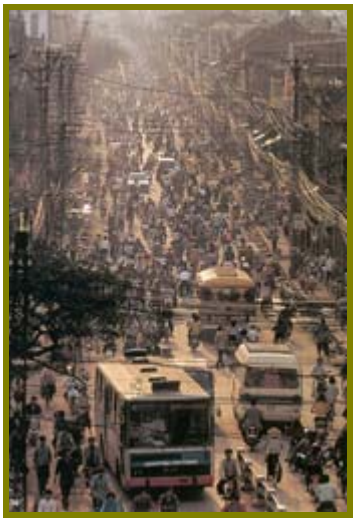
Sustainability in Professional Engineering and Geoscience:

A Primer



Part 3d: Practice-Specific Module - Transportation

Developed by the Sustainability Committee of the
Association of Professional Engineers and Geoscientists of British Columbia
APEGBC

www.apeg.bc.ca

www.sustainability.ca

Sustainability in Professional Engineering and Geoscience: A Primer

Part 3d: Practice-Specific Module - Transportation

"For those who dare, and win or lose, life is by far a more thrilling and worthwhile adventure than it is for those who merely witness."

Karl Terzaghi
Father of Soil Mechanics

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1 Introduction

APEGBC Sustainability Guidelines

Core to APEGBC's articulation of sustainability are the Sustainability Guidelines that state that, within the scope of a Member's task and work responsibility each Member, exercising professional judgment, should:

1) Develop and maintain a level of understanding of the goals of, and issues related to, sustainability .

2) Take into account the individual and cumulative social, environmental and economic implications

3) Take into account the short- and long-term consequences.

4) Take into account the direct and indirect consequences

5) Assess reasonable alternative concepts, designs and/or methodologies

6) Seek appropriate expertise in areas where the Member's knowledge is inadequate

7) Cooperate with colleagues, clients, employers, decision-makers and the public in the pursuit of sustainability.

The Association of Professional Engineers and Geoscientists of British Columbia (APEGBC) has developed the Sustainability Primer as part of its implementation of a Sustainability Management System (SMS). The Primer's purpose is to act as an initial step in raising knowledge of sustainability, and to function as a simple, readily accessible resource on sustainability for engineers and geoscientists. It is intended as an aid to help engineers and geoscientists implement sustainability principles in the course of their everyday activities.

Part I: Introduction of the Sustainability Primer outlines general issues that provide context to all our sustainability activities as professional engineers and geoscientists.

Part 2: Applying the Guidelines develops some suggested approaches to applying APEGBC's Sustainability Guidelines (left) across the spectrum of engineering and geoscience activities.

This document, ***Part 3d: Practice-Specific Module for Transportation***, provides additional resources for engineers and geoscientists addressing transportation challenges.

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2 Review of the APEGBC Sustainability Guidelines

The APEGBC Sustainability Guidelines presented in Part 2 of the Primer provide guidance on how to systematically incorporate sustainability into engineering and geoscience practice. As a quick summary, the APEGBC Sustainability Guidelines encompass the following. For further details, please see the Primer Part 2 Module.

2.1 Increasing Awareness of Sustainability

Guideline # 1:	*Develop and maintain a level of understanding of the goals of, and issues related to, sustainability.*

Guideline #1 encourages continual learning and education as important aspects of sustainability. APEGBC has identified awareness (among all stakeholders) as one of the primary barriers to the implementation of sustainability in the province. In its Communication Plan, the Sustainability Committee identified Members as its current main target group for increasing awareness. Once Members have the information they need to begin implementing sustainable solutions, the communications focus can shift toward clients, employers and wider audiences.

Many of the resources and links found in this Primer are offered with the goal in mind that engineers and geoscientists will use them as starting points for their own research and continuing education on sustainability.

2.2 Fully Investigating the Impacts of Potential Actions

"In every deliberation, we must consider the impact on the seventh generation."

From the Great Law of the Haudenosaunee (Six Nations Iroquois Confederation)

Guideline # 2:	*Take into account the individual and cumulative social, environmental and economic implications.*
Guideline # 3:	*Take into account the short- and long-term consequences.*
Guideline # 4:	*Take into account the direct and indirect consequences.*

These three guidelines address the short- and long-term, direct and indirect impacts of our designs and activities. They encourage us to think outside of traditional project boundaries and to consider the greater temporal and spatial impacts of our designs and projects. As we learn more about the way our world works – the way humans and ecosystems interact – we learn more about what it takes to ensure that we enhance the well being of current and future generations and ecosystems.

"These ideas veer sharply away from thinking in terms of "trade-offs," human vs. ecosystem wellbeing. There are obviously hundreds of small trade-offs in any practical application: between interests, between components of the ecosystem, across time and across space. However, in a macro sense, the idea of sustainability calls for each of human and ecosystem wellbeing to be maintained or improved over the long term. Maintaining or improving one at the expense of the other is not acceptable from a sustainability perspective because either way, the foundation for life is undermined."[1]

2.3 Weighing the Impacts of Alternative Solutions

"When we engineer….let us think that we engineer forever."

Department of Civil & Environmental Engineering University of Auckland, New Zealand

Guideline # 5: Assess reasonable alternative concepts, designs and/or methodologies.

Conventional engineering solutions often rely on historical data and a linear approach to problem solving. Many problems are 'solved' by plugging in a standard formula 'proven' throughout the years, irrespective of the uniqueness of that problem's particular setting, its timeframe, the people and the ecosystems involved. However, the process of even sketching out and evaluating various solutions, with the contribution of other professionals as well as affected communities, can ultimately help save money, increase public acceptance and build relationships and job satisfaction.

At the heart of the assessment of any alternative lies the consideration of whether the design contributes to human *and* ecosystem wellbeing together. "The 'positive contribution to sustainability' criterion is different from- though built upon- the 'mitigation of adverse effects' criterion that is the focus of traditional environmental and social impact assessments. The implications of the shift are two-fold. On the one hand, the positive orientation opens the door to a much fuller recognition of benefits that result from engineering and geoscience activities than has traditionally been the case with impact assessment approaches. On the other, the same positive orientation sets the bar higher- it is harder to demonstrate a contribution than it is to mitigate a negative."[2]

2.4 Fostering Consultation and Partnerships

Guideline # 6: Seek appropriate expertise in areas where the Member's knowledge is inadequate

[1] Tony Hodge, PEng, PhD, "APEGBC Sustainability Policy", Draft 2, April 2003.
[2] Ibid.

Guideline # 7: Cooperate with colleagues, clients, employers, decision-makers and the public in the pursuit of sustainability.

Partnerships with fellow professionals on areas we are unfamiliar with comprises only half of our responsibility to consult with others – the second, arguably more important aspect requires us to actively solicit local community values on what's important. Experts can often help answer "what could be", but it's up to the public to answer, "what should be".

3 Transportation: The Context

"Throughout history- from compact cities well-suited to walking, to radial towns stretched into spokes by trolley lines, to sprawling metropolises dominated by cars- transportation modes have dictated urban form."

State of the World 2001
http://www.worldwatch.org

Transportation has and always will comprise a fundamental element of human society. In its current and emerging form, though, transportation consumes a large proportion of global energy, contributes significantly to greenhouse gas & fine particulate emissions and compromises human & ecological health. Furthermore, it is estimated that at least 5% of an industrialized country's GDP is spent offsetting related health care costs, subsidies of the automobile industry, collisions and traffic fatalities.[3]

In order to appreciate what can be accomplished within BC, it is useful to first place transportation into the larger context of energy consumption, efficiency and emissions production, as well as to examine some of the current trends in transportation.

