CLIMATE OF CHANGE

Climate Crisis: Energy Solutions for BC

David Suzuki Foundation

Finding solutions

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Climate Crisis: Energy Solutions for BC

The world's top climate scientists recently stated their heightened concern over the threats caused by global warming.

Governments and industries have repeatedly promised solutions to the crisis, but consistently failed to deliver. This is unfortunate for two reasons. First, it means the climate problem is not being addressed. Secondly, it leaves BC without a clear energy plan at a time when growth and lifestyle patterns are impacting the quality of life, prices are rising and the natural environment is under increasing stress. The core of a sound climate policy is a wise energy policy – one that takes into account the full consequences of our addiction to fossil fuels and the automobile, and proposes a range of conservation and renewable energy options.

Consider BC's current situation: Costs for heating homes and running businesses are hurting individuals and the economy. The environment is being used as a free dumping ground for air pollution from fossil fuels. Climate change, one result of that pollution, is threatening many aspects of ecological and economic stability in BC.

Population growth, under today's urban development policies, is leading to an increase in the number of sprawling, low density communities in the Lower Fraser Valley, the Okanagan, southern Vancouver Island and many other parts of British Columbia. There is growing pressure on the development of agricultural land and more congestion on highways and in cities. We are seeing more air pollution, more land alienation, longer commutes to and from work, and dramatic growth in greenhouse gas emissions.

Increases in heavy duty diesel truck traffic for freight transportation are raising greenhouse gas emissions and air pollution and contributing to growing congestion problems in cities and around the province.

Increased demand for electricity and natural gas, in response to growth and development, is leading to new power plants, pipelines and gas processing facilities resulting in even greater air pollution, greenhouse gas emissions and higher energy prices.

> The core of a sound climate policy is a wise energy policy.

We, as British Columbians, have choices to make. We can choose to continue down today's well-worn path to greater social and ecological problems. Or we can choose to reduce our over-consumption of energy and environmental resources and, as a result, protect the climate, build a more sustainable society and provide ourselves with the best protection against high energy prices. To do this we must become more energy efficient in the way we live and in the way we move goods. We must design complete, compact communities with better housing, and cleaner industries and transportation systems. And we must increase renewable energy supplies, rather than encouraging more fossil fuel use.

Climate Crisis: Energy Solutions for BC contains a compilation of ideas on how to achieve these goals, as businesses, institutions and individuals. Through a combination of regulation, public investment, market mechanisms and cultural change, they can become common practice. The result will be a healthier society with a cleaner environment while we simultaneously address BC's share of the global warming problem and stimulate our economy.

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Executive summary

The evidence indicates that today carbon dioxide concentrations are 23 per cent higher than at any time over the past 420,000 years.

We know that the climate is changing due to global warming. This warming is occurring as a result of increases in the quantity of minute atmospheric gases responsible for the greenhouse effect. Scientists became aware of the greenhouse effect in the early 19th century when Jean-Baptiste Fourier conceived of the notion that trace atmospheric gases, such as carbon dioxide, were responsible for retaining some of the sun's heat in the lower atmosphere. He theorized that without these gases, the earth's temperature would not support the variety of life found on this planet.[1]

In the mid 19th century, Svante Arrhenius, a Swedish physicist used Fourier's greenhouse theory to calculate the impacts of the world's coal consumption on global temperature. His calculations suggested that, over time, concentrations of carbon dioxide would double and the average temperature would increase by 5 to 6 degrees Celsius.[2]

While these theories were considered far-reaching in their day, by the mid 1950s, scientists were measuring the carbon dioxide content in the atmosphere and finding relatively uniform readings at remote global sampling points. They found that, on average, carbon dioxide concentrations varied between 315 and 318 parts per million, with the variation attributed to changes in plant growth over the year.[3] To get a better understanding of the relevance of these findings in relation to historic patterns of carbon dioxide concentration, scientists began analyzing ice cores taken from long-lived glaciers. Since glaciers are formed by annual deposits of snow, which turn into ice, each year's accumulation has a distinct carbon dioxide content contained in air bubbles trapped with the snow. By examining these bubbles, a record of the earth's atmospheric carbon dioxide concentration can be determined. The longest ice core examined to date contains a 420,000 year record from the Vostok glacier in Antarctica. Other ice cores have been examined from glaciers around the globe yielding similar results. As such, the evidence indicates that today, carbon dioxide concentrations are 23 per cent higher than at any time over the past 420,000 years.[4]

For several thousand years prior to the Industrial Revolution, carbon dioxide concentrations fluctuated around 280 parts per million. Since then, concentrations have increased to 368 parts per million due to the combustion of massive quantities of fossil fuels and the widespread destruction of forests. With current growth levels atmospheric concentrations are expected to be two times pre-industrial levels sometime between 2030 and 2050. As a result, scientists predict that annual global temperatures will increase by an average of approximately 2.5 degrees Celsius in that period. It is anticipated that some areas, such as the Canadian Arctic, can expect to see much more drastic increases in the order of 10-12 degrees.[5]

The Canadian Arctic can expect to see much more drastic increases in the order of 10 to 12 degrees Celsius.

In response to concerns regarding the increase in carbon dioxide levels, the World Meteorological Organization and the United Nations Environment Program established the Intergovernmental Panel on Climate Change (IPCC) in 1988. The purpose of the IPCC was to assess the scientific information related to various components of climate change and formulate realistic response strategies. On publication of their first report in 1990, the IPCC concluded that, in order to stabilize carbon dioxide concentrations at current levels, immediate emission reductions of 60 per cent would be necessary.[6] In 1996 the IPPC released the Second Assessment Report on climate change which stated that "the balance of evidence suggests that there is a discernible human influence on global climate."[7] Over time the degree of scientific certainty is becoming stronger as more information is gathered and more analysis is completed. The most recent assessment states that "There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities."[8]

Following the receipt of the first IPCC report, the United Nations Framework Convention on Climate Change was developed as an international treaty aimed at preventing climate change. The UNFCC was negotiated in 1992 just prior to the United Nations Conference on Environment and Development, held in Rio de Janeiro. The treaty took effect on March 21, 1994, after the 50th country ratified it. Canada ratified on December 4, 1992. In total it has been ratified by over 176 countries.

The objective of the convention is the stabilization of "greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system." Further to the Convention there have been six Conferences of the Parties, including the Kyoto meeting held in December 1997, which resulted in a Protocol to the Convention, now known as the Kyoto Protocol. In November 2000 the sixth Conference of the Parties, which was to determine how specific emission reduction mechanisms described in the Kyoto Protocol would operate, was held in

The Hague, Netherlands. There was no conclusive result from the meeting and negotiators are expected to resume meeting in mid 2001.

At the 1997 Kyoto Conference, Canada agreed to reduce greenhouse gas emissions to six per cent below 1990 levels by 2012. On a per capita basis Canada is one of the largest consumers of fossil fuels and therefore one of the largest emitters of greenhouse gases in the world. In 1990, Canada's per capita emissions of all greenhouse gases were equivalent to 21.5 tonnes of carbon dioxide per person, but by 1997, this had grown to 22.7 tonnes.[9] Canada's per capita emissions of carbon dioxide alone equalled nearly 18 tonnes per person per year. The global average is 3.8 tonnes and the continent of Africa had per capita emissions of 1.1 tonnes.[10] In 1996, BC's per capita emissions were about 16 tonnes per person. This staggering illustration of the disproportionate levels of greenhouse gas emissions per person clearly indicates where responsibility for greenhouse gas reduction lies: the developed nations with their high levels of energy consumption.

If leadership from industrialized countries remains absent, global greenhouse gas emissions will continue to rise causing increased global warming. For every 1 degree increase in temperature there is expected to be an overall increase in precipitation of 5 per cent, leading to changes in intensity and magnitude of rain and snow fall. In other words this increase will often come in sudden downpours with negative impacts. Other expected effects include changes in soil moisture content, increases in sea level and increased prospects for extreme weather events, floods and droughts.[11] The world wide insurance industry has already noticed an increase in natural disasters over the past half century. Weather related natural disasters have increased four-fold since 1950 with the costs increasing 14 fold. By 1998, the economic costs arising from natural disasters surpassed $90 billion US. Between 1984 and 1998 economic losses in Canada rose by over 30 times, increasing from $39 million to 1.45 billion.[12]

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

Climate change has already been detected in BC. Over the past century coastal temperatures have increased by about 0.6 degrees, while the interior has warmed by over 1 degree - twice the rate of the global average.[13] Due to our mid-latitude location it can be expected that BC will continue to follow this trend in relation to global average temperature. In the short term the Lower Fraser Valley may experience some of the largest climate change impacts in southern BC. Climate model predictions suggest warmer, drier weather in the summer will produce periods of hot, stagnant weather which would result in more severe smog episodes.[14] In addition to increased air pollution, climate change may also affect the way air pollution disperses through the atmosphere because of its impact on air currents and heating patterns.[15] Climate change will also change water levels, temperature and peak flow timing for rivers and streams leading to further pressures on already critically threatened species, such as salmon, and the communities that depend on them. For example the Fraser River, one of Canada's biggest salmon producers, often reaches temperatures of 21-22 degrees while the salmon are returning to spawn. If the temperature increases a further one or two degrees, most of the returning salmon will likely die before spawning.[16]

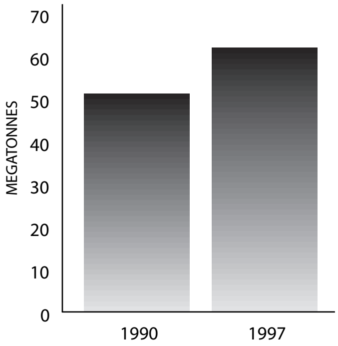

FIGURE 1. BC'S GREENHOUSE GAS EMISSIONS, 1990 AND 1997

SOURCE: Environment Canada

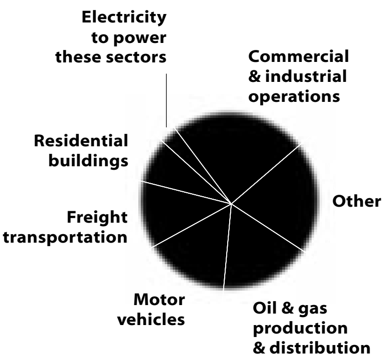

FIGURE 2. ENERGY EMISSIONS IN BRITISH COLUMBIA, 1997

SOURCE: Environment Canada

BC emissions and trends

British Columbia, which contains 13 per cent of Canada's population, is responsible for approximately nine per cent of Canada's emissions. In 1995, BC committed to stabilize greenhouse gas emissions at 1990 levels by the year 2000. In fact BC missed this target and as a result emissions grew from 51.2 million tonnes in 1990 to 61.9 million tonnes by 1997. Energy related emissions and emissions from industrial processes accounted for 54 million tonnes of that total. Emissions from agricultural operations and from decomposing organic matter and waste handling made up the remainder. The largest components of energy and process related emissions in 1997 were: commercial and industrial operations which produced 24 per cent; oil and gas production and distribution with 17 per cent; and a further three per cent for electricity which was produced to power these sectors; freight transportation which produced 12 per cent, personal motor vehicles accounted for 16 per cent and residential buildings with 8 per cent.[17]

By analyzing trends for these major energy using sectors of our economy and proposing policies which can counter these trends, we hope to provide the public and interested parties with a critical document to assist in the development of a much more efficient economy with significant greenhouse gas reductions. For each sector, analysis of current emission trends is presented with specific policies, programs, technologies and practices for achieving a highly efficient, low emission future. We intend this work to act as the basis of discussion, debate and decisions on these new economic opportunities for a cleaner environment and more liveable communities.

Urban land use and transportation

Current prospects for the urban environment in BC are not positive. In fact, due to population pressure in our major urban areas, we can expect to see more vehicles travelling greater distances, more land alienation, and more local air pollution. In 1990 approximately three million people lived in BC. Population exceeded four million by 1999 and by 2015, we are expected to grow to five million residents, resulting in an additional 500,000 new homes and apartments and 800,000 new vehicles. Eighty per cent of this population increase will be in urban areas, primarily in the Lower Mainland, on the east coast of Vancouver Island and in the Okanagan Valley.

By 2015, the Greater Vancouver area will have more than three million residents, reflecting a 30% growth rate between 2000 and 2015. At the same time, the Fraser Valley's population is expected to increase by 38%. The cities of Abbotsford, Langley and Chilliwack are expected to have growth rates in the range of 50-70%. All of these increases will put further pressure on transportation systems and energy consumption, contributing to climate change and a myriad of other environmental impacts associated with sprawling land use and auto dependence. Similar environmental stresses will become more prevalent in the Greater Victoria area which is expected to grow by 17% and in the Okanagan Valley, which is expected to grow by over 4,000 persons per year, with a 40% increase in total population by 2015 [18]

Today there are over one million vehicles registered in the Lower Mainland, making three million auto trips each day, with two million of those being made in single occupant vehicles. By 2021, it is projected that the vehicle stock will double to two million. If current trends continue it is expected that much of the growth in personal vehicle sales will be for light trucks, including pick-ups, minivans and sport utility vehicles. In the most recent energy forecast from the government of Canada, Canada's Emissions Outlook, (CEO-1999), the number of cars on the road in BC is expected to grow from 1.4 million to 1.6 million while the number of light trucks is projected to grow from 750,000 to 1.3 million.[19] Recent data support this projection since the total number of cars on the road in Canada fell from 11.1 million in 1990 to 10.6 million in 1997 while the number of light trucks increased from 3.45 million to 4.85 over the same period.[20] Since trucks are less energy efficient than cars, emissions from these vehicles grew from 75.6 million tonnes to 81.7 million. Based on current projections, BC's greenhouse gas emissions from transportation are projected to grow from about 10 million tonnes in 1990 to 16 million by 2015.

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Commercial and industrial operations

Commercial and industrial operations are a source of greenhouse gas emissions from specific processes and energy consumption directly on-site, as well as, indirectly from the sources of electricity used to power these operations. Within BC these operations consume 70 per cent of the province's electricity. In addition they produce about 24 per cent of the province's greenhouse gas emissions. From 1990 to 1997 direct emissions grew from 11 million to 12.5 million tonnes. The national energy forecast indicates that, between 1990 and 2015, direct greenhouse gas emissions from on site energy consumption and industrial processes in the commercial and industrial sectors in BC will grow to 16 million tonnes per year. In addition to the direct emissions from energy use, increased electricity demand in these sectors will result in the addition of new electricity generation plants by BC Hydro. For both commercial and industrial buildings and operations, demand for electricity in 2015 will have increased by 64% and 36% respectively. [21]

As a result of this demand and increases in residential electricity consumption, BC Hydro is projecting that overall electricity use in BC will grow by 30 per cent between 1998 and 2015.[22] While electricity has been historically produced primarily with hydropower, BC Hydro is now developing natural gas pipelines and gas fired turbines to generate electricity. Analysis of recent plans by BC Hydro reveals that, as a result of the development of these gas plants, greenhouse gas emissions for electricity generation are scheduled to increase from about 600,000 tonnes per year in 1990 to nearly 6 million tonnes by 2015.[23]

The growth in electricity generation from natural gas combustion and from population and housing trends will result in natural gas usage increasing by 2.5 per cent per year for a cumulative growth of 52 per cent over 1997 levels by 2015. This will drive the need for new natural gas development, as well as new processing plants and distribution networks, leading to greater emissions in the fossil fuel production and distribution sector.

