# Sustainable Transportation Performance Indicators (STPI)

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**ABSTRACT**

This paper reports on the development of an initial set of 14 Sustainable Transportation Performance Indicators (STPI). These indicators are designed to show movement of transportation in Canada towards or away from sustainability. The framework for the development of STPI comprised an accepted definition of sustainable transportation and seven policy questions. Several criteria served to select variables to serve as bases for STPI. They were applied strictly, to the extent that only six of the policy questions are addressed by the initial STPI set. This set is described in some detail here, and recent trends in the component STPI are illustrated. Some aspects of Canada's transportation are moving towards sustainability, but more are moving away from sustainability.

## INTRODUCTION

The Sustainable Transportation Performance Indicators (STPI) project has been conducted in three phases by the not-for-profit Centre for Sustainable Transportation (CST) with the assistance of IBI Group and Metropole Consultants. Phase 1 of the project reviewed relevant work and developed a long list of potential indicators. Phase 2 focused on identifying needs for and uses of STPI. This paper reports on Phase 3, which involved the identification and development of an initial set of STPI together with proposed shorter- and longer-term additions. The focus is on the 14 indicators that comprise the initial set of STPI. Information about CST and reports on Phases 1 and 2 of the STPI project are available at CST's Web site. (*1*,*2*)

## WHY DEVELOP STPI?

The work program of CST adopted at its founding in 1996 spoke to developing a vision and definition of sustainable transportation and to producing "quantifiable performance measurements, based on the vision and definition, that can be used to track progress toward sustainability". This item was reinforced in February 1999 by the Ministers responsible for Environment Canada and for Transport Canada. They wrote to CST saying that the Government of Canada would welcome assistance "in our efforts … to refine sustainable transportation performance indicators".

The substantive reason for developing STPI lies in the embrace of sustainable development as a global mission by almost all national governments at the 1992 United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil. The term *sustainable development* had been popularized by the World Commission on Environment and Development, and defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". (*3*) At UNCED, national governments adopted *Agenda 21*, which states that the various sectors of human activity should develop in a sustainable manner. (*4*) Sustainable transportation could thus mean meeting present transport needs without compromising the ability of future generations to meet their transport needs. The UNCED commitments were confirmed and elaborated at the World Summit on Sustainable Development held in 2002 in Johannesburg, South Africa. (*5*)

## DEFINITION OF SUSTAINABLE TRANSPORTATION

In 1997, CST developed a more complete *definition of sustainable transportation*. The current version is this:
A sustainable transportation system is one that:

- Allows the basic access needs of individuals to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

A slightly amended version of CST's definition was adopted as a working definition of sustainable transport by the ministers of transport and communications of the 15 European Union countries at their meeting in Luxembourg in April 2001.

## EVOLUTION OF THE FRAMEWORK FOR STPI

CST's initial plan was to develop indicators that added quantitative flesh to its definition. This was to be achieved by deconstructing the definition into 18 elements, quantifying each element as a target, and fashioning for each target one or more indicators that represented movement towards or away from the target. (*1*,*2*)

The initial plan was not pursued because of desire among potential users of STPI for a strong policy orientation and concern about the implications of target-setting. It was also not pursued because of data limitations, including those concerning transport's contribution to air pollution and ill-health. Figure 1 shows possible links between transport activity and lung disease. There are good data on the incidence of lung disease, to which there are several potential contributory factors of which air pollution is one. Equally, there are good data on air quality, to which there are several contributory factors of which transport emissions are one. Data are lacking as to the relative contribution of air pollution to lung disease and the relative contribution of transport emissions to poor air quality.

Accordingly, the project steering committee (listed in the Acknowledgements section) advised the project team to focus on matters close to transportation, e.g., on emissions from transport rather than on air pollution or human health.

In seeking an alternative framework for indicator development, the project team reviewed several options and chose that of the Transport and Environment Reporting Mechanism (TERM) of the European Environment Agency. (*6*) The set of 37 TERM indicators is organized as responses to seven questions each of which elaborates a policy-related topic. The set of topics and questions used in the STPI project differs from the TERM set in several details. The two sets are compared in Table 1. (The third column of Table 1 provides responses to the questions that are discussed below.)

## PURPOSES OF STPI

CST's *working definition of indicators* has been adopted from one proposed by Gudmundsson. (*7*) It is that they are "selected, targeted, and compressed variables that reflect public concerns and are of use to decisions makers".

