Richard Gilbert

Energy
and Smart Growth

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neptis
THE ARCHITECTURE
OF URBAN REGIONS

This is the third in a series of nine issue papers commissioned by the Neptis Foundation for consideration by the Central Ontario Smart Growth Panel established by the Government of Ontario.

Gilbert's paper looks at the likelihood that the demand for oil and natural gas will eventually outstrip supply, and suggests ways to maintain a similar quality of life in the Central Ontario Zone while relying less heavily on non-renewable energy sources. He describes recent patterns of energy use, compares Canadian energy use to that in other countries, and assesses the potential contributions of alternative forms of energy, such as wind power. Gilbert recommends strategies for reducing energy consumption and argues that even if energy supply and energy prices remain stable, reducing our consumption of non-renewable energy sources will have important benefits for the economy and the environment.

Richard Gilbert
Dr. Gilbert is an independent consultant specializing in transportation and energy issues.

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1 Agriculture in the Central Ontario Zone, Margaret Walton
2 Air, Water and Soil Quality, Ken Ogilvie
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Research for the series has been coordinated by Dr. Pamela Blais, of Metropole Consultants.

Neptis is an independent, privately-funded, registered charitable foundation, based in Toronto, Canada, that supports interdisciplinary research, education and publication on the past, present and future of urban regions.

Neptis Foundation
50 Park Rd.
Toronto, Ontario M4W 2N5
www.neptis@neptis.org

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Introduction and Overview

In October 1978, when the Syncrude tar sands plant opened in Fort McMurray, Alberta, a *Globe and Mail* editorial said, "The supply of conventional crude oil (the easiest to extract) is not only finite, but perhaps going to run out this century. … We will have to move to other sources of energy, or see civilization as we know it collapse."

Civilization as we know it depends on vast amounts of cheap energy, not only from oil but also from natural gas, coal, uranium, and other sources. Each Central Ontario resident now draws on the energy equivalent of 80 'energy slaves' working 14 hours a day, 365 days a year.

The *Globe* editorial was right on one point. Civilization as we know it depends on vast amounts of cheap energy, not only from oil but also from natural gas, coal, uranium, and other sources. It's hard to make precise comparisons but it's likely that a key difference between life in Central Ontario today and life here 150 years ago is the amount of energy we use: in the order of 30 times more per person.

Perhaps more than anything else, the use of this energy makes possible the differences between the two ways of living in terms of comfort, convenience, productivity, and freedom from want. It's as if each person in Central Ontario now has available the work of 80 or more 'energy slaves,' i.e., 80 human equivalents working 14 hours a day, 365 days a year.[1]

Worldwide, the beginning of the end of cheap oil appears to be in sight, likely within the 30-year time frame of the Smart Growth Strategy. The Central Ontario Zone also faces challenges in the supply of low-cost natural gas.

The editorial was also right on another point: the supply of conventional crude oil is finite. The world didn't run out of oil before 2000, but some major sources are clearly becoming exhausted, including those of the contiguous U.S. and western Canada, where production of *conventional* crude oil peaked in the 1970s.[2] Worldwide, the beginning of the end of cheap oil appears to be in sight, likely within the 30-year time frame of the Smart Growth Strategy.

More surprising may be the more imminent challenges the Central Ontario Zone faces concerning the supply of low-cost natural gas. These challenges are spelled out below.

Where the editorial was obviously wrong was in its suggestion that conventional—i.e., cheap—oil would run out in 20 years. Its continued availability in

1. McNeil, J.R., Something Under the Sun: An Environmental History of the Twentieth Century World, New York, W.W. Norton (2000).

2. For oil production in Canada, see Ivanhoe, L.F., Canada's future oil production: Projected 2000-2020, Hubbert Center Newsletter, Colorado School of Mines (April 2002), available at the URL below.
http://hubbert.mines.edu. Accessed October 22, 2002.

2003 should be a caution against such doomsaying. However, much has happened since 1978. More is known about how to squeeze oil and natural gas from the depths of the earth. More is known about what is there and the challenges in extracting it. Above all, there is wider understanding now that the most important consideration is not when oil or natural gas literally runs out, but when supply falls off and cannot keep up with demand. That's the time prices can shoot up and put into question our way of life.

The most important consideration is not when oil or natural gas literally runs out, but when supply can no longer keep up with demand. That's when prices can shoot up and put into question our way of life.

The good news is that we could live with just about as much comfort, convenience, productivity, and freedom from want while using much less energy, perhaps 50 to 75% less. It wouldn't be quite what we are used to—and would require many changes to get there—but it could be pretty good. Some of the needed changes have important implications for how we go about achieving Smart Growth, and these will be spelled out too.

The good news: we could live with almost as much comfort, convenience, productivity, and freedom from want while using perhaps 50% to 75% less energy. And much of that energy could be produced right here in Ontario.

The good news too is that much of the energy we would require for this new way of living could come from renewable, made-in-Ontario sources. Our energy future would be much more secure, and we would be freed of the burden of paying others for most of the energy we use. The requirements for producing quite large amounts of renewable energy also have implications for Smart Growth.

Because energy is so important for our way of life, and because of the real possibility of dramatic changes in energy availability—and thus prices—over the next 30 years, energy considerations should be front and centre in any planning exercise. We've managed for generations with only occasional worries about the vital matters of energy supply and price. All this could change soon.

Recent patterns of energy use in Ontario

Good data are available on Ontario's energy use, although not on use within the Central Ontario Zone. It's likely that the patterns of energy consumption in the Central Ontario Zone are similar to those for the whole of Ontario, chiefly because about two thirds of Ontario residents live in the Zone and a higher proportion of business activity is located there. The main differences in patterns of energy between the Central Ontario Zone and the rest of Ontario likely result from the Zone's generally milder climate and the greater presence of the commercial sector in the Zone. The latter factor may be offset by the greater concentration in the rest of Ontario of energy-intensive industries, notably steel, nickel, and copper production.The key Ontario trends are shown in

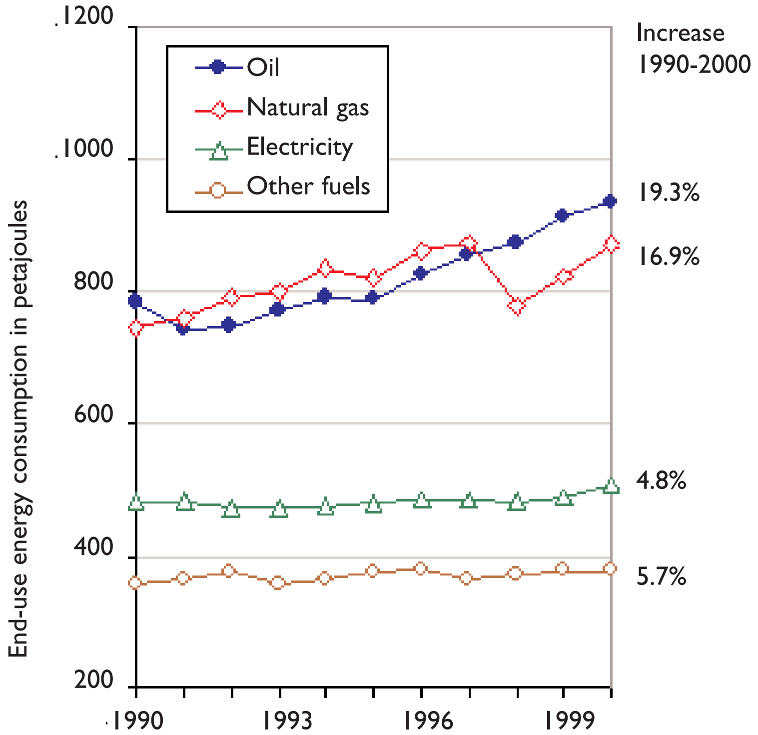


Figure 1: End-use energy consumption in petajoules, 1990-2000

Between 1990 and 2000, overall energy use in Ontario increased by 13.5%. Meanwhile, populationgrew by 13.6%.

Figure 1.[3] "Other fuels" are mostly coal and related fuels used directly by industry.

Overall, industry was the biggest user of energy—32.9% of total use—with transportation close behind.

Between 1990 and 2000, the last year for which complete Ontario data are available, overall energy use increased from 2,367 to 2,687 petajoules,[4] i.e. by 13.5%. Oil use increased at a higher rate, but natural gas use was increasing even more quickly until the warmer winters of the late 1990s curbed demand.

3. The data in Figure 1 are from the National Energy Use Database of the Office of Energy Efficiency of Natural Resources Canada, available at the URL below. A petajoule is 1015 joules (see Footnote 4). Although these data differ in detail from those provided in the recent report of the Ontario Legislature's all-party Select Committee on Alternative Fuel Sources (see Footnote 28), which came from the National Energy Board, the differences are not important for the present purposes. Natural Resources Canada data are used here because they are more comprehensive and consistent across several years. http://oee1.nrcan.gc.ca/neud/dpa/data_e/database_e.cfm. Accessed June 26, 2003.

4. A few words about the energy units used in this paper: The basic energy unit in the metric system is the joule. This is a small amount of energy in everyday terms. About 8 joules are required to raise the temperature of a teaspoonful of water by 1°C. (1055 joules are equivalent to a British Thermal Unit or Btu.) A gigajoule is a billion joules (109). A petajoule is a million gigajoules (1015). A watt is a joule of energy being produced or used for one second. Thus a 100-watt light bulb uses 100 joules in a second. Ten such bulbs use energy at the rate of one kilowatt (103). If they are alight for an hour they use a kilowatt-hour of electricity, equivalent to 3.6 million joules (i.e., 1000 x 60 x 60). Also used are terawatt-hour (1012), equivalent to a billion kilowatt-hours or 3.6 petajoules, and gigawatt, equivalent to a billion watts or a million kilowatts.

	Agriculture	Industry	Commercial	Residential	Transport	Total
Oil	3.5%	6.3%	2.3%	3.6%	84.3%	100.0%
Natural gas	1.3%	36.9%	25.3%	36.2%	0.2%	100.0%
Electricity	1.7%	33.0%	34.6%	30.4%	0.3%	100.0%
Other fuels	0.4%	89.5%	2.4%	6.4%	1.3%	100.0%
All fuels	2.0%	32.9%	15.9%	19.6%	29.6%	100.0%

Table 1. End use of energy in Ontario by sector, 2000

Meanwhile, population grew by 13.6%.[5]

Table 1 shows how the various fuels were used in 2000.[6] Oil was used mostly for transportation; "other fuels" were used mostly for industry. Natural gas and electricity were each shared somewhat evenly among the industrial, residential, and commercial sectors. Overall, industry was the biggest user of energy—32.9% of total use—with transportation close behind.