Upstream oil and gas

Upstream oil and gas is one of the fastest growing sources of emissions in BC.

In addition to the emissions released from using oil and gas as energy products, the exploration, development, production and distribution of these products results in significant greenhouse gas and other emissions. Currently this sector, referred to as "upstream" oil and gas, is one of the fastest growing sources of emissions in BC. In 1990 this sector produced 5 million tonnes of greenhouse gases, but by 1997, grew to 7.8 million tonnes, a cumulative growth rate of nearly 60 per cent. By 2015 emissions are projected to grow to 8.9 million tonnes. While this represents a 96 per cent cumulative growth rate over 1990 levels, this projection is conservative since it does not take into account any growth resulting from the recent restructuring of provincial oil and gas royalties which occurred in 1998. As a condition of the BC government's commitment to lower royalties by 20 to 40 per cent, the oil and gas industry agreed to double oil and gas production capability by 2008.[24] Recent and significant increases in the price of, and demand for, natural gas will reinforce the production and emission trends noted above.

Freight transportation

Over the past decade there has been a concerted effort to shift freight transportation away from railways and onto heavy diesel trucks. This trend has resulted in more highway congestion and in a dramatic increase in air pollution and greenhouse gas emissions. In 1990, Canada's diesel truck fleet produced nearly 25 million tonnes of greenhouse gas emissions. This figure grew to 36 million tonnes by 1997. At the same time emissions from rail transportation fell from 7.1 million tonnes to 6.4. Emissions for railroads in BC remained stable over this period at 1.47 million tonnes while emissions from on-road diesel increased from 3 million tonnes to 3.7 million.

The current forecast, CEO-1999, indicates that greenhouse gas emissions from energy consumption in the freight transportation sector in BC will grow from 4.6 million tonnes in 1990 to 7.3 million tonnes in 2015, an increase of 56 per cent. Almost all of the growth in emissions is due to increased trucking activity.[25] Between 1990 and 2015, rail activity will increase 33 per cent with no increase in emissions. According to the forecast trucking activity will increase 104 per cent with an 85 per cent increase in emissions. However from an examination of recent trends, this appears to be a very conservative forecast. Whereas BC trucking emissions grew 60 per cent in seven years, between 1990 and 1997, the forecast projects they will grow just 16 per cent in 18 years between 1997 and 2015. In essence, the forecast projects trucking activity will grow at about one-third the rate experienced since 1994.[26] However if the carbon dioxide emission trends of 1990-1997 were simply extrapolated, freight emissions in 2015 would be 12.5 million tonnes, or 184 per cent above 1990 levels and 79 per cent above the forecast used for 2015.

Greenhouse gas emissions from the freight transportation sector will increase 56 per cent.

BC needs and opportunities

Canada's energy forecast indicates that by 2015 BC's emissions will be 52 per cent over 1990 levels.[27] To counter these trends and contribute to the realization of Canada's Kyoto greenhouse gas target, which is merely a first step towards climate stabilization, significant actions are required at the federal, provincial, municipal, corporate and individual level. The David Suzuki Foundation commissioned four expert studies on specific greenhouse gas reduction measures for key energy consuming sectors of the BC economy: transportation and land use, freight movement, commercial and industrial businesses, and oil and gas production. Through the analysis of these critical sectors, and specific emission reduction steps available within each sector, it is our hope to contribute to the development of effective BC policies that will see emissions of greenhouse gases and local air pollution drop substantially.

"Powershift: Cool Solutions to Global Warming,"[28] an analysis of national greenhouse emissions by Ralph Torrie, describes a practical and achievable outcome for the implementation of today's most energy efficient technologies and practices. Using a sophisticated analytical model, Torrie Smith Associates found that the application of available technologies could reduce emissions from energy use in Canada by more than 60 per cent from what they otherwise would have been. Under current trends and assumptions, emissions would grow to 650 million tonnes by 2030 as a result of increased energy use. By allowing high efficiency techniques and technologies to be dispersed throughout the economy, emissions fall to 240 million tonnes. On a per capita basis, BC's portion would be about 13 per cent of the total or 31.2 million tonnes, roughly half of what they are today.

Applying the practices and technologies described in *Climate Crisis: Energy Solutions for BC* will allow us to make the necessary shift in how we use energy and put us on the path to sustainability described in Power Shift. For example, implementing the measures and policies found in the Land Use and Transportation report can reduce greenhouse gas emissions by 1.5 million tonnes and 2 million tonnes per year for the Vancouver area alone by 2010 and 2020 respectively, representing a reduction of between 19 and 33 per cent by 2010 and 22 to 44 per cent by 2020 from current trends. It is estimated that at a provincial level, land use planning reform alone can produce carbon dioxide emission reductions of 17% at cost savings of 20% in BC by 2010.[29]

All four reports included in *Climate Crisis: Energy Solutions for BC* indicate that reducing greenhouse gases will not only help prevent climate change but will also provide environmental, social and economic benefits. For example, reducing combustion of motor vehicle fuel through a combination of efficiency improvements, transportation demand management and sustainable community design will reduce local air pollutants from the automobiles themselves and from the production of these fuels. This will result in reductions in the major components of smog: ozone, fine particles, volatile organic compounds and acidic gases such as nitrogen oxides and sulphur oxides and thereby improve public health and quality of life. Transportation demand management and sustainable community design produce other environmental benefits as well, including reduced stormwater runoff and water pollution, preservation of green space and wildlife habitat. Reducing the amount of vehicle traffic will also increase safety for cyclists and pedestrians, reduce vehicle accidents and reduce the demand for high-cost, car-oriented infrastructure. Furthermore these policies and programs provide a positive economic benefit since they lead to a reduction in urban sprawl which saves money by reducing the costs of municipal infrastructure such as sewer, water, transport and power lines.

The U.S. is now saving $150 to $200 billion annually as a result of energy efficiency measures.

Similarly, reducing the energy intensity of freight transportation in BC will not only reduce greenhouse gas emissions but will also make the economy more competitive in the long-term since fuel costs are a key component of transportation economics. For example, the U.S. Department of Energy estimates that the country is now saving $150-$200 billion annually as a result of energy efficiency measures taken during the 1970s oil embargo. Reducing road transportation of freight also reduces road expansion costs, road damage, traffic collisions and improves the quality of life. In fact, a 20 per cent mode shift of BC inter-city freight in 2015 would reduce annual public costs by about $63 million (road costs $14 million, collision death and injury costs $17 million and congestion costs $32 million).[30] Improvements in freight management would also result in a more efficient use of trucks and drivers picking up and delivering freight and permit a reduction in the need for truck tractors which could accelerate scrapping old trucks.

Energy efficiency investments create 35 person-years of employment per million dollars invested.

There are also significant employment benefits arising out of greenhouse gas reduction strategies and programs which promote the efficient use of energy and resources. In the freight transportation sector there are opportunities for increased employment in the development of alternative fuels, fuel cells, more fuel-efficient vehicles and better management processes between modes such as truck and rail. Similarly reducing greenhouse gas emissions in the upstream oil and gas industry generally results in an overall increase in employment particularly in higher skilled jobs. For example there are increased employment opportunities for engineering and construction jobs for upgrading and replacing key components for oil and gas extraction and processing units. There is also an increased need for technical and field staff resources for power balancing, testing and leak detection and repair programs. Highly trained staff and operators will also be needed to install, maintain and operate centrally operated control systems.

Increasing the energy efficiency of residential and commercial buildings, as well as commercial and industrial operations, will also lead to increased employment throughout BC. While directing investment towards improvements in energy efficiency results in a decrease in the need for energy supply projects and power plants, the net result is an increase in overall employment and economic activity. A 1993 study commissioned by the BC Energy Council on the employment impacts of investments in energy efficiency found that, when compared with traditional energy supply projects, investments in energy efficiency create:

- Similar numbers of direct and indirect jobs but create about twice as many total jobs, due to the respending of cost savings
- Jobs that better match the skills of BC's unemployed and, therefore, make a much large contribution to reducing BC unemployment
- Jobs whose geographical distribution better matches that of the BC population, rather than jobs that are concentrated in less populated areas.
- Jobs that, on average, last longer.

The study also found that construction-related measures (e.g., improved insulation, window replacement) tend to produce more direct and indirect jobs per investment dollar than the substitution of more energy efficient equipment (e.g., lighting or motors). [31]

Similar work by the Pembina Institute found even greater disparity between job creation for energy supply in comparison to energy efficiency. Pembina reviewed 30 studies and research reports on job creation from energy related projects and found that energy efficiency investments created 35 person-years of employment per million dollars invested, compared to seven person-years of employment for similar investments in conventional energy resources.[32]

Government can further enhance the environmental, economic and employment benefits in all of these sectors by developing greenhouse gas reduction policies which:

- Encourage industries to pro-actively pursue their own research and development into equipment and process-related improvements
- Support BC firms with the ability to pioneer new technologies (e.g. Ballard fuel cells)
- Support energy efficiency in houses and businesses
- Keep research and development dollars in BC and help to preserve and develop high technology jobs.[33]

The opportunity to pro-actively address global warming and climate change while enhancing our economy is here today. The following summary reports provide an overview of available solutions for specific sectors of the economy. British Columbians can use these solutions as a foundation on which to create a more sustainable society and strengthen the economy while significantly addressing climate change and reducing environmental impacts. We look forward to seeing these economic and environmental solutions implemented.

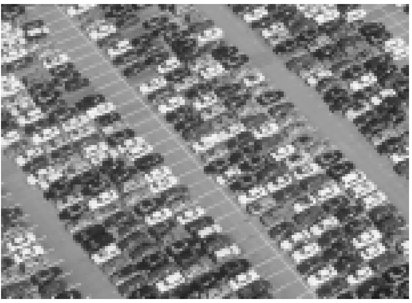
1

Urban Land Use and Transportation

BY ROB MACDONALD[34]

POLICY-MAKERS FROM AROUND THE WORLD ARE STRUGGLING WITH URBAN management issues. Population growth, decreasing rates of public transit use, energy inefficient households, and increasing levels of urban sprawl and automobile dependence are intensifying stress on the global environment and contributing to climatic change. The same issues plague politicians and planners here in BC where citizens and governments not only battle over 'defining' urban problems (e.g. is the transportation problem congestion, air pollution, cost, or all of the above?), but inconsistent public opinion results paralyse local planners.

Simply through the energy intensities of urban areas, cities play an enormous role in climate change. Transportation, land uses, and residential buildings are critical components of urban infrastructure that influence how we – as citizens – use energy. With 47% of BC's total greenhouse gas emissions coming from transportation (39%) and residential buildings (8%) in 1997, greenhouse gas management must focus on these sectors to be effective in reducing the threat of climate change, with particular attention being invested in transportation.[35]



Approximately half of all transportation greenhouse gas emissions in Canada originate in urban areas. Of this, over three-quarters come from personal use autos, vans, sport utility vehicles and light trucks. Any strategy to reduce greenhouse gas emissions from transportation must focus on urban passenger transportation.[36]

Passenger transportation is the single largest source of greenhouse gas emissions in BC and Canada, accounting for approximately 16% (BC) and 12% (Canada) of total emissions in 1997.[37] In 1997 total greenhouse gas emissions in British Columbia were 61.9 megatonnes (Mt) of carbon dioxide equivalent (CO_2E), an increase of 21% since 1990. This growth is largely attributed to increased emissions from the transportation sector, which made up nearly 40% of total greenhouse gas emissions in BC (with passenger vehicles making up approximately 40% of total transportation emissions).[38] Of particular concern is the growth in greenhouse gas emissions from light-duty passenger vehicles,

To reduce greenhouse gas emissions from cities and regions in BC we must change the way we plan, organize, and build communities.

such as sport utility vehicles, which experienced a 60% increase in emissions between 1990 and 1997. If current trends continue, between 2000 and 2015 BC's passenger transportation greenhouse gas emissions are expected to increase by 19%, with a 50% growth in emissions from light-duty trucks.[39]

With almost half of BC's energy-related greenhouse gas emissions coming from the transportation and residential buildings sector, the implementation of greenhouse gas management policies in these sectors is required now if Canada hopes to achieve its Kyoto commitment by 2008-2012.[40] These policies should aim to reduce vehicle kilometres travelled (VKT) per capita, the volume of vehicles travelling, the emissions per vehicle (i.e. improve vehicle fuel efficiency), and improve residential energy efficiency through sustainable urban development and design measures.

In order to reduce and minimize the greenhouse gas emissions from cities and regions in BC we must change the way we plan, organize, and build our communities. From integrated transportation and land use planning, to climate friendly site design practices, to the application of energy efficient technologies in our homes, these strategies can all lead to reduced energy consumption levels and decrease greenhouse gas emissions.

Urban design

In designing cities, it is widely accepted that there is an intimate relationship between transportation and land use planning.[41] This relationship determines our level of energy and resource use, environmental impacts, such as air and water pollution, social impacts, and public costs. At the heart of this relationship lies *density*. Density is the critical link that ties land use and transportation planning together, and plays a significant role in determining the efficiency of land use patterns and transportation systems.[42] It is thus believed that urban density is the most significant determinant of how dependent we are on automobiles. For example, to support public transit and local commercial services, it is important that there exists a critical mass, or density, of people that live within close proximity of these services (typically within 400 meters, or a 5-10 minute walk). The minimum density to make transit and local commerce viable is believed to be approximately 40-50 persons per hectare (i.e. 20 residential units per hectare, equating to 20 persons per acre, or 8 units per acre).[43] This is still fairly low density, comparable to single family housing. BC's largest urban area – the GVRD – is even less than 40 persons per hectare, on average, which helps explain its low levels of transit ridership and extremely high levels of vehicle use. It is believed that densities would be even lower for the Victoria and Kelowna areas. In addition, the GVRD fared much worse than other Canadian cities, which still did not meet the land use-transportation efficiency criteria that exist in European cities. Canadians are therefore much more dependent on their cars than Europeans.

As a result, transportation-related greenhouse gas emissions per person are two to four times higher in Canadian cities than in European ones.[44] Again, low-density urban sprawl is the primary reason for these differences.

This transportation and land use connection forms an *inverse relationship*, where personal vehicle use (i.e. VKT) decreases as urban densities increase (and vice versa).[45] This is effectively illustrated in the GVRD, where per capita vehicle-kilometres travelled are 40% less in urban areas where densities are double that of suburban areas.

