2,979	4,588	5,459	24,854	117,162	155,042
1986	0	2,113	6,929	162	25,535	117,439	152,178
1987	0	2,745	6,736	0	27,620	119,837	156,938
1988	0	2,734	2,369	0	29,220	126,491	160,814
1989	0	2,898	1,368	0	30,537	123,912	158,715
1990	0	3,061	1,833	0	32,387	124,374	161,655
1991	0	3,128	1,786	0	32,314	117,722	154,950
1992	0	3,223	1,464	0	33,178	120,564	158,429
1993	0	1,641	1,650	0	33,299	120,455	157,045
1994	0	1,349	1,495	0	33,687	122,562	159,093
1995	0	2,051	1,710	0	33,855	122,549	160,165
1996	0	2,547	1,701	0	34,206	121,557	160,011
1997	0	3,471	1,411	0	34,699	126,600	166,181
1998	0	2,706	1,577	0	36,118	128,404	168,805
1999	0	2,776	1,657	94	37,709	136,909	179,145
2000	0	3,032	1,870	87	38,347	132,912	176,248
2001	0	3,048	1,116	88	38,999	127,876	171,127
2002	2,793	x	x	1,587	39,599	125,561	169,540

Note: x indicates the data was suppressed. Columns may not sum to total because of rounding.

Figure 11. Energy use, final demand, in Nova Scotia (including transportation) per capita, by fuel type, 1978-2002 (in GJ/capita)

Year	Natural gas	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Steam	Electricity	Refined petroleum products	Total
1978	0.0	2.1	20.3	0.0	25.8	176.1	224.3
1979	0.0	2.1	21.6	20.6	26.3	169.3	239.8
1980	0.0	2.4	18.6	22.1	27.1	165.9	236.1
1981	0.0	2.4	14.6	15.6	26.3	152.4	211.3
1982	0.0	2.3	8.5	19.5	25.4	145.0	200.6
1983	0.0	2.3	6.2	13.8	25.7	137.2	185.2
1984	0.0	2.7	7.2	9.7	28.2	138.4	186.2

1985	0.0	3.4	5.2	6.2	28.1	132.4	175.2
1986	0.0	2.4	7.8	0.2	28.7	132.1	171.1
1987	0.0	3.1	7.5	0.0	30.9	134.1	175.7
1988	0.0	3.0	2.6	0.0	32.6	141.0	179.2
1989	0.0	3.2	1.5	0.0	33.8	137.1	175.6
1990	0.0	3.4	2.0	0.0	35.6	136.7	177.7
1991	0.0	3.4	2.0	0.0	35.3	128.6	169.3
1992	0.0	3.5	1.6	0.0	36.1	131.1	172.3
1993	0.0	1.8	1.8	0.0	36.0	130.4	170.0
1994	0.0	1.5	1.6	0.0	36.3	132.2	171.6
1995	0.0	2.2	1.8	0.0	36.5	132.0	172.6
1996	0.0	2.7	1.8	0.0	36.7	130.5	171.8
1997	0.0	3.7	1.5	0.0	37.2	135.8	178.2
1998	0.0	2.9	1.7	0.0	38.8	137.8	181.1
1999	0.0	3.0	1.8	0.1	40.4	146.6	191.8
2000	0.0	3.2	2.0	0.1	41.1	142.3	188.7
2001	0.0	3.3	1.2	0.1	41.8	137.1	180.3
2002	3.0	x	x	1.7	42.4	134.4	181.4

Note: x indicates the data was suppressed. Columns may not sum to total because of rounding.

Figure 12. Energy use, final demand, in Nova Scotia, by sector, 1978 to 2002 (in TJ)

Year	Agriculture	Public administration	Commercial & institutional	Residential	Industrial	Transportation	Total
1978	2,519	10,951	14,092	43,065	56,593	62,182	189,402
1979	2,545	10,189	14,638	42,568	62,536	71,187	203,663
1980	2,398	9,167	14,024	43,980	61,849	69,957	201,375
1981	2,406	9,354	16,358	37,120	52,116	63,268	180,622
1982	2,291	10,519	20,508	36,466	45,966	56,761	172,511
1983	7,267	11,277	24,862	27,513	39,612	50,423	160,954
1984	2,634	12,497	23,176	32,526	38,460	54,058	163,351
1985	2,726	12,540	20,634	33,945	32,548	52,647	155,040
1986	2,813	12,949	19,591	33,301	31,493	52,032	152,179
1987	2,027	13,510	19,721	34,803	29,284	57,592	156,937
1988	2,114	11,264	20,998	36,831	25,212	64,395	160,814
1989	2,504	12,385	23,146	38,968	20,231	61,477	158,711
1990	2,524	11,182	22,066	39,988	23,677	62,219	161,656
1991	3,559	10,992	20,697	36,251	22,181	61,267	154,947
1992	4,267	11,767	21,603	38,582	21,969	60,241	158,429
1993	3,042	11,028	20,294	38,560	22,007	62,114	157,045
1994	3,141	11,559	19,836	36,903	23,838	63,819	159,096
1995	3,676	10,565	21,887	33,170	25,583	65,284	160,165
1996	3,629	8,845	22,186	35,007	24,938	65,406	160,011
1997	3,904	9,322	24,357	36,594	25,049	66,957	166,183
1998	3,784	8,653	23,534	34,665	26,123	72,046	168,805
1999	3,847	8,380	25,996	35,199	28,495	77,228	179,145

2000	4,351	8,936	25,191	36,025	28,703	73,042	176,248
2001	3,701	8,951	28,173	37,720	24,828	67,728	171,101
2002	3,332	8,960	28,647	37,325	29,552	65,911	173,727

Note: Columns may not sum to total because of rounding.

Figure 13. Energy use, final demand, in Nova Scotia per capita, by sector, 1978 to 2002 (in GJ/capita)

Year	Agriculture	Public administration	Commercial & institutional	Residential	Industrial	Transportation	Total
1978	3.0	13.0	16.7	51.0	67.0	73.6	224.3
1979	3.0	12.0	17.2	50.1	73.6	83.8	239.8
1980	2.8	10.7	16.4	51.6	72.5	82.0	236.1
1981	2.8	10.9	19.1	43.4	61.0	74.0	211.3
1982	2.7	12.2	23.8	42.4	53.5	66.0	200.6
1983	8.4	13.0	28.6	31.7	45.6	58.0	185.2
1984	3.0	14.2	26.4	37.1	43.8	61.6	186.2
1985	3.1	14.2	23.3	38.4	36.8	59.5	175.2
1986	3.2	14.6	22.0	37.4	35.4	58.5	171.1
1987	2.3	15.1	22.1	39.0	32.8	64.5	175.7
1988	2.4	12.6	23.4	41.0	28.1	71.8	179.2
1989	2.8	13.7	25.6	43.1	22.4	68.0	175.6
1990	2.8	12.3	24.3	44.0	26.0	68.4	177.7
1991	3.9	12.0	22.6	39.6	24.2	67.0	169.3
1992	4.6	12.8	23.5	42.0	23.9	65.5	172.3
1993	3.3	11.9	22.0	41.7	23.8	67.2	170.0
1994	3.4	12.5	21.4	39.8	25.7	68.8	171.6
1995	4.0	11.4	23.6	35.7	27.6	70.3	172.6
1996	3.9	9.5	23.8	37.6	26.8	70.2	171.8
1997	4.2	10.0	26.1	39.2	26.9	71.8	178.2
1998	4.1	9.3	25.3	37.2	28.0	77.3	181.1
1999	4.1	9.0	27.8	37.7	30.5	82.7	191.8
2000	4.7	9.6	27.0	38.6	30.7	78.2	188.7
2001	4.0	9.6	30.2	40.5	26.6	72.6	183.5
2002	3.6	9.6	30.7	39.9	31.6	70.5	185.9

Note: Columns may not sum to total because of rounding.