Indicators, including STPI, can have several purposes and functions:

- They can help with the comparison of similar trends across jurisdictions (e.g., sprawl in different cities).
- They can help with the comparison of different phenomena (e.g., trends in energy use for home heating and for automobile use, by expressing changes in common units and relating them to a common baseline year).
- They can help with the understanding of trends (e.g., by showing the strong link between car ownership and car use, and the links between use of transit and overall economic activity).
- They can help with evaluating progress towards or away from defined goals or targets (e.g., whether progress is being made in the transport sector relevant to Canada's commitments concerning greenhouse gas emissions).

STPI are designed above all to have the last two purposes but they can also serve to meet the first two of these purposes.

## IDENTIFICATION OF STPI

A large number of variables were assessed as potential bases for indicator development. The following criteria were used:

- A qualifying variable should concern sustainable transportation as elaborated in CST's definition, or provide a clear answer to one of the seven questions in Table 1.
- A qualifying variable should be a time series, so that information could be provided on changes in performance.
- A qualifying variable should come from what the project team considers to be a reputable and reliable source.
- A qualifying variable, to the extent possible, should represent all of Canada.

The last criterion reflected an initial concern that STPI show movement towards or away from sustainable transportation for Canada as a whole, rather than within a particular geographic area of Canada or within a particular type of community. As development of STPI continues, there will be interest in disaggregated indicators, e.g., indicators of transport trends in discrete urban areas with fewer than 50,000 residents, or of trends in the Maritime as opposed to the Prairie Provinces.

## THREE SETS OF STPI

The criteria were applied with the greatest strictness to the development of the *initial set of STPI*, which is the focus of this paper. In the course of this development, consideration was given to potential shorter-term additions to the initial set (i.e., what could be achieved within three years) and to potential longer-term additions. The three sets of STPI are listed briefly in Table 2. The next section presents the initial set of STPI. The subsequent section summarizes the results of use of the initial set and assesses whether transportation in Canada is becoming more or less sustainable.

## THE INITIAL SET OF 14 STPI

When the above criteria were strictly applied, only a small number of variables qualified as bases for indicator development. Indicators not represented in the initial set failed to meet the criteria detailed above. The limited space available here does not allow discussion of them. Such discussion will be provided in the full report on the STPI project, to be available at http://www.cstctd.org/CSTcurrentprojects.htm.

The proposed 14 indicators in the initial set are described in separate sub-sections below. Some of the indicators are *indices*, i.e., they are based on variables requiring some manipulation before presentation. Each indicator is accompanied by a small chart showing the recent trend in the indicator. The charts are presented according to the respective questions with which the indicators are associated (Figures 2-7). *The vertical scale for each chart has been selected to highlight the trend in the data, or the possibility of a trend*. Falling lines reflect movement towards sustainability. Rising graphs reflect movement away from sustainability. The horizontal scales show the years across which data are represented.

**Indicator 1: Use of fossil fuel energy for all transport**

Inclusion of fossil fuel energy use for transportation is justified by the Centre's definition of a sustainable transportation system as one that minimizes consumption of non-renewable resources These resources include fossil fuels, in particular the crude oil from which gasoline and diesel fuel are produced.

Represented in Figure 2 is total energy use for transport in petajoules. More than 99.5 per cent of this energy is presently provided by gasoline or diesel fuel. (*8*)

Energy use for transport fell between 1990 and 1991 and increased in every subsequent year to a 2000 value of 21.5 per cent above the 1990 value. This trend illustrates movement *away from* sustainability.

**Indicator 2: Greenhouse gas emissions from all transport**

The inclusion of emissions of greenhouse gases (GHGs) is justified by the Centre's definition of a sustainable transportation system as one that produces emissions and waste only within the planet's ability to absorb them. The accumulation of GHGs in the atmosphere with growth in their production from human activities suggests that the absorption potential is being exceeded. (*9*)

Represented in Figure 2 are total greenhouse gas emissions from transport in megatonnes of carbon dioxide equivalents. (*8*) Greenhouse gas emissions from transportation are almost precisely correlated with fossil fuel use for this purpose under present conditions, because combustion of gasoline and diesel fuel produces constant amounts of the carbon dioxide per unit of fuel. Thus, the pattern of GHG emissions almost exactly matches that of fuel use—increasing by 21.0 per cent between 1990 and 2000—and equally represents movement *away from* sustainability.

The close matching of this and the previous indicator raises the question as to why both have been included in the initial STPI set. Both have been included because of the separate policy interests in fuel consumption in relation to oil depletion (*10*) and to global warming (*9*). The essential duplication amounts to overrepresentation of energy use in the STPI set. *Thus, caution is advised when combining individual elements of the set*.

