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Centre for Sustainable Transportation
15 Borden Street
Toronto, Ontario
Canada M5S 2M8

Phone (416) 923-9970
Fax (416) 923-6531
E-mail cstctd@web.net
Web site www.web.net/~cstctd

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SUSTAINABLE TRANSPORTATION AND THE END OF CHEAP OIL

The price of crude oil could rise dramatically during the next 10-15 years. This would help attainment of sustainable transportation but there would also be significant perverse effects. Canada's plans for reducing transport's environmental impacts should allow for the possibility of such a price rise.

Current prices of crude oil are at their lowest level in real terms since the early 1970s.[1] The world market seems awash with oil on account of resumption of sales by Iraq (the oil-for-food program), reduced growth in demand in Asian countries, and high winter temperatures early in 1998.[2] As this issue of the *Monitor* is being prepared, the main news about oil concerns social problems in oil-producing countries resulting from low oil revenues.[3]

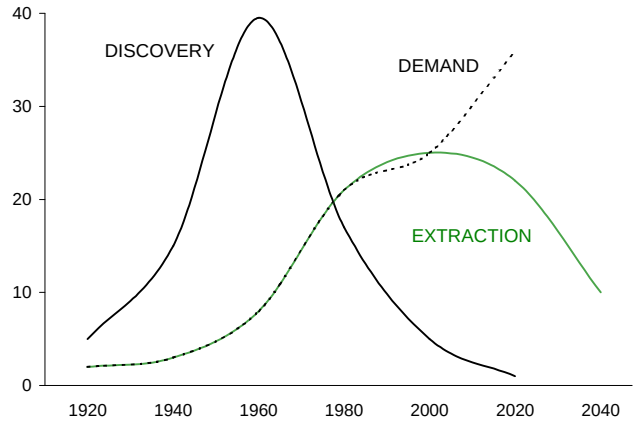
Thus it is with some hesitation that we begin this issue of the *Monitor* by reporting what appears to be **growing agreement among oil experts that we are soon to see the permanent end of cheap oil**.[4] Notable among these experts are those of the International Energy Agency (IEA), whose position on the matter is set out below.

The significant facts are these:

- **World *discoveries* of reserves of conventional oil peaked in the early 1960s** at a rate of about 40 billion barrels a year (bb/y).[5] ("Conventional oil" is oil that can be pumped from the ground, usually under its own pressure. "Unconventional oil" is pumped from seabeds or mined from oil sands or shale. Conventional oil can be recovered at relatively low cost; hence it is also known as "cheap oil." Nearly all of the oil now used in the world is conventional oil.) In spite of massive and highly sophisticated efforts since then, the rate of discovery of conventional oil has declined steadily to an estimated 1998 rate of 6 bb/y, less than one third of the rate of extraction and use (see Box 1).[6]
- The massive surveying effort means that **the total amount of conventional oil in the ground across the world has been more or less identified**.
- Various factors cause the output of an oil field to reach a maximum soon after it is first tapped and to decline when about half of the oil in the field is depleted.[7] When large numbers of fields

Box 1 CST

Actual and projected world-wide discovery, extraction, and demand for conventional oil, 1920-2040
(in billions of barrels per year)



Data sources: Oberle Oil Corporation; International Energy Agency

are considered, coming on stream at different times, this pattern of production of individual fields blends into a bell-shaped overall production curve that rises until about half of the total oil is depleted and then begins to fall.[8]

- According to Colin Campbell and Jean Laherrère, two experienced geologists specializing in fossil fuel sources, about 800 billion barrels (bb) of conventional oil had been extracted across the world at the end of 1996 and about 1,000 bb remained for extraction (including an estimated 150 bb of reserves to be discovered).[9] About half of what is still in the ground is in countries that border the Persian Gulf.[10]

Thus, given the current rate of extraction of about 25 bb per year, it seems that **half of the world's total endowment of conventional oil will have been extracted by a date early in the next decade, at which point production will begin to decline**.[11]

In the meantime, demand for oil is set to continue to rise. Even with their problems, some Asian economies grow relatively rapidly,[12] with corresponding growth in the use of oil for transportation and other purposes. High rates of growth in oil consumption occur in Africa, South America, and eastern Europe. Oil use by countries in western Europe and North America also increases.[13]

In its *World Energy Outlook*, released late in 1998, the IEA projected that without major price increases or policy changes demand for oil will increase substantially throughout the period 1995-2020, by an average of close to 2 per cent per year.[14] This growth is also illustrated in Box 1.

Thus we approach a situation in which growth in demand for conventional oil will increasingly exceed the possible supply, with little prospect of major new discoveries. The likely result will be large and continuing price increases. Some experts suggest that the price increases could start as early as 2000; others note that political instability in the Persian Gulf area could result in shortfalls in supply even during 1999.[15]

What has been presented above is one side of an argument that may be said to have three sides. The other two sides can be roughly characterized as these: (i) conventional oil is not running out, at least not for many decades; technological innovation in recovery processes will see us through;[16] and (ii) oil will quickly become irrelevant on account of falling consumption through technological innovation and will, like uranium, be left in the ground.[17]

The Centre accepts the position that the next decade or so will see the end of cheap oil because the arguments for this position are more compelling than the arguments for the other two positions,[18] **and because this is now the view of the International Energy Agency**.[19] IEA was formed in 1974 by the governments of the world's rich countries to provide sound data collection and analysis to help confront the threat of oil supply manipulation. Its conclusions and recommendations about energy supply and use are generally considered to be among the most authoritative.

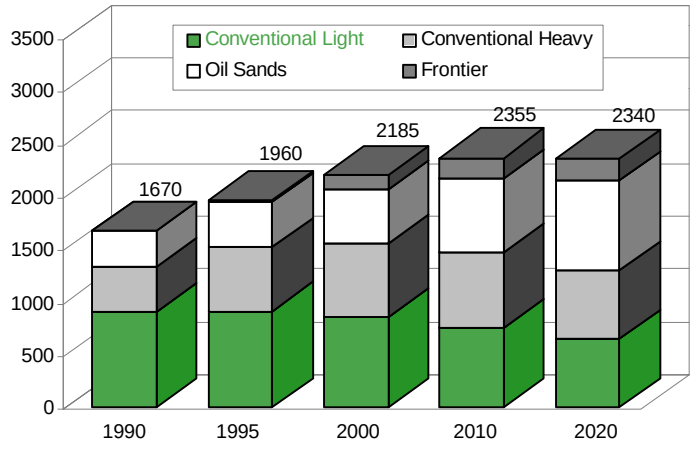
The idea that the peak in availability of conventional oil was imminent has been around for some time. It was given prominence during 1996 and 1997 by books and reports written by respected geologists and others.[20] The greatest visibility for the argument came with the publication of an article by Campbell and Laherrère in the widely read magazine *Scientific American*,[21] which led to numerous newspaper reports and magazine articles on the topic, and **growing acceptance around the world of the prospect that the age of cheap oil may soon be over**.[22]

Campbell and Laherrère and IEA differ on one significant point: the likely date of peak world production of conventional oil. This is projected to be 2003 by Campbell and Laherrère and 2013 by IEA.[23] The two authors and IEA use the same analysis but reach different conclusions about the date of the peak largely because of differing assumptions about the amount of oil left in the ground. IEA uses the U.S. Geological Survey's estimate that there are about 1.5 trillion barrels of oil left to be recovered. Most experts believe there are only about one trillion barrels, which is close to the figure used by Campbell and Laherrère.[24]

The Centre accepts with caution the earlier date for the peak in conventional oil production—on the grounds it is based on more widely accepted assumptions—but recognizes that the actual date may differ by some years. **What seems possible and perhaps likely, given the balance of the evidence, is that the peak in production of conventional oil will be reached during the period that Canada—and several dozen other countries—will be working to meet the commitments made in Kyoto, Japan, in December 1997 to reduce greenhouse gas emissions to below 1990 levels by 2012**. When the peak in production is reached, demand for oil will likely begin to exceed supply and world prices for oil will likely increase substantially from their present low levels.

Box 2 CST

Actual and Projected Oil Production in Canada, 1990-2020
(thousands of barrels per day)



Data source: Natural Resources Canada

When world oil prices rise so will the price paid in Canada, because more than half of the oil used in Canada is bought on the world market.[25] Changes in crude oil prices cause changes in the retail prices of vehicle fuels.[26] The exact relationship is not well understood, in part because pump prices were regulated in Canada and the U.S. in the 1970s when world oil prices varied substantially. A guide as to what is in store for Canadians may be what happened the last time the world oil price doubled, between 1979 and 1981; pump prices increased by about 50 per cent over this period.[27]

Given previous experience, a doubling of world oil prices from their present low level might well be expected to result from the kinds of shortages in supply illustrated in Box 1. Given the possibility that demand will begin to exceed supply before 2012, as discussed above, **it would be prudent to take into account the possibility of large pump price increases, driven by large increases in world oil prices, in developing Canada's plans for meeting the Kyoto commitment.**

How much would fuel use fall if there were a 50-per-cent increase in pump prices? Research suggests that there could be an initial reduction in fuel use of about 15 per cent, rising to 25 per cent if the increase were sustained for a few years, other things being equal.[28] Canada is committed to reducing its greenhouse gas (GHG) emissions by at least 20 per cent below what they would otherwise be in 2012.[29] Because GHG emissions from transport are almost precisely correlated with fuel use, it seems at first blush that nothing much need be done by Canadians in respect of transport's share of meeting the Kyoto commitment except wait for world oil prices to rise.

There are several things wrong with this assertion, including the following:

- Other things are not equal. Canada's population is expected to increase by about 22 per cent between 1990 and 2012.[30] Thus, **a 50-per-cent increase in pump prices could do little more than offset the increase in vehicle fuel use due to population growth**.
- The evidence on the impacts of fuel price increases is weak, particularly regarding diesel fuel. Indeed, **there is evidence, discussed below, that use of diesel fuel is hardly affected by fuel price increases**. Without specific, effective constraints, use of diesel fuel is expected to be responsible for a disproportionate share of the increase in GHG emissions from transport between 1990 and 2012, as discussed in the next section. Thus, price increases might do little to restrain a significant portion of the growth in GHG emissions.
- **Canada is one of the few countries in the world with the potential for producing relatively large amounts of non-conventional oil**, **mostly found in Alberta's oil sands**. Already about 20 per cent of Canada's oil production is from this source and, according to Natural Resources Canada, oil sands are expected to comprise 36 per cent or more of Canada's oil production by 2020.[31] Canada's supply of conventional oil will reach a peak in 1999.[32] Higher world prices are likely to stimulate further production of oil from oil sands. As well as being more costly, this oil takes more energy to produce than conventional oil, although exactly how much more is a matter of controversy.[33] As increasingly intractable oil is mined, the amount of energy required rises. Eventually more energy is needed to produce the oil than can be provided by the oil. As the energy cost increases, so does the impact of the extraction and refining processes on the environment. **Thus the effect in Canada of an increase in world oil prices during the next decade could be to make each unit of transportation less sustainable, because it uses fuel whose production has a greater impact on the environment.** Whether this effect would be more than offset by reductions in fuel use resulting from increased prices requires detailed analysis.
- **High world oil prices caused by an excess of demand over supply could pre-empt the raising of taxes on vehicle fuel.** Indeed, if fuel taxes remain the same and fuel use declines it will be more difficult for governments to provide increased support for potentially more benign transport modes. They are needed as alternatives to make it easier for people to reduce their use of current modes.