Figure 14. Electricity use by sector, Nova Scotia 1978 to 2002 (in TJ)

Year	Agriculture	Public administration	Commercial & institutional	Residential	Industrial	Total
1978	137	981	4,308	6,518	9,828	21,772
1979	178	913	4,523	7,596	9,102	22,312
1980	185	825	5,237	7,850	9,038	23,136
1981	195	1,038	5,093	7,189	8,937	22,454

1982	203	1,012	4,841	7,365	8,403	21,826
1983	214	1,057	5,291	7,779	8,010	22,351
1984	229	1,060	5,883	8,812	8,739	24,723
1985	243	1,089	6,033	9,165	8,325	24,855
1986	234	1,094	5,860	9,786	8,559	25,533
1987	278	1,120	6,975	10,395	8,852	27,620
1988	302	1,117	7,411	11,309	9,081	29,220
1989	265	1,111	7,969	12,241	8,948	30,534
1990	247	1,134	8,570	12,124	10,312	32,387
1991	215	1,082	8,258	11,968	10,791	32,314
1992	217	1,127	8,717	12,781	10,337	33,179
1993	187	1,163	8,731	12,610	10,609	33,300
1994	207	1,192	8,668	12,853	10,768	33,688
1995	198	1,155	8,933	12,603	10,966	33,855
1996	201	1,130	8,891	12,911	11,072	34,205
1997	199	1,049	9,358	13,009	11,086	34,701
1998	197	1,329	10,256	12,541	11,794	36,117
1999	201	856	10,807	12,822	13,023	37,709
2000	206	1,171	10,013	13,314	13,643	38,347
2001	236	1,208	10,288	14,296	12,960	39,004
2002	237	1,210	10,570	14,777	12,793	39,601

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 15. Refined petroleum product use in Nova Scotia, by sector, 1978 to 2002 (in TJ)

Year	Agriculture	Public administration	Commercial & institutional	Industrial	Residential	Transportation	Total
1978	2,382	9,970	8,893	30,866	34,402	62,182	148,695
1979	2,367	9,276	9,033	19,028	32,869	71,186	143,759
1980	2,213	8,342	8,064	19,125	33,778	69,955	141,477
1981	2,212	8,290	10,339	18,505	27,672	63,265	130,283
1982	2,088	9,442	14,455	15,287	26,635	56,755	124,662
1983	7,053	10,218	18,448	15,769	17,324	50,394	119,206
1984	2,371	11,322	16,216	16,236	21,403	53,886	121,434
1985	2,457	11,393	13,479	14,988	22,403	52,442	117,162
1986	2,558	11,813	12,848	17,096	21,284	51,841	117,440
1987	1,724	12,339	11,813	14,492	22,110	57,359	119,837
1988	1,786	10,037	12,545	14,213	23,619	64,292	126,492
1989	2,214	11,274	13,933	10,212	24,905	61,374	123,912
1990	2,252	10,046	12,415	11,657	25,911	62,095	124,376
1991	3,316	9,910	11,338	9,738	22,277	61,142	117,721
1992	3,916	10,640	11,830	10,241	23,808	60,129	120,564
1993	2,824	9,865	10,907	10,317	24,562	61,979	120,454
1994	2,921	10,367	10,328	11,988	23,187	63,769	122,560
1995	3,451	9,410	11,923	12,990	19,581	65,196	122,551

1996	3,391	7,716	12,041	12,119	20,990	65,299	121,556
1997	3,660	8,273	13,250	12,251	22,355	66,809	126,598
1998	3,555	7,319	12,207	12,309	21,108	71,907	128,405
1999	3,604	7,520	13,842	13,348	21,593	77,002	136,909
2000	4,116	7,761	13,778	12,490	21,793	72,972	132,910
2001	3,435	7,745	16,167	10,513	22,384	67,630	127,874
2002	3,047	7,751	15,874	11,261	21,797	65,831	125,561

Note: Columns may not sum to total because of rounding.

Figure 16. Comparison of energy use, final demand, 1978 to 2002 (in TJ)

Year	Nova Scotia	Atlantic Canada	Canada
1978	189,403	476,323	5,910,272
1979	203,664	502,200	6,170,620
1980	201,376	502,686	6,156,862
1981	180,623	460,467	5,948,585
1982	172,511	424,822	5,682,564
1983	160,955	404,093	5,515,327
1984	163,352	414,313	5,736,056
1985	155,042	402,016	5,846,583
1986	152,179	408,697	5,867,033
1987	156,938	417,482	5,918,386
1988	160,816	428,124	6,309,009
1989	158,713	439,762	6,499,076
1990	161,654	454,457	6,299,396
1991	154,949	437,839	6,208,827
1992	158,429	439,007	6,327,586
1993	157,047	436,003	6,447,440
1994	159,096	445,435	6,654,748
1995	160,166	450,287	6,785,042
1996	160,011	454,726	7,040,445
1997	166,183	472,961	7,095,477
1998	168,804	467,724	6,956,184
1999	179,145	481,323	7,132,504
2000	176,247	496,742	7,375,967
2001	171,100	484,673	7,175,442
2002	173,727	494,230	7,404,302

Figure 18. Average energy consumption of new appliances in Canada, 1990 and 2001 models

Appliance	kWh / year	
	1990	2001
Freezers	713.8	383.9
Ranges	772.2	762.5
Dishwashers	1025.7	633.7
Refrigerators	956	550*
Clothes dryers	1102.6	916.3
Clothes washers	1218	810.1

Note: The 2001 value for refrigerators was provided by Trudeau, 2005.