In 1999, 43% of Ontario's electricity was produced from nuclear sources and 24% from hydroelectric sources. Ther-mal generation produced the remainder,with 24% of total production coming from coal, 7% from natural gas, and 2% from oil.

End uses are shown in **Figure 1** and **Table 1**, i.e., the energy content of the fuels actually used in cars, furnaces, machines, and light bulbs. If energy supply is being considered, the fuels used to generate electricity must be taken into account. In 1999, 43% was produced from nuclear energy and 24% from hydroelectric sources. Thermal generation produced the remainder with 24% of the total amount generated coming from coal, 7% from natural gas, and 2% from oil.[7] Thus, when electricity production is taken into account, the 1999 totals for oil and natural gas use in Ontario were a little higher and closer together than is indicated in **Figure 1**, and the total for coal (within "other fuels") was quite a bit higher.

Figure 2 shows that during the 1990s in-building uses and transportation gained on industry as the major user of energy in Ontario.[8] Energy use for freight transport grew at a particularly high rate (44.9% over the ten years),

5. According to Statistics Canada, CANSIM Series V468558, Ontario's population grew from 10,299,571 in July 1990 to 11,697,569 in July 2000.

6. The data in Table 1 are from the source detailed in Footnote 3. Institutional and government uses are included in the commercial sector. Street lighting (about 0.5% of electricity use) is not included, nor are international travel and international freight movement.

7. The information about the fuels used for Ontario's electricity generation comes from Figure 4.6.3 of Canadian Electricity: Trends and Issues, National Energy Board, Ottawa (May 2001), available at the URL below.
http://www.neb-one.gc.ca/energy/emaelect_e.pdf. Accessed October 7, 2002.

8. The data in Figure 2 are from the source detailed in Footnote 3.

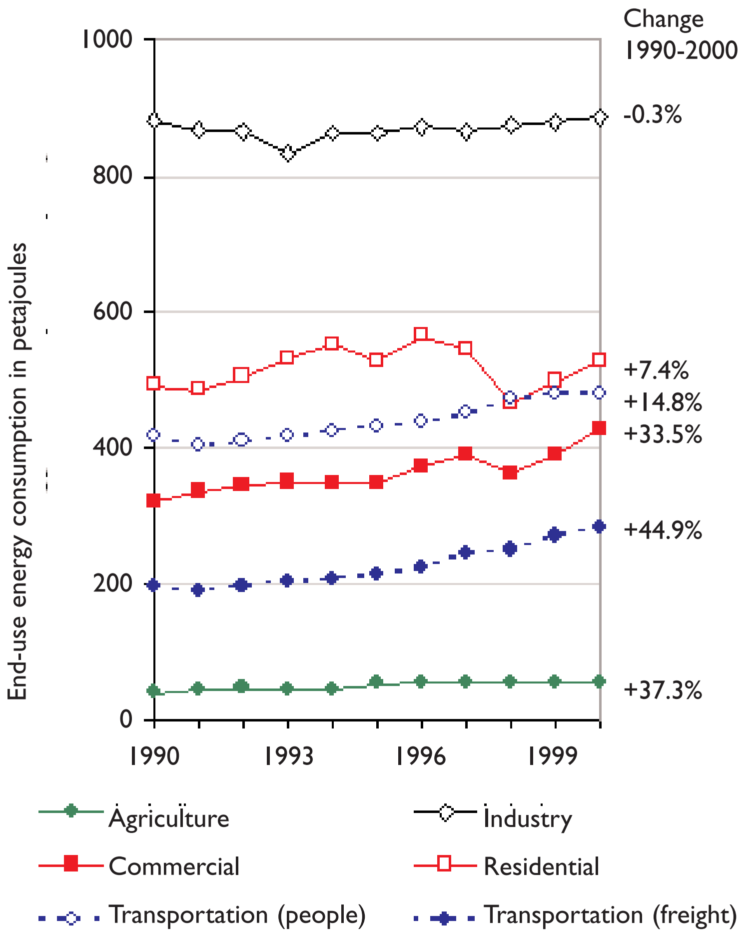


Figure 2. End use of energy in Ontario by sector, 1990-2000

Energy use for freight transportation increased by 44.9% between 1990 and 1999, but the movement of people still consumed more energy.

but movement of people used more energy. Energy use for agriculture also increased substantially, but from a small base.

In 2000, space heating and cooling comprised about 60% of the energy use by each of the commercial and residential sectors in Ontario. In total, space heating and cooling consumed 566 petajoules of energy, somewhat more than the 479 petajoules used for moving people.

Comparisons between Ontario and the rest of Canada

Figure 3 compares Ontario and the rest of Canada in energy use per person for various functions in 2000.[9] Overall, energy use was higher in the rest of Canada (313 vs. 227 gigajoules per person). This was the result of higher consumption for agriculture, industry, residential heating and cooling, and freight

9. The data in Figure 3 are from the source detailed in Footnote 3.

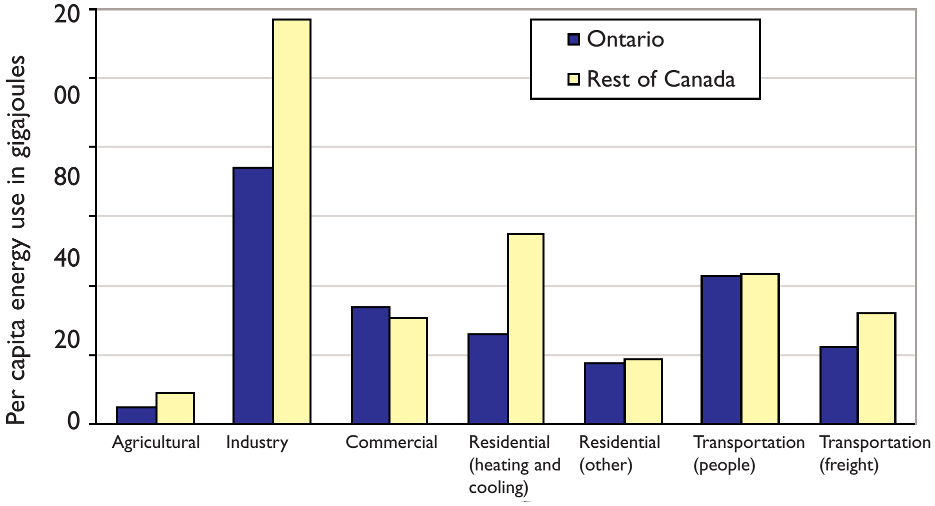


Figure 3. Per capita end use of energy by sector in Ontario and in the rest of Canada, 2000

transportation.

Energy use was higher in the rest of Canada than in Ontario, partly because Ontario's climate is milder than that of many other provinces.

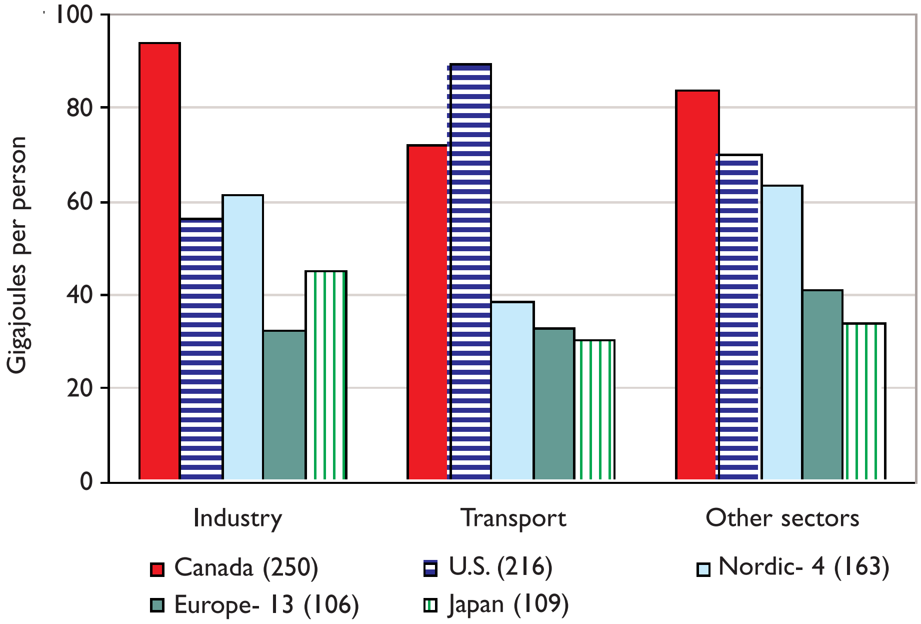
Figure 3 does not include the energy used to produce usable energy, either the energy used to produce electricity, as discussed above for Ontario, or the large amounts of energy used to produce oil from the tar sands noted at the beginning of this paper.[10] The higher energy use for industry in the rest of Canada mostly reflects the energy-intensity nature of the pulp and paper industry, which in 2000 used 15.4 gigajoules per capita in Ontario and 41.1 gigajoules per capita in the rest of Canada. The other large difference—for residential heating and cooling—likely occurred because people in Ontario generally live in a milder climate than other Canadians.

Comparisons of Canada with other affluent countries and regions

Figure 4 compares per capita energy use with other countries.[11] "Other sectors" includes both the commercial and the residential sectors. The numbers in brackets in the legend show *total* per-capita energy consump-tion for each of

10. Overall in Canada in 2000, the energy used to produce usable energy amounted to about 15% more than actual end-use energy. (See Statistics Canada's CANSIM II, Series V618545 for total primary and end-use energy, and Footnote 3 for total end-use energy.) The addition energy was used chiefly to produce electricity and to produce oil from the tar sands noted in this article's opening paragraph. According to the source detailed in Footnote 2, extraction of oil from tar sands consumes about 20% of Canada's natural gas supply. "Within a few years, Canada may have to choose between selling part of their natural gas vs. synthetic oil to the United States."

11. The data in Figure 4 are from OECD Environment Compendium 1999, Organisation for Economic Co-operation and Development, Paris, France (1999).



Canada has the world's third highest per-capita consumption of energy, higher than the United States. Canadians consume less energy for transportation than Americans, but more for industry and more in homes and offices.

Figure 4. Per capita energy use by sector in Canada and other affluent regions and countries, 1997

the countries and regions. Canada has the world's third highest per-capita consumption of energy, after Luxembourg (included in Europe-13 in **Figure 4**) and Iceland (not represented in **Figure 4**).