Energy Consumption

Fossil fuels are a finite resource. At current consumption rates, all oil reserves will be exhausted in approximately 55 years.[4]

At 6.19 tonnes of oil equivalent per capita, Canada's energy use is five times the world average.[5] This cannot be explained by climate alone, as most northern European countries consume far less.

Industrial nations house just 19% of the world's population, yet use 59% of all energy that goes into transportation.[6] North America alone accounts for 39% of the world's fuel use for transportation and 49% of the world's gasoline consumption, as shown below.

[3] Brown, Lester, Christopher Flavin and Hilary French, State of the World 2001. The Worldwatch Institute, 2001: 112.
[4] Based on oil reserve estimates from the International Energy Agency and consumption rates from the Worldwatch Institute, 2000.
[5] David R. Boyd, "Canada vs. the OECD: An Environmental Comparison." Prepared for the Eco Research Chair of Environmental Law and Policy at the University of Victoria, 2001; http://www.environmentalindicators.com/htdocs/about.htm
[6] Energy Information Administration/International Energy Outlook 2002. http://www.eia.doe.gov/oiaf/ieo

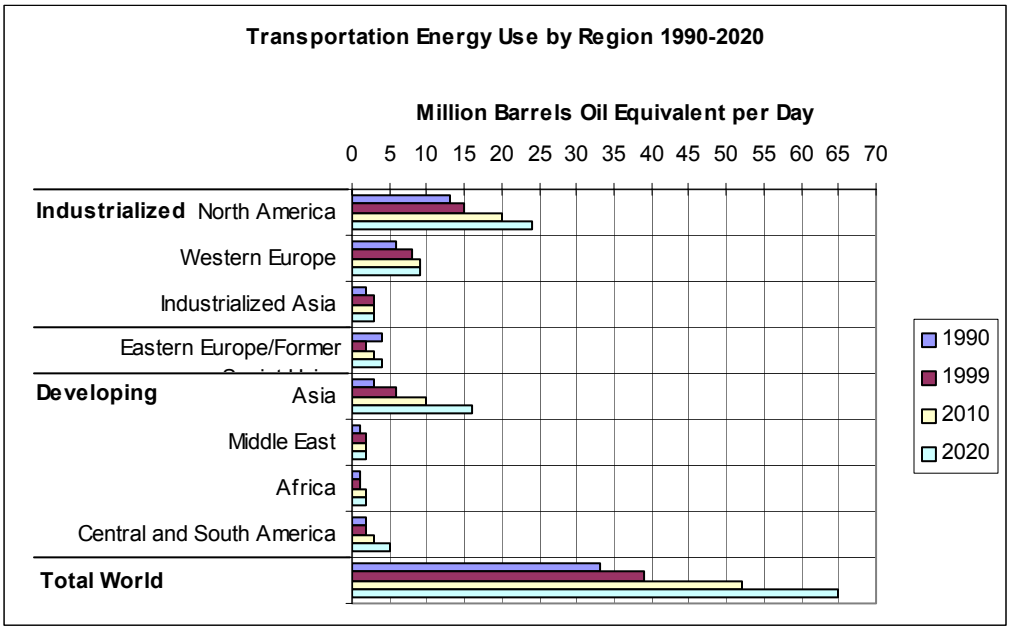

Figure 1: Transportation Energy Use by Region 1990-2020. Data Source: International Energy Outlook 2002. http://www.eia.doe.gov/oiaf/ieo/

In Canada, transport consumes about 28% of end-use energy. That energy is distributed as follows:

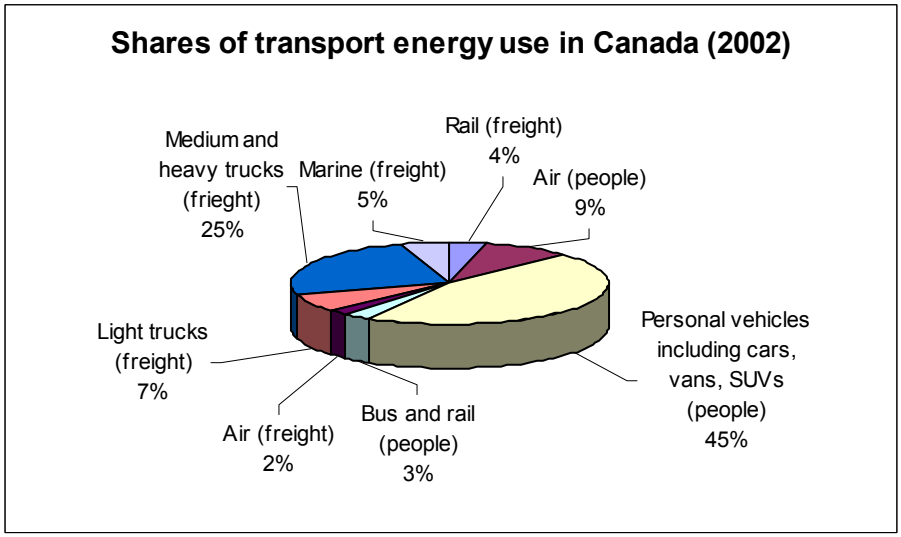

Figure 2: Shares of Transport Energy Use in Canada (2002). Source: *Background Paper for a Post-Kyoto Transport Strategy*, Centre for Sustainable Transportation, 2002: p.7. http://www.cstctd.org/CSTcstpub.htm

Fuel Efficiency

Canada is also one of the least energy efficient countries in the world. We use 0.30 tonnes of oil equivalent to generate $1000US of GDP. Canada is even 33% less efficient than the US.[7]

Even in the US, where overall energy efficiency is considerably better than in Canada, the average fuel economy of new vehicles reached a 21-year low in model year 2001 at 20.4 miles per gallon, as a result of increased sales of sport utility vehicles, vans, and pickup trucks.[8] Canada is experiencing a similar trend.

Greenhouse Gas Emissions

Canada produces 16.84 tonnes of CO_2 per capita- four times the global average. In terms of total CO_2 production, only four nations produce more: the US, Japan, Germany, UK.

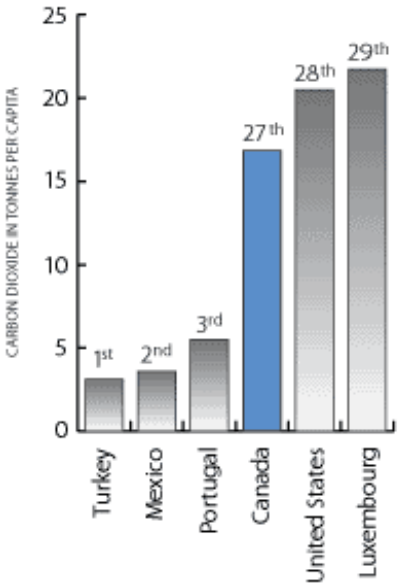

Figure 3: Emissions of Carbon Dioxide in tonnes per capita. Source: OECD Environmental Data 1999.

Transportation accounted for 23% of the global carbon dioxide emissions in 1997, up from 17% in 1971. This rise is largely due to the increase in road and air transport. Carbon emissions per unit of GDP between 1980 and 1994 fell in all sectors except transportation.

[7] Boyd, 2001: http://www.environmentalindicators.com/htdocs/about.htm.
[8] "Fuel Economy Figures Are the Worst in 20 Years, EPA Reports," *Octane Week*, Vol. 16, No. 42 (October 15, 2001), pp. 4-5.