The design of our cities not only influences our transportation behaviours and per capita emission levels, but produces a series of environmental and social impacts, such as: increased land requirements (for roads and housing) which reduces green space (i.e. agricultural lands, forests, and wetlands); higher physical infrastructure costs (e.g. utilities, roads, transit); higher per capita water use (for lawn irrigation); higher stormwater pollution (from increased runoff rates in newly developed and low-density areas); higher domestic heating energy use (i.e. shared insulation efficiencies lost in single-family dwellings); higher social costs (e.g. isolation, road rage, higher transportation costs due to the fact that auto ownership is essentially a requirement); and decreased rates of recycling (due to increased collection costs in sprawling cities).[46]

Transportation related greenhouse gas emissions per person are two to four times higher in Canadian cities than in European ones.

It is therefore important for urban centres to 'integrate' transportation and land use planning, allowing land use planning to guide transportation in order to achieve spatial and energy efficiencies. Integrated transportation and land use planning can thus reduce the social, environmental, and economic costs associated with unsustainable urban planning. As can be seen, transportation systems and land use patterns ultimately play a large role in determining the level of sustainability in our urban centres, and the extent of our influence on global climatic change.

Government action

To design and develop complete, transit-oriented communities, municipal governments – with the assistance of the provincial government – should:[47]

1. **Identify areas for compact and nodal development in regional land use plans.** This involves identifying areas for intensification, higher-density development, and mixed-use zoning and designating them in regional/ municipal land use plans.
2. **Zone for mixed-use and intensification** through:
   a. Restructuring Development Cost Charges (DCCs) to accurately reflect the differential costs incurred by different development patterns (i.e. nodal, compact and sprawl), such that DCCs encourage compact and nodal development through full-cost pricing mechanisms. This restructuring should be 'revenue-neutral,' whereby DCCs are discounted for

projects that are consistent with the principles of sustainable urban development and inflated for projects that do not conform to the goals of building compact and complete communities (i.e. sprawl-like development proposals).

b. Offering density and height bonuses to developers in areas targeted for intensification, especially near transit facilities.
c. Allowing for transfer of development rights to encourage densification of targeted areas.[48]
d. Amending the building permit process to require minimum shares of multiple housing types, compact lots, and mixed-use developments (for example, new developments that achieve the following housing mix: 20% detached single-family home, 20% attached single-family home, 20% townhome, 30% apartments/condos, and 10% affordable housing).
e. Requiring a minimum of 5,000-10,000 ft^2 of commercial/retail floor space per 1,000 residents to satisfy basic neighbourhood shopping needs, and a minimum of 20,000-30,000 ft^2 per 1,000 residents to satisfy the majority of the commercial/retail needs of a higher density, complete community.[49]
f. Reducing lot sizes by decreasing yard and building setbacks.
g. Amending zoning to allow secondary, or ancillary, suites. In the last year, several municipalities have adopted policies on secondary suites, including the District of North Vancouver, Coquitlam and Port Coquitlam. These policies legalize secondary suites in most residential zones, provided planning and building code requirements are met.[50]
h. Developing grid-like street patterns and short block lengths.
i. Developing a fast-track approval process for developments that meet or exceed guidelines.
j. Establishing urban growth boundaries (e.g. greenbelts) and growth concentration areas (GCAs) to focus growth in urbanized areas identified for population growth. These strategies reduce the spatial expansion of the city (i.e. reduce urban sprawl) and limit growth in urban fringes. Provincial legislative tools that enable municipalities and regional districts to better integrate land use planning to manage urban growth, agriculture issues, transportation, and green zone protection are the Growth Strategies Statutes Amendment Act and the Farm Practices Protection Act, which ensure long-term protection of agriculture and farming practices.
k. Requiring that all new developments include cycling, pedestrian, and transit access and amenities, such that buildings are oriented to provide pedestrians and cyclists with direct access to the streets by implementing a “Green Points” system at the provincial level. The system would

allocate points for preferred standards of development, such as density, mixed-use, transit orientation, energy efficiency in buildings, cycling routes, transit shelters, street benches, landscaping and set-backs in target areas.[51]

Transportation management policies

To reduce per capita vehicle kilometres travelled and increase vehicle fuel efficiencies, the provincial and municipal governments should implement a package of Transportation Demand Management (TDM) measures that apply incentives and disincentives to shift transport behaviour. The following package of *Primary TDM Policies* would be most effective in reducing greenhouse gas emissions in BC's urban centres:[52]

1. **Investments in public transport**: improved transit delivery, major investments in rapid transit, and the development of "Transit Incentive" programs. Transit delivery can be improved through increased bus service (i.e. frequency and speed), alternative transport services (e.g. neighbourhood shuttle services), and the implementation of Rapid Bus services. Major investment in rapid transit can be accomplished through the development of busways, LRT, commuter rail, inter-modal connections, and corridor protection for transit and inter-modal connections. To complement these measures, the following "Transit Incentive" programs should be implemented: tax exempt treatment of transit passes, transit priority measures, discounted student and employee transit passes (e.g. university U-PASS and employer EcoPass programs),[53] integration of transit amenities (e.g. schedules, shelters, benches), and enhanced Traveller Information Systems (e.g. public transit telephone information systems, transportation terminal automated information kiosks).
2. **Introduction of pricing mechanisms**, with revenues dedicated to greenhouse reduction initiatives. Mechanisms such as:
   a. Road pricing: continuous facility pricing, congestion pricing, and/or area-wide pricing.
   b. Distance-based fees: preferred or flexible insurance rates (including pay-at-the-pump premiums) and vehicle-kilometres travelled (VKT) charges which could vary by type of vehicle. Distance-based fees alone can reduce total VKT by 12%.[54]
   c. Increasing Vehicle Registration or Driver Licensing Fees.
   d. Motor Vehicle Purchase Taxes.
   e. Feebate or tax credit program.[55]
   f. Phased increases in gasoline and diesel taxes, both provincially and federally, with the province lobbying the Canadian government to

Provincial and municipal governments should implement a package of incentives and disincentives to shift transport behaviour.

match increases in fuel taxes. These tax increases should be accompanied by an equivalent decrease in other taxes (e.g. sales tax, payroll taxes, income taxes) consistent with the principles of ecological tax reform.

3. **Parking management strategies** such as:
   a. Parking pricing (with revenues dedicated to greenhouse gas reduction initiatives): Increased and marginalized parking prices, such that 'free' parking is eliminated, SOV and peak-period parking is more expensive, parking rates are no less than transit rates, and parking services are reformed from long-term permits (i.e. monthly) to short-term rates (i.e. hourly, daily).
   b. Parking supply:
      i. Parking supply restrictions and relaxed development requirements – through parking code measures, flexible zoning, and parking requirement concessions for transit facilities, discounted transit passes, or TDM programs – that limit parking stalls per resident, employee, or area (e.g. set maximum parking requirements);
      ii. Cashing out paid/free parking, enabling employees to choose between a parking space or the cash equivalent of parking to be used for transit, cycling, walking, or at the employee's discretion;
      iii. Preferential parking for rideshare vehicles through the provision of parking discounts and proximity benefits.
4. **Development of innovative ridesharing (i.e. carpool and vanpool) and carsharing programs** to increase the flexibility, service, convenience, access, and speed using technologies such as Geographical Information Systems (GIS) and the internet to improve user convenience (e.g. schedules and reservations via the internet).
5. **Public education, awareness, and outreach programs**, such as:[56]
   a. Campaigns that promote the benefits of transit, walking and cycling; and driving 'best practices'; and
   b. Vehicle maintenance, driving habits (e.g. idling), vehicle specifications, use of block heaters, fuel efficiency information, and emissions labelling.
6. **Integrate ferry, rail, and transit service schedules** to optimize intermodal travel.

The following *Secondary TDM Policies* should be used to complement the above primary policies:

1. **Lobby federal government to implement mandatory Company Average Fuel Consumption (CAFC) efficiency standards for new vehicles**; apply a combined standard to all light duty vehicles (i.e. cars, light duty sport utility vehicles, and light duty trucks) and consider an additional or combined standard for medium duty personal sport utility vehicles; and improve

existing fuel efficiency standards to 5.0 litres and 6.0 litres per 100 km for all new cars and light trucks by 2005.[57]

2. **Enhancements to the bicycle and pedestrian environment** through the following traffic calming measures: sidewalks, signalized intersections, 'end-of-trip' facilities (e.g. showers, lockers), cycle routes, direct pedestrian routes, bike racks, narrow streets, traffic circles, bus shelters, street furniture, alternative road surfaces, curb blowouts and sidewalk extensions, landscape islands, bus bulges, and improved lighting.
3. **Investment in Intelligent Transportation Systems** (ITS) to improve traffic control.
4. **Flexible work schedules**, such as telecommuting, compressed work weeks, and flex-time.
5. **School trip reduction programs** such as: discounted transit pass programs (e.g. U-PASS at the University of Victoria, which should be extended to all universities, colleges, and high schools), 'Walking/Biking School Bus' programs (e.g. *Way to Go* program for BC elementary schools), carpooling, and weekly alternative transportation day prizes/competitions.
6. **Voluntary region-wide commuter trip reduction programs** to be targeted at large employers and institutions (50-100+ employees). These programs should be co-ordinated by worksite transportation management administrators, who implement programs such as: transit and rideshare incentives (discounts and preferential parking), parking disincentives (increased SOV parking), flexible work schedules, and "cashing out paid/free parking." If unsuccessful, mandatory commuter trip reduction bylaws, such as those used in Seattle, should be developed.

Energy efficiency in new and existing residential buildings must be improved.

Energy efficiency

Energy efficiency in new and existing residential buildings must be improved through the development of municipal level 'umbrella' programs, energy-aware planning and development policies, and sustainable site design practices. In support of this measure, the following policies should be adopted:[58]

1. **Municipalities should promote and deliver energy efficiency programs** at the local level through private-public partnerships with utilities, energy management firms (EMFs), and other levels of government. BC programs could emulate the characteristics of the Better Buildings Partnership in Toronto, which successfully integrates resources, skills, knowledge, and activities of various partners.[59] Municipal Umbrella Programs and energy-aware planning and development policies should therefore include:[60]
   a. Implementation of a National Energy Efficient Housing Renovation and Retrofit Program. This program would be designed as a

comprehensive and integrated initiative to encourage consumers to upgrade the efficiency of existing homes. It could include: incentives to retrofit/renovate (tax breaks such as removal of GST, PST, HST, and/or accelerated depreciation of costs in rental housing); access to financing; home energy audits and labeling (Energuide for Houses); renovator training/certification; a retail element involving sales force training; and involvement of community based delivery agents.

b. Ensuring that new developments meet National Standards Program for Equipment and Appliances. This policy requires the federal government to develop minimum efficiency standards for a range of products, with new standards for introduction in 2004. Products to be addressed would include HVAC (heating, ventilation, and air-conditioning) equipment, including heat recovery ventilators (HRVs); major appliances; domestic water heaters; lighting; windows and doors; motors; and gas fireplaces. Energuide labeling would also be included for most products.

c. Implementation of a provincially mandated R-2000 Program as the minimum building code for 50% (minimum) of all new residential construction starting in 2001. R-2000 program has promoted energy efficient residential construction since 1982, using the “House as a Systems” approach to energy management. This policy will require more resources for marketing, access to preferred mortgage rates (in cooperation with the banking community), expanded builder training and certification, and streamlined requirements and certification process, along with a strong commitment from all levels of government and industry.

d. Sustainable site design practices which include:

   i. Use of microclimate and vegetative cover in new residential buildings. Reductions in greenhouse gas emissions are achieved by reducing the need for heating and cooling energy through the strategic use of vegetation and landscaping to provide wind shielding, solar gain and summer cooling.

   ii. Increased solar design in new residential buildings by orienting lots, building glazing and roof pitch. Passive solar design captures sunlight within the building’s elements and releases that heat during periods when the sun is not shining. Reductions in greenhouse gas emissions result from altering community layout in a way that encourages solar design, for example, orienting new developments on an east-west axis to maximize the number of dwelling that receive sunlight between 9:00 AM and 3:00 PM.

Environmental and economic benefits

The greatest greenhouse gas reduction benefits are realized when the above measures are introduced as a 'package.' The total *Land Use, Transportation, and Buildings' Measures* package may reduce greenhouse gas emissions by 1.539 Mt and 2.117 Mt per year for the GVRD alone by 2010 and 2020, representing a reduction of between 19-33% by 2010 and 22-44% by 2020 from business-as-usual scenarios.

Though the majority of greenhouse gas benefits will likely result from changes to land use and transportation planning in the GVRD, the rest of BC also holds great potential. One study concludes that BC can expect energy savings of 15-30%, cost savings of 15-30%, and carbon dioxide (CO_2) and nitrous oxide (NO_x) reductions of 30-45% by 2010 as a result of a package of community energy planning measures similar to those proposed in this study.[61] It further concluded that, at an aggregate level, land use planning reform alone is estimated to produce carbon dioxide emission reductions of 17% at cost savings of 20% in BC by 2010.

Land use planning reform is estimated to produce CO_2 emission reductions of 17% with cost savings of 20%.

In the short-term, the transportation policy package will be the most effective in reducing greenhouse gas emissions, given the lag time associated with land use changes. Furthermore, a broader package of measures and policies – that include the electricity, commercial, industrial, and heavy duty transport sectors – will be required to offset the significant population growth expected in BC in the future. However, this package of land use, transportation, and buildings measures is a *strong first step* towards helping BC and Canada not only achieve its Kyoto commitments, but address longer-term climate change concerns.

By increasing the share of compact and nodal development through zoning for mixed-use, higher density, pedestrian and transit-oriented communities, significant benefits will be experienced in the form of reduced local emissions, commonly referred to as *criteria air contaminants* (such as carbon monoxide, nitrogen oxides, volatile organic compounds, particulate matter, and sulphur dioxide). As with greenhouse gas reductions, reduction in emissions of CACs between 2010 and 2020 are expected to be three-fold.[62] In addition, compact and nodal development provides a series of other environmental and social benefits, such as reduced storm-water runoff, and thus water pollution, from smaller development footprints (i.e. fewer roads, smaller lot sizes, and increased site perviousness); preservation of green space and wildlife habitat; access to affordable housing; and improved social integration and 'sense of community.'

The implementation of the TDM policy package is expected to reduce criteria air contaminants from 15-21%, depending on the pollutant (e.g. particulate matter 2.5 is expected to decrease by 14.6% while carbon monoxide is expected to decrease by 20.9% by 2020). In addition, reduced vehicle traffic increases safety for cyclist and pedestrians, reduces vehicle accidents, water pollution, and the demand for auto-oriented infrastructure. Finally, TDM supports growth management efforts, thereby reducing the cumulative impacts of urban sprawl.

Improved energy efficiency in the residential sector not only creates healthier living and working environments, where air and lighting system improvements contribute to the comfort, health and safety of occupants, but also reduces emissions of local air pollutants.[63] Furthermore, improvements to water efficiency are typically realized, as water-efficient technologies are often installed as part of an energy efficiency retrofit.

Economic costs and benefits

Improved energy efficiency in the residential sector not only creates healthier living and working environments, but also reduces emissions of local air pollutants.

