

CANADA Report or GEO Project

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Introduction

Geography

Canada is the second largest country in the world, with a land area of 997 million hectares **(1)** . Only 4.6 percent of Canada's total land area is arable, however, and 1.6 percent is irrigated **(2)** . Canada has generous water resources, with 98.5 thousand m³ of internal renewable water per capita per year **(3)** .

Forests and woodlands accounted for nearly half of Canada's land in 1991, totaling 417.6 million hectares, and accounting for 10% of the world's total forest land **(4)** . In 1995, about 866 000 hectares of Canada's forests were clearcut harvested and another nearly 145 000 were cleared through selection harvesting and commercial thinning. In the same year, about 436 000 hectares were planted with trees **(5)** . Over the period 1992 through 1995, on average more than twice as many hectares were harvested as planted **(6)** .

Major protected areas accounted for 8.9 percent of national territory in 1993 **(7)** . There are approximately 3,500 publicly-owned protected areas, covering about 788,000 km² with another 10,000 km² held by non-government groups **(8)** .

(1) United Nations Development Programme (1997). Human Development Report 1997. New York: Oxford University Press. Table 43, p. 217.

(2) *ibid.*

(3) *ibid.*

(4) Canadian Council of Forest Ministers (1996). Compendium of Canadian Forestry Statistics. 1996 National Forestry Database Program. From website: http://www.nrcan.gc.ca/cfs/proj/iepb/nfdp/cp95/text_e/summe.htm

(5) *ibid.*

(6) derived from harvest and planting date provided in Canadian Council of Forest Ministers, op. cit.

(7) United Nations Development Program, op. cit.: Table 44, p. 221
(8) Biodiversity Working Group (1994). Canadian Biodiversity Strategy: Canada's Response to the Convention on Biological Diversity. Report of the Biodiversity Working Group. November. Environment Canada. Website: http://www.cciw.ca/eman-temp/reports/publications/rt_biostrat/cbs13.htm

Demography

Canada's population is about 29 million people (1994) and grew at an average annual rate of 1.4 percent from 1960-94 (9) . It is expected to grow at 0.9 percent between 1994 and the year 2000 (10) . Life expectancy at birth is 79 years (1994)(11) . Nearly all of adult Canadians (99 percent) are literate and there is 100 percent enrolment in primary and secondary school (12).

Overall, Canada scores 0.960 for the United Nations Development Program's Human Development Index, ranking first among all countries of the world for this index (as of 1994) (13) .

Most Canadians (77 percent, in 1994) live in urban areas (14) . All Canadians are served by municipal waste services and in 1990 each Canadian produced on average 660 kg of municipal waste (15) . Collectively, Canadians produced almost 7.8 millions tonnes of hazardous waste from 1991-94 (16).

(9) United Nations Development Program, op. cit.: Table 41, p. 218
(10) *ibid.*
(11) United Nations Development Program, op. cit.: Table 1, p. 146
(12) *ibid.*
(13) *ibid.*
(14) United Nations Development Program, op. cit.: Table 40, p. 217
(15) *ibid.*
(16) *ibid.*

Economic Development

Real GDP per capita (using Purchasing Power Parities) was \$21, 459 in 1994 (17) . Real earnings per employee grew at a very low rate between 1980 and 1992, averaging an annual increase of only 0.1 percent (18) .

(17) *ibid.*
(18) United Nations Development Program, op. cit.: Table 32, p. 209

Eight indicators of sustainability

A . Environmental Sustainability

1. Global environmental impacts

Canadian CO2 emissions from fossil fuel use rose by about 9 percent from 1990 to 1995, and are expected to be 9.5 higher than 1990 levels by the year 2000 (19) . Canadian CO2 emissions account for about 2 percent of total global CO2 emissions, but, with only 0.5 percent of the world's population, Canada is a very high per capita emitter of CO2 (20) . In fact, in 1993 Canada was the fourth highest per-capita emitter of CO2 of all the OECD countries (21) .

Canada is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC) and to the Kyoto Protocol of the UNFCCC. Under the Kyoto Protocol, Canada has committed to reducing its total greenhouse gas (GHG) emissions to 94 percent of 1990 levels by the years 2008-2012.

Currently, federal policy on reducing GHG emissions centres on a Voluntary Challenge Program, in which GHG emitters register their actions to reduce emissions. This program is voluntary and is unlikely to be sufficient to meet Canada's commitments under the Kyoto Protocol (22). In February 1998, the federal government established a Secretariat which will oversee a process of stakeholder consultation to develop a strategy for meeting Canada's commitments under the Protocol(23).