Even with these reservations and possible perverse effects, the prospect of the end of abundant and cheap oil will likely focus attention on the need for sustainable transportation and help progress towards it. **No alternative fuel has the prospect of becoming anywhere near as easy to produce, transport, and store, or as convenient to use, as conventional oil.** Thus the need to improve transport's efficiency and reduce the overall level of transport activity will be more evident. Moreover, **oil has many other valuable uses**. More than 6,000 products are produced wholly or in part from oil products including asphalt, nylon and other plastics, detergents, medicines, and pesticides. If some or all of these other uses are considered more essential than transport uses, the result will be further imperatives to make transportation sustainable.

Here are some conclusions from this very brief overview of the oil supply situation:

- **Strategies for meeting Canada's Kyoto target for reducing GHG emissions should accommodate the possibility of large increases in world oil prices before 2012. The resulting increases in pump prices may nevertheless not be enough to meet the target.**
- **In Canada, the overall impact of large oil price increases in relation to the Kyoto target could be negative, on account of increased production from oil sands and reduced investment in benign transport modes. There would also be positive features, notably reduced use of vehicle fuels.**
- **Ultimately, it is the energy cost of providing vehicle fuel that could limit its availability rather than the financial cost. If it takes a barrel of oil to produce a barrel of oil then nothing is gained, except additional pollution.**
- **The energy aspects of sustainable**

transportation are as important as its other aspects and require as much attention as transport's impacts on the local and global environments.

Campbell and Laherrère's *Scientific American* article contain some useful concluding thoughts for this section: "***The world is not running out of oil—at least not yet. What our society does face, and soon, is the end of the abundant and cheap oil on which all industrial nations depend***."[34]

But perhaps the last word should go to David Greene, a respected U.S. transport economist who has written extensively on matters of oil supply. He has said, ***"Campbell and Laherrère are experienced and credible geologists with an important message about conventional oil availability that is becoming widely accepted. Work on sustainable transportation has paid far too little attention to this matter. It should be a key consideration in our planning and strategizing."***

CANADA'S TRANSPORTATION BECOMES LESS SUSTAINABLE

Evidence that has become available since the last issue of the *Monitor* was prepared suggests that Canada's transportation systems are becoming increasingly unsustainable.

The key information in assessing whether Canada's transportation is moving towards or away from sustainability concerns fossil fuel use, particularly gasoline for personal automobiles, diesel fuel for trucks, and aviation fuel. Actual use of vehicle fuel is the most important indicator because it is almost precisely correlated with emissions of GHGs from transportation and because it is closely correlated with the extents of all other environmental impacts.

The last issue of the *Monitor* reported the following about vehicle fuels for the period 1979 to 1996. The total use of gasoline in Canada had actually declined slightly, as had use of fuel for rail and marine purposes. Total use of aviation fuel had increased a little, and total use of road diesel fuel had more than doubled. The *Monitor* emphasized the very large increase in diesel fuel use, and paid less attention to the increases in both gasoline and aviation fuel during the 1990s. However, **data for 1997 suggest that the growth in total use of all three transport fuels is accelerating**, as detailed in Box 3.[35]

Box 3 CST

Actual and expected annual rates of change in total use of fossil fuels for transport in Canada, 1979-2000

		Road fuels		Aviation fuels	Rail and marine fuels
		Gasoline	Diesel		
Actual rates during the period 1979-1990		-1.0%	4.1%	0.1%	-1.4%
NRCan's projections for 1990-2000		***0.8%***	***3.1%***	***1.5%***	***-0.1%***
Actual rates since 1990:	1990-1996	1.0%	4.7%	3.1%	-1.5%
	1996-1997	2.5%	9.3%	4.0%	0.5%

Data sources: Natural Resources Canada; Statistics Canada; Transport Canada

Box 3 shows **the use of all three fuels during the 1990s has been exceeding by wide margins what Natural Resources Canada (NRCan) projected for the period, particularly during 1997**. Thus NRCan's projections, which are the foundation of the work of the National Climate Change Process discussed below, appear to be substantial underestimates.

According to NRCan, the transport sector accounted for 27 per cent of greenhouse gas (GHG) emissions in Canada in 1990 and, without special action, will account for 28 per cent of the total in 2010 and 37 per cent of the increase until 2010.[36] However, ***if* the rates of increase in use by the transport sector have been underestimated by the amounts suggested by Box 3 for 1990-1997, and the 1990-1997 rates continue, the transport sector will account for 53 per cent of the increase in Canada's greenhouse gas emissions between 1990 and 2010**.[37]

The trends illustrated in Box 3 suggest that freight transport—which uses almost all of the diesel fuel and marine and rail fuels, amounting to about 30 per cent of use of fossil fuel for transport—will comprise a disproportionately large part of transport's share of the increase in fuel use and GHG emissions. **If the rates of increase that have prevailed over the period 1990-1997 continue until 2010, freight will be responsible for more than half of the *increase* in transport fuel use and thus more than a quarter of the increase in Canadian GHG emissions**.[38]

The recent sharp growth in gasoline use shown in Box 3 is also of concern because gasoline still comprises by far the largest part of fossil fuel use for transportation: 61 per cent, vs. 21 per cent for diesel fuel and 9 per cent for aviation fuel in 1997.[39] **The growth in gasoline use may be mostly a result of the growth in the number of automobiles on the road, which increased by 1.8 per cent during 1997, the highest rate of growth since the 1980s**.[40] Another factor may be the increase in the proportion of light trucks, vans, and sport-utility vehicles used as personal automobiles. These energy-intensive vehicles now comprise about 40 per cent of sales of vehicles for personal use and about 20 per cent of personal-use vehicles on the road.[41]

The above comments concern *environmental* sustainability. Regarding *economic* sustainability, the simplest indicator may be transport's share of the Gross Domestic Product. **New data suggest that the transport sector now comprises an increasing share of GDP after falling for several years.** This may be taken as evidence of the growing economic unsustainability of transport, on the grounds that any rising cost can

eventually become unsustainable, particularly the cost of a *means* to several ends such as transport.[42]

There is no such simple indicator of *social* sustainability. One of several indicators is the share of all journeys made by public transport. Given that transit, if available, can be used by more of the population than automobiles, an increase in transit's share can be taken to reflect a more inclusive and thus perhaps more socially sustainable society, and vice versa. **There have been some encouraging signs of growth in transit use during the last two years, but the rate of growth seems to have been no more than the rate of growth in automobile use.** Consequently, transit's share of all travel may not have increased and the encouraging signs cannot yet be taken to mean that the movement of people in Canada has become more socially sustainable.[43]

It should be stressed that **these indications of lack of movement towards the economic and social sustainability of transport are faint and controversial in comparison with the strong evidence of transport's growing environmental unsustainability.**

CANADA'S NATIONAL CLIMATE CHANGE PROCESS

Against this backdrop of the growing unsustainability of Canada's transportation system, the Government of Canada began to prepare to meet its commitment to reduce emissions of GHGs to 6 per cent below 1990 levels, made at Kyoto in December 1997. It has established 15 Tables/Groups of experts as part of the National Climate Change Process (NCCP) to develop options for reducing these emissions.[44]

Several of the Tables are concerned with transportation, although transport issues are being addressed for the most part by the Transportation Table. This Table has four subgroups concerned respectively with consultations, road vehicle technology and fuels, freight transport, and passenger transport. The freight subgroup has sub-subgroups concerned with road, marine, rail, and air freight transport, each chaired by a stakeholder, i.e., a person with a strong stake in the respective business. The passenger subgroup has two sub-subgroups, concerned with urban and intercity travel.

Transport's large share of GHG emissions, and the ongoing extraordinary growth in GHG emissions from transport, could be taken to mean that the Transportation Table has by far the largest share of the responsibility for the success of the NCCP. The Table's huge task is compounded by what appears to be strong public resistance to the kind of changes in present transport systems that would make them more sustainable. Stakeholders' resistance to change may be even stronger, especially in respect of some aspects of freight transport.

Canada's success in meeting its Kyoto commitment could in large measure be determined by her success in restraining GHG emissions from transportation, which in effect will mean her ability to reduce the use of gasoline and diesel fuel. Such dependence on success with what may be the most intractable of sectors is daunting. It becomes easy to say that changing how we move ourselves and our freight is too difficult and expensive, and that the Kyoto challenge should be met by other sectors.

THE MOVING THE ECONOMY CONFERENCE

Optimism about transportation's potential contribution to the climate change challenge was evident at the *Moving the Economy* (MTE) conference held in Toronto in July 1998. MTE brought together 540 participants from 16 countries—from business, government, and labour, as well as university researchers and community activists—to display and discuss concrete examples where moves towards sustainable transportation have resulted in economic benefits. These benefits have included job creation, increased retail sales, cost savings, revenue generation, increased productivity, and revitalized local economies. Conference themes touched on several elements of the emerging sustainable transportation sector, including sustainable freight, telecommunications, urban form, human powered transport, urban green tourism, public transit, passenger and freight rail, and more.

The conference has stimulated preparations for the establishment of MTE On-Line, a searchable electronic inventory of economic success stories in sustainable transportation, and work on an Economic Action Plan (EAP) for Sustainable Transportation in Toronto. The EAP is drawing on examples from the conference and from the expanding inventory to develop and promote economically beneficial sustainable transportation initiatives, guided by local, theme-specific advisory groups. The EAP will be presented at an MTE-inspired conference to be hosted by the Mayor of San Francisco in June 1999.[45]

NRTEE BACKGROUNDER

Also optimistic was the document *Backgrounder: Greenhouse Gas Emissions from Urban Transportation* produced late in 1998 by Canada's National Round Table on the Environment and the Economy (NRTEE).[46] The document focused on the largest Census Metropolitan Areas (CMAs). The *Backgrounder's* conclusion was that "it would be feasible for Canada, acting alone, to achieve its Kyoto target for greenhouse gas reductions as applied to urban transportation in the country's 13 largest CMAs, which account for some 80 per cent of urban transportation GHG emissions." The report added that the target could be met more easily if there were continent-wide action.

The thrust of the NRTEE report was that *packages* of measures are required for effective action. Initially, eleven individual measures were examined in terms of their GHG reduction potential. From this, three combined packages of measures were developed. The preferred package of measures comprised nine policy instruments: fuel taxes, fuel efficiency standards for new vehicles, feebates, and enhanced transit and urban design policies. This package was shown to have the potential to reduce GHG emissions by 2010 to 11 per cent below 1990 levels—or to 20 per cent below 1990 levels if the policies

were harmonized with the United States. Implementation of such a package showed much promise for improving Canada's economic efficiency in the longer term.

ACHIEVING SUSTAINABLE TRANSPORTATION

This section and the next four sections continue the discussion began in the last issue of the *Sustainable Transportation Monitor* as to how sustainable transportation might be achieved. That issue emphasized **the value of the Kyoto commitment as a stepping stone to the longer-term goal of securing sustainable transportation.** In this issue, the analysis in the NRTEE's *Backgrounder* is supplemented with a focus on four measures.

The first two of these measures—imposing fuel-efficiency standards and raising fuel taxes—were considered in NRTEE's *Backgrounder* and indeed were key components of the package of measures proposed as the most effective. The analysis here raises questions about their efficacy, even with respect to the relatively modest Kyoto target, thereby **reinforcing the view that no single measure should be relied on**.

