THE RELATIONSHIP BETWEEN PRODUCTS, SERVICES AND CLIMATE CHANGE

DISCUSSION PAPER

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1.0 INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) stated in 1995 that "the balance of evidence suggests that there is a discernible human influence on global climate."[1] Since then, governments, industry and individuals have been increasingly working to identify ways to reduce this negative human influence through the reduction of greenhouse gas emissions. Greenhouse gases are emitted through such varied activities as natural resource extraction, manufacturing and processing, transportation, as well as the use of energy and water. By considering the greenhouse gas intensity of the products and services we consume, and by giving preference to those goods and services with a lesser greenhouse gas intensity, we can help to reduce the human influence on global climate.

The purpose of this paper and the accompanying product and service profiles is to illustrate the greenhouse gas emissions associated with particular products or services, and discuss how consumers can use this information to reduce their climate change footprint. The paper is divided into two parts: first, background information on climate change and the commitments undertaken by the Canadian Government; and second, the relationship between products and services and climate change. The paper is accompanied by a series of product and service profiles that quantify the estimated greenhouse gas emissions of specific products and services in the Canadian marketplace. The profiles present a quantified performance range of products or services, and illustrate the potential greenhouse gas reductions achievable by shifting market demand toward products that are more energy-efficient or less carbon intensive. The profiles illustrate that consumers can use their purchasing power to mitigate climate change impacts. The profiles also identify that an aggressive campaign by governments and industry through incentives, for example, can dramatically reduce Canada's total greenhouse gas emissions.

2.0 BACKGROUND

2.1 Explanation of Climate Changes

Climate change is most simply described as a shift in the *average weather* that a given region experiences. It is measured in all features we associate with weather, including temperature, wind patterns, precipitation and storms.[2] It is caused by excessive greenhouse gas emissions beyond levels that are naturally assimilated.

The Earth's atmosphere naturally contains a layer of heat-retaining greenhouse gases[3] that allow some of the sun's energy to be trapped close to the Earth, warming the planet. Solar energy is emitted from the sun and travels to the Earth. Upon reaching the Earth, most of the energy is absorbed at the Earth's surface and reflected back toward space as

[1] Intergovernmental Panel on Climate Change (IPCC). 2nd Assessment Report. 1995.

[2] Government of Canada. Global Climate Change – The Science of Climate Change.

[3] The principal natural greenhouse gases are water vapour, carbon dioxide, methane and nitrous oxide.

infrared radiation. When this reflected radiation reaches our atmosphere, the greenhouse layer absorbs part of this radiation, enabling further warming of the Earth's surface. This results in enough heat being retained close to the Earth to allow an average surface temperature of 15° Celsius. Figure 1 provides a graphic illustration of this natural greenhouse effect.

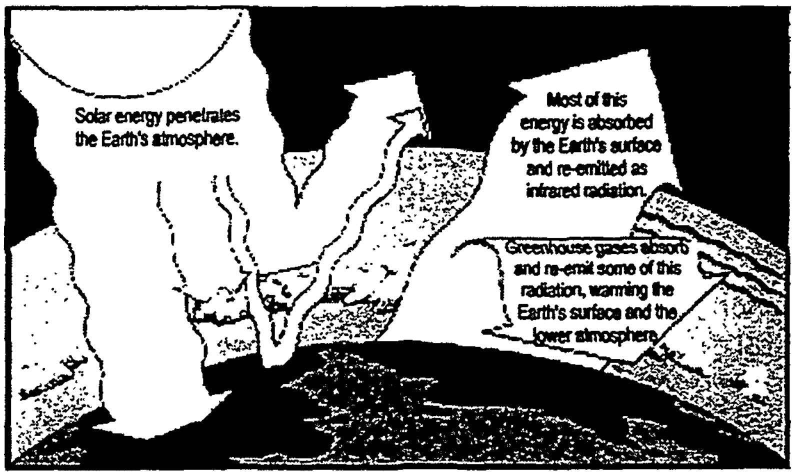

Figure 1: The Natural Greenhouse Effect

(Reproduced from "Canada's Second National Report on Climate Change", page 1.)

Without this natural "greenhouse effect," the Earth's average temperature would be –18° Celsius, and life as we know it would not exist.[4] This average "natural" temperature does not remain constant over time. Natural fluctuations have, throughout history, taken the Earth into and out of a number of ice ages. The climate change that we see today, however, varies in magnitude and rate from these historical natural fluctuations. This *human induced climate change* is the topic of current scientific debate and policy initiatives by industry, government and individuals.

From the beginning of the human era until the start of the Industrial Revolution, greenhouse gas concentrations in the atmosphere were fairly stable, at about 280 parts per million (ppm). The dramatic increase in fossil fuel burning that accompanied the Industrial Revolution, however, led to a dramatic increase in anthropogenic emissions of greenhouse gases. Since the mid 1700s, carbon dioxide concentrations have increased from 280 ppm to 360 ppm (see Figure 2); this increase represents a level not seen in 160,000 years.[5] During this same period, the average temperature of the Earth has

[4] Government of Canada. Canada's Second National Report on Climate Change. 1997: p.1.
[5] Environment Canada. Trends in Canada's Greenhouse Gas Emissions 1990-1995. 1997: p.1.

increased by approximately 0.3-0.6° Celsius[6] and nine of the past eleven years have been the warmest on record.[7] In Canada, the average increase has been 1° Celsius.[8]

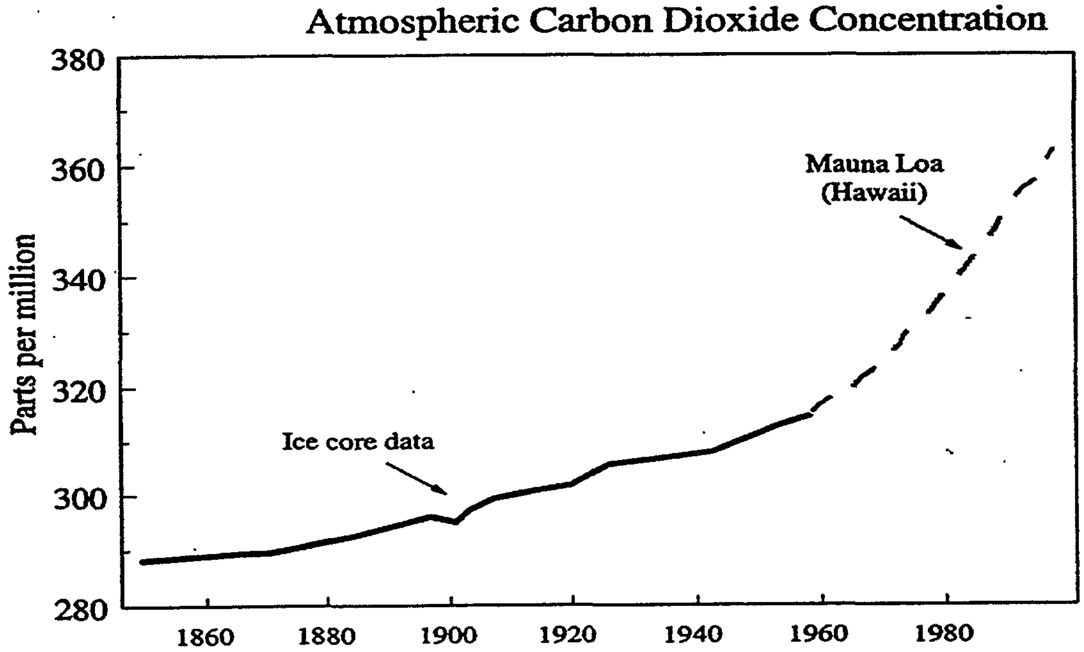

Figure 2: Atmospheric Carbon Dioxide Concentration

(Reproduced from the "Kyoto Protocol and the President's Policies to Address Climate Change," p. 16)

There has been extensive scientific debate over the relationship between the increasing anthropogenic greenhouse gas emissions and the Earth's warming temperature. To move this scientific debate forward, the World Meteorological Association and the United Nations Environment Program jointly established the Intergovernmental Panel on Climate Change (IPCC) in 1988. Comprised of over 2,000 scientists, the IPCC's role is to "assess the scientific, technical and socio-economic information relevant for the understanding of the risk of human-induced climate change."[9] The IPCC has concluded that human activities are affecting climate change.[10]

2.2 Emissions Trend

The trend of increasing greenhouse gas emissions that began with the Industrial Revolution is growing. Assuming no changes in emission profiles, the Canadian Government predicts that our greenhouse gas emissions will grow by 36% from 1990 to

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[6] Environment Canada. Trends in Canada's Greenhouse Gas Emissions 1990-1995. 1997: p.1.
[7] Ibid, p.17.
[8] Ibid, p.1.
[9] IPCC Website. [http://www.ipcc.ch]. September 1999.
[10] IPCC. 2nd Assessment Report. 1995.

2020.[11] If this increase was matched around the world by other countries, scientists predict that the average global temperature could rise by 1° to 3.5° Celsius over the next century. In Canada, this could mean an increase in annual mean temperatures in some regions of between 5° and 10° Celsius.[12]

2.3 Major Causes of Climate Change

Human influences on our climate result from the anthropogenic releases of greenhouse gases. The principal greenhouse gases are carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons and hydrofluoro carbons. All of these gases contribute to climate change at different intensities. Therefore, to simplify quantification of reductions, each of these gases is assigned a "CO_2 equivalent" – the amount of each substance that has the same climate change impact as one tonne of CO_2. For example, one tonne of methane gas has 21 times the climate change impact of one tonne of CO_2. For that reason, it is assigned a CO_2 equivalent of 21. The most significant contributor to total anthropogenic emissions of greenhouse gases is the burning of fossil fuels, such as coal and oil (see Box 1).

Box 1: Fossil Fuels and Greenhouse Gas Emissions[12]

- Each year, the world releases 5 to 5.5 billion tonnes of carbon dioxide by burning fossil fuels.
- In 1995, at least 80% of Canada's total greenhouse gas emissions resulted from the use of coal, oil and natural gas to generate electricity and to power our factories, homes and cars.
- The fossil fuels production sector and the electrical sector are responsible for about one-third of total Canadian emissions, followed closely by the transportation and industrial sectors.

Other sources of greenhouse gas emissions include deforestation,[14] methane emissions from landfill sites, industrial processes, solvent use and agricultural practices.

As this discussion illustrates, virtually all sectors of society contribute to climate change. On one hand, this makes dealing with climate change a daunting task, but on the other hand, it means that all members of society – individuals, corporations and governments – can be part of the solution.

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[11] Government of Canada. Canada's Second National Report on Climate Change – Actions to Meet Commitments under the United Nations Framework Convention on Climate Change. 1997.
[12] Environment Canada Website. [www.ec.gc.ca/envpriorities/climatechange_e.htm]. September 1999.
[13] Environment Canada Website. [www.ec.gc.ca/envpriorities/climatechange_e.htm]. September 1999.
[14] Each year the world releases 1 to 1.5 billion tonnes of carbon dioxide through deforestation (Environment Canada Website. [www.ec.gc.ca/envpriorities/climate change_e.htm]. September 1999.

2.4 Why is it a problem?

By developing better models of atmospheric and ocean circulations, climatologists and meteorologists have significantly increased scientific certainty of the impacts that will result from climate change.[15]

In 1997, Environment Canada conducted a series of studies – the *Canada Country Studies* – to predict the impacts of climate change on all regions of Canada. Some of the principal findings are summarized in Box 2.

2.5 Actions Taken

2.5.1 Government

Canada signed the Framework Convention on Climate Change (FCCC) in June 1992. This was the first international agreement that aimed to curtail greenhouse gas emissions. The Convention has been ratified by over 100 countries, including Canada, and came into force on March 21, 1994. Its aim is to:

> Achieve the stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved in a timeframe sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.[16]

As a first step, the Convention required industrialized nations, as well as countries with economies in transition, to have committed to a *goal* of stabilizing greenhouse gas emissions at 1990 levels by 2000. It should be noted that ratification of the Convention did not create a legally binding commitment on the part of countries; however, the later Kyoto Protocol would. At the 1997 United Nations General Assembly Special Session on the Environment, Prime Minister Jean Chrétien acknowledged that Canada would be unable to meet the goal of stabilization to 1990 levels by the year 2000.[17] This situation is also true for most countries, with the likely exception of the United Kingdom, Germany and Russia, each of which has undergone significant economic restructuring that has resulted in closure of many high emitting sources.

In December 1997, in Kyoto, Japan, Parties agreed to a Protocol under the Convention – the Kyoto Protocol. Once ratified and in force,[18] this protocol will create a legally binding commitment for industrialized countries to reduce emissions of the six principal greenhouse gas emissions[19] by 5.2% by 2008-2012. To reach 5.2%, each country undertook individual commitments; for its part, Canada committed to a 6% reduction.

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[15] Government of Canada. Canada's Second National Report on Climate Change – Actions to Meet Commitments under the United Nations Framework Convention on Climate Change. 1997: p.53.
[16] Framework Convention on Climate Change, Article 2. 1992.
[17] Prime Minister Jean Chretien. *Speech to the United Nations General Assembly, Special Session.* New York: June 24, 1997.
[18] To enter into force, the Protocol must be ratified by 55 countries representing at least 55% of the developed country's emissions, with developed countries being listed in an Annex to the Protocol.
[19] Carbon dioxide, methane, nitrous oxide, sulphur hexafluoride, perfluorocarbons and hydrofluorocarbons.

Box 2: Excerpts from the *Canada Country Studies to Predict the Impacts of Climate Change on Canada's Regions* [20]

Overall, the impacts of climate change on our forests, fish populations, and agriculture could be extreme. They include:

- Longer growing seasons and an extension of agriculture further north, but also risks to agriculture such as moisture deficits, pests, disease, and fires;
- Impacts on fish populations, which could increase in some areas (mostly in the Arctic and on northern areas of the Pacific coast), and decrease in others (particularly the lakes and rivers of the Canadian Shield);
- Effects on hydroelectric generating potential, with increases in Labrador and Northern Quebec, and lower potential in Ontario, the Prairies, and south-eastern B.C.;
- Risks to waterfowl populations due to lower water levels in lakes, rivers, and wetlands; and
- Projected changes in the occurrence and severity of extreme weather events, which would have serious implications for the security and integrity of Canada's natural resources, social systems, and infrastructure with subsequent implications for the insurance industry and supporting public sectors.

Regionally,

- The number of heat-related deaths could rise because of higher summer temperatures. Toronto, Montreal and Ottawa, known for their hot, humid air masses in summertime, would be most affected. Those with heart disease, respiratory conditions, the elderly, the very young, the poor and the homeless would be affected the most.
- Changes in temperature and precipitation may help the survival of insect (vector) borne diseases, causing increases or invasions into Canada of diseases such as Lyme disease and malaria.
- In the western mountain regions of British Columbia and Alberta, there could be less late season runoff because of an accelerated retreat of glaciers. This will threaten water supplies in small communities and have an effect on the cattle industry.
- In the north, loss of permafrost may cause massive terrain slumping, drainage of small lakes and increased sediment loads in rivers, threatening northern wetlands and such deltas as the Mackenzie and Peace-Athabasca.
- In the Great Lakes, water levels could change. This may threaten valuable shoreline and wetland habitats, disrupt navigation, create new infrastructure requirements, have an impact on fisheries and affect shoreline property values. Bottom dwelling organisms contributing to healthy lakes could be threatened because it would take longer for lakes to be stratified, resulting in longer late season periods of low oxygen conditions.
- Canada's wetlands are important for fish and wildlife habitats, water storage and as staging areas during migration of waterfowl. The ecology of these wetlands is very susceptible to water level changes and could be seriously threatened by alterations in regional water patterns. A number of wetlands have already been rehabilitated by Great Lakes 2000 and the North American Waterfowl Management Plan.
- In the Atlantic Provinces, and other regions susceptible to spring flooding, changes in late winter-early spring precipitation patterns could result in increased frequency of ice jams and flooding. Damages caused by these events have already cost Canadians an estimated $60 million annually.
- In the Prairies, increased temperatures may provide opportunities for growing higher valued crops, but this may not be possible where changes to regional precipitation patterns lead to insufficient rainfall and more frequent droughts.

[20] Government of Canada. Canada Country Studies. 1997.

Since 1992, various measures have been undertaken to try to reduce or reverse Canada's trend of increasing greenhouse gas emissions. The principal component of the strategy has been the *National Climate Change Voluntary Challenge and Registry (VCR) Program*. The *VCR* encourages industry, business and government to make public commitments and develop and implement voluntary action plans for reducing their greenhouse gas emissions. The *VCR* has over 850 registrants who are responsible for well over 50% of Canada's total greenhouse gas emissions.[21] While there have been individual successes by some companies under the program, it has been criticized for a lack of overall results. As of February 1999, 307 registrants had not submitted a plan to reduce their emissions, and of those who had submitted plans, a further 240 had not submitted progress reports.[22]

A number of other initiatives aimed at encouraging the reduction of emissions are summarized in Box 3.

Box 3: Sampling of Government Initiatives Aimed at Encouraging Greenhouse Gas Reductions[23]

- **Commercial Building Incentive Program** - Aimed at new commercial and institutional buildings that are designed to be at least 25% more energy efficient than the National Model Energy Code for Buildings. Natural Resources Canada will contribute to the cost of design, an amount equal to double the energy savings, above code requirements, up to $80,000.
- **Energy Innovators Plus** - To allow more organizations to take action to reduce their energy operating costs and greenhouse gas emissions, the program funds pilot retrofit projects to illustrate the benefits of investing in energy efficiency.
- **EnerGuide for Houses** - Encourages Canadians to improve the energy performance of their houses. Expanding on the well-known EnerGuide Labelling Program for home appliances and equipment, EnerGuide for Houses provides homeowners with the information to make informed decisions about energy efficiency, whether they are making improvements to their home or buying a new home.
- **Renewable Energy Deployment Initiative (REDI)** - A program to work with architects, building engineers, energy service companies and building managers to increase renewable energy market development initiatives. REDI focuses on promoting renewable energy systems for space and water heating and cooling, such as:
    - active solar hot water systems;
    - active solar air heating systems;
    - high efficiency biomass combustion systems; and
    - ground-source heat pumps.

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21 The Honourable Christine Stewart. *Speech at VCR Leadership Awards Ceremony and 2nd Council of Champions Meeting*. Hull, Quebec: February 11, 1999.
22 The Honourable Christine Stewart. *Speech at VCR Leadership Awards Ceremony and 2nd Council of Champions Meeting*. Hull, Quebec: February 11, 1999.
23 Natural Resources Canada Website. [http://www.nrcan.gc.ca/gcc/english/html/programs.html]. September 1999.

Following the Kyoto agreement, the federal and provincial governments decided to develop a *National Implementation Strategy on Climate Change*. To facilitate this process, they established the Climate Change Secretariat. The Secretariat has set up 16 stakeholder committees, each dealing with a specific industry sector or issue,[24] called Issue Tables. The goal of the issue tables is to provide expert and detailed input to the identification and analysis of greenhouse gas reduction opportunities, which will eventually feed into Canada's *National Implementation Strategy on Climate Change*.

At the local government level, a 20% Club has been established, which commits participating municipalities to reduce their emissions to 20% below 1990 levels by 2005. There are currently over 60 Canadian municipalities that have made this pledge.

2.5.2 Industry

It is difficult to characterize industry's reaction to the climate change challenge. Some leading companies have been extremely progressive and have more than exceeded the goal of stabilization to 1990 levels. For example, Suncor Energy Inc., a large integrated energy company, has reduced its greenhouse gas emission intensity to 0.480 tonnes of CO_2 equivalent per cubic meter of oil – this is a 10% reduction from 1990 levels. Suncor president and CEO Rick George said in a speech to the Vancouver Board of Trade,

> We believe that we can significantly reduce our emissions of greenhouse gases without sacrificing the economy. And we need to act now, not because we're certain the global climate is changing. We need to act because we can't ignore the scientific consensus that the balance of evidence suggests that there is a discernible influence on the world's climate.[25]

Dupont Canada recently received recognition for designing and installing a system to reduce its nitrous oxide (NO_2) emissions from its global adipic acid facility in Maitland, Ontario. NO_2 emitted from this facility is responsible for almost 2% of Canada's greenhouse gas emissions. Dupont's new technology has reduced NO_2 emissions by 50% to date, and a total reduction of 95% is expected before the year 2000.[26] Dupont also recently announced a commitment to reduce greenhouse gas emissions by 65% by 2010, while holding energy use at 1990 levels. The company plans to supply 10% of its energy from renewable sources.[27]

Certain industry sectors, such as appliance manufacturers and automobile makers, have achieved significant gains in the energy efficiency of their products, which lead to reduced emissions in the use stage of the product's life cycle. These efforts and the impact of consumers in choosing these more efficient products can help Canada to meet its target. For example, a fuel efficiency improvement of just one litre per 100 kilometres

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[24] The issue tables are: agriculture and agri-food, analysis and modeling, buildings, credit for early action, electricity, enhanced voluntary action, forestry sector, industry, Kyoto mechanisms, municipalities, public education and outreach, science and adaptation, sinks, technology, tradable permits, and transportation.
[25] Rick George, President and CEO Suncor Energy Inc. *Speech to Vancouver Board of Trade*. Vancouver: December 1997.
[26] Dupont Canada. Report to VCR Inc. [www.vcr-mvr.ca/vcr-049.cfm]. September 1999.
[27] Sustainable Business Website. [www.sustainablebusiness.com/html/insider/sep99/spotlight.cfm]. September 1999.

in Canadian cars would reduce our carbon dioxide emissions by 3.3 million tonnes each year.[28] This would have the same effect as closing two modern 450-megawatt coal-fired power plants.[29]

Other companies and industry sectors have been less active in reducing their emissions, prompting environmental groups to ask for the *Voluntary Challenge Registry* to be reformed or replaced by more aggressive approaches.

2.5.3 Individuals

Individuals are responsible for 25% of greenhouse gas emissions in Canada.[30] Polling of citizens has generally found that Canadians are aware of climate change, care about it and think it is an important issue, but do not really understand what it means. Polling has also found that citizens do not understand their role in contributing to climate change, or that individual actions could reduce the impacts.

Numerous government programs have been initiated recently to educate citizens on the causes and impacts of climate change, emission sources within their control, and how they can mitigate their contribution. For example, the CO_2 Calculator[31] (an Internet based tool) takes users through a questionnaire detailing all of their energy use habits. (i.e. type of vehicle, heating system, and so on). The Calculator then quantifies the current emission levels and the impact of various changes in the individual's purchasing choices, energy use, and other behaviour.

Programs such as this are generally in their infancy, and the effect they will have on consumer's purchasing and behavioural decisions is not yet known.

3.0 RELATIONSHIP BETWEEN PRODUCTS, SERVICES AND CLIMATE CHANGE

Canada is an extremely carbon-intensive society[32] and its greenhouse gas emissions come from all sectors of its economy and from every household. This human-made greenhouse effect is closely linked to the production and consumption levels of our current throwaway society. This section of the paper emphasizes the need to examine all stages of the product or service life cycle, as well as consumer choices in order to identify the most cost effective and non-intrusive approaches to minimize our climate change footprint. By taking a comprehensive life cycle approach, Canadian companies and individuals will be able to identify inefficiencies in their processes and procurement

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[28] Canadian Energy Pipeline (CEPA) and Canadian Gas Association (CGA). 1998. The Climate Change Chronicles, vol. 4, p.1.
[29] Ibid, p.1.
[30] Environment Canada Website. [http://www.ns.ec.gc.ca/co2/worksheet.html]. September 1999.
[31] Environment Canada Website. [http://www.ns.ec.gc.ca/co2/worksheet.html]. September 1999.
[32] Canada's economy is the third most carbon intensive in the world, surpassed only by Luxembourg and the United States.

decisions. Increasing the energy efficiency of existing products or services, and introducing alternative systems or products that have less impact on climate change can then reduce greenhouse gas emissions.