In Canada, transportation is the largest source of greenhouse gas emissions.[9] In BC, it accounts for 42% of the province's total emissions.[10]

Total greenhouse gas emissions in BC have increased over 20% since 1990. Population growth accounts for part of this increase, but the increase in emissions from the transportation sector exceeds the population growth rate, due to more vehicles on the road, an increase in the number of less fuel-efficient vehicles and to vehicles being driven longer distances.[11]

Vehicle Ownership

Vehicle sales in BC increased 7% from 1990 to 2000. This is not in itself a significant increase; however, 36% more of these new vehicles were in the commercial category, which includes light trucks, SUVs and minivans.[12]

This in part explains the increase in emissions and poor efficiency mentioned earlier, since a small car uses 38% less gas per kilometre of city driving and 40% less gas on the highway than an SUV. As a result, a small car also emits 36% less greenhouse gases than an SUV.[13]

In Summary

Much can be accomplished in the field of transportation. This sector can make significant contributions to achieving Kyoto targets simply by shifting its priorities and approaching typical transportation challenges from a broader angle. Not only do we, as professionals, have the ability to dramatically impact fuel consumption and greenhouse gas emissions but we can also contribute toward improved quality of life through the design of communities. The following sections will demonstrate some of these possibilities.

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[9] http://www.climatechange.gc.ca/english/whats_new/pdf/gofcdaplan_eng2.pdf

[10] Ministry of Water, Land and Air Protection: BC State of the Environment Report 2002. http://wlapwww.gov.bc.ca/soerpt

[11] Ibid.

[12] Ibid.

[13] Ibid.

4 Engineers' and Geoscientists' Roles in Transportation

4.1 Roles and Responsibilities

Engineers and geoscientists assume a range of roles and responsibilities within the transportation industry, including:

- Transportation policy and planning
- Infrastructure planning and maintenance
- Design of urban centres
- Design of new developments and redevelopment
- Road design
- Transportation systems design and management
- Project management
- Transportation systems modeling
- Traffic Calming
- Transportation Demand Management (TDM)
- Performance measurement
- Traffic analysis
- Goods and people transport
- Road safety engineering
- Research
- Education

4.2 Scope of Influence

The scope of influence of engineers and geoscientists within the transportation field is significant. We can affect policy at municipal, regional, provincial or federal levels and we can influence the design, implementation and assessment phases of both public and private projects. Through this work we directly influence the shape of communities and the way people experience transportation.

Our personal travel choices can also set an example for our families, neighbours, colleagues and the public.

5 Sustainable Transportation

"Adding highway capacity to solve traffic congestion is like buying larger pants to deal with your weight problem."
Michael Repogle, New York Times, "The Cost of Urban Sprawl: Unplanned Obsolescence"

So what makes one transportation system more sustainable than another?

The Centre for Sustainable Transportation has developed a widely accepted definition for a sustainable transportation system. It is one that:

1. "allows the basic needs of individuals to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations

2. is affordable, operates efficiently, offers choice of transport mode and supports a vibrant economy

3. limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise."[14]

In a similar vein, the global Organization for Economic Cooperation and Development (OECD) published the OECD Guidelines towards Environmentally Sustainable Transport in 2002. This document defines an environmentally sustainable transport system as one that:

1. "provides for safe, economically viable and socially acceptable access to people, places, goods and services;

2. meets generally accepted objectives for health and environmental quality, e.g. those set forth by the World Health Organization for air pollutants and noise;

3. protects ecosystems by avoiding exceedence of critical loads and levels for ecosystem integrity, e.g. those defined by the UNECE (http://www.unece.org/) for acidification, eutrophication and ground level ozone; and

4. does not aggravate adverse global phenomena, including climate change, stratospheric ozone depletion and the spread of persistent organic pollutants."[15]

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[14] Centre for Sustainable Transportation, *Definition and Vision of Sustainable Transportation*, 1998. http://www.cstctd.org/CSTadobefiles/definitionvisionadobe.pdf
[15] OECD Guidelines towards Environmentally Sustainable Transport, 2002. p: 43. http://www1.oecd.org/publications/e-book/9702191E.PDF

Working from these principles, engineers and geoscientists in all fields can make conscious choices that will have an impact on sustainable transportation. These include, for example:

- purchasing local materials whenever possible;
- coordinating shipping (eg, trucks come in with garbage and leave with gravel);
- for personal travel: combining trips, using alternative modes for short trips;
- choosing to live in areas where they can easily walk, cycle and take transit to services; and/or
- minimizing the design and construction of impermeable areas (eg. by using permeable pavements).

Professionals working within the transportation field can make an even more significant contribution to achieving the types of transportation systems defined previously.

Those involved in planning & policy and within the public sector can:

- develop an understanding of the real costs of automobile dependency;
- promote land development practices that provide safe and efficient roadways, accesses and parking for all travel modes;
- use knowledge of transportation's link with land use to support service to alternative modes;
- use the success of other municipalities to educate and leverage council;
- amend subdivision, engineering and zoning regulations to support alternative modes of development;
- officially commit to alterative modes of transportation, mixed use development, etc at the leadership, policy level;
- set targets for minimizing impermeable surfaces in new developments;
- budget to assess progress;
- lead by example by using sustainable forms of transportation on a daily basis;and/or
- support/initiate internal trip-reduction programs in the workplace.

Those working as transportation consultants can:

- develop an understanding of the real costs of auto dependency;
- promote land development practices that provide safe and efficient roadways, accesses and parking for all travel modes;
- consider whether assessment methods favour auto travel over alternatives (eg. try accessibility vs. mobility assessments);
- use the successes of other regions to gain buy-in from clients;

- use this knowledge to educate and suggest alternatives to clients and to assess client's and stakeholders' true needs (eg. traffic calming, walking schoolbuses near schools are a SAFETY issue);
- lead by example by using sustainable forms of transportation on a daily basis; and/or
- support/initiate trip-reduction programs within the workplace.

Benefits

More sustainable transportation systems and developments offer a number of potential financial and other benefits, including:

- reduction in the cost of detached housing;
- more efficient use of land in residential areas;
- lower maintenance costs for municipal infrastructure and utilities;
- improved access to natural amenities for all citizens;
- increased protection of habitats and water quality;
- reduction in per capita energy use for transportation and utilities.[16]

5.1 Tools

Development Guidelines/Checklists

The James Taylor Chair in Landscape and Liveable Environments produced "Sustainable Urban Landscapes: Site Design Manual for BC Communities", which includes an excellent sustainability checklist for evaluating community design proposals. Each item on the checklist is described in detail within the Guidelines, which can be downloaded at http://www.sustainable-communities.agsci.ubc.ca/projects/DesignManual.html

Such a checklist may be used as a tool during the design process to determine the relevant criteria that any resulting design must meet. Residents and other stakeholders could also be brought in to identify those criteria that are most important to them. These criteria, along with non-negotiable environmental criteria can then be used to assess alternatives and choose between them.

Excerpts from the checklist that relate most directly to the transportation aspects of a development are included in the Appendix.

[16] James Taylor Chair- http://www.sustainable-communities.agsci.ubc.ca/projects/ADS/HTML_Files/ChapterOne/Setting_the_Stage.htm

The Full Cost of Driving

"…for every dollar spent on vehicle operating costs (the cost of fuel, etc), costs of approximately $2.70 are imposed on society."
Todd Litman, Victoria Transport Policy Institute
www.vtpi.org

"…a study of road transportation in the UK found that the costs associated with air emissions, noise, congestion, road damage, and accidents outweighed the taxes paid by drivers by 3 to 1."
State of the World 2001

An appreciation of the full cost of driving can help justify the design of alternatives and to convince clients that other options may not only be more healthy and 'sustainable' but also more cost effective.