The other two measures discussed below—emissions trading and entitlements to purchase—are rationing schemes that were not addressed in the *Backgrounder*. **They are highly controversial measures, in part because they are likely to be effective in reducing fuel use and thus GHG emissions**. Such measures may be required for the post-Kyoto period after 2012 in order to secure sustainable transportation, which will involve very much larger reductions in emissions than are required to meet the Kyoto target.[47] **These measures are discussed here to emphasize that the Kyoto target is not an end but a beginning, and to help ensure there will be consideration of the post-Kyoto period while plans are being made to reach the Kyoto target.**

FUEL EFFICIENCY STANDARDS

The U.S. has been the only major country that has required its automobile manufacturers to produce more efficient cars, and therefore cars that emit less carbon dioxide. This has been through the Corporate Average Fleet Efficiency (CAFE) program, which has applied standards for fuel efficiency for *new* cars and for other personal vehicles (light trucks, minivans, and sport-utility vehicles) since 1978, backed up by per-vehicle fines levied on manufacturers who exceed required fleet averages. Since 1980, Canada has had a corresponding voluntary program, the Corporate Average Fuel Consumption (CAFC) program, coordinated and synchronized with the CAFE program.

Box 4 shows that **the remarkable reduction in the average fuel intensity of new North American automobiles began some years *before* the CAFE/CAFC programs were implemented in 1978/1980**.[48] The reduction began in 1974, soon after the oil supply disruption of 1973 and resulting fuel price increases, and just as the U.S. government announced it would be introducing fuel-efficiency standards for automobiles as an alternative to raising fuel taxes.[49] Also at this time there was a surge in the popularity of more fuel-efficient Japanese-built cars.

Would North American manufacturers have improved the fuel efficiency (i.e., reduced the fuel intensity) of their vehicles without the promise of legislation and the competition from imports? It's hard to say.

The CAFE/CAFC standard for new cars was tightened from 13.1 litres per 100 kilometres (l/100 km) in 1978 to 8.6 l/100 km in 1985, where it has remained. Light trucks, minivans, and sport-utility vehicles have a more relaxed standard, which has been stiffened slightly since 1985 and is now 11.4 l/100 km.[50]

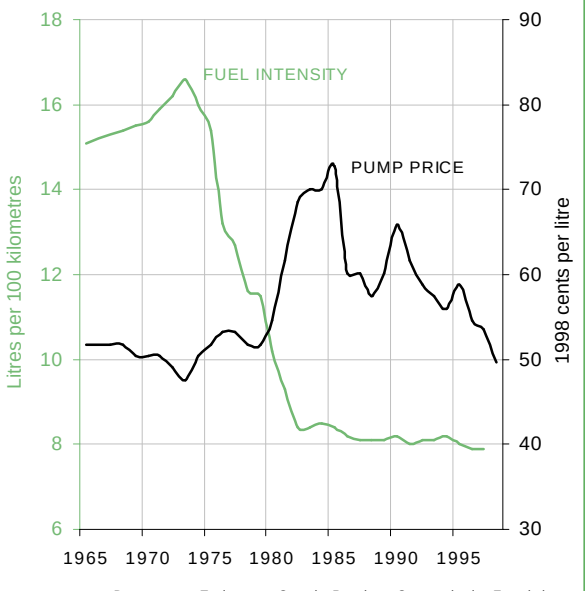
Critics of fuel-efficiency standards argue that they have had perverse effects. One has been to favour the purchase of the more fuel-intensive light trucks and other vehicles subject to the more relaxed standards. Another has been to increase distances travelled, a result of the combination of low fuel intensities and low fuel costs.[51] **Notwithstanding the perverse effects, it seems likely that the CAFE/CAFC standards have sustained fuel efficiency since 1986 even though fuel prices have fallen dramatically** (see Box 4).

Critics argue too that the same reductions in fuel intensity, and perhaps greater reductions in overall fuel use, could have been achieved through modest increases in fuel taxes, without perverse side effects and with a more beneficial impact on the economy.[52] These criticisms of CAFE are consistent with the prevailing fashion among economists for fiscal as opposed to regulatory measures.

The key question for attainment of the Kyoto target and sustainable transportation is whether fuel-efficiency standards could be relied on to achieve actual reductions in fuel use. There is no direct evidence. Indirect evidence for the effectiveness of standards comes from their apparent contribution towards widespread use of three-way catalytic con-

Box 4 CST

Fuel intensity of new North American cars and gasoline prices, Canada, 1965-1998



Data sources: Environment Canada; Petroleum Communication Foundation

verters on gasoline-fueled vehicles, and the consequent dramatic reduction in emissions of several pollutants, notably carbon monoxide.[53] Emission standards are forcing the use of electric or other zero-emission vehicles in California and perhaps in other U.S. states, with reduced carbon dioxide emissions being a likely incidental result. It is also the case that **where there have been no fuel efficiency standards fuel use has risen dramatically even, as in Europe, where fuel prices are high**.[54]

The reasonable conclusion about fuel-efficiency standards is that they are a promising measure that has already demonstrated some effectiveness with respect to smaller vehicles. The evidence that they can *reduce* fuel intensity is too slight to allow dependence on them for attainment even of the modest Kyoto target for transport.

FUEL TAXES

Evidence on the effectiveness of fuel price on fuel use (and thus on CO_2 emissions) is of two kinds. One kind—*cross-sectional* evidence—compares prices and consumption in several jurisdictions at a particular point in time. The other kind—*longitudinal* evidence—looks at the response to fuel-price changes within one jurisdiction over time. Both kinds of evidence suggest, as might be expected, that raising fuel prices can reduce fuel consumption. The relationships are not straightforward and there are many questions still to be answered, particularly with regard to the effect of raising prices on the use of diesel fuel.

Available cross-sectional evidence and analyses[55] are unsatisfactory, even if only because no distinction has been made between diesel fuel and gasoline. In Canada, as illustrated in Box 3, these two fuels have had different patterns of use. Gasoline use has changed relatively little over the last two decades, although the trend in the 1990s is for increases. Use of diesel fuel has more than doubled over the same period, with particularly steep increases in the 1990s.

Accordingly, a new cross-sectional analysis was performed for the Centre, based on data for 1993 as reported to the Organization for Economic Cooperation and Development (OECD) by national governments. Box 5 portrays the results.[56] It shows a high, significant correlation (-0.72) between price of gasoline and its use and a relatively low, *non-significant* correlation (-0.25) between diesel fuel and its use.[57]

Interpreting the lack of correlation concerning diesel fuel is difficult because of the widely differing patterns of use among the 22 represented countries. Two possibly significant factors are the proportion of all diesel fuel used in automobiles and the proportion of all freight carried in trucks. Canada and the U.S. both rank low in these respects among OECD countries.

A reasonable conclusion from the cross-sectional analyses is that the use of gasoline (which occurs almost entirely in private automobiles) varies inversely with price, but that the use of diesel fuel may not vary in this way. However, correlation is only part of the evidence for causation; alone it is far from conclusive.

Longitudinal analyses provide additional evidence for causation. Rather than correlation, longitudinal evidence is summarized by the use of the statistic known as *price elasticity*, which is the percentage change in use divided by the percentage change in price. In a jurisdiction in which a 10% increase in price appears to result in a 3% decrease in use, the price elasticity of use is said to be -0.3. One summary of studies of the price elasticity of use of gasoline in several countries distinguished between short-term elasticity (less than one year) and longer-term elasticity (five years or more). The average of 51 estimates of short-term elasticity was -0.27; the average of 45 estimates of the longer-term elasticity averaged -0.71.[58] Other surveys have shown negatively larger longer-run elasticities.[59]

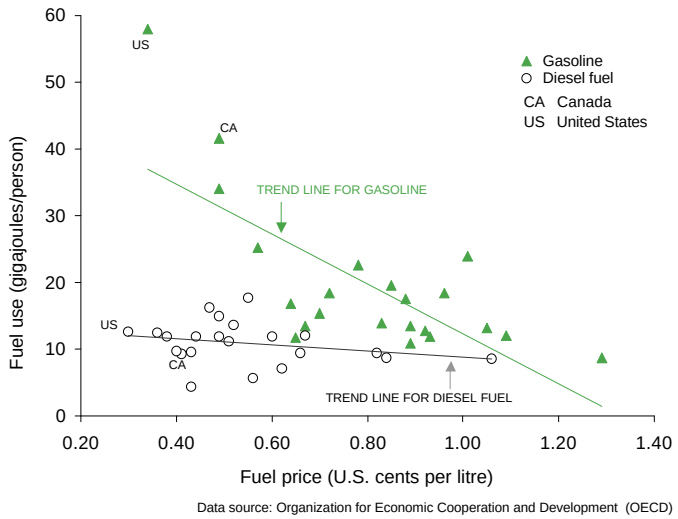
The longitudinal analyses thus support the argument that low gasoline prices contribute to high gasoline use and, equally, that raising gas prices will reduce use. The qualification must be added that short-term elasticities appear to be relatively low. People appear to adjust their driving habits slowly. Raising gas prices could have its main effect on car-purchasing behaviour rather than on driving behaviour, with the full effect of an increase occurring according to the rate of changeover of the fleet.

There appear to be no readily available reports on the price elasticity of diesel fuel. One review allows a comparison between price elasticities of gasoline, on the one hand, and crude oil, on the other hand.[60] The long-term price elasticity of gasoline was reported as -0.8, whereas those for crude oil averaged about -0.4, suggesting that the price elasticities of demand for non-gasoline products of crude oil could be even lower. This would be consistent with the position that gasoline use is much more sensitive to price than diesel fuel use.

As a matter of urgency, work needs to be done in Canada on the relation between the price of diesel fuel and its use.

Box 5 CST

Use of diesel fuel and gasoline in relation to their prices in 22 OECD countries (1993)



Data source: Organization for Economic Cooperation and Development (OECD)

Meanwhile, the only reasonable conclusion is that raising the price of diesel fuel may not reduce consumption of diesel fuel.

If the price elasticity of a fuel is known, or can be inferred, estimates can be made of the order of price increases required to produce desired reductions in use. For gasoline use in respect of the Kyoto commitment, the price increases required are fairly modest: about 5 per cent a year for each of 10 years.[61] (The U.K. government has a policy of increasing real gasoline prices by 6 per cent a year to meet environmental and other objectives.) For gasoline use in respect of attainment of sustainable transportation—say, an 80-per-cent reduction in GHG emissions from 1990 levels over 30 years—real price increases near 10 per cent per year would be required for the post-Kyoto period.[62]

Here are some reasonable conclusions from this analysis: **Modest regular real increases in the price of or tax on motor gasoline would be an effective measure in securing some of the reduction in CO_2 emissions required to secure transport's contribution to meeting the Kyoto target. Much larger increases in price or tax would be required to meet a sustainability target, at a level that may be intolerable.** The present flimsy evidence suggests that consumption of diesel fuel would be little affected by price increases.

Effectiveness in reducing fuel consumption is one among several reasons for raising fuel taxes. Raising revenue to support public transit and non-motorized modes could also be considered a strong justification. Moreover, if it is indeed the case that only use of gasoline and not diesel fuel is affected by price increases, raising diesel fuel prices could nevertheless be justified on the grounds that use of diesel fuel usually results in higher emissions per kilometre of nitrogen oxides and breathable particulates.[63]

EMISSIONS TRADING

This kind of scheme should properly be called "entitlements trading." It has become respectable with its apparent success in the U.S. in limiting emissions associated with local and regional pollution from stationary sources (e.g., electricity generating stations). Entitlements to pollute are allocated, auctioned or sold. A business that wants to pollute more than the amount allowed by its entitlement can purchase entitlements from other businesses.

