Innovating toward a low-carbon Canada: Using technology to transform tomorrow

Methodologies

This report tracks the amount of GHG emissions reductions that could be enabled by the application of ICT. These figures are not immediately available and hard to pin down. The following principles have guided how we calculated the potential benefits:

- Where published third-party data and future forecasts are available, they have been used. In certain cases, data about penetration rates and behaviour patterns have been carried over to apply to Canadian circumstances.
- If published, reviewed data was not available, we have collected data from businesses in the field, crosschecked it for credibility, and clearly indicated this is how the data was obtained.
- Where published data has had a possible range of values, conservative numbers have been chosen.
- In certain cases, we have made what seemed to us to be reasonable estimates of penetration rates or behaviour patterns. We have clearly indicated such assumptions, and provided the data to enable readers to calculate results for themselves if they disagree with the assumptions.
- The methodology calculates the potential impact of each recommendation separately. It is recognized that some of these recommendations have cross-effects. The reduction in the numbers of commuters through tele-work means that the number of commuters used in the ride sharing calculation could be smaller than the number we've used. The amount of electricity to be saved in residences might be less than used in our calculations if automatic controls have already been installed.

APPENDIX A

Methodology – Expanding Tele-work

The TIAX report prepared for the Consumer Electronics Association in the US is a thorough analysis of the impact and potential of telecommuting in North America[i]. This report has leaned on the analysis in that report, which used the following considerations to arrive at its conclusions. Adjustments were made to reflect the different average commute distance to work for Canada, and to adjust for tele-working replacing all forms of transportation to work, not just driving.

- Percentage of workers telecommuting: The TIAX report found that 4-6 million US workers tele-commuted at least once a week. A similar fraction of Canadian work force would consist of 470,000 – 700,000 workers. This report conservatively estimates 500,000 telecommuters currently or 2.7 per cent of the work force, well toward the bottom of the TIAX report range.

- Ground Transport: travel to and from work, including side trips, and including the embodied energy of fuel and vehicles. The TIAX calculation reduced mileage by about 40 per cent, reflecting the fact that telecommuters often use their cars for other purposes in the day. That assumption is maintained in this report. This report used a different average commute to work than in the TIAX report. This analysis differs from that in TIAX because the average Canadian commute to work is 11.5 km (versus 12 miles for US)ii. This was a difficult number to calculate. In 1996, Statistics Canada published both a median commuting distance and data about the distribution of commutes over different distances. From this, it was possible to estimate a mean commute distance of 10.6 km. Statistics Can later stated that in 2006, there had been an 8.6% increase in median commuting distance since 1996; applying this to the 10.6 km resulted in an estimate of average 2006 commuting distance of 11.5 km.

  Our analysis also took into account that tele-working could be replacing many modes of transportation, including public transit and walking or bicycling, and riding to work in a private vehicle, not just driving.

- Distribution of number of days tele-worked per week, which were assumed to be

days per week	1	2	3	4	5
% of workers	23.5	13.5	7.9	9.5	45.6

- Home and office ICT: operation of PCs, printers and network equipment

- Office building embodied energy: The energy consumed to construct the building, and the materials involved

- Commercial floor space reduction: reduction in the embodied energy for construction and operation of office space. This study assumes that office space is reduced 100 per cent for four and five-day telecommuters, 50 per cent for three-day telecommuters, and 0 per cent for one- and two-day telecommuters.

- Home energy consumption

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- PC and peripherals embodied energy: The TIAX study conservatively calculates that each tele-worker has an incremental laptop to allow the telecommuting, an assumption also in this report.

Putting all this together, there is a reduction of 1.43 tonnes of CO2e per year per telecommuter. The chart below shows the impact of increasing penetration even beyond this report's goal and stretch goal penetrations.