(19) Canadian Global Change Program (1996). Canada and Climate Change: Responding to Challenges and Opportunities. A submission to Canada's Provincial and Federal Ministers of Energy and Environment. November.

(20) *ibid.*

(21) From data provided in Organisation for Economic Coordination and Development (1995). OECD Environmental Data Compendium 1995. Paris: OECD.

(22) Robert Hornung (1998). "The Voluntary Challenge Program Will Not Work". Policy Options, 19(4): 10-13

(23) Environment Canada (1998). "Reinforcing Canada's action plan on climate change". Press release dated February 11, 1998. Website: http://www.doe.ca/press/cc-plan_n_e.htm

Variable	1990	1995
Total energy-related CO2 emissions megatonnes) (24)	447.6	488.8
Population (millions) (25)	27.791	29.615
CO2 per capita (tonnes)	16.10593	16.50515
Growth in CO2 emissions from 1990 to 1995		9.2%
Vector	0	0

(24) Numbers represent CO2 emissions from fossil fuel combustion. Source: Environment Canada, Indicators. website:

http://199.212.18.79/~ind/English/Climate/Tables/cctb05_e.htm

(25) Source: Natural Resources Canada, Residential Sector Energy Use database.

2. Local environmental impacts

Canadian NO_x, VOCs and SO₂ emissions all fell over the period 1990 to 1995.

Canada has established a number of agreements and commitments with respect to these emissions. In 1990, the Canadian Council of Ministers of the Environment adopted the NO_x/VOC Management Plan, which is "aimed at reducing ozone in Canada to values less than the maximum acceptable air quality objective (82-ppb one-hour average) by the year 2005" **(26)**. Included in this program are, among other initiatives, standards for vehicle emissions and cleaner diesel and gasoline, emission guidelines for large stationary sources **(27)**.

In 1985, the federal government and seven eastern Canadian provincial governments established the Canadian Acid Rain Control Program. Under this program, participating provinces agreed to reduce their collective SO₂ emissions to 2.3 million tonnes by 1994, a target which was exceeded in 1993: total eastern Canadian SO₂ emissions in 1994 were 1.7 million tonnes, representing a 56 percent decline from 1980 levels **(28)**.

In 1991, Canada and the US signed the Canada-United States Air Quality Agreement. Under this agreement, Canada agreed to establish, by the year 2000, a permanent national limit on SO₂ emissions of 3.2 million tonnes and a 10 percent reduction in NO_x emissions from stationary sources **(29)**. In April 1997, Prime Minister Chretien and US President Clinton agreed to develop a Joint Plan of Action Addressing Transboundary Air Pollution, pursuant to the Canada-United States Air Quality Agreement, which will focus on ground-level ozone and particulates **(30)**.

- (26)** Environment Canada (1996a). "Canadian 1996 NO_x/VOC Science Assessment. Executive Summary". Website: http://www.ec.gc.ca/phase2/science_e.htm
(27) Environment Canada (1997a). "Ottawa unveils next steps on smog". Press release dated November 7, 1997. Website: http://www.ec.gc.ca/press/smog1_n_e.htm
(28) Environment Canada (1996b). "Canada's National Environmental Indicator Series: Acid Rain". Website: http://199.212.18.79/~ind/English/AcidRain/Bulletin/ar_iss_e.htm
(29) *ibid.*
(30) Environment Canada (1997b). "Backgrounder: Federal Smog Management Plan, Phase Two". November 7, 1997. Website: http://www.ec.gc.ca/press/smog1_b_e.htm

Variable	1990	1995
Nitrogen Oxide Emissions (Kt) (31)	2106	1999
Volatile Organic Compound Emissions (Kt) (32)	2829	2679
Sulphur Dioxide Emissions (Kt) (33)	(34) 3296	2805
Growth from 1990 to 1995		

NO _x		-5.08%
VOCs		-5.30%
SO ₂		-14.90%
Vector		
NO_x	0	0.056452
VOCs	0	0.058914
SO₂	0	0.16552
<p>(31) Source: Environment Canada, Pollution Data Branch. website: http://www.doe.da/pdb/eft/tabsec_e.htm</p> <p>(32) <i>ibid.</i></p> <p>(33) <i>ibid.</i></p> <p>(34) The reported value is 3305, but the sum of provinces is 3296.</p>		

B . Social Sustainability

3. Rural electrification

Very nearly all Canadian households have access to electricity (99.6 percent in 1995, which is only very slightly higher than in 1990).