The full cost of driving must include internal and external costs. Internal costs include the cost of the vehicle, gas, lubricant, and insurance. External costs include:

- emissions from vehicle use,
- the cost of time spent traveling,
- the cost of vehicle collisions,
- opportunity cost of land used by roads,
- the cost of motor vehicle noise,
- water pollution and hydrological impacts of vehicle use and roads, and
- impacts from vehicle water disposal.[17]

Indeed, the price individuals pay for personal automobile transport, for goods that are shipped by freight or for a plane ticket is substantially less than the true cost of travel when environmental and social impacts are taken into account.

Another major problem associated with automobile dependency is that it disproportionately affects those who drive less or not at all. These include low income individuals and families, disabled people, children and seniors, who bear more than their share of the external costs associated with vehicle use.

A curious finding is that while many people associate personal vehicles with freedom, safety and comfort, "Urban Sprawl and traffic congestion" is a major concern, tied for first with "crime and violence" (from a U.S. study).[18]

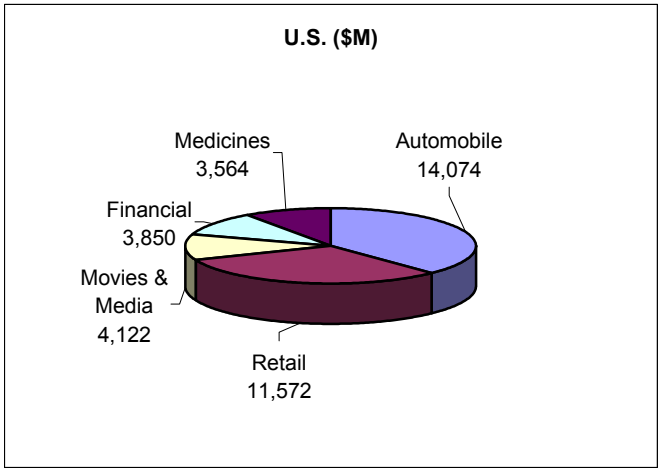
An important question is why, given the plentitude of sound evidence in support of vehicle alternatives and given most people's acknowledgement of the shortcomings of vehicle dependency, the personal vehicle maintains such prominence in the North American conscience. Some of the practical reasons that transportation professionals can help tackle include:

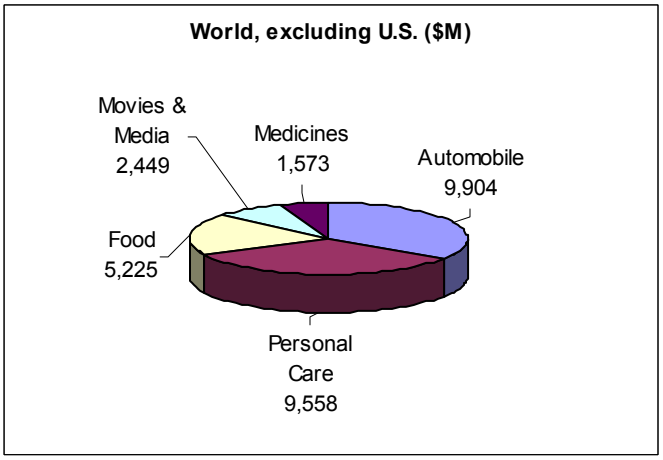
- lack of modal choice

[17] Taylor, Amy and Mark Anielski, Pembina Institute: *The Alberta GPI Accounts: Transportation*, 2001. p.10. http://www.pembina.org/publications_item.asp?id=45
[18] Ehrlich, Paul, Strategic Thinking by Paul Ehrlich, *Human Nature*. Washington, DC: Island Press, 2000, P: 327.

- urban design that discourages walking and other alternate modes
- perceived risk in using alternate modes, eg. cycling in traffic
- concern for personal safety, eg. waiting for buses at night
- perceived or real increase in travel time when using alternate modes
- perceived superior convenience of personal vehicles
- need to travel longer distances
- vehicle insurance price structure that discourages use of alternate modes

An important and less often considered piece of the picture is advertising. Divided by sector, advertising spending by the automobile sector is number one by a long shot.





Figures 4&5: 1998 Advertising Spending by Sector. Source: *Total Measured U.S. Ad Spending by Category & Media in 1998* and *Measured Ad Spending by Category*, Advertising Age. In State of the World 2001, p:121.

Not only does the automobile industry spend more on advertising than any other sector, but notably the U.S. spends more than the rest of the world combined on automobile advertising. As Canadians, we are obviously exposed to most of this advertising. Given that North Americans are the most auto-dependent people in the world, this link with the advertising industry cannot be ignored. It likely informs policy and political decisions as much as it does personal choice.

More Tools

Measuring the Health Effects of Sprawl
http://www.smartgrowthamerica.org/report/HealthSprawl8.03.pdf
A very interesting report, conducted by Smart Growth America's Surface Transportation Policy Project, detailing the relationship between urban sprawl, vehicle dependency and obesity in the US.

Sustainable Urban Landscapes: Alternative Development Standards for Sustainable Communities
http://www.sustainable-communities.agsci.ubc.ca/projects/ADS.html
Another useful product of the James Taylor Chair, these standards include cost benefit analyses that demonstrate that by using a combination of alternative design practices, the cost of detached residential housing can be significantly reduced.

Policy Instruments for Achieving Environmentally Sustainable Transport
http://www.oecd.org/document/53/0,2340,en_2649_34363_1955509_1_1_1_37433,00.html
The Organization for Economic Cooperation and Development (OECD) published this guide as part of its Environmentally Sustainable Transport (EST) project. It adopts a 'backcasting' approach, whereby long-term targets are set and then shorter terms strategies are devised to meet those targets.

Guidelines towards Environmentally Sustainable Transport
http://www1.oecd.org/publications/e-book/9702191E.PDF
Also published by the OECD and its EST project, these guidelines will be useful for governments and decision makers at all levels. They "represent a desirable and feasible approach for the transport sector that may also be of value in the sustainable development of other sectors."

6 Measurement/Assessment

Keeping in mind the requirements and goals of sustainable transportation, how do we now measure progress toward these goals and objectives?

6.1 Performance Indicators

Engineers working in the transportation field are familiar with measuring the performance of transportation systems.

Indicators associated with transport have typically considered only a narrow range of vehicle-related indicators such as level of service, vehicle delay time, average vehicle speeds, and vehicle capacity.

In order to assess a system from a sustainability perspective, it is essential to shift focus to indicators that include social, environmental, and full cost economics. Performance indicators can be used to evaluate an existing transportation system and to measure the success of changes or improvements.

Evaluating progress and the state of existing systems takes time and resources. However, measurement is really the only way to gauge the effectiveness of a policy or a system over time. Fortunately for those just embarking on this path, several organizations and local and regional governments have already developed indicators that relate to transportation system performance, which can be adapted to local applications and conditions. A sampling is included below.

For New Developments

The following were site location and transport indicators for the Beddington Zero Energy Development in London, England.[19]

Site location Indicators:
Pedestrian travel distance to railway station
Number of bus routes within 100m of site boundary
Pedestrian travel distance to nearest doctor/health centre
Pedestrian travel distance to nursery facilities
Pedestrian travel distance to café or pub
Pedestrian travel distance to infant, junior, senior schools

Acceptable distances were then set, with a 5-minute walk being the preferred standard.