The assumptions supporting the savings estimates for tele-workers are as follows:
- Driving costs: $.52/km based on the average of 13 rates across Canada from the Treasury Boardiii (less than CAA's estimate of $.60/kmiv) for the all-in cost of operating a year. With an 11.5 km. one-way commute, and 231 working days per year, this works out to $2,762.76 annually.
- Parking Costs: $205/month is used for the estimate for parking in a central business district. 25% is used as an estimate of the proportion of commuters who park in a downtown CBD (a recent study showed that 38% of commuters paid for parking in downtown Manhattan; the assumption here is that the proportion will be lower in Canada). This yields $615 annually for parking.

These factors yield an annual cost of $3,377.76/year for commuters.

Applying this cost to the adoption rate of tele-workers, adjusted for the number of days they tele-work and the 40% rebound effect described above gives us 17,967,700 times 5% times 68% times 60% times the annual cost savings for a savings of $1.24 billion at the target. A similar calculation for 10% adoption yields $2.47 billion at the stretch target.

The assumptions supporting the savings estimates for corporations are as follows:
- The cost of Class A office space in CBD as $44/sq. ft, and Class A suburban office space as A$29.79/sq. ft.v

This results in savings for employers of $844 million (for only Class A office space) at 5% adoption and $1.688 million at 10%.

The cost savings for local, provincial and federal governments due to reduced need for infrastructure are impossible to measure. There would have to be a massive shift in behaviour to totally eliminate a highway. However, with the cost of highway and road contribution at $15 billion per year, even a small percentage reduction is significant.

APPENDIX B

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Methodology – Ride Sharing, Car Sharing

Ride Sharing
A drive saved is a drive saved, whether it arises from a telecommuter not going to work, or from a ride sharer saving a drive in another car. However, ride sharing reduces CO2e less than tele-working, because there are no savings on office accommodation. However, no rebound effect is calculated for a ride shared, so in this regard the saving is greater than teleworking. The assumption is that one driver's use of a car is eliminated completely, and that there is no compensating 40% usage for other purposes.

From the same 1996 data used in the tele-working section, coupled with other Statistics Canada data regarding mode of travel to work, we estimated a total CO2e consumption of 7.22 Mt for all light commuting vehicles (cars, trucks, vans). This figure was then adjusted upwards by 8.6% (to account for the increase in average commute since 1996) and then by 61% (to account for the increase in the size of the workforce between 1996 and 2007), yielding a total small-vehicle-commute footprint of 12.62 Mtonnes of CO2e, or 0.96 tonnes per worker.

Thus, eliminating 12% of these vehicles by ride sharing represents 1.51 million tonnes of GHG emission savings, while eliminating 20% would yield 2.52 million tonnes of GHG emission savings. The costs calculated above for the commuters are used in the calculation of financial savings for ride sharing. Calculating the cost savings for ride sharing, we have 17,967,700 times 12% of the work force times the annual savings yields a saving of $7.28 billion at the target; a similar calculation yields $12.14 billion at the stretch target.

Car Sharing
The car sharing calculations were based on data obtained from the largest car sharing organizations in Canada, which have memberships as follows vi:

Communauto	14,000
ZipCar	10,000
Autoshare	7,500
Co-operative Auto Network	3,000
Total	34,500

Data for Autoshare and ZipCar showed .023 and .035 cars per member; this study chose the lower ratio of .023 to calculate the number of cars owned by car sharing organizations for all of Canada when the number was not otherwise known (i.e. for Communauto and Co-operative Auto Network). For each car provided by a car sharing organization, a certain number of private cars are not purchased – the lowest estimate of this number of cars was eight cars per shared car. This leads to an estimate that car sharing at current levels takes 7,368 cars off the road.

Carbon savings are calculated as follows. We have used Shaheen's estimate of a 35% reduction in mileage[vii] and the 3.99 tonnes CO2e average annual vehicular emissions from government sources, applied to the 34,500 car sharing members in Canada, to give 48,186 tonnes of annual savings from car operations.