The obvious comparison is with the United States, which has higher energy use for transportation, but lower use for other purposes. The higher use for transportation reflects in part the greater distances travelled domestically by Americans, about 25,000 kilometres per person annually compared with 19,000 kilometres by Canadians and 12,500 by Europeans.[12] Canada's higher use for industry could reflect in part the greater prominence of the energy sector—of which the U.S. is the chief beneficiary (see below)—but also lower economic efficiency of Canada's energy use (also see below). Canada's higher use in the residential and commercial sectors could reflect climatic differences.

Figure 4 also provides comparisons with two groups of European coun-tries: the four continental Nordic countries (Nordic-4), and the 13 other countries of western Europe. The Nordic countries provide a better comparison with Canada, being more similar in terms of distances between communities, cli-

12. These year-2000 data on travel per person (domestic and intra-EU) are from the following sources: Canada, the source detailed in Footnote 3; U.S., National Transportation Statistics 2002, Bureau of Transportation Statistics (2003), available at the first URL below; European Union, European Union, Energy and Transport in Figures 2002, European Commission, Directorate-General for Energy and Transport (2002), available at the second URL below.
http://www.bts.gov/publications/nts/2002/index.html. Accessed July 18, 2003.
http://europa.eu.int/comm/energy_transport/etif/etif_2002.pdf. Accessed July 18, 2003.

mate, and the importance of the energy sector. Their per-capita energy use is lower in every respect, especially for transportation. Energy use by other European countries and Japan is even lower.

Figure 5 shows comparisons among the same countries and regions of energy consumption per unit of GDP. Canada used more than twice as much energy in relation to its GDP as Japan and non-Nordic European countries, and about 50% more than the U.S. and Nordic countries. The costs of energy use may already be a burden on the Canadian economy, to the extent they raise the prices Canadians have to charge for goods and services. If energy prices increase, the burden will increase proportionate to energy use.

On the other hand, as a major energy exporter, Canada's economy would ben-

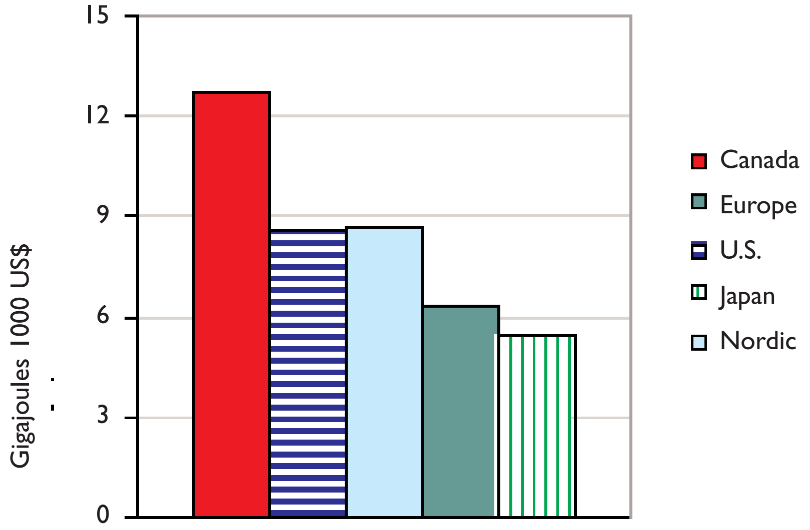


Figure 5. Energy consumption per unit of GDP, 1997 (legend as for Figure 4)

The costs of energy use may burden the Canadian economy, because they raise the prices Canadians have to charge for goods and services. If energy prices increase, the burden will increase. On the other hand, as a major energy exporter, Canada's economy would benefit from higher energy prices.

efit from higher energy prices. In 2000, net energy exports—chiefly oil and natural gas to the U.S., but also coal to Japan and South Korea—were worth $35.5 billion, ranking second to forestry as a contributor to Canada's positive trade balance.[13]

Another international comparison is shown in **Figure 6**, which compares per capita energy use within urban regions for the movement of people only.[14]

13. The information in this paragraph is from Natural Resources Statistics: Statistics and Facts on Energy, Natural Resources Canada (April 2002), available at the URL below. http://www.nrcan.gc.ca/statistics/energy/default.html. Accessed October 7, 2002.

14. The data in Figure 6 are from J. Kenworthy and F. Laube, The Millennium Cities Database for Sustainable Transport, Union Internationale des transports publics (UITP), Brussels, Belgium,

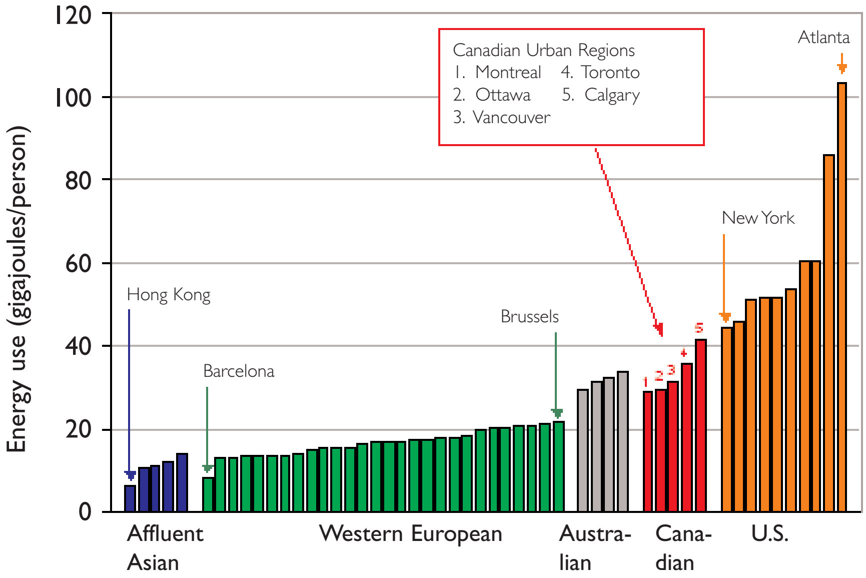


Figure 6. Per capita energy use for the movement of people in 52 affluent urban regions, 1995

In the Greater Toronto Area, energy use per capita is about six times that of the urban region with the lowest energy use (Hong Kong), but only about a third of that of the urban region with the highest use (Atlanta).

Here, the comparison is with the Greater Toronto Area, where energy use per capita was six times that of the urban region with the lowest energy use (Hong Kong), but only about a third of that of the urban region with the highest use (Atlanta). Most of the Asian, European, and U.S. urban regions represented in **Figure 6** had—and still have—a higher GDP per capita than the Canadian urban regions, so it's not a simple question of some regions using less energy because they are poorer.

Natural gas prospects

We usually think about oil, specifically fuel for road vehicles, when the spectre of energy shortages is raised. Today, our supply of natural gas is more vulnerable to early price increases. In energy terms, Ontario uses about as much natural gas as oil (see **Figure 1**), but the use of natural gas is spread across more sectors (see **Table 1**) and may for that reason be less conspicuous.

Our supply of natural gas is vulnerable to early price increases. We use about as much natural gas as oil, but the use of natural gas is spread across more sectors.

It's easy to take comfort in a recent report by the U.S. Energy Information Administration that points to a bountiful supply of natural gas world-wide.[15] Another such report is that of the International Energy Agency, which said that "Reserves of coal and natural gas are particularly abundant, while there is no

15. The EIA report is International Energy Outlook 2002, Energy Information Administration, United States Department of Energy, Washington DC (March 2002), available at the URL below
http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2002).pdf. Accessed October 6, 2002

lack of uranium for nuclear power production."[16]

Close reading of these reports reveals that markets for natural gas are essentially continental. It is difficult to move natural gas across oceans. It can be liquefied, shipped as liquefied natural gas (LPG), and "regassed," but this process is energy-consuming, expensive, and potentially dangerous. (Indeed, one of the reports suggests that the NIMBY challenges in siting a further LPG-receiving terminal in the U.S. may be "insurmountable.") [17]

At present, the U.S. and Canada are responsible for about 35% of natural gas consumption worldwide but have only about 4% of reserves. (Mexico is a net natural gas importer—from the U.S.—and is likely to remain so.) Moreover, North American demand, i.e., potential consumption, is set to grow by 50% by 2020, largely because of expansion of natural-gas-fuelled electricity generation in the U.S. Much of the increase in natural gas supply is projected to come from Canada, which currently uses more than half its production to provide for about 20% of U.S. consumption in an integrated market. LPG imports from outside North America are not expected to provide more than a few percent of 2020 demand.[18]

The U.S. and Canada are responsible for about 35% of natural gas consumption worldwide, but have only about 4% of reserves.

The problem with the above demand projection is that there seems to be little potential for increasing North American natural gas production. The Canadian situation has been charted by the Alberta Energy and Utilities Board. It envisages production there gradually declining after 2003.[19] The Canadian Gas Potential Committee—a group of senior geoscientists from industry and government—has noted that supplies from the Scotia Shelf and Mackenzie Delta together could not amount to more than about 15% of present production.[20] The Committee's report concluded that "the era of low-cost gas supplies has now effectively ended."

There seems to be little potential for increasing North American natural gas production. One report notes that "the era of low-cost gas supplies has now effectively ended."

16. The quote is from Page 29 of World Energy Outlook 2002, International Energy Agency, Paris, France (2002).

17. See Page 48 of the report detailed in Footnote 15

18. The information in this paragraph comes from the source detailed in Footnote 15.

19. See Alberta's Reserves 2000 and Supply/Demand Outlook 2001-2010, Alberta Energy and Utilities Board, Calgary (June 2001). A backgrounder on this expensive report is available at the URL below. http://www.eub.gov.ab.ca/BBS/new/newsrel/2001/nr2001-18-backgrounder.htm. Accessed October 6, 2002.

20. See Woronuk RH, Canadian Natural Gas Resources, Canadian Gas Potential Committee (January 2002), available at the first URL below. See also Riva JP, Canadian gas, our ace in the hole? Hubbert Center Newsletter, Colorado School of Mines (April 2002), available at the second URL below. See also the quote in Footnote 10.