Figure 19. Energy efficiency of Canadian refrigerators, 1990-2002

Year	kWh / year	
	Stock	New
1990	1,524.8	956.2
1991	1,477.8	931.2
1992	1,427.0	901.7
1993	1,363.1	719.6
1994	1,293.7	650.4
1995	1,230.2	641.6
1996	1,166.5	640.4
1997	1,105.3	656.6
1998	1,047.0	653.5
1999	993.1	645.5
2000	945.1	639.5
2001	895.6	559.4
2002	849.3	550.0

Figure 21. Efficiency of thermal-electric power stations in Canada, by fuel type, 1980 to 2002

Year	Percent energy conversion to electricity		
	Average coal	Average oil	Natural gas
1980	31.6	28.7	26.9
1981	31.1	30.7	25.7
1982	31.7	31.1	26.2
1983	31.7	30.7	25.8
1984	32.5	31.0	24.5
1985	32.1	31.0	24.8
1986	34.3	33.3	25.1
1987	34.7	32.9	27.4
1988	34.6	32.5	29.0
1989	34.4	33.8	31.6

1990	34.5	33.2	29.5
1991	33.1	32.4	29.7
1992	35.3	33.1	30.7
1993	34.5	33.8	33.2
1994	32.2	32.1	29.1
1995	32.3	34.0	35.1
1996	32.6	31.9	33.3
1997	33.2	32.4	35.4
1998	33.6	32.6	34.7
1999	33.3	31.8	35.4
2000	32.4	30.7	35.1
2001	31.2	31.2	34.4
2002	32.0	31.5	35.9

Figure 22. Number of transmission outages in Nova Scotia, 1993 to 2004

Year	Number Outages
1993	168
1994	150
1995	161
1996	161
1997	178
1998	126
1999	125
2000	160
2001	125
2002	133
2003	139
2004	131

Chapter 6

Figure 23. Nova Scotia CO emissions by category, 2000

Category	Emissions (t)
Industrial	7,302
Fuel combustion	52,778
Transportation	229,704
Incineration	457
Miscellaneous	389
Open sources	2,476

Figure 24. Per Capita CO emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000 (t/capita)

Year	Industrial fuel combustion	Industrial & commercial fuel combustion	Electric power generation (utilities)	Residential fuel combustion	Residential fuel wood combustion	Total non-transportation energy sources
1970	n/a	1	0	8	n/a	9.0
1972	0	n/a	1	7	0	9.0
1974	0	n/a	1	5	6	12.5
1976	1	n/a	2	3	14	20.8
1978	2	n/a	1	3	13	19.6
1980	2	n/a	2	3	25	31.7
1985	0	n/a	6	3	30	40.1
1990	n/a	n/a	1	5	55	61.9
1995	n/a	n/a	1	1	114	116.2
2000	n/a	n/a	5	0	51	56.5

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 25. Nova Scotia TPM emissions, 2000, by category (excluding open sources) and Figure 26. Total Nova Scotia TPM emissions, 2000, by category (including open sources)

Category	Emissions (t)
Industrial	21,631
Fuel combustion	14,109
Transportation	1,879
Incineration	34
Miscellaneous	299
Open sources	354,229

Figure 27. Per Capita TPM emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000 (t/capita)

Year	Comm. fuel	Indust. Fuel	Indust. & comm. fuel	Electric power (utilities)	Resident. Fuel	Resident. wood	Upstream fuel process.	Total non-transport.
1970	n/a	n/a	5	4	3	n/a	0	11.8
1972	3	2	n/a	15	3	1	0	25.5
1974	1	2	n/a	17	3	3	0	26.2
1976	1	7	n/a	25	1	2	0	36.5
1978	1	2	n/a	13	1	2	0	19.3
1980	1	2	n/a	15	1	6	0	24.1
1985	0	3	n/a	5	1	8	10	26.7

1990	0	n/a	n/a	7	1	8	3	18.3
1995	0	n/a	n/a	2	0	15	0	18.2
2000	0	n/a	n/a	6	0	8	0	15.5

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 28. Nova Scotia SO_x Emissions by Category, 2000

Category	Emissions (t)
Industrial	17,130
Fuel combustion	146,549
Transportation	2,596
Incineration	101
Miscellaneous	0
Open sources	0

Figure 29. Per Capita SO_x emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000 (t/capita)

Year	Commercial fuel	Industrial Fuel	Indust. & comm. fuel	Electric power (utilities)	Resident. Fuel	Total non-transportation
1970	n/a	n/a	44	65	19	128.1
1972	41	25	n/a	91	21	178.7
1974	16	24	n/a	106	18	163.8
1976	12	107	n/a	111	13	242.0
1978	11	36	n/a	134	12	193.8
1980	10	37	n/a	147	10	203.3
1985	5	18	n/a	147	6	175.3
1990	3	n/a	n/a	157	7	167.2
1995	4	n/a	n/a	145	5	154.0
2000	4	n/a	n/a	150	4	157.0

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 31. Nova Scotia NO_x Emissions by Category, 2000

Category	Emissions (t)
Industrial	4,424
Fuel combustion	30,514
Transportation	35,663
Incineration	69
Miscellaneous	0
Open sources	79

Figure 32. Per capita NO_x emissions from stationary energy-related sources, Nova Scotia, 1970 to 2000 (t/capita)

Year	Comm. fuel	Indust. Fuel	Indust. & comm. fuel	Electric power	Resident. Fuel	Resident. wood	Total non-transport.
1970	n/a	n/a	6	16	2	n/a	24.7
1972	7	5	n/a	26	3	1	41.8
1974	3	5	n/a	30	3	1	42.2
1976	3	25	n/a	35	3	0	66.2
1978	3	8	n/a	47	3	0	61.2
1980	2	4	n/a	36	3	0	45.4
1985	1	3	n/a	25	2	0	31.2
1990	1	n/a	n/a	25	2	1	28.7
1995	1	n/a	n/a	26	2	1	30.4
2000	1	n/a	n/a	29	2	1	32.7

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity.

Figure 33. Nova Scotia VOC emissions by category, 2000

Category	Emissions (t)
Transportation	19,047
Miscellaneous	13,827
Fuel combustion	11,473
Industrial	9,152
Open sources	2,298
Incineration	286

Figure 34. Per capita VOC emissions from stationary energy-related sources, Nova Scotia, 1970-2000 (t/capita)

Year	Comm. fuel	Indust. Fuel	Indust. & comm. fuel	Electric power (utilities)	Resident. Fuel	Resident. wood	Upstream fuel process.	Total non-transport.
1970	n/a	n/a	1	0	2	n/a	0	3.2
1972	0	0	n/a	0	2	0	0	3.1
1974	0	0	n/a	0	1	7	0	9.6
1976	0	1	n/a	1	1	8	0	9.9
1978	0	1	n/a	0	1	3	15	20.0
1980	0	0	n/a	0	1	1	15	16.7
1985	0	0	n/a	0	0	5	0	5.7
1990	0	n/a	n/a	0	0	31	0	31.9
1995	0	n/a	n/a	0	0	31	0	31.7
2000	0	n/a	n/a	0	0	12	0	12.3

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity.