[19] http://www.bedzed.org.uk

Transport indicators:

Covered bike space per home
Charging facilities for electric vehicles

The design guidelines and checklist detailed in the "Tools" section also provides a good focal point for assessing new residential developments.

For Municipalities/Communities

The indicators below were part of the **City of Richmond's** State of the Environment 2001 Report:[20]

Transportation Choices:
Percentage of morning rush hour trips made by automobile driver, automobile passenger, transit, walking and cycling.
Number of registered vehicles per 1000 residents
Percentage of roads meeting minimum standards for pedestrian friendliness
Percentage of roads meeting higher standard of pedestrian friendliness
Absolute kilometers and percentage of roads with cycling lanes

Below is a sampling of transportation related indicators from **The Alberta Genuine Progress Indicators.**[21]

Social Sustainability Indicators:
Time use:
Commuting time
Leisure Time

Health and Wellness:
Premature mortality
Cost of Automobile accidents
Cost of unhealthy lifestyles

Environmental Sustainability Indicators:
Air quality and greenhouse gas emissions
Carbon footprint
Noise pollution
Depreciation costs of public infrastructure

[20] http://www.city.richmond.bc.ca/environment/environment_index.htm
[21] http://www.pembina.org/publications_display.asp?category=3

Below is a sampling from the City of Calgary's **Sustainable Calgary: the State of our City Report 2001**.[22] For municipalities considering this type of measurement, the Sustainable Calgary Report is an excellent starting point. It includes detailed explanation of all indicators and also makes recommendations for improvement where found lacking.

Indicators (better, worse, no change):

Air Quality
Food Grown Locally
Ecological Footprint
Energy Use
Population Density
Transit usage for work trips
Transportation infrastructure spending (breakdown by roads, transit, pathways)

The Centre for Sustainable Transportation has developed a set of 14 Sustainable Transportation Performance Indicators designed to be applicable to any community in Canada and to indicate whether progress of a system is toward or away from sustainability.[23] They are listed in the Appendix along with a suggested measurement unit for each. The report should be referred to for a full explanation of each indicator. Engineers and geoscientists can use these indicators to both evaluate and justify sustainable projects and expenditures.

Other Indicators and Resources

The Alberta Genuine Progress Accounts: Transportation Report #7, October 2001
http://www.pembina.org/publications_display.asp?category=3
Published by the Pembina Institute, these reports provide a detailed breakdown of internal and external costs of transportation. Scroll down to the Transportation subject heading.

The US Environmental Protection Agency's Green Community Checklist
http://www.epa.gov/greenkit/gccheck.htm

The Centre for Sustainable Transportation
www.cstctd.org
The nationwide CST offers a wealth of resources and guidance for developing and measuring sustainable transportation systems.

[22] http://www.sustainablecalgary.ca/projects/sooc/
[23] www.cstctd.org/CSTcurrentprojects.htm

7 Case Studies

This section is devoted to on-the-ground, project specific examples of ways communities within BC have incrementally moved toward more sustainable transportation. Most solutions presented below are low-cost, or comparable to the cost of a conventional upgrade.

7.1 Policy and Planning Solutions

City of Quesnel

The City of Quesnel's Development Guidelines include requirements and incentives that will lead to increased mixed use development and development in higher density areas, such as:

- *"allow multi-family residential development within the downtown designation only when the ground floor contains mixed uses."*
- *offer density bonuses to developers providing that a development "...be within a 5 minute walk of the downtown core or west Quesnel commercial area."*

A community of 11,000, the City of Quesnel is an excellent example of the leadership and progress toward sustainability that is viable even within small communities with limited resources. The City has identified several goals related to its community development that have important links to transportation. These goals include improving local air quality, meeting 2010 Kyoto targets and bolstering the economy and environment.

The City recognized that a reduction in automobile dependence could contribute significantly to improvements in air quality and overall liveability. A fundamental shift would therefore be required in terms of the way the community shaped its development.

These goals are addressed throughout the City's new Official Community Plan (OCP), adopted in 1999. The OCP's development model aims to create pedestrian-friendly roadways with access to most services within a 5-minute walk of homes. To achieve this end, the OCP encourages mixed land uses and increased density in commercial areas (see side bar).

In terms of transport-specific goals, the OCP commits to improving sidewalk access, establishing bike and pedestrian trail networks and developing an effective long-term transit system. The community had implemented a service in 1993 that only lasted for 20 months due to low ridership, and had until recently only operated a bare-bones handiDART system for special needs users. The sentiment reflected in the OCP was that a transit system could be successful, provided that it accurately identified and served local needs.

The new incarnation of the Quesnel transit system was implemented in 2001. It has since undergone service type and route adjustments in response to user feedback. The current system uses two Polar 20-passenger buses for the fixed-route service, plus a small van for handiDART service. The "McGruff on the Bus" traveling Safe House program was also launched in October 2002. This program adds value to the transit service by providing a traveling safe haven for anyone who is lost or afraid.

Even given the small size and sometimes harsh climate of Quesnel, the community's progressive OCP and new transit service are yielding great results: ridership was at 28,000 riders in its second year of operation (2002); sidewalks are being installed and upgraded throughout existing and new developments; and its 10km Riverfront

Trail has become one of the City's most popular and well-used focal points.

To learn more about Quesnel's transportation and development initiatives, visit these sites:

http://www.energyaware.bc.ca/tk_c_quesnel1.htm

http://www.fraserbasin.bc.ca/SOFB2003/AwardNominees.html#coq

http://www.city.quesnel.bc.ca

Others

City of Kelowna
http://www.city.kelowna.bc.ca/citypage/scripts/index%2Ecfm?MenuLevel=Transportation%20Division&MenuButton=Transportation%20Demand%20Management&MenuStyle=style4%2Ecfm
The City of Kelowna- the most auto-dependent region in the province- has committed to the reduction of Single Occupant Vehicle traffic through its varied and comprehensive Transportation Demand Management strategies.

City of Kamloops Travelsmart Program
http://www.fcm.ca/scep/case_studies/transportation/kamloops_trans_sum.htm
http://www.city.kamloops.bc.ca/transportation/index.html

City of Vancouver Downtown Transportation Plan
http://www.city.vancouver.bc.ca/dtp/

City of Vancouver Greenways Program

http://www.city.vancouver.bc.ca/engsvcs/streets/greenways/

Saanich, BC

Victoria's largest suburb, Saanich became a member of the Federation of Canadian Municipalities' 20% Club (now known as Partners for Climate Protection) in 1999. This group of municipalities across Canada voluntarily committed to reducing greenhouse gas emissions by 20% by 2005 (see http://www.fcm.ca/scep/support/PCP/pcp_index.htm to learn more).

The focus of Saanich's transportation efforts has been "Active Transportation". This commitment has resulted in the development of over 64km of bike lanes, secure bike parking and shower facilities at City Hall, as well as development guidelines that require workplaces to provide secure bicycle facilities and change rooms.

Together with the City of Victoria, Capital Regional Parks, Capital Commission, the Greater Victoria Cycling Coalition and hundreds of volunteers, the city of Saanich helped realize the Galloping Goose/Lochside Trail. This 3m wide, 55km long trail follows an old rail line and links residential communities within Saanich and other parts of Greater Victoria. Over 2000 people per day use the trail. The same length of residential roads would only carry 1000 vehicles per day and cost twice as much.