**Indicator 3: Index of emissions of air pollutants from road transport**

The justification for including emissions of air pollutants is the same as that for greenhouse gas emissions. Emissions of pollutants into the air from transport (sulphur dioxide, nitrogen dioxide, volatile organic compounds, and carbon monoxide) are a major source of poor air quality.

The index plotted in Figure 2 represents emissions of the above four pollutants weighted according to their respective mean emissions during the 1990s and adjusted so that the 1990 value equals 100. (The index is based on estimates of emissions submitted by the Government of Canada in January 2002 to meet reporting obligations with respect to the United Nations Economic Commission for Europe. These estimates are to be updated shortly and thus the present source is not formally cited.)

Having an index representing four pollutants avoids overrepresentation of this category of emission in the initial STPI set. The particular form of the index avoids overrepresentation of carbon monoxide, emitted weights of which exceed the total weights of the other three pollutants in each of the represented years by more than a factor of three.

The declining values in the early 1990s represent progress towards sustainable transportation, but this was not maintained into the later part of the decade.

**Indicator 4: Index of incidence of injuries and fatalities from road transport**

According to the Centre's definition, safety is the first requirement of a sustainable transport system. Well over 90 per cent of transport-related fatalities and injuries involve road vehicles, and these are represented in this indicator.

The index plotted in Figure 2 counts each fatality as equivalent to 70 injuries (reflecting the incidences during the 1990s) and is set to have a 1990 value of 100. (*11*) The chart reflects progressive and substantial reductions in the annual numbers of transport injuries and fatalities—for a total decline of 22 per cent between 1990 and 2000—and thus steady progress *towards* sustainability.

Inclusion of this indicator in the initial STPI set has been controversial. At a workshop held in April 2002 to review the progress of the project, several participants argued that matters of safety were not relevant to sustainability. This view was also expressed in a subsequent communication to CST from the Air Transport Association of Canada. CST's view continues to be that safety is a requirement for sustainability.

**Indicator 5: Total motorized movement of people**

The Centre's definition of a sustainable transportation system does not speak to reducing the amount of travel by Canadian residents, although it is addressed by the second topic and question of the list in Table 1. It is not in the definition because travel can be sustainable, if, for example, it makes use of renewable energy. However, almost all travel today makes use of non-renewable energy. Thus, other things being equal, reductions in the amount of motorized movement of people—in person-kilometers—would be in the direction of sustainability, and vice versa.

Moreover, motorized travel of any kind has environmental impacts and there can be merit in reducing the amount of travel. A further point is that travel is mostly not an end in itself but a means to an end, and if the end can be achieved with fewer means, all the better.

The chosen indicator is total person-kilometers travelled in a year. Some kinds of travel can more sustainable than others. For example, travel in a well-occupied small automobile can be more sustainable than travel in a mostly empty bus. Nevertheless, use of the sum total of travel by all motorized modes as an indicator can be justified because it represents the disposition of Canadians to travel, which can be an important feature of analyses of transport activity.

Figure 3 shows a mostly increasing trend in travel—i.e., *away from* sustainability—although with a possible levelling off in the most recent years. (*8*)

**Indicator 6: Total motorized movement of freight**

The justification for this indicator is the same as that for Indicator 5. In particular, there is a similar justification for using *total* freight movement in tonne-kilometers as the indicator even though the total combines more and less sustainable modes.

Figure 3 shows a mostly increasing trend in freight activity. (*8*) Overall, movement of freight has been increasing at a much higher rate than movement of people (a 37-per-cent vs. a 15-per-cent increase between 1990 and 2000). In these terms, freight transport activity has been less sustainable.

**Indicator 7: Share of passenger travel *not* held by land-based public transport**

As in the cases of Indicators 5 and 6, this indicator does not directly reflect a feature of the CST's definition of sustainable transportation. Moreover, there is no question on *share* of passenger travel in the STPI questions in Table 1. A TERM question in Table 1 does address 'modal split', which usually refers to the share of travel held in an urban region by public transit as opposed to the usual alternative of the automobile.

*The present indicator is the national equivalent of modal split*, extended to take into account all movement of people in Canada including inter-urban travel. Because air travel, a form of public transport, can be regarded as less sustainable than many other modes (*12*)—and because of the negligible travel by water—the indicator shows the share of travel by land-based public transport (urban transit and inter-city bus and train) as a per cent of all travel. To maintain the requirement that sustainability is associated with a falling indicator, the indicator is inverted and shows share of travel *not* held by land-based public transport.