Figure 36. Nova Scotia Power's mercury releases and transfers, 1999 to 2002 (kg)

State of Mercury	1999	2000	2001	2002
Recycled	6.2	6.2	4.2	0.1
Disposal	36.7	36.7	23.6	16.9
On-site releases (emissions)	267.0	267.0	184.6	163.0

Figure 37. Nova Scotia's GHG emissions by category, 2002

Category	kt CO_2 eq.
Stationary combustion	12,600
Transportation	5,770
Fugitive sources	480
Industrial	210
Wastes	730
Agriculture, forestry, land use	601
Solvent & other product use	14
Total	20,400

Figure 38. Nova Scotia's stationary energy-related GHG emissions by source, 1990 to 2002 (kt CO_2 eq.)

Sector	Electricity & heat	Industrial	Commercial & institutional	Residential	Agriculture & forestry	Coal mining	Total
1990	6,830	1,512	810	2,210	107	1,200	12,700
1991	7,010	1,490	794	1,950	191	1,300	12,735
1992	7,410	1,487	948	2,060	237	1,200	13,342
1993	7,350	1,600	789	2,090	154	1,100	13,083
1994	7,190	1,421	735	1,950	148	970	12,414
1995	6,850	1,637	817	1,680	203	830	12,017
1996	7,070	1,598	809	1,790	227	830	12,324
1997	7,520	1,537	946	1,910	250	690	12,853
1998	7,800	1,563	756	1,790	222	510	12,641
1999	8,060	1,449	865	1,810	209	330	12,723
2000	8,830	1,692	922	1,830	237	250	13,761
2001	8,499	1,411	1,070	1,880	140	270	13,270
2002	7,513	2,107	1,040	1,820	120	270	12,870

Note: Columns may not sum to total because of rounding. Since 2001 data for electricity and heat, mining (within the industrial stationary combustion category), and agriculture and forestry, have been suppressed for confidentiality reasons. Data for these sectors were therefore estimated using Environment Canada's Provincial/Territorial Analysis.

Figure 39. Nova Scotia stationary energy-related GHG emissions by source with electricity emissions attributed to end use, 1990 to 2002 (kt CO_2 eq.)

Year	Industrial	Commercial & institutional	Residential	Agriculture & forestry	Coal mining	Total
1990	3,687	2,856	4,767	159	1,200	12,700
1991	3,831	2,820	4,546	238	1,300	12,735
1992	3,796	3,147	4,914	285	1,200	13,342
1993	3,942	2,973	4,873	195	1,100	13,083
1994	3,719	2,839	4,693	192	970	12,414
1995	3,856	2,858	4,230	243	830	12,017
1996	3,887	2,880	4,459	269	830	12,324
1997	3,939	3,201	4,729	293	690	12,853
1998	4,110	3,258	4,498	265	510	12,641
1999	4,233	3,358	4,551	252	330	12,723
2000	4,834	3,497	4,896	284	250	13,761
2001	4,235	3,575	4,995	191	270	13,267
2002	4,534	3,275	4,623	165	270	12,867

Note: Columns may not sum to total because of rounding.

Appendix A

Figure 42. Energy use, final demand, by fuel including transportation, Atlantic Canada, 1978 to 2002 (TJ)

Year	Natural gas	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Steam	Electricity	Total refined petroleum products	Total
1978	84	3,582	21,222	n/a	74,659	376,776	476,323
1979	96	3,881	22,859	18,080	76,378	380,907	502,201
1980	82	4,106	20,408	20,342	79,697	378,050	502,685
1981	71	4,044	14,810	14,729	81,103	345,711	460,468
1982	68	3,890	9,897	17,966	77,918	315,082	424,821
1983	55	3,987	7,444	13,068	81,701	297,838	404,093
1984	38	4,633	7,862	9,800	90,919	301,061	414,313
1985	36	5,506	6,199	6,730	91,599	291,948	402,018
1986	28	4,439	12,231	1,437	97,611	292,950	408,696
1987	25	5,374	8,016	1,261	101,998	300,807	417,481
1988	0	5,783	3,757	982	107,451	310,149	428,122
1989	0	6,362	2,820	950	111,766	317,863	439,761
1990	0	6,168	6,519	2,138	112,717	326,917	454,459

1991	0	6,390	4,953	2,158	114,424	309,914	437,839
1992	0	6,932	4,886	2,055	116,694	308,442	439,009
1993	0	4,678	4,615	1,798	117,657	307,258	436,006
1994	0	3,993	6,210	4,726	118,649	311,860	445,438
1995	0	6,580	6,230	4,393	120,528	312,558	450,289
1996	0	7,330	6,520	4,274	121,761	314,839	454,724
1997	0	9,142	7,433	5,933	125,575	324,878	472,961
1998	0	7,166	6,817	6,304	125,406	322,032	467,725
1999	0	7,567	6,091	6,451	127,867	333,350	481,326
2000	0	9,691	7,551	6,332	132,532	340,636	496,742
2001	4,156	x	2,932	6,127	131,256	327,227	471,698
2002	14,738	x	2,868	7,478	134,653	324,303	484,040

Note: x indicates the data was suppressed. Columns may not sum to total because of rounding.

Figure 43. Energy use, final demand, by fuel including transportation, Canada, 1978 to 2002 (TJ)

Year	Steam	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Natural gas	Electricity	Total refined petroleum products	Total
1978	n/a	50,808	246,927	1,485,517	1,032,732	3,094,294	5,910,278
1979	43,816	61,999	255,232	1,553,330	1,059,308	3,196,938	6,170,623
1980	43,140	62,518	252,316	1,522,770	1,107,030	3,169,091	6,156,865
1981	45,742	60,517	226,627	1,512,963	1,144,372	2,958,366	5,948,587
1982	63,159	69,785	205,121	1,546,028	1,134,048	2,657,173	5,675,314
1983	50,642	70,047	215,096	1,510,129	1,186,972	2,482,445	5,515,331
1984	46,443	75,520	238,151	1,641,336	1,277,535	2,457,074	5,736,059
1985	33,966	84,857	238,518	1,763,867	1,336,111	2,389,268	5,846,587
1986	32,235	79,997	228,131	1,713,402	1,396,554	2,416,717	5,867,036
1987	27,597	85,645	223,241	1,697,170	1,452,216	2,432,523	5,918,392
1988	16,392	95,336	229,986	1,883,077	1,524,745	2,559,477	6,309,013
1989	24,433	99,905	219,763	1,957,305	1,559,037	2,638,641	6,499,084
1990	26,585	98,051	178,537	1,910,700	1,558,741	2,526,788	6,299,402
1991	30,799	104,903	185,175	1,929,062	1,576,604	2,382,290	6,208,833
1992	22,942	115,696	183,870	2,014,671	1,592,940	2,397,472	6,327,591
1993	16,795	101,135	173,960	2,086,863	1,626,394	2,442,304	6,447,451
1994	23,129	103,170	175,849	2,155,411	1,648,263	2,548,931	6,654,753
1995	29,655	123,230	178,279	2,215,063	1,681,139	2,557,684	6,785,050
1996	28,335	108,967	179,313	2,366,249	1,708,204	2,649,384	7,040,452
1997	24,834	113,779	178,816	2,327,877	1,729,396	2,720,783	7,095,485
1998	28,727	99,863	177,570	2,163,769	1,719,379	2,766,883	6,956,191

1999	33,070	95,850	182,328	2,231,992	1,753,580	2,835,693	7,132,513
2000	33,981	99,671	189,286	2,346,735	1,812,245	2,894,055	7,375,973
2001	35,714	106,621	178,974	2,161,963	1,809,650	2,882,525	7,175,447
2002	35,503	99,737	177,847	2,358,145	1,845,767	2,887,311	7,404,310

Note: Columns may not sum to total because of rounding.