As governments around the world begin to restrict the allowable emissions of carbon to meet their FCCC and Kyoto Protocol commitments, greenhouse gas emissions will begin to take on the characteristics of a market commodity, rather than a free emission. As this happens, as with our limited resources, those that operate efficiently will be at an economic advantage. By identifying less carbon intensive processes, products and services earlier rather than later, Canadian industry has an opportunity to market these products and services internationally as demand grows in an increasingly carbon-constrained economy. There is intense competition among businesses to take advantage of this changing international marketplace; however, Canada is generally regarded as lagging behind. Without rapid, directed effort, Canada will fall further behind more efficient economies in Europe and Asia. For example, Canada uses almost four times as much energy for each thousand dollars of Gross Domestic Product (GDP) as Japan, and twice as much as the Netherlands and Sweden. Canadian businesses are ranked 25th in the world in minimizing the amount of industrial waste per unit of production,[33] and it has also been estimated that Canadian manufacturers are losing $40 billion annually through *eco-inefficiency*.[34]

Companies that have tried to get ahead have had significant success. For example, Aeroquip Corporation, a manufacturer of hoses, fittings and couplings, has developed a $250 million product line by focussing on products that reduce emissions.[35] Xerox, through its Asset Recycling Management program, saved $300-400 million in 1995 alone through recycling components of used and leased copiers into their new product lines.[36] By recovering and remanufacturing products utilizing used components, Xerox reduces the number of components that need to be manufactured from virgin materials. This multiple life cycle approach reduces the climate change impacts of the company's operations.

Another company addressing the environmental impacts of their operations is Interface Inc., a company involved in the commercial interiors market, offering products such as floor coverings and fabrics. Every year 769 million square metres of carpet are disposed of in the United States, amounting to approximately 1.6 billion kilograms for landfills to handle.[37] Interface has changed the way they do business from selling products to selling the services that carpets and other furnishings provide. Thus, the consumer purchases continually renewable furnishings with worn components recycled into new products. This functional approach has definite climate change benefits, as it reduces the energy and emissions that would result from increased manufacturing and landfill disposal.

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[33] Environment Canada. "Improving Productivity in a Sustainable Society" Draft Paper. 1999: p.4.
[34] Ibid. p.4.
[35] Ibid, p.4.
[36] Ibid, p.8.
[37] Lowe, E., E. Warren, and S. Moran. Discovering Industrial Ecology. An Executive Briefing and Sourcebook. Columbus: Batelle Press. 1997: p.85.

Despite a number of proactive companies, the North American approach to reducing greenhouse gas emissions to date has been criticized as piecemeal, undirected and non-strategic. The uneven uptake and reporting under the *Voluntary Challenge Registry* shows that many companies have not examined their processes for potential greenhouse gas emissions reductions. Many of the companies that have, have not systematically examined their product or service life cycles to determine and rank the cost efficiency of all potential greenhouse gas reductions.

The remainder of this paper and the attached product or service profiles will help product or service providers and purchasers to: examine systematically the climate change impacts of their activities; identify a range of options for reducing their greenhouse gas emissions, improving efficiency, and in many cases, saving money.

3.1 Life Cycle Impacts

For decades, managing industrial environmental impacts was largely limited to managing the environmental emissions from plants.[38] Recently, however, a combination of increasing consumer demands and government requirements has forced producers to conduct a more comprehensive examination of all of the environmental impacts of their products and/or services. This has led to the more widespread application of concepts such as life cycle management and design for environment. Companies are beginning to re-examine their approach to decisions such as product and packaging design, material selection, production processes, energy consumption and supplier management.[39]

Using a life cycle approach to managing greenhouse gas emissions entails examining all stages of a product or service's life cycle to identify releases of greenhouse gas emissions and identifying possible system changes to reduce emissions. These changes could affect the design of products or services, the choice of raw material inputs and suppliers, transportation of supplies to and from manufacturing facilities, all stages of the manufacturing process, transportation of products to market, consumer use patterns, and final disposal. The focus of these efforts should be on identifying opportunities to minimize emissions, improve efficiency, and reduce costs.

The results of a life cycle assessment can help designers to create products that have a reduced environmental impact. Paton (1994) points out that when designing products, focus should be on ensuring that all products meet at least six environmental characteristics:

- Minimize environmental impacts;
- Be safe for their intended uses;
- Optimize consumption of energy and materials;
- Meet or exceed all applicable legal requirements;

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[38] Paton, Bruce. "Design for Environment: A Management Perspective." Industrial Ecology and Global Change. Eds: R. Socolow, C. Andrews, F. Berkhout and V. Thomas. Cambridge University Press. New York. 1994: p.349.

[39] Ibid, p.349.

- Be reusable and/or recyclable; and
- Ultimately be disposed of in an environmentally safe and responsible manner.[40]

In assessing the life cycle of a product or service, companies need to consider a range of factors in addition to the greenhouse gas emission reductions that would result from changes. This type of assessment should consider the effect on business and how a change in design could contribute to a measure of competitive advantage and business success by:

- Contributing to revenues, profits and growth;
- Minimizing delays in market introduction;
- Avoiding mistakes that harm sales; and
- Eliminating barriers that prevent worldwide acceptance.[41]

By examining a number of these variables, (including the greenhouse gas reductions that would be incurred) companies will be able to prioritise greenhouse gas reduction initiatives. They can then select for early action those that are either cost beneficial or neutral in the short to medium term, and those that will give them a competitive advantage vis-à-vis their competitors.

Once these emission reduction opportunities are quantified, companies will be faced with the decision of which initiatives to undertake. In making these decisions, companies are traditionally influenced by a combination of: company values, shareholder expectations, legal requirements, customer expectations and competitive pressure.[42] As consumers increasingly demand information from producers and service providers on the energy intensity and greenhouse gas intensity of their products and services, this provides an opportunity for companies to pursue more aggressive reduction opportunities to meet evolving consumer expectations.

Since each product is unique, the life cycle assessment process must be tailored to consider the environmental impacts associated with that type of product, service, and production process. Companies should conduct life cycle assessments to determine where they can make significant, cost-effective reductions. There are a number of common features that should be considered when looking at the life cycle of products or services:

i. Product/Process design

The product design and production process is the best opportunity to harness the creative energy of a company and direct it into ensuring that the product or service meets all market and corporate requirements. As such, it is the best stage at which to identify potential greenhouse gas reduction opportunities. During the design process, producers

[40] Paton, Bruce. "Design for Environment: A Management Perspective." Industrial Ecology and Global Change. 1994: p.350.
[41] Ibid, p.350.
[42] Paton, Bruce. "Design for Environment: A Management Perspective." Industrial Ecology and Global Change. 1994: p.251.

can consider such factors as the greenhouse gas intensity of raw materials used, the energy sources used, the greenhouse gas emissions created during the production process, and the energy requirements of the product during use. Once the company has identified the most greenhouse gas intensive aspects of the product, the producer can select appropriate changes that result in decreased emissions.

ii. Supply decisions

The boundary of the life cycle assessment is a very important decision. Often, inputs or raw materials for a product or service can be very greenhouse gas intensive. In these situations, the assessment should not be limited to the "factory floor," but should include an assessment of the climate change footprint of inputs, and identification of available, less greenhouse gas intensive alternatives.

iii. Transportation

The mode of transportation used both for raw material supply and product service delivery can have significant impacts on the life cycle climate change impact of a product or service. As a sector, transportation accounts for approximately 30% of Canada's CO_2 emissions and 27% of total greenhouse gas emissions.[43] The 1996 breakdown of CO_2 emissions associated with the different modes of transportation commonly used by industry is as follows:

- Road - Light Vehicle 50.3%
- Road - Trucks 23.5%
- Aviation 10.5%
- Marine 5.2%
- Rail 4.0%[44]

The greenhouse gas emission intensity associated with these different modes of transportation varies greatly; thus choices in modes of transportation can have a significant impact on a product's climate change footprint.

iv. Use

A large number of products and services generate greenhouse gases during their intended use through energy consumption. For example, any appliance or vehicle that requires electricity or fossil fuel to operate releases greenhouse gases to the atmosphere. When purchasing a product or service, consideration should be given to its energy requirements and its relative energy efficiency, compared with similar products and services.

v. Disposal/Reuse/Recycle

Methane and CO_2 emissions from landfills account for 3% of Canada's total greenhouse gas emissions.[45] While this is not one of the largest constituents of our greenhouse gas

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[43] Environment Canada. Trends in Canada's Greenhouse Gas Emissions – 1990-1995. 1997: p.17.
[44] Natural Resources Canada, Office of Energy Efficiency. Energy Efficiency Trends in Canada 1990 to 1996. 1998: p.79.

inventory, it may be addressed in the context of other decisions. Increasingly, companies are integrating disposal management into their environmental management processes. As a part of these decisions, the climate change impact associated with disposal options should also be considered.

3.2 Environmental Performance Indicators

Once a decision has been made to examine the life cycle of a product or service for greenhouse gas reduction opportunities, environmental performance indicators allow a company and its customers to quantify progress. Illustrating the maxim "if you can't measure it, you can't manage it," a great deal of work has been done recently on developing environmental performance indicators to quantify environmental improvements.

On a macro level, countries and industry sectors are examining models that go beyond simply measuring total emissions of greenhouse gases and tracking how they grow or shrink over time. It is argued that simply measuring numerical growth and reduction disadvantages countries that are experiencing economic and/or population growth and industry sectors and companies that are expanding. As an alternative, indicators have been developed that measure the positive impacts of reducing energy consumption per unit of production or per capita. Nonetheless, the absolute measure of total emissions will always be needed on a macro level because Canada's Kyoto commitment is expressed as an absolute reduction. Similarly, on a scientific level, the magnitude of climate change will depend on net greenhouse gas emissions to the atmosphere, not on the energy efficiency or carbon intensity of products from which they are generated.

Two concepts that go beyond merely measuring emissions, and allow improvements in greenhouse gas intensity to be considered rather than simply total emissions have attracted considerable attention: energy intensity indicators and economic activity indicators. Each of these measures can provide consumers with valuable information regarding the greenhouse gas emissions associated with a specific product or service.

3.3 Energy Intensity

Measuring the energy intensity of a product or process allows a company to quantify the greenhouse gas emissions associated with each unit of production. Canada's National Roundtable on the Environment and the Economy (NRTEE) (1999) has recently completed an extensive examination of the use of environmental indicators as a measure of eco-efficiency. In a study with eight Canadian companies,[46] NRTEE found that an energy intensity indicator should be a measure of the energy consumed by the company per unit of output (product or service). To measure energy intensity, study participants used the model presented in Figure 3.

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[45] Environment Canada. Trends in Canada's Greenhouse Gas Emissions – 1990-1995. 1997: p.61.

[46] 3M Canada, Alcan, Nortel Networks, Monsanto Company, Bell Canada, Noranda, Pacific Northern Gas Ltd. (representing WestCoast Energy), and Proctor and Gamble.

Schematic of Full Complementary Indicator Set for Energy Intensity

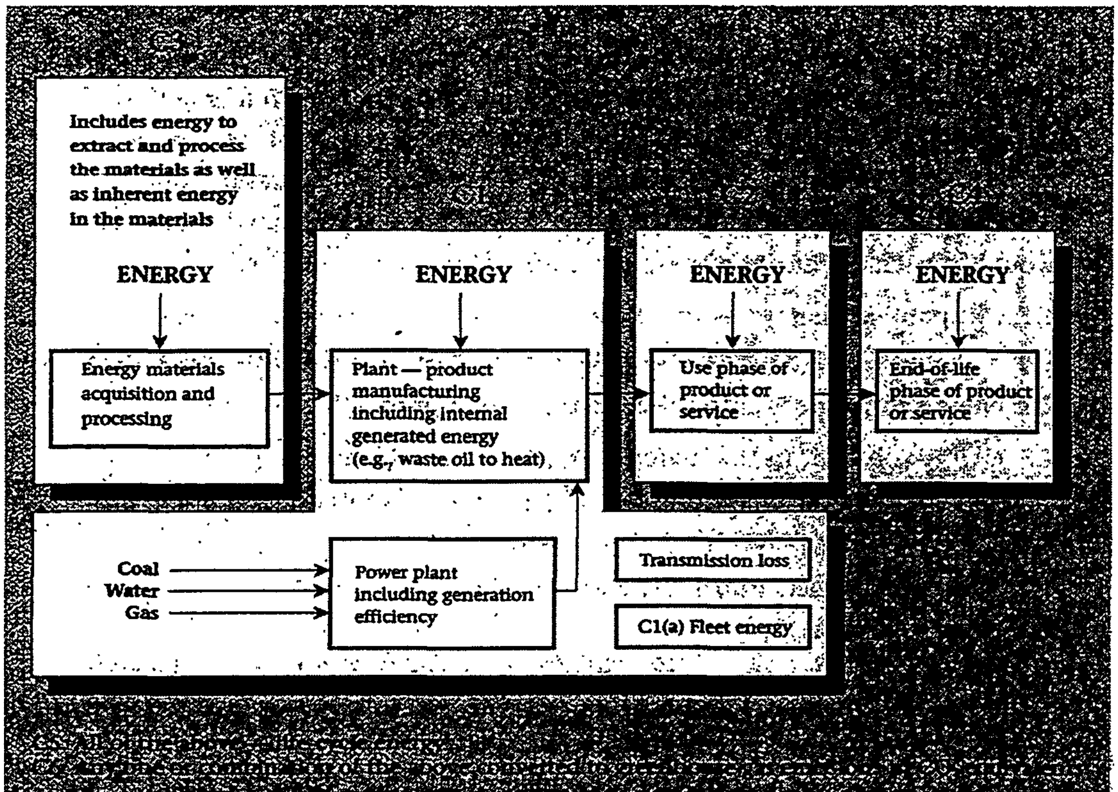

Figure 3: Schematic of Full Complementary Indicator Set for Energy Intensity

(Reproduced from "Measuring Eco-efficiency in Business: Feasibility of a Core Set of Indicators." NRTEE. 1999: p.12)

The symbols used in Figure 3 are described below in Box 4.

The Complementary Energy Intensity Indicator Set

- C1: "expanded energy" consumed by the company per unit of output, defined as the total amount of energy (electric and non-electric), including energy delivered to or generated within the plant or service entity, plus the energy consumed by energy delivery (losses during production/generation and distribution). Conversion data from the National Energy Reliability Council would be used to calculate energy consumed by energy delivery.
- C1a: "expanded energy" as in C1, plus fleet energy, namely the energy consumed by fleets transporting products or services to their intended markets.
- C2: energy consumed during the use phase of a product's life-cycle.
- C3: energy inherent in the materials used in manufacturing a product, and energy consumed in the acquisition and processing of materials entering the manufacturing process or service entity.
- C4: energy consumed and/or generated in the end-of-life phase of a product's life-cycle, that is, in disposal.
- C5: life-cycle energy, that is, the energy consumed during the entire life-cycle of a product. These indicators are shown schematically in Figure 3.
- C6: energy-related GHG emissions — the GHG emissions associated with each of the energy types and sources measured under any of the above complementary indicators or the minimum indicator above.

Figure 4: The Complementary Energy Intensity Indicator Set

(Reproduced from "Measuring Eco-efficiency in Business: Feasibility of a Core Set of Indicators." NRTEE. 1999: p.11)

This type of energy intensity indicator would provide consumers with valuable information regarding the energy consumption associated with a product or service, taking into account all energy used throughout its life cycle.

This indicator provides a measure of greenhouse gas emissions associated with energy use, which accounts for approximately 85% of total greenhouse gases.[47] The pollution dispersal indicator, described below, differs in that it calculates greenhouse gas emissions emanating from *sources other than energy.*

[47] Environment Canada. Trends in Canada's Greenhouse Gas Emissions – 1990-1995. 1997: p.9.

3.4 Pollution Dispersion

While a large majority of greenhouse gas emissions are associated with energy use, some emissions are unrelated to energy efficiency and consumption. Methane gas emissions from landfill sites and carbon dioxide emissions from cement manufacturing, for example, are more similar in nature to emissions of other common pollutants and, as such, their intensity can be similarly measured. For these sources, companies could calculate the amount of CO_2 released as a ***pollutant*** (as opposed to energy use) per unit of production.

There has been some debate around the feasibility of using a cumulative pollutant intensity indicator, where companies could measure their total pollutant releases per unit of production. The NRTEE (1999) study participants concluded that it would be unrealistic and inaccurate to use a single intensity indicator for all pollutants, since all pollutants have different environmental impacts and a cumulative intensity indicator would fail to take into account these differing toxicity levels, thus painting an incomplete picture.[48] Study participants did suggest, however, that pollutants could be grouped into classes, as has been done under the *Accelerated Reduction and Elimination of Toxics (ARET)* program. So, for example, all *ARET* level A1 toxics (highly toxic, persistent and bioaccumulative) could be added together and companies could compute the intensity of each of these classes. The NRTEE study concluded that non-energy greenhouse gas emissions should fall into their own distinct category.[49]

An indicator of the pollutant intensity of non-energy-related greenhouse gas emissions, used in combination with the energy intensity indicator, would give the consumer a complete picture of the total greenhouse gas emissions associated with the product or service being purchased. This type of information could be used to compare products and services within the same class to identify those that have smaller climate change footprints.

3.5 Economic Intensity And Population Growth

On a national level, there is debate over whether other indicators should be considered in the allocation of allowable greenhouse gas emission levels, in addition to straightforward reduction levels from current or historic emission levels. It has been argued that, for developing countries and economies in transition especially, allowance should be given for growth in their economies. For example, a country could agree to a "moving target" of a 10% reduction over current levels, but with the absolute allowable level increasing by the same percentage as economic growth.

It has also been suggested that population growth be taken into account in determining allowable emission levels. Some countries have asked for a per capita greenhouse gas emission allocation, based on the argument that all individuals have an equal entitlement to greenhouse gas emissions. This per capita approach would result in countries with less

[48] NRTEE. Measuring Eco-efficiency in Business: Feasibility of a Core Set of Indicators. 1999: p.32.
[49] Ibid, p.32.

developed economies and large populations having a share of emission rights well beyond current emission levels and, in a carbon constrained economy, a tremendous stockpile of a new valuable commodity – the right to emit greenhouse gases.

4.0 PURCHASING DECISIONS

Ultimately, success in reducing greenhouse gas emissions will depend on the willingness of consumers to use their purchasing power to demand products and services with lower climate change impacts. To achieve this success, consumers must be aware of the climate change impacts of products and services. Figure 4 illustrates the 1996 residential carbon dioxide emissions by end-use. This figure identifies those areas in the household where purchasing decisions can be targeted to have the most impact. For example, purchasing a washing machine that is both water and energy efficient would help reduce emissions in both the water heating and appliance areas, which account for 35.4% of total household emissions.[50]

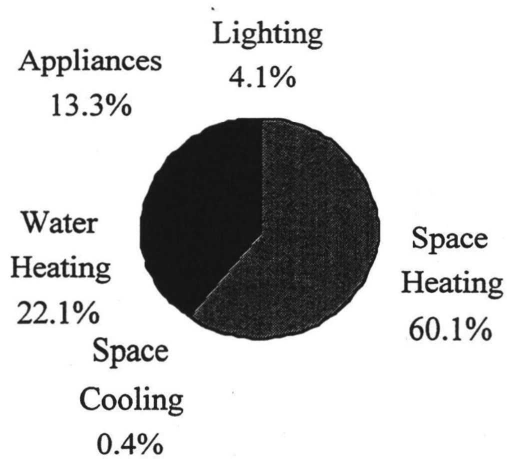

Figure 4: Residential Carbon Dioxide Emissions by End-Use, 1996

(Reproduced from Energy Efficiency Trends in Canada. NRCan, OEE. 1998: p.26.)

To make informed purchasing decisions that achieve these emission reductions, however, consumers need to have simple access to information about the climate change impacts of the products and services they purchase. Provision of this information is a complicated task for product and service providers. There are two key difficulties – gathering a comprehensive profile of the greenhouse gases emitted through the life cycle of the product or service; and making this information available to the consumer in a way that usefully informs their decisions.

The challenge of gathering information on climate change impacts throughout the life cycle of products or services was addressed earlier in this paper, so this discussion is

[50] Natural Resources Canada, Office of Energy Efficiency. Energy Efficiency Trends in Canada 1990 to 1996. 1998: p.70.

limited to making the information available to consumers in a useful format. Making data available on the amount of greenhouse gases emitted or energy used in the production of a good or service is an important first step.

The Canadian Pulp and Paper Association has developed the Environmental Profile Program to provide companies and their customers with detailed environmental information on the life cycle environmental attributes of specific paper products. This program is intended as a "voluntary reporting tool aimed at commercial clients of manufacturers of pulp, newsprint and other uncoated mechanical printing paper."[51] This information is presented in the form of Environmental Profile Data Sheet (EPDS), which identify the environmental burden associated with the raw material acquisition and manufacturing stages of the product life cycle. One section of the EPDS deals specifically with the global climate change potential of the product, expressed in CO_2 equivalent per product unit. An independent third party verifies all information reported on the EPDS.

Other, more comprehensive inventories, such as the National Pollutant Release Inventory (NPRI), track the release of pollutants from a very wide range of sectors. However, this inventory does not collect data on energy use or releases of greenhouse gases.

For this information to be of maximum use, it should be presented in a format that is understandable to procurement professionals and consumers. The environmental indicators above can provide useful measures of the greenhouse gas intensity of certain products. The Canadian Pulp and Paper Association's EPDS, for example, expresses greenhouse gas emissions in emissions per unit produced. This measure provides more useful information to the consumer than, for example, total greenhouse gas emissions generated in the manufacture of that product line.

Once this information is made available, the second equally important step is to provide consumers with the context within which informed decisions can be made. Consumers do not know the climate change impact of a specified number of tonnes of greenhouse gas emissions. It is therefore necessary to provide the consumer with a frame of reference for decision-making. For example, do one company's automobiles have significantly lower emissions per vehicle than those of other automakers? Similarly, it would be useful for consumers to know if an entire class of products could be replaced with an alternative product with a smaller climate change footprint.

Certification and labelling systems play an important role by providing procurement professionals and consumers with information about specific aspects of a product or service. For example, environmental labels for certain appliance products provide information on the energy efficiency rating of specific models (e.g. the EnerGuide label), and labels on electronic products demonstrate that specific energy standards are met (e.g. the Energy Star program). This type of labelling or rating system allows consumers to choose products from a specified product category that have a lower climate change

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[51] TerraChoice Environmental Services. Environmental Profile Data Sheet User's Guide. Ottawa: TerraChoice Environmental Services. 1997.

impact. As standards are developed for more product lines and sectors, consumers will be better able to make informed decisions.

5.0 PRODUCT AND SERVICE PROFILES

A series of product and service profiles is appended to this discussion paper to illustrate how consumer and purchasing preferences can affect the overall greenhouse gas emission profile of a particular product or service. Each profile deals with a specific product or service in the Canadian marketplace and provides summary information on:

- Size of the Canadian market;
- Current use patterns and trends;
- Average life span of the product;
- Life cycle stage with the highest greenhouse gas emissions (GHG) loading;
- Performance range of a product or service and its greenhouse gas emissions; and
- Potential to reduce greenhouse gas emissions associated with the product or service. This is addressed through a variety of scenarios: i) attrition (natural turnover); ii) an aggressive approach that induces a shift in customer demand toward less greenhouse gas intensive products and services; and iii) a best case scenario if all products or services were replaced with the most efficient option available. The projections over time do not take into account any further technology changes that may take place or the benefits that these may provide from a global warming perspective.