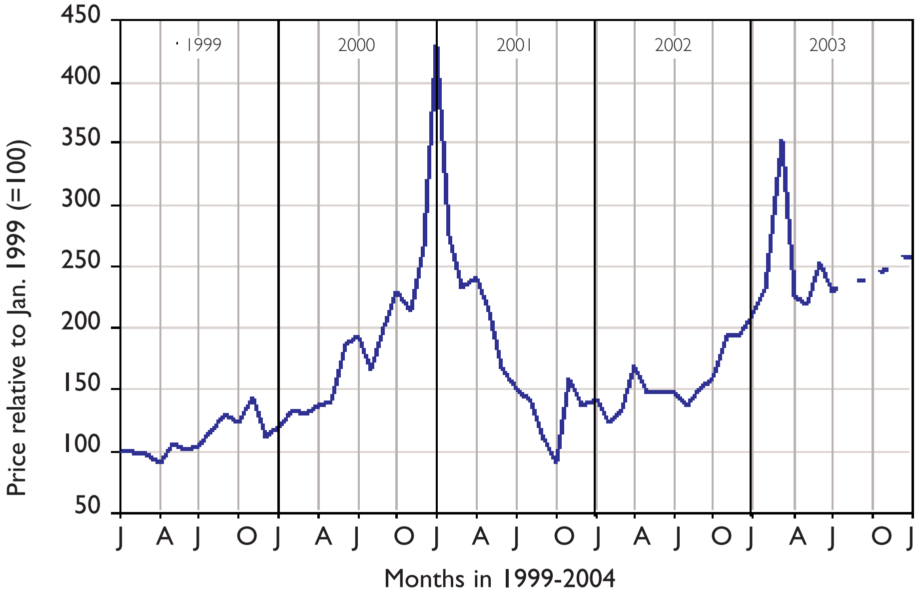


Figure 7. Monthly wholesale natural gas prices

Natural gas prices spiked in January 2001. The spike was short-lived, but led to a 50%-plus increase in natural gas bills in the 2000-2001 season.

The situation in the U.S. is, if anything, bleaker. It was set out in testimony to the U.S. Congress in July 2002 by Matthew Simmons, a banker specializing in energy investments and a member of the U.S. National Petroleum Council, an oil and natural gas advisory committee to the Secretary of Energy. Mr. Simmons said that natural gas supply "continues to stay flat in the U.S. as it has done for the past eight years, despite a natural gas drilling boom of historic proportion in both the U.S. and Canada. ... The precarious supply/demand imbalance of 15 months ago is now headed towards a colossal mismatch between a need for demand to soar while supply drops."[21]

The "imbalance of 15 months ago" referred to a time when natural gas prices in North America reached historic high real values. This peak is shown in **Figure 7**, which charts wholesale prices for the period January 1999 to July 2003, with anticipated prices to January 2004.[22] The imbalance resulted in a more than threefold increase in wholesale prices in January 2001 over the pre-

21. Matthew Simmons' July 16, 2002, testimony to the Subcommittee on Energy and Mineral Resources of the Committee on Resources of the U.S. House of Representatives is available at the URL below.
http://www.simmonsco-intl.com. Accessed October 6, 2002.

22. Wholesale natural gas prices represented in Figure 7 are those posted by Centrepoint Energy Minnegasco at the first URL below. This price is used because of the convenient manner in which the source provides historical prices and futures. The North American natural gas market is mostly integrated, and thus the numerous other sources would shown the same pattern, e.g., the Alberta Gas Reference Price, provided by the Alberta Department of Energy at the second URL below.
http://www.minnegasco.centerpointenergy.com/pdf/gas_prices_lvdf.pdf. Accessed July 15, 2003.
http://www.energy.gov.ab.ca/gmd/gas/agrp.asp. Accessed July 14, 2003.

vious year.

The period of extreme prices was short-lived but the general result was a 50%-plus increase natural gas bills in the 2000-2001 season in the Central Ontario Zone compared with a year earlier.

During the winter of 2003-2004, the natural gas price for Ontario homeowners seems set to rise by a further 50%, and not fall again.

Prices returned to quite low levels during the winter of 2001-2002[23] before entering what may be the beginning of the "colossal mismatch" anticipated by Mr. Simmons. Figure 7 shows a further price peak during the winter of 2002-2003, *without the subsequent decline to relatively low levels.* The likely impact on next winter's retail prices in the Central Ontario Zone is hard to predict. A reasonable guess may be that they will rise to above $0.40 per cubic metre, i.e., to more than 50% above prices at the start of the winter of 2002-2003, *and they continue to rise.*

It's the longer term that may be the real problem. The Canadian Gas Potential Committee anticipates *declines* in production of more than 50% by 2020.[24] Given the potential demand for natural gas—including plans to convert Ontario's coal-fired generating plants—the discrepancies between North America supply and North American demand will be huge. Real retail prices of natural gas could increase by a factor of several times, enough to cause changes in how and where we live and work.

Oil prospects

Oil, unlike natural gas, is readily transportable across oceans and thus there is a world market for oil. Canada pro-duces about 50% more oil than Canadians consume. Most is pro-duced in the west and exported to the United States..

A similar story, differing only in detail, applies to oil. The same two agencies—the U.S. Energy Information Administration and the International Energy Agency—are bullish on world oil supplies, at least until about 2020, projecting a gradual rise in crude oil prices to about US$30 a barrel (which happens to be below the price at the time of writing). There is a substantial body of informed

23. The January 2001 peak in natural gas prices (see Figure 7) may have been enhanced by a deliberate short-term withholding of supply from the market designed to affect electricity prices in California (McNulty S, El Paso price manipulation settlement. Financial Times (London, UK), March 24, 2003; available at the first URL below). Prices during the winter of 2001-2002 may have been low because of lower-than-usual economic activity following the events of September 11, and because of what has been described as irresponsibly rapid depletion of Ladyfern, a major natural gas find that began producing in 2001 and by the end of 2002 was near depletion (Nikiforuk A, Northern greed, Canadian Business, May 12, 2003; available at the second URL below).
http://dukeemployees.com/deregulation4-03.shtml. Accessed July 17, 2003
http://www.canadianbusiness.com/shared/print.jsp?content=20030512_53695_53695. Accessed July 17, 2003.

24. See the source detailed in Footnote 19, particularly Figure 11 of that source.

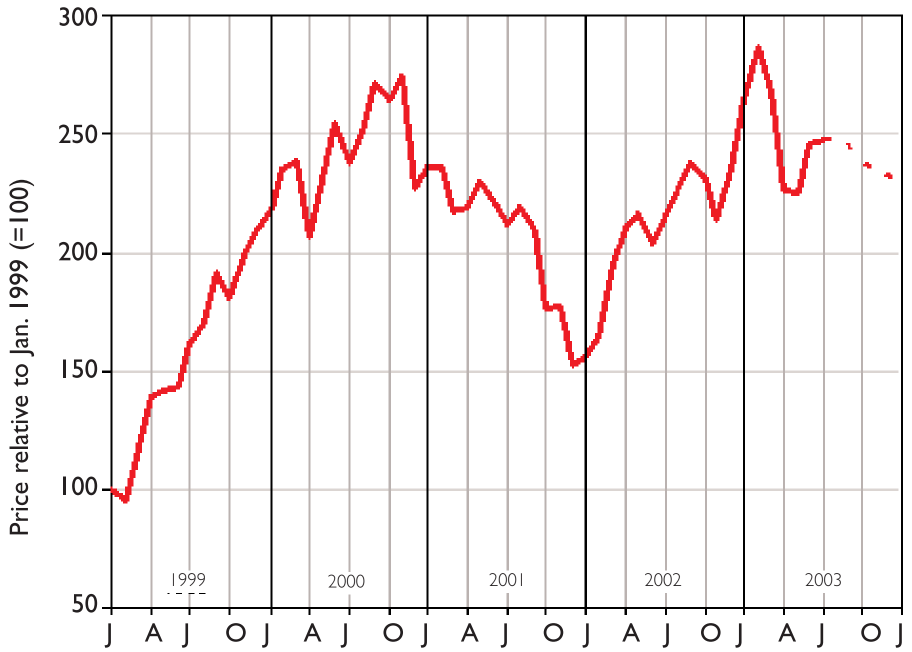


Figure 8. Monthly crude oil prices

Since January 1999, the price of crude oil has increased by about the same amount as the wholesale price of natural gas, but with much less fluctuation.

opinion supporting an alternative view, which is that there will be severe challenges around 2010 and perhaps earlier.

The chief difference between natural gas and oil is that the latter is readily transportable across oceans and thus there is a world market for oil. Canada is very much part of this world market. We are a net exporter, producing about 50% more than we consume. However, most of the oil is produced in the west and exported to the U.S.—comprising a larger amount than U.S. imports from Saudi Arabia, when refined products are included—and about half our consumption is imported into the east, all done at world market prices.[25]

How crude oil prices have changed since January 1999 is shown in **Figure** 8, with anticipated changes until January 2004.[26] The overall change in price has been similar to that for wholesale natural gas, but with less fluctuation. Crude oil prices are not reflected so strongly in retail gasoline and diesel fuel prices

25. Information in this paragraph is from BP Statistical Review of World Energy 2003, BP, London (UK) (2003), available at the first URL below, and from the U.S. Energy Information Administration at the second URL below.
http://www.bp.com/files/16/statistical_review_1612.pdf. Accessed July 18, 2003.
http://www.eia.doe.gov/neic/rankings/rankindex.htm. Accessed July 18, 2003.

26. Crude oil prices represented in Figure 8 are for West Texas Intermediate crude as provided by the Alaska Department of Revenue at the URL below. Futures prices are those at the New York Mercantile Exchange in mid-July 2003.
http://www.tax.state.ak.us/PRICES/index.htm. Accessed October 6, 2002.

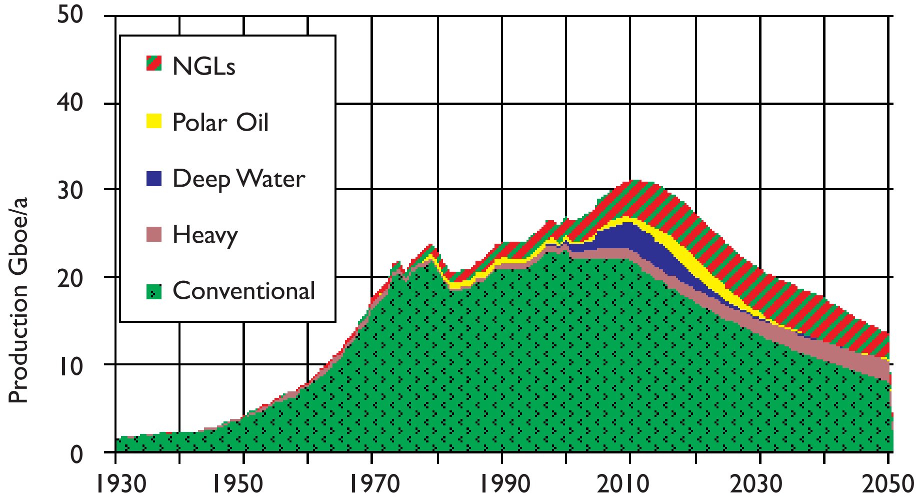


Figure 9. Actual and projected production of all oil and natural gas liquids, 1930-2050)

The UK-based Oil Depletion Analysis Centre estimates that production of oil and other liquid fossil fuels will begin to decline in about 2012. A likely result, should potential demand continue to increase, would be very steep increases in road fuel prices.

because of the high tax component (in Ontario in mid-2003, federal and provincial taxes on road fuel each comprised just over 20% of retail prices).