To calculate the savings from the embodied energy of an average car not bought, we have started with Rocky Mountain Institute's figure of 11 to 1 ratio of total energy to embodied energy over the lifespan of a car[viii], which is to say a 10 to 1 ratio of operating energy to embodied energy. Thus, given a 12 year lifespan of a car, and 3.99 tonnes per year, we have a total lifetime operational savings of 47.89 tonnes, thus yielding 4.79 tonnes for the embodied energy[ix]. For 7,368 cars, that yields 35,283 tonnes. Given the estimated 12 year lifespan of a car, that results in 2,940 tonnes per year.

Thus the total carbon savings are 51,126 tonnes per year for the 34,500 current car share members, which works out to 133 Ktonnes for the target number of 90,000 car sharers and 222 Ktonnes for the stretch target of 150,000 car sharers.

	Current	**Target**	**Stretch**
Car Sharers	**34,500**	**90,000**	**150,000**
Carbon saved (tonnes CO2e) – operating	48,186	125,703	209,505
Carbon saved (tonnes CO2e) – embodied	2,940	7,670	12,784
Total Carbon saved annually (tonnes CO2e)	51,126	133,373	222,288
Lifetime Savings ($millions) – embodied	$ 147.36	$ 384.42	$ 640.70
Annual Savings ($millions) – operating	$ 19.67	$ 51.31	$ 85.51
Annual Savings ($millions) - embodied = LIFETIME / 12	$ 12.28	$ 32.03	$ 53.39
Total Annual Savings ($millions)	$ 31.95	$ 83.34	$ 138.90

At an average cost of $20,000 per car (based on taking 7,368 cars off the road), there is a saving of $147 million. Increasing this by a ratio of 90,000/34,500 would give a figure of $384 million for the target and by 150,000/34,500 would produce $641 million for the stretch target, due to members not buying cars.

The 48,186 tonnes of CO_2e represent 19.67 millions litres of fuel (since there are 2.45 Ktonnes of CO_2e per million litres of fuel), or $19.67 million for the current car sharers (at $1 per litre). This represents $51.31 million and $85.51 million at the target and stretch target for annual operational costs. Adding to that 1/12 of the cost of ownership (based on 12 year average life of car), gives us a savings of $83.31 million and $138.90 million at the target and the stretch target.

APPENDIX C

Methodology -- Transportation Optimization

Idling Reduction

Idling time was assumed to be 2,400 hours/year per vehicle based on data in *Greening the Freight Industryx* or 15.6 tonnes CO_2e and 5,717 litres of fuel per year, again using data from the same report. The same report states that this idling time represents about 48% of the operating time of a typical vehicle.

When some controls on idling are in place, that idling time is reduced to 22%, while implementing a thorough program to reduce idling can bring the percentage down to 12%. These represent reductions of 69.4% or 85.2% of idling time compared to when no attempt is made to control idling.

Applying these ratios to the 294,000 Class 8 trucks in Canada yields 3.19 million tonnes CO_2e of GHG emission reduction with some idling control attempts, and 3.91 million tonnes when a program is in place. Estimating fuel cost at $1/litre means that the financial savings in fuel alone are $ 1.17 billion with attempts to control idling and $1.43 billion with a specific idling management program.

Route Optimization

Using transportation-related data from Canada's Energy Outlook 2006, the 2012 values were interpolated.

The Energy Use per Vehicle (GJ) of 87.5 GJ was obtained by dividing total Canadian energy use by the total number of trucks. The energy use for freight trucks, of 500.9.GJ, was calculated by multiplying vehicle-kilometre-travelled (VKT) per truck by freight-truck energy intensity (11 MJ per VKT).

For light-duty trucks and freight trucks, multiplying the energy use by emission factor for gasoline/diesel, of 0.070 tonne CO2e/GJ, yields 6.12 tonnes and 35.06 tonnes CO2e per vehicle, respectively.