Emissions trading is in vogue. Indeed, the December 1997 Kyoto Protocol allows signatories to reach national targets through purchase of credits for other nations' successes in reducing emissions of GHGs. Ontario Hydro appears to be meeting its internal targets for reductions in GHG emissions by purchasing emissions credits from other utilities. The 1997 *Economists Statement on Climate Change*, endorsed by 2,800 North American economists, called for the implementation of climate policies "through market mechanisms such as carbon taxes and the auction of emissions permits."

An emissions trading scheme is essentially a way of setting a cap on the amount of permitted pollution, equivalent to the value of entitlements that are issued. In essence, **emissions trading is a form of rationing, but a very flexible form in which no individual or company is specifically restricted, as long as there are entitlements to be purchased from other potential polluters**.

A system involving moving sources of pollution (i.e., motorized vehicles) has not yet been implemented, but many are being discussed—within, for example, the Australian, Netherlands, Swiss, and U.S. governments.[64] In Canada, the *National Forum on Climate Change*, organized by the NRTEE, considered "the merits of using instruments such as personal credit cards for energy consumption," which included consumption of vehicle fuels.[65]

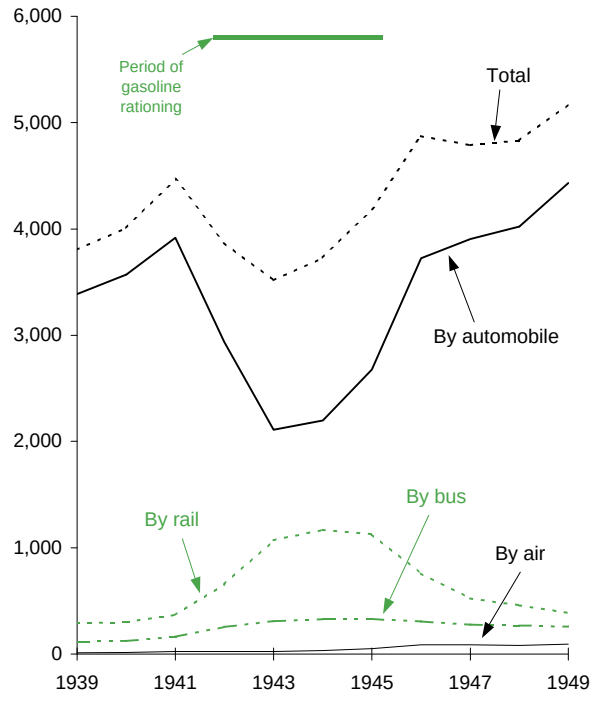
Simple rationing of vehicle fuel has been extremely effective. As Box 6 shows, the period of wartime fuel rationing in the United States was associated with a sharp decline in inter-city automobile use and less than compensating increases in travel by other motorized modes.[66]

There is every reason to suppose that the sophisticated, market-based system of rationing known as emissions trading could be an effective way of helping Canadians achieve the very large reductions in emissions that will be required to achieve sustainable transportation. Such a system may be too drastic and too complex for the relatively modest targets set in the Kyoto commitment, but the need for later measures of this kind should be kept in mind in fashioning the strategy for the Kyoto period.

Here is the emissions trading scheme proposed by the Netherlands government for an OECD study concerned with securing very large reductions in GHG and other emissions by 2030.

Box 6 CST

Per-Capita inter-city travel in the U.S., 1939-1949
(passenger-kilometres per person)



Data source: Eno Foundation

Each resident would have an emissions budget for personal travel of 160 kg of CO_2 per year. This is the amount that can be permitted if total CO_2 emissions from personal travel are to be reduced by 80 per cent. The total of 160 kg would allow roughly 1,400 passenger-kilometres (pkm) of use of a 1998 automobile, 7,100 pkm in a car of the kind expected to be available in 2030, and 46,700 pkm of travel by the kind of rail service expected in 2030. The initial allocation of CO_2 permits in the amount of 160 kg to each person would be without charge. Individuals could buy or sell their allowances in a formal or informal permit market.[67]

The Netherlands' proposal also includes an emissions trading scheme for freight transport. In this, all permits to emit CO_2 for freight transport purposes would have to be purchased from a pool provided by government. The permits could be traded after purchase. An alternative mechanism for freight transport, not proposed by the Netherlands, would give individuals a larger allowance and require deliverers of freight transport services to purchase entitlements from individuals, presumably through an organized market.

ENTITLEMENTS TO PURCHASE VEHICLES

Box 7 portrays a remarkable relationship concerning automobile use.[68] It is that **the total distance travelled by personal vehicles (cars and light trucks, etc., used as cars) appears across the years to be almost precisely correlated with the number of such vehicles on the road**. This arises because the number of kilometres travelled per vehicle is extraordinarily constant, also portrayed in Box 7. Similar constancies have been found for other countries examined.[69]

It follows that the main factor contributing to vehicle use, and thus GHG and other emissions, may be vehicle ownership. It follows too that reducing vehicle ownership may be an effective way of reducing automobile use. Indeed, if the link between ownership and use is as tight as portrayed in Box 7, reducing vehicle ownership may just about be the *only* way to reduce vehicle use.

Measures to reduce car ownership may be even more unpopular than measures to reduce car use. In part this may be because measures to reduce ownership are seen as inequitable,[70] even though measures to reduce use may, in reality, be equally inequitable.

Another argument for reducing use rather than ownership is that it is use that causes environmental impacts; a car in the garage harms no one. Thus, measures to reduce use are considered to be more appropriate. Indeed, the aim of some transport policies seems to be that everyone should have a car and no one should use one. (Such policies appear to disregard the environmental impacts of production, storage, and disposal, which may amount to a quarter of a vehicle's full life-cycle impacts.[71])

For the most part, only authoritarian governments have sought to restrict ownership of vehicles. Singapore's government has restricted automobile ownership since the 1970s, arguing that unrestrained ownership would be a barrier to economic growth. Initially, ownership was restricted through high purchase taxes. As incomes grew, high taxes proved inadequate. In 1990 a rationing system was introduced that involves monthly auctions of entitlements to purchase. Successful bidders paid close to C$35,000 each for entitlements valid in January 1999.[72]

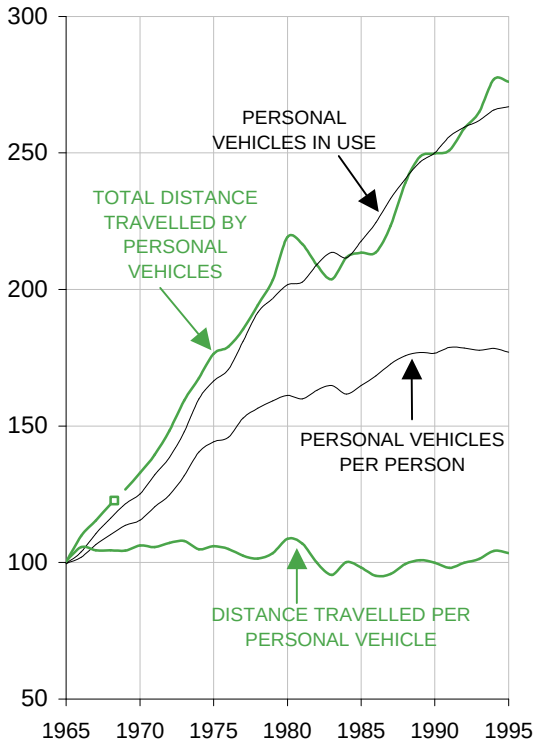
With the introduction of island-wide road pricing during 1998 and 1999, Singapore is retaining rationing of ownership but reducing the high purchase taxes and annual licence fees in favour of new charges for road use that will allow better control over congestion. The government's strategy is to suppress the overall level of use through reducing ownership and to address temporary, local high levels of use through road pricing. The costs of car ownership will still be among the world's highest.

Attempts to reduce use through limiting ownership do not have to involve rationing or high purchase taxes. In several places, usually near city centres, a majority of people choose not to own automobiles even though they could afford to do so. This is because access to employment, goods and services, and social activities is readily available without a car. **One approach to reducing car ownership would be to design and arrange all parts of an urban area so that non-ownership would be as equally advantaged as ownership, if not more advantaged**.[73]

The rationing of both vehicle use (emissions trading) and vehicle ownership (auctioned entitlements to purchase) should be among the matters discussed when packages of measures are chosen for attainment of the Kyoto target. Neither measure is likely to be introduced during the next decade, but both kinds of rationing may be required in later years. **Measures implemented for meeting the Kyoto target should be selected with a view to what will be needed later.** For example, electronic road pric-

Box 7 CST

Distance travelled and ownership of personal vehicles, Canada, 1965-1995 (1965=100)



Data sources: Transport Canada; Statistics Canada

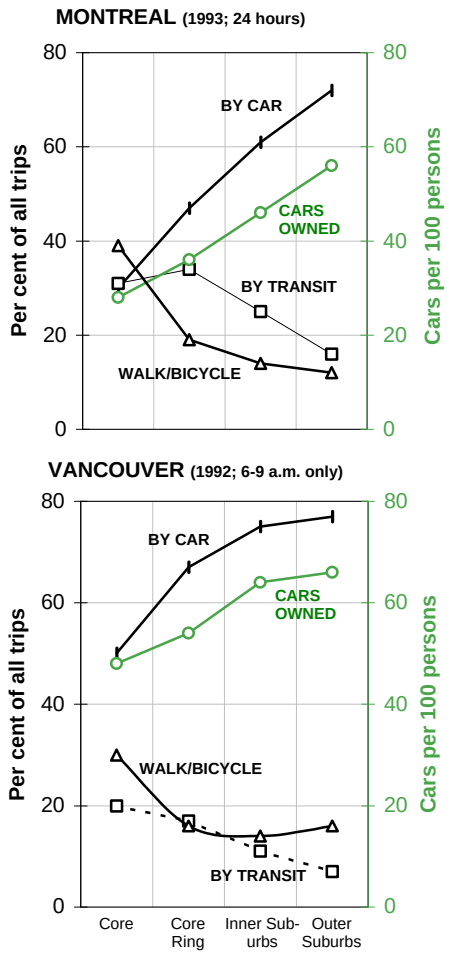
ing could be favoured over fuel taxes because it requires development of the kind of information technology that will facilitate emissions trading designed to help secure sustainable transportation.

COORDINATED TRANSPORT POLICY-MAKING IN CANADA'S MAJOR URBAN REGIONS

The last issue of the *Monitor* highlighted some of the transport features of the Toronto Region. This region is increasingly dominated by low-density suburbs where there are high levels of automobile ownership, and consequent high levels of automobile use. Public transit accounts for about 13 per cent of trips within the region; walking and bicycling account for another 8 per cent of all trips.

Box 8 CST

Modal splits and car ownership according to place of residence



Data sources: Ecole Polytechnique de Montréal; Greater Vancouver Regional District

Canada's second and third largest regions have similar features. Montreal has had lower rates of economic growth and population growth than Toronto and Vancouver, and lower rates of car ownership, but the overall characteristics of the three conurbations are similar. Box 8 shows how in each region car ownership and use increase with distance from the downtown (the "Core" in Box 8), and transit use falls.[74] In all three regions, the increases in population and employment take place almost entirely in their outer suburbs. **As a consequence, Canada's three large urban regions are increasingly characterized by more-or-less complete dependence on use of the automobile—notwithstanding the thriving downtown areas that dominate the regions' public images.**

What distinguishes Montreal and Vancouver from Toronto is that steps have been taken by the Quebec and British Columbia governments to address the transport challenges of the Montreal and Vancouver regions.