The cost of altering land use alone is negative, meaning that reducing sprawl and greenhouse gas emissions *saves* money. Net benefits of $56.00-$95.00 (1997 $) per ton of CO_2 equivalents reduced are expected, with benefits being greatest when municipal infrastructure costs are included.[64] This benefit is due to cost savings in municipal infrastructure spending (such as sewer, water, and power lines), energy costs, and transportation investments (i.e. roads). Thus, the proposed land use changes will bring economic benefits to BC communities.

The following economic benefits arise from transportation management policies: tax reduction on transit passes, potential revenues that could be generated by road pricing or parking charges, and possible travel-time savings. Furthermore, both ‘parking supply management’ and ‘education/awareness/outreach’ policies provide significant net economic benefits.

Research indicates that greenhouse gas abatement in the transportation sector is achieved at significant savings to BC, with savings ranging from $140 to $230 per tonne.[65] In addition, research indicates that transit investments provide twice the economic returns than highway investments and enhance the overall economic efficiency of a city.[66] For example, for every $1 million invested in public transportation, 21.4 full-time jobs are created.[67]

The cost effectiveness of energy efficiency improvements for residential buildings varies, with greenhouse gas abatement costs estimated at $41/ton for the National Energy Efficient Housing Renovation and Retrofit Program, $22/ton ($13/ton for the GVRD) for the National Standards Program for Equipment and Appliances program, $29/ton for the R-2000 program, and $0/ton (i.e. no cost) for Microclimate Landscaping initiatives.[68] However, other studies suggest that CO_2 abatement costs in the building sector can provide net economic benefits ranging from $28-$78 per ton.[69]

Community level energy efficiency programs generate employment and business opportunities, foster the development of export technologies and workforce skills, and increase consumer spending on energy efficient goods and services. For example, investments in energy efficiency create four times as many jobs as equivalent investments in new conventional energy supply.[70] In addition, projects under the Better Buildings Partnership in Toronto – a public-private partnership – have generated approximately 3,000 person-years of employment.[71]

Furthermore, approximately 80% of home visits follow through with at least one recommendation, with 20% being major energy-efficiency improvements (e.g. increase insulation, upgrade heating system). In Ontario, the average expenditure per household has ranged from $1,100–$2,500, resulting in a positive impact of more than $100 million.[72]

Investments in energy efficiency create four times as many jobs as equivalent investments in new conventional energy supply.

2

Commercial and industrial energy reduction measures

BY KRISTANN BOUDREAU[73]

> Lowering BC's greenhouse gas emissions will involve the increased application of energy conservation practices, efficiency improvements, fuel switching and renewable technologies.

The most recent national energy demand forecast[74] indicates that between 1990 and 2015, greenhouse gas emissions from energy consumption in the commercial and industrial sectors, expressed as carbon dioxide equivalents, will grow from 11 million tonnes to 16 million tonnes per year. In 1990, 5% of the electricity generated in BC was produced by fossil fuel combustion, while in 2015, this proportion will have grown to 26% of electricity supply. If BC is to reduce its greenhouse gas emissions over the period 2000-2015, it will need to find ways of significantly reducing the consumption of electricity, natural gas and petroleum products by these two sectors.

The economic and technical potential for reductions in the industrial sector is lower than in the commercial sector: while the commercial sector is capable of achieving emissions reductions in excess of those proposed under the Kyoto Protocol, the industrial sector will have more difficulty achieving its share of reductions absent a broad based economic instrument. Lowering BC's greenhouse gas emissions in both sectors will involve the increased application of energy conservation practices, efficiency improvements, fuel switching and renewable technologies.

While there are significant barriers to the implementation of these greenhouse gas abatement actions, there are a growing number of innovative policy measures aimed at overcoming them. These measures include codes/standards, financial incentives, educational/awareness campaigns, research and development programs. Some of these measures have already been implemented with success, while others are still under development.

Apart from having obvious environmental benefits, successful implementation of these measures also impacts positively on employment and investment at the provincial level. The increased investment in GHG emission reduction technologies, practices and designs results not only in reduced emissions but also in greater employment, both in terms of direct, indirect and induced jobs, as well as additional jobs generated by respending of the energy cost savings.

Energy conservation techniques and practices

There are a number of energy conservation techniques and practices, sometimes referred to as energy management "actions", which can be implemented in the commercial sector in BC to reduce GHG emissions. These include technologies, practices and designs which conserve energy, improve energy efficiency, allow for fuel switching to lower carbon fuels, and make greater use of renewable energy sources.

COMMERCIAL SECTOR

Most of the opportunities for energy efficiency and conservation in the commercial sector relate to building improvements. There are four key times when the energy management actions, such as those described in the table below, can be implemented: when the building is first constructed, in the course of regular operations and maintenance, during building renovations, and as the result of a retrofit program.[75]

TABLE 2.1: OPPORTUNITIES FOR ENERGY CONSERVATION AND IMPROVED EFFICIENCY IN COMMERCIAL BUILDINGS AND OPERATIONS

END USE	ENERGY EFFICIENT TECHNOLOGIES/PRACTICES/DESIGNS
Lighting	Compact fluorescent lamp/ballasts to replace incandescent lamps
	Quartz-halogen lamps to replace incandescent lamps
	Optical reflectors
	Small LED lamps for Exit signs and other low intensity purposes
	High intensity discharge lamps for lighting large indoor or outdoor areas
	Automated lighting controls, either demand-based (e.g., occupancy sensors) or schedule based (e.g., control systems)
	Daylighting – greater use of natural daylight through better design of buildings, combined with controlled reduction in artificial light (using photocell-controlled dimming systems) when natural light is available
Office Equipment	Desktop computers with power management software, laptop computers an LCD screens
	Ion deposition photocopiers with power management software
	Ink jet printers to replace low volume laser printers
Space Cooling	High efficiency chillers and air conditioners
	Economizers/evaporators to take advantage of cool outdoor air and humidity levels
	Desiccant cooling to remove moisture and latent heat it contains from the air
	Solar driven absorption systems using solar collectors to power a refrigerant system
Space Heating (building envelope)	Better roof and wall insulation
	Windows with lower heat transmittance (low-E, gas filled, double or triple glazed, insulated spacers, insulated frames) and lower solar heat gain (reflective coatings)
	Better sealing of cracks and other openings to reduce infiltration
	Use of passive solar design/thermal mass storage to maximize solar gain and reduce heat loss due to wind

TABLE 2.1: **CONTINUED**

END USE	ENERGY EFFICIENT TECHNOLOGIES/PRACTICES/DESIGNS
HVAC Energy Loads	Carbon dioxide sensors to maintain a preset level of CO_2 by control of outdoor air
	Displacement ventilation, which introduces a reduced amount of outside air at the floor, causing it to rise and displace stale air which is removed at ceiling
	Desiccant dehumidification of outdoor air during the warm part of the year
	Compartmentalized and variable volume air handling systems
	Low temperature air distribution systems to reduce fan and pump energy
	Radiant heating and cooling panels combined with displacement ventilation to reduce fan energy
	Higher efficiency motors to replace existing motors
	Fan speed reduction to reduce system airflow
	Variable speed motor controls for fans and pumps controlled by load
	Heating equipment (furnaces, boilers, water heaters) using natural gas can now be selected to operate at seasonal efficiencies in excess of 90% (for oil fired equipment, equivalent efficiency = 85%)
	Unitary cooling and heat pump equipment with seasonal energy efficiency ratings of 10.0 and higher, using scroll compressor technology and better heat exchanger design
	Automated systems and digital controls to schedule and operated fans, pumps and dampers at optimum energy-saving levels in large buildings
Refrigeration	High efficiency centrifugal chillers to replace CFC type refrigerants
	Multiplexed compressors, with advanced controllers and defrosters, which can serve individual refrigerators and coolers instead of operating at one level for the whole refrigeration system
	Glass doors and covers on refrigeration cases
Cooling	Higher efficiency equipment
Service Water Heating (SWH)	Heat from other processes (air conditioning, refrigeration, exhaust air, overheated spaces such as boiler rooms, waste water) can be recovered and/or stored for later use (short term peak shaving, matching SWH needs to process heat recovery)
	Reducing the temperature for storage and distribution of SWH
	Low flow showerheads/aerators and automatic tap shutoffs
	Using solar and renewable energy to meet thermal storage needs

SOURCE: Based on information presented by BC Hydro (1993) and ARC (1999).

INDUSTRIAL SECTOR

Given the complexity of the industrial sector, it would be challenging to provide a comprehensive list of specific technological opportunities for energy conservation and improved efficiency which can be applied in the sector. The table below provides examples of cross-cutting facility- and process-related actions. Specific technological opportunities for facility-related actions include those described for the commercial sector.

TABLE 2.2: OPPORTUNITIES FOR ENERGY CONSERVATION AND IMPROVED EFFICIENCY IN INDUSTRIAL FACILITIES AND PROCESSES

FACILITY-RELATED OPPORTUNITIES	PROCESS-RELATED OPPORTUNITIES
Energy efficient lighting retrofits	Installation high efficiency motors, pumps, fans, compressors, conveyors
Heating, ventilation, and air conditioning (HVAC) retrofits	Energy efficient changes in production processes
Implementation of heat recovery systems and processes	Increased recycling of energy-intensive material
Improvements to the insulation of building envelopes	Equipment maintenance and repair
Implementation of energy management systems	Demand management
Adoption of high efficiency boilers	Changes to refrigeration and cooling systems
Fuel switching (from coal/oil to natural gas)	Increased application of cogeneration
	Reduction of process heat loss through heat recovery processes and advanced control systems
	Fuel switching (from coal/oil to natural gas)

SOURCE: Based on information presented in Goss Gilroy Inc. (1998)

Measures to facilitate the implementation of efficiency and conservation

COMMERCIAL SECTOR

Table 2.3 describes 19 stand-alone measures, and two packages comprised of different combinations of these measures, which were developed by the Commercial Buildings Table of the National Climate Change Process. The potential GHG emissions reductions projected for 2010 for each of these measures (on a stand-alone basis) and for the two packages are provided, as are the costs of the reductions (where available).

TABLE 2.3: **GHG EMISSIONS REDUCTION MEASURES PROPOSED FOR THE COMMERCIAL SECTOR**

MEASURE		APPLICATION	DESCRIPTION	KTS GHG SAVINGS IN 2010			$/TONNE
				(KTS)	(KTS)	(KILOTONNES ECO_2)*	
C-1	National Commercial Building Labeling & Rating System	New and existing buildings	Development and promulgation of a multi-part rating and labeling system to assist in comparing actual operating costs with benchmarks and goals.	12	16	28	–
C-2B	Improved Model National Energy Code for Buildings (MNECB+)	All new buildings + additions to existing buildings	Increase the provincial minimum energy efficiency regulations for new construction by adopting the National Energy Code for Buildings.	25	40	65	5
C-3	Advanced Building and Equipment Demonstration Initiative	New and existing buildings	Enabling Measure for long-term improvements in energy efficiency	14	18	32	–
C-4	Commercial New Building Incentive Program (CBIP II)	New buildings	Extend and expand the current CBIP Program	22	31	53	11
C-5	Commercial Building Design Guidelines/ Greenprints	Commercial buildings, including multi-unit residential buildings	Enabling Measure tied to Green Building/Climate Change Information Services and commercial building programs	14	19	33	–
C-6	Professional Continuing Education Program	Professional designers and builders	Expansion of provincial association-led programs and university/college continuing education programs for designers and builders	16	21	37	–
C-7	Public Buildings Initiative	Provincial and municipally-owned or funded existing buildings (schools, hospitals, etc.)	Refocusing, enhancement, and expansion of a public building targeted program along the lines of: the Federal Buildings Initiative; spin-off for municipal buildings; and the New Brunswick Building Initiative.	108	126	234	15
C-8	Commercial Building Retrofit program	Privately-owned existing buildings in the retail, office, hospitality and warehouse sub-sectors, especially buildings under 5,000 square feet.	Refocusing, enhancement and expansion of private sector building targeted program along the lines of the Toronto Better Buildings Partnership, Energy Innovators Plus and the Voluntary Challenge Registry.	180	220	400	(7)

TABLE 2.3: **CONTINUED**

MEASURE		APPLICATION	DESCRIPTION	KTS GHG SAVINGS IN 2010 (KTS)	(KTS)	(KILOTONNES ECO_2)*	$/TONNE
C-9	National Building Operator Training Program	Building facility managers and operators	Expansion of Seneca/SAIT community college program to national level with access to both full-time and continuing education programs	16	21	37	–
C-11	EE Equipment Tax Measure	New and existing buildings	Faster tax write-offs for capital costs of EE equipment, construction, and renovations and/or exemption from GST/ PST/HST	34	207	241	5
C-13	National Commercial Building Checkup Program	Existing commercial buildings	Technical and monetary support to building owners and facility managers to verify the operation for the buildings.	32	41	73	–
AE-1	National Standards Program for Equipment and Appliances	Energy-using equipment	Regulate additional equipment under the Energy Efficiency Act and/or increase the efficiency levels of currently regulated equipment	121	245	366	8
AE-4	Technology Commercialization Program	Residential & Commercial/ Institutional buildings	New program to promote technologies such as integrated systems/heat pumps; solar & instantaneous domestic and service water/hot water heating systems; lighting with dimmable ballasts; ground source heat pumps; and other proven technologies that have not yet developed a market.	14	18	32	–
AE-5	Energy Star Labeling Program	Commercial energy-using equipment	Consumer-oriented labeling of high performance lighting products and other equipment.	7	52	59	4
AE-7	Government Procurement Program for High Efficiency Products	High efficiency equipment for new and retrofit applications	Public agencies and their partners commit to purchasing only equipment that meets qualifying level of energy efficiency.	24	61	85	33
AE-9	Window Market Transformation Program	Commercial new and existing buildings	Five year program to eliminate non-low E double glazing from the Canadian market.	59	10	69	(24)

TABLE 2.3: CONTINUED

MEASURE		APPLICATION	DESCRIPTION	KTS GHG SAVINGS IN 2010 (KTS)	(KTS)	(KILOTONNES ECO_2)*	$/TONNE
RT-1	Expanded Renewable Energy Deployment Initiative (REDI)	General	Expand coverage under REDI to include other renewable energy systems and applications and increase maximum grant level and feasibility funding.	3	6	9	51
RT-2	Market Development Program for On-Site Renewables	On-site power & heat	Promotion and financing packages for on-site renewable energy technology and fuel cells. Financing would be provided through utility energy bills (including net billing for electricity generating systems), monthly rental/leasing program, and/or government assistance through innovative mortgage financing, interest-free loans, etc.	2	3	5	–
	Options Package 1: Comprehensive Scenario	All areas of concern - buildings, equipment, etc.	All measures	390	839	1,229	–
	Options Package 2: Targeted Scenario	Depends on measure	C-2B, C-6, C-7, C-8, C-8A, C-9, C-13, AE-1, AE-5, AE-9	337	748	1,085	–

SOURCE: Based on information provided Bay Consulting Group (1999).