The weighted average of 10.13 tonnes CO2e per vehicle was calculated using 86.2% light-duty and 13.8% freight trucks. (These percentages are derived from the light-duty trucks' stock of 8.1 million and freight trucks stock of 1.3 million.)

Applying this emission intensity (10.13 tonnes CO2e/vehicle) to 976,000 vehicles (10% of all vehicles), considered potential candidates for ICT route optimization, yields 9,886,880 tonnes CO2e. Furthermore, if 10% of potential candidate vehicles use the ICT-enabled route optimization, the final savings will be 988,688 tonnes CO2e.

The stretch goal of having 20% of vehicles using route optimization leads to savings of 1.977 megatonnes CO2e.

APPENDIX D

Methodology – Electronic conferencing, collaboration, training

Calculating the greenhouse gases avoided because of distance conferencing involves calculating the CO2e impact of the business travel that has been avoided, minus the small adjustment for the CO2e arising from electronic conferencing.

Statistics Canada provides data about the number of trips for business travel by Canadians from which one can estimate the amount of CO2e createdxi.

	M Trips	Kg CO2e per trip	Mt CO2e
Canada	20.1	128	2.6
USA Total	5.9	325	1.9
Overnight	2.2	354	.8
Same Day	3.7	307	1.1
Overseas	.6	1,432	.9
Total	26.6		5.4

Compare this to the miniscule energy used and carbon emitted for conferencing: 0.27 kg CO2e per participant for telephone conferencing and 1.04 kg CO2e for video conferencing.

Thus, eliminating 20% of business travel through electronic conferencing would save 20% of the CO2e impact of 5.4 Mtonnes, or 1.08 Mtonnes. Reaching the stretch target of 30% of business travel would result in savings of 1.62 Mtonnes.

The cost savings for electronic conferences derive from the avoided travel costs, which include airfare, hotel, and meal expenses, as well as lost productivity. Since no published data was found, an arbitrary estimate was made of

- $3000 for each international trip avoided
- $1000 for each US or domestic trip avoided

These numbers are admittedly very rough estimates, but seem sufficiently conservative to at least provide a base level estimate of savings.

The cost of teleconferencing systems should be subtracted from this amount. Special equipment is not required for simple audio conferencing or conferencing over an existing PC, while video conferencing can range from $10,000 to a high of $500,000 for high-end videoconferencing. Since these costs pay off in such a short period of time, this subtraction was not made.

Since the total cost of business travel in Canada works out to $27.8 billion, replacing 20% of business travel with electronic conferencing would save companies $ 5.56 billion a year, and replacing 30% would save $ 8.34 billion a year.

APPENDIX E

Methodology – E-transactions

Again the TIAX study is drawn upon for the analysis of savings from electronic mail replacing physical mail. There are savings on delivery energy from the mail, savings in the energy use and embodied energy of the printer and computer, paper consumption, offset by a small energy usage for delivery of the email.

A significant offset to the savings resulting from electronic mail depends on whether the recipient chooses to print the bill after receiving it. It is to be expected that the proportion of bills that will be printed will decline over time, as consumers gain more confidence and trust in their ability to access the required information online.

The US Postal services identifies that bill statements and payments account for nearly 50 per cent of its first class volumexii and Canada Post data shows that Canadian mail is over 50 per cent commercial. Thus, the amount of savings that could result ranges up to 50 per cent, which led to the development of our goal and stretch goal.

Studies have shown costs ranging from $.63 to $1.90 per bill mailed. This calculation has estimated a conservative $1.00 per bill.

Canada Post's annual report for 2006 cites 5,471 million pieces of 'transaction mail'xiii, which term is a synonym for first class mail. Assuming that half of that is commercial mail, which in turn are half bill statements and half payments would mean that 1,367 million pieces of mail are bill statements. Thus, replacing 40% (the target) of those 1,367 million pieces of mail, with the recipient printing 20% of them would result in savings of 10.5 Ktonnes of CO2e. Replacing 80% of the bills (the stretch target), with the recipient printing 5% of them, would result in savings of 21.9 Ktonnes of CO2e. The cost savings are $0.55 billion at target or $1.09 billion at stretch target for the companies involved.