Figure 44. Energy use, final demand per capita, by fuel including transportation, Atlantic Canada, 1978 to 2002 (GJ/capita)

Year	Natural gas	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Steam	Electricity	Total refined petroleum products	Total
1978	0.0	1.6	9.5	0.0	33.4	168.7	213.3
1979	0.0	1.7	10.2	8.1	34.0	169.6	223.6
1980	0.0	1.8	9.0	9.0	35.3	167.6	222.9
1981	0.0	1.8	6.6	6.5	35.9	153.0	203.8
1982	0.0	1.7	4.4	7.9	34.4	139.0	187.4
1983	0.0	1.7	3.3	5.7	35.7	130.1	176.5
1984	0.0	2.0	3.4	4.3	39.4	130.6	179.7
1985	0.0	2.4	2.7	2.9	39.6	126.1	173.6
1986	0.0	1.9	5.3	0.6	42.1	126.3	176.2
1987	0.0	2.3	3.4	0.5	43.9	129.4	179.6
1988	0.0	2.5	1.6	0.4	46.1	133.0	183.6
1989	0.0	2.7	1.2	0.4	47.7	135.5	187.5
1990	0.0	2.6	2.8	0.9	47.8	138.6	192.7
1991	0.0	2.7	2.1	0.9	48.3	130.7	184.7
1992	0.0	2.9	2.1	0.9	49.1	129.7	184.6
1993	0.0	2.0	1.9	0.8	49.3	128.8	182.8
1994	0.0	1.7	2.6	2.0	49.7	130.8	186.8
1995	0.0	2.8	2.6	1.8	50.6	131.3	189.1
1996	0.0	3.1	2.7	1.8	51.2	132.3	191.1
1997	0.0	3.9	3.1	2.5	52.9	137.0	199.4
1998	0.0	3.0	2.9	2.7	53.2	136.6	198.3
1999	0.0	3.2	2.6	2.7	54.3	141.6	204.5
2000	0.0	4.1	3.2	2.7	56.4	145.0	211.5
2001	1.8	x	1.3	2.6	56.1	139.8	201.5
2002	6.3	x	1.2	3.2	57.5	138.5	206.8

Note: x indicates the data was suppressed. Columns may not sum to total because of rounding.

Figure 45. Energy use, final demand per capita by fuel including transportation, Canada, 1978 to 2002 (GJ/capita)

Year	Steam	Natural gas liquids (NGL's)	Coal, coke & coke oven gas	Natural gas	Electricity	Total refined petroleum products	Total
1978	0.0	2.1	10.3	62.0	43.1	129.1	246.6
1979	1.8	2.6	10.5	64.2	43.8	132.1	255.0
1980	1.8	2.6	10.3	62.1	45.2	129.3	251.1
1981	1.8	2.4	9.1	61.0	46.1	119.2	239.7
1982	2.5	2.8	8.2	61.6	45.1	105.8	226.0
1983	2.0	2.8	8.5	59.5	46.8	97.9	217.4
1984	1.8	2.9	9.3	64.1	49.9	96.0	224.0
1985	1.3	3.3	9.2	68.3	51.7	92.5	226.2
1986	1.2	3.1	8.7	65.6	53.5	92.6	224.8
1987	1.0	3.2	8.4	64.2	54.9	92.0	223.8
1988	0.6	3.6	8.6	70.3	56.9	95.5	235.5
1989	0.9	3.7	8.1	71.7	57.1	96.7	238.2
1990	1.0	3.5	6.4	69.0	56.3	91.2	227.4
1991	1.1	3.7	6.6	68.8	56.2	85.0	221.5
1992	0.8	4.1	6.5	71.0	56.2	84.5	223.1
1993	0.6	3.5	6.1	72.8	56.7	85.2	224.8
1994	0.8	3.6	6.1	74.3	56.8	87.9	229.5
1995	1.0	4.2	6.1	75.6	57.4	87.3	231.6
1996	1.0	3.7	6.1	79.9	57.7	89.5	237.8
1997	0.8	3.8	6.0	77.8	57.8	91.0	237.3
1998	1.0	3.3	5.9	71.7	57.0	91.7	230.7
1999	1.1	3.2	6.0	73.4	57.7	93.3	234.6
2000	1.1	3.2	6.2	76.5	59.1	94.3	240.3
2001	1.2	3.4	5.8	69.7	58.3	92.9	231.3
2002	1.1	3.2	5.7	75.2	58.9	92.1	236.1

Note: Columns may not sum to total because of rounding.

Figure 46. Energy use, final demand per capita, by sector, Atlantic Canada, 1978 to 2002 (GJ/capita)

Year	Agricult.	Public admin.	Comm. & other institut.	Resident.	Indust.	Transport.	Total
1978	3.1	10.7	18.9	46.6	65.4	68.5	213.3
1979	3.1	9.7	18.4	43.6	69.9	79.0	223.6
1980	3.2	8.6	19.4	44.7	69.8	77.2	222.9
1981	3.2	9.6	20.9	38.5	61.5	70.1	203.8
1982	3.1	10.8	24.3	37.9	53.7	57.6	187.4

1983	6.4	10.5	28.6	29.6	48.7	52.8	176.5
1984	3.3	10.8	27.2	32.4	50.8	55.2	179.7
1985	3.3	11.0	24.0	33.5	46.5	55.3	173.6
1986	3.1	10.4	24.2	33.5	49.9	55.1	176.2
1987	2.3	10.5	23.6	34.4	48.6	60.2	179.6
1988	2.3	9.9	23.8	36.4	44.5	66.6	183.6
1989	2.8	11.0	25.3	38.6	43.5	66.4	187.5
1990	2.7	10.6	25.0	39.8	47.3	67.4	192.7
1991	3.3	10.3	23.5	38.1	43.7	66.0	184.7
1992	3.8	10.1	23.3	39.9	42.1	65.3	184.6
1993	3.3	9.8	22.8	39.5	41.8	65.7	182.8
1994	3.4	10.8	22.8	37.7	45.3	66.8	186.8
1995	3.9	10.8	23.4	34.9	47.3	68.9	189.1
1996	3.8	9.9	23.5	36.0	47.0	70.8	191.1
1997	4.2	11.4	25.3	37.5	48.9	72.1	199.4
1998	4.2	11.0	23.9	35.2	48.2	75.8	198.3
1999	4.2	10.8	25.2	35.3	48.6	80.3	204.5
2000	4.1	11.4	27.1	36.0	53.1	79.8	211.5
2001	3.4	11.0	28.7	36.4	50.7	76.9	207.0
2002	3.3	10.6	29.4	37.1	55.3	75.5	211.1

Note: Columns may not sum to total because of rounding.