NOTE: Costs shown in ( ) are negative costs.

*GHG emission reductions and CO_2 abatement costs resulting from the implementation of individual Measures were modelled on a “stand-alone” basis. When combined into packages, the impacts of individual Measures cannot simply be added together. Certain Measures are independent while others overlap and have reduced impacts since they target the same actions. Therefore, the total impact of the Comprehensive Options Package is less than the sum of the impacts of the stand-alone Measures.

Additional measures which could be implemented include:[76]

1. *Federal Support for District Energy.* The federal government should: 1) amend the Income Tax Act to provide accelerated capital cost allowance treatment for investments in the infrastructure required for district energy systems (e.g., pipes), 2) co-operate with municipalities and the private sector to initiate demonstration projects to document and illustrate the economic and environmental benefits of district energy systems, and 3) provide financing assistance for the development of district energy systems over the long-term (e.g., low interest loans, loan guarantees, seed money for new projects).

   A recent adjustment to the Capital Cost Allowance (CCA) system under the Income Tax Act has changed the tax class for district energy systems resulting in a modest increase in the CCA from 4 to 8%.[77] While this is an improvement, it is not as significant as the 30% declining balance CCA currently applied to alternative and renewable energy systems. There is clearly room for the federal government to increase the CCA for district energy systems further to create a greater incentive.

2. *National Building Energy Efficiency Securitisation Fund.* A loan guarantee fund to provide security for municipal governments who invest capital in retrofitting commercial buildings (municipally- and privately-owned) to reduce energy consumption. The fund could be capitalized by contributions from federal and provincial governments in partnership with private sources.

   Examples of such a fund include the two small revolving funds totalling $125 million secured by the Federation of Canadian Municipalities (FCM): the $100 million Green Municipal Investment Fund (GMIF) and the $25 million Green Municipal Enabling Fund (GMEF).[78] The GMIF will provide financial services, such as loan guarantees and interest-bearing loans (up to 15% of a projects' capital costs) to improve the economic viability of projects using new and advanced technologies. The GMEF will provide grants to municipal governments for up to 50% of the costs of studies into the latest technologies. Eligible projects include those which reduce the energy demands or improve the effectiveness of energy and other services such as water service delivery, wastewater treatment, waste management, and public transportation.

   While the creation of these two funds is encouraging, there are 4,000 municipal governments competing for these resources and the amounts in question are only sufficient to capture a small portion of the energy efficiency gains which are currently available. The federal government should increase its financial commitment to this program.

3. *Municipal Building Energy Efficiency Codes.* In the event that the provincial government chooses not to reflect the Model National Energy Codes for Buildings and Houses (MNECB & MNECH) in their provincial building codes, then municipal governments should be given the authority to adopt the two codes and enforce them under local regulatory regimes. This would require the provincial government to amend the Municipal Act.
4. *Feebates for Energy Efficient Buildings.* As an alternative to the above measure, municipal governments could introduce feebates – a sliding scale for building development and permit charges, to entice building owners/developers to construct and renovate buildings to higher energy efficiency standards.
5. *Update of BC's Energy Efficiency Standards Regulation*. The provincial government could undertake an update of the existing regulation, which covers approximately 30 products but has not been updated for several years.
6. *Qualification of Provincially-Funded Buildings for Commercial Building Incentive Program (CBIP) Funding*. In addition to adopting the Model National Energy Code for Buildings (MNECB), the provincial government could attempt to qualify all new provincially-funded buildings for funding under the federal CBIP which requires new buildings to exceed MNECB standards by 25%.

The provincial government established an initiative in December 1999 which should complement this last measure (#6): the Green Buildings BC program.[79] Green Buildings BC targets both new and existing provincially-funded buildings through two related programs: the New Buildings Program and the Retrofit Program.

Under the New Buildings Program, a series of pilot projects will be required to meet an aggressive environmental standards at less than or equal to the cost of conventional facilities. For example, the projects will beat national energy efficiency standards by at least 50%.

The Retrofit Program is an opportunity for provincially-funded schools, universities, colleges, and health care institutions to upgrade their existing facilities with energy and water efficiency enhancements, as well as waste-saving measures. The retrofits will pay for themselves through the utility savings they generate. Preliminary estimates indicate that the program could:

- Reduce energy use in participating institutions by 18%
- Reduce water use by 24%
- Reduce greenhouse gas emissions by up to 230 kilo tonnes per year
- Yield cost-savings of up to $34 million per year

The Green Buildings BC program is an initiative with clear potential to bring about increased energy conservation/efficiency and GHG emissions reductions. The provincial government will want to expand this program to capture the full potential in the province.

INDUSTRIAL SECTOR

Given the complexity of the industrial sector, developing tailored measures to reduce GHG emissions for each industry and each source of emissions (energy, non-combustion and non-energy) would be challenging. The use of broad-based economic instruments is therefore more appropriate for this sector.[80] Economic policy can send clear signals to industry to reduce GHG emissions while letting individual firms find innovative and cost-effective ways to achieve those reductions. These and other efficiency measures are more likely be developed by the federal government. However, opportunities for provincial involvement also exist. Potential policy changes which could bring about reductions in industrial GHG emissions are discussed below.

Measures to be implemented by the federal government[81]

1. *Cap and Allowance Emissions Trading System for Industry*. A regulated emissions cap would be established for total emissions from all participants in the system. Rights to emit emissions within the cap are allocated to the participants in the system in the form of allowances. All participants must hold allowances equivalent to their actual emission levels. Participants who emit less than they were permitted can sell their surplus allowance to participants who do not have enough to cover their emission levels. Stiff penalties are required to protect the integrity of the system.
2. *Improved regulated energy efficiency standards* for industrial motors and equipment.
3. *Financial incentives* for investments in energy efficiency improvements and climate friendly technologies and practices.
4. *Removal of barriers to cogeneration* (e.g., providing markets for excess electricity).
5. *Expansion of Federal Research & Development in Low Greenhouse Gas Technologies.* Increase support for research and development in the areas of efficiency and alternative energy.
6. *Increased Performance-Based Research and Development Tax Credits*. These existing credits should be linked to the development of technologies that significantly reduce GHG emissions.

Measures to be implemented by the provincial government[82]

1. *GHG Emission Measurement and Reporting*. Direct the British Columbia Utilities Commission and BC Environment to amend the appropriate operating licences and approvals under their jurisdiction to require measuring and monitoring by all significant emitters of greenhouse gas emissions, according to provincial guidelines, and report those emissions on an annual basis in a standardized format.

The BC Government could provide incentives for qualifying investments in commercialization and demonstration of new technologies that reduce GHG emissions.

2. *Tax Incentives to Increase Market Penetration of Energy Efficient and Renewable Energy Technologies*. The BC Government could provide incentives in the form of 50% tax credits for qualifying investments in commercialization and demonstration of new technologies that can verifiably reduce GHG emission through significant improvements in energy efficiency, process efficiency, or greater adoption of renewable energy sources. This would also apply to research and development investments in commercializing emerging energy efficiency and/or renewable (non-electric) technologies.
3. *Mandate the British Columbia Utilities Commission to Address GHG Emissions*. The BC Government could mandate the BCUC to consider the GHG efficiency of new and re-licensed projects and to ensure that projects are maximizing GHG efficiency before approval is granted. Applicants would be required to provide information on: GHG emission intensities, best available technologies considered, and their plan to mitigate/minimize the GHG emission impacts of the project.
4. *Provincial Ecological Tax Shifting*. This would shift part of the tax burden away from productive activities (e.g., employment and investment) and onto environmentally damaging activities (e.g., pollution) without changing the overall tax burden.

Economic and employment benefits

There are a number of employment and investment opportunities arising from the implementation of GHG reduction policy measures and programs such as: codes and standards, financial incentives, awareness/education campaigns, and research and development programs. The end result of the successful implementation of these measures is greater penetration of GHG emission reduction technologies, practices and designs. The increased investment associated with energy conservation, improved efficiency, fuel switching, and the application of renewable technologies results not only in reduced emissions but also in greater employment.

In 1993, the BC Energy Council commissioned a study[83] on the employment impacts of investments in energy efficiency. Some of the key findings of the study were that, when compared with traditional energy supply projects, investments in energy efficiency:

- create similar numbers of direct and indirect jobs but create about twice as many total jobs, due to the respending of cost savings
- create jobs that better match the skills of BC's unemployed and, therefore, make a much large contribution to reducing BC unemployment
- create jobs whose geographical distribution better matches that of the BC population, rather than jobs that are concentrated in less populated areas

- create jobs that, on average, last longer.

The study also found that construction-related measures (e.g., improved insulation, window replacement) tend to produce more direct and indirect jobs per investment dollar than the substitution of more energy efficiency equipment (e.g., lighting or motors).

In terms of actual job creation, the study modelled an energy efficiency scenario which involved attaining a level of annual savings of 5000 gigawatt hours of electricity and 20,000 terajoules of natural gas in the year 2010. This level of annual electricity savings is within the economic potential range predicted for the commercial sector in BC Hydro's Electricity Conservation Potential Review, and presumably, the natural gas savings are equally achievable. These investment in efficiency improvements to achieve these savings would result in the creation of 19,000 to 21,000 direct, indirect and induced jobs, and 14,500 to 16,000 from the respending of consumer savings, for a total of 33,500 to 37,000 jobs. This employment is expected to be distributed across job skill levels such that 10-15% of the jobs would be highly skilled, 30-40% skilled and 50-60% un/semi-skilled. The average duration of these jobs would be 10 to 20 years and would be distributed geographically throughout the province in proportion to population.

Investments in efficiency improvements would result in a total of 33,500 to 37,000 jobs.

There are also other potential economic benefits associated with investment in energy efficiency. For example, federal and provincial investment in the provision of incentives for and promotion of research and development of GHG reduction, mitigation or sequestration technologies would:

- Encourage industries to proactively pursue their own research and development into equipment- and process-related improvements
- Allow BC to strengthen and diversify its economy
- Support BC firms with the ability to pioneer new technologies (e.g. Ballard fuel cells)
- Keep R&D dollars in BC and help to preserve/develop high technology jobs.[84]

3

Freight transportation greenhouse gas reduction opportunities

BY AGRITRADE AND TRANSPORT[85]

According to the Organization for Economic Cooperation and Development (O.E.C.D.), the overall framework of analysis for sustainability must consider the inter-relation between production and transportation.[86] Trying to reduce freight emissions without analyzing the link with production and distribution would be like trying to do urban transportation planning in isolation of land use planning.

Although technical advances have been made to improve the fuel efficiency of traffic, growth in the amount of traffic has overwhelmed these savings. Future advances in technology will also be insufficient to overcome increased environmental impacts.[87] Individual and disconnected measures can work at cross purposes by shifting freight to less fuel-efficient modes. Simply improving fuel efficiency of transport supply can induce additional transport demand.

Evolution of the production and distribution system to just-in-time logistics has had the following impacts which increase emissions:[88]

- Increase in market share for trucking, the most energy inefficient inter-city mode of land transport
- Increase in shipment distances as globalization breaks down local economies
- Increase in out-sourcing of components
- Decrease in density of shipment and increase in shipment frequency
- Shift in distribution costs from private warehouses to public roads

While these trends are often viewed as a market preference, there is an implicit subsidy involved through the road system, and the transfer of costs for pollution, global warming and traffic accidents to society. The market does not reflect full costs of these factors.

Buying products over the internet will also likely increase emissions in the freight sector more than anticipated, particularly air freight. Truck manufacturers are currently stepping up production of medium-sized trucks for more dispersed shipping patterns. UPS is gearing up for an expected expansion in home delivery.

However, consumers will create fewer emissions in driving to and from the store, except where shopping is a stop-off during a trip that will occur anyway.

The national Climate Change Transportation Table Options Paper is a good source of information on technical solutions to reduce freight emissions, but its approach to freight demand issues is limited.[89] Implementing all of its *most promising* and *promising* measures for freight modes and truck vehicles/fuels (as well as the *less promising* measures for trucking) would reduce BC freight emissions in 2015 by 1.83 Megatonnes (Mts). BC freight emissions would then be 5.35 Mts, still 23 per cent above the Kyoto target. The difference is due to the strong growth in trucking activity.

This analysis outlines an alternative approach with more aggressive technical solutions to reduce emissions, as well as conservation measures, for example, shifting to more efficient modes and influencing the amount and type of freight demand.

Although technical advances have been made to improve the fuel efficiency of traffic, growth in the amount of traffic has overwhelmed these savings.

Measures

Replacing 40 per cent of freight trucks with trucks powered by fuel cells would reduce 2015 emissions by 1.32 Mts.[90] Note, however, that the cost of the hydrogen fuel is 50-100 per cent higher than current diesel prices. Limiting truck speeds to 90 kilometre per hour would save 0.44 Mts. Driver training and better maintenance would save 0.56 Mts. Non-engine improvements (tracking, load matching, tires, lower vehicle weight, electronic border clearance) would save 0.28 Mts.

Implementing a marine code of practice and shore power reduces domestic marine freight emissions by 0.017 Mts. Because marine freight emissions are already very low, and there is a slow replacement rate for vessels, there is little opportunity or benefit for fuel cells by 2015.

Electrifying main rail lines in BC would reduce emissions by 0.66 Mts, after including emissions to generate and transport electricity.[91] However, the railways would be unable to finance the $800 million cost of electrification on their own at current diesel prices. Using electric railway locomotives would save as much in emissions, at lower cost, than developing new hydrogen fuel cell locomotives. Reducing the gap in tax treatment on the purchase of rail equipment compared to trucks would save 0.06 Mts.

Limiting truck speeds to 90 kilometres per hour would save 0.44 megatonnes.

More compact land use planning could reduce urban trucking emissions by 0.12 Mts. Pooling urban delivery systems could reduce emissions by 0.12 Mts by reducing circuitous routings and increasing load factors. Several firms could combine to operate their pick up and distribution, based out of an intermodal freight terminal and distribution centre.

Increasing local production and consumption is assumed to reduce emissions by 0.24 Mts (75 per cent reduction in shipping distance for 10 per cent of inter-city truck hauls). For example, currently milk produced in BC is shipped to Alberta for processing, and then shipped back to BC. Processing the milk in BC would reduce emissions.

The Transportation Table examined one intermodal option for BC, which was to shift 18 per cent of point-to-point truck traffic between Calgary and Vancouver from truck to rail. It estimated emission reductions at 0.006 Mts. This paper will instead examine a more systematic approach, including the removal of current market and regulatory distortions that act as barriers to increased intermodal transport and artificially increase the growth rate of truck transport.

TABLE 3.1: POTENTIAL EMISSION REDUCTIONS IN MEGATONNES FROM MODE SHIFT

	TOTAL TRUCK EMISSIONS 2015	INTER-CITY TRUCK	TRUCK EMISSION REDUCTIONS	ADDITIONAL RAIL OR MARINE	EMISSIONS FROM PICK UP AND DELIVERY TERMINALS	2015 NET CHANGE EMISSIONS
Shift 10%	5.521	3.11	-0.31	0.068	0.027	-0.215
Shift 20%			-0.62	0.136	0.054	-0.429
Shift 30%			-0.93	0.204	0.082	-0.644

Currently, milk produced in BC is shipped to Alberta for processing and then shipped back to BC.