Household energy prices have risen considerably in the last decade. The overall residential energy price index in 1995 was more than twice its value in 1986 and 35 percent higher than the 1990 value. Efficiency adjusted residential fuel oil and natural gas prices increased only slightly from 1990 to 1995, by about 6 and 7 percent, respectively. Electricity prices, on the other hand, grew by almost 55 percent over the same period (35).

(35) Residential fuel price data are from Natural Resources Canada (1997a). Canada's Energy Outlook: 1996-2020. Energy Forecasting Division, Energy Policy Branch, Energy Sector, Natural Resources Canada. Ottawa: Minister of Supply and Services. April. p. C-4

Variable	1990	1995
Percentage of rural households with access to electricity (36)	99.388%	99.641%
Vector	0	0.41339869
<p>(36) Data on the percentage of rural households with access to electricity were not available. The percentage of households with a one or more refrigerators was used as a proxy since refrigerators are, in the majority of cases, fueled by electricity and refrigerators might be considered "necessities" compared to appliances such as air conditioners or televisions. Source of data: Statistics Canada, Household Facilities and Equipment data.</p>		

4. Employment intensity

Employment in the energy sector is a fairly insignificant part of total employment in Canada: representing about 1.4 percent of total employment in 1996. In contrast, investment in energy accounted for nearly 15 percent of total investment in Canada in 1996. This difference is reflected in the number of jobs per million dollars invested which is an order-of-magnitude lower in the energy sector than in the economy as a whole. Further, while the number of jobs per million dollars invested increased slightly from 1990 to 1996 for the whole economy, it actually fell slightly in the energy sector. The energy sector does slightly better in terms of jobs created (37) per million dollars invested: it is still an order-of-magnitude lower than in the economy as a whole, but this measure increased significantly from 1990 to 1996. However, the single year estimate (1996) masks considerable variation in job creation in the energy sector. While the number of jobs in the energy sector rose in 1996 from the previous year, it fell from the previous year in 1995 and 1997 (by approximately 1000 and 6000 jobs, respectively).

(37) measured here as the change in jobs from the previous year .

Variable	1990	1996
Total investment (\$ million, current) (38)	136,210	135,271
Energy sector investment (\$ million, current) (39)	19,841	19,900

Total employment (persons) (40)	13,165,100	13,676,200
change from previous year (persons)	79,100	170,700
Energy sector employment (persons)(41)	196,448	190,352
change from previous year (persons)	813	3,787
Jobs per \$ million invested - total economy	96.6529623	101.10223
Jobs per \$ million invested - energy	9.90110125	9.5654146
Vector	0	-0.0038695
Jobs created per \$ million invested - total economy	0.58072095	1.2619113
Jobs created per \$ million invested - energy	0.04095056	0.1903099

Vector	0	0.276709
<p>(38) Number represents total capital expenditure. Source: Statistics Canada, CANSIM database; 1990 is from matrix 1190, series D842190; 1995 and thereafter are from matrix 3101, series D864148.</p> <p>(39) Number represents capital expenditure for total energy. Source: Statistics Canada, CANSIM database, matrix 2480, series E305300.</p> <p>(40) Numbers represent employment of persons 15 years old and older, annual average, and are from Statistics Canada's CANSIM database, matrix 3472, series D984670.</p> <p>(41) Numbers represent total energy sector direct employment and are derived by summing reported employment in coal mining, utilities and crude petroleum and natural gas production. Source: Statistics Canada's CANSIM database matrix 3472, series D984735 (utilities) and matrix 4285, series L56877 and L56878 (coal mining and crude petroleum and natural gas production, respectively). Data are reported on a monthly basis in the latter two series, so reported values were averaged over 12 months to derive annual values.</p>		

C) Economic Sustainability

3. Resilience to external impacts

Canada is a net energy exporter. Energy exports accounted for just over 2 percent of total exports in 1997, down slightly from the 1990 share.

Variable	1990	1997
Value of Energy Exports (\$ million, current) (42)	15,973	30,632
Value of All Exports (\$ million, current) (43)	702,052	1,374,144
Share of energy exports in total exports	2.28%	2.23%

Vector	0	0.0223
<p>(42) Source: Statistics Canada CANSIM database, series E7020 (43) Number represents the value of all goods and services exports. Source: Statistics Canada CANSIM database, series D15471.</p>		

6. Burden of energy investment on development

The Canadian federal government has traditionally been a significant investor in energy development, particularly in conventional sources like fossil fuels. In recent years, however, the government has begun to reduce its investment levels. As can be seen in the above table, federal government investment in conventional energy sources dropped by half from 1990 to 1996 and appears to continue to be dropping (in fiscal year 1998/99 federal spending on conventional energy sources will be \$124.6 million, nearly a 50 percent reduction from the previous year (44)). Federal spending on unconventional sources such as alternative and renewable energy has remained fairly constant over the 1990s at just over \$30 million. In fiscal year 1988/99 it will be \$31.2 million (45) .