Many of the profiles examine the energy use of products or services in the market. Energy is an important indicator because higher energy use relates directly to climate change and global warming, and there is also a direct relationship between energy savings and cost savings. Energy use is converted into a carbon dioxide equivalent using a general conversion factor of 0.257 kilograms of carbon dioxide equivalent per kilowatt-hour (kg CO_2 equivalent/kWh) throughout the profiles. This is based on carbon dioxide, methane and other GHG emissions factors,[52] and their IPCC Greenhouse Gas Potential values,[53] thus representing carbon dioxide equivalent radiative forcing in the atmosphere (the scientific measure for greenhouse effect). Electric power emissions are based on generation sources for Canada's national power grid (hydroelectric, nuclear, coal, natural gas, and other), and include adjustments for distribution and transmission of electricity. See the ***Electricity Product Profile*** for more detailed information.

The Life Cycle Considerations field of the profile provides a rough estimate of where, in the life cycle of the product, the majority of environmental burdens are expected to occur. Many of the products included are durable, use-intensive items, whose environmental profiles correlate to their energy consumption at the use phase. This is not to undervalue

[52] Table D-8, *CO_2-Equivalent Emissions of Individual Greenhouse Gases from Power Plants and Upstream Processes in Grams per Kilowatt-Hour Delivered.* Centre for Transportation Research, Argonne National Laboratory. Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity. Argonne: U.S. Department of Energy. 1998.

[53] Intergovernmental Panel on Climate Change. 1995 Second Assessment Report. Geneva: IPCC.

other environmental burdens at other life cycle stages, and not associated with energy or greenhouse gases. For services, a parallel assessment is provided.

It is useful to examine one of the profiles as an example. Since appliances are a broad product category within which significant improvements in energy efficiency have been made,[54] it is interesting to consider the case of refrigerators and their associated greenhouse gas emissions. Substantial improvements in the efficiency of refrigerators have been achieved with a typical new efficient model using less than half the energy of the average refrigerator stock.[55]

Statistics reveal that there are approximately 14 million refrigerators in the Canadian marketplace, and that the average refrigerator has a life span of about 17 years. An assessment of a refrigerator's life cycle – from the extraction of raw materials to the disposal of the used product – illustrates that the highest greenhouse gas loading occurs during the refrigerator's use.[56] Figure 5 summarizes the refrigerator's greenhouse gas performance range for both current and future scenarios. A shift in the curve to the left from the present case, indicates improved product specific performance and distribution. The height of each curve corresponds to the size of the market. Two basic forces determine the total greenhouse gas loading (represented by the area under the curve): better products contributing to lower per-unit emissions; and market share. As the market is often increasing, more emissions may be generated from a greater number of products in use.

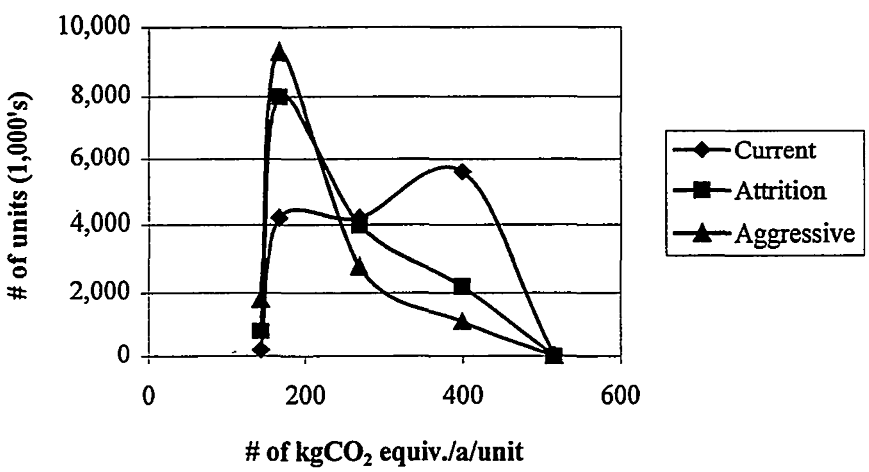


Figure 5: Product Distribution for Refrigerators

[54] Manufacturers of major appliances have achieved significant reductions in the energy consumption of their products through substantial research and development. These R & D efforts have been encouraged by the establishment of minimum performance requirements under the *Energy Efficiency Regulations* and the EnerGuide program, both of which were authorized under Canada's *Energy Efficiency Act*, 1992.

[55] Natural Resources Canada, Office of Energy Efficiency. Energy Efficiency Trends in Canada 1990 to 1996. 1998: p.23.

[56] German Environmental Protection Agency. Germany's "Blue Angel" Eco-label, In the Interest of Global Warming Management. Bonn. 1995: p.15.

Figure 6 identifies the reduction in CO_2 equivalent that is possible through attrition, and a more aggressive replacement approach, for some of the other common household appliances.

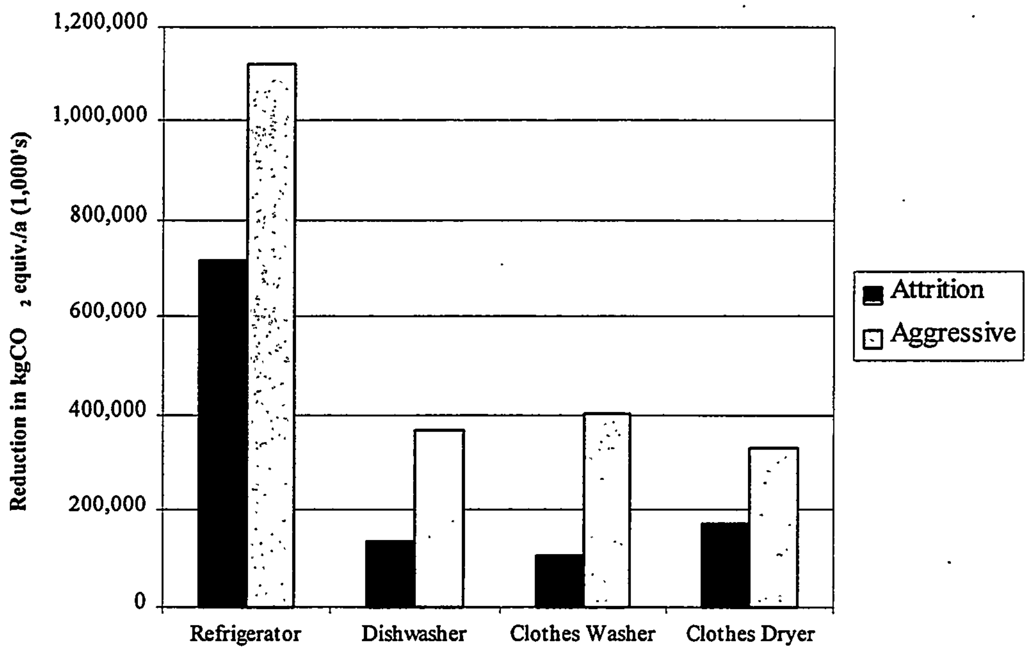


Figure 6: Reduction in GHG Emissions Through Attrition and Aggressive Replacement

If the government wanted to encourage earlier replacement of appliances, it could offer incentives to owners who replace older units with newer models that meet minimum energy efficiency criteria. If the government chose to introduce a financial incentive for this purpose, it would need to consider a multitude of factors, including:

- Age of appliance to be targeted (e.g. for refrigerators, should the threshold level be set at models that are older than 7 years? 10 years? 12 years?). This decision will be informed by the relative gains in energy efficiency between different years of manufacture.
- Level of incentive required to encourage owners to replace an appliance at this stage in its life span, rather than at the end of its life; and
- Value placed on the reduction of 100 kilowatt-hours (kWhr) of energy and associated greenhouse gas emissions (i.e. by how much would the government be willing to subsidize this reduction of greenhouse gases).

This type of analysis would allow a government to approximate the extent to which it can catalyze an earlier-than-normal shift in the distribution of appliances in Canada toward more energy efficient models. Such incentive programs often entail collaboration among several partners, including different levels of government, utility companies, and producers.

While the appliance sector offers some promise for GHG reduction through capital stock depletion and replacement with newer more energy efficient units, the same is not true for light duty vehicles. Three prevailing trends are in fact causing GHGs to rise from this sector in spite of continuing technological improvement:

- the total number of vehicles in the fleet is increasing;
- the annual kilometers driven per vehicle per year is increasing; and
- the new vehicle fleet, which, in the 1996-1999 period, had an average fuel economy equal to the total in-use fleet, is becoming less fuel efficient as a result of the popularity of less fuel efficient vehicles such as vans and sport utility vehicles.

Capital stock depletion and replacement with newer vehicles will not provide reductions in total GHGs unless:

- consumers seek out downsized (ie smaller) vehicles to replace larger ones;
- manufacturers can produce similar size vehicles but with better fuel efficiency; or
- a major change in technology is introduced broadly in the new vehicle fleet.

All of the product and service profiles appended to this discussion paper present an estimated curve of current product distribution according to greenhouse gas intensity, and provide an indication of how this distribution may be expected to change through attrition and an aggressive replacement program. While these graphs are useful tools to raise awareness of how purchasing decisions can directly affect greenhouse gas emissions, it must be emphasized that the profiles are to be used for illustrative purposes only.

During preparation of these profiles, substantial data gaps were identified, requiring the authors to make numerous assumptions. Some of these gaps likely stem from the relative infancy of greenhouse gas emission monitoring and reporting, and highlight the need for further research in these areas. As such, the information presented herein will need to be refined, as more information becomes available.

6.0 DRIVERS FOR CHANGE

The "aggressive" scenarios described in the product and service profiles will not happen by themselves. There is a need for appropriate "drivers" for change, and these may vary considerably from product to product. Several different kinds of drivers are available and have been used. Typically, they fall into four categories: regulatory; economic; social; and market.

Regulatory drivers are designed to force behaviour change. For example, a corporate average fuel economy (CAFE) standard imposes a fuel economy standard on the new vehicle fleet, which could halt and reverse the current trend of a worsening new fleet average fuel consumption rate. If this were applied more broadly, say to appliances, new refrigerators, dishwashers, etc. would be required to have energy consumption rates below a specified level.

Economic drivers are designed to offer financial incentives for behaviour change. Providing large discounts on hot water pipe insulation or on energy efficient dishwashers, giving tax relief for the purchase of the most energy efficient products or providing cash rewards for turning in energy inefficient products are all examples of economic drivers. The concept of paying people to retire old, inefficient appliances was discussed earlier in the paper as a way of encouraging a more aggressive turnover of the capital stock. If this were applied to refrigerators, where the range of performance of the current stock varies from a best case of 150 kg of CO_2 per unit per year to a high of about 500 kg of CO_2 per unit per year (an older unit), and combined with a requirement to purchase a new replacement at the best case level, the following would apply:

> *A rebate of $100 is paid to replace a refrigerator responsible for 500 kg of CO_2 per unit per year with one responsible for 150 kg of CO_2 per unit per year. Assuming that the replaced unit had five years of life left, and that it would have been replaced in five years with a unit responsible for 268 kg of CO_2 per year, the net benefit over fifteen years would be (5 X (500-150)) + (10 X (268-150) = 2,930 kg of CO_2. The cost per tonne of the avoided CO_2 is then $34.13. This cost is in the range of the projected CO_2 pricing ($20 to $200 per tonne) should a future trading system be developed.*

Social drivers are designed to inform and accordingly persuade individuals and organizations to change behaviour. Large scale communication activities promoting the climate change benefits of certain types of products and services can be effective in modifying behaviour. For example, identifying the climate change performance of individual appliances together with a mass media campaign could help inform people of the need to take personal action on the issue of climate change.

Market drivers are designed to turn purchasing dollars into a market force for change. Two primary examples of market drivers are eco-labelling and emission trading systems. While some would argue that these are more like social and economic drivers, they operate sufficiently differently that they should be considered as a separate category. Markets drivers operate best when parallel information programs are in place, particularly when the public at large is being engaged. Eco-labelling identifies products and services that are demonstrated to be environmental leaders over their respective life cycles. Climate change, as an issue, cuts across a range of environmental impacts, from chemical use, to recycled content, to extended life and to energy efficiency. Many eco-labelled products, therefore, have better climate change performance than most competing products. As well, such programs already exist in more than thirty-five countries world-wide. In Canada, the Environmental Choice Program (ECP) has been in place for over 10 years and is regarded as a credible vehicle for assisting purchase choices. In the Program's May 1999 EcoBuyer catalogue, the products and services which also provided a climate change benefit were identified with the Government of Canada's Global Climate Change symbol. This represented the first time that an eco-labelling program has focussed on climate change and presents an indicator of how such programs could be used on the climate change issue.

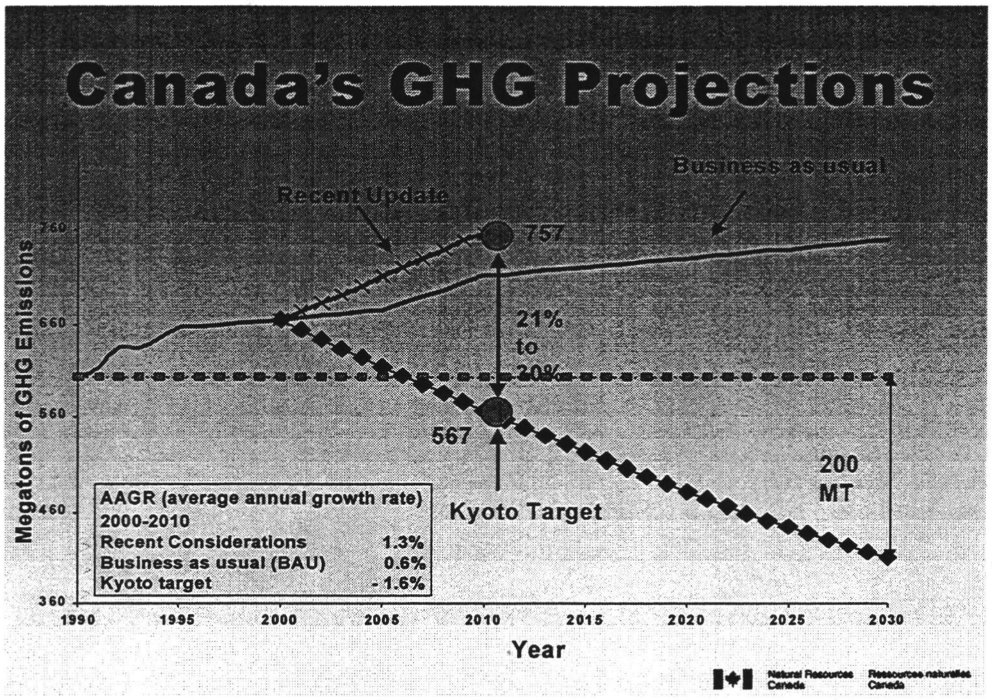
A formal emission trading system for CO_2 on the other hand is not yet in place. Nonetheless, trades and banking are already taking place and hold the promise of allowing the marketplace to develop a cost-effective means of reaching environmental targets related to climate change.

The challenge is to use these different drivers on a selective basis and perhaps in tandem with each other to achieve the best results possible. Appropriate regulation, selected economic incentives, environmental education and information programs and product and service eco-labelling offer real short-term opportunities for progress on the issue of climate change.

7.0 CONCLUSIONS

Climate change is, in many ways, an environmental issue in its infancy, yet its effects are already being felt. With greenhouse gases being so predominant in all sectors of our economy and lifestyles, policy responses must be rapid. Government, industry and individuals will soon be faced with a carbon-constrained economy, which will present challenges and opportunities. As a first step, Canada should develop the tools for more comprehensively measuring the greenhouse gas emissions throughout the life cycle of products and services, and provide this information to purchasers in an easily understandable format. This would allow purchasers to make choices that will reduce their climate change impacts.

The potential benefit of these type of choices must be considered in the context of Canada's green house gas (GHG) projections which are shown in the diagram below. The diagram plots the past and projected emissions of GHGs between 1990 and the year 2030. Clearly, in order to meet the Kyoto target by the year 2012, action must begin now.



In attempting to quantify the potential GHG benefit of the products and services studied in this report, the "attrition" and "aggressive" scenarios were compared to the current baseline conditions. The summary is displayed in the following table. From this, one can surmise that, with the natural replacement of capital stock with newer, more energy efficient products (ie attrition), a reduction of some 13 megatonnes of GHG emissions is probable. By using a more aggressive replacement strategy, a reduction of some 16 megatonnes of GHGs is possible. With a "ruthless" replacement strategy, a reduction of some 30 megatonnes might be realized. In all these three cases, growth in the total number of products has been included in the analysis.

Table of Potential GHG Reductions
- Kilotonnes of CO2 / Year –

Product	GHG Impact	Attrition Reduction	Aggressive Reduction	Max Reduction Potential
Air Conditioners	944	68	125	356
Office Bldg Management	7,116	537	750	1,516
Commercial Carpet	55	5	10	36
Clothes Driers	2,546	172	332	448
Clothes Washers	2,617	103	401	1,935
Coffee Makers	424	56	75	302
Computer & Monitor	1,271	390	500	725
Dishwasher	1,271	132	369	906
Fax Machines	30	9	9	15
Hot Water Heater	27,709	7,909	7,909	11,170
Lamps	5,282	117	1,007	3,710
Photocopier	85	13	16	26
Printer	58	18	22	27
Refrigerator	4,113	720	1,123	1,983
Low Flow Shower Head	17,761	3,305	3,305	7,435
Business Telephones	6	0	0	1
Low Flush Toilet	106	9	23	69.8
TOTAL	71394	13563	15976	30660.8

auto, electricity, paper, insulation & windows not included

Reductions in the order of 15 megatonnes may not seem significant in the context of a national burden of 660 megatonnes which is predicted to rise to 757 megatonnes within 12 years. However, with a reduction target of about 100 megatonnes from today's levels (ie 567 megatones), an achievable 13 to 16 megatonne reduction becomes significant, so much more so when one considers that only 17 products and services were included in the analysis. Furthermore, there may well be further, synergistic GHG reductions resulting from reduced demand for "marginal" fossil fuels. In most parts of Canada one less kWhr consumed will normally reduce the burden on thermal sources – commonly called the marginal fuels approach. For purposes of this report the GHG/ kWhr factor of 0.257 was based on total CO2 from electricity generation sources divided by total electricity generated.

In closing, any strategy to reduce GHGs should clearly look at both large scale emission sources as well as efficiencies that will accrue from replacement of less efficient products and services with more efficient ones. Furthermore, the technologies already exist and these technologies will only improve with time.

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AIR CONDITIONER PRODUCT PROFILE

Product/Service Description:

In much of Canada, air conditioners are heavy users of electric power in the summer months. The majority of environmental loadings for this product are associated with their power consumption. Until recently, the environmental burdens of air conditioners were dominated by CFC emissions, associated with stratospheric ozone depletion and greenhouse effect; however, with the switch from CFC to HFC and other refrigerants, the greenhouse gas burdens of air conditioning units are associated primarily with energy consumption.

Of significance, a whole new generation of air conditioners has become available in the last few years. These newer units use about two-thirds the energy of previous similar models. Cooling energy efficiency of air conditioners is usually referred to by the term EER (Energy Efficiency Ratio), which is the ratio of the air conditioner's capacity to its power consumption. New air conditioner units have EER ratings from 8.5 to 10.0, or higher – where higher ratings correlate to better efficiency.

A mid-size unit with a capacity of 15,000 BtU/hr covering 90 to 120 square meters is used in this profile as representative of in-window home air conditioners. A/C units operating at five EER performance levels (15, 10, 8, 6, 4) were examined to represent the future, better, medium, worse, and worst available technologies (respectively) for households.

Canadian Market Size:

There are a projected total of 1.6 million in-window air conditioning units in households across Canada based on 1995 statistics. Approximately 620,000 units were sold in 1995, including sales to both the retail and builder markets.[1] Today the average consumer will purchase an air conditioning unit with an EER rating of 8 or 9.

Annual Usage:

Units are assumed used four months out of the year, operating at full capacity for approximately one third of the day.

Product Turnover:

The average life of a unit is 8 years.[2]
There is a turnover of approximately 6% of the stock every year.[3]

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[1] Statistics Canada. Household Facilities and Equipment, 1997.
[2] Yanagitani and Kawahara, "LCA of Air Conditions with an Alternative Refrigerant", *The Third International Conference on Ecobalance*. November 25-27, 1998.
[3] Statistics Canada, 1997.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	*Production*	*Use / service*	*Disposal*
		X	

GHG (CO_2 Equivalent) Performance Range:

AIR CONDITIONERS

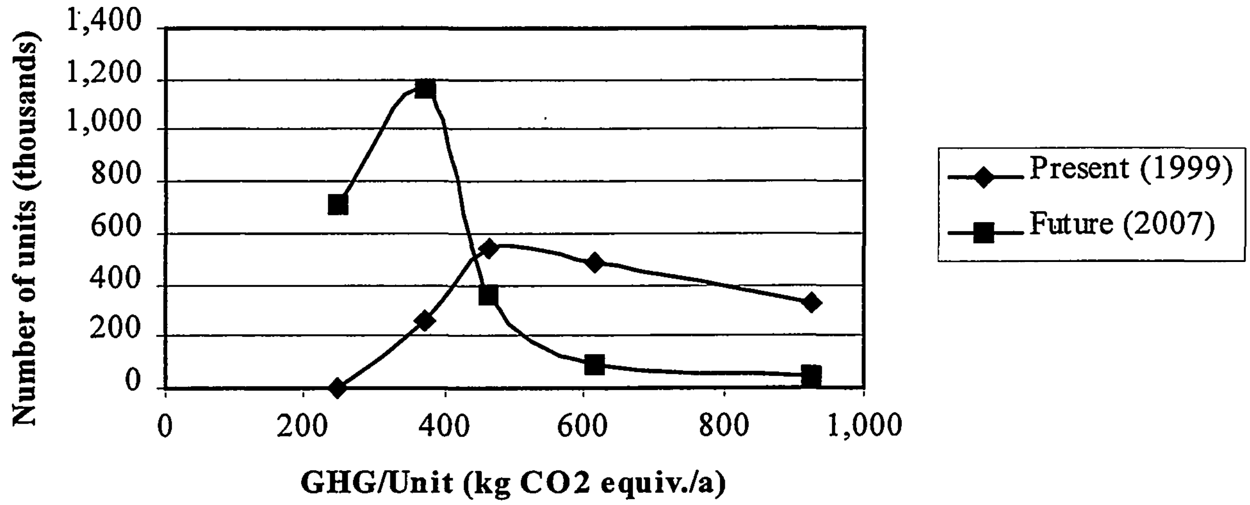
Present (1999)					***Future (2007)***	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	960	247	0	0	715	176,365
Better	1,440	370	258	95,333	1,168	432,095
Medium	1,800	463	547	253,227	357	165,342
Worse	2,400	617	483	297,914	95	58,788
Worst	3,600	925	322	297,914	48	44,091
Totals			**1,610**	**944,389**	**2,383**	**876,683**

The best possible scenario would replace all future units with models from the best category to achieve total GHG of 588 x 10^6 kg CO_2 equivalent per year.

Working Assumptions/Limitations:

1. Air conditioner purchases from 1993 to 1995 were extrapolated to estimate the annual growth rate of A/C units on the Canadian marketplace.
2. Future best-available technology A/C units are estimated to have an EER rating of 15.
3. The breakdown in present market share was assumed to be 0%, 16%, 34%, 30% and 20% for the best, better, medium, worse, and worst models, respectively.
4. The future scenario assumes a market share of best, better, medium, worse, and worst models of 30%, 49%, 15%, 4%, and 2%, respectively.

Product Distribution:



AUTOMOBILE PRODUCT PROFILE

Product/Service Description:

The automobile, or "Light Duty Vehicle" (LDV), has become a pervasive product in the Canadian marketplace that has significant greenhouse gas impacts. It plays a multifaceted role in human life, and is complex in both the range of materials used in its construction, and the functions incorporated into its design. The LDV is meant to encompass all the vehicles that today's consumer drives: from the sub-compact, through the family car (now often a minivan), to the "SUV" and the "pickup" truck (in various sizes).