Shifting 20 per cent of inter-city truck traffic in 2015 to rail (e.g. carload, container or piggyback) or marine would reduce emissions by 0.429 Mts, after including emissions from a 25 kilometre truck pick up and a 25 kilometre truck delivery. About two-thirds of the shift would displace the traffic growth forecast for trucking. As a result of the shift, rail/domestic marine traffic would increase about seven per cent.

An example of intermodal opportunity is the truck traffic that crosses the mountains. About 1,100 westbound trucks a day cross the Alberta/BC border daily and another 1,100 eastbound. These amounts will grow by 2015. There are opportunities with new short lines serving the Okanagan and Vancouver Island. With aggressive local marketing, short line railways have proved effective at taking truck traffic off highways, even over short distances. BC Rail is also owned by the Government of BC. The opportunities for greater use of the marine freight mode include coastal areas, the Fraser River in the lower mainland and north-south lakes in the interior.

Implementing all of the above measures would reduce BC freight emissions by 4.3 Mts to 3.0 Mts, compared to the target of 4.3 Mts. However, there is some overlap or double counting between individual fuel efficiency measures. Subsequent measures apply to a somewhat smaller base of emissions. Assuming a 25 per cent overlap, the total emission reduction is 3.2 Mts to a level of 4.1 Mts.

The following table summarizes the possible measures that could be used to reduce freight greenhouse gas emissions in BC.

TABLE 3.2: POSSIBLE MEASURES TO REDUCE FREIGHT EMISSIONS IN BC

		BC 2015 MTS	BC 2015 BY MODE
Trucking: replace 40% of trucks with trucks powered by fuel cells	technology	1.32	23.9%
Trucking : tracking, load matching, tires, lower vehicle weight, electronic border clearance	technology	0.28	5.1%
Trucking: limit speeds to 90 kms/hr	technology	0.444	8.0%
Trucking: driver training, preventative maintenance	conservation	0.56	10.1%
Trucking		**2.604**	**47.2%**
Rail freight car capital cost allowance	technology	0.016	1.1%
Rail locomotive capital cost allowance	technology	0.046	3.1%
Rail, electrification	technology	0.663	44.5%
Rail		**0.725**	**48.7%**
Marine freight, code of practice	conservation	0.007	2.7%
Marine, shore power	technology	0.01	3.9%
Marine		**0.017**	**6.7%**
Compact land use planning	demand	0.12	
Pool urban deliveries	demand	0.12	
Shift 20% of 2015 truck freight to rail or marine	demand	0.429	
Increase local production & consumption	demand	0.24	
Measures to influence nature and amount of demand		**0.909**	
Freight, emission reduction before adjustment for overlap among measures		4.26	58.6%
Freight, eliminate 25% overlap		**3.195**	**44.0%**

Diesel taxes and license fees cover about 60 per cent of the cost imposed on the road system by the typical tractor-trailer truck.

Infrastructure issues

The trucking industry uses roads and traffic controls built and maintained at public expense. Diesel taxes and license fees cover about 60 per cent of the cost imposed on the road system by the typical tractor-trailer truck.[92] However, there is one toll highway between Hope and Kamloops. The latest (1997) National Highway System study recommends spending an additional $2.9 billion for highways in BC in the designated national system, including $806 million to expand capacity with additional lanes.

Research work for the Transportation Table on infrastructure issues finds that increasing highway capacity would increase emissions. Although fuel is saved by reducing congestion for a while, the additional capacity induces new traffic that increases emissions overall. The O.E.C.D. states that the provision of additional road infrastructure is rarely a solution, but rather adds to the problem.[93] Intelligent highway systems (e.g. high tech traffic control and incident management systems) could both reduce emissions caused by congestion, and also increase emissions by expanding highway capacity.

Economic instruments are not a stand-alone 'magic bullet' to reduce emissions in freight transport, but there can be a role for them to support other policies.

Rail track capacity is adequate for present traffic volumes, but there is congestion in the Vancouver area. Traffic ranges from one to two trains per day on branch lines to 25 to 35 trains per day on the main lines. About 35 per cent of the CPR main line is double track, with major segments between Golden and Revelstoke, Sicamous and Kamloops and Agassiz to Coquitlam. Westbound grain traffic has declined 35 per cent since 1994 as transport subsidies were cut and Canada integrates with the continental grain economy. An increase in the exchange rate or integration of railway companies could alter the routing of some bulk shipments to U.S. ports. Coal traffic could decline as the Kyoto process increases the marginal cost of carbon to customers. Any decline in bulk traffic would free up additional capacity for intermodal traffic, but it would also mean that other traffic would have to cover a bigger share of fixed costs. Mode shift to rail could require infrastructure improvements, depending on the future volumes of bulk traffic.

The most recent Transport Canada inventory of freight infrastructure and activity in BC has very little information about domestic marine activity which appears to be small compared to overseas traffic. The Federal Government is currently implementing a user pay system for marine.

Possible economic instruments

Economic instruments are not a stand-alone magic bullet to reduce emissions in freight transport, but there can be a role for them to support other policies.

Research for the Transportation Table concludes that increasing diesel taxes by 50 cents per litre would still leave trucking emissions in 2010 at 35 per cent over 1990 levels. Fuel taxes have a bigger impact in passenger transport because BC commuters cannot drive via the U.S. Most of the rail tonnage, and much of the truck tonnage, can. Thus, increased diesel taxes in BC would shift some freight emissions to the U.S. unless U.S. fuel taxes were also raised.

Road pricing based on truck weight and distance driven is a better way to recover road costs because fuel taxes undercharge heavy vehicles. For sake of discussion, if the mileage toll for a tractor-trailer on the Coquihalla highway were applied to all trucks operating in BC, and replaced the fuel tax and license fee, this would increase truck costs about 17 per cent. This would shift about eight to 19 per cent of truck traffic to other modes.[94] There may be competitiveness issues which will need to be addressed through appropriate design of specific program elements such as revenue recycling.

Under a freight carbon ceiling, shippers would be required to purchase carbon quotas or credits if a shipment produced more than a certain amount of emission per tonne-kilometre. Shippers using rail or marine should be able to earn and sell credits for shipping below the threshold. The carbon ceiling would be reduced to meet targets.

Charges collected for freight transport congestion, collisions, infrastructure and pollution could be recycled through shadow tolls to more environmentally-friendly modes. This would be revenue neutral to government and minimize impacts on competitiveness.

Economic and environmental benefits

Reducing GHG emissions will create opportunities for investment and employment, for example to develop alternative fuels, fuel cells, more fuel-efficient vehicles, intermodal management processes and to electrify railways. Whether or not the U.S. implements the Kyoto protocol, it will have to reduce its dependence on imported oil as supplies of inexpensive conventional oil decline. BC would then be in a good position to export its expertise and technology to the U.S. restructuring in a seller's market.

Reducing the energy intensity of transportation in BC will make the BC economy more competitive in the long-term. Fuel prices are already escalating as the world's supply of inexpensive conventional crude oil declines. For example, the U.S. Department of Energy estimates that country is today saving $150-$200 billion annually as a result of energy efficiency measures taken during the 1970's oil embargo.

The trucking industry estimates there is a shortage of 50,000 truck drivers in Canada. Intermodal would result in a more efficient use of truck drivers picking up and delivering freight at intermodal terminals, thereby relieving the long-haul driver shortage. It would also permit a reduction in the fleet of truck tractors which could assist the program to scrap old trucks.

The benefits of mode shift go beyond reducing GHG emissions, to reducing road expansion costs, road damage, traffic collisions, and improving the quality of life. For example, a 20 per cent mode shift of BC inter-city freight in 2015 would reduce annual public costs by about $65 million (road costs $14 million, collision death and injury costs $17 million and congestion costs $32 million).[95] Thus, it would be economically efficient for the government to offer some shadow tolls or tax credits.

Reducing greenhouse gas emissions will reduce the cost of health care and the financial losses caused by drought, forest fires, and extreme weather such as flash floods. There should be a cost estimate of the "do nothing" option as a benchmark against the cost of implementing reduction measures. The costs of emission reduction measures, no matter how sophisticated, are meaningless without an estimate of the cost of business as usual.

Reducing the energy intensity of transportation in BC will make the BC economy more competitive in the long-term.

4

Reducing greenhouse gas emissions from oil and gas production

BY THE PEMBINA INSTITUTE[96]

British Columbia's oil and gas industry is the third largest in Canada, after Alberta and Saskatchewan. Currently the "upstream" oil and gas sector isone of the fastest growing sources of emissions in BC. In 1990 this sector produced 5 million tonnes of greenhouse gases, but by 1997, this grew to 7.8 million tonnes, a cumulative growth rate of nearly 60 per cent. By 2015, emissions are projected to grow to 8.9 million tonnes. Most of the industry activity in BC is concentrated in the northeast part of the province around Fort St. John. Greenhouse gas emission reductions from the oil and gas sector are essential for Canada to meet its commitment to reduce national emissions by six per cent of 1990 levels by the period 2008-2012. This report examines the greenhouse gas emissions associated with the oil and gas industry in BC, focusing especially on the identification of investment opportunities to reduce greenhouse gas emissions in the sector.

The *upstream* oil and gas industry comprises all infrastructure used to find, produce, process, and treat natural gas, liquefied petroleum gas, condensate, crude oil, heavy oil and crude bitumen. *Downstream* activities include petroleum refining, petroleum and natural gas transportation and distribution, and petrochemical production. Both upstream and downstream activities have been assessed for their potential carbon dioxide-equivalent (CO_2E)[97] emissions contribution in BC as well as for their potential for reductions. Where examples are available, this report identifies initiatives undertaken to reduce greenhouse gas emissions that are similar to the opportunities described in the report.

Greenhouse gas emission reductions from the oil and gas sector are essential for Canada to meet its commitment.

Emission reduction opportunities

Greenhouse gas emissions can be reduced in various ways, from addressing combustion sources and equipment leaks to the way fossil fuel reservoirs are accessed from the surface. The following section highlights a number of these emission reduction initiatives and cites actual field applications when such examples were available.

EMISSION REDUCTION – EQUIPMENT LEAKS

Emissions reductions from equipment leaks can be achieved in a variety of ways including:

- minimizing the number of potential leak points (back weld unnecessary threaded connectors; install caps, plugs, blinds or a second valve on open-ended lines; use closed-purge or closed-vent sampling systems, vent compressor seals and distance pieces to a control device; and vent pressure relief valves to control devices);
- specifying low leak or sealless components; and
- performing regular leak detection and repair (LDAR) activities.

SaskEnergy-TransGas has reduced emissions from their operations by 12.5 kT CO_2E/year, as of 1998, by installing caps on 1022 bypass valves at their town border stations.[98]

Greenhouse gas emissions can be reduced in various ways, from addressing combustion sources and equipment leaks to the way fossil fuel reservoirs are accessed from the surface.

ALTERNATIVES TO SOLUTION GAS VENTING AND FLARING

Gas produced from a well containing primarily oil is referred to as "solution gas." Some wells produce only oil or gas, but many wells produce both. When the solution gas is found in uneconomic quantities, industry may seek approval to dispose of the gas rather than recovering it. Disposal traditionally has occurred by venting or flaring the solution gas.

Alternatives to solution gas venting and flaring include:

- *Increased Conservation:* Collecting, processing and selling gas that is now flared according to current gas conservation requirements. Northstar Energy Corporation now sells previously flared solution gas from its treaters, reducing emissions by approximately 3.6 kt CO_2E/year.[99]
- *Clustering:* Gathering small volumes of solution gas from multiple wells using small diameter, low pressure pipelines. This provides enough gas to justify the cost of constructing a pipeline to connect the gas to a processing facility, undertaking deep well injection, or establishing a microturbine site. In 1996, Paramount Resources Ltd. tied in several of its single well oil batteries in the Kaybob West area that had been flaring all solution gas produced into a gas gathering system. This conserves over six million cubic metres of natural gas per year and has reduced greenhouse gas emissions by approximately 15.6 kt.[100]
- *Re-injection:* The disposal of solution gas into a depleted hydrocarbon-bearing zone or the use of solution gas to enhance recovery in an active hydrocarbon-bearing zone. Northstar Energy Corporation is injecting solution gas at its Carmangay Compressor facility to maintain reservoir pressure. Flaring at the site has been eliminated, resulting in a reduction of approximately 10.5 Mm3/year of solution gas, or approximately 27 kt of CO_2E/year.[101]

Alternative energy technologies are now available that use natural gas to drive pumps and instruments but do not vent natural gas to the atmosphere.

- *Electrical Generation:* Solution gas can be conserved and used to generate electricity.
- *Incineration:* Incineration provides a small reduction in greenhouse gas emissions by ensuring more complete combustion of methane. Incineration avoids the release of hazardous air pollutants from flaring, but results in an increase in emissions of NO_x. Petro-Canada has reduced its sour gas emissions and CO_2E by 4.8 kt/year by replacing a flare with a sour gas incineration system at one of its gas plants.[102]
- *Prevent Solution Gas Flaring During Gas Plant Turnarounds:* An important emission reduction activity would be to establish a corporate policy preventing the production of oil wells containing solution gas when solution gas processing facilities are not operational. The Red Deer regional office of the Alberta Energy and Utilities Board introduced a policy in 1997 that prevented the flaring of solution gas during plant turnaround.[103] "Turnarounds" are scheduled facility shutdowns for major upgrading or plant wide maintenance. Companies met the requirement for zero flaring by a combination of:
  - re-injecting the gas;
  - sending the gas to a plant that was not shut down;
  - minimizing plant turnaround time period;
  - scheduling maintenance of parallel oil production infrastructure to coincide with gas plant turnaround; and
  - temporarily shutting-in of well production.

The Alberta Energy and Utilities Board recently released EUB Guide 60 - *Upstream Petroleum Industry Flaring Requirements*[104] specifying flaring reduction and management expectations of the oil and gas industry in Alberta.

Husky Oil Operations Limited modified its turnaround maintenance schedule as of 1996 at its Ram River gas plant, reducing the amount of gas to be flared during shutdowns. This has reduced comparative emissions by 1 kt CO_2E/year.[105]

METHANE CONTROLLED PNEUMATIC DEVICES OR INSTRUMENT AIR

Natural gas is routinely used to drive pumps and some instruments and to control equipment in well site and processing facility locations that do not have electrical power. In the past, these devices were designed to operate by venting the natural gas to the atmosphere, resulting in large emissions of methane.

Alternative technologies are now available that use natural gas to drive pumps and instruments but do not vent natural gas to the atmosphere.

- One example is the Handfield Glycol Pump,[106] which exhausts the gas used to drive the pump in a natural gas dehydrator to an accumulator for use as glycol re-boiler fuel.
- Another example is the Blair Air System[107] which operates as a closed system in any pressurized flowing gas stream, to compress air, operate instrumentation,

inject methanol into flowing gas to prevent hydrates and ice plugs, inject glycol for gas dehydration, and inject other chemicals used in oil and gas production.