The relatively optimistic views of oil supplies are challenged above all by geologists associated with the UK-based Oil Depletion Analysis Centre (ODAC). Estimates of possible worldwide production produced by ODAC are summarized in **Figure 9.**[27] It shows that overall production of liquid fossil fuels will peak in about 2012 and decline quite steeply thereafter. Regarding conventional (i.e., cheap) oil, the key data are these: (i) annual discoveries peaked in the early 1960s and now amount to less than a quarter of annual consumption; (ii) production from an oil field tends to decline when about half of what is in the field has been extracted, as happened in the U.S. and Canada in the 1970s and in the UK (North Sea oil) in the 1990s.

A reasonable conclusion is that oil prices will rise progressively until about 2012 because of the growing share of production from expensive sources (tar sands and deep-water oil). Then they will rise substantially because overall supply will begin to fall to levels well below potential demand. What could be meant by "substantially" is not clear, but it may be reasonable to expect a doubling or more of real pump prices.

27. Figure 9 is taken from material produced in connection with the Second International Workshop on Oil Depletion, Institut Français du Pétrole, Paris, May 26-27, 2003. Proceedings of the workshop are available at the URL below. See also Bentley RW, Global oil and gas depletion: an overview. Energy Policy, 30, 189-205, 2002. NGLs are natural gas liquids, i.e., liquid fuels such as propane and butane that become available during extraction of natural gas. http://www.peakoil.net/iwood2003/iwood2003.html. Accessed July 18, 2003.

Implications for the Central Ontario Zone, and Solutions

Planning for the Central Ontario Zone needs to take energy price forecasts into account for two reasons. (1) Well over 85% of Ontario's energy supply is imported and higher prices for imports will make it harder to Ontario to maintain a positive trade balance. (2) Individuals and businesses will be financially worse off if they have to pay more for energy purchases.

Few things are certain, but there do seem to be strong possibilities arising from the above considerations that natural gas and road fuel prices will rise substantially during the Smart Growth planning period, i.e., during the next three decades. The most rapid increases in natural gas prices could occur during the first decade of this period, i.e., before about 2012, because supply in North America will not be able to keep up with demand. Gasoline and diesel fuel prices could also rise considerably before 2012 as more expensive resources are brought into use. However, the most rapid increases in vehicle fuel prices could occur after 2012, as the world adjusts to a regime of declining availability of conventional oil.

It could be prudent to take these energy price scenarios into account in planning for the Central Ontario Zone, for two reasons. The first is that well over 85% of Ontario's energy supply is imported, mostly as oil products and natural gas, and to a lesser extent as coal; presently, some electricity is imported. Higher prices of imports make it harder for Ontario to maintain the positive trade balance in goods and service that is the basis of a sound economy. The second reason is that individuals and businesses will be financially worse off if they have to pay more—perhaps a lot more—for energy purchases, especially if they are locked into particular patterns of use that allow little freedom for manoeuvre.

Two things can be done. One is to move to alternatives to oil and natural gas. This is discussed in the next section, with particular reference to Smart Growth. The other is to reduce energy consumption. This is discussed in the subsequent section, again with particular reference to Smart Growth. It's not a question of one or the other. Both are required.

Alternative fuels

Ontario's all-party Select Committee on Alternative Fuel Sources developed 141 recommendations designed to make Ontario a "leader in North America in the support and use of alternative fuels/energy."

In June 2001, the Ontario Legislature appointed the all-party Select Committee on Alternative Fuel Sources, "to investigate, report and recommend ways of supporting the development and application of environmentally sustainable alternatives to our existing fossil [carbon-based] fuel sources." The Committee reported in June 2002 with 141 recommendations in 20 topic areas. The recommendations were designed "to establish an overall policy framework to support the development of alternative fuels/energy, and outline policy and programs to support specific alternative fuel/energy sources and technologies … to make Ontario a leader in North America in the support and use of alternative fuels/energy."[28]

The Committee reached the following broad conclusions with respect to particular fuels:

Water power and wind power hold significant potential as sources of renewable energy for Ontario in the future.

- **Water power** has significant additional potential in Ontario. The Committee emphasized the refurbishment of existing facilities, but also noted the opportunity for installation of at least an additional two gigawatts of generating capacity, including the Niagara River Beck 3 site.
- **Wind power** has significant immediate potential within Ontario. Commercially viable wind resource sites exist along the north shores of the Great Lakes and elsewhere, and there may be significant potential in the Hudson and James Bay lowlands. Production of electricity at the Atikokan and Thunder Bay coal-fired generating stations should be replaced by production from wind farms within three years.

Biomass fuel could be used for power generation. Solar power has potential for use in remote locations. Ethanol and biodiesel fuels could be used as additives to or replacements for gasoline or diesel fuel.

- **Biomass fuel** has significant additional potential for power generation. The committee noted opportunities for further collection of landfill gas and for further use of wood and other wastes. It urged that production of methane from manure be developed, and proposed assessment of the potential for using crops grown as fuel, e.g., switchgrass.
- On **energy from waste** (i.e., incineration), the Committee could not reach consensus, but "accepts that … modern energy-from-waste installations may be considered in the treatment of municipal waste."
- **Solar power**—e.g., photovoltaic generation of electricity—requires renewed attention for smaller-scale urban and remote locations, and there is significant potential for passive solar design in new construction and major renovation of buildings. The Committee noted the relatively high cost of photovoltaic generation, and the constraints arising from Ontario's latitude.
- **Ethanol and biodiesel fuels** (the former produced from waste or other biomass) should be encouraged as additives to or replacements for gasoline

28. The information in this paragraph comes from the Select Committee's June 2002 final report. The Committee had issued an interim report in November 2001 and commissioned a consultant's report (Review of Policies for the Promotion of Alternative Fuels and Technologies, Navigant Consulting Ltd., Toronto, January 2002). These reports are available respectively at the following URLs, all accessed on October 7, 2002. http://www.ontla.on.ca/Committees/INTERIM_ENG.pdf.
http://www.ontla.on.ca/Committees/Navigant_Consulting_Final_Report.pdf
http://www.ontla.on.ca/Committees/Alt_Fuels_Report.pdf.

and diesel fuel, and the capacity to produce and distribute them should be established.

- **Fuel cell applications** should be further investigated, as should the production of hydrogen by electrolysis using off-peak power from nuclear and hydro sources. The Committee noted that at present "fuel cells may only be practical in high mileage bus, truck or railway operations" and that there are "unresolved technical and development issues related to the source, availability and distribution of hydrogen from fuel cells."[29]

Fuel cells may be practical only in high-mileage bus, truck, and railway operations. Other energy alternatives include cogeneration, nuclear fusion, earth energy, and geothermal energy.

- **Other alternative fuel applications** with promise include cogeneration (use of waste heat from electricity generation), nuclear fusion, earth energy (use of the natural heating or cooling properties of the earth or water bodies in conjunction with heat pumps or heat exchangers), and geothermal energy (steam or hot water from deep bores).

Specific recommendations included the elimination of fossil-fuel-based electricity generation in Ontario by 2015, incentives for the installation of solar panels on 100,000 homes, and establishment of aggressive targets for the use of alternative transport fuels.

The Committee made numerous recommendations under "land use planning and development," including one concerning the Smart Growth process: "The Ministry of Municipal Affairs and Housing shall review the 'healthy environment component' of the municipal Smart Growth initiative to include measures to promote the use of alternative fuels/energy, including efficiency and conservation measures." Another recommendation under this topic was that municipalities should "make provision for alternative fuel/energy" in their land-use control measures.

The Committee recommended that the Smart Growth initiative include measures to promote the use of alternative forms of energy.

A consultant's report commissioned by the Committee concluded that cogeneration "is likely to be the most economic and efficient form for new electricity generation in Ontario in the near term."[30] This report was less obviously enthusiastic about the potential for wind power—the production of electricity from wind energy—noting institutional and economic barriers. Institutional barriers include "absence of a land-use planning framework that accounts for

The Ontario Wind Power Task Force estimated Ontario's land-based wind-power capacity to be up capable of producing 19.7 terawatt-hours of electricity annually, or about 14% of current consumption.

29. For an informative discussion of the prospects for fuel cell vehicles, see Brooks AN, Perspectives on fuel cell and battery electric vehicles. Paper presented at the Zero Emissions Vehicle (ZEV) Workshop held by the California Air Resources Board (CARB), Sacramento, December 2002, available at the URL below.
http://www.arb.ca.gov/msprog/zevprog/2003rule/1202wkshp/brooks.pdf. Accessed July 18, 2003.

30. See Page 7 of the Navigant report detailed in Footnote 28.

Figure 10. Bockstigen offshore wind farm, Sweden

the specific circumstances of wind power." The main economic barrier was said to be the lack of competitiveness of wind power compared with cogeneration using natural gas.

As fossil fuel prices increase, the main barrier to the use of many alternative energy sources will cease to exist.

The Committee itself was more enthusiastic about wind power, as indicated above. The recommendation to eliminate fossil-fuel-based electricity generation has a reasonably solid basis. The February 2002 report of the Ontario Wind Power Task Force—which the Select Committee considered—estimated Ontario's land-based wind-power capacity to be up to 7.5 gigawatts, capable of producing 19.7 terawatt-hours of electricity annually, equivalent to 71 petajoules, or about 14% of electricity consumption in 2000 (see **Figure 1**).[31] That report also noted the huge potential for offshore wind power (not evidently pursued by the Select Committee). The Ontario part of Lake Erie alone could produce more than Ontario's total current electricity consumption. Use of James Bay and shallow parts of the other Great Lakes could perhaps more than

31. For an explanation of the measurement units, see Footnote 4 on Page 5. It follows from that explanation that if the wind-power capacity of up to 7.5 gigawatts could be achieved continuously for a year the total output would be 65.7 terawatt-hours. However, the estimate output of only 19.7 terawatt-hours means that the wind turbines were assumed to produce electrical energy at only about 30% of the theoretically possible rate (mostly because of the inherent variability of wind).