Figure 47. Energy use, final demand per capita by sector, Canada, 1978 to 2002 (GJ/capita)

Year	Agricult.	Public admin.	Comm. & other institut.	Resident.	Indust.	Transport.	Total
1978	8.0	6.0	31.2	48.7	79.8	72.9	246.6
1979	8.1	6.0	30.8	48.5	83.6	77.9	255.0
1980	7.7	5.0	29.9	48.2	81.7	78.7	251.1
1981	7.6	5.6	33.2	44.3	76.7	72.3	239.7
1982	6.9	5.7	36.2	45.6	69.0	62.7	226.0
1983	9.7	5.3	34.7	40.9	67.4	59.4	217.4
1984	6.5	5.0	35.5	42.1	73.1	61.8	224.0
1985	6.6	5.0	34.5	43.6	73.7	62.9	226.2
1986	6.7	5.2	33.9	42.5	74.3	62.1	224.8
1987	6.3	5.1	31.1	40.6	76.1	64.6	223.8
1988	6.7	5.2	32.9	42.8	79.2	68.6	235.5
1989	7.3	5.3	34.1	44.9	78.0	68.6	238.2
1990	7.2	5.2	32.9	43.5	72.5	66.2	227.4
1991	7.0	4.8	32.9	42.2	70.6	64.0	221.5
1992	6.9	4.7	32.9	42.9	69.1	66.5	223.1
1993	6.9	4.6	33.8	43.8	68.8	66.9	224.8

1994	6.8	4.9	32.9	44.4	70.8	69.7	229.5
1995	7.1	4.9	34.2	43.0	71.9	70.5	231.6
1996	7.5	4.5	34.5	45.9	73.6	71.8	237.8
1997	7.7	4.5	35.3	43.3	73.5	73.0	237.3
1998	7.5	4.3	33.6	39.2	71.3	74.8	230.7
1999	7.6	4.1	34.9	40.5	71.6	75.9	234.6
2000	7.6	4.3	38.3	42.0	73.9	74.3	240.3
2001	7.0	4.1	38.2	40.0	69.8	72.2	231.3
2002	6.6	4.1	40.8	41.3	71.5	71.7	236.1

Note: Columns may not sum to total because of rounding.

Figure 48. Energy use, final demand by sector, Atlantic Canada, 1978 to 2002 (TJ)

Year	Agricult.	Public admin.	Comm. & other institut.	Resident.	Indust.	Transport.	Total
1978	6,877	23,809	42,222	104,181	146,164	153,067	476,323
1979	6,874	21,806	41,237	97,918	156,897	177,468	502,200
1980	7,319	19,344	43,689	100,925	157,335	174,075	502,686
1981	7,184	21,586	47,336	87,019	139,002	158,341	460,467
1982	6,966	24,577	55,172	85,887	121,753	130,467	424,822
1983	14,627	23,939	65,444	67,773	111,511	120,798	404,093
1984	7,547	24,969	62,708	74,692	117,113	127,284	414,313
1985	7,651	25,439	55,625	77,591	107,679	128,031	402,016
1986	7,202	24,125	56,118	77,660	115,814	127,777	408,697
1987	5,408	24,398	54,848	79,927	113,021	139,878	417,482
1988	5,459	23,153	55,474	84,771	103,882	155,387	428,124
1989	6,536	25,684	59,382	90,474	101,959	155,727	439,762
1990	6,340	24,957	58,866	93,932	111,519	158,843	454,457
1991	7,731	24,305	55,627	90,230	103,579	156,367	437,839
1992	9,072	24,069	55,484	94,916	100,128	155,336	439,007
1993	7,758	23,299	54,334	94,210	99,648	156,754	436,003
1994	8,210	25,739	54,360	89,818	107,937	159,371	445,435
1995	9,314	25,749	55,620	83,060	112,572	163,975	450,287
1996	9,034	23,582	56,001	85,698	111,857	168,552	454,726
1997	9,894	27,053	59,952	89,072	115,915	171,079	472,961
1998	9,864	25,942	56,474	82,971	113,662	178,812	467,724
1999	9,938	25,392	59,260	83,104	114,491	189,140	481,323
2000	9,514	26,771	63,576	84,561	124,841	187,480	496,742
2001	7,952	25,713	67,236	85,128	118,693	179,951	484,673
2002	7,694	24,726	68,743	86,928	129,353	176,788	494,230

Note: Columns may not sum to total because of rounding.

Figure 49. Energy use, final demand by sector, Canada, 1978 to 2002 (TJ)

Year	Agricult.	Public admin.	Comm. & other institut.	Resident.	Industrial	Transport.	Total
1978	191,989	144,558	747,403	1,166,740	1,912,106	1,747,475	5,910,271
1979	196,715	145,612	746,493	1,172,768	2,023,890	1,885,137	6,170,615
1980	189,592	121,472	731,994	1,181,477	2,003,867	1,928,455	6,156,857
1981	187,568	138,420	825,276	1,100,630	1,902,812	1,793,878	5,948,584
1982	173,758	142,073	908,145	1,144,475	1,732,820	1,574,042	5,675,313
1983	246,383	133,689	880,777	1,037,760	1,709,268	1,507,458	5,515,335
1984	167,204	127,991	908,480	1,077,828	1,870,780	1,583,770	5,736,053
1985	170,406	129,105	891,272	1,126,868	1,903,706	1,625,227	5,846,584
1986	175,735	136,006	884,939	1,108,839	1,939,961	1,621,557	5,867,037
1987	167,144	134,658	822,789	1,072,621	2,011,871	1,709,303	5,918,386
1988	180,378	140,210	881,248	1,145,960	2,121,816	1,839,400	6,309,012
1989	200,451	145,864	930,305	1,224,387	2,127,556	1,870,517	6,499,080
1990	199,155	144,045	910,352	1,204,043	2,008,930	1,832,876	6,299,401
1991	195,243	134,403	923,149	1,183,145	1,977,752	1,795,136	6,208,828
1992	196,859	133,660	933,407	1,216,263	1,961,556	1,885,842	6,327,587
1993	198,765	132,053	968,598	1,256,662	1,973,194	1,918,174	6,447,446
1994	195,795	143,142	954,431	1,286,711	2,053,352	2,021,320	6,654,751
1995	209,249	143,347	1,002,619	1,259,102	2,105,632	2,065,089	6,785,038
1996	222,920	134,136	1,020,353	1,358,158	2,180,523	2,124,710	7,040,800
1997	230,044	135,866	1,054,808	1,295,115	2,196,881	2,182,902	7,095,616
1998	224,728	130,284	1,012,330	1,183,519	2,149,029	2,256,632	6,956,522
1999	229,865	124,522	1,061,446	1,232,263	2,177,297	2,307,283	7,132,676
2000	231,927	131,288	1,176,423	1,287,825	2,268,624	2,279,845	7,375,932
2001	218,075	126,813	1,184,065	1,239,970	2,166,287	2,240,367	7,175,577
2002	205,655	129,793	1,280,530	1,295,129	2,243,667	2,249,769	7,404,543

Note: Columns do not sum to total in original Statistics Canada data possibly because of rounding and other unknown factors.