Canadian Market Size:

In 1995 there were a reported 15.8 billion LDV's on Canadian roads. In 1999 the number will be very close to 20 million.

Annual Usage:

In 1995 LDVs each covered 17,600 kilometres (km) for a total of 278 billion kilometers. In 1999, it can be assumed (based on current trends) to have risen to 20,000 and 400 billion kilometers respectively.

Product Turnover:

The average "useful life" of LDVs is rising toward ten years. New car sales are about 10% of the fleet; a somewhat lesser percentage is taken out of service each year.

Life Cycle Considerations:

Raw material extraction	Production	Use / Service	Disposal
		X	

GHG (CO2 Equivalent) Performance Range:

Best	3,717		Best	25
Medium	4,956	**The market share percentages***	Medium	55
Worst	6,490	**for these categories.**	Worst	20

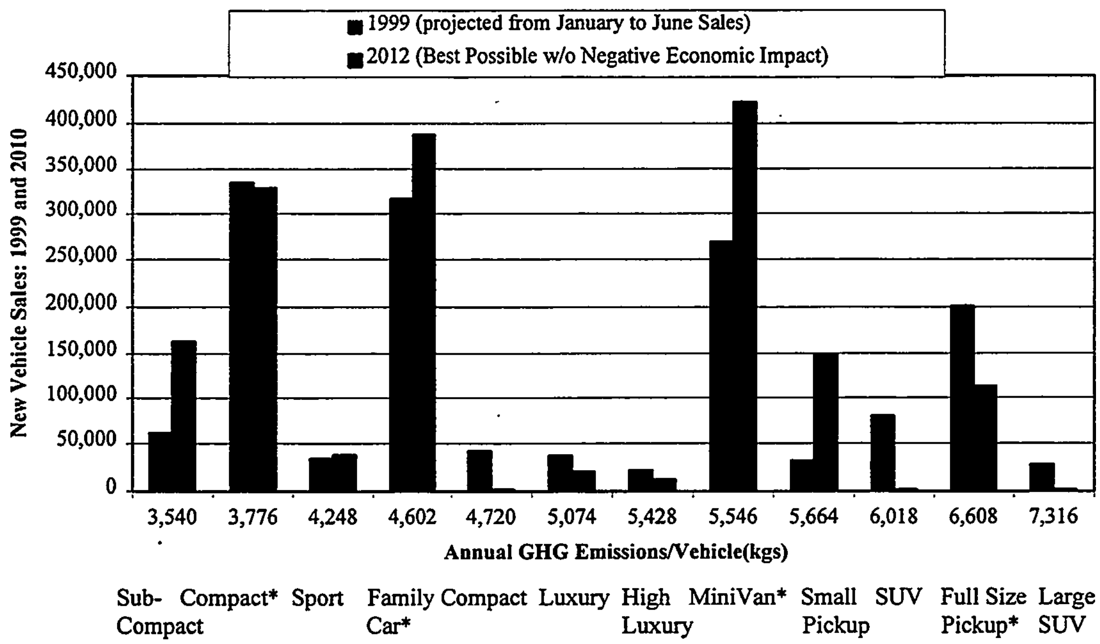
*The market share percentages shown here are considered to be representative, at this point in history, of both the In-Use Fleet and New-Car Sales.

Working Assumptions/Limitations:

The above data, and the sales distribution by GHG emissions which follows, have been estimated from information contained in NRCan's Energy Efficiency Trends in Canada 1990 to 1996, June 1998; ENERGUIDE 1999 (fuel consumption ratings for LDVs –NRCan and TC); Canadian Auto World August 1999 and personal communications from EC officials as well as their factor of 2.36 kgs of CO_2 per litre of gasoline burned. The assumptions for the potential market share shift are included with the discussion on the next page.

Product Distribution 1999/2010:

GHG Emissions by Vehicle Category: 1999 and 2010



*These four categories contain about 75% of the LDV's on the road today, with the SUV's (Sport/Utility Vehicles) of various sizes bringing the percentage to 85.

Future Emissions of GHG: Problems and Possibilities

From the graph one can see that the "four pillars" of new vehicle sales (Compacts, Family Cars, Minivans and Full Size Pickups) contain about 75% of the LDV's on the road today (with the SUV's - Sport/Utility Vehicles of various sizes bringing us to 85%). This sales distribution among the 12 vehicle categories shown has resulted from the working of a (relatively) free market with automobile manufacturers competing with each other and with the manufacturers of other products for the consumer dollar. Given that free market, it can be assumed that this distribution meets our current transportation needs. Attempting to abruptly change that distribution with economic disincentives on new cars and/or gasoline could have unexpected or even perverse consequences.

Canada's Kyoto target is a decrease of 6% in GHG emissions from the 1990 reference year by 2010. Assuming normal population growth with no change in technology, one means of reaching the target is to arrive in 2010 with all cars on the road no larger than Compacts. Note that this would require that, effective in 2001, no vehicle larger than a compact could be sold in Canada.

Current trends do not auger well for such a scenario. In spite of energy improvements, three factors are responsible for LDV emissions in 1999 being about 20% higher than 1990:

- Number of vehicles in use is rising;
- Annual kilometers driven per year for each vehicle is rising; and
- Market share of less fuel efficient vehicles such as SUVs, Large Pickup Trucks, and luxury minivans is rising* each year.

[*As a result of that market shift to greater size, luxury and power, the average fuel consumption of the new vehicle fleet is, for the first time in a quarter century, higher than the average for the vehicles they are replacing.]

The non-intervention, "business as usual" scenario is therefore very bleak. Under the following optimistic assumptions:

- Total vehicles on the road rises by only 12%;
- There is only a 5% increase in kilometers per year per vehicle; and
- Automotive engineers are able* to continue a 25-year average of 1%/yr better efficiency,

we will arrive in 2010 about 35% over the target level. [*in spite of the Law of Diminishing Returns]

There are, however, a number of technological changes/shifts which might be fairly easily accomplished without large disruptions in the marketplace:

- SUVs could be manufactured on minivan chassis;
- A 50% shift from Full Size to Small pickups (modestly larger with higher GVW ratings);
- 50% of the Luxury and High Luxury cars could, at a small cost (easily borne by this class of vehicle), be redesigned to the fuel consumption of the "Family Car" category; and
- a 25% shift of Compacts to the fuel consumption of Sub-Compacts (w/o a size reduction).

This "best possible without negative economic impact" scenario (above graph) reduces emissions by about 3 megatonnes but still leaves us 30% above the Kyoto target.

If government were prepared to bring in rather large economic incentives (or penalties) it might be possible to improve on the latter scenario by moving all cars in each category to the "best-in-class" fuel consumption. This gets the LDVs down to only 20% over the Kyoto target.

Should the automobile industry be able to introduce high fuel efficiency technologies quickly and at a substantial penetration level, there is substantial scope for CO_2 reduction from the LDV sector.

OFFICE BUILDING MANAGEMENT SERVICE PROFILE

Product/Service Description:

The commercial/institutional building sector consists of offices, which account for 26% of the estimated floor space, followed by retail/wholesale, warehouse, hotel and restaurant, health care and recreation. Regionally, Ontario dominates with an estimated 36% of the floor space, followed by Quebec, Alberta, British Columbia and the Territories, the Maritimes, Saskatchewan and Manitoba.

Buildings use energy for space heating, space cooling, lighting, service water heating, auxiliary motor loads, plug loads, refrigeration and cooking. The largest end-use in the commercial sector is space heating accounting for approximately half of the total energy use; lighting requirements are second at 14%.[1] Within each of these uses, a variety of available and future technologies offer options, which can reduce energy consumption.

Canadian Market Size:

There are approximately 430,000 commercial/institutional buildings in Canada. The 'office' component of the commercial building sector is an estimated 350 million square feet (sq. ft.).

Annual Usage:

The weekly operating hours of an office building are 50 hrs, resulting in annual energy use of approximately 2,600 hours.

Product Turnover:

The book life cycle of buildings in North America is approximately 35-40 years. However, in reality, it is much longer. The life cycle of the building components varies considerably from 5 years to the full life cycle of the building. Generally, once the building reaches about 20 years of age, systems and components begin to require renewal on an irregular but consistent basis, necessitating an annual investment of 1% to 3% of the original building cost over the balance of its useful life.

Life Cycle Considerations:

The life cycle stage of product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

Greenhouse gas emissions due to new construction of commercial/ institutional buildings is relatively small compared with the overall size of the building stock.

[1] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.

GHG (CO2 Equivalent) Performance Range:

Greenhouse gas emissions related to the construction, renovation and operation of buildings represented an estimated 12.4% of total secondary energy use in 1996.[2] The emissions from a particular building depend heavily on the structure (building type), use of the building (activity), choice of fuels in the building, and geographical location. Location relates both to weather and the energy source for electricity.

The annual energy consumption per square foot and the consequent emissions based on the marginal fuels approach are as follows:

Best	18kWh/SF/yr.	9.9 kg CO_2
Medium	39kWh/SF/yr.	21.5 kg CO_2
Worst	60kWh/SF/yr.	33.0 kg CO_2

COMMERCIAL BUILDING MANAGEMENT

Current				*Proposed*	
Category	GHG/Unit ($kgCO_2$ $/ft^2/a$)	Number of Units ($ft^2 \times 10^6$)	Total GHG ($kgCO_2$ equiv. $/a \times 10^6$)	Number of Units ($ft^2 \times 10^6$)	Total GHG ($kgCO_2$ equiv. $/a \times 10^6$)
Low	9.9	70	693	110	1,089
Medium	21.5	245	5,268	240	5,160
High	33	35	1,155	10	330
Totals		**350**	**7,116**	**350**	**6,579**

The best possible scenario would involve upgrading all high energy use buildings and 25% of the medium energy use buildings to achieve total greenhouse gas emissions of 5,600 x 10^6 kg CO2 equivalents per year

Or a reduction of some 1.5 megatonnes CO2 per year.

Working Assumptions/Limitations:

1. Floor space is used as a proxy indicator of commercial activity.

2. There is significant limitation of national data on actual unit energy consumption in the building sector. A data collection/analysis project, which will provide detailed segment by segment end use data is currently being undertaken. This will include accurate space, fuel share and Energy Utilization Indices (EUIs) for all segments and regions in Canada. This data will represent the starting point for measurement of energy efficiency gains and greenhouse gas emission reductions. In the absence of this data the best/ worst case scenario

[2] NRCan, OEE. Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.

is based on the most comprehensive data gathered to date by Engineering Interface Inc. It is primarily focused on the energy consumption in offices in Toronto, Ontario.

3. The carbon dioxide emissions are based on the 50/50 fuel mix of electricity and natural gas with 0.93 and 0.21 CO_2 emissions (kg/kWh delivered) for electricity and natural gas respectively.

4. A 30% emission reduction is assumed based on reasonably achievable improvements in energy efficiency in office buildings. Energy savings of $1.00-$1.50 per sq. ft. of floor space is achievable.[3]

5. Much of the information contained within this profile is supplied by an industry representative with knowledge of the commercial building management field.

[3] BOM/Energy Decisions. A Report to Building Management. [http://www/plug-in.org/whosaving/bom.html] September 17, 1999.

CARPET FLOORING PRODUCT PROFILE

Product/ Service Description:

There are a variety of carpet products available in the Canadian marketplace. All components of carpet are petroleum based except for a small percentage of wool and other natural sources. Carpet backing is 95% or more petroleum based and a small percentage has natural rubber backing. Carpet is used for design, aesthetics, sound control, safety, et cetera.

Traditional broadloom and carpet tiles are popular products and meet a variety of needs. Carpet tiles have an average life span of 3 times that of traditional broadloom in heavy traffic commercial environments. Carpet tiles also provide the flexibility to replace worn out tiles rather than replacing the entire floor, and they can make redecorating possible without buying replacement material.

Canadian Market size:

Approximately 225 million dollars worth, or 21.38 million square metres (m^2) of carpet were sold in Canada in 1998.[1] Canadian mill production only represents about 46% of the market, resulting in approximately 9.76 million m^2 of domestic carpet shipments.[2] There are approximately 8 major carpet manufacturers in Canada.[3]

Annual Usage:

The annual usage of carpet is a reflection of product sales, which were 21.38 million m^2 in 1998.[4]

Product Turnover:

The average life span for broadloom carpet in heavy traffic commercial environments, is 5 years. Carpet tiles, in the same environment, have an average life span of 15 years. There is an approximate turnover of 16% of the carpet flooring stock every year.[5]

Life Cycle Consideration:

The life cycle stage with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
	X		

[1] Canadian Carpet Institute. Apparent Market Report, 1st Quarter 1999. Ottawa: Canadian Carpet Institute.
[2] Ibid.
[3] Carisse, Jean-Claude. Canadian Carpet Institute. Personal communication September 20, 1999.
[4] Canadian Carpet Institute. Apparent Market Report, 1st Quarter 1999. Ottawa: Canadian Carpet Institute.
[5] Marikkar, Rahumathulla. Interface Flooring Systems (Canada) Inc. Personal communication September 24, 1999.

The production of both the raw materials required for manufacturing the carpet (Nylon, PVC, SBR, PP, PU etc.), as well as actual carpet production, are considered to have the greatest greenhouse gas loading. The emissions are derived mainly from the energy consumed during the manufacturing process. Carpet manufacturing was chosen as the basis for evaluation because raw material greenhouse gas loading can be assumed as common for all manufacturers.

GHG (CO2 Equivalent) Performance Range:

CARPET FLOORING

Current				*Proposed*	
Category	GHG/Unit ($kgCO_2$ equiv./m^2)	Number of Units ($x 10^3$)	Total GHG ($kgCO_2$ equiv. /a $x 10^3$)	Number of Units ($x 10^3$)	Total GHG ($kgCO_2$ equiv. /a $x 10^3$)
Low	0.84	2,138	1,795	4,500	3,780
Medium	2	12,010	24,020	12,600	25,200
High	4	7,230	28,920	5,100	20,400
Totals		**21,378**	**54,735**	**22,200**	**49,380**

The best possible scenario would replace all units with product from the low category to achieve total greenhouse gas emissions of 18,648 x 10^3 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. Purchase information is based on shipment data supplied by Canadian manufacturers to the Canadian Carpet Institute and is believed to closely reflect purchasing behaviour.

2. Energy data is limited to the manufacturing of carpet. The energy required, and the associated greenhouse gas emissions from the transportation of raw materials to the site of manufacturing is therefore ignored. The embodied energy of raw materials is assumed to be at the same level for different types of carpets.

3. Broadloom carpet calculations should include underpad greenhouse gas loading since the use of broadloom requires underpad in all installations. Stabilized backing of carpet tiles are meant to be the underpad.

4. Information on GHG/Unit (kilogram [kg] carbon dioxide [CO_2] equivalent per square metre [m^2]) is based on the best available information.[6]

5. Industry averages were supplied by an industry source using the British thermal unit (btu) loading per square metre of carpet produced. These figures were converted to kilowatt-hours (kWh) based on the fact that one kilowatt-hour equals 3,412 British

[6] Marikkar, Rahumathulla. Interface Flooring Systems (Canada) Inc. Personal communication September 24, 1999.

GHG (CO2 Equivalent) Performance Range:

CLOTHES DRYERS

Current					*Attrition*		*Aggressive*	
Category (Average)	Performance Range (kWh/a)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)
Best	877	225	150	33,808	600	135,233	1,600	360,622
Low	885	227	1,825	415,087	4,675	1,063,305	6,000	1,364,670
Medium	1,103	283	3,950	1,119,710	3,450	977,975	1,725	488,987
High	1,283	330	2,960	976,004	600	197,839	0	0
Worst	1,300	334	5	1,671	0	0	0	0
Totals			**8,890**	**2,546,280**	**9,325**	**2,374,352**	**9,325**	**2,214,280**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 2100 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. Purchasing information is based on the 1997 retail and builder market shipment data from the Canadian Appliance Manufacturers Association (CAMA), and product turnover is based on retail only data, as a percentage of the total number of households with dryers. Shipment data is believed to closely reflect purchasing behaviour.

2. The most efficient dryer listed in the 1999 EnerGuide is selected for the best category with an annual energy consumption rating of 877 kilowatt-hours (kWh). This machine has a drum capacity of only 126 litres (L), whereas the highest energy consuming model at 950 kWh/year, has a capacity of 198 L.[6] An average of 885 kWh/year from 1996 is used for the low category.[7] This rating is assumed to be representative of models in the marketplace over the last few model years.

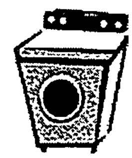
3. Considering the 18 year average life span for a dryer, dates are selected in 9 year intervals to determine the other categories. The average annual energy consumption of a dryer in 1990 was 1,103 kWh, and is therefore used to represent the average medium category.[8] Assuming the same energy efficiency gains were achieved between 1981 and 1990, as were achieved between 1990 and 1996, the 1981 annual energy consumption for the average high category is assumed to be 1,283 kWh. The worst category is assumed to be 1,300 kWh.

4. Annual sales of 505,000 units, and a product turnover of 5% are assumed for the product distribution of clothes dryers. It is also assumed that all dryers will be replaced with a clothes dryer from one of the two most efficient categories, and that an increase in efficiency will not occur.

5. The "attrition" scenario presents the situation in 6 years (chosen because it represents a third of the product's life span) based on the natural turnover of stock; and the "aggressive"

[6] NRCan, OEE. EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.
[7] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.
[8] Ibid.

CLOTHES DRYER PRODUCT PROFILE



Product/Service Description:

Clothes dryers are used to dry clothing using hot air. Energy is required to heat the air and operate the motors that spin the drum. Clothes dryers have achieved energy consumption reductions of roughly 20% between 1990 and 1996.[1] Reductions in energy consumption can be achieved by the consumer through choosing dryers that automatically shut off as soon as the clothes are dry, and by substituting the use of a clothes dryer with hanging clothes to dry.

Canadian Market Size:

There are 8.89 million households with clothes dryers in the Canada, and the majority (8.51 million), are electric as opposed to gas.[2] In 1997, approximately 505,000 clothes dryers were purchased, and 78.4% of Canadian households had dryers.[3]

Annual Usage:

Clothes dryers average about 416 operations per year.[4]

Product Turnover:

The average life expectancy of a clothes dryer is 18 years.[5]
The replacement market turnover rate is 5% per year.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

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[1] Canadian Appliance Manufacturers Association (CAMA). Major Appliance Industry Trends and Forecast. 1998.
[2] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.
[3] CAMA. Major Appliance Industry Trends and Forecast. Toronto: CAMA. 1998.
[4] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.
[5] NRCan, OEE. All About EnerGuide for the Appliance Salesperson. Ottawa: Government of Canada. 1999.

thermal units.[7] This unit was then converted using the CO_2 equivalent conversion factor of 0.257 kg/CO_2 equivalent/kWh.

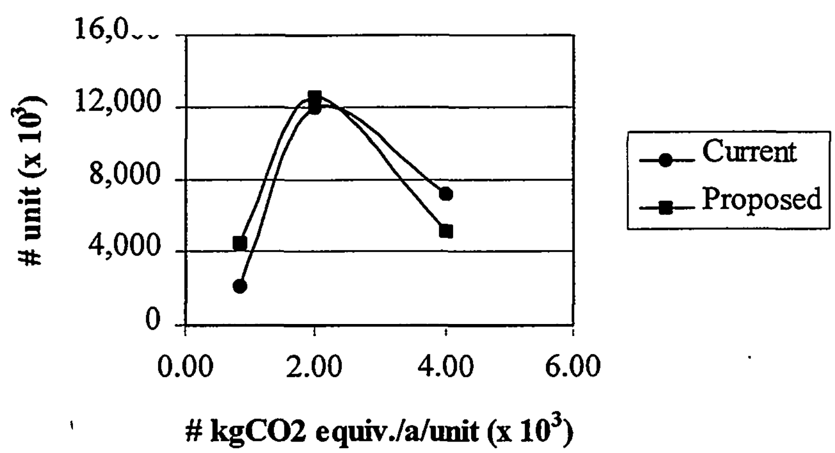
- Industry average low:
  11,165 btu/m^2 or 3.27 kWh or 0.84 kg/CO_2 equivalent/kWh
- Industry average:
  34,000 btu/m^2 or 9.96 kWh or 2.56 kg/CO_2 equivalent/kWh

6. It is assumed that the low category represents 10% of the market. Through calculations it is determined that the medium category is represented by 57% of the market, and the high category by 33%.

7. The market shift that could be possible from a change in purchasing decisions can easily translate to 75%.[8] The textile industry utilizes a range of energy efficiencies and there is room to adapt new more efficient practices.

8. The proposed scenario, however, represents a 10% shift, assumes a 4% increase in sales, and occurs over 5 years.

Product Distribution:

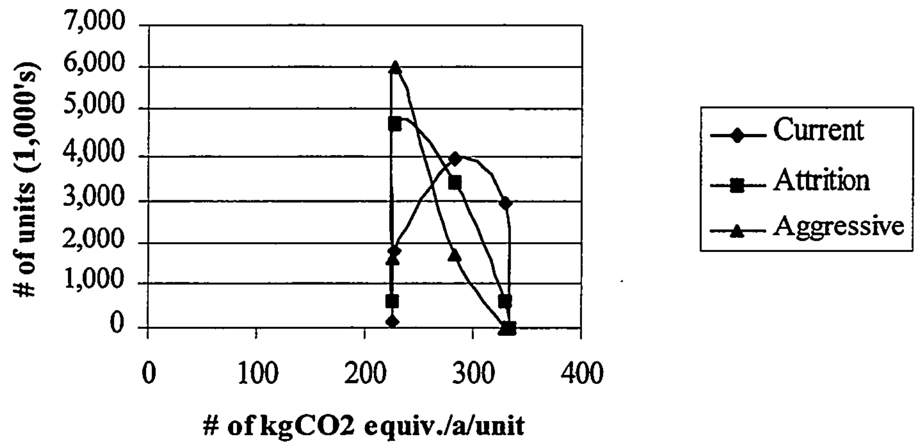


[7] Brackley, Peter, Joint Energy Programme of the Royal Institute of International Affairs and Policy Studies Institute. Energy and Environmental Terms: A Glossary. Gower: Aldershot Publishing Company Limited. 1988.

[8] Marikkar, Rahumathulla. Interface Flooring Systems (Canada) Inc. Personal communication September 24, 1999.

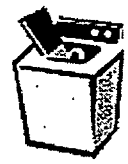
scenario assumes an accelerated turnover of 50% of old dryers, but does not assume what driver is used to achieve this acceleration. A 5% growth rate is also assumed over this 6 year period.

Product Distribution:



Area under the curve represents the total greenhouse gas emissions:
Current – 2,546,280 x 10^3 kgCO_2 equiv./a
Attrition – 2,374,352 x 10^3 kgCO_2 equiv./a
Aggressive – 2,214,280 x 10^3 kgCO_2 equiv./a

CLOTHES WASHER PRODUCT PROFILE



Product/Service Description:

Clothes washers consume energy, heated water, detergent, and perhaps other washing agents in producing clean clothing. A 22% gain in energy efficiency was achieved with washers between 1990 and 1996.[1] This is a factor of research and development initiatives from industry, as well as the implementation of energy efficiency regulations stipulating minimum requirements.