Air can be used instead of natural gas to power pneumatic devices. However, instrument air systems do require electrical power to be available on site.

SaskEnergy-TransGas reduced emissions by 1.63 kt CO_2E from the replacement of fuel gas to air pneumatic controls.[108]

Reduction of Venting from Well Completion and Servicing Procedures

Prevention of venting of gas during well completion and well servicing operations represents a significant opportunity to reduce emissions. Although flaring is preferable to venting because the more potent greenhouse gas methane is reduced to carbon dioxide, flaring results in the formation and release of substantial volumes of hazardous air pollutants, including BTEX compounds.[109]

Central Production Testing has engineered and designed a separating system that allows operators to re-enter, re-complete, stimulate, and clean up the well without interrupting the production of gas for processing.[110] This system avoids, or significantly reduces, the need to flare during maintenance or repair work.

Reduction of Well Testing Emissions

Newly drilled gas wells are pressure tested before being brought into production. This is normally done by allowing the well to flow to a flare at near its maximum rate for 2 to 21 days while the rate and pressure of the gas reservoir are measured. The information gathered is used to size pipelines and determine processing requirements.

In areas where a pipeline network is already in place, gas from a well test can be directed into a pipeline, avoiding the need to release any emissions to atmosphere. In-line testing rather than flare testing substantially reduces local air pollutants and greenhouse gas emissions by directing the gas to a processing facility for market instead of flaring it.

Coil tubing was used by Alberta Energy Company Ltd. to tie in wells prior to testing, preventing test gas from being flared. In 1998, this application resulted in a greenhouse gas reduction of 56.4 kt CO_2E.[111]

Remote Shut-down Capability of Gas Field

When a gas plant is shut down, the inlet gas must be shut off or flared. Shutting off the inlet gas can result in flaring at the source gas well sites unless they too are shut down. Co-ordinating a system-wide shutdown can be accomplished relatively easily if a central computer, possibly located at the gas plant, controls the wells. SCADA,[112] or other types of remote operating control systems, allow an operator to start and stop wells and pipelines from a remote location, avoiding the need to drive to each well location and manually close valves to avoid flaring.

Prevention of venting of gas during well completion and well servicing operations represents a significant opportunity to reduce emissions.

Fugitive emissions can be minimized by designing facilities with the fewest possible components and connections.

ACID GAS INJECTION

Sour gas plant facilities that dispose of acid gas[113] by deep well injection generally have far lower emissions of SO_2 than facilities that recover sulphur or flare acid gas. Acid gas injection provides the additional benefit of sequestering the CO_2 fraction of the acid gas stream.

Acid gas disposal is a proven technology and is being implemented in a growing number of oil and gas facilities. In 1990, there were two acid gas disposal facilities in Canada. By 1998, there were twenty, disposing of over 700 tonnes of CO_2.[114]

Anderson Exploration Ltd. reduced its CO_2E emissions by 316 tonnes during fiscal year 1998 with an acid gas injection scheme at its sour gas processing plant in North Normandville.[115] Westcoast Energy Inc. reduced its CO_2E emissions by 40.5 kt in 1997 by implementing an acid gas re-injection program at its Jedney I and Jedney II plants.[116]

LEAK DETECTION AND REPAIR

All connections and components leak to some degree. These leaks, referred to as "fugitive emissions," can be minimized by designing facilities with the fewest possible components and connections and by avoiding components that are known to cause significant fugitive emissions.

Leak detection and repair (LDAR) programs involve routine preventative maintenance on equipment that is known to leak, as well as conducting physical checks of equipment for methane emissions and carrying out repairs. The best LDAR programs use low methane measurement thresholds to determine when a repair is warranted and they have minimal time between leak detection and repair.

Details of some of the technologies available to reduce fugitive emissions from wells and facilities are described in a 1993 report entitled "Options for Reducing Methane and VOC Emissions from Upstream Oil and Gas Operations."[117]

TransCanada implemented a leak detection and repair program in its operations in 1998, resulting in reductions of over 124 kt in CO_2E emissions in the same year.[118]

TANK VAPOUR CONTROL AND RECOVERY

Fugitive emissions from tanks occur when vapours in the tank are displaced by incoming or outgoing liquids, by evaporation or by "flashing losses" due to rapid changes in pressure and temperature when liquids enter the tank. Processing facility system designs that avoid the use of tanks to store hydrocarbon liquids prevent tank fugitive emissions and the formation of tank sludge and other wastes. Several technology options are available to reduce or prevent fugitive emissions from tanks. These include:[119]

- *Floating Roofs* – Floating roofs help reduce fugitive emissions by minimizing the exposure of tank liquids to air, thereby reducing evaporative losses and displacement losses. Floating roofs can be installed on virtually any tank used in the upstream oil and gas industry.
- *Vapour Control Systems* – Vapour control systems are used to recover tank vapours either for use as sales gas or fuel gas, or to be destroyed by incineration or flaring. These systems may involve compression (suction) and they work best if contamination with air is avoided. These systems can also be combined with a condenser – a refrigeration unit that recovers all condensable hydrocarbons leaving mostly methane that can be used as fuel or destroyed. Mobil Oil Canada installed two vapour condensers upstream of its vapour recovery units at the Battrum Battery 21. These act to condense more vapours from flash treated oil, thus reducing the amount of hydrocarbons flared. The initiative has reduced CO_2E emissions by 22 kt/year since 1997.[120]
- *Carbon Adsorption* – A carbon adsorption unit consists of two carbon beds and a steam or vacuum regeneration system. While one bed is active the other is regenerating. Hydrocarbon compounds are preferentially removed by physical adsorption onto the surface of carbon. Carbon adsorption may be used to recover hydrocarbons from vent flows containing significant amounts of air. Consequently this technology may be most applicable to truck loading terminals. However, hydrogen sulphide can contaminate carbon beds.
- *Lean Oil Absorption* – This technology is based on the use of a lean solvent solution and pressure to dissolve hydrocarbon compounds. Hydrocarbon compounds are then recovered by heating the solvent and condensing the vapours.
- *Membrane Vapour Separation Systems* – Membrane technology has been proven for liquid separation applications but vapour separation was still under development in the 1990s. Compressed and cooled vent gases are passed though a separator and condensed liquids are removed. The saturated gas stream is passed through an array of semi-permeable membrane modules that separate the gas into a stream of volatile organic compounds (VOCs) that can be recovered, and a methane stream that can be flared.
- *Vapour Exchange System* – Transport tanks can have VOC emissions that are similar to stationary tanks discussed above. Emissions occur when vapours are displaced during filling of the tank, by evaporation promoted by agitation during transport, and by spillage during connection or disconnection. A vapour exchange system is achieved by connecting vapour spaces between the storage tank and the transport vehicle tank using a hose with appropriately sized connections. This allows the head space vapours to be exchanged

between vessels rather than displacing vapours to the atmosphere, thus reducing emissions.

- *Gas Boot System* – Emissions reductions at battery facilities may be achieved by installing gas boot systems at sites where they do not currently exist. The gas boot system incorporates a low-pressure vessel between the treater and the storage tank. The low-pressure tank acts to "absorb" any excess gases going through the system. Sites using a gas boot system can reduce emissions to 0.45 m^3/m^3 of production. This compares to 3.2 m^3/m^3 of production where the oil is produced directly from the treater to the stock tanks and 5.0 m^3/m^3 of production where the oil is produced directly from the inlet separator to the stock tanks.[121 122]

Energy operations often have an impact on surface ecosystems.

DRILLING MULTIPLE WELLS FROM A SINGLE PAD

Energy operations often have an impact on surface ecosystems; for example, forests may be cleared to allow access to a well site. Measures intended primarily to reduce impacts to surface ecosystems can also reduce the energy intensity of oil and gas operations. Drilling multiple wells from a single pad location reduces surface disturbance impacts and lowers energy consumption of drilling operations by decreasing well pad and road construction emissions as well as rig transportation emissions. Multiple wells on a single pad also allow more efficient recovery of solution gas and vent gases.

Energy supply and efficiency options

IMPROVED ENERGY EFFICIENCY IN PROCESS UNITS AND BUILDINGS

There are many ways to reduce energy consumption in process units and buildings through insulation, improving the efficiency of furnaces and boilers, minimizing lighting energy in buildings through skylights and windows, and other mechanisms. For example, ATCO Gas reduced its consumptive emissions at its Atkinson Building by adding insulation and refitting its heating system. This resulted in a reduction of 200 tonnes CO_2 E/year.[123] For more information on options to reduce emissions from buildings, see the Pembina Institute's "Climate Change Solutions" website.[124]

GENERATION OF ELECTRICITY

One approach to reducing emissions is to direct solution gas to a microturbine to produce electricity. The most significant direct benefit of microturbines is that they nearly eliminate the hazardous air pollutants emitted by flares. However, the power produced by microturbines could potentially offset power from natural gas and coal burning facilities, thereby reducing overall emissions of greenhouse gases and other air emissions. These types of benefits depend on the source of the electricity that is offset by power from microturbines. The current economic viability of microturbines is sensitive to government royalty and electrical industry regulatory policies, including royalty treatment of otherwise flared gas, access to the electrical grid, the level of standby charges and capital cost allowance rates, among others.[125 126]

Husky Oil Operations Limited is assessing the viability of installing a gas turbine to generate roughly 2 MW of electricity from gas that is now being flared from a battery. Tapping this 9 Mm^3 annual supply could potentially reduce greenhouse gas emissions by roughly 25,000 tonnes of CO_2E/year in Alberta.[127]

Canadian Occidental Petroleum Ltd. is participating in a pilot project to use a small-scale gas turbine. The turbine will use gas that would otherwise be flared to generate 75 kW of electricity.[128]

In 1997, Crestar Energy Inc. began burning flared sour solution gas in a turbine power generator at a Crestar Energy-operated oil battery. A second unit was installed at another location in 1998, also using gas that would otherwise be flared. This has reduced power costs by 70 per cent and significantly lowered flared gas volumes.[129]

Numac is evaluating the feasibility of using microturbines to generate electricity from flared solution gas. Numac estimates that 10-15 per cent of currently flared solution gas will be eliminated from its operations.[130] Mercury Electric of Calgary began commercial production of its Parallon 75 Mini Turbine in April 2000. Mercury is building several multi-unit skid-mounted projects and expects to have roughly 50 units in the field by the fall of 2000. Numac is one of its current clients.[131]

In August 1999, Mercury Electric installed a Parallon 75 Mini Turbine Beta test unit at a battery owned by Husky Oil Operations Limited. The mini turbine will use flare gas, at a rate of up to 700 m^3/day of the 3,500 m^3/day that is flared at this site, to produce electric power. Husky will continue monitoring this facility for one year.[132]

Since 1995 Fletcher Challenge Energy has been working with Capstone Turbine Corporation to test mini turbines at batteries. The mini turbines generate up to 30 kW of electricity, using sour gas that would otherwise be flared. In 1998, 145 tonnes of CO_2E were saved as a result of the pilot.[133]

ENERGY EFFICIENT DRILLING RIGS

Drilling rigs are usually powered by large diesel engines. BP Amoco designed its Liberty and Northstar production drilling projects in Alaska's North Slope to use electrical power generated by on-site turbine engines that are a cleaner source of power than diesel internal combustion engines.[134]

The Canadian Association of Oilwell Drilling Contractors estimates that using more efficient rig engines would result in a fuel cost savings of approximately

$13.41 million per year and reduce industry wide drilling engine fuel use by 14.91 per cent (using data from 1996 for the calculation base).[135]

Retiring existing units early and replacing them with modern equipment can substantially reduce direct or indirect emissions of greenhouse gases and NO_x emissions.

EFFICIENCY IMPROVEMENTS – GLYCOL DEHYDRATORS

The Canadian upstream oil and gas industry committed to reduce benzene emissions from glycol dehydrators according to a series of emission limits with a target of 90 per cent reduction from 1995 levels by 2005.[136] Measures to reduce benzene from glycol dehydrators can also reduce greenhouse gas emissions; these include:

- reduction in glycol pump circulation rate and rate of firing in the glycol regeneration boiler. Glycol circulation rates traditionally have been set higher than necessary and are not reduced to match declines in gas throughput. Reduced glycol circulation rates correspond with a lower rate of firing in the glycol regeneration boiler. Northstar Energy Corporation reduced the glycol pump circulation rates on its boilers, resulting in an annual emissions reduction of 200 tonnes of CO_2.[137]
- conversion of a glycol dehydrator to a separator. In some cases when gas volumes have declined it may be possible to operate the glycol dehydrator as a separator and simply shut off the circulating pump and re-boiler.

REDUCE STACK TOP TEMPERATURE

Large sour gas plants are required to manage the temperature of waste gases exiting incinerator stacks to ensure that the pollutants are adequately dispersed. This is accomplished by burning additional fuel gas in the incinerator. In some cases, stack top temperature requirements can be reduced while maintaining adequate dispersion of pollutants, resulting in reduced fuel gas combustion and lower emissions.

Husky Oil Operations Limited reduced the sulphur plant incinerator stack top temperature at its Ram River Plant, while still meeting environmental requirements. It is expected that CO_2E emissions have been reduced by 22,300 tonnes/year as a result.[138]

ACCELERATED TURNOVER OF INEFFICIENT UNITS

Significant improvements have been made in the combustion efficiency of industrial boilers, heaters, compressors, pumps and other large electricity and gas powered equipment. Retiring existing units early and replacing them with modern equipment can substantially reduce direct or indirect emissions of greenhouse gases and NO_x emissions.

Alberta Natural Gas Company has replaced older, less efficient gas turbines and compressors with new, high efficiency units. Since 1992, three units have been replaced, each avoiding the excess release of 15,000 tonnes of CO_2 per year.[139]

REDUCED EMISSIONS FROM EXISTING OPERATING EQUIPMENT

It is common practice to over-power pumpjacks, circulating motors, cooling fans, and other equipment to ensure uninterrupted operations of oil and gas facilities. This is due in part to the changing power needs of wells as they are depleted (e.g., glycol circulating motors in gas dehydration units can be turned down, but oil pumpjacks likely need to be turned up). The tendency to err on the side of over-powering can lead to unnecessary greenhouse gas emissions. Periodic power-use surveys give operators the information needed to properly match and tune facility power needs over time.

Union Pacific Resources Inc. (formerly Norcen Energy Resources Ltd.) reduced its CO_2E emissions by 3.9 kt/year by matching its motor size to pumpjack loads.[140]

Electric powered variable frequency drives (VFDs) for cooling fans for compressor engines, amine regenerators, and other equipment can reduce noise impacts as well as emissions of nitrogen oxides and greenhouse gases. Variable frequency drives allow cooling fans to be turned down under low ambient air temperature conditions (i.e., night-time and during the winter) rather than running at a constant rate. VFDs can also be installed on mainline pumping units, reducing control valve throttling and corresponding energy losses.