32. Except for the last sentence, which is the author's estimate, the information in this paragraph is from the report of the industry-based Ontario Wind Power Task Force, available at the URL below.
http://www.canwea.ca. Accessed October 7, 2002.

quadruple this output.[32]

Offshore wind power is more expensive to establish, but its return is greater because winds at turbine height tend to be stronger and steadier over water than over land. **Figure 10** shows a Swedish offshore wind farm, with more extensive land-based installations in the background.[33] Denmark has invested more heavily in offshore wind farms, but the largest project in progress may be one in the Irish Sea. With rapid exploitation of wind power at numerous sites around the world, the cost of electricity generation from wind is declining and could soon be competitive with current generation costs, not to mention costs when fossil fuel prices increase.

No alternative fuel should ruled out. As fossil fuel prices increase, the main barrier to the use of manyother them will cease to exist.

Other alternative fuels show less promise, but should not be ruled out. As fossil fuel prices increase, the main barrier to the use of many of them will cease to exist. Perhaps the greatest challenges lie in provision of alternative fuels for transportation. Production of liquid biofuels for use in combustion engines could be energy-intensive to the point of inutility. Fuel cells, the focus of much of the research and development work of the automotive industry, seem far from practical, cost-effective realization. Moreover, what is presently the only commercially practicable source of the hydrogen that most fuel cells require, natural gas, is rapidly becoming expensive, as noted above.[34]

Given the promise of wind energy, electricity could well become more available as a fuel for transportation. Battery-powered vehicles will always have the inherent limitation of batteries' low power/weight ratios, but there could nevertheless be many appropriate urban and other uses.[35] (For comparison, there is about 100 times the usable energy in an equivalent weight of gasoline as in a lead-acid battery; the best conceivable technological improvements would not reduce that to better than about 20 times.)

Tethered electric vehicles, including trains, streetcars, trolley buses, and trolley trucks, are remarkably efficient and will likely play more important roles as our energy sources change.

Tethered electric vehicles—e.g., trains, streetcars, trolley buses, and even trolley trucks—are remarkably efficient and will likely play more important roles as

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33. Figure 10 was taken from Wind Power: A survey, Swedish National Energy Administration, 2000, available at the URL below.
http://www.ecd.dk/baltic/Windpower/wind.pdf. Accessed July 18, 2003.

34. For fuller discussion of the points in this paragraph and the next two paragraphs see Issue No. 5 of the Sustainable Transportation Monitor, Centre for Sustainable Transportation, Toronto (November 2001), available at the URL below. See also the source detailed in Footnote 29.
http://www.cstctd.org/CSTadobefiles/STM5_English.pdf. Accessed October 7, 2002.

35. See the source in Footnote 29 for a favourable assessment of prospects of battery vehicles.

our energy sources change. The challenge here is that conventional tethered vehicle technologies are more appropriate to transit vehicles rather than to personal vehicles (i.e., automobiles, SUVs, etc.).[36]

Whichever modes prevail, a society dependent on renewable energy will likely be more dependent on electricity as the immediate fuel for most functions. An overriding advantage of electricity is that there are numerous ways of generating it—wind, solar, water, nuclear, waste materials, etc.—and thus numerous ways of exploiting a range of renewable resources.

A society dependent on renewable energy will likely be more dependent on electricity as the immediate fuel for most functions.

Thus, the implications for Smart Growth of forthcoming changes in Ontario's energy regime could well include the need to accommodate very much more production of electricity from renewable resources, redesign of buildings and communities to take advantage of solar energy, greater use of public transit, and correspondingly lesser use of personal vehicles. Each of these directions has in turn profound implications for the way in which land (and water) would be used in the Central Ontario Zone.

The time frame for changes in energy regime is uncertain. The Ontario Wind Power Task Force spoke of having up to three gigawatts of capacity in place by 2010, producing about nine terawatt-hours of electricity annually and requiring an investment of $4.5 billion. The Select Committee spoke of replacing all fossil fuel generation of electricity by 2015, i.e., generating about 44 terawatt-hours per year from wind, solar, biomass etc. Most of this would likely come from wind energy, say 36 terawatt-hours, or four times the 2010 target of the Wind Power Task Force.[37]

Assuming an established reasonable rate of return, the required investment in

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36. One interesting concept is Personal Rapid Transit (PRT), which comprises fully automated small vehicles carrying 1-6 passengers running on guideways at, above or below ground providing direct origin-to-destination service. A useful review of these and other innovative technologies can be found at a Web site maintained by Jerry Schnieder of the University of Washington, at the URL below.
http://faculty.washington.edu/jbs/itrans/. Accessed July 18, 2003.

37. On July 3, 2003, the Ontario government introduced a Green Power Standard, whereby Ontario's electricity system will be required to secure an additional one per cent of its current electricity needs from renewable sources in each of eight years, beginning in 2006 (see the press release at the URL below). By 2014, this could thus amount to at least 8% of the current installed capacity, or about two gigawatts of what would likely be mostly wind generation capacity. (The present total generation capacity is 24.7 gigawatts.) The commitment falls short of the three-gigawatt target for 2010 proposed by the Wind Power Task Force, but it is nevertheless probably "the single biggest commitment to renewable power by any jurisdiction in North America" claimed in the government's announcement.
http://www.est.gov.on.ca/index.cfm?fuseaction=english.news&body=yes&news_id=37. Accessed July 18, 2003.

wind power of some $20 billion over twelve or so years would not necessarily be the main problem. (The total investment in Alberta oil, gas, and oil sands in 2001 alone was $20.6 billion.[38]) The more substantial problem could be the siting of what could amount to 4,000 3-megawatt turbines, many of which would likely have to be offshore. Inclusion of facilitating elements in Ontario's Smart Growth strategy could be of critical importance.

The required investment in wind power of some $20 billion over twelve years would pose less of a problem than the siting of what could amount to 4,000 3-megawatt turbines, many of which would likely have to be offshore. Inclusion of facilitating elements in Ontario's Smart Growth strategy could be of critical importance.

The Smart Growth strategy could also facilitate development of cogeneration, other uses of waste heat, and exploitation of deep lake-water cooling by promoting the establishment of district heating and cooling systems. The Central Ontario Zone's electrical generating stations produce enough waste heat—currently dumped into Lake Ontario—to provide district heating for a substantial portion of the Zone's buildings. What could be conceived is a massive district heating system based on a spine linking the Zone's electrical generating stations with downtown Toronto's existing major system.

The Central Ontario Zone's electrical generating stations may produce enough waste heat—currently dumped into Lake Ontario—to provide district heating for a substantial portion of the Zone's buildings.

The district heating system in Malmö, Sweden, is an example of the varieties of waste heat can that can be put to productive use. There, the hot-water distribution network that heats most buildings makes use of waste heat from an electric power generating plant, a refuse incinerator, a smelting plant, a sewage treatment plant, a sugar refinery, a carbon black factory, a pet crematorium, and a dung-fired boiler at the local horse-racing track.

As likely climate changes unfold, the cooling of buildings will become more important. The Central Ontario Zone is blessed by proximity to a huge reservoir of cold water suitable for this purpose, namely the depths of Lake Ontario from about five kilometres offshore. Enwave District Energy Ltd. is moving towards exploitation of this renewable resource and establishment of a district cooling system. Its deep lake-water cooling project, initiated in June 2002 with an investment of $180-million, is projected to reduce electricity use for cooling in downtown Toronto by up to 80%, according to the degree of market penetration,[39] with the first use of this cold water scheduled to begin in April 2004. The potential for use of deep lake-water cooling elsewhere in Central Ontario may be huge.

Enwave District Energy's deep lake-water cooling project, initiated in June 2002, is projected to reduce electricity use for cooling in downtown Toronto by up to 80%.

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38. See Investment in the oil and gas industry, Department of Energy, Government of Alberta (August 2002), available at http://www.energy.gov.ab.ca/cmn/docs/oilgasinvest.pdf. Accessed October 7, 2002

39. For details of this estimate, contact Kevin Loughborough, Vice president, Enwave District Energy Ltd. at kloughborough@enwave.com.

Reducing energy consumption

High energy prices themselves contribute to reductions in energy consumption. For every percentage point of price increase for gasoline, there is a corresponding reduction in con-sumption of 0.6%.

Even if Ontario's current rate of electricity production were to be generated entirely from renewable resources or nuclear energy, and if an equivalent amount of other energy could be realized from cogeneration, deep lake-water cooling, and passive solar means, the total available energy would be less than half of recent use (see **Figure 1**). There still would be substantial dependence on what could be increasingly expensive oil and natural gas, unless strong measures to reduce energy use were put in place.

High energy prices themselves contribute to reductions in energy consumption. The long-term price elasticity of demand for gasoline is perhaps around -0.6, meaning that for every percentage point of price increase there is a reduction in consumption by 0.6%.[40] Some of this is achieved through purchase of more fuel-efficient vehicles. Some is achieved through travelling by different modes or by reducing the amount of motorized travel.

Elements of the Smart Growth policy could be critical to the way in which individuals and businesses are able to reduce their energy consumption for transportation through travelling by different modes and by reducing the amount of motorized travel. Travelling by different modes requires availability of more public transit, which in turn requires settlements of a size and density sufficient to support transit. Travelling fewer motorized kilometres again requires denser settlements, as well as amenities for pedestrians and cyclists.

Energy use for the movement of people is closely related to ur-ban density. This is shown in **Figure 11**, in which the energy use data shown in Figure 6 are plotted against residential densities.[41] The 52 urban regions fall on or close to a straight line whose slope suggests that a given relative difference in density is associated with a somewhat smaller relative difference in energy use for the movement of people. (More specifically, the slope of the log-log plot in Figure 11 suggests that the square of the energy use is inversely associated with the cube of the density.)

An indication of how things change within an urban region, specifically the

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40. For a review of gasoline price elasticities, including North American studies, see Glaister S, Graham D, The effect of fuel prices on motorists. Automobile Association, London, UK (September 2000), available at the URL below.
http://195.167.162.28/policyviews/pdf/effect_fuel_prices.pdf. Accessed October 7, 2002.