Figure 3 shows that the balance between land-based public transport and the other modes (car, plane) was fairly stable during the 1990s or shifting towards public transport, except for a sharp, unexplained decline between 1993 and 1994. (*8*) Overall, there is no readily evident trend.

The case could be made that the changes are in any case small and thus insignificant. However, when considered on the base of the share of land-based public transit, the changes are considerably larger (overall, an increase in share from 8.0 to 8.6 per cent between 1990 and 2000).

**Indicator 8: Movement of light-duty passenger vehicles**

CST's definition does not speak to reducing vehicle movement, for the kind of reason given for Indicator 5. However, adverse effects of transport are more closely linked to vehicle-kilometers-moved than to person- or tonne-kilometers moved (on which the previous three indicators are based). Moreover, most vehicle-kilometers are performed by light-duty passenger vehicles, which include automobiles, SUVs, minivans, and light trucks used mainly for moving people. Thus, the chosen indicator of vehicular activity is vehicle-kilometers moved by light-duty passenger vehicles.

Data on vehicle-kilometers moved by light-duty passenger vehicles used for Indicator 8 are in the database from which Indicators 1, 2, 5, 6, and 7 were developed, but they are not represented in the cited source. (*8*) The necessary data were provided separately (unpublished data provided by Nathalie Trudeau, Natural Resources Canada, by e-mail dated August 6, 2002).

Figure 3 indicates an increasing trend in this indicator with a levelling off in recent years, similar to that for Indicator 5.

**Indicator 9: Rate of use of urban land**

The Centre's definition of sustainable transportation speaks to minimizing the use of land, for two reasons. Land use for transport and for settlement has environmental impacts. Low-density settlement, particularly in urban areas, is a stimulus to transport activity. The chosen indicator is the average rate of use of urbanized land across Canada, in square meters of land per resident. Increasing rates of land use mean that more land is being urbanized for a given population. This indicator thus concerns both aspects of land use in the CST definition. Land use for transport is also touched on by the next indicator.

Rate of land use is the inverse of the more familiar density of land use, often expressed in persons per hectare. Rate of use is employed here to provide an indicator that increases with movement away from sustainability.

Figure 4 shows that the rate of use of urban land in Canada has been increasing, more steeply between 1991 and 1996 than before. (*13*). The overall increase from 1971 to 1996 was 29 per cent. This trend indicates movement *away from* sustainability.

**Indicator 10: Length of paved roads**

This indicator reflects the main land use for transport (see Indicator 9), the environmental effects of which include disruption of habitat and migration paths as well as those arising from installation and maintenance. The indicator also addresses the parts of the Centre's definition concerned with efficiency and resource use (e.g., cement production). Moreover, added roads can induce traffic (*14*).

Figure 5 shows that the total length of road—in two-lane-kilometer equivalents—increased across the indicated period, overall by 24 per cent, indicating movement *away from* sustainability. (Of the data presented here, these may be the least reliable and valid.)

**Indicator 11: Index of relative household transport costs**

The Centre's definition of sustainable transportation requires that transport be affordable. However, if transport were too inexpensive it would be used unduly and thus unsustainably. Nevertheless, considered as part of a set of indicators, declining relative cost of transport—i.e., in relation to available income—is probably more consistent with overall sustainability than increasing average relative cost. For this indicator, an index has been created that in each year is the ratio of the transportation component of the consumer price index to the real total household expenditure, with the 1996 value of the index set to 100. Thus, the index declines when transport prices decline or when overall expenditures increase.

Figure 6 shows data for the years in which Canada-wide surveys of household expenditure were conducted. (*15*,*16*) There is no suggestion in this indicator of a trend towards or away from sustainability.

**Indicator 12. Index of the relative cost of urban transit**

This indicator shares the justification for Indicator 11; it reflects a more specific aspect of affordability in relation to sustainability. A particular issue concerning affordability is the cost of urban transit in relation to the marginal cost

of alternatives. The major component of this marginal cost is that of fuel. Thus, the index portrayed is the ratio of the average cost of a transit trip to the average cost of a litre of gasoline in each year, adjusted normalized so that the 1990 value is 100. Falling relative transit costs could be considered to be consistent with progress towards sustainability in that, where transit costs less, there may be more incentive to use it rather than to travel by automobile. (*17*)

The index is plotted in Figure 6. It has been generally increasing from the 1990 value, indicating movement *away from* sustainability, although it fell quite steeply at the end of the decade.

**Indicator 13: Index of energy intensity of the road vehicle-fleet**

This indicator addresses aspects of CST's definition concerned with efficiency, resource use, and emissions. It focuses specifically on changes in the energy intensity of road-vehicle operation. Reductions in energy intensity usually result from technological improvements, but can also result from changes in driving speed and style. Reductions indicate improved efficiency and reduced resource use and emissions (other things being equal) and are thus consistent with sustainability.