It is difficult to estimate the savings from a wide range of other materials described above. CDs are one example of the digital replacing the material. There are approximately 23.8M CDs sold annually in Canada. Including the jewel cases, these CDs might weigh some 1.43 thousand tonnes. Manufacture of one tonne of product results in a CO2e footprint of approximately 2.5 tonnes, and shipping represents another 0.11 tonnes per tonne. This yields a total impact of some 3,700 tonnes of GHG. It is conservative to assume CD's represent no more than one-third of the total physical items that could be replaced by electronic – consider print media such as newspapers, magazines, Canadian Tire flyers, telephone directories, and all sorts of business directories going electronic, as well as the coming onslaught of digital movies replacing DVDs. This brings the savings to 11.1 Ktonnes of CO2e. Adding together these two sources yields .021 Mtonnes and .033 Mtonnes of CO2e savings at the target and stretch target.

APPENDIX F
Methodology – Building Metering and Controls

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'Smart' Meters
Assessing the potential GHG reduction in this area requires an estimate of the penetration of smart meters and of the impact of smart meters once installed.
Reductions in household energy consumption have the greatest impact in provinces with coal-fired electricity generation – Ontario, New Brunswick, Alberta, Nova Scotia and Saskatchewan. In these provinces, if energy reductions are achieved we expect coal-fired plants will see the first reductions. (This study looks at savings only in these provinces.)

There are commitments to reach 100 per cent penetration rate in Ontario and BC. Given that the overall penetration in Canada is estimated to be 86% in 2012, one can derive an average penetration rate of 76% for the rest of Canada. Ontario is projected to use 50.6 billion kWh by 2012 (with 100% smart meter penetration), while New Brunswick, Nova Scotia, Alberta and Saskatchewan are expected to consume 22 billion kWh (at 76% penetration), for a total of 67.4 billion kWh smart-metered in the 5 provinces.

The Ontario Energy Board Smart Price Pilot ran in Hydro Ottawa's territory for seven months ending February 2007. The participants achieved a reduction in overall electricity consumption by an average of 6%xiv, which was used for the near-term target. 6% of 67.4 billion kWh results in 4.04 billion kWh avoided. Since coal has an emission coefficient of 1.074 kg CO_2e per kWh, applying that to the 4.04 billion kWh would yield 4.34 Mtonnes of CO_2e avoidance. The stretch target of 10.85 Mtonnes of carbon is based on the 10.10 billion kWh avoided with a 15% reduction in consumption.

Assuming a cost of $.051 per kWh, the above reductions in consumption result in savings of $206 million for consumers at the 6% target reduction and $515 million at the 15% stretch target.

The Ontario Power Authority estimates the cost of infrastructure to support peak needs at $67 per MWh. If we assume that the reduction in consumption reduces the peak power needs, then the target of 4.04 billion kWh avoided results in a one-time infrastructure savings of $271 million while the stretch target of 10.10 billion kWh avoided yields savings of $677 million.

'Intelligent' Controls
Assessing the potential for GHG reduction in commercial, industrial buildings and residential buildings again requires both the penetration rate and the impact per system installed.

Estimates of potential have ranged from just under 5% up to 30-45% in various reportsxv. Applying savings estimates of 10% for space heating, water heating and space cooling and of 75% for lighting to the total GHG emissions of the residential and commercial/industrial sectorsxvi yields a potential savings of 18.7Mt CO2e. This represents an overall savings of 13.2% of the total CO2e footprint of 141.8 Mt, which accords well with the other estimates above.