41. The data shown in Figure 11 are in the source detailed in Footnote 14.

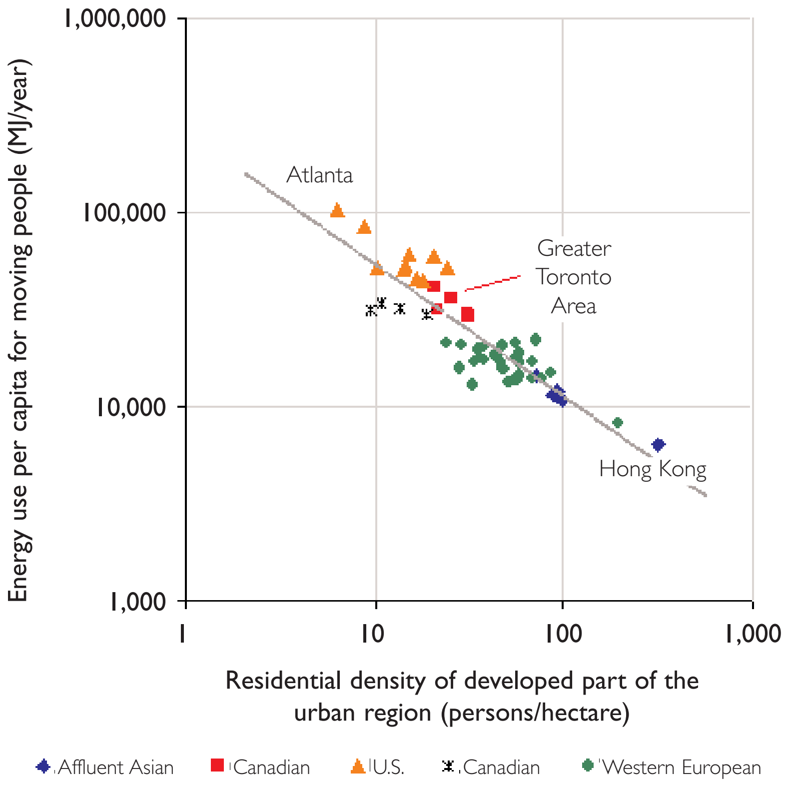

Figure 11. Energy use for moving people and settlement density, 52 affluent urban regions, 1995 (log scales)

Travelling by different modes requires the availability of public transit, which in turn requires settlements of a size and density sufficient to support transit. Travelling fewer motorized kilometres also requires denser settlements. However, quite large changes in density may be required to produce quite small changes in energy use for the movement of people.

Greater Toronto Area (GTA), is in **Figure 12** and **Table 2.**[42] Both travel mode and total distance travelled change with settlement density. Indeed, the actual differences within the GTA correspond closely to the differences between urban regions portrayed in **Figure 11.**[43] This suggests, for example, that transport energy use in the GTA's outer suburbs could be halved by developing and redeveloping them to the density of the core ring.

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42. The data in Figure 12 and Table 2—except the estimates of density and energy use in the bottom two rows of Table 2, which are the author's—are from the 2001 Transportation Tomorrow Survey, Joint Program in Transportation, University of Toronto (2002), available at the URL below. 'Core' is Planning District 1 as used in the Survey, 'Core Ring' comprises adjacent planning districts (Nos. 2, 3, 4, and 6), 'Inner Suburbs comprises the rest of what is now the City of Toronto, and 'Outer Suburbs' comprises the rest of the Greater Toronto Area (not including what is now the City of Hamilton). Note that the estimates of distances travelled are based of trips having a straight-line distance of less than 61 kilometres only, and are corrected for actual routes taken. Car and transit journeys are assumed to require 3.48 and 1.74 megajoules per passenger-kilometre respectively.
http://www.jpint.utoronto.ca/tts96/tts96.html. Accessed July 17, 2003.

43. More specifically, if the estimates in the bottom two rows of Table 2 are plotted in Figure 12, they fall close to the indicated trend line. This suggests that the relationship between transport energy use and residential density found within urban regions may be the same as that between urban regions.

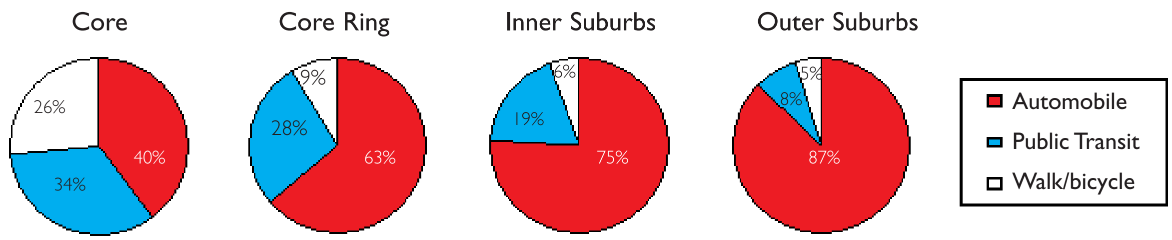

Figure 12. Shares of weekday trips by residents of different parts of the Greater Toronto Area, 2001

Car ownership levels, shown for concentric parts of the GTA in Table 2, appear to be critical factor in transport energy use, for the following reason. For a given country, the number of kilometres driven per personal vehicle is remarkably constant from year to year. In Canada, for example, it changed only from 17,300 to 18,000 kilometres per vehicle between 1990 and 2000.[44] Other countries show similar or greater constancy in this value. Thus, an important factor in the distance travelled by automobile in a country is the number of vehicles in use. If the number of vehicles goes up by 10% then the distance driven goes up by about 10%. It seems to be a case of "have car, will travel." It follows that strategies designed to reduce car use that do not seek to reduce car ownership may be likely to fail.

Overall car ownership rate is a critical variable. When the number of vehicles in a country increases by 10% then the total distance driven by that country's residents goes up by about 10%. It seems to be a case of "have car, will travel."

Thus, as well as increasing density and adding transit facilities, there may be a need to design communities so that living in them without a car is at least as appealing as living with a car (or living with one car rather than two per household, or two cars rather than three).

Information about how energy use for *freight* transport varies with urban form is not available. Distance travelled could vary inversely with density, as it does for the movement of people, but other factors may apply differently. There is at present no equivalent in freight transport to the greater opportunities to provide and use public transport that are available where densities are higher. Conceiving, designing, and implementing such opportunities will likely become a major challenge as energy constraints become more evident.[45]

More energy is used in Ontario for space heating and cooling than for the movement of people, but the costs are less because taxes on this use of energy are lower.

As noted in connection with **Figure 1**, more energy is used in Ontario for space heating and cooling than for the movement of people. However, households

44. Information about distance travelled per vehicle is from the source indicated in Footnote 3, supplemented by information provided in an Excel file (adjDistpass.xls) attached to an e-mail from Nathalie Trudeau of Natural Resources Canada to the author dated August 6, 2002.

45. More efficient movement of freight in urban areas could involve greater use of common carriers and cooperative delivery arrangements, and even the use of automated systems sharing the PRT infrastructure touched on in Footnote 36.

	Core	Core ring	Inner suburbs	Outer suburbs
Number of motorized trips per day per person	2.08	2.31	2.34	2.67
Distance travelled by transit (km. per person)	4.4	4.5	4.5	3.3
Distance travelled by automobile (km. per person)	7.5	11.6	15.3	24.8
Households with no car	51%	29%	17%	5%
Annual energy use for transport (MJ per person)	12,300	17,600	22,300	33,600
Residential density (persons per sq. km. of urbanized area)	9,900	6,100	3,100	2,500

Table 2. Travel data, car ownership, and residential density in the Greater Toronto Area, 2001

and businesses spend considerably less on these functions because there is much less tax on energy used for heating and cooling. Energy use in buildings varies with many factors—including building size, type, shape, age, orientation, composition, use, maintenance record, immediate location, etc.—that for the most part obscure relationships with settlement density.

Perhaps the clearest relationship is the obvious one: other things being equal, the amount of heating and cooling required is closely related to the floor area that is being used. Thus, reductions in per capita in-building energy use can usually be achieved by reducing the amount of floor space used per person.

Reductions in per capita in-building energy use can be achieved by reducing the amount of floor space used per person.

What is also clear is that buildings can be designed to maintain comfort in winter with no or almost no use of added heating. This can be easier for large buildings, e.g., the headquarters building of Ontario Power Generation (OPG) in Toronto, which relies mainly on adroit capture and use of heat from bodies, lighting, and machines. There are several examples of smaller Ontario buildings, such as the home of Anthony and Mary Ketchum in Hockley Valley, which is not on the electrical grid and relies on heavy insulation, solar heating, earth energy, and occasional use of a wood stove.[46] Summer cooling is a challenge for larger buildings, which can have large amounts of internally produced heat to offset.

As energy prices rise, there will be more incentive to upgrade buildings to reduce unnecessary heat loss in winter and unnecessary heat gain in summer. A Smart Growth strategy could mandate low-energy-use building designs and provide incentives for upgrading, funded by taxes on fossil-fuel energy delivered to buildings.

Upgrading existing buildings to use no or little energy for space heating and

46. O'Reilly D., "How to live in 1,600-sq.-ft. home and keep utility costs under $500." Toronto Star, September 26, 2002.

cooling can be a major undertaking,[47] but almost every building can benefit from attention to unnecessary heat loss in winter and unnecessary heat gain in summer. As energy prices rise, there will be more incentive to upgrade buildings. Energy consumption will become a major criterion in the purchase of new homes and other buildings. Also, many buildings will be more intensively used, to reduce per-person energy costs. This could have profound implications for the Smart Growth strategy.

A comprehensive Smart Growth strategy could facilitate reduction of energy consumption within buildings by mandating low-energy-use designs and providing incentives for upgrading, funded by taxes on fossil-fuel energy delivered to buildings (analogous to the use of gasoline taxes to fund transit, an increasingly appealing strategy across Canada).

Increasing settlement densities alone is likely to have much less effect on in-building energy use than on transport energy use.

What if no action is taken, and energy prices increase?

A legitimate point of view could be that more certainty about supply prospects and consequent prices is required before action be taken to switch fuels and curb energy consumption. If prices increases occur, this argument could continue, they will achieve whatever correction in consumption is required.

The difficulty with this argument is that the kind of "correction in consumption" that can be made depends critically on what is available. If distances that must be travelled are large, and there is no transit service, a person or business faced with high fuel prices can only (1) not take essential trips; (2) try to share the trips; (3) suffer the high fuel costs; or (4) buy a more fuel-efficient vehicle. If distances are shorter because urban form is more compact, and transit is available because the compact urban form makes it feasible, the personal or business traveller will have more options, including making the trip by transit

If distances that must be travelled are large, and there is no transit service, a person or business faced with high fuel prices can only (1) not take essential trips; (2) try to share the trips; (3) suffer the high fuel costs; or (4) buy a more fuel-efficient vehicle.