There have been different trends for different types of vehicle. For example, the energy intensity of small cars and gasoline-fuelled light trucks increased across the 1990s, while that of other road vehicles declined. Accordingly, a fuel intensity index has been used in which the change in fuel intensity of each type of vehicle since the previous year—expressed in megajoules per kilometer—is weighted by that mode's proportion of total road-vehicle energy use in the indicated year, with the index being set at 100 for 1990. (*8*)

Figure 7 shows that the index fell between 1990 and 1991, increased steeply until 1994, and then remained more or less constant until the end of the decade. Overall, the index shows some movement *away from* sustainability, by just over 4 per cent.

**Indicator 14. Index of emissions intensity of the road-vehicle fleet**

This indicator addresses aspects of CST's definition concerned with emissions. It was designed to show the extent of technological progress by tracking *unit* reductions in locally acting pollutants—those represented by Indicator 3—across the whole road-transport fleet. Unit reductions are usually expressed for a particular type of vehicle by showing them as a function of distance travelled. Here, they are shown as a function of energy used so that one indicator can represent the whole road fleet.

Thus, what the index in Figure 7 in effect shows is progress in reducing the amount of emissions resulting from the burning of a litre of gasoline or diesel fuel. The index was constructed from the sources used for Indicators 3 (emissions) and 1 (energy use). The actual values were arrived at by taking the values of the index used for Indicator 3 and dividing them for each year by energy use for all road transport expressed as a proportion of the 1990 value, and setting the 1990 value as 100.

Figure 7 shows an initial increase between 1990 and 1991 and then a decline in each year thereafter, amounting to a total fall of more than 25 per cent between 1990 and 2000. This represents substantial progress *towards* sustainable transportation.

## SUMMARIZING THE INITIAL STPI SET; NEXT STEPS

What is shown by the initial set of indicators can be summarized as responses to the seven policy questions posed in the centre column of Table 1. Such responses are provided in the right-hand column of Table 1.

The responses are mixed or indeterminate. On balance they show movement away from rather than towards sustainable transportation, but the particular conclusion drawn may depend on how the indicators are weighted in making the assessment.

The authors of this paper would give more weight to energy use (Indicator 1) and to energy intensity (Indicator 13) than to the other indicators. We believe present levels of fossil fuel use to pose the largest problems for future generations, and lack of progress in reducing the intensity of this use to be the main barrier to progress towards sustainability. However, we recognize that persons concerned, for example, with the extent of locally acting emissions (Indicators 3 and 14) could take more comfort than we do from what is demonstrated by the initial set of STPI.

We hope to be able to continue with the development of STPI over the next few years in four ways:

- by maintaining and enhancing the initial set of STPI;
- by developing the indicators listed under "shorter-term additions" in Table 2;

- by preparing for development of the indicators listed under "longer-term additions" in Table 2;
- by helping with application of the developed STPI to policy development.

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**LIST OF TABLES AND FIGURES**

**TABLE 1 Framework topics and questions for STPI development compared with TERM topics and questions**

| **TERM topics and *questions*** | **STPI topics and *questions*** | **Answers from the initial set of STPI** |
|---|---|---|
| Environmental consequences of transport<br>*Is the environmental performance of the transport sector improving?* | Environmental and health consequences of transport<br>*Is the performance of the transport sector improving in respect of its adverse impacts on environment and health?* | Undetermined. Energy use is increasing; local emissions, fatalities and emissions are falling |
| Transport demand and intensity<br>*Are we getting better at managing transport demand and at improving the modal split?* | Transport activity<br>*Is transport activity changing in directions consistent with positive answers to the other questions?* | Transport activity is increasing, which is mostly associated with movement away from sustainability. |
| Spatial planning and accessibility<br>*Are spatial planning and transport planning becoming better coordinated so as to match transport demand to the need for access?* | Land use, urban form and accessibility<br>*Are land use, urban form, and transportation systems changing so as to reduce transportation effort?* | Urban land is being used less intensively, which is associated with movement away from sustainability. |
| Supply of transport infrastructure and services<br>*Are we optimizing the use of existing transport infrastructure capacity and moving towards a better balanced inter-modal transport system?* | Supply of transport infrastructure and services<br>*Are we increasing the efficiency of use of current infrastructure and changing the infrastructure supply in sustainable ways?* | The road network has been increasing in extent, which is associated with movement away from sustainability. |
| Transport costs and prices<br>*Are we moving to a fairer and more efficient pricing system, which ensures that external costs are internalized?* | Transportation expenditures and pricing<br>*Are the patterns of expenditure by governments, businesses, and households, and the associated pricing systems, consistent with moving towards sustainability?* | Undetermined in respect of overall household transport costs. However, urban transit has been becoming relatively more expensive, which is associated with movement away from sustainability. |
| Technology and utilization efficiency<br>*How rapidly are improved technologies being implemented and how efficiently are vehicles being used?* | Technology adoption<br>*Is technology being used more in ways that make vehicle transport systems and their utilization more sustainable?* | Undetermined. Energy intensity has increased although recently stable; emissions intensity has fallen substantially. |
| Management integration<br>*How effectively are environmental management and monitoring tools being used to support policy- and decision-making?* | Implementation and monitoring<br>*How effectively are environmental management and monitoring tools being used to support policy- and decision-making towards sustainability?* | Undetermined. No indicators have yet been developed. |