The boldest moves have been in B.C., where the Greater Vancouver Transportation Authority (GVTA) will begin work in April 1999 with responsibilities throughout the region for the planning and provision of public transit, construction and maintenance of major roads, traffic management, and the control of air pollution. It will be funded through transit revenues, a share of the provincial gasoline tax, a share of property taxes, a levy on residential electricity bills, and tolls on new roads. It will be governed by a board mostly comprising local politicians appointed by the board of the Greater Vancouver Regional District (GVRD). This is the regional government for just about all of Vancouver's urban region.[75]

There are two related reasons for the formation of the GVTA. One is to address the poor performance of transit in the region, which has had among the highest costs and lowest service levels of major transit systems in Canada.[76] The other is to help support implementation of the Livable Region Strategic Plan of the GVRD.[77] This Plan speaks to doubling the region's transit system capacity by 2008. It also speaks to a substantial increase in automobile use, although less of an increase than might be expected from 'business as usual.'

The GVTA could prove to be no more than a device for accelerating investment in facilities for automobiles. It may be more likely to favour judicious investments in public transit on the grounds that they are more cost-effective and more consistent with environmental objectives. The key feature of the GVTA is that it will have the choice. **For the first time in North America, there will be a regionally focused agency responsible for most of the major decisions about transportation throughout almost all of a large urban region, and able to deploy dedicated revenue streams.**

Montreal's closest equivalent of the GVTA is the Agence métropolitaine de transport (AMT), created in 1996 to improve coordination among transport authorities in the Montreal urban region and to develop intermodal services.[78] It has fewer powers than are proposed for the GVTA, particularly in relation to roads, and it is potentially weaker as well because it functions within a governmentally much more fragmented region.[79] However, **with revenues from shares of car-registration fees and new gasoline taxes, from municipal and provincial contributions, and from integrated fares and suburban train fares,[80] Montreal's AMT has the potential to enhance public transit on a regional basis**.

The Quebec government is also in the process of establishing the Commission de développement de la métropole (CDM). Its responsibilities are to include preparation of both an integrated transportation plan for the Montreal region, for people and goods, and a region-wide, land-use planning framework. The AMT and CDM both report to the Quebec government minister responsible for the Montreal region (la métropole). They have overlapping responsibilities and, accordingly, some rationalization may well occur during the next few years.[81]

Growth in capacity for regional action is not entirely absent from Toronto.

The Greater Toronto Services Board began operation in January 1999 with responsibility for managing the suburban train system and the system's bus services, and for promoting coordinated decision-making among the region's municipalities regarding the development and use of infrastructure, including transportation infrastructure.[82]

Whether these actual, emerging, and forthcoming regional structures will be up to the task of restraining the pressure points of transport growth in Canada remains to be seen. Evidence from Canada and elsewhere suggests that the movement of people and freight becomes more sustainable only if use of road modes is restrained.[83] It is not clear that any of the institutions noted above—even the GVTA—has or will soon have the powers and resources needed to achieve the necessary restraint.

LEVELLING THE FIELD

One of the paradoxes of the United States is that it has what is probably the most unsustainable transportation in the world, and yet it is the source of some of the most innovative and effective moves towards sustainability. One of Canada's challenges is to emulate the good practice rather than the bad. Two things worth emulating are the moves towards removing the pro-automobile bias in discussion of transport and removing unequal tax treatment of commuters by car and by public transit.

BIASED LANGUAGE. The City Administrator of West Palm Beach, Florida, started the move against biased language. In a November 1996 memo,[84] he advised the City's managers as follows: "Much of the current transportation language was developed in the 1950s and 1960s. This was the golden age of automobiles and accommodating them was a major priority. Times have changed, especially in urban areas where creating a balanced, equitable, and sustainable transportation system is the new priority. … There are several biased words and phrases that have been identified and summarized at the end of this memo. Suggested objective language is also summarized. … "

Box 9 provides a few of the examples found at the end of the City Administrator's memo.

Box 9 CST

Examples of biased and objective language in municipal transportation reports

Biased language	Objective language
The following street *improvements* are recommended.	The following street *modifications* are recommended.
Upgrading the street will require a wider right-of-way.	*Widening* the street will require a wider right-of-way.
Alternative modes of transportation are important to the downtown.	*Non-automobile* modes of transportation are important to the downtown.
Motor vehicle *accidents* kill 200 people every year in the County.	Motor vehicle *collisions* kill 200 people every year in the County.
We have *protected* this right-of-way.	We have *purchased* this right-of-way.
Let us widen the road so that cars operate *more efficiently*.	Let us widen the road so that cars operate *faster*.

Source: City of West Palm Beach, Florida, U.S.A.

TAX TREATMENT. The U.S. government provides tax exemptions for employer-provided parking and for employer-provided transit passes (although the limit is higher for the former benefit: US$165 vs. $60 per month). The Government of Canada taxes both, but with generous exemptions for parking to the extent that only about one in twelve of employees using subsidized parking pays tax on the benefit.[85]

There is compelling evidence that both reducing the cost of transit passes and increasing the cost of workplace parking encourage commuting by transit. Implemented together these measures appear to have a synergistic effect: the total effect is much larger than the sum of the separate effects.

Thus, to encourage sustainable transportation, the appropriate strategy would be tax parking and not transit. A good first step would be to level the field in Canada by exempting employer-provided transit passes.

PROMISING SIGNS

This section focuses on developments in Canada that bear on the use of diesel fuel by road vehicles, chiefly heavy trucks and buses. As noted in Box 3, this kind of transport fuel use has showed by far the highest rate of increase among transport fuels over the last two decades. **There are basically four methods of reducing transport fuel use: (i) increasing the loading of vehicles (e.g., by avoiding return journeys by empty vehicles); (ii) shifting transport activity to more efficient modes; (iii) improving engine efficiency; and (iv) reducing overall transport activity**.[86] This section touches on the first three of these methods.

INCREASING LOADING. Calgary-based Trimac Transportation, among North America's largest bulk trucking companies, and four other carriers have formed the Alliance of Bulktruck Carriers. Members of the Alliance are to collaborate in load matching and capacity sharing so as to increase the actual loading of vehicles on the road. This move is said to be driven by the requirements of chemical shippers to maximize supply chain efficiencies.[87] If successful, it will reduce emissions per tonne-kilometre of freight carried.

MODE SHIFTS. Since July 1996, 21 sections of rail track no longer required by the major operators (Canadian National and Canadian Pacific) were transferred to short-line rail freight operators.[88] By keeping the lines open and running them efficiently, the short-line operators are raising the possibility that freight movements will be made by rail rather than road, not only along the short-line route but also for the whole journey.

Canadian Pacific's "Iron Highway" service between Toronto and Montreal promises to get truck trailers off crowded expressways and on to the underused railway system. 1998 saw the end of what was considered to be a successful trial of the service, a doubling of service frequency between the cities, and the development of plans to link Montreal and Toronto in this way with De-

troit. The service involves trains comprising one or more 366-metre-long flexible rail-car elements, supported by sophisticated logistics management. Trailers can be readily driven on and off the elements without cranes, special tracks or loading docks. The trains run on regular schedules with transport times, including terminal transfers, comparable to regular truck transport.[89]

TECHNOLOGICAL IMPROVEMENTS. The use of diesel fuel is raising concerns not only on account of the amounts of it that are being used but also because of its associated emissions. Diesel engines are responsible for nearly half of all transport-related emissions of nitrogen oxides in Canada, and more than half of such emissions of breathable particulates. Both are hazardous to health, as are several other toxic products of diesel engines. Compressed natural gas (CNG) provides many benefits as a fuel for large vehicles. Emissions of toxic compounds are much lower per vehicle-kilometre.[90] If refuelling is tightly controlled, there are also substantial reductions in GHG emissions.

Several Canadian companies are among pioneers in the development of CNG-fuelled trucks and buses. Fiba Canning Inc. of Toronto has developed a CNG-fuelled truck. New Flyer Industries of Winnipeg, Nova BUS of Montreal, and Orion Industries of Mississauga produce CNG-fuelled buses.[91] Orion is also developing what it calls the "wireless trolley," a hybrid-power vehicle that uses a constant-speed CNG engine and regenerative braking to charge batteries that drive electric motors on each wheel. Hybrid power-train systems typically use much less fossil fuel than their conventional equivalents.[92] The design also readily allows for a low floor throughout the passenger area, an increasingly desirable feature of transit vehicles, but one that is more difficult to achieve when wheels are driven directly by internal combustion engines.

THE CENTRE FOR SUSTAINABLE TRANSPORTATION

The Centre is a federally chartered, non-profit organization.

It began work in 1996 with start-up funds from Environment Canada and Transport Canada.

Its mission is to provide leadership in achieving sustainable transportation in Canada by facilitating cooperative actions, and thus contributing to Canadian and global sustainability.

To achieve its mission the Centre provides reliable information, fills knowledge gaps through research, educates stakeholders and raises awareness among them, and offers strategic policy advice in selected areas.

The Centre's first publication was its *Definition and Vision of Sustainable Transportation*, published in mid 1997. You are reading the second issue of the *Sustainable Transportation Monitor*, published annually or more frequently. The first issue appeared in March 1998. It is available at the Centre's Web site, as are the Centre's other publications (visit www.web.net/~cstctd). The *Monitor* provides evaluation of progress towards or way from sustainable transportation and discussion of related matters.

Comments on this issue of the *Monitor* and proposals as to what should be covered in coming issues are much appreciated. E-mail is the preferred mode of communication but feedback by any mode is welcome. **Please see Page 1 for our e-mail address, fax and phone number, and mailing address**. Contact the Centre as well if you would like to find out how to become a corporate or individual member of the Centre.

REFERENCE NOTES

1. See *Oil and Gas News* (<www.westgov.org/wieb/news/oilgas98.htm>). The mid-December 1998 price of crude oil was around US$11.00 per barrel. It was last so low in real terms in 1972, when the current price was US$1.97 per barrel. According to some forecasts, the price may go as low as $5.00 per barrel during 1999 "unless OPEC deepens cuts." (see *Financial Post*, Toronto, November 20, 1998). Retail gasoline prices in Canada are also at their lowest since the early 1970s, as illustrated in Box 4 of this issue of the *Sustainable Transportation Monitor*.
2. For Iraqi oil resumption see U.S. Energy Information Administration, *Monthly Energy Chronology 1998* (<www.eie.doe.gov/emeu/cabs/monchron.html>). For lower Asian demand and reduced heating oil use see Daniel Yergin and Joseph Stanislaw, "How OPEC lost control of oil," *Time*, April 6, 1998. Also see Yergin and Stanislaw for another reason for the oil glut: oil-producing nations have been losing the ability to cooperate on production cuts. According to Environment Canada, 1998 was the warmest on record; 1997 was the warmest year before that. (<www1.tor.ec.gc.ca/ccrm/bulletin/>). The contribution of each of these factors, apart from the Iraq sales, is somewhat speculative. Iraq sales, which recommenced in March, amounted to 3.4% of world production in late 1998 (U.S. Department of Energy, Energy Information Administration (EIA), *OPEC Fact Sheet* <www.eia.doe.gov/emeu/cabs/opec.html>). This is a small amount, but enough even in itself to turn a balance of supply and demand into a surplus of supply sufficient to lower prices.
3. *Toronto Star*, December 12, 1998, "Oil producers warn of social unrest."
4. For a discussion of how the consensus is emerging see *Oil Shock: Energy Supply and Demand, Past, Present and Future*, by Robert Meier et al, Obele Oil Corporation, 1998 (<www.obeleoil.com>). See particularly the section beginning on Page 33 entitled "Why are so many analysts not forecasting an oil shock?" and this comment on Page 34, "Although the question of when worldwide oil will exceed global oil supply is stubbornly ignored by the popular press, a growing number of informed U.S. and European evaluations are coming into synch with the views of L.F. Ivanhoe [see Note 20 below], and put this crisis as coming no later than 2014, and *perhaps as soon as 2000*." [italics in original]
5. See the source cited in Note 4, particularly Pages 30-35, and Figures 19 and 20.
6. For a discussion of the decline in discovery, see Colin H. Campbell, *A Guide to Determining the World's Endowment and Depletion of Oil* (<hubbertpeak,com/campbell/guide.htm>), Page 1. The information in Box 1 is schematic and can be considered to represent smoothed moving averages of actual and projected values of the three variables of production, extraction (production), and demand (consumption or potential consumption). The information on discoveries and extraction has been taken from the source cited in Note 4, particularly Figure 20. Demand is assumed to have more or less tracked supply until now, and to increase at the rate projected by the IEA until 2020 (see Note 14).
7. See the source cited in Note 6, especially Section 8 and Figure 1. The main factors are loss of 'natural' pressure in the field (see the source in Note 4, Page 9) and increasing remoteness of the oil in the reservoir from the wellbores (see the source in Note 6, Page 6).
8. This is the famous "Hubbert Curve" named for geologist M. King Hubbert, who used the relationship in the 1950s to predict correctly that oil production from the lower 48 states of the U.S.A. would peak around 1969.
9. The estimates of what has been and remains to be extracted are the 1996 figures of Colin J. Campbell and Jean H. Laherrère, "The End of Cheap Oil," *Scientific American*, March 1998, Pages 78-83. In the source cited in Note 6, Campbell gives slightly different numbers. For the end of 1997, he reported that 795 bb had been extracted, 823 bb of reserves had been identified, and 182 bb was yet to be found, meaning that 44 per cent of the endowment had been extracted—compared with the end-of-1997 estimate of 46 per cent based on the *Scientific American* numbers (assuming production of 25 bb/year). The *Scientific American* numbers and the production assumption together point to a peak in production in 2001. The other numbers, with the same assumption about production rate, point to a production peak in 2002. There is a graph in the *Scientific American* article (p. 81) suggesting that the peak will be in 2003.
10. See the source cited in Note 6, Figure 5.
11. Arithmetically, peak production will occur in 2001 or 2002, according to which of Campbell's estimates referred to in Note 9 is used.
12. For example, China, the key economy in the region after Japan, is projected to experience economic growth of 6.7% during 1999, India 6.5%, Vietnam 4.7%, and Taiwan 4.4% (*The Economist*, January 16, 1999, "GDP growth forecasts 1999").
13. World oil consumption has risen every year since 1991 (*Oil and Natural Gas Industry Foundation Paper*, prepared for the National Climate Change Secretariat, Government of Canada, September 1998).
14. In *World Energy Outlook, 1998 Edition*, the International Energy Agency projects a increase in world energy demand of 65% between 1995 and 2020 (i.e., 2% per year), assuming no large changes in prices or policies, with two thirds of the increase occurring in China and other developing countries. Details of the business-as-usual projection are given in Table 7.7 of the *Outlook*, the full version of which is not on the IEA web site (<www.iea.org>) and thus was not available while this issue of the *Monitor* was being prepared. However, information is given elsewhere on IEA's website for oil supply/use in 1996 and 2020. It is respectively 3,310 and 5,250 million tonnes (35.3% and 38.3% of the totals), an increase of 58.5%. (8 barrels of oil weigh about one tonne—<www.iea.org/pubs/studies/files/weo/defconv.htm>.)
15. See the source in Note 4 on both these points.
16. This is the view of the United States Department of Energy's Energy Information Agency (EIA). EIA's *Annual Energy Outlook 1999* (<www.eia.doe.gov/oiaf/ieo99/oil.html>), published in December 1998, speaks to continually rising produc-

tion at least until 2020 (Pages 46-47), with no hint of constraints on availability. According to an EIA representative, "We don't see the peak happening until after the limit of our outlook. We think technology and developing Middle East production capacity will provide the oil" (Linda Doman, quoted in Richard A. Kerr "The Next Oil Crisis Looms Large—and Perhaps Close," *Science*, 281(5380), pp. 1128-1131, August 21, 1998). An extreme version of the view that oil supplies are for practical purposes limitless was provided in an article by Henry Linden in the December 28, 1998, issue of the *Oil & Gas Journal* entitled "Flaws seen in resource models behind crisis forecasts for oil supply, price" (pp. 33-37). The article criticizes projections based on the Hubbert Curve (see Note 8) and argues that as much as 3 trillion barrels—rather than 1.0 or 1.5 trillion barrels—are available for extraction. Linden's estimate seems to be based on inclusion of reserves with as little as a 10-per-cent chance of recovery of the estimated amount. More conservative appraisals are based on estimates involving a 50-per-cent chance of recovery, for the reason that errors in such estimates tend to cancel each other out.

17. The view that oil will become irrelevant is that of the respected energy analyst Amory Lovins (*Science*, 282(5386), p. 47, October 2, 1998). He has argued, "Together, these [just discussed] technical and barrier-busting innovations could make oil uncompetitive even at low prices before it becomes unavailable even at high prices."

18. Much space could be spent in what is already a long discussion in illustrating the basis for the Centre's preference among the three positions. For the moment, it can be said that the arguments of Amory Lovins (see Note 17) are compelling but his timetable requires much more study. The analysis of the EIA (see Note 16) appears to contain many flaws and inconsistencies. For example, the document cited in Note 16 suggests that non-OPEC oil production will reach about 55 million barrels a day by 2010 (125% of the 1997 rate) and remain at that level until 2020 (see fig. 39 on p. 47 of that document). Elsewhere, in its 1998 *Non-OPEC Fact Sheet* (<www.ei.doe.gov/emeu/cabs/nonopec.html>), EIA presented the more widely held view that at the end of 1997 non-OPEC reserves were sufficient to provide only 14 years of production left at the 1997 rate of use. This would mean that, taking into account the expected annual 1.7% increase in production, non-OPEC oil would be totally exhausted *before* 2010. The discrepancy between these EIA documents could in theory be bridged by new discoveries. EIA seems to pin its hopes on there being nearly 200 bb in the Caspian Sea area. This is questionable as an amount and would in any case be incapable of supplying the required annual output (Richard. Kerr, "Big Oil Under the Caspian," *Science*, 281(5380), August 21, 1998, p. 1130). Part of EIA's argument for sufficient availability of supplies beyond 2020 is that improvements in technology will allow higher yields from dying wells. But EIA information itself provides the strongest argument against this proposition. Fig. 101 on p. 76 of EIA's *Annual Energy Outlook 1999* (see Note 16) projects that throughout 2000-2020 production from the lower 48 states will be below the 1990 level, which itself was less than one third of the 1970 level. If technology is not expected to raise yields from dying wells in the U.S., where the incentives to produce indigenous oil are very high, it cannot reasonably be expected to raise yields elsewhere.

19. Colin Campbell and Jean Laherrère (see the bullet point on Page 2 of this issue and also Note 9) met several times with IEA officials late in 1997 (see <www.hubbertpeak.com/debate/index.html>). As a result, IEA changed its earlier position that world supplies of conventional oil would continue to rise for several decades. IEA advised the G8 energy ministers in March 1998 that the peak availability would be reached in 2013, with a subsequent decline. For the statement prepared for the G8 energy ministers in March 1998, see <www.iea.org/g8/world/oilsup.htm>. This position of IEA was reinforced in the *World Energy Outlook, 1998 Edition* (see Note 14). The specific reference to IEA's use of the Hubbert Curve (see Note 8) is in the discussion of the IEA's new 1998 World Energy Model (<www.iea.org/ead/model.htm>).

20. See, for example, Walter Youngquist, *GeoDestinies*, National Book Co, 1997; Craig Bond Hadfield, *Hubbert Center Newsletter* #97/4 (<hubbert.mines.edu/news/v97n4/mkh-new5.html>); James McKenzie, *Oil as a finite resource: When is global production likely to peak?* World Resources Institute, Washington DC, 1996 (<www.wri.org/wri/climate/finitoil/index.html>); Richard Duncan, *The world petroleum life-cycle; Encircling the production peak.* Institute on Energy and Man, Seattle, 1997 (<dieoff.com/page133.htm>); Colin Campbell, *The Coming Oil Crisis*, Multi-Science Publishing and Petroconsultants, Brentwood, U.K., 1997. L.F. (Buzz) Ivanhoe, "Petroleum position of the United States", *Hubbert Center Newsletter #98/1* (<hubbert.mines.edu/news/v98n1/usa.html>).

21. Cited in Note 9.

22. For example, *Forbes* (U.S.), June 15, 1998; *Barrons* (U.S.), October 19, 1998; *The Observer* (U.K.), July 26, 1998. Most significant of all may be an opinion piece entitled "Oil Price Outlook" by Bob Costello and Diego Saltes of the American Trucking Associations in the December 21, 1998, issue of the trucking industry publication *Transport Topics* (<www.ttnews.com>). The article acknowledges that the reserve-to-production ratio has been falling since the 1960s and that "Some believe production could peak as soon as the next two or three years for public oil companies. If this does develop, prices would most likely increase substantially and once again promote the status of the Persian Gulf producers." Also of note is the following statement in an article by A.T. Kearney in the January 1999 issue of *Report on Business Magazine* (*Globe & Mail*, Toronto): "In the short term, chronic overcapacity in all oil and gas sectors will keep prices low and pressure the business. Ironically, the biggest longer-term challenge is the looming peak in world oil production, which could come as early as 2002, given ever-increasing energy demand (expected to double in the next 50 years). Energy companies are placing emphasis on a range of options, from renewables to wind energy, also they are still behind the curve in wind energy." (p. 16).

23. For the 2003 estimate see Note 9. For the IEA's 2013 estimate see the sources cited in Note 19.

24. The actual USGS cited range is 2.1 to 2.8 trillion barrels of ultimately recoverable oil. IEA used 2.3 trillion barrels, but also says that 3.0 trillion barrels is possible (see the IEA presentation to G8 ministers referenced in Note 19, where the reference to the use of the USGS projection is documented). MacKenzie (see Note 20) reviewed 41 estimates of the total of

ultimately recoverable oil; most of them put the total as below 2.0 trillion barrels (including what has already been recovered). There seems to be agreement that about 800 billion barrels have already been recovered, leaving reserves and potential reserves of near 1.0 trillion barrels if you believe most of the experts cited by MacKenzie or near 1.5 trillion barrels if you believe the USGS/IEA. Another possible difference between Campbell and Laherrère and IEA lies in the estimates of rate of growth of consumption of oil. IEA uses variously 1.6% (in the G8 ministers presentation, referenced in Note 19) and 2.0% (in the source in Note 14, where the discrepancy may be resolved). This is also the rate used by the EIA in its *International Energy Outlook 1998*, p.16 (<www.eia.doe.gov/oiaf/ieo98/oil.html>). Campbell and Laherrère used the higher rate.