47. The City of Toronto's Better Buildings Partnership comprises programs to reduce energy use in five types of building, and a program whereby loans are repaid through savings in fuel costs. According to the Partnership's Web site, at the URL below, to date $126 million has been invested resulting in energy-cost savings of about $19 million a year. The goal for 2012 is to have completed retrofits of commercial and industrial buildings representing 40% of the total such floor area, i.e., about 40 million out or about 10 0 million square metres. http://www.city.toronto.on.ca/wes/techservices/bbp/index.htm. Accessed July 22, 2003.

and in many cases by foot or bicycle.[48]

For a business that has to make essential deliveries, more compact urban form could mean a smaller impact of high prices and perhaps more opportunity to enter into cooperative delivery arrangements.

Similarly, if less energy is being used in buildings when price increases occur, the impact of the higher prices will be proportionately less.

What if action is taken, and energy prices don't increase?

There will be value in reducing energy use for four reasons. The first is economic. If energy consumption can be reduced while maintaining productivity, Ontario will need to import less energy and the economy will improve as a result.

There are four reasons for reducing energy use: (1) the economy will benefit if Ontario lowers its energy imports. (2) Ontario would have a market advantage when reducing energy becomes a global objective. (3) air quality will improve. (4) Canada will be able to meet its commitments to reduce fossil fuel consumption.

The second is also economic. To the extent that Ontario leads in the development and use of energy saving innovations and processes, it will have a market advantage when reducing energy use becomes a continental objective, and even a global objective.

The third reason is environmental. Other things being equal, the amount of air pollution, whether from vehicles or buildings, is closely related to the amount of energy used. Thus energy conservation will improve air quality.

It's not only urban air quality that will improve. A monitoring station that records among the highest smog levels in the Central Ontario Zone is Stouffville, 45 kilometres north east of downtown Toronto. Smog is mainly ground-level ozone, formed by the action of sunlight on emissions from combustion processes (in vehicle engines but also in factories and other buildings). It takes time for the smog to form, and so it's often places downwind of the source—such as Stouffville—that have the highest pollution levels.

The fourth reason for reducing energy use is also environmental. Emissions of greenhouse gases are almost directly proportional to consumption of fossil fuels. Reduction in fossil fuel use will contribute toward attainment of Canada's commitments in connection with the United Nations Framework

48. The need to prepare for a 'soft landing' rather than a 'hard landing' when energy prices increase was emphasized in Gilbert R, Will the last one out … . Globe & Mail, May 22, 2003, available at the URL below.
http://www.est.gov.on.ca/index.cfm?fuseaction=english.news&body=yes&news_id=37. Accessed July 18, 2003.

Convention on Climate Change, including the Kyoto Protocol and subsequent agreements that may be undertaken.

How much change can be achieved in 30 years?

It's likely most of the buildings and transport infrastructure that is now in place will be here 30 years from now, just as most of what was here in 1973 is still in place. But, if population of the Central Ontario Zone continues to increase at its recent rate, it will grow by more than 3.5 million by 2033, rising from the present just under 8 million to about 11.5 million, an increase by almost 50%.

Such high rates of population growth offer huge opportunities for intensification of existing development and for creating intensively arranged new development. Growth can be directed. For example, the transformation of Toronto's core into a major population centre over the last 25 years is largely the result of deliberate decisions made in the mid-1970s, notably adoption in 1976 of the former City of Toronto's Central Area Plan.

Growth can be directed. The transformation of Toronto's core into a major population centre over the last 25 years is largely the result of deliberate decisions made in the mid-1970s.

Rapid population growth also offers major opportunities for refashioning the Zone's transportation arrangements, particularly if decisions about land use and transportation facilities are carefully coordinated. For example, the proposed extension of the Spadina subway line to Vaughan City Centre could become entirely feasible if the corridor from Downsview station to Vaughan, through York University, were to become intensively developed. Currently, the projected 2025 employment for the corridor is 125,000, including post-secondary students, and the projected residential population is 28,000, of whom respectively 55,000 employees/ students and 15,000 residents will be within 500 metres of the proposed subway stations. These levels are unlikely to provide sufficient ridership to justify the $1.4 billion cost.[49] However, if the corridor's residential population were to rise to around 200,000 by the time the extension opens, ridership on the extension could well be above the 150,000 or so passengers per day a day that may be required to justify the extension.[50]

Decisions about land use and transportation facilities need to be carefully coordinated.

49. The projections of employment, post-secondary students, residential population, and construction cost are all from Spadina-York Subway Extension—Business Case: A Solution for Gridlock in the Northwestern GTA, Prepared for the Spadina-York Subway Extension Committee by PricewaterhouseCoopers LLP (June 2001).

50. The ridership requirement 150,000 daily trips on the extension is a 'back-of-the-envelope' estimate by the author that requires substantiation. It may be compared with a reported anticipated peak ridership of about 5,000, equivalent to about 60,000 per day (Globe & Mail, November 15, 2000). The capital subsidy for 60,000 trips per day is in the order of three dollars per trip (assuming current interest rates throughout a 35-year amortization period).

The downside of rapid population growth is that without early appropriate action the additional residents could well be accommodated in the kinds of energy-intensive greenfield development prevalent in the GTA during the last 30 years.[51] Such continued sprawl could dramatically compound the challenges resulting from the high energy prices to come.

Energy aspects of the reports of the Smart Growth Panels

An early draft of this paper was prepared as part of the work done by the Neptis Foundation for the Central Ontario Smart Growth Panel, formed to advise the Ontario government as to its forthcoming Smart Growth Strategy. Energy concerns are featured in the last of the Panel's 44 final recommendations: "Energy efficiency and district energy should be priorities in planning, both in subdivision design and built form, and incorporated in the planning process." The Panel's final report indicates that this should occur "to manage demand for energy and maintain our lifestyle in the face of declining supplies of traditional energy sources".[52]

As well, the Panel recommended action on its interim advice of November 2002, which proposed establishment of a "green development program". This program could include a voluntary rating system under which credits could be given for "sustainable community and site design … energy efficiency and alternative energy sources … . The program participants would be rewarded with the promotional benefits of having achieved green development credits".

Implementation, according to the Panel's final report, should include consideration of road pricing to "encourage energy conservation, transit use, and compact form".

Achieving more compact settlement form was the first of the Panel's "strategic directions", primarily to make transit more attractive and cost effective, to protect agricultural and other land, and to build livable vibrant communities. The text of the final report suggests that "Communities should be built so that

51. For accounts and critiques of recent development patterns see Blais P, Inching Towards Sustainability: The Evolving Structure of the GTA. Neptis Foundation, Toronto, 2000. See also, Gilbert R, Integrity of land-use and transportation planning in the GTA. In Lee E, Perl A (eds.), The Integrity Gap: Canada's Environmental Policy and Institutions. University of British Columbia Press, pp. 192-217, 2003.

52. The April 2003 final report of the Central Ontario Smart Growth Panel, Shape the Future, is available at the URL below.
http://www.smartgrowth.gov.on.ca/userfiles/HTML/nts_2_5152_1.html. Accessed July 22, 2003.

walking and cycling to destinations is a viable alternative to taking the car". The text also proposes use of alternative energies as a response to declining supplies of traditional energy sources, with appropriate provision in the planning process.

The Central Ontario Panel's final report does not highlight energy issues as requiring further research and analysis before development of the provincial Smart Growth Strategy.

Two more of the five Smart Growth panels had released their final reports by July 2003, the Northwestern Panel and the Northeastern Panel.[53] A key concern in these two reports is that of ensuring the availability of reliable, affordable, and stable supplies of energy. The report of the Northeastern Panel also spoke to pursuing "the widest variety of opportunities to maximize the sustainable value of our natural resources". Examples include "... capturing renewable energy ...".

Concluding remarks

Our present way of life depends on ready availability of relatively in-expen-sive energy. This alone provides sufficient reason to take account of energy factors in a forward planning exercise of the scale and scope of the development of the provincial Smart Growth Strategy. Strong indications that availability of the two most-used fuels—natural gas and oil—could become constrained during the planning period add to the need to consider where Ontario's energy will come from and how it will be used.

This paper suggests that prices of natural gas will rise sharply during the present decade and continue to rise thereafter. Oil prices will rise more slowly until after about 2012, when there could be steep increases. These worrying prospects deserve much closer attention than has been possible for the preparation of this paper.

There are two ways to meet these challenges. One is to move to alternative fuels, particularly renewable fuels. The other is to reduce energy consump-tion. Both should be done. There is already much interest in alternative fuels, particularly wind power. Full realization of the nature of our energy predicament could strengthen this interest dramatically. Present attitudes and land-use practices, however, can impose severe constraints on development of alternative

53. These two reports are available at the URL in Footnote 52.

fuels. These matters need to be addressed in the Smart Growth Strategy.

Reducing energy consumption can be an equally challenging undertaking. The general direction of Smart Growth is towards patterns of development that require less energy use, particularly for transportation. Energy considerations strongly support the need for Smart Growth, and perhaps even more intensification of development than is now being contemplated.

Transportation poses special challenges because of the weak prospects for continued availability of affordable, independently powered vehicles such as present automobiles and trucks using liquid fuels. Tethered vehicles—powered by electricity from a rail or wire—offer the best hope for transport in an energy-constrained world. Their development and deployment should be matters of some urgency.

Even if present indications of large fuel price increases turn out to be false, there are good reasons to include changes in energy practices among the objectives of the Smart Growth Strategy. Carefully implemented, such changes could enhance Ontario's economy, improve air quality, and contribute to worldwide efforts to moderate the extent of climate change.

Even if present indications of large fuel price increases turn out to be false, including changes in energy practices among the objectives of the Smart Growth Strategy could enhance the economy of the Central Ontario Zone, improve its air quality, and contribute to worldwide efforts to moderate the extent of climate change,

If the analysis here is correct, failure to take appropriate action could have profound adverse consequences on Ontario's economy and environment, and even its social fabric. Development of the Smart Growth Strategy provides opportunities to ensure that Ontario residents will be able to cope with erosion of a foundation of modern industrialized societies, access to essentially unlimited amounts of fossil-fuel energy.

The best outcomes of this brief paper would be a full-scale assessment of the matters raised in it, and appropriate recognition of the importance of energy factors in the emerging Smart Growth Strategy.

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