(44) Energy Policy Branch, Natural Resources Canada
(45) *ibid.*

Tables C-1 and C-2 below show detailed breakdowns of federal government spending on conventional energy and unconventional energy, respectively. As can be seen in Table C-1, a large proportion of federal support for conventional energy has gone to petroleum megaprojects and nuclear energy. However, support levels for both have fallen over the 1990s, although support to nuclear energy is still significant at \$100 million in fiscal year 1998/99.

Variable	1990	1995	1996	1997
total public investment in energy (\$ million, current)	663.7	527.3	315.7	200.0
conventional energy (46)	630.6	494.1	285.0	170.0
unconventional energy (47)	33.1	33.2	30.7	30.0
(\$ million, current) (48)	678135	799129	820323	850000
percentage of public energy investment to				
conventional and unconventional energy	0.10%	0.07%	0.04%	0.03%
conventional energy only	0.09%	0.06%	0.03%	0.02%

Vector: All energy	0	0.325805	0.606781	0.693751	
Vector: Conventional energy only	0	0.335094	0.626387	0.718926	
<p>(46) Numbers represent Natural Resources Canada spending (grants, contributions and equity participation) on conventional energy (megaprojects, other petroleum, coal and electricity). Natural Resources Canada spending represents the bulk of federal government spending on energy -- in the order of 80% (personal communication, Don Cunningham, Energy Policy Branch, Natural Resources Canada, July 7, 1998). These numbers are provisional and are provided for fiscal years (ending March 31st). Source: Energy Policy Branch, Natural Resources Canada.</p> <p>(47) Numbers represent the federal interdepartmental Program on Energy Research and Development spending (grants, contributions and equity participation) on unconventional energy (renewable and alternative energy, conservation, alternative transportation fuels and other). These numbers are provisional and are provided for fiscal years (ending March 31st). Source: Energy Policy Branch, Natural Resources Canada.</p> <p>(48) Source: Statistics Canada, CANSIM database. matrix 6575, series D16464.</p>					

D. Technological Sustainability

7. Energy productivity

Over the period 1990 to 1995, the energy productivity of the Canadian economy increased slightly, by less than 3 percent. Energy use increased in all sectors of the Canadian economy over this period, but GDP grew by a larger amount, resulting in an increase in the measure GDP/energy use.

In the residential sector, the use of energy per household declined significantly between 1990 and 1995 due largely to improvements in space heating and appliance energy efficiencies. This was offset, however, by an increase in the number of households so that overall energy use in this sector increased by 4 percent **(51)**. Similarly, energy intensity in the commercial sector declined by 2.6 percent over this period, due to improved energy efficiency of buildings and equipment and better energy management practices (as well as a decline in occupancy rates). This was offset, however, by an increase of over 10 percent in floor area, leading to an increase in overall commercial sector energy use of 9 percent **(52)**.

Passenger transportation energy use increased over this period by almost 9 percent, largely due to an increase in passenger-kilometres. The average fuel economy of light passenger vehicles improved by almost 4 percent from 1990 to 1995, but this was partially offset by a trend towards heavier vehicles such as Sport Utility Vehicles **(53)**. There was also a small shift in mode from rail to road which increased energy use slightly (because road transport tends to be more energy-intensive than rail) **(54)**.

Freight transportation energy use increased by 6.4 percent, due to increased activity (tonne-kilometres) and a shift from marine and rail to trucks (trucking tends to be more energy-intensive). This shift reflects the advent of "just-in-time" delivery which favours trucking over other modes as well as a shift in production from bulk commodities to manufactured products **(55)**. The increase in activity and shift to more energy-intensive modes was partially offset by improvements in energy intensity **(56)**.

Industrial energy use increased by about 9 percent, due to an increase of almost 6 percent in industrial activity (GDP) and a shift in the composition of production towards more energy-intensive industries **(57)**. Overall industrial energy intensity increased by about 1 percent,

but there were significant improvements in some industries such as pulp and paper, iron and steel, aluminum and cement, largely due to technological improvements (58) .

(51) Natural Resources Canada (1997b). Energy Efficiency Trends in Canada 1990 to 1995. Ottawa: Minister of Public Works and Government Services Canada.