Have a look at http://www.gov.saanich.bc.ca/leisure/cycling/cycling.htm for a bicycle touring map, commuter tips and more. For further information, contact Colin Doyle, Corporation of the District of Saanich, 250-475-5494, Doylec@gov.saanich.bc.ca.

Source: www.crd.bc.ca/parks/parkgse.htm

East Clayton Neighbourhood Community Plan

Principle No. 1 *Conserve land and energy by designing compact walkable neighbourhoods. This will encourage pedestrian activities where basic services (e.g., schools, parks, transit, shops, etc.) should be within a five- to six- minute walk of people's homes.*

No. 2 *Provide different dwelling types (a mix of housing types, including a broad range of densities from single-family homes to apartment buildings) in the same neighbourhood and even on the same street.*

No. 3 *Communities are designed for people; therefore, all dwellings should present a friendly face to the street in order to promote social interaction.*

No. 4 *Ensure that car storage and services are handled at the rear of dwellings.*

No. 5 *Provide an interconnected street network, in a grid or modified grid pattern, to ensure a variety of itineraries and to disperse traffic congestion.*

No. 6 *Provide narrow streets shaded by rows of trees in order to save costs and to provide a greener, friendlier environment.*

No. 7*. Preserve the natural environment and promote natural drainage systems (in which storm water is held on the surface and permitted to seep naturally into the ground).*

The City of Surrey's East Clayton Neighbourhood Concept Plan was officially adopted in April 2002. This project is set to become the first subdivision development that is built according to sustainable planning and design principles.

The project is guided by the 7 Sustainable Design principles that were developed early in the process (see sidebar).

Some recommendations and lessons learned from this innovative project include:

- "Ensure industry involvement and secure developer buy-in of the development's concept and objectives;
- Secure senior government support;
- Educate local politicians, city staff, and community members on the project and its objectives;
- Secure project partners to share the risk;
- Develop a homebuyer education program."[24]

For information and updates on the progress of this project, please see http://www.sustainable-communities.agsci.ubc.ca/projects/Headwaters.html.

Source: http://www.sustainable-communities.agsci.ubc.ca/projects/Headwaters.html

[24] http://www.gvrd.bc.ca/sustainability/casestudies/eastclaytont.htm

Technical Engineering Solutions

Roundabouts

Photo source:
www.town.ladysmith.bc.ca/history.htm

According to Joe Friesenhan, Director of Public Works for the Town of Ladysmith, "…the roundabout has been an overwhelming success. During the construction we received numerous negative comments about the roundabout. We have since had a number of those that were most vocal against it come back to us and tell us how well it works and apologizing for being so short sighted. I would have to say that the roundabout is 100% successful. To my knowledge there have been no accidents at the roundabout and the traffic has moved through the intersection more smoothly than any set of traffic lights could deliver."

The Town of Ladysmith on Vancouver Island was faced with the upgrade of a non-signalized intersection at First Ave and Symonds that was the site of major congestion and accidents. Based on standard practice, the Town was going to install a light to solve the problem. The Insurance Corporation of BC (ICBC) approached the Town and proposed that the intersection be used to pilot a traffic roundabout instead of a light.

Photo courtesy of Joe Friesenhan

The roundabout has been in place for about two years. Not only has the roundabout improved safety and reduced vehicle delays and idling, it was also constructed as an aesthetically appealing landmark that reflects the town's seaside character.

For more information, contact Joe Friesenhan, jfriesenhan@town.ladysmith.bc.ca.

Photo Source: www.town.ladysmith.bc.ca/departments/public-works/engdept.htm

Sustainable Streets

Model Biofiltration swale on Seattle's Street Edge Alternative Project

Source: http://www.ci.seattle.wa.us/util/SEAstreets/

Sustainable Streetscapes is a City of Vancouver pilot project that incorporates a number of features of sustainable transportation. The project was born out of a Local Improvement request to repair the road and install curb and gutter on a semi-rural street in south Vancouver. City Engineers and landscape architects saw this as an opportunity to try something new. With the extensive involvement of local residents, the resulting design successfully addressed traffic calming, parking, aesthetics, stormwater and boulevard maintenance.

The design has the following features:

- use of permeable materials for sidewalks and parking areas to minimize impermeable areas;
- meandering and narrowing of the street both physically and perceptually to reduce sight lines, slow traffic without requiring frequent vehicle stops and create a more pleasant pedestrian atmosphere;
- construction of biofiltration swales to treat stormwater and moderate flow into nearby Musqueam Creek (the last remaining salmon-bearing stream in Vancouver); and
- planting of native low-maintenance plants on boulevards and use of local recycled and salvaged materials for landscape features like curbstops.

Illustration of Sustainable Street Design by Lexi Steed.

The project is slated to begin construction early in 2004. For more information about the project, visit:

http://www.city.vancouver.bc.ca/engsvcs/streets/design/enviro.htm.

Country Lanes

Lane south of 700 E. 27th Ave.

Local residents pitch in

The City of Vancouver's Country Lanes Demonstration Project is a trial project aimed at developing an alternative to the traditional asphalt lane. The purpose of the program is to provide a durable driving surface for cars, while minimizing impermeable areas and stormwater runoff and creating a safe, aesthetically pleasing, financially viable back lane.

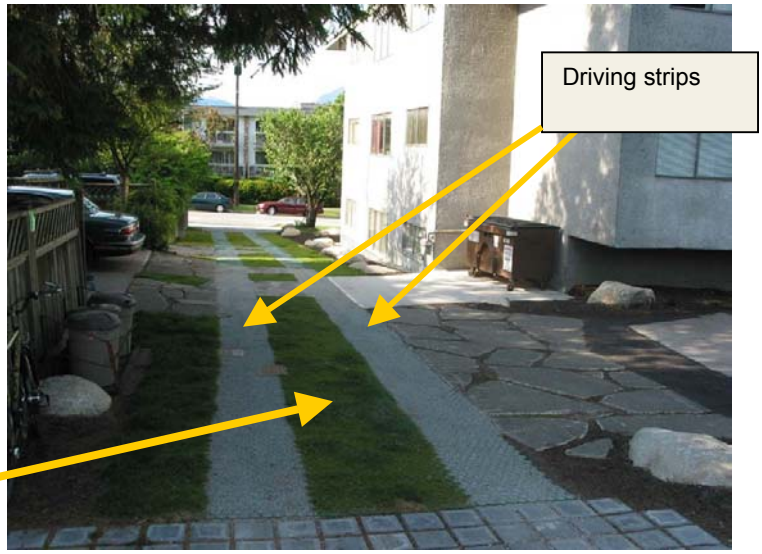
The City has completed three Country Lanes projects (700 E. 27th Ave, 2100 Maple St. and 2700 Yale St.), each experimenting with different methods but applying the same basic principles. A key component of the program was community involvement in all phases of project development and construction. The City was thus able to educate residents about stormwater management as well as to give ownership of the project to the residents.

Benefits of this type of design include:

- reduced flow into the City's sewer system
- provision of natural drainage and replenishment of groundwater
- natural filtration
- greener and more aesthetically pleasing back lanes
- reduced vehicle speeds (narrow driving surface)

The Structural Grass functions to:
- support vehicle weights, spread loading
- prevent soil and grass root compaction
- prevent soil rutting

Structural Grass (filled with topsoil and seeded)



Lane east of 2100 Maple St.

All photos and information are courtesy of City of Vancouver Engineering Services. For more information, please contact the Local Improvements Branch at 604-873-7928 or locals@city.vancouver.bc.ca.