**TABLE 2 The initial set of STPI in relation to the framework topics and questions, with proposed shorter-term and longer-term additions to the initial set**

| Framework topic and question | Initial indicator set | Shorter-term additions | Longer-term additions |
|---|---|---|---|
| 1. Environmental and health consequences of transport<br>*Is the performance of the transport sector improving in respect of its adverse impacts on environment and health?* | 1. Use of fossil fuel energy for all transport<br>2. Greenhouse gas emissions from all transport<br>3. Index of emissions of air pollutants from road transport<br>4. Index of incidence of injuries and fatalities from road transport | Air quality levels or exceedances<br>Waste from road transport<br>Marine oil discharges<br>Land use for transport<br>Proximity of infrastructure to sensitive areas | Health effects<br>Noise levels or exceedances<br>Ecosystem fragmentation |
| 2. Transport activity<br>*Is transport activity changing in directions consistent with positive answers to the other questions?* | 5. Total motorized movement of people<br>6. Total motorized movement of freight<br>7. Share of passenger travel *not* held by land-based public transport<br>8. Movement of light-duty passenger vehicles | Urban automobile vehicle-kilometres in largest urban areas<br>Travel by non-motorized modes in urban areas<br>Journey-to-work mode shares | Urban and intercity person-kilometres<br>Freight efficiency<br>Freight modal participation |
| 3. Land use, urban form and accessibility<br>*Are land use, urban form, and transportation systems changing so as to reduce transportation effort?* | 9. Rate of use of urban land | Residential density by urban size and zone<br>Employment density by CMA, urban size class, and zone<br>Walking to work (mixed use)<br>Ratio of jobs to employed labour force | Share of urban population and jobs served by transit<br>Share of population and employment growth on already-urbanized lands<br>Total travel by urban zone<br>Modal split by urban zone. |
| 4. Supply of transport infrastructure and services<br>*Are we increasing the efficiency of use of current infrastructure and changing the infrastructure supply in sustainable ways?* | 10. Length of paved roads | Length of sustainable infrastructure<br>Transit seat-kilometres per capita | Congestion index |
| 5. Transportation expenditures and pricing<br>*Are the patterns of expenditure by governments, businesses, and households, and the associated pricing systems, consistent with moving towards sustainability?* | 11. Index of relative household transport costs<br>12. Index of the relative cost of urban transit | Net government expenditures on roads<br>Share of total government transport expenditures going to ground-based public transport | Transport-related user charges<br>Expenditures by businesses on transportation |
| 6. Technology adoption<br>*Is technology being used more in ways that make vehicle transport systems and their utilization more sustainable?* | 13. Index of energy intensity of the road vehicle-fleet<br>14. Index of emissions intensity of the road-vehicle fleet | | Use of alternative fuels<br>Percent of labour force regularly telecommuting |
| 7. Implementation and monitoring<br>*How effectively are environmental management and monitoring tools being used to support policy- and decision-making towards sustainability?* | | Indicators of sustainable transportation in use<br>Extent of public support for 'green' transport | Number of CMAs where the planning and delivery of transportation and related land uses are integrated region-wide. |