Approximately 92% of the energy used by clothes washers is consumed for heating water, with the rest used for running the machines motors.[2] A substantial gain in energy efficiency can therefore be achieved if washers are designed to be more water efficient. New improved energy and water efficient products are beginning to emerge in the marketplace with some manufacturers claiming up to 47% water reduction per wash load.[3] The development of these front-loading machines is an industry response to expected new energy standards soon to be announced by the U.S. government.[4]

Canadian Market Size:

There are a total of 9.07 million automatic clothes washers in the Canadian marketplace based on 1997 statistics.[5] Approximately 620,000 units were sold in 1997, including sales to both the retail and builder markets.[6]

Annual Usage:

Clothes washers are generally used an average of 416 loads per year.[7]
The average energy consumption per cycle is around 2 kilo-watt hours (kWh).[8]

Product Turnover:

The average life span of a clothes washer is 14 years.[9]
There is a turnover of approximately 6% of the stock every year.

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[1] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.
[2] NRCan, OEE. Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.
[3] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.
[4] Anne Wilkins. NRCan, OEE. Personal communication September 28, 1999.
[5] Gillian Huntley. Environment Canada, National Water Issues Branch. Personal communication September 23, 1999.
[6] Canadian Appliance Manufacturers Association (CAMA). Major Appliance Industry Trends and Forecast. Toronto: CAMA. 1998.
[7] NRCan, OEE. EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.
[8] NRCan, OEE. All About EnerGuide for the Appliance Salesperson. Ottawa: Government of Canada. 1999.
[9] Ibid.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

The typical washing machine has significant environmental impacts during the use stage of its life cycle. These include: the energy required to heat water and operate motors and valves; water consumption and discharge; as well as the use of detergents and other washing products. A comprehensive LCA would probably weight the use stage as having the highest GHG loading to reflect the long time span during which its environmental impacts occur.[10]

GHG (CO_2 Equivalent) Performance Range:

CLOTHES WASHERS

Current					*Attrition*		*Aggressive*	
Category (Average)	Performance Range (kWh/a)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)
Best	275	71	200	14,135	700	49,473	1,700	120,148
Low	954	245	2,330	571,265	4,300	1,054,265	5,100	1,250,408
Medium	1,175	302	5,550	1,675,961	4,200	1,268,295	2,800	845,530
High	1,380	355	900	319,194	400	141,864	0	0
Worst	1,585	407	90	36,661	0	0	0	0
Totals			**9,070**	**2,617,216**	**9,600**	**2,513,897**	**9,600**	**2,216,085**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 682 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. The product turnover is based on the 1997 retail market shipment data from the Canadian Appliance Manufacturers Association (CAMA), as a percentage of the total number of households with washers. Shipment data is believed to closely reflect purchasing behaviour.

2. The range in efficiency of clothes washers listed in the 1999 EnerGuide is 275 kWh to 1,102 kWh of annual energy consumption. This range in energy consumption is also influenced by the varying volume capacity of the washers, ranging from 51.5 litres (L) to 93 L. An average of 954 kWh from 1996 is used for rating the low category.[11] This rating is assumed to be representative of models in the marketplace over the last few model years.

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[10] Note: An interesting related study performed by Franklin Associates for the American Fiber Manufacturers estimated that the energy used for laundering a woman's polyester blouse was four times that used in manufacturing the garment. Graedel, Thomas. Designing the Ideal Green Product: LCA/SCLA in Reverse. International Journal of Life Cycle Assessment, vol. 2, no. 1. 1997.

[11] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.

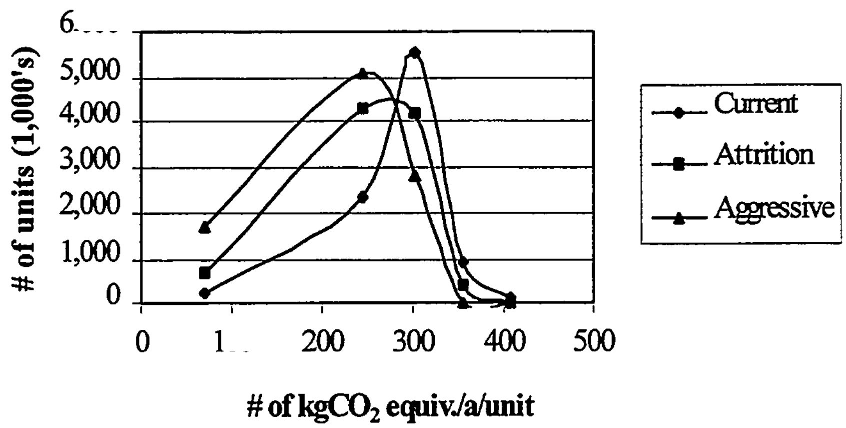
3. Based on the life expectancy of 14 years for a washer, categories were selected using 7 year intervals. In 1992 the average annual consumption of a washer was 1,175 kWh.[12] The 1972 annual energy consumption of a washer was 3.81 kWh/cycle, or 1,585 kWh (based on 416 "normal cycles" per year).[13] This represents the worst category, assuming some of these units may still exist in the marketplace. The median between this 1972 rating and the 1990 rating, is 1,380 kWh/a, which is used for the average high category.

4. The energy ratings are based on a "normal cycle" and include the energy required to heat the water, using an electric hot water tank. Energy ratings can be reduced by 50% if a gas-fired or propane water heater is used, and by 20% if an oil-fired water heater is used.[14]

5. In our distribution projections we assume a 6% product turnover per year, and that all washers will be replaced with a clothes washer from two of the most efficient categories, as these are representative of what is currently available in the marketplace. We also assume the current sales figures of 620,000 units per year, and do not infer a projected increase in efficiency.

6. The "attrition" scenario presents the situation in 5 years (chosen because it represents a third of the product's life span) based on the natural turnover of stock; and the "aggressive" scenario assumes an accelerated turnover of 50% of old washers, but does not assume what driver is used to achieve this acceleration. A 5% growth rate is also assumed over this 5 year period.

Product Distribution:



Area under the curve represents the total greenhouse gas emissions:
Current – 2,617 x 10^6 $kgCO_2$ equiv./a
Attrition – 2,514 x 10^6 $kgCO_2$ equiv./a
Aggressive – 2,216 x 10^6 $kgCO_2$ equiv./a

[12] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.
[13] Association of Home Appliance Manufacturers Website. [http://www.aham.org/mfrs/stats/egy_wash.htm] September 27, 1999.
[14] NRCan, OEE. All About EnerGuide for the Appliance Salesperson. Ottawa: Government of Canada. 1999.

COFFEE MAKER PRODUCT PROFILE

Product/Service Description:

Coffee makers come in many different formats: automatic drip, drip, French-press, stovetop, espresso, cappuccino, and Turkish. Each machine will require different accessories such as filters, steamers or frothers, depending on the design. Some are designed with a well-insulated thermal carafe, while others are equipped with a hot plate to maintain optimal drinking temperature. The energy requirements will also vary depending on the model. This product profile focuses on one of the more common machines: the automatic drip.

Typical automatic drip coffee machines consume between 750 W to 950 W. Total energy consumption over the coffee consuming activity will vary with the model and according to consumer behavior. For example, models with a hot plate will consume electricity at a "standby" power while the machine is left on; whereas machines with a thermal carafe will not require electricity beyond the time to brew the coffee itself.

Other burdens associated with coffee brewing include those associated with the filter – some machines use paper (bleached or unbleached) and some use metal mesh or cloth filters – and the burdens associated with growing, picking, roasting, and transporting the coffee itself. This profile presents an inventory of the burdens associated with operating the automatic drip coffee machine equipped with a bleached paper filter.

Canadian Market Size:

There are approximately 11.7 million households in Canada, approximately 80% of which consume coffee. The average household is assumed to consume 454 g (one pound) of coffee in two weeks or about 12 kg per year.

Annual Usage:

Coffee drinkers in North America tend to consume coffee every day of the year. Hence in a typical coffee-drinking household, one or more pots of coffee are made daily. Therefore, each year each individual in North America consumes approximately 4 kg of coffee.

Product Turnover:

The lifetime of a coffee maker depends on the model. One life cycle study[1] analyzed a coffeepot with a five-year life span. High-end coffee makers, such as those designed with a thermal carafe and metal filter will likely be used beyond 5 years.

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[1] PRe Consultants BV. SimaPro Coffee-Pot demo, Amersfoort, The Netherlands, 1998.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	*Production*	*Use / service*	*Disposal*
		X	

GHG (CO_2 Equivalent) Performance Range:

Coffee Makers

Current				***Future***		
Category (Average)	GHG/Drinker (kgCO_2 equiv./a)	# of Coffee Drinkers (x 10^6)	Total GHG (kgCO_2 equiv. /a x 10^6)	GHG/Unit (kgCO2 Equiv./a)	Number of Units (x 10^6)	Total GHG (kgCO_2 equiv. (/a x 10^6)
Best	5.14	4.3	22.10	5.14	9.48	48.72
Medium	21.73	10.8	234.68	21.73	11.85	257.50
Worst	26.08	6.4	166.91	26.08	2.37	61.81
Totals		**21.5**	**423.69**		**23.70**	**368.03**

The best possible scenario would replace all future units with models from the best category to achieve total greenhouse gas emissions of 121.8 x 10^6 kgCO_2 equivalents per year.

Working Assumptions/Limitations:

1. The GHG burdens associated with coffee growing, transporting, roasting, and decaffinating in some instances were not included in this analysis.

2. 1994 per capita consumption of coffee (4 kg) in the U.S. was used to estimate the average per capita consumption of coffee in Canada in 1997 and 2004. It is assumed that coffee consumption remains static over those years.

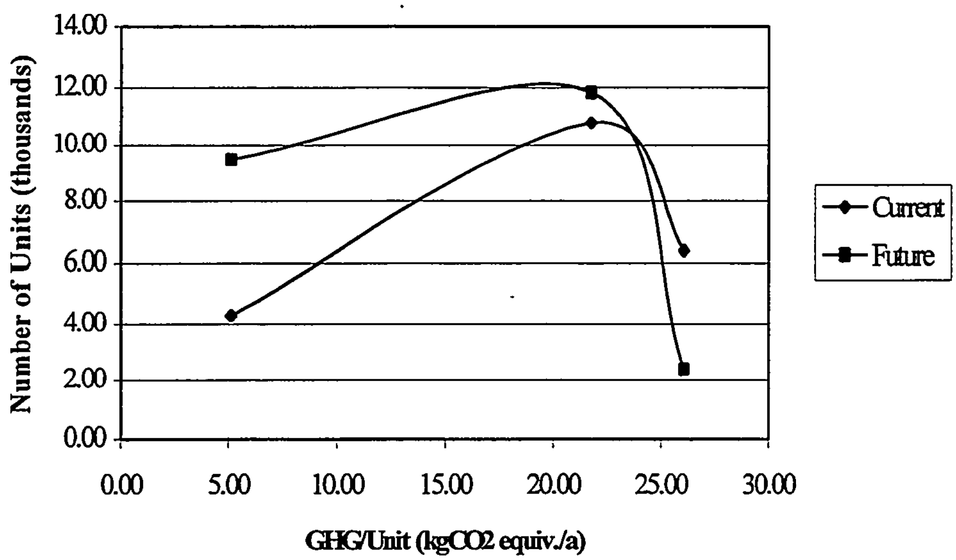
3. The model assumes that 4 kg of coffee makes approximately 123 10-cup pots of coffee per year.

4. It is assumed that, with 80% of households drinking coffee at 2.3 coffee drinkers per household, there will be 25 million coffee drinkers in Canada and that this will grow by 2% per year.

5. The market distribution in 1999 was assumed to be 20, 50, and 30% for best, medium, and worst coffee maker models.

6. In 2004 the distribution of coffee makers in households was assumed to shift towards more efficient models. The distribution was assumed to be 40, 50, and 10 % for best, medium, and worst, respectively.

Product Distribution:



COMPUTER AND MONITOR PRODUCT PROFILE

Product/Service Description:

Computers and monitors account for up to 7% of electric power consumption in the commercial sector – the fastest growing greenhouse gas load in office equipment. But because most people leave their computers on throughout the business day, much of this energy is wasted. Approximately 25% of computers are left running at night and on weekends, even though they are used an average of four hours per day.[1]

Energy savings are achieved via the implementation of lower energy states from "stand-by mode," where the machine is not performing but is available for immediate operation. Depending on the make and model, the sequence for low-power mode may include "energy-saver mode," "sleep mode" or "off-mode." Performance requirement guidelines are widely available for computers and monitors based on the Energy Star program in the USA.

Considered here are desktop personal computers, typical of office (and also home) use. When an energy-efficient computer enters "stand-by" it typically drops to 50% of maximum power consumption. In its low-power "sleep" mode, this reduces to 15% of maximum. Monitors also enter a power saving mode: after 15-30 minutes of inactivity conventional computer are assumed go to stand-by at about 15 watts, and then power down further into sleep mode after a total of about 60 minutes of inactivity, at about 8 watts. If power management features are taken advantage of, a typical office can save 50% of its electricity costs associated with office equipment.[2]

Canadian Market Size:

There are about 6 million office workers in Canada situated in home offices or regular places of business.[3] It is assumed that there would be one computer/monitor per user, amounting to about 6,000,000 units in use in Canada.

Annual Usage:

The baseline assumes computers and monitors remain on all the time and are ready for use 45 hours per week, 48 weeks per year.

Product Turnover:

Average life span is assumed to be 5 years. Monitors tend to be used longer than computers.

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[1] United States Environmental Protection Agency. A Buyer's Guide To Purchasing ENERGY STAR ® -Compliant Office Equipment, US EPA, Air and Radiation 6202J, EPA 430-K-94-006. May 1998.
[2] Energy Star Program, United States Environmental Protection Agency. [http://www.epa.gov/appdstar/esoe/savcalc.html], Washington, DC: 1999.
[3] Statistics Canada. 1996 Census. Ottawa: Government of Canada. 1998.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

At least one Life Cycle Assessment study of a computer has identified the use phase as being the most important stage, with the bulk of greenhouse gas emissions attributed to the use of the product.[4] Also significant may be the manufacturing loadings associated with electronics production, and the generation of waste from end-of-life disposal of the product.

GHG (CO_2 Equivalent) Performance Range:

Personal Computer and Monitor

Present (1999)					***Future (2004)***	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	43	11	120	1,317	2,028	22,264
Better	271	70	1,500	104,293	2,808	195,237
Medium	427	110	1,920	210,782	1,716	188,386
Worse	1,310	337	1,380	464,598	780	262,599
Worst	1,766	454	1,080	490,067	468	212,363
Totals			**6,000**	**1,271,058**	**7,800**	**880,848**

The best possible scenario would replace all units with models from the best category to achieve total GHG of 85,630x 10^3 (kg CO_2 equiv./a) for the future scenario.

Working Assumptions/Limitations:

1. Natural Resources Canada information was used to define and calculate performance of the five scenarios, based on data from the American Council for an Energy-Efficient Economy.[5] Desktop computers most commonly are coupled with cathode ray tube (CRT) monitors, which typically use about half as much energy as the computer itself.
2. The "worst" category corresponds to a high-end system always on, "worse" to a basic system always on, "medium" to a basic system off at night and weekends and "better" to basic system on/off during the day utilizing full power management features.
3. The "best" category in this profile represents future technology. It is well known that the most energy efficient computer/monitor combination is a laptop unit; therefore this kind of product was used to model the new generation desktops that are incorporating laptop technologies like liquid crystal displays (LCD) and small footprint low-power designs.
4. The number of units in each scenario was based on product life span and the characteristics of units available for current sale. Present scenario for number of units in use is 2%, 25%, 32%,

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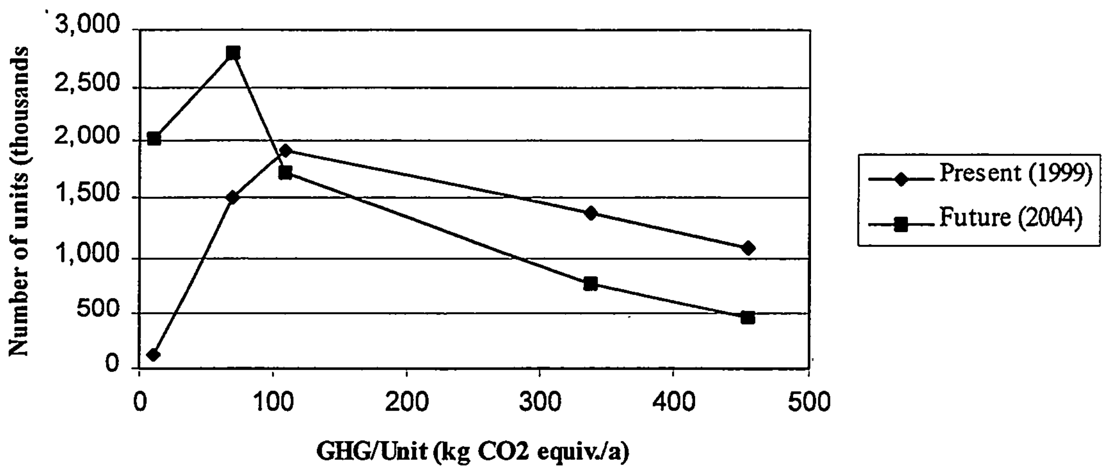
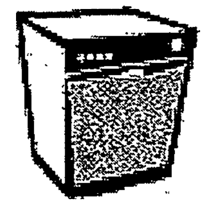
[4] S. Miyamoto. *Proposal of LCA System for Electronic Products*, Proceedings of The Third International Conference on EcoBalance, Nov. 25-27, 1998, Tsukaba, Japan, pp. 267-270.
[5] NRCan, OEE. Guide to buying and using energy-efficient office equipment. Ottawa: Government of Canada. 1995.

23% and 18% for the best, better, medium, worse and worst categories respectively. For future scenario the breakdown was 26%, 36%, 22%, 10% and 6%, assuming growth of 6% and attrition to 2004.

Product Distribution:



DISHWASHER PRODUCT PROFILE



Product/Service Description:

Dishwashers are becoming an increasingly popular home appliance for the convenience and timesaving features they offer. The bulk of their energy consumption (88%) comes from heating the water used to clean the dishes.[1] A 35% gain in energy efficiency was achieved with dishwashers between 1990 and 1996.[2] Changes to spray arms and filtering systems improved the washing action of dishwashers, and subsequently decreased hot water usage, thereby contributing to these reductions.[3]

Canadian Market Size:

Based on 1997 statistics, there are a total of 5.62 million households with built-in and portable dishwashers in the Canadian marketplace.[4] Approximately 415,000 units were sold in 1997, including sales to both the retail and builder markets.[5]

Annual Usage:

Dishwashers run an average of 322 loads per year.[6]

Product Turnover:

The average life span of a dishwasher is 13 years.[7]
There is a turnover of approximately 6% of the stock every year.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

[1] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.
[2] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.
[3] NRCan, OEE. All About EnerGuide for the Appliance Salesperson. Ottawa: Government of Canada. 1999.
[4] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.
[5] Canadian Appliance Manufacturers Association (CAMA). Major Appliance Industry Trends and Forecast. Toronto: CAMA. 1998.
[6] NRCan, OEE. EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.
[7] NRCan, OEE. All About EnerGuide for the Appliance Salesperson. Ottawa: Government of Canada. 1999.

The typical dishwasher has similar environmental impacts during the use stage of its life cycle to that of a washing machine. These include: the energy required to heat the water and operate motors and valves; water consumption and discharge; as well as the use of detergents.

GHG (CO_2 Equivalent) Performance Range:

DISHWASHERS

Current					*Attrition*		*Aggressive*	
Category (Average)	Performance Range (kWh/a)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)
Best	238	61	124	7,585	434	26,546	1,534	93,829
Low	666	171	1,486	254,347	3,300	564,835	3,700	633,299
Medium	908	233	1,610	375,703	1,500	350,034	750	175,017
High	1,026	264	2,395	631,518	750	197,762	0	0
Worst	1,343	345	5	1,726	0	0	0	0
Totals			**5,620**	**1,270,879**	**5,984**	**1,139,176**	**5,984**	**902,145**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 365 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. The units sold, as well as the product turnover rate is based on the 1997 retail market shipment data from the Canadian Appliance Manufacturers Association (CAMA). Shipment data is believed to closely reflect purchasing behaviour.

2. Dishwashers include the Heat On/Air Dry option, and a "normal cycle" includes the energy required to heat the water.

3. The most efficient dishwasher listed in the 1999 EnerGuide is used to identify the best category, at 238 kWh of annual energy consumption.[8] Available data from 1996 is used to represent the average low category at 666 kWh/year, based on the assumption that it represents a number of the models in the marketplace.

4. Based on the life expectancy of 13 years for a dishwasher, categories were selected using 7 year intervals. In 1992 the average annual consumption of a dishwasher was 908 kWh, and is used to represent the average medium category.[9] The worst category is based on the 1972 average annual energy consumption of a dishwasher at 4.17 kWh/cycle, or 1,343 kWh (based on 322 "normal cycles" per year).[10] The assumed high category is 1,026 kWh/year, and is derived from the median between the 1972 and 1992 ratings, accounting for a slight improvement in efficiency to estimate the 1985 rating.

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[8] NRCan, OEE. EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.

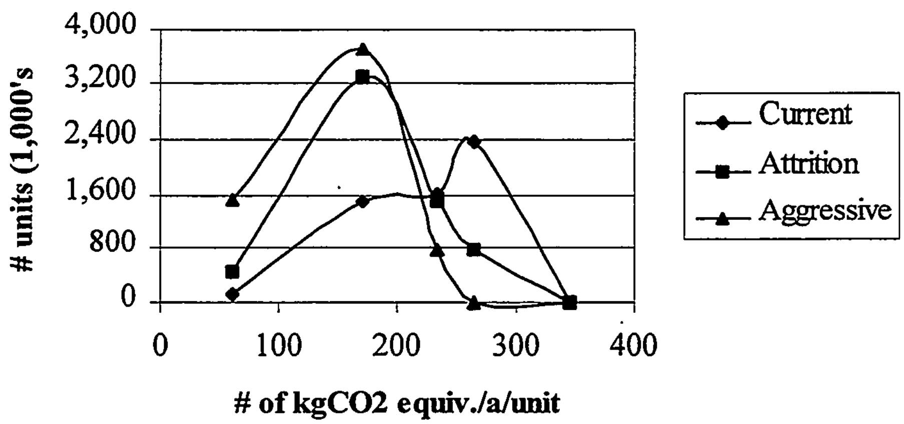
[9] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.

[10] Association of Home Appliance Manufacturers Website. [http://www.aham.org/mfrs/stats/egy_dish.htm] September 27, 1999.

5. A product turnover rate of 6% is assumed, with annual sales of 415,000 units for the product distribution. It is also assumed that all dishwashers will be replaced with a dishwasher from the two most efficient categories and a projected increase in efficiency is not inferred.

6. The "attrition" scenario presents the situation in 5 years (chosen because it represents close to a third of the product's life span) based on the natural turnover of stock; and the "aggressive" scenario assumes an accelerated turnover of 50% of old dishwashers, but does not assume what driver is used to achieve this acceleration. A 5% growth rate is also assumed over this 5 year period.

Product Distribution:



Area under the curve represents the total greenhouse gas emissions:
Current – 1,270,879 x 10^3 $kgCO_2$ equiv./a
Attrition – 1,139,176 x 10^3 $kgCO_2$ equiv./a
Aggressive – 902,145 x 10^3 $kgCO_2$ equiv./a

ELECTRICITY GENERATION PROFILE

Product/Service Description:

Electricity is generated from a combination of sources such as coal, oil, natural gas, hydro, nuclear and alternative sources such as solar, wind, and tidal power for example. Sources vary regionally across the country, with Quebec and British Columbia using primarily hydroelectric power, and the Maritimes consuming mostly coal. "Green power" is electricity produced from renewable resources such as wind or solar energy, and offers real potential to lower global greenhouse gas emissions if it can displace some of the existing power generation that is heavily reliant on the use of fossil fuels. Canadians are the heaviest per capita electricity consumers in the world.[1]

Canadian Market Size:

Based on 1995 data:

Approximately 535 terawatt-hours (TWh or 10^{12} watt-hours) of electricity were generated in Canada, of which 38 TWh of electricity were net exports.[2]

Annual Usage

In 1995, approximately 497 TWh (or 497×10^{12} watt-hours) of electricity was consumed in Canada. This amounts to enough electricity to power approximately 207 billion 100-watt light bulbs for one full day.