Appendix B

Figure 50. Relative and absolute levels for CO emissions from stationary energy sources (stationary combustion and coal mining) for Nova Scotia, 1970 to 2000

Year	CO From Energy Sources (kt)	Stationary Energy Emissions as Percent of Total CO Emissions
1970	7	1.3
1972	7	1.9
1974	10	2.6
1976	17	4.3

1978	17	5.2
1980	27	7.6
1985	35	11.9
1990	56	17.4
1995	108	34.1
2000	53	18.0

Figure 51. Per capita CO emissions from stationary energy sources for Atlantic Canada, 1970 to 2000 (t/capita)

Year	Indust. & comm. fuel	Indust. Fuel	Electric power (utilities)	Resident. Fuel	Resident. Wood	Total non-transport.
1970	1	n/a	0	6	0	7.3
1972	n/a	0	1	4	0	5.5
1974	n/a	0	1	2	7	11.3
1976	n/a	1	1	2	14	18.2
1978	n/a	1	1	1	13	17.5
1980	n/a	1	1	2	36	40.1
1985	n/a	1	3	1	58	63.1
1990	n/a	n/a	2	17	31	50.1
1995	n/a	n/a	1	0	125	127.1
2000	n/a	n/a	3	0	63	66.4

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 52. Per capita CO emissions from stationary energy sources for Canada, 1970 to 2000 (t/capita)

Year	Indust. & comm. fuel	Indust. Fuel	Electric power (utilities)	Resident. Fuel	Resident. Wood	Total non-transport.
1970	1	n/a	0	n/a	3	4.7
1972	n/a	1	1	0	2	3.4
1974	n/a	1	1	5	1	7.2
1976	n/a	1	1	9	1	11.4
1978	n/a	1	1	10	1	12.6
1980	n/a	2	1	16	1	19.6
1985	n/a	22	2	24	1	48.9
1990	n/a	n/a	2	23	1	26.3
1995	n/a	n/a	1	35	0	36.8
2000	n/a	n/a	1	22	0	23.2

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 53. Relative and absolute levels for TPM emissions from stationary energy sources for Nova Scotia, 1970 to 2000

Year	TPM From Energy Sources (kt)	Stationary Energy Emissions as Percent of Total TPM Emissions
1970	9	12
1972	20	28
1974	21	24
1976	31	40
1978	16	24
1980	21	27
1985	24	33
1990	17	34
1995	17	4
2000	14	4

Figure 54. Per capita TPM emissions of stationary energy sources for Atlantic Canada, 1970 to 2000 (t/capita)

Year	Upstream Fuel Process.	Resident. Wood	Resident. Fuel	Electric power (utilities)	Comm. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	0	n/a	3	5	n/a	n/a	5	12.5
1972	0	2	2	10	2	2	n/a	19.4
1974	0	4	2	11	1	3	n/a	21.2
1976	0	2	1	13	1	7	n/a	23.6
1978	0	2	1	8	1	3	n/a	14.8
1980	1	8	0	12	1	3	n/a	24.5
1985	4	14	0	9	0	2	n/a	31.0
1990	1	6	0	4	0	n/a	n/a	12.6
1995	0	17	0	2	0	n/a	n/a	18.9
2000	0	11	0	3	0	n/a	n/a	14.7

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 55. Per capita TPM emissions of stationary energy sources in Canada, 1970 to 2000 (t/capita)

Year	Upstream Fuel Process.	Resident. Wood	Resident. Fuel	Electric power (utilities)	Comm. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	0	n/a	2	10	n/a	n/a	6	17.8
1972	0	1	1	7	1	3	n/a	13.8
1974	0	2	1	8	1	2	n/a	15.0
1976	3	2	0	8	0	3	n/a	15.8

1978	3	2	0	7	0	2	n/a	14.8
1980	4	4	0	6	0	2	n/a	16.9
1985	6	6	0	4	0	4	n/a	21.0
1990	3	4	0	6	n/a	0	n/a	12.4
1995	0	5	0	3	n/a	0	n/a	8.1
2000	0	3	0	4	n/a	0	n/a	8.1

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 56. Relative and absolute levels for SO_x emissions from stationary energy sources for Nova Scotia, 1970 to 2000

Year	SOx From Energy Sources (kt)	Stationary Energy Emissions as Percent of Total SOx Emissions
1970	102	86
1972	143	82
1974	134	76
1976	202	91
1978	164	88
1980	173	90
1985	155	91
1990	152	85
1995	143	86
2000	147	88

Figure 57. Per capita SO_x emissions from stationary energy sources for Atlantic Canada, 1970 to 2000 (t/capita)

Year	Resident. Fuel	Electric power (utilities)	Comm. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	17	52	n/a	n/a	55	123.7
1972	17	80	35	29	n/a	161.1
1974	15	85	17	35	n/a	153.7
1976	10	72	9	99	n/a	190.1
1978	9	96	8	46	n/a	159.7
1980	6	119	9	43	n/a	177.1
1985	3	107	4	20	n/a	134.0
1990	5	131	3	n/a	n/a	139.5
1995	3	92	3	n/a	n/a	97.7
2000	2	106	4	n/a	n/a	111.8

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 58. Per capita SO_x emissions from stationary energy sources for Canada, 1970 to 2000 (t/capita)

Year	Resident. Fuel	Electric power (utilities)	Comm. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	10	22	n/a	n/a	41	72.2
1972	7	29	11	22	n/a	69.8
1974	7	25	9	21	n/a	66.7
1976	5	26	5	32	n/a	68.7
1978	4	30	5	25	n/a	64.5
1980	3	31	4	19	n/a	56.4
1985	1	29	1	9	n/a	39.4
1990	1	25	1	n/a	n/a	26.8
1995	1	18	0	n/a	n/a	19.5
2000	0	21	1	n/a	n/a	22.1

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 59. Relative and absolute levels for NO_x emissions from stationary energy sources in Nova Scotia, 1970 to 2000