Road Diets

East Whalley Ring Road Details:
Road classification = arterial road
# of lanes before = 2, 4 and 5 lane segments
# of lanes after = 2, 3 and 5 lane segments, with bike lanes
Year implemented = 1995
1995 traffic volume = 10,600 to 12,100 vpd
2001 traffic volume = 9,000 to 12,900 vpd

"Initially, conversion of the 4 lanes to 3 lanes was not well received but has now been well accepted by motorists and cyclists alike and has proven to be beneficial from a capacity and safety perspective as anticipated."

-Brad Fisher, Engineering Assistant, Transportation Division, City of Surrey

A "road diet" is a transportation management strategy that addresses the fact that increasing road capacity often results in equal or greater congestion, while reducing capacity- when planned properly- can have the reverse effect while simultaneously achieving safety and accessibility objectives.

Road diets typically refer to 4-lane arterial roads that have been reduced to 3 or 2 lanes, while increasing capacity for alternate modes such as cycling and walking.

It is instructive to note that in many of the places where road diets were implemented, the public was nearly 100% opposed, fearing that the reduction in lanes would result in worsened flow. Contrary to this belief, flow of cars remained the same; the incidents of dangerous vehicles maneuvers and accidents fell dramatically; and the viability of modes such as transit, cycling and walking improved significantly.

East Whalley Ring Road (EWRR) in Surrey BC is a regional example of a successful road diet project. The segment of arterial road in question was scheduled for repaving in 1995, while the City of Surrey was looking to demonstrate its commitment to improving road conditions for cyclists. The main component of the project involved converting a 600m long segment of road from 4 lanes to 3 lanes and adding bicycle lanes on both sides (bicycle lanes also were added 700m south and 700m north of this segment).

As Brad Fisher- the City of Surrey's Bicycle Coordinator- points out, several factors contributed to this road being an ideal candidate for a road diet and for the ultimate success of the project:

New 3-lane cross-section of EWRR with bike lanes, converted from 4 lanes. Photo: courtesy of City of Surrey.

- Transit did not operate on EWRR, meaning that the only changes required were repainting rather than the localized widening that would have been required to provide for stops on the new cross-section;
- Traffic patterns (heavy left turns at major intersections) were conducive to 3 lanes being more efficient than 4 from a capacity perspective;
- EWRR is a minor arterial road whose capacity will always be constrained by signal timing. Long-term capacity was therefore not a concern; and
- High left turn accident rates at major intersections due to lack of left turn bays made a 3-lane cross-section a safer option than 4 lanes.

For more information on EWRR, contact Brad Fisher, BRFisher@city.surrey.bc.ca. To read a more in-depth article on road diets, see: http://www.walkable.org/download/rdiets.pdf.

Others

Traffic Circles, Speed Humps, Raised Intersections, Chicanes, Chokers
http://www.ite.org/traffic/circle.htm
The Institute of Transportation Engineers has put together some comprehensive definitions with recommended uses and sample designs for a variety of traffic calming measures.

Parking Lot and Paving Alternatives
http://www.city.victoria.bc.ca/cityhall/pressroom_rel_030205a.shtml
The City of Victoria now encourages the use of permeable surfaces for parking areas and has amended its Zoning Regulation Bylaw accordingly.

http://www.toolbase.org/tertiaryT.asp?TrackID=&CategoryID=1438&DocumentID=2160.
The PATH Technology Inventory is a good general resource on permeable pavements.

Further Resources

The National Guide to Sustainable Municipal Infrastructure
http://www.infraguide.gc.ca/indexe.html
The Federation of Canadian Municipalities has put together this extensive guide for best practices in municipal engineering. Topics cover municipal roads, potable water, storm and wastewater, decision making & investment planning and environmental protocols. Each of these topic areas is then broken down into a wealth of technical best practices.

7.2 Social Engineering Solutions

'Social engineering' solutions- more commonly known as *Transportation Demand Management (TDM)* solutions- are ones that seek to encourage changes in behaviour. Socially oriented solutions create options and empower people to make choices. Engineers and geoscientists- particularly those working for municipalities and in smaller communities where their responsibilities tend to be more broad- may find a 'social engineering' solution to be an effective and low-cost alternative to a 'technical fix'.

Way to Go! School Program

15-20 years ago, most kids walked or cycled to school, whereas now, almost half of BC's urban and suburban kids make the trip in a car. In the GVRD, for example, travel to school now represents 20-25% of peak period motor vehicle trips- a significant proportion.

Ironically, many parents drive their kids to school due to perceived threats that are either directly or indirectly caused by vehicle dependence, including:

- fear of traffic (safety)
- fear of unfamiliar neighbourhoods
- distance
- fear of bullying, abduction

ICBC and the Insurance Brokers of BC fund the *Way to Go!* School Program in an effort to address and alleviate some of these fears by building a supportive community around non-vehicle travel. The two organizations work closely with individual elementary and middle schools, and local engineers, to find solutions.

In general, the process begins with a student travel survey, which students can later update with their progress. Parents also fill out a travel survey to establish reasons for driving, barriers to using alternate modes, and opportunities to try alternatives.

Mapping of best routes to school is the next step. Municipal engineers typically help with this task. It determines safest routes and areas where parental supervision is needed, as well as locations of students' homes, safe refuges, and best crossing locations. Copies of the maps with pedestrian safety information go out to all families at the beginning of the school year. Safety education on all modes of active transportation is a critical component provided by Way to Go!

As an example, the mapping exercise at one school revealed that a lot of students lived near a key crossing location that had no crosswalk, so parents had basically been driving their kids across the

road. Engineers were able to respond to this identified need by installing a special crosswalk with curb extensions.

Walking schoolbuses are a typical solution implemented through this program. Parents take turns walking groups of kids who live along particular routes to school. One elementary school in Richmond now has six different walking schoolbuses that all follow different routes. Engineers helped out by lengthening the pedestrian light at a trickier intersection.

Many schools use seasonal focused walking day opportunities such as International Walk to School Day, publicized community-wide with the help of municipalities. In general, successful *Way To Go!* programs:

- link a wide variety of issues and concerns (safety, environmental awareness, health and fitness, community development);
- relate to curriculum being taught in many subjects;
- include the whole school community (students, parents, teachers, administration);
- create a sense of fun; and
- associate behaviour change with a positive identity.

Today, almost two-thirds of BC's elementary and middle schools have requested the resource package and one-third are actively participating in the program. To get involved or learn more, visit www.waytogo.icbc.bc.ca or contact waytogo@telus.net.

Where students live and best routes to school for Hawthorne Elementary students in Ladner.

U-Pass, Transpass, ProPass, ComPass

The University of Victoria offered subsidized bus passes beginning in 1995 and implemented its universal bus pass (**U-Pass**) in September 1999. All students pay $54/semester and their student card serves as their universal bus pass.

Several benefits have been realized through this program:

- high off-peak transit use;
- increased student travel to and from downtown;
- increased business for cabs returning students from downtown late at night;
- increased overall transit ridership; and
- easier revenue forecasting for transit authority.

However, in the case of UVIC, much of the increase in transit ridership came from users who were formerly carpool passengers. Parking at the university may still be too cheap or the price structure (pay on a yearly basis) does not allow flexibility for Single Occupant Vehicle drivers to choose transit some days. This outcome highlights the need to consider combining different TDM strategies to achieve desired results.

UBC and SFU implemented **UPass** programs in September 2003. See http://www.trek.ubc.ca for more information on the UBC program and results (transit ridership, mode share etc) as they become available.