Product Turnover

Electricity is a one-time use product.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
	X		

Most impacts from electricity are associated with its generation and transmission. The environmental impacts associated with the production of electricity include: acid precipitation; the emission of greenhouse gases; depletion of nonrenewable resources; waste disposal problems; and site alterations. Hydroelectric power generation is often viewed as leading to fewer negative impacts, with the exception of "mega projects." However, researchers are

[1] Government of Canada. The State of Canada's Environment. Ottawa: Ministry of Supply and Services. 1991.
[2] Environment Canada. Trends in Canada's Greenhouse Gas Emissions 1990 – 1995. Ottawa. 1997.

concluding that significant methane and CO_2 emissions are being emitted from rotting vegetation drowned in the creation of hydroelectric reservoirs.[3]

Green House Gas Performance Range (CO_2 Equivalents):

ELECTRICITY GENERATION

Current					***Proposed***	
Fuel Source	% of Total Generation (%)	TWh (10^9 kWh)	Total GHG (kgCO_2 equiv. /a x 10^9)	Emissions of CO_2 equiv./kWh	TWh (10^9 kWh)	Total GHG (kgCO_2 equiv. /a x 10^9)
Hydro	62.0	332.0	0.01	0.031 x 10^{-3}	336.6	0.01
Nuclear	17.0	91.0	6.3	0.069	91.0	6.3
Coal	15.7	84.0	108.9	1.297	75.6	98.0
Natural Gas	3.2	17.0	13.2	0.774	17.0	13.2
Oil	1.5	8.0	9.1	1.138	7.2	8.2
Other (tidal, solar wind, etc.)	0.6	3.0	0	0	7.6	0
Totals	**100.0**	**535.0**	**137.5**	**3.3**	**535.0**	**125.7**

Working Assumptions/Limitations:

1. Emissions include carbon dioxide (CO_2) emissions, and CO_2 equivalent emissions for methane (CH_4), nitrous oxide (N_2O), non-methane organic compounds (NMOCs), carbon monoxide (CO), and nitrogen oxides (NO_X).[4]

2. Emissions for coal, oil, natural gas and nuclear are based on emission factors from Argonne National Laboratory. Specifically from Table D-8 "*CO_2-Equivalent Emissions of Individual Greenhouse Gases from Power Plants and Upstream Processes in Grams per Kilowatt-Hour Delivered.*"[5]

3. The system boundaries for coal, oil, natural gas and nuclear include emissions from:
   - Upstream processes (feedstock recovery, transport, fuel production and delivery);
   - Power plants; and
   - Electricity transmission (N_2O emissions from corona discharge from high-voltage transmission lines).

4. For coal, oil and natural gas, the majority of CO_2 equivalent emissions come from combustion of feedstock at the power plant. For nuclear, the majority comes from upstream processes.

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[3] Cutter Information Corp. Global Environmental Change Report, vol. 11, no. 17. September 10, 1999.
[4] Center for Transportation Research, Argonne National Laboratory. Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity. Argonne: US Department of Energy. 1993.
[5] Ibid.

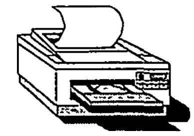
5. For hydro power, CO_2 and CH_4 can be emitted as a result of the decomposition of organic matter from large impounded areas in the early years of impoundment. These emissions have been included here assuming:
   - Emissions and generation of electricity over a 50 year period;
   - Data estimated from two large reservoirs; and
   - Emissions from oil-fired, peak-load stations (0.5% of power), and from diesel fuel used during construction of facilities.

6. The emissions data for hydro has been sourced from A.Chamberland, C.Bélanger and L.Gagnon. "Hydro-Electricity Versus Other Options" In Ecodecision Winter 1996.

7. Other assumptions:
   - Natural gas combustion is through a turbine, not a boiler.
   - Electricity transmission and distribution is 92% efficient.
   - Units are kg CO_2 equivalent emissions per kWh delivered to the end user.
   - Emissions based on a 100-year time horizon.

8. The proposed scenario assumes a 10% reduction in both coal and oil generation. This creates 9.2 TWh which are reallocated evenly between hydro and 'other' generation to maintain the same total generation. This shift results in a 11.8 megatonne carbon dioxide equivalent reduction.

FAX MACHINE PRODUCT PROFILE



Product/Service Description:

Fax machines are a modern business necessity. Associated with their use are numerous manufacturing requirements typical of electronic components; the use of paper, ink and/or other consumables; and the power requirements during the use of the product. Only the latter is considered here, as a variable in the product profile.

Considered here are plain paper fax machines (e.g., ink jet/bubble jet, laser/LED, and thermal transfer) whose primary function is sending and receiving faxes. Fax machines are often left on continuously, although they are actually faxing only about one hour per day.

Energy savings are achieved via the implementation of lower energy states from "stand-by mode," at which the machine is not performing but is available for immediate operation. Depending on the make and model, the sequence for low-power mode may include "energy-saver mode," "sleep mode," or "off-mode." Performance requirement guidelines were introduced under the Environmental Choice Program in Canada in January 1998,[1] and under the Energy Star program in the USA in July 1995.[2]

Canadian Market Size:

There are about 6 million office workers in Canada situated in home offices or regular places of business.[3] It is assumed that there would be one machine per 10 users, amounting to about 600,000 units in use in Canada.

Annual Usage:

Based on a 9.5 hr work-day with 1 hr of active time per day over a business year (250 days), approximately 100% of units are left on overnight (365 days).[4]

Product Turnover:

Average life span is assumed to be 5 years.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

[1] Environment Canada. ECP-71 Facsimile Machines, Environmental Choice Program. Government of Canada: Ottawa. Jan. 29, 1998.
[2] Energy Star Program, United States Environmental Protection Agency. Energy Star – Labeled Office Equipment [http://www.epa.gov/appdstar/esoe/], US Environmental Protection Agency, Washington, DC: 1999.
[3] Statistics Canada. 1996 Census. Ottawa: Government of Canada. 1998.
[4] Energy Star, *op cites*.

At least one Life Cycle Assessment study of a fax machine has identified the use phase as being the most important stage, with 90% of GHG attributed to the use of the product.[5] Also significant may be the manufacturing loadings associated with electronics production, and the generation of waste from end-of-life disposal of the product.

GHG (CO_2 Equivalent) Performance Range:

FAX MACHINES

Present (1998)					*Future (2004)*	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	70	18	30	538	490	8,788
Better	126	32	300	9,744	286	9,276
Medium	279	72	270	19,386	41	2,929
Totals			**600**	**29,668**	**816**	**20,993**

The best possible scenario would replace all units with models from the best category to achieve total GHG of 14,688 x 10^3 (kg CO_2 equiv./a) for the future scenario.

Working Assumptions/Limitations:

1. Energy Star (US Environmental Protection Agency) estimates were used to calculate performance of the three scenarios, more information is available at http://www.epa.gov/energystar.
2. The "medium" category was drawn from Energy Star estimates for conventional office equipment, assumed to be equivalent in function, but having little or no energy efficiency features.
3. The "better" category corresponds to baseline performance requirement guidelines for this product under the Environmental Choice Program (equal to Energy Star performance requirement guidelines in the USA). Average 15 W in Low-Power Mode for 0-7 pages per minute equipment; 30 W in Low-Power Mode for 7-14 pages per minute.
4. The "best" category represents best-available equipment, which exceeds baseline energy efficiency requirements. Information was drawn from a list of Energy Star labeled products for manufacturers and models. Adjustments were then made to other data to calculate GHG performance.
5. The number of units in each scenario was based on product life span and the characteristics of units available for current sale. Present scenario for number of units in use is 5% best, 50% better, and 45% medium. For future scenario is 60% best, 35% better, 5% medium, assuming turnover to 2004.

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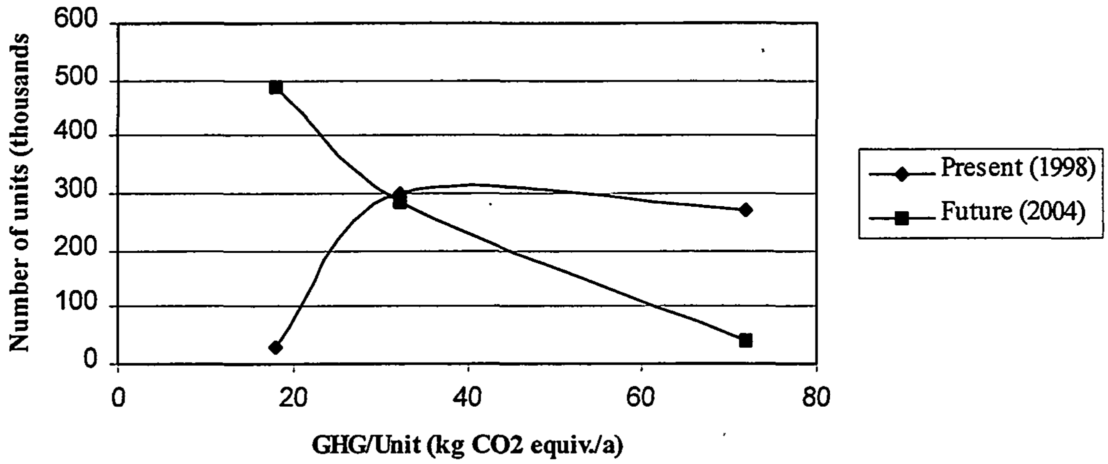
[5] S. Miyamoto, *Proposal of LCA System for Electronic Products*. Proceedings of The Third International Conference on EcoBalance, Nov. 25-27, 1998, Tsukaba, Japan, pp. 267-270.

Product Distribution:



HOT-WATER HEATER PRODUCT PROFILE

Product/Service Description:

The average Canadian family consumes between 125 and 250 L of hot water each day. Significantly, water-heating units can account for as much as 20% of a household's total energy consumption.[1]

The energy efficiency of a water heater depends on two factors:

1. the efficiency of heat transferred from the heater to the water (recovery efficiency); and

2. the energy required to maintain the hot water at a desired temperature once it has been heated (standby energy).

Keeping a hot storage tank well-insulated will reduce standby losses, and reduce the energy demand and corresponding greenhouse gas emissions.

On-demand water heating systems, which are more common in Europe are more efficient than stored-tank heating systems, which are the dominant system in North America. However, on-demand systems are becoming more prevalent now in North America, and are likely to have a significant market share in the next twenty years.

High efficiency water-heating tanks recover between 88 and 97% of combusted energy. Inefficient and poorly insulated tanks have poorer heat recovery efficiencies, as low as 50%.

Canadian Market Size:

In 1999, there were approximately 14.1 million households with hot water heaters. 50% of these households use natural gas as a principal heating fuel, 34% use less efficient electricity, 13% use oil and liquid fuel, and the remaining 3% use wood, coal or other fuels.[2]

Annual Usage:

Hot water is used all year round. During the spring and summer months, the majority of a household's natural gas usage is for water heating. Natural Resources Canada projects a significant decline in residential energy demand by the year 2020 as a result of regulations and more efficient new furnaces. Additionally, solar water heaters may take a bigger share of the market in the future since they consume no fuel at all.

Product Turnover:

A 20 year life-span was selected for this product profile.

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[1] Natural Resources Canada (NRCan). The Household Equipment of Canadians. National Energy Use Database. 1995.
[2] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / service	Disposal
		X	

GHG (CO_2 Equivalent) Performance Range:

Hot-Water Heaters

Present (1999)						*Future (2020)*	
Category (Average)	Performance Level 1999 (GJ/unit)	Performance Level 2020 (GJ/unit)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^6)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^6)
Best	15	9	1020	0	0	9,804	10,000
Better	21	12	1428	4230	6,040	5,462	7,800
Medium	31	22	2108	8460	17,834	949	2,000
Worst	40	35	2720	1410	3,835	0	0.0
Totals				**14,100**	**27,709**	**16,215**	**19,800**

The best possible scenario would replace all future units with models from the best category to achieve total GHG of 16,539 x 10^6 kg CO_2 equivalent per year.

Working Assumptions/Limitations:

1. The model uses Natural Resources Canada's projections on future trends in residential heating. These projections predict a decrease of 29% in total hot-water heating demand over the next 20 years.

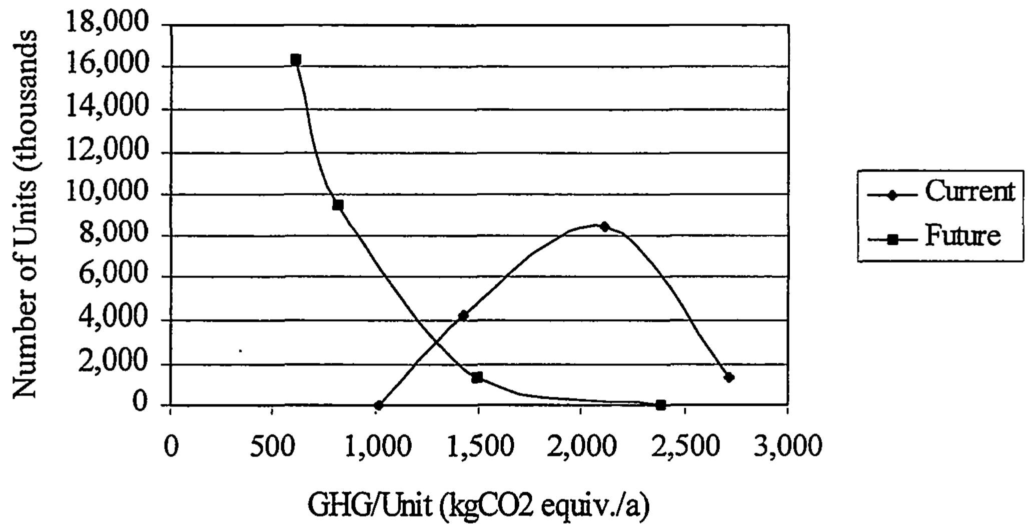
2. The model simplistically assumes all households in Canada use natural gas boilers.

3. The average hot water heater consumes approximately 30 GJ/year. A range of heating units consuming 9 GJ/year for best, and 40 GJ/year for worst.

4. The breakdown for present market share was assumed to be 0%, 60%, 30%, and 10% for the best, better, medium, and worst models, respectively.

5. The future scenario assumes a market share of best, better, medium, and worst models of 60%, 35%, 5%, and 0%, respectively.

Product Distribution:



INSULATION PRODUCT PROFILE

Product/Service Description

Insulation refers to the materials in buildings that reduce or resist conductive heat flow or loss. Designing residential buildings with thick thermal insulation of high thermal resistance is critical in northern climates, where the unit must be heated for approximately 8 months out of the year. A building's R-value is the property that measures its resistance to heat loss. Building codes typically require a minimum insulation level for each component of the building envelope. Common R-values for insulation range between 22 and 50 $hrft^{2o}F/Btu$. The U.S. EPA's EnergyStar program recommends selecting insulation materials with R-values between 38 and 49 for buildings situated in northern climates. In addition, EnergyStar specifies that a well insulated home can achieve a 30% energy savings over a poorly insulated home.

This product profile focuses on wall and roof insulation; however, it must be stressed that insulating the foundation, and piping and heating equipment are all critical to conserving energy and minimizing the associated release of greenhouse gases. The system selected is based on a study from the University of Michigan, which compared glass wool insulation in a standard house[1] with sprayed-in cellulose in an energy efficient house, both 2450 ft^2 in size.

In the model, annual GHG emissions are those associated with heating each residential unit. It is difficult to allocate the GHG burdens to the insulation alone since energy consumption depends on the performance of other building properties, such as caulking and sealing, and window performance. Hence the GHG burdens of this particular product are difficult to assess in isolation from other building properties, and should not be compared to other appliances and building components of the residential unit. What is important is the differences that better insulation can make.

Canadian Market Size:

There are approximately 11.6 million households in the ten provinces in Canada, based on 1997 statistics.

Annual Energy Usage:

The comparative performance of insulation systems must be considered all year round. A well-insulated house will reduce energy consumption for cooling during the warm months, in addition to energy consumption for heating during the cold months.

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[1] Peter Reppe and Steven Blanchard, *Life Cycle Analysis of a Residential Home in Michigan*, Master's Project, 1998. This study compared two houses, one a standard 2,450 ft2 house based on typical design strategies for new homes in Michigan, and one energy efficient house of the same size but designed with the best available energy-savings and environmental performance technologies.

Product Turnover:

The growth rate of insulation installed in new homes is approximately 9% per year.

Life Cycle Considerations:

The life cycle stage of this product with the highest GHG loading:

Raw material extraction	Production	Use / service	Disposal
		X	

Insulation influences significant environmental impacts while in use. Other life cycle stages are comparatively small.

GHG (CO2 Equivalent) Performance Range:

Insulation

Present (1999)				*Future (2024)*	
Category (Average)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^6)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^6)
Better	6,500	5,790	37,635	1,010	6,565
Worst	18,600	5,790	107,694	252	46,872
Totals		**1,158**	**528,053**	**1,262**	**493,883**

The best possible scenario would replace all future units with models from the best category to achieve total GHG of 8.2 x 10^6 kg CO_2 equivalents per year.

Working Assumptions/Limitations:

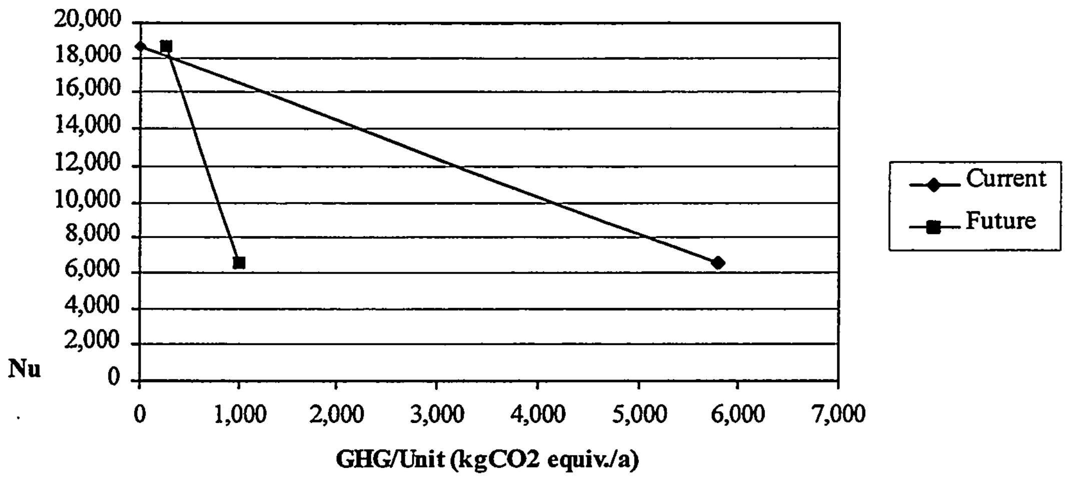
1. This analysis was based on a life cycle inventory study of two houses built in Michigan. The performance of each house was assumed to represent the average performance of houses situated in Canada.

2. The model estimates that there will be a 30 % shift towards better insulation in the year 2020, assuming that all new homes incorporate the better product and older homes upgrade.

3. The model assumes all houses in Canada use natural gas heating.

4. The Michigan study modeled the house over 50 years of use. In this profile, the year 2025 was selected as a future scenario assuming that older households may upgrade to better insulation.

Product Distribution:



LAMP PRODUCT PROFILE

Product/Service Description:

Electricity use for lighting represents 4% of all residential energy demand.[1] Measures taken to reduce the electrical energy used by lamps will help to reduce emissions associated with the production and generation of electricity.

A variety of different lamps exist in the marketplace consuming varying amounts of energy to produce light. Some of the most common types include incandescent, fluorescent, and halogen lamps. Each lamp can produce a different amount of light (measured in lumens [lm]), and require a different amount of energy to produce that light (measured in watts [W]). The efficiency of a lamp is a measure of the ratio of energy input to light output (measured in lumens/watt [lm/W), and is called efficacy.[2] Compact flourescents emit between 3 to 4 times more light than incandescents (ranging from 25 and 85 lm/W; compared to 8 to 20 lm/W).[3] Fluorescents also convert more of the energy they consume to light rather than producing waste heat (70% versus 10% conversion of energy to light).[4]

Canadian Market Size:

Standard incandescent lamps account for 91% of lighting in Canadian households.[5] The Canadian Residential Energy End-Use Data and Analysis Centre (CREEDAC) estimates the unit lamp breakdown per household to be: incandescents 24.6; fluorescents 2.2; and halogens 0.4.[6] With 11.58 million households in Canada and an average of 27.2 bulbs per dwelling, this equates to approximately 315 billion lamps in the residential market.

Annual Usage:

CREEDAC estimates that Canadian households use an average of 1,767 kilowatt-hours (kWh) of energy per year for lighting purposes.[7]

Product Turnover:

Different lamp types have different life spans. The standard incandescent lamps are rated for 1,000 hours of operation; halogens 2,500 to 3,000 hours; and compact fluorescent lamps for 10,000 hours of operation.[8]

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[1] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Efficiency Trends in Canada. Ottawa: Minister of Natural Resources. 1998.
[2] NRCan. Energy Ventures, Technical Information. Ottawa: Minister of Natural Resources. 1994.
[3] Ibid.
[4] Ibid.
[5] NRCan, OEE. Energy Efficiency Trends in Canada. Ottawa: Minister of Natural Resources. 1998.
[6] Ibid.
[7] Ibid.
[8] NRCan. Energy Ventures, Technical Information. Ottawa: Minister of Natural Resources. 1994.

Life Cycle Considerations:

The life cycle stage of product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

The main environmental impacts associated with a lamps life cycle is the energy used to operate the lamp, and the life span or durability of the lamp. Although compact fluorescent lamps require more energy to manufacture than incandescents, this difference is minimized over their longer life.[9] Other aspects of lamp manufacture are similar, however, the longer-life lamps would create less waste at the disposal stage of the life cycle.

GHG (CO2 Equivalent) Performance Range:

LAMPS

Current					*Proposed*	
Category	Performance Range (W)	GHG/Unit ($kgCO_2$ equiv. /a)	Number of Units ($x\ 10^6$)	Total GHG ($kgCO_2$ equiv. /a $x\ 10^6$)	Number of Units ($x\ 10^6$)	Total GHG ($kgCO_2$ equiv. /a $x\ 10^6$)
Best	20	5	0	0	15	77
Low	41	15	25	373	25	366
Medium	41	15	5	67	5	73
High	67	17	285	4,841	270	4,649
Totals			**315**	**5,282**	**315**	**5,165**

The best possible scenario would replace all incandescents with lamps from the best category to achieve total greenhouse gas emissions of 1,595 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. The discussion is reserved to residential lighting products.

2. The best category represents compact fluorescents that have a limited market share due to their cost. The average low category is represented by fluorescents, and the average medium category by halogens, which are primarily used for outdoor lighting purposes. The worst category is incandescent lamps that consume 75% more energy than compact fluorescent lamps.[10]

3. A report by Natural Resources Canada, Office of Energy Efficiency was utilized to calculate the average performance ranges, as well as to determine product distribution numbers.

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[9] No author given. Technical Briefing Note on Energy Efficient Lights for Household Use. Ottawa: Environmental Choice Program. No date given.

[10] U.S. Department of Energy Website. [http://www.energystar.gov/prodcuts/cflbulbs.html] September 17, 1999.