25. Even though Canada produces about a third more oil than it consumes, the crude oil price in Canada is closely related to the world price, not the least because more than half of Canada's consumption is imported into eastern Canada each year from other oil-producing countries. The actual numbers for 1995 are these, in thousands of barrels per day: production 1960, imports 735, exports 1285, consumption 1410 (from Chart 4.10 in *Canada's Energy Outlook 1996-2020*, Natural Resources Canada). Thus about 66% of Canada's production is exported—almost all from western Canada—and about 52% of Canada's consumption (735 bbd) is imported—almost all into eastern Canada.

26. The correlation between average annual crude oil prices and average annual pump prices in Canada for the period 1977-1996 was +0.43; the correlation with the *previous* year's crude oil prices was even higher: +0.56. According to Rohlf FJ, Sokal RR, *Statistical Tables*. WH Freeman and Co., San Francisco, Ca., 1969, Table Y, a correlation of +0.43 among 20 pairs of data would occur by chance less than five times in 100; a correlation of +0.56 would occur by chance less than one time in 100.

27. Average real gasoline prices at the pump in Canada increased by 43 per cent between 1979 and 1982 in response to the 1979 oil crisis (by 96 per cent in current dollar terms). The crisis consisted of a doubling of the real world oil price between 1979 and 1981. (Canadian pump prices are taken from the *Canadian Global Almanac* for various years; world oil prices are from *International Energy Outlook 1996*, U.S. Department of Energy.)

28. See the discussion of elasticities in the section on "Fuel Taxes" in this issue of the *Monitor*. The short- to medium-term elasticity of fuel prices seems to be in the order of -0.3 to -0.5, meaning that a 50% increase in the real pump price would result in a reduction in fuel use of from 15 to 25%.

29. The estimate of 20% is based on information in *Canada's Energy Outlook 1990-2020*, Natural Resources Canada (<nm1.nrcan.gc.ca/es/ceo/toc-96e.html>); "at least" was added to reflect the current high rates of use (see the next section of this issue of the *Monitor* and particularly Box 3).

30. Statistics Canada (<www.statcan.ca/english/Pgdb/People/Population/demo03.htm> and <www.statcan.ca/english/Pgdb/People/Population/demo23a.htm>).

31. The 36% comes from the source in Note 29. The use of "or more" is justified by the comments on expansion of oil sands production in the October 1998 *Update* to the CEO discussed below in Note 35.

32. Box 2 has been redrawn from Chart 4.9 in the source in Note 29, using data provided on Pages 5 and 6 of the Annex to this publication found at <netra.es.nrcan.gc.ca/ceo/toc-96E.html>. The same source projects that exports of oil from Canada will also reach a peak in 1999; then they will amount to 33 per cent of production, falling to 24 per cent in 2020. According to the *Globe & Mail* (January 14, 1999), extraction of conventional oil fell between 1997 and 1998 and is expected to be below the 1997 level in 1999. Thus the peak in production of conventional oil in Canada may have been reached in 1997.

33. Youngquist (Note 20) said that "With the strip mining and refining now in use, it takes the energy equivalent of two barrels of oil to produce one barrel." However, Suncor's *Action Plan and Annual Progress Report* for the 1997 Climate Change Voluntary Challenge (www.syncrude.com/5_env/ 5_04/03.htm) program says that 1.41 million BTUs resulting in 126 kg CO_2 are required to produce a barrel of oil (which has an intrinsic value of 5.8 million BTU and when burned produces about 400 kg CO_2). Also see Note 35.

34. From the source cited in Note 9, Page 83 (final paragraph). The quote that follows is taken with permission from an e-mail to the Centre from David Greene dated January 21, 1999. Greene is with the Oak Ridge National Laboratory, Oak Ridge, Tennessee, a multi-program research facility managed for the U.S. Department of Energy.

35. The actual rates of increase set out in Box 3 for 1979-1990 and 1990-1996 were calculated from Transport Canada's 1997 T-Facts file "Refinery Sales of Petroleum Products - Transportation by Fuel," which is based on Statistics Canada's *Quarterly Report on Energy Supply-Demand in Canada*, #57-003. The rates for 1996-1997 were calculated from an extension to the above series provided by Christian Beauregard of Transport Canada on December 17, 1998, and checked against the current issue of the *Quarterly Report*. NRCan's projections for 2000 are from Transport Canada's 1998 T-Facts file "Demand by fuel," which is based on Natural Resources Canada's *Canada's Energy Outlook*, April 1997. This document (CEO) is Canada's "official" projection of greenhouse gas emissions. CEO was updated in October 1998 by a working paper entitled *Canada's Emissions Outlook: An "Events-Based" Update for 2010*, issued by NRCan's Energy Forecasting Division. The CEO estimate of total emissions of GHGs of 564 million tonnes (megatonnes or mt) of CO_2 equivalent in 1990 has been revised upwards by 35 mt to 599 mt. The "business-as-usual" projection for 2010 has been revised upwards by 34 mt from 669 to 703 mt. These changes reflect improvements in methodology. They do not materially affect the information provided in Box 3. The *Update* report also identifies nine events that could serve to make the latter projection higher. By far the most significant of these is an expected increase in synthetic crude oil production, from a projected 380,000 to 1,030,000 barrels a day in 2010. This could well be the result of the factors discussion in the previous section. This oil is assumed by NRCan to have an emission factor of 88 or 98 kg CO_2/barrel. None of the changes touched on in this Note bears directly on emissions from transportation. (Also see Note 33.)

36. Confusingly, two sets of percentages are given for transport's share of greenhouse gas emissions resulting from the activities

of Canadians. For 1990 and 2010 they are 26.5% and 28.1%, on the one hand, and 30.6% and 31.2%, on the other hand. Both sets are derived from Natural Resources Canada's *Canada's Energy Outlook*, April 1997. The former set, which it may be more appropriate to use, take into account emissions from sources other than those related to the production and combustion of fossil-fuel energy, e.g., emissions from landfill sites. Transport Canada's 1998 T-Facts, however, gives the second set without comment.

37. The 53% was calculated by estimating the increase in use of fuel from transport over the period 1990-1997, concluding that the average annual rate of increase has been 1.95% rather than the projected 1.11%, and applying this larger rate to transportation alone for the period 1990-2010. (See the CST file "Transport fuel use in Canada, 1979-2010.xls", which is available on request.) Note that the assumption that "other factors remain the same" may not be warranted. Natural gas use for all purposes seems to be increasing at a higher rate than projected. CANSIM D674087, "Final demand - Natural Gas," indicates an increase in total use of natural gas of 2.8%/year for 1990-1997, which seems much higher than any increase projected by NRCan. On the other hand, the *rate* of use of transport fuels appears to be increasing, meaning that application of the 1990-1997 rate to 1990-2010 may be an underestimate.

38. Freight's actual share of transport GHG emissions would be 53%. See the CST file "Transport fuel use in Canada, 1979-2010.xls", which is available on request. It is a coincidence that "53%" occurs in this and in the previous note.

39. See the CST file "Transport fuel use in Canada, 1979-2010.xls", available on request.

40. The figure of 1.8% comes from Statistics Canada document 53-219-XIB *Road Motor Vehicle Registrations*, September 1998. Whether it is truly the highest since the 1980s still requires better confirmation. The data in 53-219-XIB go back only to 1993, and in enumerating trucks there is no distinction between trucks used for commercial freight-carrying and light trucks used as personal automobiles. There are earlier data in Transport Canada's 1998 T-Facts (highway.xls, "Vehicles") and in *The Canadian Global Almanac 1992* (but not later years) that suggest no larger increase in the 1990s. The real point here however is the linking of energy use to automobile ownership. This is based on the evidence that kilometres driven per automobile is more-or-less constant, which is to be discussed later in this issue of the *Monitor*.

41. According to Industry Canada's *Statistical Review of the Canadian Automotive Industry (1998)*, there were 661,000 "passenger cars" sold in Canada in 1996 (Page 13) and 489,000 "light trucks" (Page 15), which includes "pickup trucks" (200,000), "sports utility vehicles" (96,000), and "vans" (192,000). Thus light trucks comprised a maximum of 43% of purchases of personal vehicles —37% if it is assumed that at least half the pickup trucks are used for carrying freight. The respective percentages for 1990 are 31% and 26%, hence the assertion of an increase. An estimate of the extent of their use is found in Figure 10-6 of Transport Canada's *Transportation in Canada 1996*, which suggests that light trucks comprised 20% of the total vehicle-kilometres driven in cars and light trucks in 1995. Factoring this 20% down to allow for non-personal use of pickup trucks, as before, suggests a revised estimate of 17%. The estimate of 37% of sales in 1996 and 17% on the road in 1995 were rounded up to 40% and 20% to allow for growth since those years.

42. The evidence here is from Transport Canada's 1998 T-Facts (economy.xls, "Transport and the Economy"), which shows that in 1997 transport began assuming a larger share of the economy over the previous year for the first time since 1992. (1996 showed the lowest portion since 1982.) Whether occupying more of the economy means that transportation is becoming less economically sustainable is a debatable point, presently beyond the scope of the *Monitor*.

43. There is no direct evidence of the share of person-kilometres held by transit systems. Information from the Canadian Urban Transit Association (*Summary of Canadian Transit Statistics: 1997 Operating Data*, November 1998) indicates the number of passengers carried by transit systems across Canada increased in 1997 for the first time since 1990, by 2.2%; vehicle-kilometres increased by 0.6%. Box 3 indicates that the growth in gasoline use from 1996-1997 was 2.5%. Thus public transit's share of passenger kilometres did not appear to increase, notwithstanding the increase in transit use.

44. The information in this section comes mostly from the Web site of the National Climate Change Process (<www.nccp.ca>) and from information provided by participants in the Process.

45. For more information on the items in this section contact Sue Zielinski at (416) 392-1556 or at <szielins@city.toronto.on.ca>.

46. This document (ISBN 1-895643-76-7) was prepared by the IBI Group and Management of Technology Services and is available from the National Round Table (<www.ntree-trnee.ca>).

47. The Centre for Sustainable Transportation has provisionally proposed that reduction in GHGs in the order of 80% from 1990 levels will be required in rich countries for attainment of environmental sustainability. (See the Centre's *Definition and Vision Statement*, 1997.) This degree of reduction is also proposed by OECD and the Swiss government. As noted above, Canada's Kyoto target requires reductions in GHG emissions of 6% below 1990 levels.

48. The information represented in Box 4 comes from *Canada's National Environmental Indicator Series* produced by Environment Canada, specifically SOE Technical Supplement No. 98-5, Canadian Passenger Transportation, Technical Supplement, Figure 6. Note that "automobiles" here means new North American automobiles, not imports and not vans, trucks, sport-utility vehicles, etc. 1996-7 data for fuel intensity come from the 1997 report to parliament by Transport Canada. 1996-8 data on fuel prices come from the Petroleum Communication Foundation (<www.pcl.ab.ca/weeklypump.html>). These prices are based on self-serve stations in 10 cities and have been corrected to correspond to the Environment Canada data before inclusion in the series.

49. For a discussion of the introduction of CAFE standards see Chapter 5 of *The Extra Mile* (Brookings Institute, Washington D.C., 1995) by Pietro S. Nivola and Robert W. Crandell.

50. See *Transportation in Canada 1997* (Transport Canada), Table 7-1, Page 102.

51. The paradox that reductions in fuel intensity can increase fuel use is known various as the rebound, snap-back or Jevons ef-

fect—the last from a 19th-century economist who correctly forecast that improvements in the efficiency of steam engines would lead to more use of coal. The perverse effects are taken from the source in Note 49, where the other criticisms of CAFE can be found.