The penetration rate of smart controls is difficult to estimate. It makes sense for 100% of new large buildings to have such controls, and large-scale intelligent retrofits can pay back in as little as 1.4 yearsxvii. This could yield a range of savings shown below:

For each 10% penetration in commercial buildings, .966 Mtonnes of emissions are eliminated. For each 10% penetration in residential buildings, .9001 Mtonnes of emissions are eliminated. Thus the target of 6.63 Mtonnes is calculated based on 50% penetration in commercial buildings and 20% penetration in residential. The stretch goal of 12.23 Mtonnes is calculated based on 80% penetration in commercial and 50% penetration in residential buildings.

At the penetration rates of 50% commercial and 20% residential, 25.6 billion kWh are avoided, while at 80% commercial and 50% residential penetration, 47.2 billion kWh are avoided; at a cost of $.051 per kWh, that yields cost savings of $ 1.30 billion or $ 2.41 billion for the consumers of that electricity.

i www.ce.org/ENergy_and_greenhouse_Gas_Emissions_Impact_CEA_July_2007.pdf
ii Canadian census data at www.statcan.ca/english/census96/mar17/commut/dist1.htm
iii www.tbs-sct.gc.ca/pubs_pol/hrpubs/TBM_113/temp/b_e/asp
iv Canadian Automobile Association, "Driving Costs 2007"
v Colliers survey from 2007
vi The figures from the different car sharing operations were obtained through contacts with the companies, who have run surveys to collect this data from their members.
vii Shaheen, S.A., Meyn, M.A. (2002) Shared use vehicle services: a survey of North American Market
viii Jonathan W. Fox and David R. Cramer (1997) Hypercars: A Market-Oriented Approach to Meeting Lifecycle Environmental Goals
ix This figure is calculated based on an assumption that the ratio of embodied CO2e to CO2e from driving is the same as the ratio of embodied energy to operating energy. This is how we moved from the estimates of total energy to total CO2e. Technically, this would only be true if all energy used to manufacture a car came from gasoline consumption. This is undoubtedly not exactly true, but it would seem to be a reasonable surrogate and probably relatively accurate.
x Greening the Freight Industry, page 6.
xi The calculations in this section come from detailed spreadsheets based on data from Stats Can travel data, and work analysis by Bell Canada and WWF. The spreadsheet can be requested from WWF.
xii US Postal Service incidates that over half its first class mail is bills at http://www.govexec.com/fpp/fpp01/postal_service.htm
xiii www.canadapost.ca/textonly/common/corporate/about/annual_report/highlights2006-e.asp

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xiv
http://www.oeb.gov.on.ca/documents/communications/pressreleases/2007/press_release_smartpricepilot_backgrounder_20070726.pdf
xv

30-45%	Energy savings of 30-45% from intelligent buildings are possible in commercial real estate, according to Ron Zimmer, executive director of the Continental Automating Buildings Association, an international trade group based in Ottawa. Estimate found at http://nreionline.com/technology/Energy_costs_green_smart/
20-22%	A study quoted on AutomatedBuildings.com identifies that integrated HVAC controls can save 15% to17%, and integrated lighting controls another 5%. See http://www.automatedbuildings.com/news/nov05/articles/ibttl/ibttl.htm
12%	An article at IntelligentBuildingsToday.com suggests a rule of thumb of 12% energy savings for intelligent buildings, found at http://www.intelligentbuildingstoday.com/CDA/Archives/a9f770306d34b010VgnVCM100000f932a8c0____
4.45%	Another report at http://www.businessballs.com/intelligentbuildingsdesign.htm claims energy savings of 75% of lighting consumption, and light represents 5% of the total energy consumption of residential and commercial sectors (thus 3.75%), and 10% savings on heating, cooling and hot water production, which represents up to 7% of total energy consumption (thus .7%), yielding a total of 4.45%

xvi NRCAN provides the proportional energy consumption for the period 2000-2004 at:
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?fuseaction=Selector.showTree
xvii http://www.intelligentbuildingstoday.com/CDA/Archives/a9f770306d34b010VgnVCM100000f932a8c0