**FIGURE 1 Schematic indication of the role of transportation in lung disease**

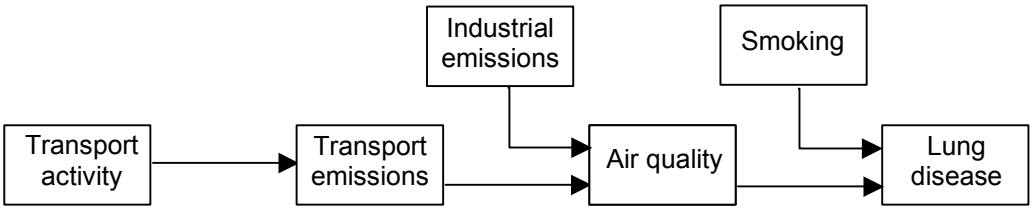
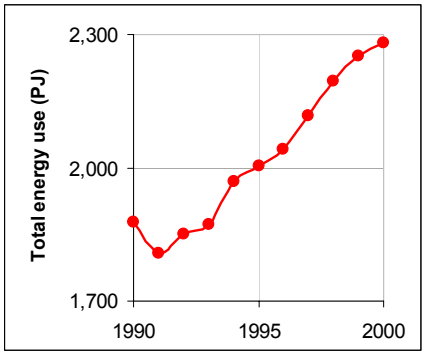
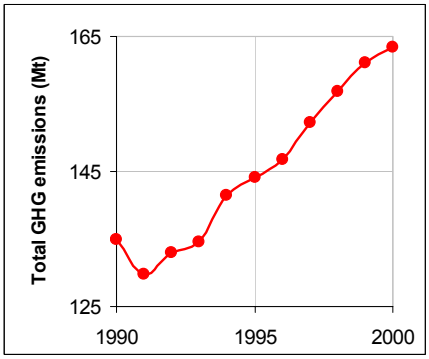


**FIGURE 2 Indicators for responding to the question "Is the performance of the transport sector improving in respect of its adverse impacts on environment and health?" (Canadian data)**

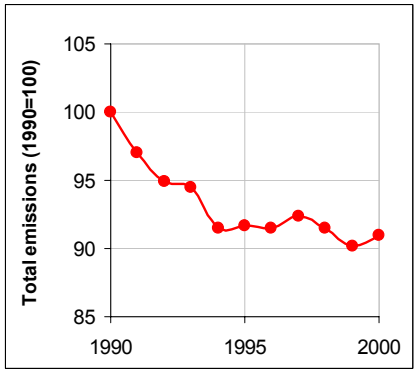
**Indicator 1**: Use of fossil fuel energy for all transport




**Indicator 2**: Greenhouse gas emissions from all transport




**Indicator 3**: Index of emissions of air pollutants from road transport




**Indicator 4**: Index of number of road fatalities and injuries

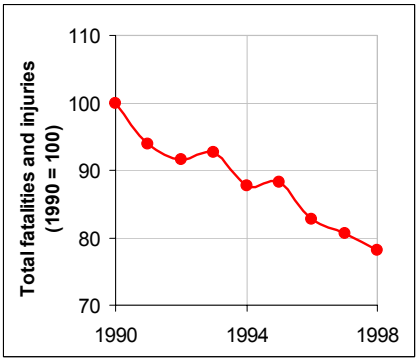
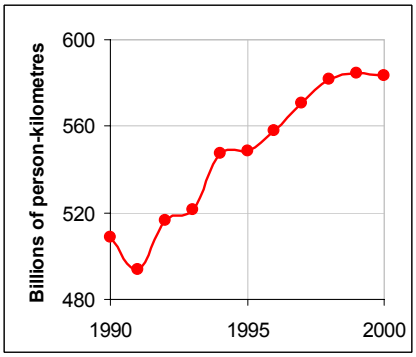
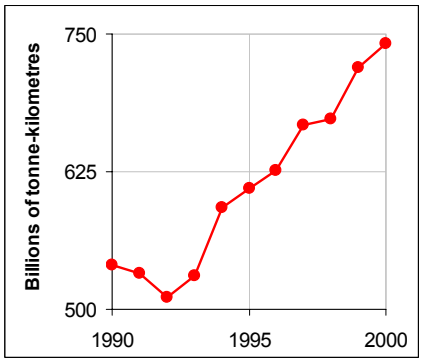


**FIGURE 3 Indicators for responding to the question "Is transport activity changing in directions consistent with positive answers to the other questions?" (Canadian data)**

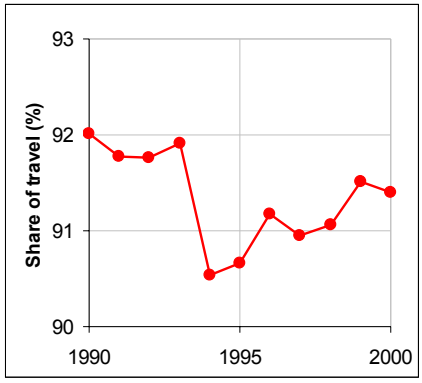
**Indicator 5**: Total motorized movement of people