TransPass and **ComPass** are bus passes aimed at residents in new and existing developments. The South West Mission Area Plan, for example, is a proposed new community development for 33,000 people that is aiming to implement a TransPass program. In essence, this program would require the developer to purchase 2 years worth of bus passes for each new resident, with the option that residents take over the program after 2 years. The UBC **ComPass** is a similar program for the 9,500 non-student residents living at UBC that is currently undergoing a feasibility study.

ProPass is a BC Transit universal bus pass program designed for employees, whereby discounted bus passes are offered to employers, provided that 5 or more employees participate. To learn more, visit http://www.transitbc.com/regions/vic/transitplus/propass.cfm or http://www.translink.bc.ca/Programs_and_Services/Employer_Pass_Program/default.asp for Translink's **Employer Pass Program**.

Others

Car Sharing
Car share programs provide a car at low cost and high convenience to members when a car is needed, without burdening the driver with the associated costs of owning a car. These programs encourage people to drive only when they need to, thereby reducing the number of vehicles on the roads and ultimately improving the health and well being of individuals and communities.

Greater Vancouver is served by the Co-operative Auto Network (http://www.cooperativeauto.net/page1.htm).

Victoria (http://www.victoriacarshare.ca/) and Nelson (http://www.nelsoncar.com/) also have smaller scale car share programs.

Incentives
City of Seattle's One Less Car Demonstration Study
http://www.cityofseattle.net/waytogo/demostudy.htm
Since 2000, households in Seattle have participated in this demonstration project that offers a small stipend in exchange for giving up the second car for a period of 9 weeks. Participants kept journals to track how they got around and how they found the general experience. In addition to saving money, participants achieved significant results in reduced vehicle mileage and greenhouse gas emissions. Several have sold their second car as a result of the experiment. Resource packages for starting your own program are available through the website.

Further Resources

The Victoria Transport Policy Institute's On-Line TDM Encyclopedia
http://www.vtpi.org/tdm/
The VTPI maintains an exhaustive list of Transportation Demand Management strategies that includes evaluation, measurement and case studies.

Employee Commuting Success Stories
http://www.fhio.gc.ca/commuting/employee_commuting.htm
A government of Canada website that offers tips on starting commuting programs in the workplace, as well as describing some success stories.

8 Funding and Support Opportunities

Translink Employer Pass Program
http://www.translink.bc.ca/Programs_and_Services/Employer_Pass_Program/default.asp
For employers with 30 or more employees willing to purchase discounted bus passes through payroll deduction.

BC Transit Employer Pass Program- ProPass
http://www.transitbc.com/regions/vic/transitplus/propass.cfm
A discount bus pass program for 5 or more employees through Victoria Regional Transit.

Go Green Choices
www.best.bc.ca/programsAndServices/goGreenChoices.html
Better Environmentally Sound Transportation (BEST) offers training, education and follow-up support to workplaces within the GVRD to develop their transportation choices.

Personal Vehicle Program
http://oee.nrcan.gc.ca/vehicles/home.cfm
Provides motorists with helpful hints on buying, driving, and maintaining their vehicles to reduce fuel consumption and greenhouse gas emissions.

Green Municipal Enabling Fund
www.fcm.ca/scep/support/Gmef/gmef_index.htm
Provides grants to support feasibility studies for innovative municipal projects in categories of energy and energy services, water, solid waste management, sustainable transportation services and technologies and sustainable community planning. Grants of up to 50% of eligible costs to a maximum of $100,000 are available on an on-going basis to Canadian municipalities and their public/private sector partners.

Environment Canada's Funding Programs
www.ec.gc.ca/fund_e.html
List of the available funding programs offered through or associated with Environment Canada, including the Climate Change Action Fund.

Government of Canada's Action Plan for Transportation
www.nrcan.gc.ca/www3/cc/english/action_plan/na_intro.shtml
The Government of Canada's Action on Climate Change includes two initiatives related to transportation: Future Fuels and Freight Efficiency and Technology Initiatives. The initiatives encompass voluntary programs, education, and funding for pilot projects.

9 Appendix

Excerpts from the James Taylor Chair in Landscape and Liveable Environments' "Sustainable Urban Landscapes: Site Design Manual for BC Communities" sustainability checklist for evaluating community design proposals. Each item on the checklist is described in detail within the Guidelines, which can be downloaded at http://www.sustainable-communities.agsci.ubc.ca/projects/DesignManual.html

No.	Item	Yes	No	Take Action
1	Do site development, engineering and subdivision requirements reflect the purpose and goals of the regional growth strategy?			
2	Do site development, engineering and subdivision requirements reflect Official Community Plan principles?			
4	Does the development utilize existing infrastructure networks?			
5	Does the development support coordination between land use and transportation?			
15	Is the development concentrated around commercial and transportation nodes?			
16	Do residential and employment densities support the regional transit system?			
17	Does the development incorporate a mix of uses?			
18	Is the street system interconnected to allow multiple paths for movement through the community?			
19	Are all residences in the development located within a 400m (5 minute walk) of neighborhood stores, parks and transit?			

20	Are greenways and bikeways integrated into the transportation network?			
24	Are opportunities for regional food production maximized?			
27	Are streets designed to infiltrate and treat storm water?			
30	Does the street network respond to existing topography and minimize earth works and site engineering?			
31	Are commercial activities centered on a pedestrian oriented 'Main Street'?			
32	Are on-site parking requirements minimized while on-street parking is maximized?			
33	Is parking located such that it does not detract from the pedestrian environment?			
34	Are streets designed to be safe and comfortable for pedestrians and cyclists?			
35	Are streets designed to frame important views?			
36	Are blocks designed to maximize the infiltration and storage of ground water?			
38	Do sidewalks connect blocks on both sides of the street?			
39	Are interruptions to the sidewalk minimized?			
40	Are blocks short enough to provide easy movement for pedestrians?			
41	On longer blocks are there mid-block connections to greenways or trails?			
42	Are there multiple lot sizes within each block to accommodate many housing and			

	tenure types?			
50	Do homes present a friendly face to the street?			
51	Are garages placed behind or recessed back from a house?			

The Centre for Sustainable Transportation has developed a set of 14 Sustainable Transportation Performance Indicators designed to be applicable to any community in Canada and to indicate whether progress of a system is toward or away from sustainability.[25]

Indicator		Measurement unit	Progress?
1	Use of fossil fuel energy for all transport	Total energy use (PJ)	
2	Greenhouse gas emissions from all transport	Total GHG emissions (Mt)	
3	Index of emissions of air pollutants from all transport	Total emissions (1990=100)	
4	Index of road fatalities and injuries	Total fatalities and injuries (1990=100)	
5	Total motorized movement of people	Billions of person-kilometres	
6	Total motorized movement of freight	Billions of tonne-kilometres	

[25] www.cstctd.org/CSTcurrentprojects.htm

7	Share of motorized movement of people *not* by land-based public transport	Share of travel (%)	
8	Movement of light duty passenger vehicles	Billions of vehicle-kilometres	
9	Intensity of use of urban land	Per capita land use (m2/resident)	
10	Length of paved roads	Thousands of two-lane kilometres	
11	Index of relative household cost of transport	% of all spending on transport	
12	Index of affordability of urban transit fares	Relative cost of transit (1990=100)	
13	Index of energy intensity of cars and trucks	Energy use per unit distance (1990=100)	
14	Index of fleet emissions intensity	Emissions per unit of energy use (1990=100)	