(52) *ibid.*

(53) *ibid.*

(54) *ibid.*

(55) *ibid.*

(56) *ibid.*

(57) *ibid.*

(58) *ibid.*

Variable	1990	1995
GDP (\$ million, current)(59)	678,135	799,129
Primary energy demand (petajoules)(60)	9,583.6	10,971.2
GDP/Total primary energy	70.76	72.84
Growth from 1990 to 1995		2.94%
Vector	0	0.003264
(59) Source: Statistics Canada, CANSIM database. matrix 6575, series D16464.		
(60) Source: Natural Resources Canada (1997a), op. cit.: p. C-9.		

8. Sustainable energy deployment

Over the period 1990 to 1995, the share of renewables and conservation in total primary energy consumption nearly doubled. It is, however, still fairly low, at less than 10 percent. The share of renewables increased about 1 percent from 1990 to 1995, to a share of 5.8 percent.

For many applications, the price of renewables is barely competitive with more conventional sources (compare Tables D-1 and D-2 below). Canada's National Energy Board finds that barriers to development of renewable energy sources include "land use requirements, high initial capital costs, small and fragmented industry, procedures for environmental assessment and licensing, and the intermittent nature of the energy supplied from several of the

renewable sources" (61) .

In their outlook for energy supply in Canada to the year 2010, the National Energy Board of Canada does not expect the contribution of renewables to total energy supply to "change notably" (62) . Similarly, Natural Resources Canada finds that the contribution of renewables to electricity generation will increase to only 3 percent by 2020 (63) .

Table C-2 above shows federal government spending on alternative energy and renewables and conservation. Spending levels have remained fairly constant over the 1990s, in the range of \$21-25 million per fiscal year, and well below spending on conventional energy sources such as fossil fuels and nuclear electricity.

(61) National Energy Board (1994a). Canadian Energy Supply and Demand 1993-2010. Technical Report. Calgary: Minister of Public Works and Government Services Canada. p. 10-11.
 (62) *ibid.*
 (63) Natural Resources Canada (1997a), op. cit.: p. 59.

Variable	1990	1995
Primary energy demand - total (petajoules) (64)	9583.6	10971.2
Primary energy demand - renewables (petajoules) (65)	452.1	641.2
Conservation from 1990 (petajoules)(66)		283.7
Share of renewables and conservation	4.72%	8.43%
Vector	0	0.00000581

(64) Source: Natural Resources Canada (1997a), op. cit.: p. C-9.

(65) *ibid.*

(66) This is estimated by subtracting actual 1995 energy use in 5 sectors (passenger transport, freight transport, industry, residential and commercial) from energy use calculated using 1990 intensities and 1995 activity levels. As such, it is only a proxy for true conservation. Unfortunately, data for true conservation at the national level were not

available for Canada. Energy use data are taken from Natural Resources Canada's Energy Efficiency Indicators Database for Energy Efficiency Trends in Canada (website: <http://eeb-dee.nrcan.gc.ca>).

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Table D-1: Efficiency-Adjusted End Use Conventional Energy Prices (\$/GJ)		
		1992 Prices (\$/GJ)⁽⁶⁷⁾
Residential Sector	Electricity	15-20
	Light Fuel Oil	16-18
	Natural Gas	6-12
Commercial Sector	Electricity	20-34
	Light Fuel Oil	10-14
	Natural Gas	4-10
Industrial Sector	Electricity	11-19
	Coal	3-10
	Heavy Fuel Oil	3-4
	Natural Gas	2-5

(67) Source of data: National Energy Board (1994b). *Canadian Energy Supply and Demand 1993-2010. Appendix to Technical Report*. Calgary: Minister of Public Works and Government Services Canada. Table A10-1, p. 252.

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Table D-2 : Alternative Energy Supply Costs (\$/GJ) (68)

Source	Application	Supply Cost (\$/GJ), circa 1992
Wind	Electricity Generation	14-28
Active Solar	Domestic Hot Water	20-33
	Pool Heating	14-25
	Industrial Air Heating & Ventilation	6-12
Small Hydro	Electricity Generation	6 to >36
Biomass	Wood Heating (Rural)	3-12
	Wood Heating (Urban)	12-42
	Industrial and Commercial Heating & Electricity Generation	3-17
Photovoltaics	Electricity Generation	150-460
SEWthermal	Heating & Electricity Generation	13-21
Tidal	Electricity Generation	15 to >44

(68) Source of data: National Energy Board, (1994b), op. cit.: Table A10-2, p. 253.

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