PanCanadian Petroleum Limited installed variable speed drives at six satellite locations and has realized a CO_2E reduction of 200 tonnes/year as a result.[141]

PIPELINES

The Canadian transmission pipeline industry moves oil to refineries and natural gas to the marketplace. It produces just under three per cent of Canada's total greenhouse gas emissions. Direct sources of greenhouse gas emissions result from the use of natural gas to fuel compressor engines, pumps and heaters. Indirect emissions of natural gas, commonly referred to as fugitive emissions, are caused by leaking components or sources designed to emit natural gas during normal operations. Methane is also released during routine maintenance and construction practices. Carbon dioxide is the main greenhouse gas produced from this sector, accounting for 64 per cent of the industry's direct greenhouse gas emissions, followed by methane at 34 per cent and nitrous oxide at one per cent.[142]

There are several major oil and gas pipeline networks in BC, with the pipeline sector of the petroleum industry accounting for about 1,652 kilotonnes of CO_2E emissions per year.[143]

Direct sources of greenhouse gas emissions result from the use of natural gas to fuel compressor engines, pumps and heaters.

Emission reduction opportunities

LEAK DETECTION AND REPAIR

Fugitive emissions make up 85 per cent of Natural Gas Transmission's (subsidiary of TransCanada Transmission) total methane releases. Eighty per cent of fugitive volumes come from 20 per cent of identified leak-susceptible equipment, which includes control valves, blowdown seat valves and instrument control vents.[144]

Leak detection and repair programs can be implemented to reduce greenhouse gas emissions from equipment sources. Such programs emphasize inspections of pipeline equipment that is known to generate fugitive emissions. TransCanada Transmission implemented a company-wide leak detection and repair system to record fugitive emissions, track mitigation measures and identify problem pipeline components. The 1997 pilot project obtained emissions reductions of 21,000 tonnes CO_2E. The 1998 full scale implementation achieved 124,000 tonnes of emissions reductions and demonstrated that a systematic approach to fugitive emissions can be cost-effective. Integral to TransCanada Transmission's program is the use of a recently-developed device called a Hi-Flow Sampler, which provides accurate field measurement of leaks.[145]

REDUCED PURGING – TESTING AND CLEANING

Pipeline maintenance and construction normally require purging of pipeline contents, and purged gas is usually vented or flared. Co-ordinating maintenance and construction work in the overall pipeline system can help reduce unnecessary emissions associated with purging the line. This includes tie-ins of new gas, cleaning and testing.

Leak detection and repair programs can be implemented to reduce greenhouse gas emissions from equipment sources.

Improved pig valves[146] can substantially reduce the amount of pipeline product drained, vented or flared off during pigging operations. Conventional pigging, using launchers and receivers, requires all piping between a closed upstream and downstream valve to be vented off. Specialized pig valves manufactured by Argus Machine Co. Ltd.[147] require that only the small area between the seats on the single pig valve be purged, reducing emissions by 85 to100 per cent. Methane is a more potent greenhouse gas than carbon dioxide so flaring purged gas produces fewer greenhouse gas emissions than venting.

REDUCED PURGING – PULL-DOWN COMPRESSION

Before pipeline maintenance and testing can be done, the pipeline normally must be depressurized and purged of gas, which is usually vented or flared to the atmosphere. Pull-down compression, or "sucking" the gas out of the pipeline, rather than the direct venting of pipelines prior to maintenance or testing avoids a significant greenhouse gas emission.

In 1995, Westcoast Energy reduced methane emissions by 30,000 tonnes CO_2E using a portable pull-down compressor at three sites.[148]

PREVENTION OF PIPELINE RUPTURES

High standards of construction, preventing corrosion and monitoring pipeline integrity can reduce leaks and the risks related to ruptures of pipelines and subsequent gaseous emissions. One program in the marketplace that addresses pipeline operations risk assessment is PIRAMID™. It was designed by C-FER Technologies Inc. as a joint industry product and is now supported by Alberta Research Council.[149] SaskEnergy-TransGas is also supporting research in pipeline risk assessment.[150]

High standards of construction, preventing corrosion, and monitoring pipeline integrity, can reduce leaks related to ruptures of pipelines.

REMOTE SHUT-DOWN CAPABILITY OF GAS FIELD

When a pipeline is unexpectedly shut down, the gas from processing facilities and wells must be shut off or directed to a flare. Having centralized remote control of gas field components using a SCADA, or comparable system, allows an operator to respond quickly to an unplanned pipeline disruption by shutting down facilities and wells, thus minimizing the duration of flaring incidents.

Energy supply and efficiency

USE OF TURBO-EXPANDERS

Turbo-expanders used by Foothills Pipe Lines Ltd. capture the energy released from decompressing a gas stream prior to its entering a natural gas liquid extraction plant. This energy is then used to recompress the gas before it is put back into the pipeline and shipped to market. Over 108,000 tonnes of CO_2E/year since 1990 have been saved as a result.[151 152]

TURNING LINE HEATERS DOWN OR OFF IN SUMMER

Line heaters reduce the risk of hydrate formation in gas pipelines and maintain fluidity in multiphase, oil, and produced-water[153] pipelines. Although line heaters are configured for winter operating conditions they often are not turned down during the summer months.

Suncor Energy turned off its line heaters at oil and gas production sites in the Blueberry area during the summer months, producing a fuel gas savings and CO_2E emissions reduction of 940 tonnes.[154]

USING LARGER DIAMETER PIPELINES

Installing larger diameter pipe can help increase product throughput and allow the overall pipeline system to operate more efficiently.

There is potential for significantly expanded use of renewable energy technologies by the upstream oil and gas industry.

Enbridge Pipelines Inc. installed larger diameter pipe to reduce the number of pumping units needed to ship increased volumes through its lines. Variable frequency drives were also installed on some pumping units to improve control and operating efficiency. These improvements have reduced indirect emissions by 130 kt of CO_2E per year since 1995.[155]

RENEWABLE ENERGY USE FOR OIL AND GAS OPERATIONS

Renewable energy technologies (RETs) transform renewable sources of energy such as wind and solar radiation to useful forms of energy, such as motive power or electricity. Emissions reductions are realized when renewable energy sources displace the energy sources that would otherwise have been used. The oil and gas sector has used RETs in a limited capacity for such things as lighting, office equipment, security, communications (SCADA), cathodic protection, hazardous gas and gas leak detection and alarm systems, and company vehicles (e.g., vehicle fleets fueled by wood or grain-derived ethanol).[156] There is potential for significantly expanded use of RETs by the upstream oil and gas industry.

PanCanadian is using solar devices at 57 locations to provide power for automation systems and remote terminal units in the field, resulting in a reduction of 12.4 kt CO_2E.[157]

In company buildings, it is possible to maximize solar energy gains and minimize heat losses. Passive solar design is the art of balancing solar heat gains and a building's heat losses to achieve the best performance. Solar panels can also be used to collect heat from the sun to pre-heat water before it goes into a conventional water heater that uses electricity or fossil fuels. Finally, solar energy can be integrated into industrial heating and cooling, similar to the passive solar building designs mentioned above. Integrating special building materials into the south face of large industrial buildings can reduce heating and cooling costs, thus displacing natural gas for those applications. For example, "SolarWall" cladding[158] attached to the side of a building serves the dual role of protecting the wall and heating and/or cooling the building.

Measures to reduce greenhouse gas emissions from the upstream oil and gas industry generally result in a net increase in employment.

Economic impacts

Measures to reduce greenhouse gas emissions from the upstream oil and gas industry generally result in a net increase in employment. Jobs lost by increased automation are replaced by different, more highly skilled jobs. Measures that result in job shifting and job creation include:

- Accelerated upgrading – engineering and construction jobs associated with accelerated upgrading and replacement of older inefficient compressors, boilers, motors, pneumatic devices and other oil and gas extraction/processing units.

- Gas conservation skills – Greenhouse gas reduction measures such as using alternatives to thermal destruction of gas, in-line testing, reduced purging and venting of pipelines and wells contribute to increased conservation of natural gas. These systems require highly specialized skills. New jobs designing and building systems to gather gas that would otherwise be wasted and jobs operating the new systems to bring the gas to market are created.
- Power balancing – A shift in operations from routine overpowering to periodic power use surveys and power balancing of pumpjacks, circulating motors, cooling fans, and other oil and gas extraction/processing units results in an increased need for technical and field staff resources.
- Integrity testing and leak detection and repair programs – New well and pipeline integrity testing and leak detection and repair programs require staff to design and carry out the program, and maintenance staff to carry out repair and replacement work.
- Increased automation such as the use of central computer-operated wells and pipelines can lead to fewer jobs for field operators who conduct routine visits to well sites and pipelines, perform visual inspections of the equipment, read meters, do basic maintenance functions, and open and close valves. These jobs are generally lower-skilled labour positions. More skilled and experienced field operator staff who can respond to problems and repair and replace equipment will still be needed. Centrally-operated systems also require highly trained staff and operators to install, maintain and operate the system.

Actions to prevent or reduce greenhouse gas emissions also reduce local air pollutants.

Local air quality improvement

In most cases, actions to prevent or reduce greenhouse gas emissions also reduce local air pollutants. The primary local and regional air contaminants of concern emitted by the oil and gas industry include: sulphur dioxide (SO_2), nitrogen oxides (NO_x), volatile organic compounds (VOCs), ground level ozone (O_3),[159] air toxics (such as hydrogen sulphide, benzene, polycyclic aromatic hydrocarbons, and carbon monoxide), and fine particulate matter (PM).

Sulphur dioxide (SO_2) is produced by the combustion of fossil fuels containing sulphur and through the combustion of hydrogen sulphide present in "sour" natural gas. SO_2 is associated with acid deposition, which has widely-documented impacts on lakes, forests, crops, and buildings. SO_2 can also combine with other compounds in the air to form fine particulates. Acute exposure to high concentrations of SO_2 can irritate the upper respiratory tract and aggravate cardiac respiratory disease. Long-term exposure may increase the risk of developing chronic respiratory disease.

Greenhouse gas reduction measures that contribute to reduction in SO_2 emissions include acid gas injection and prevention and reduction of thermal destruction of sour gas.[160]

Nitrogen oxides (NO_x) are by-products formed from the combustion of fossil fuels. As with SO_2, NO_x contributes to acid deposition and the formation of fine particulate matter. Nitrogen dioxide (NO_2), a component of NO_x, is known to irritate the lungs and increase susceptibility to respiratory infections in humans. Combined with ozone or sulphur dioxide, low concentrations of NO_2 can cause injury to plants. NO_x also plays an important role in the formation of ground level ozone through a complex photochemical reaction with volatile organic compounds.

Measures that prevent or reduce combustion-related greenhouse gas emissions result in direct reductions of NO_x. Examples include: replacement of inefficient compressors, boilers, and other equipment with new efficient units; alternatives to flaring and incineration of waste gases; power-use optimization of extraction/processing equipment such as pumpjacks, glycol dehydrators and line heaters; co-generation of heat and electricity; heat recovery; and the reduction of sour gas plant incinerator stack top temperature.

Ground level ozone also reduces the productivity of agricultural crops and forests and is a major constituent of smog.

Volatile organic compounds (VOCs) are released directly through the volatilization of raw and refined oil and gas products and are also formed from the combustion of fossil fuels. VOCs include hazardous air pollutants such as BTEX compounds (benzene, toluene, ethylbenzene, and xylene) that are known to be toxic and, in some instances, carcinogenic. VOCs contribute to the formation of particulate matter and react with NOx to produce ground level ozone. Measures that prevent fugitive emissions of greenhouse gases, primarily methane, directly reduce VOC emissions. Examples include: prevention of venting and purging from wells and pipelines, flaring or incineration versus venting of raw gas, leak detection and repair programs, replacement of pneumatic devices that vent to atmosphere, and alternatives to flaring.

Ground level ozone (O_3) adversely affects humans, irritating the eyes, nose, and throat, reducing lung function, and contributing to the development of chronic respiratory disease. Ground level ozone also reduces the productivity of agricultural crops and forests and is a major constituent of smog.

Hazardous Air Pollutants (HAPs) are substances that can have an immediate or a long-term harmful effect on human health and ecosystems. Examples of HAPs include SO_2, VOCs, carbon monoxide (CO), BTEX compounds, and polycyclic aromatic hydrocarbons (PAHs). PAHs are persistent and bio-accumulative. Carbon monoxide impedes the absorption of oxygen into the bloodstream and can cause permanent injury or death in high enough concentrations. Compounds such as benzene, styrene and toluene are listed in the National Pollutant Release Inventory (NPRI) and are monitored because of their toxicity or carcinogenicity.

Hydrogen sulphide is acutely toxic to humans at low levels, with instantaneous death occurring at levels of 1,000 ppm.[161]

Particulate Matter (PM) is tiny pieces of solid and liquid matter small enough to be suspended in the air. The finest of these particles are primarily soot and exhaust combustion products from both natural and human-induced sources. They can irritate the respiratory tract and contribute to smog formation. Secondary sources of PM include SO_2, NO_x, and VOCs, which act as precursors to PM formation in the atmosphere. Of special concern are PM_{10} and $PM_{2.5}$. These are referred to as "fine" particulate matter because they are, respectively, less than 10 and 2.5 microns[162] in diameter. Fine particulates can penetrate deeply into the lungs where they can seriously affect respiratory function. Increased ambient levels of $PM_{2.5}$ have been linked to increased incidents of hospitalizations and premature death from respiratory and cardiac disease.

Measures that reduce the risk of spills and leaks reduce human health risks and reduce greenhouse gas emissions.

Measures that are intended primarily to reduce impacts on surface ecosystems[163] can also reduce the energy intensity of oil and gas operations. For example, drilling multiple wells from a single pad location reduces the impacts of road and well pad construction and well site operation on terrestrial and aquatic ecosystems.

Remote operation of well sites and pipelines eliminates the need for most routine and non-routine visits of well sites by operators, along with the associated transportation related greenhouse gas emissions. Fewer site visits by field operators means less pressure on wildlife movement and reduces road kill numbers.

Measures that reduce the risk of well and pipeline spills and leaks (through initiatives such as integrity testing) reduce human health risk of exposure to emissions and explosion hazards, lower the incidence of soil and water contamination, reduce greenhouse gas emissions associated with flaring, and reduce direct releases of production gases to the atmosphere.

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54 Converting vehicle insurance and registration fees from fixed to per-mile charges provides a significant financial incentive to reduce driving, while making these charges more fair and affordable. This is predicted to reduce vehicle travel by approximately 12%, reduce crash rates by a greater amount, increase equity, and save consumers money. Litman, T, *Win-Win Transportation Solutions: Cooperation for Economic, Social, and Environmental Benefits*, Victoria Transport Policy Institute, Victoria, BC, December 1, 1999

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78 For more information, see the Federation of Canadian Municipalities internet website at: http://www.fcm.ca/_vti_bin/shtml.dll/index.html
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93 *ibid.*, 3.3
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