Year	NOx From Energy Sources (kt)	Stationary Energy Emissions as Percent of Total NOx Emissions
1970	20	43
1972	34	48
1974	35	45
1976	55	61
1978	52	61
1980	39	51
1985	28	36
1990	26	36
1995	28	39
2000	31	43

Figure 60. Per capita NO_x emissions from stationary energy sources for Atlantic Canada, 1970 to 2000 (t/capita)

Year	Resident. Wood	Resident. Fuel	Electric power	Comm. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	0	2	11	n/a	n/a	7	20.8
1972	1	2	17	6	5	n/a	32.5
1974	1	2	19	3	6	n/a	32.1
1976	0	3	19	2	23	n/a	47.4
1978	0	2	27	2	10	n/a	42.4

1980	0	2	23	2	6	n/a	33.3
1985	13	1	12	1	3	n/a	30.2
1990	1	1	21	1	n/a	n/a	24.0
1995	2	1	19	1	n/a	n/a	22.5
2000	1	1	24	1	n/a	n/a	27.0

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 61. Per capita NO_x emissions from stationary energy sources for Canada, 1970 to 2000 (t/capita)

Year	**Resident. Wood**	**Resident. Fuel**	**Electric power**	**Comm. Fuel**	**Indust. Fuel**	**Indust. & comm. fuel**	**Total non-transport.**
1970	n/a	2	8	n/a	n/a	10.0	19.6
1972	1	2	9	3	7	n/a	22.1
1974	1	2	10	3	7	n/a	22.1
1976	0	2	9	2	16	n/a	29.0
1978	0	2	10	2	13	n/a	27.5
1980	0	2	9	1	11	n/a	23.7
1985	0	1	10	1	11	n/a	23.0
1990	0	1	9	1	n/a	n/a	11.5
1995	0	1	9	1	n/a	n/a	11.5
2000	0	1	10	1	n/a	n/a	12.3

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 62. Relative and absolute levels for VOC emissions from stationary energy sources in Nova Scotia, 1970 to 2000

Year	**VOCs From Energy Sources (kt)**	**Stationary Energy Emissions as Percent of Total VOC Emissions**
1970	3	3
1972	3	3
1974	8	10
1976	8	10
1978	17	21
1980	14	21
1985	5	9
1990	29	42
1995	29	37
2000	11	20

Figure 63. Per capita VOC emissions from stationary energy sources for Atlantic Canada, 1970 to 2000 (t/capita)

Year	Upstream Fuel Process.	Resident. Wood	Resident. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	0	n/a	2	n/a	1	2.8
1972	0	0	1	0	n/a	2.3
1974	0	8	1	0	n/a	9.6
1976	0	8	0	1	n/a	9.3
1978	6	3	0	0	n/a	10.7
1980	6	0	0	0	n/a	7.7
1985	0	10	0	0	n/a	10.3
1990	0	26	0	n/a	n/a	25.9
1995	0	33	0	n/a	n/a	33.1
2000	0	15	0	n/a	n/a	15.7

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 64. Per capita VOC emissions from energy sources for Canada, 1970 to 2000

Year	Upstream Fuel Process.	Resident. Wood	Resident. Fuel	Indust. Fuel	Indust. & comm. fuel	Total non-transport.
1970	0	n/a	1	n/a	2	3.1
1972	0	0	1	0	n/a	1.4
1974	0	5	0	0	n/a	6.4
1976	0	5	0	0	n/a	6.0
1978	6	2	0	2	n/a	11.4
1980	6	0	0	2	n/a	9.0
1985	4	4	0	2	n/a	10.5
1990	0	9	0	n/a	n/a	9.5
1995	0	14	0	n/a	n/a	14.0
2000	0	5	0	n/a	n/a	5.2

Note: Columns may not sum to total because of rounding and because sectors with very low emissions were excluded for graphing clarity

Figure 65. Relative and absolute levels for GHG emissions from stationary energy sources (stationary combustion and fugitive coal mining emissions) in Nova Scotia, 1990 to 2002

Year	GHGs From Energy Sources (kt)	Stationary Energy Emissions as Percent of Total GHG Emissions
1990	12,669	66
1991	12,735	66
1992	13,342	67
1993	13,083	66
1994	12,414	65
1995	12,017	63
1996	12,324	65
1997	12,853	65
1998	12,641	64
1999	12,723	63
2000	13,761	64
2001	13,270	64
2002	12,870	63

Figure 66. Per capita GHG emissions from energy sources for Atlantic Canada, 1990 to 2002 (t CO_2 eq. / capita)

Year	Electricity & heat	Indust.	Comm. & instit.	Resident.	Agricult. & forest.	Coal mining	Total Stationary
1990	6.2	2.9	0.8	2.0	0.1	0.5	12.5
1991	5.8	2.7	0.8	1.8	0.1	0.5	11.8
1992	6.3	2.5	0.8	1.9	0.2	0.5	12.2
1993	5.8	2.7	0.7	1.8	0.1	0.5	11.7
1994	6.0	2.6	0.7	1.7	0.1	0.4	11.5
1995	6.3	2.7	0.8	1.5	0.2	0.3	11.8
1996	6.0	3.0	0.8	1.6	0.2	0.3	11.8
1997	7.2	3.0	0.9	1.6	0.2	0.3	13.2
1998	7.8	3.6	0.7	1.5	0.2	0.2	14.0
1999	7.3	3.0	0.8	1.5	0.2	0.1	12.9
2000	7.8	3.2	0.9	1.5	0.2	0.1	13.7
2001	x	3.1	1.0	1.5	x	0.1	14.7
2002	x	4.3	0.9	1.5	x	0.1	14.8

Note: x indicates the data was suppressed. Columns may not sum to total because of rounding and suppressed data.

Figure 67. Per capita GHG emissions from energy sources for Canada, 1990 to 2002 (t CO_2 eq. / capita)

Year	Electricity & heat	Indust.	Comm. & instit.	Resident.	Agricult. & forest.	Coal mining	Total Stationary
1990	3.4	7.9	0.9	1.6	0.1	0.1	14.1
1991	3.4	7.5	0.9	1.5	0.1	0.1	13.6
1992	3.6	7.5	1.0	1.5	0.1	0.1	13.8
1993	3.3	7.4	1.0	1.6	0.1	0.1	13.4
1994	3.3	7.6	0.9	1.6	0.1	0.1	13.6
1995	3.4	7.7	1.0	1.5	0.1	0.1	13.8
1996	3.4	7.8	1.0	1.7	0.1	0.1	14.0
1997	3.7	7.4	1.0	1.6	0.1	0.1	13.8
1998	4.1	7.5	0.9	1.4	0.1	0.0	14.0
1999	4.0	8.1	1.0	1.4	0.1	0.0	14.5
2000	4.3	8.2	1.1	1.5	0.1	0.0	15.2
2001	4.3	7.9	1.1	1.4	0.1	0.0	14.7
2002	4.1	8.3	1.1	1.4	0.1	0.0	15.0

Note: Columns may not sum to total because of rounding.