Information such as average lamp wattage, average hourly daily lamp usage, and kilowatt-hours per dwelling per year are provided.[11]

4. The 1997 statistic of 11.58 million households is used in determining total greenhouse gas emissions.[12]

5. The proposed scenario assumes a conservative market uptake of compact fluorescents, and does not account for increased sales growth.

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[11] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.

[12] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.

PAPER PRODUCT PROFILE

Product/Service Description:

Paper products are commonly used in the Canadian marketplace for a variety of purposes. Paper is used for communication purposes in offices, schools, and households across the country. Its use has increased with the use of computers and photocopiers. Paper is also used for a variety of packaging needs. A growing amount of paper products now contain an increasing amount of post-consumer recycled content. For the purposes of this profile, the typical 8½ x 11 inch sheet of printing and writing paper will be examined.

Canadian Market Size:

Canadian market size information is assumed to be similar to annual usage figures (see below).

Annual Usage:

Total Canadian consumption of paper and board in 1998 amounted to 7.12 million tonnes, of which printing and writing paper comprised 2.02 million tonnes.[1] This amounts to approximately 895.13 x 10^6 reams (500 sheets in a ream), or 448 billion sheets of paper per year. It takes approximately 17 trees to make one tonne of newsprint, and the calculation for one tonne of printing and writing paper would be slightly higher.

Product Turnover:

Although paper may be reused and/or recycled, the argument can be made that it is a one-time use product, experiencing a short life span and constant turnover.

Life Cycle Considerations:

The life cycle stage with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
	X		

The most intense stage in the paper product life cycle from a global warming perspective is associated with energy production processes. Examples include off-site electricity generation (e.g. energy purchased from the grid), and on-site electricity and steam generation from non-biomass sources.

[1] Canadian Pulp and Paper Association (CPPA). Reference Tables 1998. Montreal: CPPA. 1999.

GHG (CO_2 Equivalent) Performance Range:

PAPER PRODUCTS

Current				*Proposed*	
Category (Average)	GHG/Unit ($kgCO_2$ equiv./sheet ($x 10^{-3}$)	Number of Units ($x 10^9$)	Total GHG ($kgCO_2$ equiv. /a $x 10^6$)	Number of Units ($x 10^9$)	Total GHG ($kgCO_2$ equiv. /a $x 10^6$)
Best	2.69	8.95	24.08	18.80	50.57
Low	2.87	102.94	295.44	145.68	418.10
Medium	4.04	223.78	904.07	234.97	949.28
High	4.99	102.94	513.67	70.49	351.75
Worst	11.70	8.95	104.72	0.00	0.00
Totals		**447.56**	**1,841.97**	**469.94**	**1,769.70**

This table is a reflection of virgin paper production. Making paper with 100% recovered waste could yield up to 35% reduction in energy consumption.[2]

Notes:
1. The distribution of GHG/unit is assumed to be normal;
2. Printing and writing paper represent only 2 million tonnes of the pulp produced in Canada.
3. Significant greenhouse gas reductions could also be achieved by applying these assumptions to the other 5 million of paper and paperboard products in the marketplace.

Working Assumptions/Limitations:

1. Annual usage of the standard sheet (8½ x 11 inch) of printing and writing paper used in Canada in one year was determined assuming:
   - Paper composition is approximately 75% pulp, 20% filler, 4% moisture and 1% starch.
   - One bone dry tonne of pulp makes 1,250 kg of copy paper
   - One 8½ x 11 inch sheet of paper at a basis weight of 75 grams per square metre (g/m^2) weighs 4.524 grams (g).
   - Therefore, one ream of paper (500 sheets) weighs 2.26 kilograms (kg).
   - We know that 2.023 million tonnes of printing and writing grade paper were consumed in Canada in 1998.
   - This equates to 895.13 x 10^6 reams, or 448 billion sheets (almost ½ trillion) of paper consumed per year.

2. As per guidelines prescribed by the Intergovernmental Panel on Climate Change, the greenhouse gas inventorying process did not include the combustion of biomass, chemical pulping, and effluent and sludge treatment.

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[2] Rhodes, Stanley. Life Cycle Inventory. Wastepaper III Conference Proceedings, Millar Freeman, Inc. San Francisco. 1992.

3. Data used to determine performance ranges include estimates of air emissions from electricity and fuel use, and direct measurements at the mill. Boundaries include the activities at the pulp and paper mill, activities occurring off-site that would normally occur at the mill, and the energy used:
   - By off-site saw/chipmills,
   - To transport fibrous materials to the mill,
   - In the off-site processing of key bleaching chemicals, and
   - The off-site processing of fibre sources.[3]

4. The approach taken for determining the carbon dioxide equivalent (or greenhouse gases) emitted assumes that the electrical energy has been produced by a marginal fuel. The pulp and paper sector is the largest user of electricity in Canada, using much more energy than other Canadian industrial sectors.[4] Most Canadian pulp and paper mills are connected to a major electricity grid. Major Canadian utilities supplying electricity to these grids do so by keeping either hydroelectric and/or nuclear facilities operating at the maximum required rate. To fulfill any marginal or incremental power demands, the utilities generally use fossil fuels (i.e. oil, coal). Therefore, when the electricity requirements of a pulp or paper mill changes, or incrementally increases, the marginal change in power generation supplied by the utility is done with fossil fuels. In fact, in almost all cases in Canada, whether supplying the pulp and paper industry or others, the "marginal electricity" is generated by fossil fuels.[5]

   Special cases exist where the utility may be a net exporter of electrical energy. For example, Hydro Quebec is a net exporter of power to the United States and uses hydroelectricity as a marginal fuel. Although increased demands on Hydro Quebec may be filled by hydroelectricity; this same hydroelectricity should reduce the marginal fuel consumption (coal or oil) in the United States. Therefore, the marginal fuel is still considered to be fossil fuel-based.[6]

5. In determining average categories, information was based on a small sample size of 11 Canadian pulp mills.

6. The distribution of pulp production is unknown, therefore, a normal distribution is assumed.

7. A 5% growth rate is assumed for the proposed scenario.

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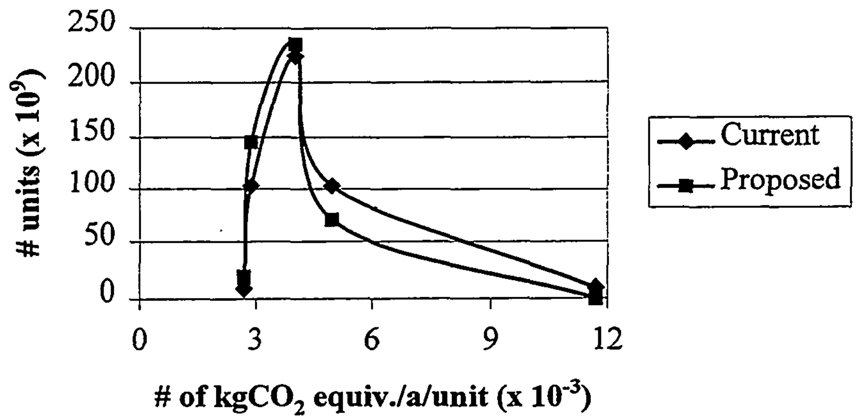
[3] TerraChoice Environmental Services Inc. Environmental Profile Data Sheet User's Guide. Ottawa: TerraChoice Environmental Services Inc. 1997.
[4] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). Energy Efficiency Trends in Canada 1990 to 1996. Ottawa: Minister of Natural Resources. 1998.
[5] TerraChoice Environmental Services Inc. Environmental Profile Data Sheet User's Guide. Ottawa: TerraChoice Environmental Services Inc. 1997.
[6] Ibid.

Product Distribution:



Area under the curve represents the total greenhouse gas emissions:
Current – 1,842 x 10^6 kgCO_2 equiv./a
Proposed – 1,770 x 10^6 kgCO_2 equiv./a

PHOTOCOPIER PRODUCT PROFILE

Product/Service Description:

Photocopiers are a modern business necessity, now finding application in home offices and residences too. Associated with their use are numerous manufacturing requirements typical of electronic components; the use of paper, ink and/or other consumables; and the power requirements during the use of the product.

Copiers consumer more energy per unit than other types of office equipment. They are usually left on continuously, although they are actually in active use a fraction of the workday. Although, when put in context, it takes ten times more energy to produce a piece of paper than to copy an image to it. Only the power for the machine is considered here as a variable in the product profile.

Medium capacity copiers (20 to 44 pages per minute) are used to represent the entire market, for sake of simplicity. These are intended solely to make duplicate images (i.e. modern multi-function machines are excluded).

Energy savings in copiers are achieved via the implementation of lower energy states from "stand-by mode," where the machine is not performing but is available for immediate operation. Depending on the make and model, the sequence for low-power mode may include "energy-saver mode," "sleep mode," or "off-mode." Performance requirement guidelines were introduced under the Environmental Choice Program in Canada in January 1998,[1] and under the Energy Star program in the USA in July 1995.[2] Energy Star labelled copiers actually turn off after a period of inactivity, reducing energy consumption by approximately 60%.

Canadian Market Size:

There are about 6 million office workers in Canada situated in home offices or regular places of business.[3] It is assumed that there would be one machine per 10 employees, amounting to about 600,000 units in use in Canada, with about 130,000 new copiers sold each year.[4]

Annual Usage:

Medium capacity copiers (20 to 44 pages per minute) are used to represent the entire market, for sake of simplicity. Based on a 9.5 hour work-day with no inactive time over the day, and a business

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[1] Environment Canada. ECP-46 Photocopiers, Environmental Choice Program. Government of Canada: Ottawa. Jan. 29, 1997.

[2] Energy Star Program, United States Environmental Protection Agency. Energy Star – Labeled Office Equipment [http://www.epa.gov/appdstar/esoe/]. US Environmental Protection Agency, Washington, DC: 1999.

[3] Statistics Canada. 1996 Census. Ottawa: Government of Canada. 1998.

[4] USA statistics indicate seven million photocopiers in use across that country, with 1.5 million sold each year. It is reasonable that Canada has about 10% of this. Energy Star Program, United States Environmental Protection Agency. Energy Star – Labeled Office Equipment. [http://www.epa.gov/appdstar/esoe/]. US Environmental Protection Agency, Washington, DC: 1999.

year (250 days), approximately 70% of units are left on overnight (365 days).[5] Duplexing (double-sided copying) is not accounted for.

Product Turnover:

Average life span is assumed to be 8 years.

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

At least one Life Cycle Assessment study of a photocopier has identified the use phase as being the most important stage, with most GHG attributed to the use of the product, including power and paper.[6] Environment Canada reviewed currently available life cycle information on photocopiers and noted that EnerGuide compliant machines will "produce an environmental benefit through a reduction of waste to landfill, a reduction of chemical emissions and the conservation of energy."[7] Also significant, in the total environmental assessment, may be the manufacturing loadings associated with electronics production, and the generation of waste from end-of-life disposal of the product.

GHG (CO_2 Equivalent) Performance Range:

PHOTOCOPIERS

Present (1998)					*Future (2006)*	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	287	74	30	2,213	475	35,050
Better	424	109	300	32,690	277	30,206
Medium	719	185	270	49,891	40	7,317
Totals			**600**	**84,795**	**792**	**72,574**

The best possible scenario would replace all units with models from the best category to achieve total GHG of 58,417 x 10^3 (kg CO_2 equiv./a) for the future scenario.

Working Assumptions/Limitations:

1. Energy Star (US Environmental Protection Agency) estimates were used to calculate performance of the three scenarios, more information is available at http://www.epa.gov/energystar.

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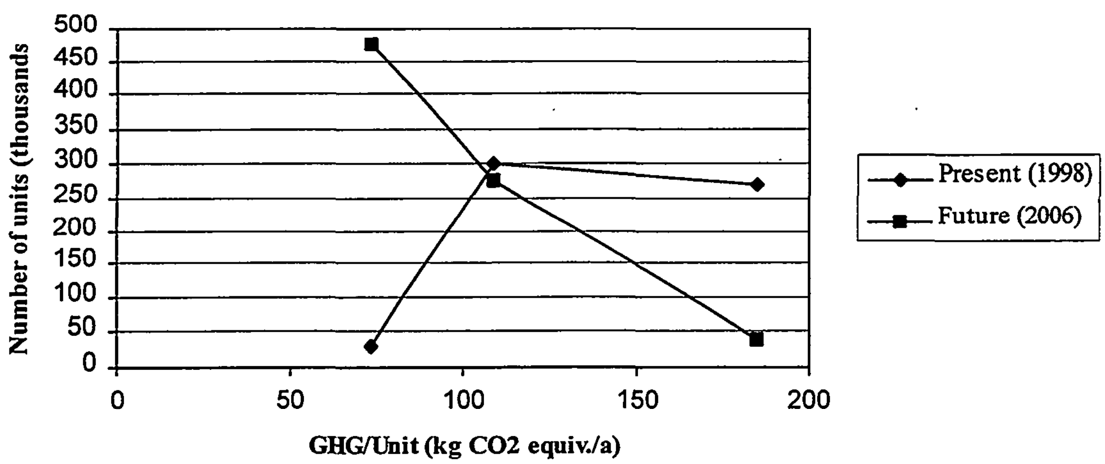
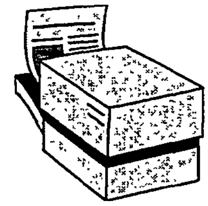
[5]. Energy Star Program, United States Environmental Protection Agency. Energy Star – Labeled Office Equipment. [http://www.epa.gov/appdstar/esoe/]. US Environmental Protection Agency, Washington, DC: 1999.
[6] S. Miyamoto. *Proposal of LCA System for Electronic Products*, Proceedings of The Third International Conference on EcoBalance, Nov. 25-27, 1998, Tsukaba, Japan, pp. 267-270.
[7] Environment Canada, *op cites*.

2. The "medium" category was drawn from Energy Star estimates for conventional office equipment, assumed to be equivalent in function, but having little or no energy efficiency features.
3. The "better" category corresponds to baseline performance requirement guidelines for this product under the Environmental Choice Program (equal to Energy Star performance requirement guidelines in the USA). Average 15 W in Low-Power Mode for 0-7 pages per minute equipment; 30 W in Low-Power Mode for 7-14 pages per minute.
4. The "best" category represents best-available equipment (general newer to market), which exceeds baseline energy efficiency requirements. Information was drawn from a list of Energy Star labeled products for manufacturers and models. Adjustments were then made to other data to calculate GHG performance.
5. The number of units in each scenario was based on product life span and the characteristics of units available for current sale. Present scenario for number of units in use is 5% best, 50% better, and 45% medium. For future scenario is 60% best, 35% better, 5% medium, assuming turnover to 2004.

Product Distribution:



PRINTER PRODUCT PROFILE



Produc /˜erv˙ce Description:

Printers are a modern business necessity. Associated with their use are numerous manufacturing requirements typical of electronic components; the use of paper, ink and other consumables; and the power requirements during the use of the product. Only the latter is considered here, as a variable in the product profile.

Considered here are standard desktop printers such as ink jet, laser/LED, dot matrix, as well as high-end color printers (thermal wax transfer, color laser, and high-end laser-quality ink jet). Printers are generally left on continuously, although they are only printing a small fraction of the time.

Energy savings are achieved via the implementation of lower energy states from "stand-by mode," at which time the machine is not performing but is available for immediate operation. Depending on the make and model, the sequence for low-power mode may include "energy-saver mode," "sleep mode," or "off-mode." Performance requirement guidelines were introduced under the under the Energy Star program in the USA in July 1995.[1] Using the power-management feature on printer also means it will produce less heat, providing a more comfortable work environment, and reducing air-conditioning requirements.

Canadian Market Size:

There are about 6 million office workers in Canada situated in home offices or regular places of business.[2] It is assumed that there would be one machine per 5 users, amounting to about 1,200,000 units in use in Canada.

Annual Usage:

Based on a 9.5 hr work day with 5.5 hr of inactive time per day over a business year (250 days), approximately 80% of units are left on overnight due to use of networked printers (365 days).[3]

Product Turnover:

Average life span is assumed to be 6 years.

[1] Energy Star Program, United States Environmental Protection Agency. Energy Star – Labeled Office Equipment [http://www.epa.gov/appdstar/esoe/]. US Environmental Protection Agency, Washington, DC: 1999.
[2] Statistics Canada. 1996 Census. Ottawa: Government of Canada. 1998.
[3] Energy Star, *op cites.*

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

It is assumed that printers would exhibit similar Life Cycle Assessment profiles to other office equipment like fax machines, with the majority of GHG attributed to the use of the product. Energy Star estimates that the automatic "power-down" feature could cut a printer's electricity use by over 65 percent. Also significant may be the manufacturing loadings associated with electronics production, and the generation of waste from end-of-life disposal of the product.

GHG (CO_2 Equivalent) Performance Range:

PRINTERS

Present (1998)					*Future (2004)*	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	72	19	60	1,117	979	18,237
Better	109	28	600	16,866	571	16,056
Medium	290	74	540	40,229	82	6,079
Totals			**1,200**	**58,212**	**1,632**	**40,372**

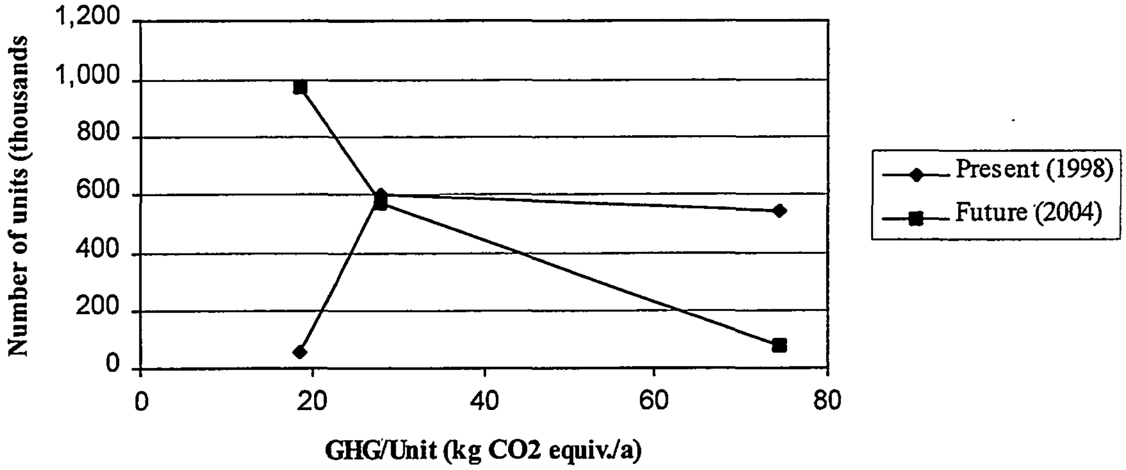
The best possible scenario would replace all units with models from the best category to achieve total GHG of 30,395 x 10^3 (kg CO_2 equiv./a) for the future scenario.

Working Assumptions/Limitations:

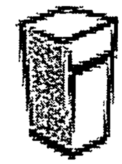
1. Energy Star (US Environmental Protection Agency) estimates were used to calculate performance of the three scenarios, more information is available at http://www.epa.gov/energystar.
2. The "medium" category was drawn from Energy Star estimates for conventional office equipment, assumed to be equivalent in function, but having little or no energy efficiency features.
3. The "better" category corresponds to baseline performance requirement guidelines for this product under the Energy Star performance requirement guidelines for the USA; Canadian circumstances would be similar. Average 15 W in Low-Power Mode for 0-7 pages per minute equipment; 30 W for 7-14 pages per minute; and 45 W for >14 pages per minute models.
4. The "best" category represents best-available equipment, which exceeds baseline energy efficiency requirements. Information was drawn from a list of Energy Star labeled products for manufacturers and models. Adjustments were then made to other data to calculate GHG performance.
5. The number of units in each scenario was based on product life span and the characteristics of units available for current sale. Present scenario for number of units in use is 5% best, 50%

better, and 45% medium. For future scenario is 60% best, 35% better, 5% medium, assuming turnover to 2004.

Product Distribution:



REFRIGERATOR PRODUCT PROFILE



Product/Service Description:

Refrigerators are major home appliances that are used to preserve foods by keeping them chilled and/or frozen. They come in a variety of sizes with different features. The typical energy efficient refrigerator with automatic defrost and freezer on-top uses less than 650 kilowatt-hours (kWh) per year, whereas a 1973 model consumed nearly 2,000 kWh per year.[1] Technological advances and the introduction of energy efficiency regulations have reduced the energy consumption of many modern household appliances.

Canadian Market Size:

There are a total of 11.56 million households with refrigerators in Canada based on 1997 statistics.[2] Close to 100% of households have one refrigerator, and in 1997, 19.4% had more than one refrigerator.[3] This means that there are approximately 14 million refrigerators in the Canadian marketplace. In 1997, 688,000 new regular refrigerators were sold.[4]

Annual Usage:

Refrigerators generally run 24 hours a day, 365 days a year = 8,760 hours/year.

Product Turnover:

The average refrigerator has a life span of 17 years.[5]
There is a turnover of approximately 5% of the stock every year.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

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[1] American Council for an Energy-Efficient Economy. [http://www.acee.org.htm]. September 1999.
[2] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.
[3] Canadian Appliance Manufacturers Association (CAMA). Major Appliance Industry Trends and Forecast. Toronto: CAMA. 1998.
[4] Ibid.
[5] Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.

GHG (CO_2 Equivalent) Performance Range:

REFRIGERATORS

Current					*Attrition*		*Aggressive*	
Category (Average)	Performance Range (kWh/a)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)	Number of Units (x 10^3)	Total GHG ($kgCO_2$ equiv. /a x 10^3)
Best	554	142	200	28,476	800	113,902	1,800	256,280
Low	646	166	4,200	697,292	8,000	1,328,176	9,300	1,544,005
Medium	1,044	268	4,200	1,126,894	4,000	1,073,232	2,800	751,262
High	1,553	399	5,600	2,235,078	2,200	878,066	1,100	439,033
Worst	2,000	514	50	25,700	0	0	0	0
Totals			**14,250**	**4,113,439**	**15,000**	**3,393,377**	**15,000**	**2,990,581**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 2,130 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. Purchase information is based on shipment data supplied by manufacturers to the Canadian Appliance Manufacturers Association (CAMA) and is believed to closely reflect purchasing behaviour.

2. The 5% product turnover rate is based on retail market shipment data from CAMA for 1997.

3. For the purpose of this profile the following classification of refrigerators was chosen from the EnerGuide: Type 3 - refrigerator-freezers with automatic defrost, with top-mounted freezer, without through-the-door ice service, and all refrigerators without freezers but with automatic defrost, sized (4.6 to 5.2 cubic metres, or 16.5 to 18.4 cubic feet).[6] Type 3 refrigerators account for 86% of refrigerators put on the market, and this size refrigerator is one of the most common, representing 47% of the Type 3 market distribution in 1996.[7] Therefore, this type and particular size of refrigerator make it a realistic classification to choose.

4. The most efficient refrigerator listed in the 1999 EnerGuide has an annual energy consumption rating of 554 kWh and was therefore selected as the best category. Due to the fact that many of these units will not have entered the market yet, 1996 data from Natural Resources Canada was chosen to represent the average low category at 646 kWh. This average annual energy consumption is representative of the stock between the model years 1994 to 1999, where efficiency ratings were similar.

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[6] NRCan, OEE. EnerGuide Appliance Directory. Ottawa: Government of Canada. 1999.

[7] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.