**Indicator 6**: Total motorized movement of freight




**Indicator 7**: Share of motorized movement of people *not* by land-based public transport




**Indicator 8**: Movement of light-duty passenger vehicles

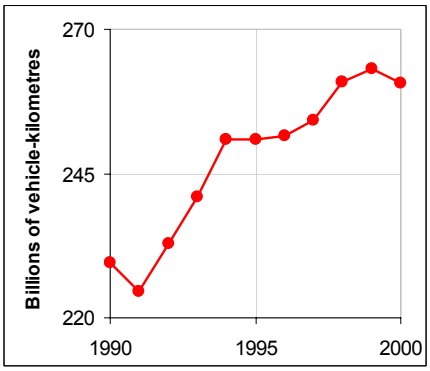


**FIGURE 4 Indicator for responding to the question "Are land use, urban form, and transportation systems changing so as to reduce transportation effort?" (Canadian data)**

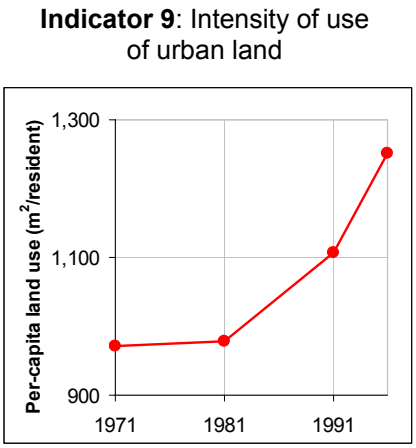


**FIGURE 5 Indicator for responding to the question "Are we increasing the efficiency of use of current infrastructure and changing the infrastructure supply in sustainable ways?" (Canadian data)**

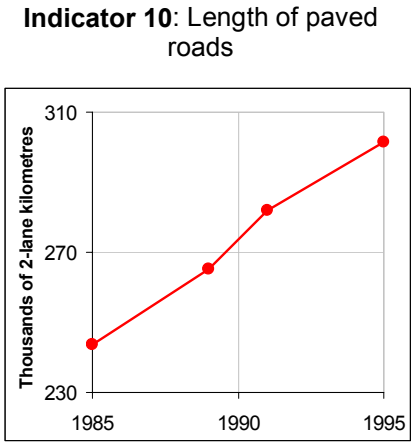
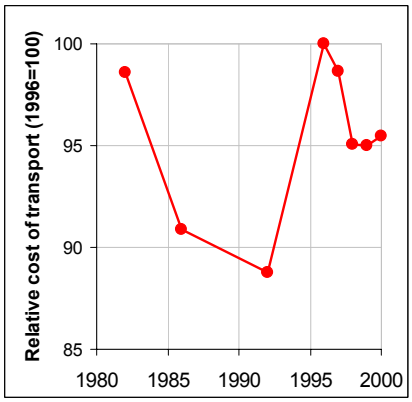


**FIGURE 6 Indicator for responding to the question "Are the patterns of expenditure by governments, businesses, and households, and the associated pricing systems, consistent with moving towards sustainability?" (Canadian data)**

**Indicator 11**: Cost of transport relative to all household spending




**Indicator 12**: Urban transit fares in relation to gasoline prices

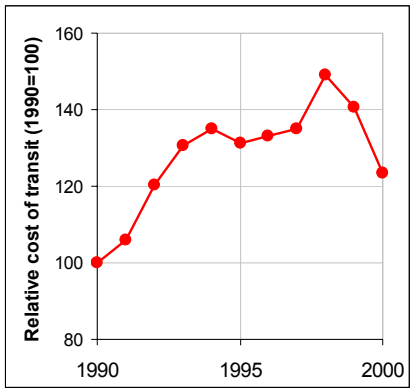
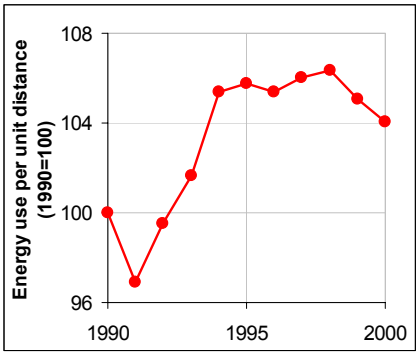


**FIGURE 7 Indicator for responding to the question "Is technology being used more in ways that make vehicle transport systems and their utilization more sustainable?" (Canadian data)**

**Indicator 13**: Energy intensity of the road vehicle fleet




**Indicator 14**: Emissions intensity of the road vehicle fleet