52. See, for example, the source cited in Note 49.

53. The use of three-way catalytic converters appears to be a major cause of the increase in emissions of nitrous oxide (N_2O, laughing gas), one of the six greenhouse gases addressed by the Kyoto protocol. According to the *New York Times* of May 29, 1998, "The EPA calculated that production of nitrous oxide from vehicles rose by nearly 50 per cent between 1990 and 1996 as older cars without converters have neared extinction. ... nitrous oxide now accounts for about 7.2 per cent of the gases that cause global warming. Cars and trucks ... produce nearly half that nitrous oxide."

54. During the period 1980-1993, motor fuel use per capita increased by about 40 per cent in 15 western European countries and by less than 5 per cent in North America (although the North American base level of use was more than three times higher than the European base). See *OECD Environmental Data 1997*, Tables 9.5A and 12.1A. It is also worth noting that vehicles using diesel fuel in North America, mostly heavy-duty vehicles, have not been subjected to fuel-efficiency standards and that overall use of diesel fuel in Canada has more than doubled since 1979; overall use of gasoline—mostly used in vehicles subject to fuel-efficiency standards—while presently increasing is still below the 1979 level (see Box 3).

55. See, for example, the source cited in Note 49 (fig. 1-6); Royal Commission on Environmental Pollution, *Transport and the Environment* (18th Report). HMSO, London, U.K., 1994, Fig. 7-III; and Schipper L, Determinants of automobile use and energy consumption in OECD countries, *Annual Review of Energy and Environment*, 20: 325-386, 1995, Fig. 15.

56. The data for the cross-sectional analysis portrayed in Box 5 were taken from the OECD's 1995 *Environmental Data Compendium*. The 1995 Compendium was used instead of the more recent 1997 *Compendium* because, unlike the latter, it provided data on both price and use for a recent common year. The use data are taken from Table 9.5A, modified by the population data in Table 12.1. The price data are taken from Table 9.5B. Of the 24 OECD Member countries whose data are represented in the tables only 22 are used; the two extremes in use for both diesel fuel and gasoline, Luxembourg and Turkey, were not used.

57. According to the source in Note 26, a correlation of –0.72 among 22 pairs of data would occur by chance less than one time in 100; a correlation of –0.25 would occur by chance more than five times in 100.

58. See Goodwin PB, A review of new demand elasticities with special reference to short and long run effects of price changes. *Journal of Transport Economics and Policy*, 26(2), 155-169, 1992., Table 1.

59. See Nivola PS, Crandall, RW, *The Extra Mile*. The Brookings Institute, Washington D.C., 1995, Page 44, for a brief overview.

60. See Huntington HG, Inferred demand and supply from a comparison of world oil models. In Sterner T, ed. *International Energy Economics*. Chapman & Hall, London, U.K., 1992, Table 14.4.

61. Assuming a medium-term elasticity of -0.5, a 5% annual increase in real price will produce a 2.5% annual reduction in use, which cumulates to a 22.4% reduction over 10 years.

62. To go from a 22.4% to an 80% reduction in 20 years, assuming a long-term elasticity of -0.7, a 9.4% annual increase in real price would be required for each of the 20 years.

63. For comparisons of emissions from vehicles using different fuels see, for example, OECD, *Motor Vehicle Pollution: Reduction Strategies Beyond 2010*, 1995.

64. For a proposal by the Australian government's Bureau of Agricultural and Resource Economics for tradable GHG emission permits for Australian businesses see the *Sydney Morning Herald*, March 20, 1998. For the suspicions of the American Petroleum Institute that the U.S. government is thinking about fuel rationing, see the Institute's August 1996 press release. For work on rationing done for the Netherlands government see the later part of this section. For the Swiss government's proposal to ration air travel see the 1997 publication of the Swiss Agency for the Environment, Forests and Landscape, *Climate in Danger: Facts and Implications of the Greenhouse Effect*.

65. From McMaster University's *Energy Studies Review*, June 1998.

66. The data in Box 6 are from Rosalyn A. Wilson, *Transportation in America: Historical Compendium 1939-1995*, Eno Foundation, 1997, p. 20.

67. This scheme has been proposed by the Netherlands as part of the OECD's Environmentally Sustainable Transport project (<www.oecd.org/env/trans/>).

68. The data in Box 7 come primarily from Transport Canada's *Transportation in Canada 1996*. The numbers of vehicles come from the background table to Figure 10-4. Combined figures are given in this table for cars and all trucks. An assumption is made that throughout the period two-thirds of all trucks can be classified as personal automobiles. This is based on the same source, Page 105, where Figure 10-3 indicates that about 80 per cent of trucks are light trucks and the text indicates that about 80% of the use of light trucks can be considered personal use. The data on vehicle-kilometres travelled come from the background table to Figure 10-6, where cars and light trucks are portrayed separately. The light truck figure is accordingly reduced by 20% to give personal use. Population data come from Statistics Canada, CANSIM, matrices 6367-6379: "Population and average annual growth rates, Canada, the provinces and territories."

69. See Richard Gilbert, *World Transport Policy & Practice*, 4(4), 1998, pp. 21-26.

70. See, for example the statement in the report on Transport and the Environment by the UK Royal Commission on Environmental Pollution (1994), "the increased cost of mobility should be imposed on the use rather than on the ownership of cars, in part because we do not consider it equitable to erect high barriers against car ownership." (p. 254).

71. See David Martin and Laurie Michaelis, *Research and Technology Strategy to Help Overcome Environmental Problems in Relation to Transport*, Final Report of Study Group 2 pre-

pared under contract to DG XII of the European Commission, March 1992. See also Gregory Keolian et al., *Industrial Ecology of the Automobile: A Life-cycle Perspective*, American Technical Publishers (ISBN 1-56091-985-X), 1997. See also <www.umich.edu/~nppcpub/research/>.

72. Land Transport Authority, Singapore, "Results of December 1998 Vehicle Quota Exercise" (<www.lta.gov.sg/announce/results.htm>).

73. See Richard Gilbert, *Reducing automobile use in urban areas by reducing automobile ownership: The EANO principle.* Presentation at a workshop entitled "the Future of Urban Travel", Centre Jacques Cartier, Lyon, France, December 1998.

74. The data for the Montreal region in Box 8 were taken from the 1993 MADEOD survey conducted by the MADITUC group at the École Polytechnique de Montréal (see <www.transport.polymtl.ca/eodmtl/titre.htm>). The "Core" in Box 8 corresponds to Montreal Downtown; the "Core Ring" to Montreal Urban Community (MUC) Centre; the "Inner Suburbs" to MUC East, MUC West, MUC South West, and South Shore Near; and the "Outer Suburbs" to Laval, North Shore, and South Shore Remaining. The data for the Vancouver region in Box 8 were taken from Report No. 3 of the 1992 Greater Vancouver Travel Survey, conducted by the Greater Vancouver Regional District's Strategic Planning Department. The "Core" in Box 8 corresponds to Vancouver CBD; the "Core Ring" to Rest of Vancouver/UEL; the "Inner Suburbs" to West Vancouver/Lions Bay, North Vancouver District, Richmond, New Westminster, and Burnaby; and the "Outer Suburbs" to Delta, Surrey, White Rock, Langleys, Port Moody/Anmore/Belcarra, Coquitlam, and Port Coquitlam. The basic travel data for both the Montreal and the Vancouver regions are trips made by residents of the respective areas within the respective regions during the indicated periods.

75. See *Bill 36, Legislature of British Columbia, Greater Vancouver Transportation Authority Act* (<www.legis.gove.bc.ca/bills/3rd_read/gov36-3.htm>).

76. See "Analysis of the Recommended Agreement on Transportation Governance and Funding for Greater Vancouver," Stromaxis International Corp., January 1998 (<www.stromaxis.com/subsidy.html>).

77. Greater Vancouver Regional District, "Backgrounder: Transportation Governance and Funding, Inprovements for Greater Vancouver," November 1997 (<www.gvrd.bc.ca/archive/planning/pr/tranpln.htlm>).

78. See "Financing Urban Transportation in the Montreal Region", a paper presented by Michel Beaulé, Office of the Minister for the Métropole, at the 1998 Annual conference of the Transportation Association of Canada, Regina, Saskatchewan, September 21, 1988 (<www.metropole.gouv.qc.ca/docum/atc_ang.htm>).

79. See Richard Gilbert and Don Stevenson, *Governance and Economic Performance: The Montreal, Toronto, and Vancouver Regions*, a paper presented at an OECD workshop held in Toronto in October 1997 entitled "Better Governance for More Competitive and Livable Cities" and published by the Urban Affairs Division of the OECD during 1998. This paper credits the Montreal region as having 111 local governments and 14 upper-tier governments, and the Vancouver region, with a little over half the Montreal region's population, as having 24 local governments and two upper-tier governments. The exact numbers depend on what is included within the urban region. The Toronto region, with three times Vancouver's population, now has 25 local governments and four upper-tier governments.

80. See the source in Note 78.

81. See <www.metropole.gouv.qc.ca/docum/pl92afrm.html>.

82. The *Greater Toronto Services Board Act, 1998* was given third reading in the Ontario Legislature in December 1998. The GTSB met for the first time on January 22, 1999.

83. For sources bearing on this point see several articles in *World Transport Policy & Practice* including 3(4), pp. 30-36, 4(1) pp. 4-8, and 4(1) pp. 30-35. See, above all, the source cited here in Note 46.

84. The City of West Palm Beach has received enquiries about its language policy from municipalities in ten states. The State of Florida now seems more inclined to use objective language, at least in communications with the City. For further information about the City's policy, call Ian Lockwood of the City of West Palm Beach, Florida, U.S.A. at (561) 659 8031.

85. The information in this section is taken from a position paper prepared by the Canadian Urban Transit Association entitled *Employer-Provided Income Tax-Exempt Transit Benefits (TEI): A Step Towards Sustainable Transportation* (January 1999).

86. According to work at the OECD, the balance of the effort required for attaining sustainable freight transportation will be as follows. Technological improvements resulting in improved fuel efficiency and other aspects of performance will contribute 48% of the total effort, reduced transport activity (i.e., fewer tonne-kilometres) 17%; mode shifts (e.g., from road to rail) 24%; and improved loading 10%. The Canadian component of this project, based on the Quebec-Windsor corridor, projects an almost identical breakdown (47:20:26:7). See <www.oecd.org/env/trans/> for further details of this work.

87. See <www.cybersudbury.com/hosts/transport/news/index.html>.

88. See <magi.com/~churcher/candate/candate.htm> for a list of transfers. Also see *A Layman's Guide to Shortline Railroading in Canada*, published by the Railway Association of Canada and Transport Canada, 1998.

89. Information provided by Roger Cameron of the Railway Association of Canada (<www.railcan.ca>). See also *Globe & Mail*, January 11, 1999.

90. See the source in Note 63.

91. For Fiba Canning see <www.fibacanning.com>; for New Flyer Industries see <www.newflyer.com>; for Nova Bus Corporation see <www.novabuses.com>; for Orion see <www.transit-center.com/Orion/vi.htm>.

92. For example, the fuel intensity of Honda's hybrid gasoline-electric car, due to be sold in North America during 1999, is said to have only a little more than half of the fuel intensity of the equivalent gasoline vehicle (3.4 vs 6.8 litres per 100 kilometres, compared with about 7.9 l/100km for *average* new vehicles—see Box 4).