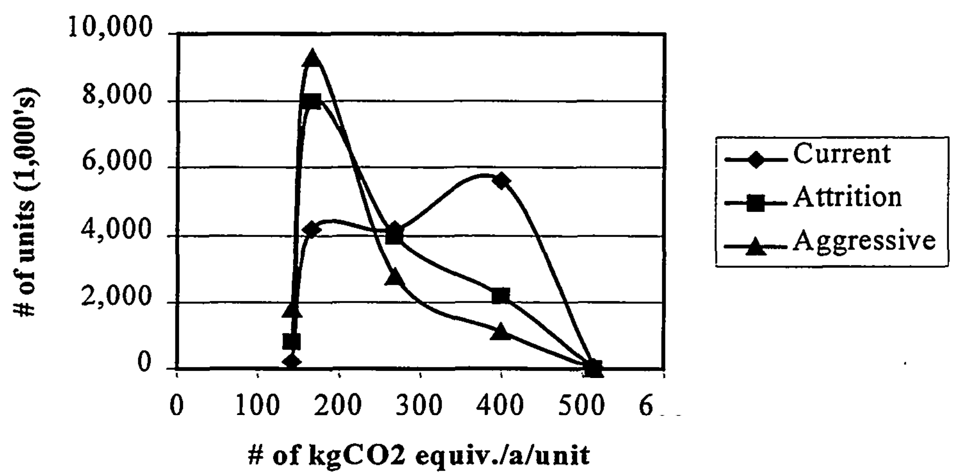
5. Considering the 17 year average life span for a refrigerator, 8 year intervals were selected to determine the other categories. The average annual energy consumption of a 4.6 to 5.2 cubic metre (16.5 to 18.4 cubic feet) refrigerator in 1990, was 1,044 kWh.[8] Based on the knowledge that a 1973 refrigerator used 2,000 kWh[9] and assuming a linear improvement in efficiency, 1,553 kWh was selected as representative of the average high category for the year 1981.

6. Potential CFC releases are not included.

7. In our distribution projections we assume there will be a natural turnover of 5% per year, and that all refrigerators will be replaced with a refrigerator from one of the two most efficient categories, as these are representative of new refrigerators on the market. We also assume the current sales figures of 700,000 units a year, and do not infer a projected increase in efficiency.

8. The "attrition" scenario presents the situation in 6 years (chosen because it represents a third of the product's life span) based on the natural turnover of stock; and the "aggressive" scenario assumes an accelerated turnover of 50% of old refrigerators, but does not assume what driver is used to achieve this acceleration. A 5% growth rate is also assumed over this 6 year period.

Product Distribution:



Area under the curve represents the total greenhouse gas emissions:
Current – 4,113,439 x 10^3 $kgCO_2$ equiv./a
Attrition – 3,393,377 x 10^3 $kgCO_2$ equiv./a
Aggressive – 2,990,581 x 10^3 $kgCO_2$ equiv./a

[8] NRCan, OEE. Energy Consumption of Major Household Appliances Marketed in Canada, Trends from 1990 to 1996 – DRAFT. 1999.
[9] American Council for an Energy-Efficient Economy. [http://www.acee.org.htm]. September 1999.

SHOWER PRODUCT PROFILE

Product/Service Description:

In 1996 the average Canadian household consumed 6,000 litres (L) of water per week for indoor use.[1] Of this indoor water, 65% is used in the bathroom.[2] Converting to low-flow toilets and showerheads could achieve savings of up to 2,000 L/week in.[3] By reducing water consumption in the shower, consumers can lower their water/sewer bills, as well as realizing savings from reduced water heating costs.

Showering and bathing consume 35% of the indoor water use in the residential sector.[4] Conventional showerheads have a flow rate of 15-20 litres/minute (L/min.), whereas low-flow units are less than 15 L/min., and generally between 7 and 12 L/min.[5] The Canadian Standards Association has set a maximum flow rate of 9.5 L/min. in the National Building Code.[6]

Canadian Market Size:

According to Statistics Canada there are 11.56 million households with installed baths or showers.[7] Statistics Canada also estimates that 28.1% of households have low-flow showerheads, which equates to approximately 3.25 million low-flow units.[8]

Annual Usage:

A 1999 bathroom habits survey undertaken by American Standard (a plumbing product manufacturer) in the United States indicates that 57% of the respondents took a shower every day, and 6.6% took a shower more than once/day.[9] Greater than 60% of the respondents take 5-10 minute showers, and 35% take 11-20 minute showers.[10] Assuming that Canadian behaviour is similar to the U.S., these habits would equate to 211.12 million minutes that Canadians spend in the shower each day. The water consumption for these showers would range from 1.48 billion L if low-low showerhead units were used, to 4.22 billion L if a more conventional 20 L/min. showerhead was used.

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[1] Environment Canada Website. [http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm] September 22, 1999.
[2] Ibid.
[3] Ibid.
[4] Ibid.
[5] Environment Canada Website. [http://www.ec.gc.ca/water/en/manage/effic/e_retro.htm] September 22, 1999; and Energy Pathways Inc. Technical Briefing Note on Water-Conserving Showerheads and Devices. Ottawa: Environmental Choice Program. 1990.
[6] Edwin Ho. Canadian Standards Association. Personal communication September 20, 1999.
[7] Statistics Canada. Household Facilities and Equipment. Ottawa: Ministry of Industry. 1997.
[8] Statistics Canada. Human Activity and the Environment. Ottawa: Ministry of Science, Industry and Technology. 1994.
[9] American Standard Website. [http://www.americanstandard-us.com/scripts/trade/default.asp] September 22, 1999.
[10] Ibid.

Product Turnover:

The average life span for a low-flow showerhead is estimated between 5 and 10 years according to a source at Teledyne Water Pik. The variance is due to consumers wanting to upgrade their current showerheads, as well as technological changes in showerhead development.[11]

The number of households purchasing low-flow showerheads in the 1998 replacement market was 573,000; 1997, 647,000; and in 1996, 556,000.[12] This provides an estimate of 5.1% for the approximate market stock turnover on a yearly basis for low-flow showerheads.

Life Cycle Considerations:

The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

The use stage is considered to have the highest GHG loading because the consumption of water requires large amounts of energy for pumping and heating the water, and then pumping and treating the wastewater. The energy and chemicals required for wastewater treatment are not considered for the purposes of this profile.

GHG (CO2 Equivalent) Performance Range:

Approximately 77 x 10^9 minutes of showering occur annually in Canada, and 28% of the existing showerheads in the marketplace are low-flow (based on the 1991 statistics and confirmed by industry source to still be representative of the market). In the current situation therefore:

- Low-flow: average water usage 9 L/min.
- Conventional: average water usage 18 L/min.
- To determine the total water used by Canadian households the following equation is used: total shower minutes x [(L/min. flow rate x market share of low-flow) + (L/min. flow rate x market share of conventional]
- Therefore, 1,192 x 10^9 L/year of water are used for showering in Canada.

Scenario #1:

- If 60% of the showerheads were low-flow units, a potential water savings can result.
- Calculation: total shower minutes x [(L/min. flow rate x new market share of low-flow) + (L/min. flow rate x new market share of conventional]
- Therefore, 970 x 10^9 L/year are used resulting in a potential water savings of 222 x 10^9 L/year.
- This water savings can be translated into energy savings by multiplying by the kilowatt-hours (kWh) required to pump one litre of water to a household, and the energy required to heat one litre of water.

[11] Peter Leany. Teledyne Water Pik. Personal communication September 24, 1999.
[12] Ibid. Replacement market does not include new home construction installations.

- Therefore, 13 x 10^9 kWh, or 3,304 x 10^6 kilograms of carbon dioxide equivalents/kilowatt-hour (kgCO_2 equiv./kWh) can be saved.

GHG (CO_2 Equivalent) Performance Range:

SHOWER HEADS

Current				*Scenario #1*		
Category	Total Shower Time (mins/a x10^9)	Units (litres/a x10^9)	Total GHG (kgCO_2 equiv. /a x 10^6)	Total Shower Time (mins/a x 10^9)	Units (litres/a x 10^9)	Total GHG (kgCO_2 equiv. /a x 10^6)
Low Flow	21.56	194.0	2,890.6	46.2	415.8	6,195.4
Conventional	55.44	998.0	14,870.2	30.8	554.4	8,260.6
Totals	**77.0**	**1,192.0**	**17,760.8**	**77.0**	**970.2**	**14,456.0**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 10,326 x 10^6 kgCO_2 equivalents per year.

Working Assumptions/Limitations:

1. For the purposes of this profile the following average flow rates are assumed: low-flow 9 L/min., and conventional 18 L/min.

2. Annual usage calculations are based on U.S. market survey results, and are assumed to be similar for the Canadian market.

3. Teledyne Water Pik based on a 1998 survey of 10,000 households provides information on product turnover. Turnover percentage is determined based on an average of the total households with showers, as reported by Statistics Canada.

4. The energy required to pump water to a household is calculated based on a common submersible house pump to draw the water from a depth of 30.5 metres (at 1/2 horsepower, 20 pounds of pressure), as well as water heating calculations. Water heating energy is based on a standard hot water tank, assuming a setting of 60°C with water coming in at 10°C. Therefore, 5.81 x 10^{-2} kWh of energy is required to pump, pressurize and heat one litre of water.[13]

[13] Morrison, Rick. Canadian Standards Association. Personal communication September 16, 1999.

BUSINESS TELEPHONE PRODUCT PROFILE

3

Product/Service Description:

Telephones are a modern business necessity. Associated with their use are numerous manufacturing requirements typical of electronic components, the provision of the telephone service itself, and the power requirements during the use of the product. Only the latter is considered here as a variable in the product profile.

Over the last decades there has been a move to more fully featured devices. This has been accomplished either via the use of a AC plug-in power supply – in addition to the low current provided over the phone line – or through the use of telecommunications systems, linking multiple terminals together with a central switching unit. Consequently, the energy demands and therefore GHG emissions associated with this product have increased – but the nature of the service has changed dramatically. Except for mobile telephones, little attention has been paid to energy consumption. But in the scheme of things, telephones as a category consume very little energy in relation to other office products.

Considered here is a fully featured business telephone typical of large or medium sized offices. It is part of a system that includes a central switching unit. The phone includes display features, memory and hold buttons, and speaker and intercom capabilities.

Canadian Market Size:

There are approximately 11 million employed persons in Canada, of this about 6 million are office workers including managers, clerical and professional work categories, whether at home offices or regular places of business.[1] It is assumed that each of these office workers would require one unit; although, clearly this is a simplification of a more diverse market.

Annual Usage:

Business telephones are in active use 25 hours per week. On a business day there are 19 hours/day in idle mode, 3 hours/day with handset and 2 hours/day on hands-free mode. During the balance of time, non-business, it is in idle mode. Each mode entails different energy consumption, with a typical total energy consumption of about 4.3 kWh/year per unit.[2] This excludes requirements from the switching unit.

Product Turnover:

The average life span of a business telephone is 11 years.[3] However, a specific business will likely turnover their telephones at a much faster rate, say each 6 years. Business phones, which tend to be more valuable than consumer phones, usually have more than one life. Refurbished models are often exported outside Canada.

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[1] Statistics Canada. 1996 Census. Ottawa: Government of Canada. 1998.
[2] Nortel and Environment Canada. LCA of a Business Telephone. Ottawa: Environment Canada. 1999, in publication.
[3] *Ibid.*

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

Several LCA studies of business telephones have identified the use phase as being most important with respect to GHG. The manufacturing loadings associated with electronics production are also significant, as is the generation of waste form end-of-life disposal.[4, 5]

GHG (CO_2 Equivalent) Performance Range:

BUSINESS TELEPHONE

Present (1998)					*Future (2004)*	
Category (Average)	Performance Level (kWh/a)	GHG/Unit (kg CO_2 equiv./a)	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3	Number of Units x 10^3	Total GHG (kg CO_2 equiv. /a) x 10^3
Best	2.6	0.7	1,200	796	6,528	4,328
Medium	4.3	1.1	4,800	5,304	1,632	1,804
Totals			**6,000**	**6,100**	**8,160**	**6,132**

The best possible scenario would replace all units with models from the best category to achieve total GHG of 5,411 x 10^3 (kg CO_2 equiv./a) for the future scenario.

Working Assumptions/Limitations:

1. The "medium" category assumes 4.3 kWh/year per unit.
2. The "best" category assumes a 50% improvement in energy efficiency of the product only in its idle mode, which amounts to a 40% performance improvement from the medium category.
3. Performance estimates do not include the system switching unit.
4. The number of telephones in each category was assumed with a simple 20% best, 80% medium for present scenario; and 80%, 20% for future, base on a time horizon of 6 years, and the 11 year product life span.

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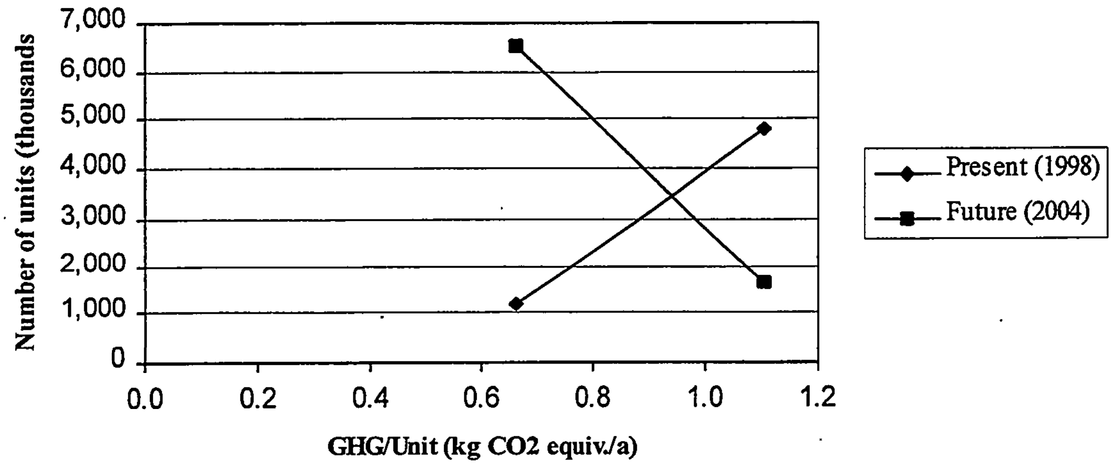
4 *Ibid.*

5 AT&T Demonstration Project. In Life Cycle Design Framework and Demonstration Projects, EPA/600/R-95/107, Washington: US Environmental Protection Agency. July 1995.

Product Distribution:



TOILET PRODUCT PROFILE

Product/Service Description:
Toilets are one of the major water consuming devices in Canadian households. Approximately 30% of household water use can be attributed to toilet flushing.[1] The supply of water to households, as well as the removal of liquid wastes, have a variety of environmental impacts from the depletion of a natural resource, the heating and pumping of water which requires energy, to the use of chemicals in wastewater treatment. By reducing the use of water, the direct and indirect environmental impacts can also be reduced.

Different types of toilets exist on the market with varying degrees of water consumption per flush. Changes in the National Building Code in 1993 stipulated that 13 litres (L)/flush toilets be installed in any new home construction, and in 1996 this was reduced to 6 L/flush.[2] These changes have encouraged the shift away from the standard toilet that uses approximately 19 litres of water/flush, to the low-flush at 13.2 L/flush, and now the ultra-flow flush of 5.7 L/flush.[3] This water reduction has cost savings to consumers in their water/sewer bills, because not only are they using less water, but they are also producing less wastewater.

Canadian Market Size:
There are approximately 11.56 million households with installed toilets in the Canadian marketplace.[4] A Statistics Canada survey in 1991 estimated that roughly 10% of Canadian households had low-flow toilets.[5] This would equate to 1.16 million low-flush units.

Annual Usage:
A general usage rate utilized by Environment Canada is 4 flushes per person per day. If a standard toilet is used this would equate to nearly 28,000 litres of water used in one year to get rid of 650 litres of body waste.[6] However, if an ultra-low flush toilet were used only about 8,300 litres of water would be required.

Product Turnover:
The life span of a toilet depends on factors such as its construction, use and care, however, 25 years is estimated as the average life.

Life Cycle Considerations:
The life cycle stage of the product/service with the highest GHG loading:

Raw material extraction	Production	Use / Service	Disposal
		X	

[1] Environment Canada Website. [http://www.ec.gc.ca/water/en/manage/effic/e_weff.htm] September 22, 1999.
[2] Yvan Castonguay. Region of Ottawa-Carelton, Environment and Transportation Department, Waste Division Branch and Water Efficiency Strategy. Personal communication September 21, 1999.
[3] Environment Canada Website. [http://www.ec.gc.ca/water/en/manage/effic/e_toilet.htm] September 22, 1999.
[4] Statistics Canada. Household Facilities and Equipment. Ottawa: Ministry of Industry. 1997.
[5] Statistics Canada. Human Activity and the Environment. Ottawa: Ministry of Science, Industry and Technology. No more up-to-date statistics were available from Statistics Canada. 1994.
[6] Environment Canada Website. [http://www.ec.gc.ca/water/en/manage/effic/e_retro.htm] September 22, 1999.

The life cycle considerations regarding toilets is considered to be highest in the use stage. The lower the water consumption of the toilet, the lower the energy and infrastructure required to purify and pump water to households, and treat sewage. Studies show that low-flush toilets can increase the functioning and decrease the maintenance costs of septic systems and municipal sewage systems.[7] The energy and chemicals required for wastewater treatment are not considered for the purposes of this profile.

GHG (CO_2 Equivalent) Performance Range:
TOILETS

Current					*Attrition*		*Aggressive*	
Category (l/flush)	Total number of Units ($x 10^3$)	Total Water Used ($l/a x 10^9$)	Total Energy Used ($Kwh/a x 10^6$)	Total GHG ($kgCO_2$ equiv. $/a x 10^6$)	Number of Units ($x 10^6$)	Total GHG ($kgCO_2$ equiv. $/a x 10^6$)	Number of Units ($x 10^3$)	Total GHG ($kgCO_2$ equiv. $/a x 10^6$)
6	200	2.6	1.4	0.4	2960	5.3	6,000	10.7
13	3,000	85.4	44.9	11.5	4,200	16.2	5,000	19.2
19	16,800	699.0	367.7	94.5	13,440	75.6	9,600	54.0
Totals	**20,000**	**787.0**	**414.0**	**106.4**	**20,600**	**97.1**	**20,600**	**83.9**

The best possible scenario would replace all units with models from the best category to achieve total greenhouse gas emissions of 36.6×10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. A 15% market share of low flush toilets is assumed based on the 1991 statistic of 10%.
2. Population statistics are based on 1998 statistics.[8]
3. 0.000526 KWHr of energy is required to pump water to a household was calculated based on a common submersible house pump to draw the water from a depth of 30.5 metres (at 1/2 horsepower, 20 pounds of pressure).
4. Total flushes per day = population x days/year x flushes/day = 43.8 billion flushes.
5. Of the 20 million existing toilets in the marketplace, this means that each toilet flushes 2,190 times per year.
6. It is estimated that 15% of toilets are low-flush units (based on the 1991 statistics of 10%).
7. The available toilets in the market have the following performance levels:
    - Very Low-flush: average water usage 6 L/flush
    - Low-flush: average water usage 13 L/flush
    - Conventional: average water usage 19 L/flush
8. To determine the total water used by Canadian households using different types of toilets, the following equation was used: total flushes/toilet/year x # of toilets x litres/flush (based on toilet type)
9. To determine the GHG related to water pumping, water use x 0.000526 (energy to pump 1 litre) x 0.257 (conversion to GHG)

[7] Energy Pathways Inc. Technical Briefing Note on Water-Conserving Toilets. Ottawa: Environmental Choice Program. 1990.
[8] Statistics Canada Website. [http://www.statcan.ca/english/Pgdb/People/Population/demo02.htm] September 16, 1999.

WINDOW PRODUCT PROFILE

Product/Service Description:

Windows contribute to a large amount of heat loss in buildings, particularly in northern climates where buildings consume heat energy for approximately eight months out of the year. For this reason, sealed double-glazed windows have become commercially popular in the last twenty years because of their improved insulating properties compared to single-glazing. Important properties that determine the energy efficiency of windows are:

1. a low solar energy gain coefficient (SEGC), U, the property that regulates the thermal flow through the window and solar transmission in the building; and
2. a low thermal emissivity factor, the property that allows for small radiative heat transfer through the window and high reflectance.

Double glazed, argon gas filled windows with a low emmissivity (low-e) coating are currently among the best available window technology because they provide optimal thermal insulation performance. Future developments in window technology include triple and quadruple glazed, low-e coated windows with krypton gas fill. In the 1990's, 90% of new window purchases have been double-glazed, of these, 30% have been Ar-filled with a low-e coating.[1]

The product system studied is a 200 m^2 home (2000 sq. ft.) with 30 m^2 of window area using a gas furnace. Four window technologies have been modeled to account for the future, best, medium and worst available technologies on the market both today and in the future. These window technologies are:

1. Best: Triple-glazed, Kr-filled, low-e coated
2. Better: Double-glazed, Ar-filled, low-e coated
3. Medium: Double-glazed
4. Worst: Single-glazed

In the model, annual GHG emissions account for heating a residential unit of such a size, equipped with windows having these four performance levels. It is difficult to allocate the GHG burdens to the windows alone since energy consumption depends on the performance of other building properties, such as insulation. Hence, the GHG burdens of this particular product are difficult to assess in isolation to other building properties, and should not be compared to other appliances and building components of the residential unit.

Canadian Market Size:

There are approximately 11.6 million households in the ten provinces in Canada, based on 1997 statistics.[2]

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[1] Randi Ernst. Gas Filling of IG Units. Buffalo: F.D.R. Design Inc. 1995.
[2] Statistics Canada. Household Facilities and Equipment. Ottawa: Minister of Industry. 1997.

Annual Usage:

The relative comparative performance of different window systems is best illustrated during the winter months when residential units are heated. Their performance relative to one another is assumed to have minimal impact during the summer months.[3]

Product Turnover:

The growth rate of new window installations is approximately 9% per year.[4]

Life Cycle Considerations:

The life cycle stage of the product with the highest GHG loading:

Raw material extraction	Production	Use / service	Disposal
		X	

Windows influence significant environmental impact during their use stage. Other life cycle stages are comparatively small.

GHG (CO_2 Equivalent) Performance Range:

WINDOWS

Present (1998)					***Future (2020)***	
Category (Average)	Performance Range (m3/a)	GHG/Unit ($kgCO_2$ equiv./a)	Number of Units ($x 10^3$)	Total GHG ($kgCO_2$ equiv. $/a \times 10^3$)	Number of Units ($x 10^3$)	Total GHG ($kgCO_2$ equiv. $/a \times 10^3$)
Best	17	44.564	0	0	3,407	151,847
Better	19	49.401	3,126	154,430	7,951	392,768
Medium	23	57.606	7,294	420,185	1,262	72,699
Worst	29	73.773	1,159	85,414	0	0
Totals			**11, 588**	**660,030**	**12,620**	**617,313**

The best possible scenario would replace all units with models from the best category to achieve total GHG of 562 x 10^6 $kgCO_2$ equivalents per year.

Working Assumptions/Limitations:

1. The average performance of the best, better, medium, and worst categories is averaged over the west, central, and east provinces in Canada (i.e., the model geographically represents weather conditions in the three broad regions of Canada).

2. The average lifetime of a window unit is assumed to be 40 years. Households are assumed to replace all windows at once. The analysis does not take into account replacement, repair or maintenance burdens.

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[3] US Department of Energy. http://www.efficientwindow.org. 1998.
[4] .Statistics Canada, 1997.

3. The growth in households is estimated to be 9% per year based on 1997 Statistics Canada population data.

4. For the Future scenario, a growth rate of 0.8 million dwellings per year was assumed; hence 0.8 million new window installations per year. A time-horizon for the year 2020 was assumed. The model assumes that all single-glazed windows are retired and replaced with double-glazed windows.

5. Market share data for single, double, and double-glazed windows with Ar-fill comes from a study by FDR Design Inc. for sales in the northern U.S. states and has been assumed to apply in the Canadian market.

6. The program used to estimate annual heating and cooling energy for residential buildings equipped with the three window technologies is RESFEN. RESFEN was developed by the US Department of Energy.

Product Distribution: