BC Climate Action Secretariat

Development of an Electrification Policy Framework for British Columbia

Final Report
June 1, 2010

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Introduction

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1. INTRODUCTION

1.1 OBJECTIVE OF STUDY

The objective of this study is to develop an electrification policy framework for British Columbia. Within that framework, specific policy actions will be recommended. The intent of these policy actions is to reduce both the use of fossil fuels and greenhouse gas emissions while increasing the use of efficient electricity from clean generation resources over the next 40 years.

1.2 SCOPE OF STUDY

The scope of this study is to identify and evaluate opportunities for electrification. This includes identifying policy actions to encourage electrification opportunities and evaluating the impact of those opportunities. In addition, the impact of electrification on energy use and greenhouse gas emissions in 2020 and 2050 are documented.

The study does not include evaluation of impacts on energy prices and jobs. While energy efficiency actions are included in the analysis, the evaluation of the impact of other climate actions such as renewable electricity planning, carbon capture and storage, cap and trade and forestry practice measures are not in the scope.

1.3 DEFINITION OF ELECTRIFICATION

Electrification is the modification of a system so that it operates using electricity. In our context, electrification refers to the modification of British Columbia's existing energy system of supply and end use to a system that increases the use of efficiently generated electricity from clean generation sources while decreasing the use of fossil fuels and improving efficiency.

Sources of energy supply discussed in this study include water (i.e. hydroelectric power), natural gas, biomass, coal, petroleum and other renewables (including; biomass, wind, solar, geothermal and ocean energy). End uses for the energy are disaggregated into the residential, commercial, industrial and transportation sectors.

1.4 ELECTRIFICATION BENEFITS

Key benefits from the production of additional efficiently generated electricity from clean generation resources (efficient electricity), with a corresponding decrease in the use of fossil fuels, include:

- Creation of an energy security legacy by making the bold investments and policy decisions required for BC to prosper in a future global economy that is powered by clean energy and technologies;
- Creation of a 'clean energy powerhouse' in British Columbia and the corresponding attraction of new investment to the province;
- Diversification and expansion of the resource sector industries in BC by creating new business for forest and mining industries through clean energy generation;
- Expansion of district scale energy systems in BC municipalities and First Nations communities using municipal waste to energy and other renewables (e.g. ocean energy in coastal communities), thereby strengthening locals economies, and creating clean energy supply, maintenance and operations jobs;
- Reduction in greenhouse gas emissions (which will significantly contribute to the government's directions on greenhouse gas reduction targets, namely a 33% reduction from 2007 levels by 2020 and an 80% reduction from 2007 levels by 2050);
- Creation of a long-term and consistent demand for the development of clean generation resources (which will contribute to the government's directions on electricity self-sufficiency and zero net greenhouse gas emissions from new generation projects);
- Increase export of electricity (e.g. to California and Alberta) from clean energy generation sources, thereby providing additional BC Government revenues and offsetting production of electricity from fossil fuel sources with a corresponding decrease in greenhouse gas emissions;
- Addition of BC revenues from taxes and water rentals;
- Creation of a major new export industry sector in British Columbia for clean energy generation from renewables, with the creation of well-paying jobs (technical, professional, construction, operation and maintenance). This is driven by the emphasis on construction of clean energy generation projects[1] and new facilities and retrofit of existing facilities to use clean energy;
- Improved efficiency of all sectors;
- Reduced noise;
- Reduced emissions of sulphur oxides, nitrogen oxides and particulates;
- An increase in natural gas exports which displaces higher greenhouse gas emitting coal fired generation in the US and Alberta;
- Increased use of the Province of BC's wood waste for energy use;
- Improved competitiveness and efficiency of industrial facilities to ensure an industrial future for BC; and
- The attraction of electricity intensive industries such as server farms, smelters and others.

[1] Economic Impact Analysis of Independent Power Projects in British Columbia, PwC, December 2009.

1.5 BARRIERS TO ELECTRIFICATION

There are a number of barriers to electrification. These barriers are listed below. Many of these barriers can be overcome with specific policy actions identified in Section 4.

ACCESS TO GRID POWER

A large portion of the mining, petroleum and natural gas production facilities are located in remote locations of British Columbia where grid access is not available.

AVAILABILITY OF RESOURCES

The forestry tenure system does not ensure a low cost, secure supply of wood waste for biomass combined heat and power projects.

Air source heat pumps require backup for cold periods.

TECHNOLOGY

Hybrid electric vehicles (HEV) and plug-in hybrid electric vehicles (PHEV) technology applications are not yet developed for heavy trucks and fuel cell systems for heavy trucks have not received the same attention as for cars and buses.

In many cases, electricity does not provide a viable substitute to existing processes (e.g. cement kiln furnaces, aircraft engines, heavy-duty petroleum fuelled engines for ships and trucks).

MARKETS AND SOCIAL CHANGE

Electric vehicle technology has not been deployed for light duty vehicles outside of manufacturers' demonstration programs. Charging infrastructure needs to be installed.

PHEVs and fully electric light duty vehicles are not yet readily available and will require many years before they form a significant portion of the BC fleet following introduction to BC showrooms.

It takes time for people to accept and change the way a system works. For example, are people willing to charge their PHEVs at night rather than fuelling up their internal combustion engines (ICE) at the gas station?

CAPITAL INVESTMENT AND CAPITAL STOCK TURNOVER

In most cases, it is not economical to retrofit existing equipment in the short term. Four factors limit potential for retrofitting clean energy technologies in the built environment: limited impact of energy costs on operating budgets of commercial enterprises and rental buildings in the residential market; long payback periods for retrofits; the requirement for firm (uninterrupted) energy supply; and operational disruptions caused by major retrofits.

Similar challenges exist for equipment replacement in industry and commercial enterprises. The necessary consortia and investment vehicles are not yet in place to affect the scale of investments needed for the portfolios of larger projects envisioned in this report such as:

- Forest and mining industry diversification into clean energy sales;
- Electrification of rail;
- Biofuel industry expansion district energy systems (municipalities, business parks and rural communities); and
- Shift to rail for medium haul heavy goods movements in BC.

PHEVs and HEV fuel cell vehicles in the light vehicle fleet offer the largest single potential to cut GHGs in the Province. However, PHEVs are expected to be significantly more expensive than ICE and HEV vehicles when introduced and it may take a decade or more before they reach price parity with ICE vehicles and HEVs. Fuel Cell HEVs face similar challenges.

1.6 REPORT OUTLINE

The report is organised as follows:

- Section 1: Introduction – provides a brief background on the objective and scope of the study, the benefits and barriers to electrification and an outline of the report;

- Section 2: Methodology – provides a description of the methodology used to develop an electrification policy framework for BC;

- Section 3: British Columbia's Energy System – provides a summary in the form of energy flow diagrams of BC's energy system for 2010 and reference case projections for 2020 and 2050;

- Section 4: Electrification Opportunities – outlines the opportunities for electrification in each of the residential, commercial, industrial and transportation sectors;

- Section 5: Impact of Electrification – provides a summary of the impact of electrification on both energy usage and greenhouse gas emissions for each of the above four sectors. This includes energy flow diagrams for 2020 and 2050 with electrification actions considered;

- Section 6: Conclusions – summarises the policy actions to implement electrification; and

- Section 7: Report Submission – identifies the key authors of the report.

Section 2

Methodology

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2. METHODOLOGY

The methodology used to develop an electrification policy framework for BC is described as follows:

- Projection of "business as usual" energy end-use and energy supply to the years 2010 and 2050 (reference cases);
- Identification of electrification policy opportunities and calculation of their impact on energy end-use and supply in 2050;
- Result interpolation for the year 2020; and
- Greenhouse gas emissions calculations.

The following section provides a high-level description of these steps. Specific assumptions and data used for each sector of the economy (residential, commercial, industrial, and transportation) are discussed in the result sections.

2.1 ENERGY USE – 2010 AND 2050 REFERENCE CASES

"Business as usual" cases are used as reference to measure the impact of the electrification policies. Energy end-use and energy supply requirements are calculated from public literature (a list of the references used in this study is provided in Appendix F). The primary references used to project BC's energy end-use and supply to 2010 and 2050 include:

- Statistics Canada census data;
- NRCan energy surveys;
- Gross Domestic Product (GDP) in British Columbia – historical data;
- Establishment counts and employment in British Columbia – historical;
- Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC) and Canadian Residential Energy End-use Data and Analysis Centre (CREEDAC) reports; and
- MKJA (2009)[2] energy forecast.

These projections are based on continuous trends from historical hard data and do not include any impacts from the Climate Action Plan (CAP). Results were found to be consistent with MKJA (2009) end-use energy forecast. The key parameters used in the energy forecast include:

- Residential sector: population, dwelling type, energy source, end-use and energy efficiency, construction trends, technology adoption rates;
- Commercial sector: GDP by sub-sector, floor space and construction trends, energy intensity, energy source and end-use by sub-sector, technology adoption rates;
- Industrial sector: GDP, employment, energy source and end use; and

[2] MK Jaccard and Associates Inc (MKJA), 2009, Reference Case Scenario and Marginal Abatement Cost Curves for British Columbia - Draft Report, December 15.

- Transportation: licensed vehicles, gasoline and diesel fuel sales, population demographical data, TransLink and BC Transit data, transit trips, private vehicle trips, gateway data – marine, air, rail, truck, technology developments and adoption rates.

2.2 ENERGY USE – 2050 ELECTRIFICATION SCENARIO

A detailed review of power generation potentials in BC, current and developing power generation technologies, penetration rate, and cost forecast were completed. To realise these potentials, the authors used their professional judgment to a) identify a list of policy actions that would encourage electrification in the province and b) estimate the impact that these policies could have in 2050 on power consumption and other energy flows in BC. The policy actions and their potential impact are detailed in Section 4 of this report.

2.3 2020 INTERPOLATION

"Business as usual" and electrification scenario results for the year 2020 are calculated based on a linear interpolation between the 2010 and 2050 results.

The electrification scenario results for the year 2020 should be used with caution as some policy actions originally developed for 2050 may have less impact in 2020 than that calculated by the interpolation.

2.4 GREEN HOUSE GAS EMISSIONS CALCULATIONS

Greenhouse Gas (GHG) emissions are calculated as the product of end-use energy with the associated emissions factors. Both direct (on-site) and indirect (upstream) GHG emissions are accounted for. Direct and indirect emissions factors used in this study are listed in Table 2.1.

The direct emissions factors associated with the combustion of petroleum products, natural gas and coal are taken from the Intergovernmental Panel on Climate Change (IPCC) Guidelines[3]. Indirect emissions factors associated with the fuel cycle of petroleum products, natural gas, coal, and biofuels are averages from MKJA (2009).

The indirect emissions factors associated with power generation are also taken from MKJA (2009) but it is assumed in the 2020 and 2050 electrification scenarios that the emissions factors are equal to that of the 2010 reference case – based on the assumption that an electrification program will trigger clean power generation.

The GHG emissions that result from the combustion of biomass and biofuels are not accounted for, as per common practice. The indirect emissions associated with biomass and waste are assumed negligible, an assumption acceptable at the level of this study but which should be reviewed in future research.

[3] Intergovernmental Panel on Climate Change (IPCC), 2006, Guidelines for National Greenhouse Gas Inventories - Volume 2.

Table 2-1: Emissions Factors (t CO_2eq/TJ)

Energy Source	Emissions Type	2010	2020	2050	Electrification	Reference
Electricity	Direct			0		
	Indirect	9.1	16.3	40.5	9.1 [1]	MKJA (2009)
Petroleum Products	Direct			72.0		IPCC (2006)
	Indirect			7.5		MKJA (2009) - average over 2010-2050
Natural Gas	Direct			56.1		IPCC (2006)
	Indirect			8.0		MKJA (2009) - average over 2010-2050
Coal	Direct			95.0		IPCC (2006)
	Indirect			2.3		MKJA (2009) - average over 2010-2050
Biomass & Waste [2] *(excluding biofuels)*	Direct			0		
	Indirect			0		
Biofuels	Direct			0		
	Indirect			20.8		MKJA (2009) - average over 2040-2050

Notes and References

[1] The GHG emissions intensity of power generation for the 2020 and 2050 Electrification Scenarios is assumed equal to that of the 2010 Reference Case.

[2] Waste emissions accounted for in the 'Agriculture and Waste' sector

MK Jaccard and Associates Inc (MKJA), 2009, *Reference Case Scenario and Marginal Abatement Cost Curves for British Columbia - Draft Report, December 15.*

Intergovernmental Panel on Climate Change (IPCC), 2006, *Guidelines for National Greenhouse Gas Inventories - Volume 2.*

Section 3

British Columbia's Energy System

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3. BRITISH COLUMBIA'S ENERGY SYSTEM

British Columbia's energy system is depicted on an energy flow chart (known as a "Sankey" Diagram, which is a flow diagram in which the width of the arrows is shown proportionally to the flow quantity) that shows the existing energy supply sources (namely hydroelectricity, natural gas, biomass, coal and petroleum and other renewables), and the end-use of that energy in each of the residential, commercial, industrial and transportation sectors. Conversion of the energy supply sources to electricity is also shown on the flow chart. The units of energy are converted to a single unit of measure, namely petajoules (PJ). In terms of energy equivalence, one PJ is equal to:

- The energy of 160,000 barrels of oil;
- The energy consumed annually by 9,000 average BC single, detached houses; or
- The energy used by a fleet of 7,000 automobiles.

Figure 3-1 shows British Columbia's 2010 energy flows, while Figures 3-2 and 3-3 show forecast energy flows for 2020 and 2050 respectively. Detailed numerical results associated with Figures 3-1, 3-2 and 3-3 are provided in Appendices A, B, C and D. Figures 3-2 and 3-3 are used as reference cases, based on "business as usual" projections of energy supply and end use. They do not include impacts from the Climate Action Plan. Appendix E provides a list of assumptions made to develop these Figures.

Figure 3-1: British Columbia's Energy Flow - 2010 (units in Petajoules)

June 1, 2010

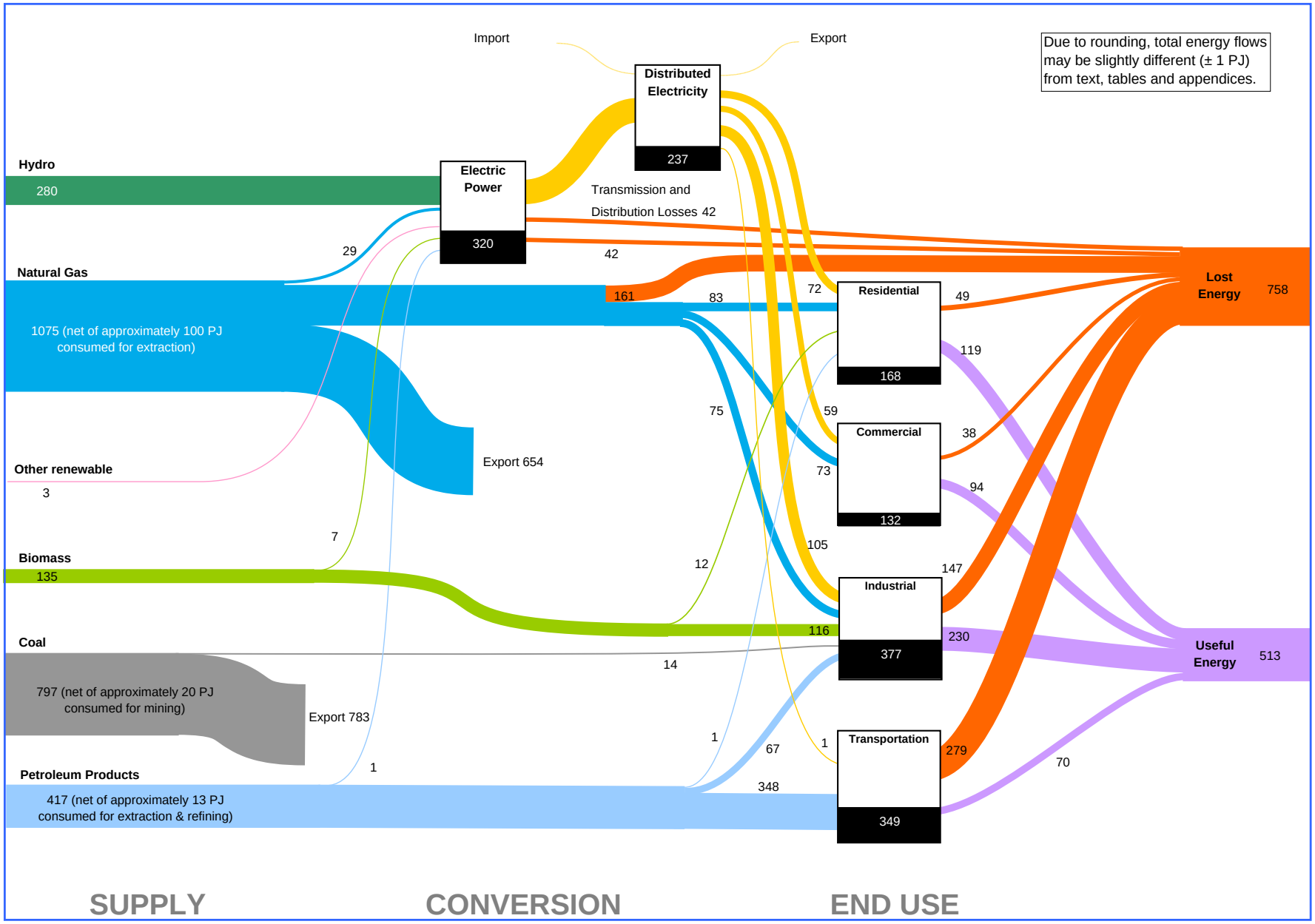


Figure 3-2: British Columbia's Energy Flow - 2020 Reference Case (units in Petajoules) **June 1, 2010**

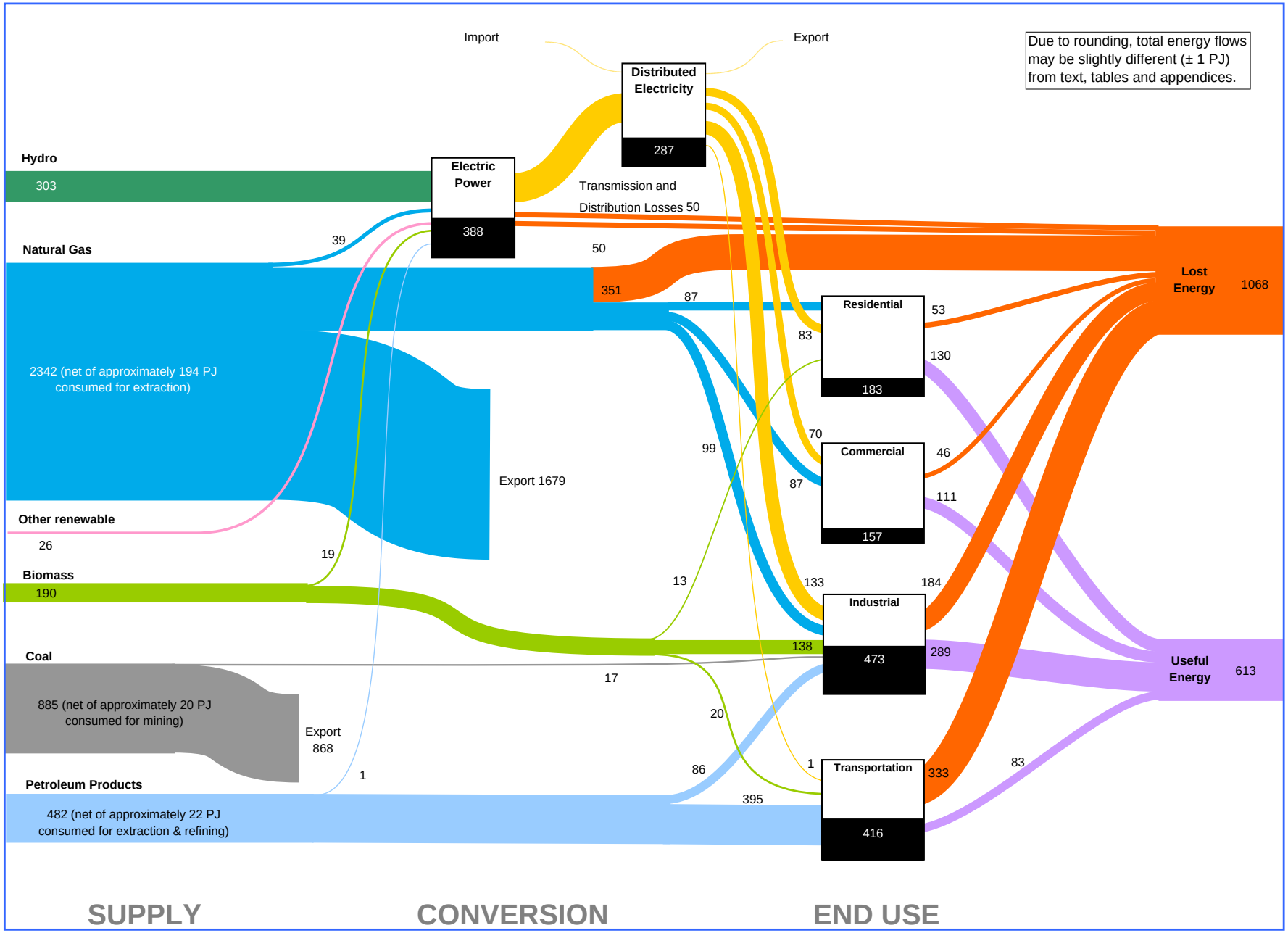
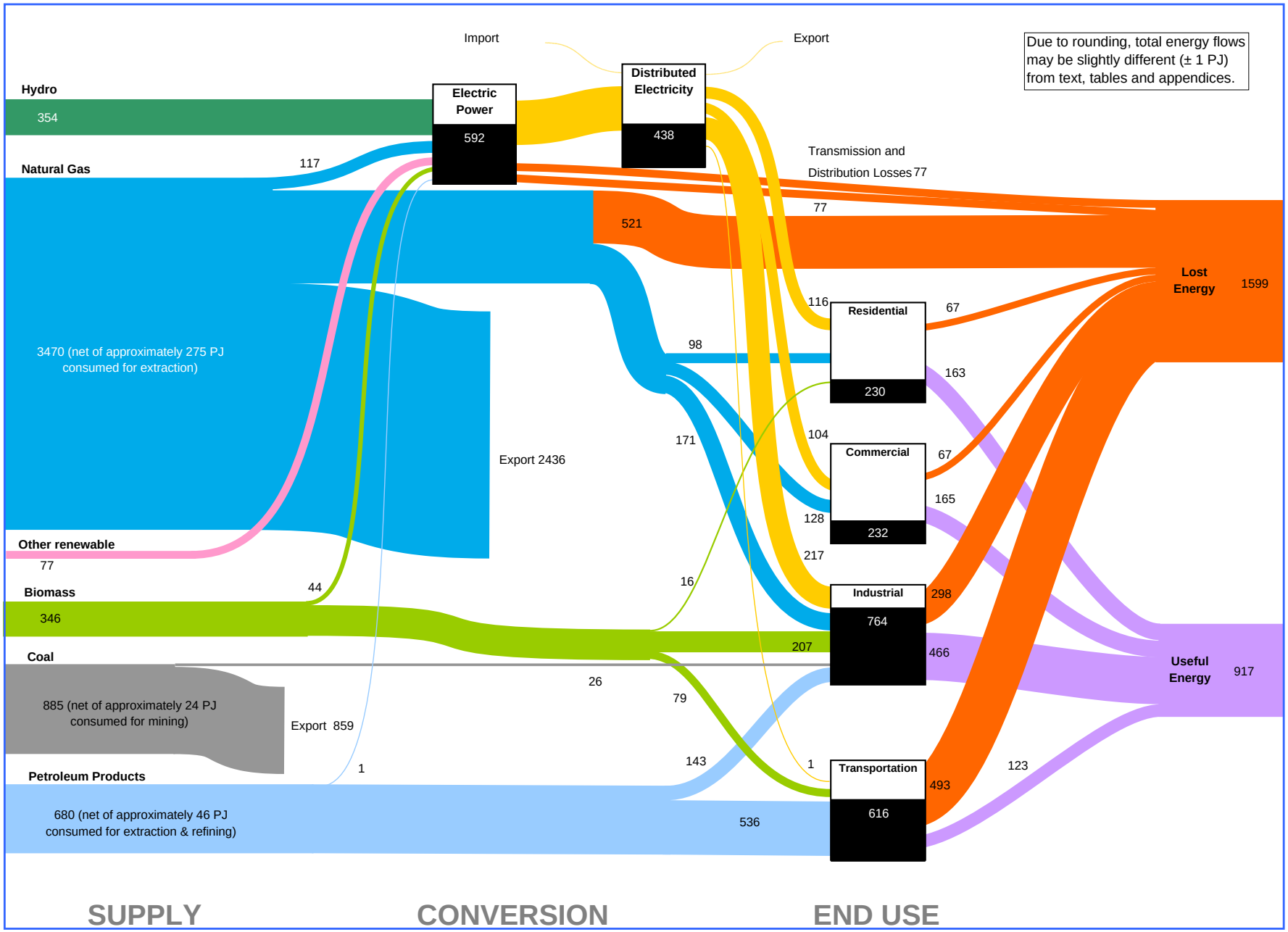


Figure 3-3: British Columbia's Energy Flow - 2050 Reference Case (units in Petajoules) **June 1, 2010**



Section 4

Electrification Opportunities

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4. ELECTRIFICATION OPPORTUNITIES

This section summarizes opportunities for electrification, policy actions and impact for the residential, commercial, industrial, and transportation sectors.

4.1 RESIDENTIAL SECTOR

SECTOR PROFILE

Figure 4-1 shows the breakdown of energy use by the residential sector in 2010 and forecast consumption in 2050. This sector comprises two main types of dwellings namely single-family houses and multi family. The multi family type includes low rise/row houses, high rises, and all other dwellings. These dwelling types have significantly different energy use profiles. Metro Vancouver, which currently has 45% of BC's households, is projected to account for 65% of B.C.'s multi-family dwellings by 2050.

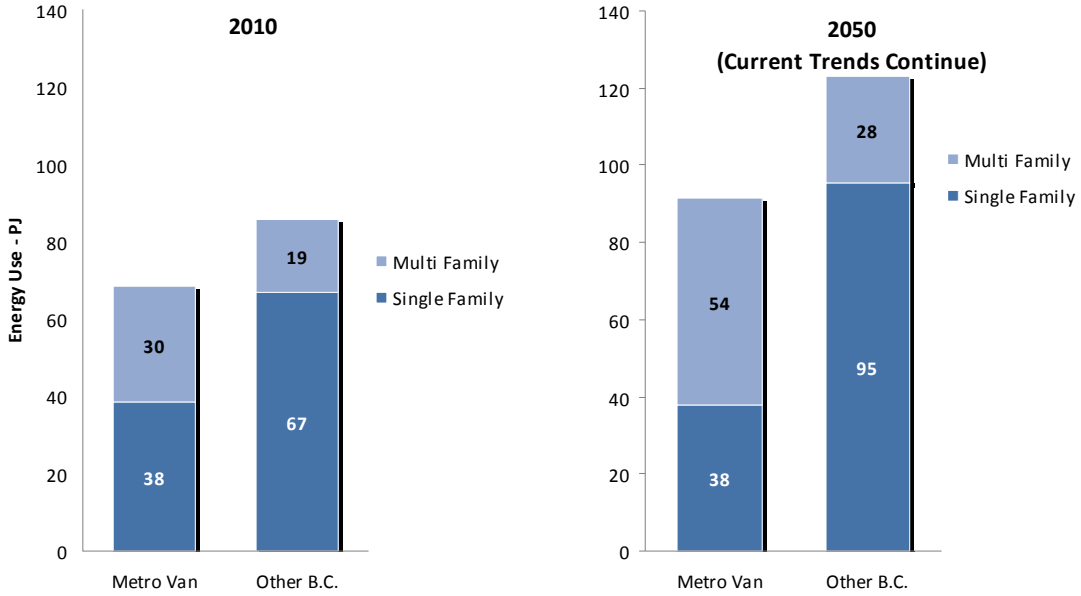

Figure 4-1: Electricity and Natural Gas Energy Consumption by Residential Buildings [4,5]

In 2010 there are estimated to be 1.8 million households consuming 167 PJ. If present trends continue, by 2050, there would be 2.6 million households consuming 230 PJ. The energy efficiency of the sector is improving in Metro Vancouver due primarily to urban densification. In 2010 average single-family dwellings consumed 110 GJ per year and average multi family dwellings consumed 65 GJ per year. In 2010 it is estimated that 58% of households in Metro Vancouver live in multi family dwellings. By 2050, if present

[4] From NRCan Surveys of Household Energy Use (SHEU) in 2003 and 2007, CIEEDAC reports, Statistics Canada census data, Metro Vancouver reports, and BC Stats employment data and reports on a Canadian Residential Energy End-use and Emission Model from CREEDAC.

[5] Plus 12 PJ of woodwaste and 1 PJ of petroleum in 2010 and 16 PJ of woodwaste in 2050.

trends continue, 71% will live in multi family dwellings. In addition to densification in Metro Vancouver, continual improvements in building efficiency and the efficiency of electrical appliances mean that residential sector energy intensity (GJ/m^2) is declining. The main contributors to this improvement are: more efficient furnaces, increased insulations and weather stripping, more efficient windows, lighting and hot water savings.

Figure 4-2 shows the breakdown by end use for the residential sector. In 2010 natural gas consumption for space heating totalled 83 PJ in the residential sector. If present trends continue natural gas consumption would increase to 98 PJ by 2050.

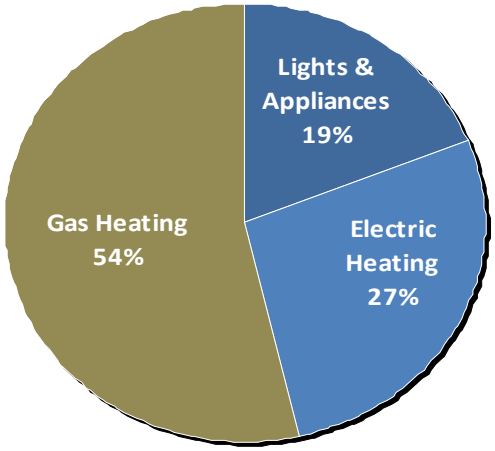

Figure 4-2: Breakdown of Residential Energy by End Use (2010)

ELECTRIFICATION POTENTIAL AND POLICY ACTIONS

There are a number of high potential electrification opportunities in this sector:

New Construction

The use of geo-exchange systems, air source heat pumps, solar hot water, low emission wood pellet stoves and building integrated solar photovoltaic[6] in new construction.

Policy Action: Change the BC Building Code to require net zero emission buildings by 2015 through the use of geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in new construction. This policy action is supported by the CAP requirement for new homes to to meet new energy efficiency standards equivalent to EnerGuide 77.

The use of renewable district energy systems for new developments and redevelopments. This policy action is supported by the CAP Green Building Code provision for energy efficiency for buildings; on-site renewable energy; energy efficient devices; and community energy planning.

[6] Tracking the Sun II, The Installed Cost of Photovoltaics in the U.S. from 1998-2008, Lawrence Berkeley National Laboratory, October 2009.

Policy Action:

- Through the Local Government Act require Official Community Plans to encourage renewable district scale co-generation; and
- Change the BC Building Code to require buildings to have heating systems that enable connection to district energy systems in the future.

Existing Facilities

The use of geo-exchange systems, air source heat pumps, solar hot water, low emission wood pellet stoves and building integrated solar photovoltaic for retrofit of existing facilities.

Policy Action: Change the BC Building Code to require net zero emission buildings by 2050 through geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in existing facilities.

The cost of renewable power generation alternatives is not expected to be a major barrier to the implementation of the policy actions proposed in the study. Figure 4.3 shows that wind and geothermal are already competitive while the cost of solar PV is expected to significantly decline. The cost of a 5 MWh/year residential PV installation is expected to decrease from $20,000 in 2010 to $5,000 in 2020, and $2,500 in 2050.

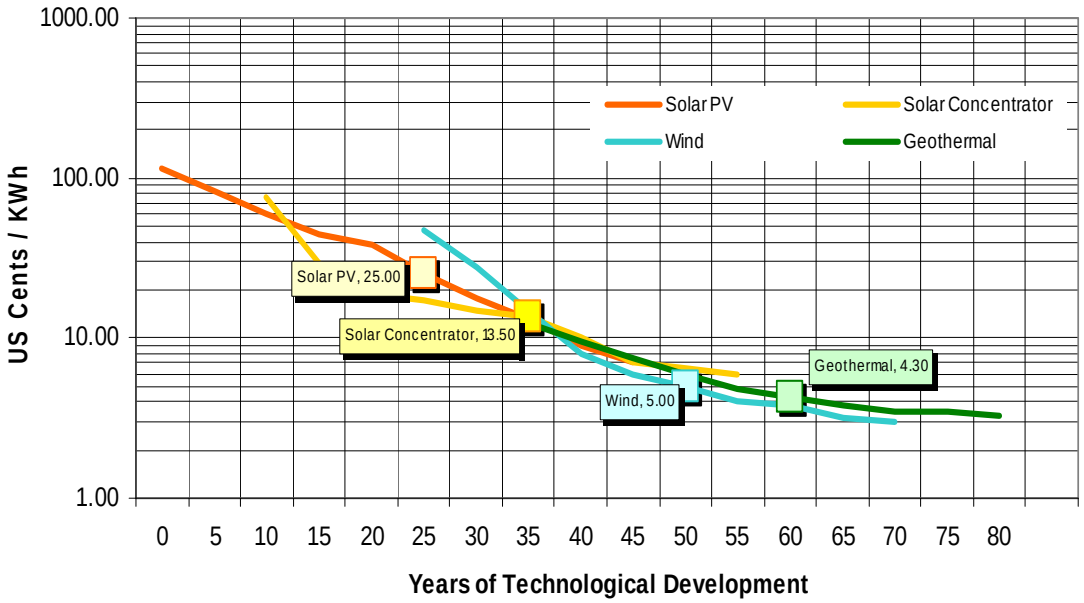

Figure 4-3: Cost Forecast of Renewable Electricity Technologies[7]

[7] This energy cost technological evolution is based on DOE Energy Analysis Office Data. 2005 Energy Cost Curves with historical data between 1980 and 2004 and current projections to 2025.

IMPACTS OF POLICY ACTIONS

Based on the opportunities and policy actions above, the changes in electrification of the residential sector are described below:

- Fifty percent of single family and low rise multi-family dwellings have air source or geo-exchange heat pumps installed by 2050 (displacing 49 PJ of natural gas with 15 PJ of electricity);
- Solar photovoltaic panels are installed on 50% of residential buildings supplying a range of 50 to 100% of each household electrical requirements by 2050; and
- Thirty five PJ of biomass (municipal waste and wood pellets) are used for space heating by 2050.

Figure 4-4 shows the comparison of energy consumption for the residential sector for 2010, 2050 reference case and 2050 with electrification.

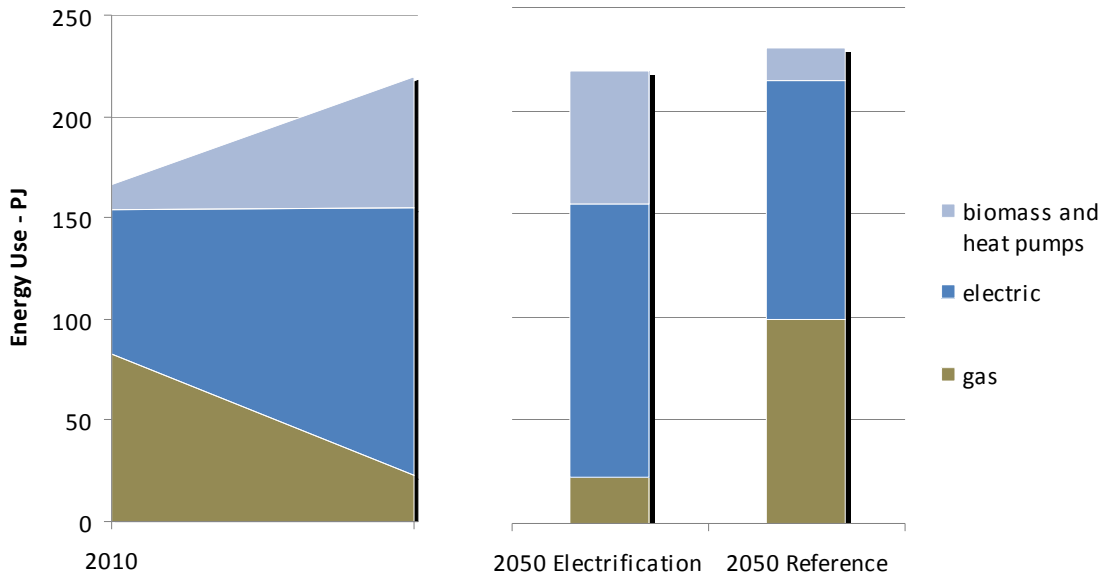

Figure 4-4: Comparison of Residential Energy Consumption

4.2 COMMERCIAL SECTOR

SECTOR PROFILE

Figure 4-5 shows the breakdown of energy use by the commercial sector in 2010 and forecast consumption by 2050. The sector is broken down into four sub-sectors, namely, retail and wholesale trade, public sector buildings, business offices, and other commercial or institutional. This sector comprises four sub-sectors with significantly different energy use and supply profiles as discussed below.

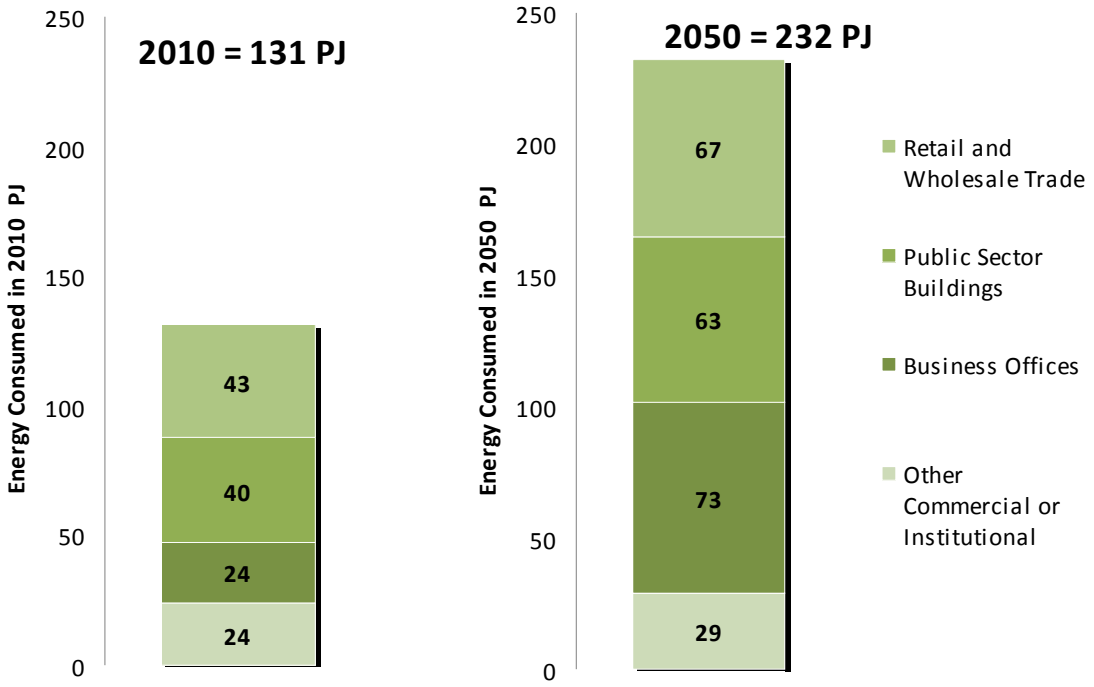

Figure 4-5: Trend in Energy Consumption by Commercial Sector

Retail and Wholesale Trade: There are estimated to be 47,000 establishments covering 40 million square metres of floor space in use for retail, wholesale and warehousing operations in 2010. In total, they are estimated to consume 43 PJ of energy per year. By 2050, if present trends continue, these businesses could require 65 million square metres of floor space and consume 67 PJ of energy. Wholesale and warehouse operations user about 0.87 GJ/m^2 while retail sales operations use about 1.32 GJ/m^2 due to more complex lighting, auxiliary motors and equipment.

Public Sector Buildings: Healthcare facilities, educational facilities and public administration and other public services are estimated to cover 32 million square metres of floor space and consume 40 PJ of energy in 2010. Growth of public sector service floor space is expected to follow population increases and could reach 65 million square metres in 2050 with an energy consumption of 63 PJ. Even though public sector buildings tend to be more energy efficient, they also have the highest consumption of natural gas primarily for hot water and space heating for health care services.

Business Offices: An estimated 40,000 establishments including; financial and business services, professional and technical services, cultural and information services, make up this sector. In Metro Vancouver, growth in this sector is characterized by rapid expansion in business parks (according to Metro Vancouver reports business parks are expanding at four times the rate of municipal "downtowns"). This trend is of particular interest to transportation planners since business parks are generally not well served by public transit and therefore cause increasing vehicle traffic and GHG emissions growth.

This is also the fastest growing part of the commercial and institutional sector. In 2010 there are estimated to be 15 million square metres of private sector office floor space and by 2050 this could grow to 48 million square metres. Energy consumption in these high and low-rise office buildings is estimated to be 24 PJ in 2010. By 2050, if current trends continue, energy consumption would expand to 73 PJ. Annual energy consumption per square metre of floor space is among the highest in the sector at 1.6 GJ/m^2.

Energy supply to private sector office buildings is 55% natural gas (mainly for space heating) and 45% electricity.

Other Commercial and Institutional: The balance of this sector includes buildings for vehicle repair and maintenance, places of religious assembly, accommodation, food services and drinking establishments and a variety of other services and institutions. Services and institutions are estimated to cover 14 million square metres of floor space and consume 24 PJ of energy in 2010. If present trends continue, all other services and institutions will grow to cover 17 million square metres and consume 29 PJ of energy in 2050.

ELECTRIFICATION POTENTIAL AND POLICY ACTIONS

There are a number of high potential electrification opportunities in this sector:

New Construction

The use of geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in new construction.

Policy Action: Change the BC Building Code to require net zero emission buildings by 2015 through the use of geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in new construction. This policy action is supported by the CAP provision for commercial buildings built after 2010 to meet ASHRAE 90.1-2004 standards.

Business Parks

The use of district scale co-generation in business parks to supply both efficient electricity and space heating using municipal waste streams and local renewables (such as biomass, solar, geothermal (hot rock).

Policy Action:

- Through the Local Government Act require Official Community Plans to encourage renewable district scale co-generation; and
- Change the BC Building Code to require building to have heating systems that enable connection to district energy systems in the future.

Ensuring business park integration into transportation systems to facilitate access to electric transit/light rail and requiring electric vehicle charging facilities.

Policy Action:

- Through the Local Government Act require Official Community Plans that require Business Park zoning to encourage access to transit in zoning and development plans; and
- Change the BC Building Code to require 20% of parking stalls in commercial buildings to have charging facilities for electric vehicles.

Existing Facilities

Replacing existing heating systems with "heat pumps" to displace natural gas used for space and water heating.

Policy Action:

- Through legislation, regulation or special direction require electric utilities to provide an incentive program to encourage heat pumps; and
- Develop a program for government buildings. The CAP proposes all new commercial buildings built for the public sector are required to meet LEED Gold™ standards.

Installation of solar photovoltaic panels in the existing building stock.

Policy Action: Through legislation, regulation or special direction require electric utilities to provide a net metering or feed-in tariff in the order of $0.75/kWh for solar photovoltaic power.

IMPACTS OF POLICY ACTIONS

Based on the opportunities and policy actions above, the change in electrification of the commercial sector is described below:

New Construction

- 100% of public sector new construction from 2010 utilizes heat pumps for space heating displacing natural gas;
- 40% of all other commercial new construction utilizes heat pumps for space heating displacing natural gas;
- 30% of new construction utilizes solar photovoltaic panels to supply electricity for auxiliary equipment, motors and lighting;
- 50% of buildings built before 2011 fitted with heat pumps (assumes most of these aged buildings are replaced); and

- Heat pumps, solar and district energy systems replace 50% of natural gas space heating and hot water heating in Health Care and Education facilities.

Business Parks

Thirty per cent of business offices are located in business parks, and space heating is supplied by steam from co-generation waste to energy systems.

Existing Facilities

- Fifty per cent of the 2010 private sector office buildings and retail, wholesale and warehousing buildings have been retrofitted with heat pumps for space heating by 2050; and
- Twenty five per cent of all other commercial and institutional building stock 2010 have been retrofitted with heat pumps for space heating by 2050.

Figure 4-6 shows the comparison of energy consumption for the commercial sector for 2010, 2050 reference case and 2050 with electrification.

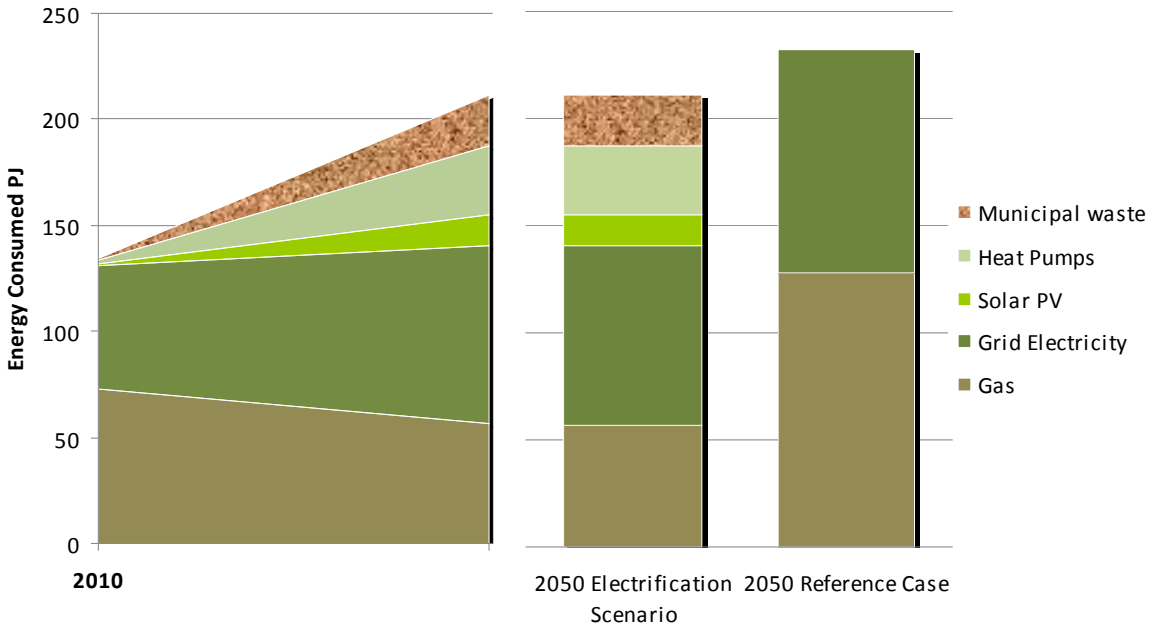

Figure 4-6: Comparison of Commercial Energy Consumption[8]

[8] 32 PJ of heat pump energy supply in 2050 not shown.

4.3 INDUSTRIAL SECTOR

SECTOR PROFILE

Figure 4-7 shows the breakdown of energy used by the industrial sector in 2010 and forecast consumption by 2050. This sector comprises all goods producing industries including agriculture.

In 2010, goods-producing industries in BC are estimated to consume approximately 377 PJ. If pipelines and losses in the oil and gas extraction industries are included total energy consumed would be close to 600 PJ per year. If present trends continue by 2050, the industrial sector will consume 764 PJ with another 200 PJ or more consumed by pipelines and losses in the oil and gas extraction industries.

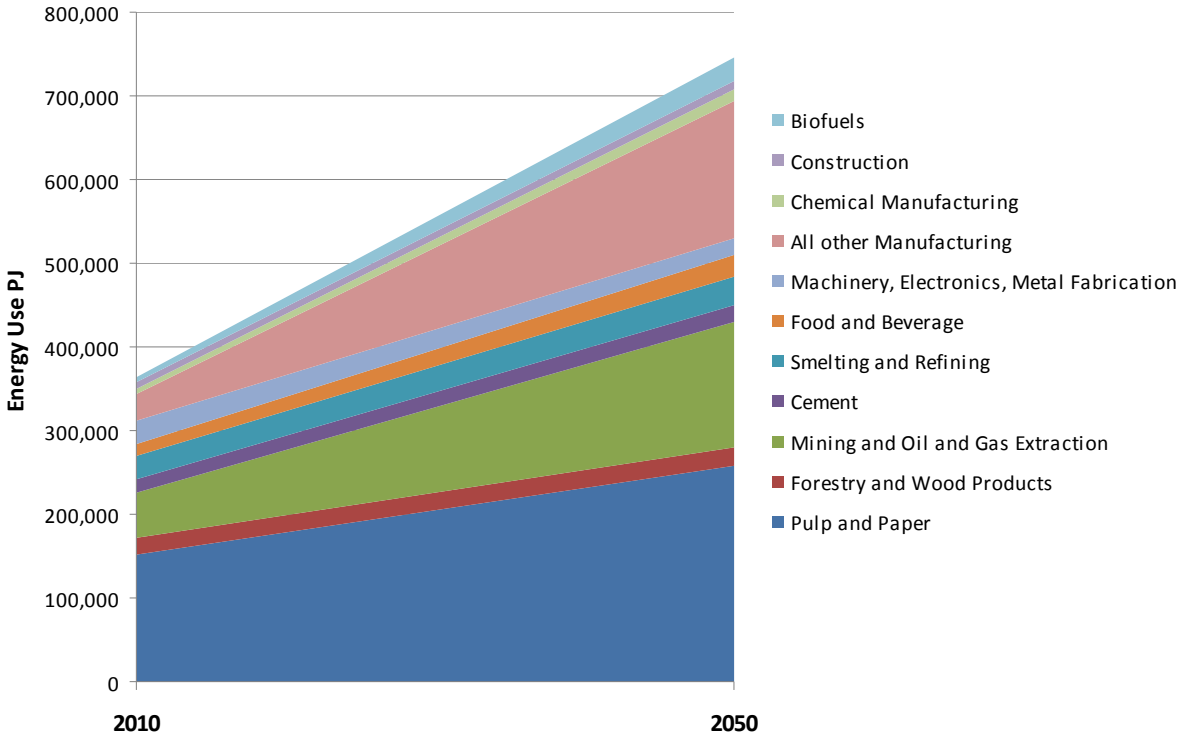

Figure 4-7: Trend in Energy Consumption by Industrial Sector[9]

[9] From Natural Resources Canada, Statistics Canada, BC Stats, BC Progress Board, Forintek and Paprican (now FPInnovations), Industry Canada, National Energy Board.

Figure 4-8 shows total energy consumption for the industrial sector in 2010 by energy source.

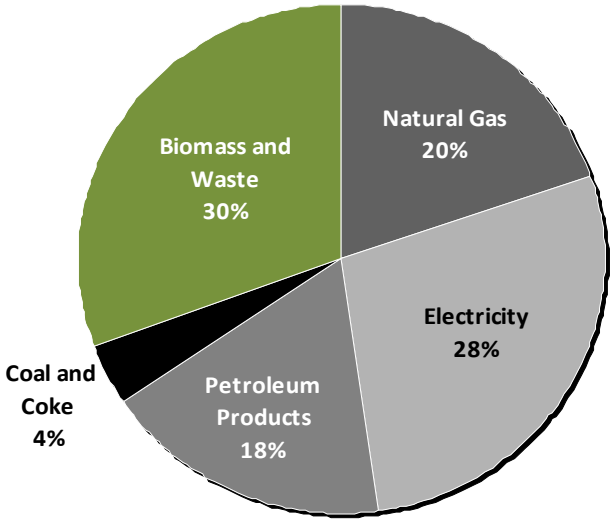

Figure 4-8: Breakdown of Industrial Sector Energy Use by Source (2010)

The largest energy consumers are primary industries including forestry, pulp and paper, mining, oil and gas, and smelting and refining. Figure 4-9 shows the breakdown of energy use in 2010 in the industrial sectors.

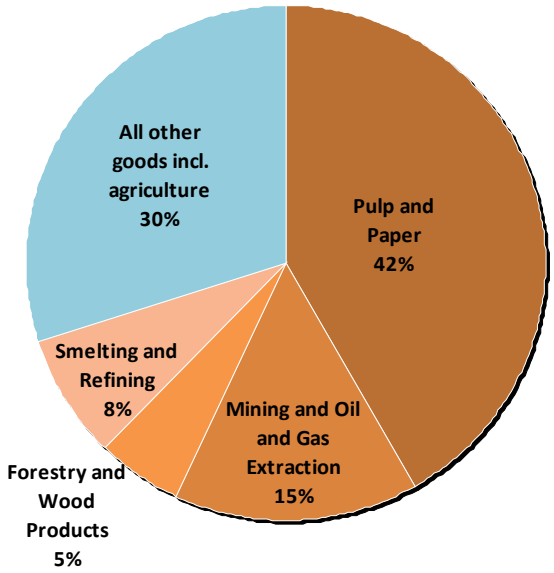

Figure 4-9: Breakdown of Industrial Sector Energy Use (2010)

Pulp and paper energy consumption has been dropping significantly. Since 2000, energy consumption has dropped by over 50% due to mill closures. Pulp mills derive more than 60% of their energy requirements from process waste recovery and the use of hog fuel (wood waste) for co-generation of efficient electricity and process heat.

ELECTRIFICATION POTENTIAL AND POLICY ACTIONS

There are a number of high potential electrification opportunities in the industrial sector.

1. Increase biomass co-generation of efficient electricity and process steam in the pulp and paper and wood products sector;
2. Develop the electric powered biofuel industry to meet projected market demand (note: this increases electricity demand significantly and cuts GHG emissions both in production processes for biofuels and in the use of biofuels by consuming sectors – particularly transportation). This policy action is supported by CAP actions on biofuels:
   a) Increase the renewable content of gasoline and diesel fuels. A policy that requires gasoline and diesel fuel sold in British Columbia to have 5% renewable content by volume after 2010, and 10% renewable content by energy in 2020. The renewable fuel standard applies to all sectors that consume diesel and gasoline for transportation purposes;
   b) The federal ethanol excise tax exemption of $0.10/L and the provincial $0.11/L tax exemption for ethanol;
   c) Reduce the carbon content in the fuels we use;
   d) B.C. is targeting at least a 10 per cent reduction in the average carbon intensity of transportation fuels by 2020.
3. Shift to electrified rail and biofuels/electric equipment for forestry equipment;
4. Increase use of electric equipment in mining and smelting;
5. Increase use of biofuels in mining and smelting equipment;
6. Increase use of geothermal power for mining and smelting;
7. Displace coal with natural gas in the cement industry and produce electricity from disposal of municipal waste;
8. Displace natural gas with efficient electricity for space heating in the food, machinery, electronics, metal fabrication, and other manufacturing sectors;
9. Deploy PHEVs for delivery trucks;
10. Develop waste to energy projects in industrial parks;
11. Increase use of waste hydrogen from the chemical manufacturing to displace petroleum;
12. Increase use of flare gas for power generation has from oil and gas extraction industries;
13. Develop carbon capture and sequestration schemes for oil and gas sector; and
14. Increase large–scale renewable power development (e.g. biomass, hydro, geothermal, ocean, wind) by industry both for internal use and product diversification.

The following policy actions would encourage these electrification opportunities.

Policy Actions:

- Introduce a cap and trade program; the CAP proposes applying cap and trade to the large industrial emitters;
- Increase carbon tax; the CAP includes a Carbon tax on greenhouse gas emissions scheduled to rise in $5/tonne CO2e increments until 2012;
- Bring the electrons to the load (i.e. power lines) with infrastructure investments to access remote industries;
- Reduce stumpage for wood waste to energy projects;

- Improve fibre supply tenure to ensure security of fibre supply for waste to energy projects;
- Provide capital investment incentives through tax policy;
- Provide pricing signal through industrial electricity rates to encourage electrification;
- Improve programs for utilities to purchase surplus power from industry; and
- Provide utility programs to encourage electrification of industrial equipment.

IMPACTS OF POLICY ACTIONS

Based on the opportunities and policy actions above, the changes[10] in electrification of the industrial sector are described below:

- Electrification of 90% of natural gas pipeline compressor stations;
- Electrification of 40% of forestry, mining, construction and agriculture equipment and supply 40% with biofuels by 2050;
- Electrification of 50% of smelting and refining fossil fuelled equipment with electrification efficiency improvements and biofuels reducing energy demand by 15% by 2050;
- Electrification (PHEV) of 80% of delivery trucks by 2050;
- Electrification of industrial parks to produce 200 MW (5 PJ per year) of electricity from waste and cement plants, and to produce 50 MW (1 PJ per year) of electricity from municipal waste by 2050; and
- Electrification of industrial plants to produce 80 PJ per year of electricity from large-scale renewable energy development (e.g. biomass, hydro, geothermal, ocean, wind) by 2050.

Figure 4-10 shows total energy consumption increases to 854 PJ in 2050. However, in the electrification scenario the industrial facilities produce 79 PJ per year of electricity surplus to their needs.

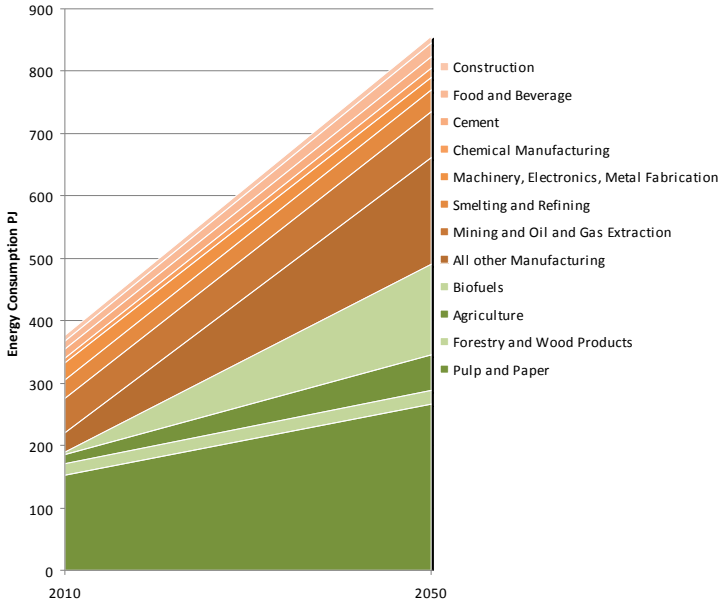

Figure 4-10: Comparison of Industrial Energy Consumption[11]

[10] To estimate the scale of energy consumption in each sub-sector in 2050, projections of existing data for GDP, employment and energy use from BC Stats, NRCan and CIEEDAC were used.

4.4 TRANSPORTATION SECTOR

SECTOR PROFILE

Figure 4-11 shows the transportation sector is estimated to consume 349 PJ in 2010, nearly all of which (348 PJ) is petroleum. By 2050, if present trends continue, transportation will account for 616 PJ.

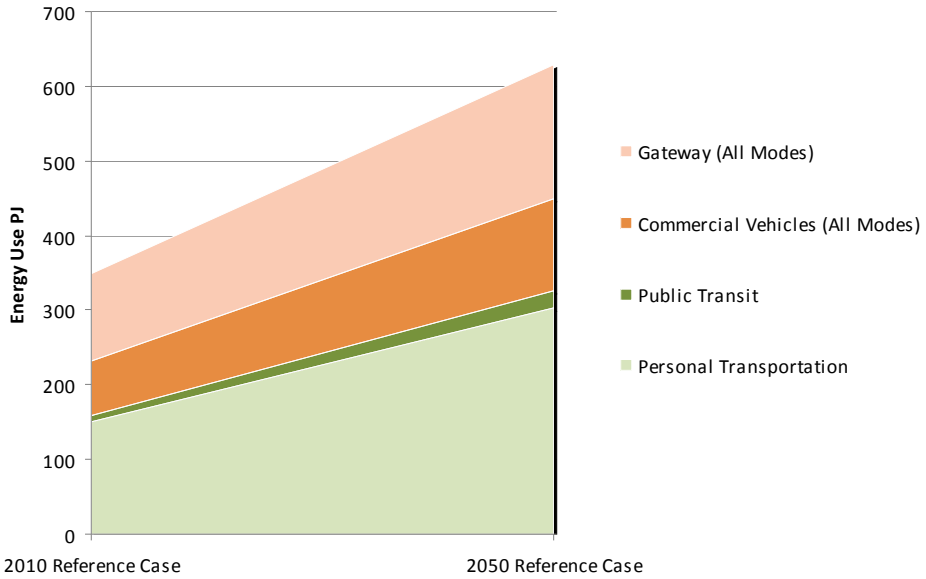

Figure 4-11 Energy Consumption by Transportation Sector

The transportation sector comprises four sub-sectors, namely gateway transportation (ships, airplanes, trains and long haul trucks), commercial vehicles (vans, trucks, coastal vessels and off-road vehicles), public transit (buses, sky-train, ferries and light rail) and personal transportation (cars, sport utility vehicles, pick-ups and light trucks). Opportunities for electrification in these sub-sectors are discussed below.

Gateway Transportation: Air passengers through Vancouver International Airport have expanded from 16 million in 2000 to 18 million in 2008, while cargo movements through the Port Metro Vancouver expanded from 101 million tonnes in 1996 to over 115 million tonnes in 2005 with further growth in container volumes through 2008. In 2010 there are estimated to be approximately 60,000 rail car moves/week.

As Metro Vancouver accounts for more than 90% of B.C.'s gateway transportation, urban transportation infrastructure efficiency has a significant impact on energy use.

[11] 2010 – 2050 Climate Abatement Scenario

Figure 4-12 shows the breakdown of gateway transportation energy use in 2010. Marine, air, and surface gateway transportation is estimated at 118 PJ in 2010. If present trends continue, energy consumption will expand to 204 PJ by 2050.

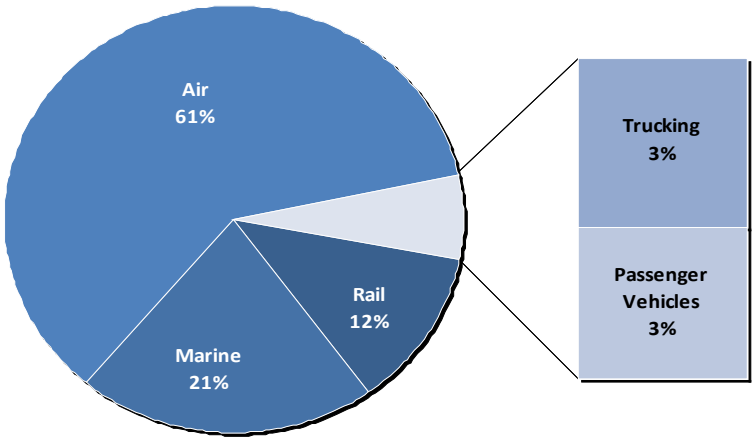

Figure 4-12: Gateway Transportation Energy Use

Commercial Vehicles: comprises all delivery vehicles, trucks of all sizes involved in goods movements, coastal marine and off road vehicles as well as a significant number of transient trucks and vans from other jurisdictions. There are estimated to be 690,000 licensed commercial vehicles in BC. The total energy consumption of the domestic commercial transportation sub-sector is 71 PJ. If present trends continue, energy consumption for international goods and passengers will expand to 116 PJ by 2050.

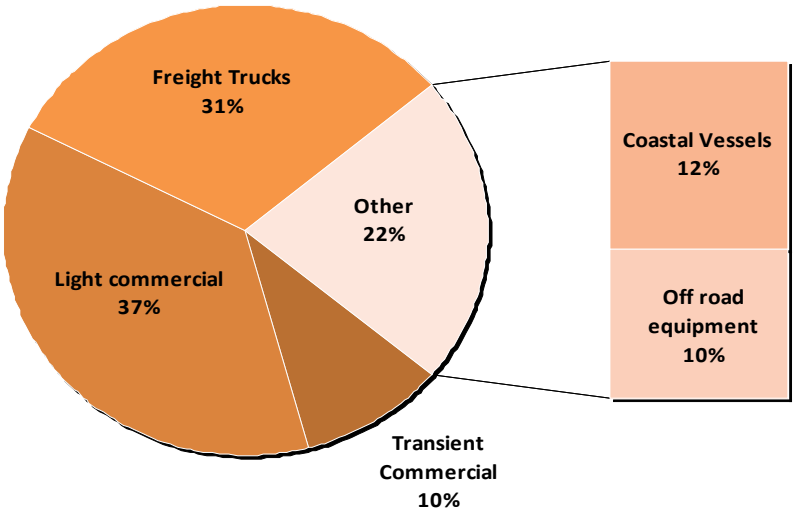

Figure 4-13: Commercial Transportation Energy Use

Public transit: comprises buses, ferries, electric transit and light rail. Metro Vancouver accounts for most of the public transit ridership in BC. In the year 2000, 129 million trips were taken by public transit in Metro Vancouver. This is expected to increase to 200 million trips by 2010. In 2007, public transit in Metro Vancouver accounted for

11 % of all household trips. If present trends continue that share would increase to 15%, and energy consumption by public transit in BC would increase to 16 PJ in 2050 from 10 PJ in 2010.

However, TransLink has established targets that by 2040, public transit trips per household per year will meet or exceed private vehicle trips. Under these circumstances and assuming similar expansions in other areas of BC, total public transit ground transportation would expand significantly.

The energy use of public transit compares to automobiles (2010 models) as follows:

Table 4-1: Comparison of Energy Use by Transportation Mode

Mode	Trips/GJ
Skytrain	276
Buses and Electric Trolleys in Metro Vancouver	48
Car, Sport Utility Vehicles, Pick-ups and Vans	10

The BC Ferries fleet was included in these assessments. However, significant electrification opportunities were not identified.

Personal Transportation: There are approximately 2.1 million licensed passenger vehicles in BC that consume 160 PJ of energy per year. Figure 4-14 shows cars and sport utility vehicles consume over 60% of this energy.

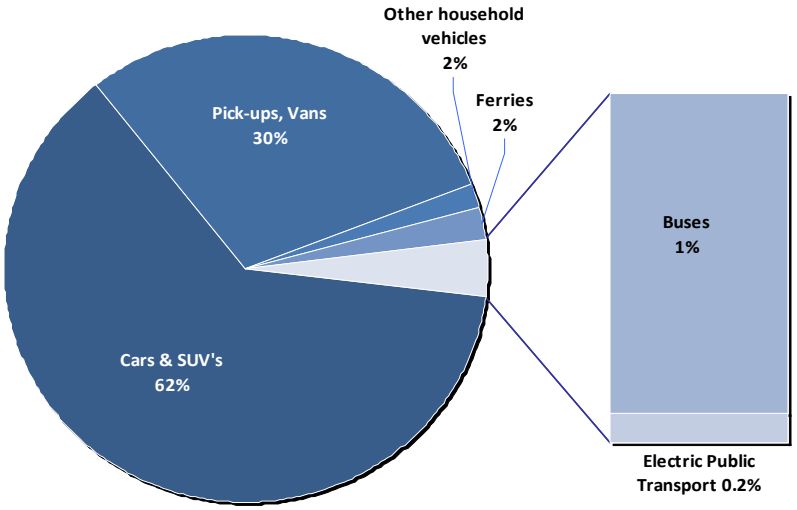

Figure 4-14: Public Transit and Personal Transportation

The main trends are improving efficiency in the light vehicle fleet and an expanding role for public transportation.

Automakers have steadily improved the efficiency of internal combustion engines (ICEs) in new model cars introduced into the Canadian and US markets (see Figure 4-15). Today's models develop over 60% more kilowatts per litre of fuel consumed per 100 kilometres in 2010 than in 1990.

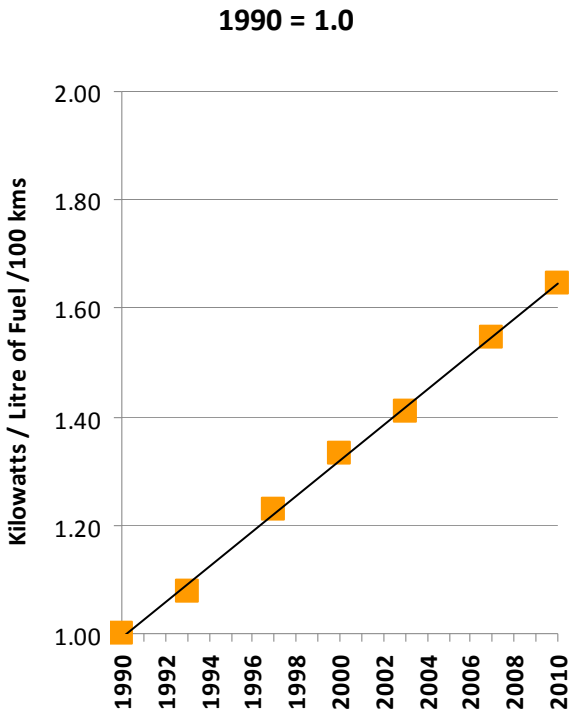

Figure 4-15: Trend in Vehicle Energy Efficiency[12]

HEVs will allow this trend to continue – HEV fuel consumption is currently 30 to 40% better than an equivalent ICE automobile. HEVs comprise 2.2% of the US automobile fleet. US studies (Argonne National Labs) on advanced vehicle buying decisions indicate that HEVs could grow to 65% of new vehicle sales provided the sticker price is no more than 7% higher than an equivalent ICE automobile and the price of gasoline remains high.

However, these gains in efficiency are offset by the increasing power and weight of new models. In 1990, the average new automobile models had 100 kW engines, by the 2000 model year average engine power rose to 140 kW and by 2007 to 170 kW. This trend may have abated since 2008 due to high fuel costs, but it is unlikely that manufacturers will offer less performance without shifts in consumer behaviour.

On the horizon is the planned introduction of PHEVs. These vehicles use a small ICE primarily for recharging purposes and offer the potential of dramatic cuts in fuel consumption. US data indicates energy consumption of about 11 kWh/100 kilometres. This would translate into an energy consumption four times lower than the best 2010 models replacing 70% or more of the fuel consumed by an automobile with electricity.

[12] Based on DOE and NRCan data.

Based on existing electricity and gasoline prices, electricity costs for PHEVs would be 10-15% of gasoline costs for an existing ICE vehicle[13].

ELECTRIFICATION POTENTIAL AND POLICY ACTIONS

There are a number of high potential electrification opportunities particularly from the introduction of PHEVs into the light vehicle fleet and expanded use of public transit.

Gateway

For Gateway transportation there are a number of areas where electrification is possible, however, in total these would amount to less that 10 PJ/year and therefore do not figure prominently in the 2050 Electrification scenario. Further work to investigate rail electrification to displace truck transport is warranted.

Policy Action:
- Provide incentives to electrify rail and substitute truck transport with rail transport; and
- Increase carbon tax.

Commercial Vehicles

For the commercial light vehicle fleet it is assumed that taxis, delivery vehicles and other vans and trucks will be 80% HEV and 20% PHEV by 2050.

Policy Action:
- Encourage PHEVs through increasing carbon tax; and
- Provide vehicle licensing feebates (cost for emitting vehicles, credit for non-emitting vehicles) to minimize premium for PHEVs.

Charging infrastructure will also be necessary to encourage PHEVs.

Policy Action:
- Change the Building Code to require all new buildings to provide electric vehicle charging facilities for a proportion of the parking stalls; and
- Change the Electrical Code to require retrofits to existing building when an electrical permit is requested to provide electric vehicle charging facilities for a proportion of the parking stalls.

Public Transit

There are significant opportunities to increase public transit in Metro Vancouver and urban areas throughout the Province. For example, if Skytrain expands at the current rate of expansion, it would provide over 200 million trips in 2050. With the rest of the public transit system in Metro Vancouver expanding at the same rate, trips by public transit would exceed trips by private automobile by 2050 (estimated at 1 billion trips / year). It is estimated 20% of other household BC travel could be by public transit or light rail by

[13] Based on existing road taxes applied to gasoline and no road tax applied to electricity.

2050. In addition, electrified rail infrastructure could be used for passenger and goods movements in other areas of BC.

Policy Action:
- Increase carbon tax;
- Provide leadership through Translink to develop further electrified transit in the Lower Mainland including Evergreen Line, Broadway Corridor, Fraser Valley Rail, High Speed Rail between Vancouver and Seattle; and
- Provide leadership through BC Transit to develop electrified transit/passenger rail for other parts of BC such as Vancouver Island and the Okanagan.

Personal Transportation

Due to the oil price shocks of the 1970s and early 1980s the automobile industry improved fuel economy mainly through using smaller engines. If 2010 model year automobiles averaged the same power as 2000 model year vehicles, average fuel economy would improve by 23%, and with the same power as 1990 models, fuel economy would improve by 64%. Even larger savings are possible with the introduction of HEVs and PHEVs.

Policy Action:
- Encourage PHEVs through increasing carbon tax; and
- Provide vehicle licensing revenue neutral feebates (cost for emitting vehicles, credit for non-emitting vehicles) to neutralize capital cost premium for HEVs and PHEVs.

Electric vehicle charging infrastructure is necessary to encourage PHEVs.

Policy Action:
- Change the Building Code to require all new buildings to provide electric vehicle charging facilities for a proportion of the parking stalls; and
- Change the Electrical Code to require retrofits to existing building when an electrical permit is requested to provide electric vehicle charging facilities for a proportion of the parking stalls.

Biofuels can play a larger role in the future to displace petroleum.

Policy Action:
- Continue to increase regulations requiring a higher percentage of biofuels in gasoline and diesel; and
- Continue research and development investments to develop biofuels.

Many of the policy actions relating to the light vehicle fleet are supported by the CAP. The net overlap in terms of a reduction in fossil fuel consumption and energy efficiency improvements from 2010 to 2050 is estimated at approximately 80PJ or 27% of this report's electrification scenario to 2050. For ready reference, the CAP actions, taken from various sections of the CAP, are listed below in italics.

The CAP actions for public transit are all included in the 2050 electrification scenario:

- *By 2020, the plan calls for the provincial government and its federal and local government partners to commit $14 billion to significantly expand transit in communities across the Province and to double transit ridership;*
- *$10.3 billion for four new and updated rapid transit lines serving communities across Metro Vancouver—the Canada Line, the Evergreen Line, the UBC Line and the upgraded and expanded Expo Line;*
- *$1.2 billion for new RapidBus BC lines—energy-efficient, high-capacity buses on nine major routes in the high-growth urban centres of Kelowna, Victoria and Metro Vancouver. This will provide frequent, fast, reliable service with the look and feel of rapid transit and, in some cases, operating on dedicated laneways;*
- *$1.6 billion for new, clean-technology buses to bolster the provincial fleet and provide communities with more frequent service to meet the needs of transit users;*
- *Increase transit ridership across the Province to over 400 million trips a year;*
- *Attract to transit a market share of 17 per cent in Metro Vancouver by 2020, laying the foundation to attract 22 per cent by 2030; and*
- *Support increased population and employment densities near transit hubs and along transit corridors. This change in urban form will, in turn, increase transit use and further decrease GHG emissions.*

The CAP actions relating to the transition of the vehicle fleet to hybrids and electric vehicles are all included as sub-sets of the Electrification scenario:

- *Vehicle emissions standard for new vehicles;*
- *Reduce greenhouse gas (GHG) emissions and other air contaminants from cars by 4.7 million tonnes cumulatively by 2020;*
- *Sales tax exemption for low emission vehicles. Low emissions vehicles (e.g., hybrid cars) sold in British Columbia receive a sales tax exemption equal to $2,000 (2005$);*
- *Subsidies to energy efficient personal vehicles, household appliances and residential shells provided under the federal ecoENERGY program;*
- *Tailpipe emission standards are an effective way of reducing greenhouse gas emissions associated with personal vehicles by encouraging manufacturers to sell a more fuel-efficient fleet of vehicles in British Columbia;*
- *The Province is investing $15 million to enhance and expand the successful Scrap-It program across British Columbia, giving people real incentives to take old automobiles with higher greenhouse gas emissions off the road;*
- *The Province has waived the Provincial Sales Tax on hybrid vehicles since 2002, saving buyers up to $2,000. A similar sales tax exemption is now also in place for alternative-fuel vehicles, saving buyers up to $2,000; and*

- *Regulations introduced in 2007 require retrofits of all heavy-duty diesel trucks made between 1989 and 1993. Diesel oxidation catalyst filters must be installed on these trucks by 2009.*

The CAP actions envisaged on biofuels are all incorporated as steps on the Electrification scenario path:

- *Increase the renewable content of gasoline and diesel fuels. 5% renewable content by volume after 2010, and 10% renewable content by energy in 2020. The renewable fuel standard applies to all sectors that consume diesel and gasoline for transportation purposes;*
- *The federal ethanol excise tax exemption of $0.10/L and the provincial $0.11/L tax exemption for ethanol;*
- *Reduce the carbon content in the fuels we use; and*
- *B.C. is targeting at least a 10 per cent reduction in the average carbon intensity of transportation fuels by 2020.*

IMPACTS OF POLICY ACTIONS

Based on the opportunities and policy actions above, changes in electrification of the transportation sector are described below:

- 70% of light duty vehicles is PHEV and balance is HEV by 2050;
- 50% of personal vehicle pick-ups and truck fleet is PHEV and Balance is HEV by 2050; and
- 40% of liquid fuel is biofuels (ethanol and biodiesel) by 2050.

Figure 4-16 shows that based on the policy actions above energy use in the transportation sector is forecast to be 329 PJ in 2050 compared to 616 PJ in 2050 under the reference case.

Figure 4-16: Comparison of Transportation Energy Consumption (2010-2050)

Section 5

Impact of Electrification

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5. IMPACT OF ELECTRIFICATION

Figures 5-1 and 5-2 show these energy flows for 2020 and 2050 respectively. Figure 5-1 is based on a linear interpolation of the electrification scenario forecast prepared for 2050 (Figure 5-2). Appendix E provides a list of assumptions required to complete these Figures. The key changes comparing Figure 5-2 (2050 electrification scenario) to Figure 3-3 (2050 reference case) are:

Residential

Natural gas declines to half the reference case and biomass increases by over two times. There is a moderate reduction in grid electricity use. The reduction in grid electricity usage is due to the displacement of less efficient electric resistant heating with more efficient heat pumps, and district energy systems. Additional reductions are due to onsite photovoltaic generation and other increases in energy efficiency. The other main impact is due to increased biomass through use of rural wood pellet stoves and other technologies.

Commercial

Natural gas declines to half the reference case and biomass increases from almost zero to 24 PJ per year. The reduction in grid electricity usage is due to the displacement of less efficient electric resistant heating with more efficient heat pumps. Additional reductions are due to site photovoltaic generation and other increases in energy efficiency. The other main impact is due to increase biomass for district energy systems.

Industrial

Natural gas declines to about half the reference case and coal is completely displaced. Petroleum drops to 30% of the reference case. The use of biomass doubles. There is an increase in electricity of over 50%. The main impacts are due to electrification of industrial facilities (including oil and gas facilities in the northeast of the province) and equipment, and transportation. In addition, the installation of combined heat and power from biomass and production of power from renewables add significantly to the clean electricity produced by the industrial sector.

Transportation

Petroleum declines to 35% of the reference case. Biofuels increase by over 45%. Electricity increases from about 1 PJ per year to 28 PJ per year. The main impacts are due to PHEVs, increase in biofuels and transit trips displacing personal vehicle trips. As PHEVs use about 25% of the energy of ICE vehicles, there is a large drop in the amount of energy used. There is also a reduction in energy use as transit trips use a fraction of the energy of personal vehicle trips.

Tables 5-1 and 5-2 provide summaries of the impact of electrification on energy usage and greenhouse gas emissions respectively, showing the 2010 Base Case as well as both the 2020 and 2050 scenarios with electrification actions (GHG emissions factors provided in Section 2).

Figure 5-1: British Columbia's Energy Flow - 2020 Electrification Scenario (units in Petajoules) **June 1, 2010**

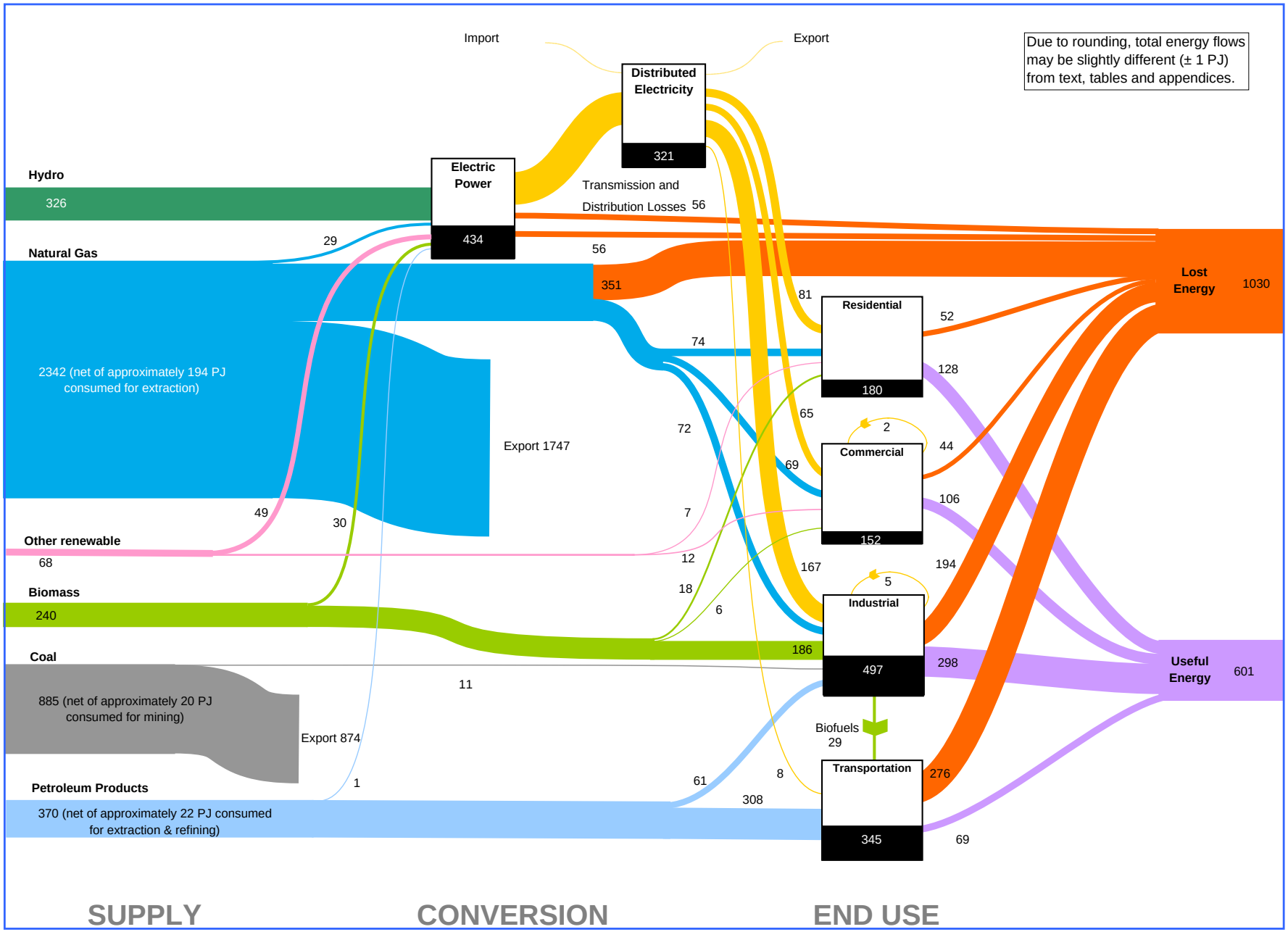

Figure 5-2: British Columbia's Energy Flow - 2050 Electrification Scenario (units in Petajoules)

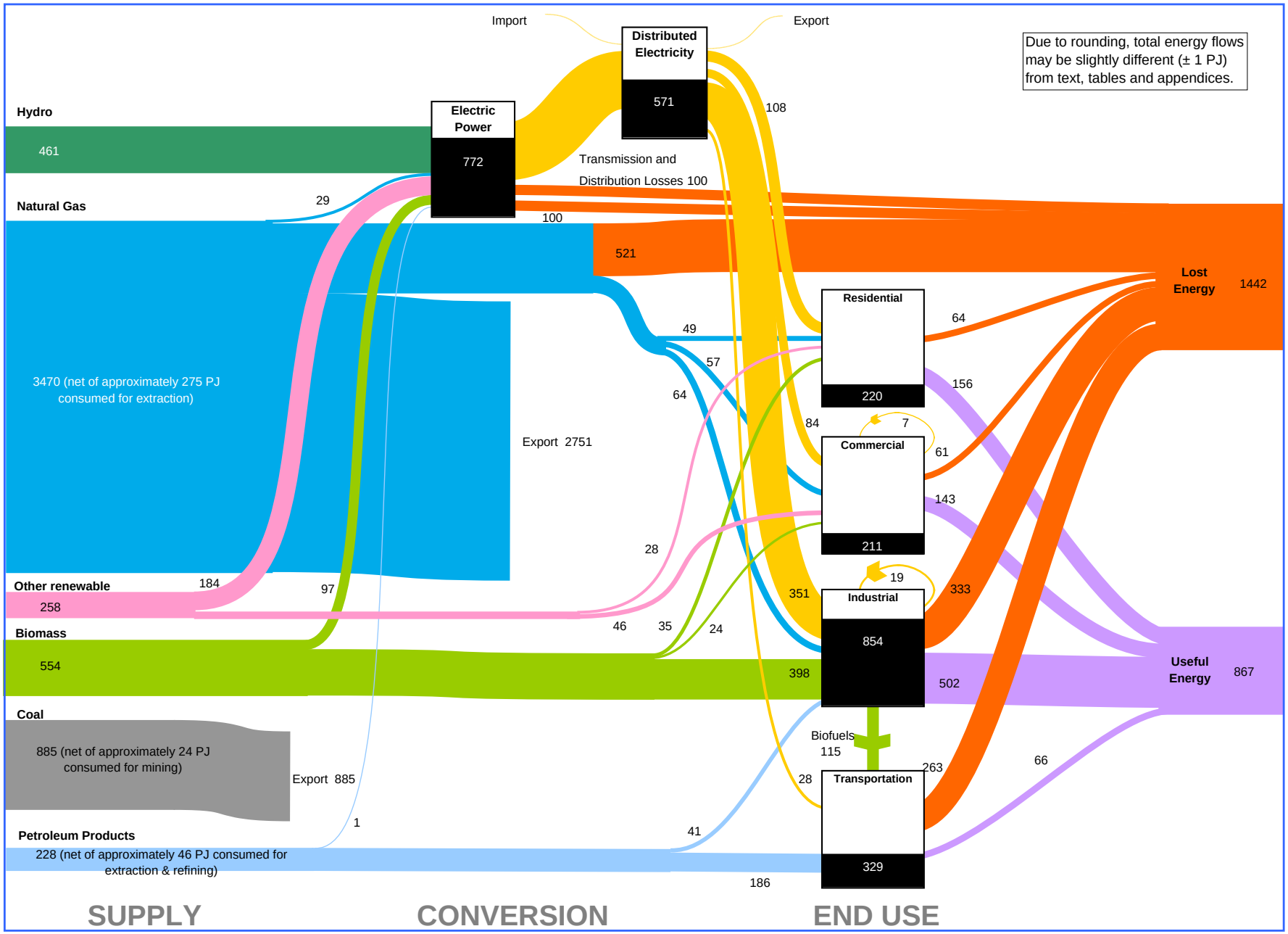

Table 5-1: Impact of Electrification on End-Use Energy Usage (PJ)

Sector	Reference Case			Electrification Scenario		Energy Saving	
	2010	2020	2050	2020	2050	2020	2050
Residential	167	182	230	180	220	3	10
Commercial	131	156	232	151	211	5	21
Industrial & Agriculture	377	474	764	496	854	-22	-90
Transportation	349	416	616	344	329	72	287
TOTAL END-USE[1]	**1,024**	**1,228**	**1,842**	**1,171**	**1,615**	**57**	**227**

Notes and References:

[1] End-use does not include production, processing, and transportation of energy supply.

Table 5-2: Impact of Electrification on Greenhouse Gas Emissions (Mt CO_2eq)

254.052

Sector	Emissions Type	Reference Case			Electrification Scenario		GHG Reduction	
		2010	2020	2050	2020	2050	2020	2050
Residential	Direct	4.7	4.9	5.5	4.2	2.8	-0.7	-2.7
	Upstream	1.3	2.0	5.5	1.3	1.4	-0.7	-4.1
Commercial	Direct	4.1	4.9	7.2	3.9	3.2	-1.0	-4.0
	Upstream	1.1	1.8	5.2	1.1	1.2	-0.7	-4.0
Industrial[1]	Direct	9.5	12.5	21.3	8.5	5.4	-4.0	-15.9
	Upstream	2.0	3.5	11.1	2.4	3.8	-1.1	-7.3
Transportation	Direct	25.1	28.4	38.6	22.2	13.4	-6.2	-25.2
	Upstream	2.6	3.4	5.7	3.0	4.0	-0.4	-1.7
Agriculture & Waste[2]	Direct & Upstream	7.0	8.0	10.0	8.0	10.0	0	0
Supply Sectors[3]	Direct & Upstream	7.3	15.3	20.7	15.3	20.7	0	0
TOTAL		**64.7**	**84.7**	**130.8**	**69.9**	**65.9**	**-14.8**	**-64.9**
Comparison with the BC Emissions Targets								
BC Emissions Targets			44.4	13.5	44.4	13.5		
Target Gap			*40.3*	*117.3*	*25.5*	*52.4*		
Reconciliation with MKJA results								
MKJA (2009) - Business as Usual		62	85	134				
MKJA (2010) - CAP (reference) and Electrification		65	69	80	52	38	-17	-42

Notes and References:

[1] Agriculture not included.

[2] Results from MKJA (2009).

[3] Most supply emissions are accounted for as indirect emissions to the Residential, Commercial, Industrial, and Transportation sectors. The remaining supply emissions are those associated with the production of exported feedstock, i.e., coal and natural gas, Results derived from MKJA (2009).

MK Jaccard and Associates Inc (MKJA), 2009, *Reference Case Scenario and Marginal Abatement Cost Curves for British Columbia - Draft Report, December 15.*

MK Jaccard and Associates Inc (MKJA), 2010, *Economic Impact of Generating Electricity from Renewable Resources for Export to California, February 26.*

Section 6

Conclusions

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6. CONCLUSIONS

Specific policy actions to reduce the production and use of fossil fuels in British Columbia while increasing the use of efficient electricity from clean generation resources over the next 40 years are listed in Table 6-1.

Table 6-1: Electrification Policy Actions

Energy Sector	Policy Action
Residential	▪ Increase carbon tax. ▪ Change the BC Building Code to require net zero emission buildings by 2015 through geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in new and existing construction. ▪ Through the Local Government Act require Official Community Plans to encourage renewable district scale co-generation. ▪ Change the BC Building Code to require building to have heating systems that enable connection to district energy systems in the future.
Commercial	▪ Increase carbon tax. ▪ Change the BC Building Code to require net zero emission buildings by 2015 through the use of geo-exchange systems, air source heat pumps, solar hot water and building integrated solar photovoltaic in new construction. ▪ Through the Local Government Act require Official Community Plans to encourage renewable district scale co-generation. ▪ Change the BC Building Code to require building to have heating systems that enable connection to district energy systems in the future. ▪ Ensuring business park integration into transportation systems to facilitate access to electric transit/light rail and requiring electric vehicle charging facilities. ▪ Through the Local Government Act require Official Community Plans that require Business Park zoning to encourage access to transit in zoning and development plans. ▪ Change the BC Building Code to require 20% of parking stalls in commercial buildings to have charging facilities for electric vehicles. ▪ Replacing existing heating systems with “heat pumps” to displace natural gas used for space and water heating. ▪ Through legislation, regulation or special direction require electric utilities to provide an incentive program to encourage heat pumps. ▪ Through legislation, regulation or special direction require electric utilities to provide a net metering or feed-in tariff in the order of $0.75/kWh for solar photovoltaic power.
Industrial	▪ Introduce a cap and trade program. ▪ Increase carbon tax. ▪ Reduce stumpage for wood waste for energy projects. ▪ Improve fibre supply tenure to ensure security of fibre supply for waste to energy projects. ▪ Provide capital investment incentives through tax policy. ▪ Provide pricing signal through industrial electricity rates to encourage electrification. ▪ Improve programs for utilities to purchase surplus power from industry. ▪ Provide utility programs to encourage electrification of industrial equipment.

Energy Sector	Policy Action
Transportation	▪ Provide incentives to electrify rail and substitute truck transport with rail transport. ▪ Increase carbon tax. ▪ Change the Building Code to require all new buildings to provide electric vehicle charging facilities for a proportion of the parking stalls. ▪ Change the Electrical Code to require retrofits to existing building when an electrical permit is requested to provide electric vehicle charging facilities for a proportion of the parking stalls. ▪ Provide leadership through Translink to develop further electrified transit in the Lower Mainland including Evergreen Line, Broadway Corridor, Fraser Valley Rail, High Speed Rail between Vancouver and Seattle. ▪ Provide leadership through BC Transit to develop electrified transit / passenger rail for other parts of BC such as Vancouver Island and the Okanagan. ▪ Provide vehicle licensing revenue neutral feebates (cost for emitting vehicles, credit for non-emitting vehicles) to neutralize capital cost premium for HEVs and PHEVs. ▪ Change the Building Code to require all new buildings to provide electric vehicle charging facilities for a proportion of parking stalls. ▪ Continue to increase regulations requiring a percentage of biofuels in gasoline and diesel. ▪ Continue research and development investments to develop biofuels.

Electrification is a key strategy for BC to meet its 2020 and 2050 greenhouse gas reduction targets. Based on the policy actions identified and the evaluation in this report electrification contributes 15 Mt (37%) to the 2020 target and 65 Mt (55%) to the 2050 target compared to the 2050 reference case.

The key electrification actions through the above policies are:

- Increase the use of air and ground source heat pumps in residential and commercial buildings for space and hot water heating;
- Increase the use of building integrated photovoltaics;
- Increase the use of biomass and biofuels;
- Increase efficient electricity use in the industrial sector through new transmission lines and incentives, energy pricing and programs to encourage electro technologies;
- Deploy electric vehicles; and
- Encourage electrified transit to reduce personal vehicle use.

Figure 6-1 graphically depicts the impact on greenhouse gas emissions on policy actions to encourage electrification in BC. The Figure shows:

- The Province's targets for total greenhouse gas emissions in 2020 and 2050;
- A "business as usual" scenario whereby greenhouse gas emissions keep increasing;
- The impact of the Climate Action Plan on those emissions;
- The impact of electrification on those emissions; and

- An estimate of the combined impacts of the Climate Action Plan and the electrification of the Province on those emissions (this is an estimate since some policy actions in this study overlap with policy actions in the Climate Action Plan).

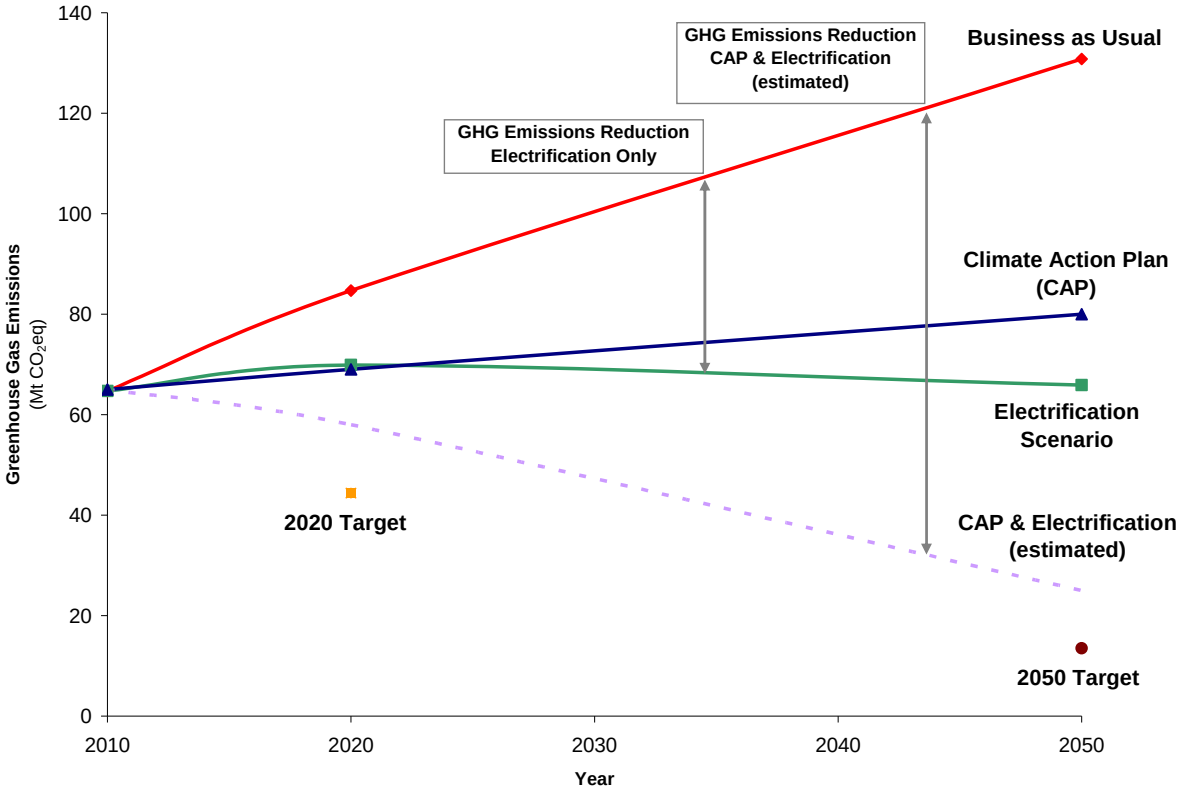

Figure 6-1: Greenhouse Gas Emissions (2010 – 2050)

In summary, the realization of the Province's goals regarding greenhouse gas reduction targets would be greatly facilitated by specific policy actions to encourage electrification in BC.

Section 7

Report Submission

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7. REPORT SUBMISSION

Prepared by:

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Appendix A

Residential Sector Tables

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Table A-1: Residential Buildings - 2010 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Location & Household Type[1]	Number of Households	Electricity Use		Natural Gas Use	Petroleum Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
		Electricity from the Grid	Self Generated Electricity (BIPV)[2]					
Metro Vancouver								
Single Detached	349,575	16.1	0	21.5			0	**37.6**
Multi-Family Units	483,366	16.3	0	14.0			0	**30.3**
Rest of British Columbia								
Single Detached	622,194	28.6	0	38.2			0	**66.8**
Multi-Family Units	306,902	10.5	0	8.9			0	**19.4**
Total	**1,762,036**	**71.5**	**0**	**82.6**	**1.0**	**12.2**	**0**	**167.4**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	4.6	0.1	0	0	**4.7**
Indirect GHG Emissions	Mt CO_2eq	0.7	0	0.7	0.0	0	0	**1.3**
Total	Mt CO_2eq	**0.7**	**0**	**5.3**	**0.1**	**0**	**0**	**6.0**

Notes and References:

[1] Energy use and greenhouse gas emissions from mobile dwellings are not accounted for.

[2] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[3] Other renewable include air and ground energy collected through heat pumps.

Table A-2: Residential Buildings - 2020 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Location & Household Type[1]	Number of Households	Electricity Use		Natural Gas Use	Petroleum Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
		Electricity from the Grid	Self Generated Electricity (BIPV)[2]					
Metro Vancouver								
Single Detached	350,347	16.1	0	21.5	0		0	**37.6**
Multi-Family Units	574,998	21.1	0	15.0	0		0	**36.2**
Rest of British Columbia								
Single Detached	689,198	33.3	0	40.7	0		0	**74.0**
Multi-Family Units	339,952	12.1	0	9.3	0		0	**21.4**
Total	**1,954,494**	**82.6**	**0**	**86.6**	**0**	**13.1**	**0**	**182.3**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	4.9	0	0	0	**4.9**
Indirect GHG Emissions	Mt CO_2eq	1.3	0	0.7	0	0	0	**2.0**
Total	Mt CO_2eq	**1.3**	**0**	**5.5**	**0**	**0**	**0**	**6.9**

Notes and References:

[1] Energy use and greenhouse gas emissions from mobile dwellings are not accounted for.

[2] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[3] Other renewable include air and ground energy collected through heat pumps.

Table A-3: Residential Buildings - 2050 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Location & Household Type[1]	Number of Households	Electricity Use		Natural Gas Use	Petroleum Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
		Electricity from the Grid	Self Generated Electricity (BIPV)[2]					
Metro Vancouver								
Single Detached	352,662	16.1	0	21.6	0		0	**37.7**
Multi-Family Units	849,896	35.4	0	18.3	0		0	**53.7**
Rest of British Columbia								
Single Detached	890,209	47.4	0	48.1	0		0	**95.5**
Multi-Family Units	439,103	17.0	0	10.5	0		0	**27.5**
Total	**2,605,752**	**115.9**	**0**	**98.5**	**0**	**15.6**	**0**	**230.0**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	5.5	0	0	0	**5.5**
Indirect GHG Emissions	Mt CO_2eq	4.7	0	0.8	0	0	0	**5.5**
Total	Mt CO_2eq	**4.7**	**0**	**6.3**	**0**	**0**	**0**	**11.0**

Notes and References:

[1] Energy use and greenhouse gas emissions from mobile dwellings are not accounted for.

[2] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[3] Other renewable include air and ground energy collected through heat pumps.

Table A-4: Residential Buildings - 2020 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Location & Household Type[1]	Number of Households	Electricity Use		Natural Gas Use	Petroleum Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
		Electricity from the Grid	Self Generated Electricity (BIPV)[2]					
Metro Vancouver								
Single Detached	350,347	15.5	0.4	19.8	0		0.7	**36.4**
Multi-Family Units	574,998	20.7	1.5	13.3	0		0.8	**36.3**
Rest of British Columbia								
Single Detached	689,198	32.7	1.3	33.1	0		1.5	**68.5**
Multi-Family Units	339,952	11.7	0.7	8.1	0		0.3	**20.8**
TOTAL	**1,954,494**	**80.6**	**3.8**	**74.3**	**0**	17.9	**3.3**	**179.8**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	4.2	0	0	0	**4.2**
Indirect GHG Emissions	Mt CO_2eq	0.7	0	0.6	0	0	0	**1.3**
TOTAL	Mt CO_2eq	**0.7**	**0**	**4.8**	**0**	**0**	**0**	**5.5**

Notes and References:

[1] Energy use and greenhouse gas emissions from mobile dwellings are not accounted for.

[2] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[3] Other renewable include air and ground energy collected through heat pumps.

Table A-5: Residential Buildings - 2050 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Location & Household Type[1]	Number of Households	Electricity Use		Natural Gas Use	Petroleum Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
		Electricity from the Grid	Self Generated Electricity (BIPV)[2]					
Metro Vancouver								
Single Detached	352,662	13.7	1.5	14.7	0		2.6	**32.6**
Multi-Family Units	849,896	33.6	5.9	11.3	0		3.3	**54.2**
Rest of British Columbia								
Single Detached	890,209	45.1	5.0	17.8	0		5.8	**73.7**
Multi-Family Units	439,103	15.5	2.7	5.4	0		1.3	**25.0**
Total	**2,605,752**	**107.9**	**15.2**	**49.3**	**0**	**34.7**	**13.1**	**220.2**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	2.8	0	0	0	**2.8**
Indirect GHG Emissions	Mt CO_2eq	1.0	0	0.4	0	0	0	**1.4**
Total	Mt CO_2eq	**1.0**	**0**	**3.2**	**0**	**0**	**0**	**4.1**

Notes and References:

[1] Energy use and greenhouse gas emissions from mobile dwellings are not accounted for.

[2] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[3] Other renewable include air and ground energy collected through heat pumps.

Appendix B

Commercial Sector Tables

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Table B-1: Commercial Buildings - 2010 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Surface Area (m^2)	Surface Area Increase Since 2010 (m^2)	Electricity Use			Natural Gas Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
			Electricity from the Grid	Self Generated Electricity (BIPV)[1]	Self Generated Electricity (CHP)[2]				
Retail and Food Services	19		13.6	0	0	11.1	0	0	**24.8**
Business Offices	15		10.7	0	0	13.0	0	0	**23.7**
Public Administration	3		1.3	0	0	1.2	0	0	**2.5**
Wholesale and Warehousing	22		10.3	0	0	8.2	0	0	**18.5**
Healthcare	13		7.0	0	0	14.3	0	0	**21.4**
Accommodation	1		0.9	0	0	1.0	0	0	**1.9**
Education	17		4.9	0	0	11.6	0	0	**16.5**
Other	13		9.8	0	0	12.3	0	0	**22.0**
Total	**103**		**58.6**	**0**	**0**	**72.7**	**0**	**0**	**131.3**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG emissions
Direct GHG Emissions	Mt CO_2eq	0	0	0	4.1	0	0	**4.1**
Indirect GHG Emissions	Mt CO_2eq	0.5	0	0	0.6	0	0	**1.1**
Total	Mt CO_2eq	**0.5**	**0**	**0**	**4.7**	**0**	**0**	**5.2**

Notes and References:

[1] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[2] Self generated electricity from Combined Heat and Power (CHP) biomass plants also displaces electricity that would have been purchased from the grid. However, the amount of raw biomass is accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[3] Other renewable include air and ground energy collected through heat pumps.

Table B-2: Commercial Buildings - 2020 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Surface Area (m^2)	Surface Area Increase Since 2010 (m^2)	Electricity Use			Natural Gas Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
			Electricity from the Grid	Self Generated Electricity (BIPV)[1]	Self Generated Electricity (CHP)[2]				
Retail and Food Services	22.2	3	15.5	0	0	12.7	0	0	**28.2**
Business Offices	23.3	8	16.3	0	0	19.8	0	0	**36.1**
Public Administration	3.2	0	1.5	0	0	1.4	0	0	**2.9**
Wholesale and Warehousing	25.1	3	11.7	0	0	9.4	0	0	**21.1**
Healthcare	15.4	2	8.0	0	0	16.3	0	0	**24.3**
Accommodation	1.2	0	1.0	0	0	1.1	0	0	**2.1**
Education	19.1	2	5.6	0	0	13.2	0	0	**18.8**
Other	13.4	1	10.2	0	0	12.8	0	0	**23.0**
Total	**123**	**20**	**69.8**	**0**	**0**	**86.6**	**0**	**0**	**156.4**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG emissions
Direct GHG Emissions	Mt CO_2eq	0	0	0	4.9	0	0	**4.9**
Indirect GHG Emissions	Mt CO_2eq	1.1	0	0	0.7	0	0	**1.8**
Total	Mt CO_2eq	**1.1**	**0**	**0**	**5.6**	**0**	**0**	**6.7**

Notes and References:

[1] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[2] Self generated electricity from Combined Heat and Power (CHP) biomass plants also displaces electricity that would have been purchased from the grid. However, the amount of raw biomass is accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[3] Other renewable include air and ground energy collected through heat pumps.

Table B-3: Commercial Buildings - 2050 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Surface Area (m^2)	Surface Area Increase Since 2010 (m^2)	Electricity Use			Natural Gas Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
			Electricity from the Grid	Self Generated Electricity (BIPV)[1]	Self Generated Electricity (CHP)[2]				
Retail and Food Services	31	11	21.2	0	0	17.3	0	0	**38.5**
Business Offices	48	32	33.1	0	0	40.1	0	0	**73.2**
Public Administration	4	2	2.1	0	0	1.9	0	0	**3.9**
Wholesale and Warehousing	35	13	16.0	0	0	12.8	0	0	**28.8**
Healthcare	21	8	10.9	0	0	22.3	0	0	**33.2**
Accommodation	2	1	1.4	0	0	1.5	0	0	**2.9**
Education	26	10	7.6	0	0	18.1	0	0	**25.7**
Other	15	2	11.4	0	0	14.3	0	0	**25.7**
Total	**182**	**78**	**103.7**	**0**	**0**	**128.2**	**0**	**0**	**231.9**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	0	7.2	0	0	**7.2**
Indirect GHG Emissions	Mt CO_2eq	4.2	0	0	1.0	0	0	**5.2**
Total	Mt CO_2eq	**4.2**	**0**	**0**	**8.2**	**0**	**0**	**12.4**

Notes and References:

[1] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[2] Self generated electricity from Combined Heat and Power (CHP) biomass plants also displaces electricity that would have been purchased from the grid. However, the amount of raw biomass is accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[3] Other renewable include air and ground energy collected through heat pumps.

Table B-4: Commercial Buildings - 2020 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Surface Area (m^2)	Surface Area Increase Since 2010 (m^2)	Electricity Use			Natural Gas Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
			Electricity from the Grid	Self Generated Electricity (BIPV)[1]	Self Generated Electricity (CHP)[2]				
Retail and Food Services	22.2	3	14.5	1.1	0	11.4	0	1.1	**28.1**
Business Offices	23.3	8	14.7	0	1.7	12.2	6.0	2.2	**35.2**
Public Administration	3.2	0	1.4	0.1	0	1.2	0	0.1	**2.9**
Wholesale and Warehousing	25.1	3	10.9	0.8	0	8.4	0	0.8	**20.9**
Healthcare	15.4	2	7.5	0.6	0	12.7	0	1.4	**22.2**
Accommodation	1.2	0	1.0	0.1	0	1.0	0	0.1	**2.1**
Education	19.1	2	5.2	0.4	0	10.3	0	1.2	**17.1**
Other	13.4	1	9.6	0.6	0	11.6	0	1.0	**22.8**
Total	**123**	**20**	**65.0**	**3.6**	**1.7**	**68.7**	**6.0**	**8.0**	**151.3**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG Emissions
Direct GHG Emissions	Mt CO_2eq	0	0	0	3.9	0	0	**3.9**
Indirect GHG Emissions	Mt CO_2eq	0.6	0	0	0.5	0	0	**1.1**
Total	Mt CO_2eq	**0.6**	**0**	**0**	**4.4**	**0**	**0**	**5.0**

Notes and References:

[1] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[2] Self generated electricity from Combined Heat and Power (CHP) biomass plants also displaces electricity that would have been purchased from the grid. However, the amount of raw biomass is accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[3] Other renewable include air and ground energy collected through heat pumps.

Table B-5: Commercial Buildings - 2050 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Surface Area (m^2)	Surface Area Increase Since 2010 (m^2)	Electricity Use			Natural Gas Use	Wood and Biomass Use	Other Renewable Use[3]	Total Energy Use
			Electricity from the Grid	Self Generated Electricity (BIPV)[1]	Self Generated Electricity (CHP)[2]				
Retail and Food Services	31	11	17.1	4.3	0	12.0	0	4.5	**38.0**
Business Offices	48	32	26.8	0	6.7	9.8	24.1	8.9	**69.6**
Public Administration	4	2	1.7	0.4	0	1.3	0	0.5	**3.9**
Wholesale and Warehousing	35	13	12.9	3.2	0	8.9	0	3.3	**28.3**
Healthcare	21	8	9.1	2.3	0	7.7	0	5.8	**24.8**
Accommodation	2	1	1.1	0.3	0	1.1	0	0.4	**2.9**
Education	26	10	6.3	1.6	0	6.3	0	4.7	**18.8**
Other	15	2	9.2	2.3	0	9.5	0	4.1	**25.1**
TOTAL	**182**	**78**	**84.2**	**14.3**	**6.7**	**56.6**	**24.1**	**32.2**	**211.3**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type	Unit							GHG emissions
Direct GHG Emissions	Mt CO_2eq	0	0	0	3.2	0	0	**3.2**
Indirect GHG Emissions	Mt CO_2eq	0.8	0	0	0.5	0	0	**1.2**
TOTAL	Mt CO_2eq	**0.8**	**0**	**0**	**3.6**	**0**	**0**	**4.4**

Notes and References:

[1] Self generated electricity from Building Integrated PhotoVoltaics (BIPV) displaces electricity that would have been purchased from the grid.

[2] Self generated electricity from Combined Heat and Power (CHP) biomass plants also displaces electricity that would have been purchased from the grid. However, the amount of raw biomass is accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[3] Other renewable include air and ground energy collected through heat pumps.

Appendix C

Industrial Sector Tables

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Table C-1: Industrial Sectors - 2010 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use		Natural Gas & Natural Gas Liquids Use	Petroleum Use	Coal & Coke Use	Biofuel, Biomass & Waste		Total Energy Use
	Electricity from the Grid	Self Generated Electricity (CHP)[1]				Feedstock Use	Biofuel Production[2]	
Pulp and Paper	25.8	0	14.4	6.1	0	105.2		**151.6**
Forestry and Wood Products	3.5	0	6.1	3.3	0	6.7		**19.6**
Mining and Oil and Gas Extraction	12.0	0	16.3	21.8	5.4	0		**55.5**
Cement	1.7	0	2.9	1	8.8	0.5		**14.7**
Smelting and Refining	25.7	0	1.3	1.3	0	0		**28.3**
Food	5.4	0	5.8	3.0	0	0		**14.3**
Machinery, Electronics, Metal Fabrication	11.0	0	11.9	6.1	0	0		**29.0**
All other Manufacturing	11.6	0	12.7	6.5	0	0		**30.8**
Chemical Manufacturing	5.9	0	0.2	0	0	0		**6.1**
Construction	0	0	2.0	6.9	0	0		**9.0**
Biofuel Production	1.5	0	0	0	0	3.2	0	**4.7**
Total Industrial	**104.0**	**0**	**73.7**	**55.9**	**14.2**	**115.7**	**0**	**363.6**
Agriculture	1.3	0	0.8	11.3	0	0	0	**13.4**
Total	**105.3**	**0**	**74.6**	**67.3**	**14.2**	**115.7**	**0**	**377.0**

Greenhouse Gas Emissions[3] (Mt CO_2eq)

GHG Emissions Type								GHG Emissions
Direct GHG Emissions	0	0	4.1	4.0	1.3533719	0		**9.5**
Indirect GHG Emissions	0.9	0	0.6	0.4	0	0		**2.0**
Total	**0.9**	**0**	**4.7**	**4**	**1**	**0**		**11.5**

Notes and References:

[1] Self generated electricity from Combined Heat and Power (CHP) biomass and natural gas plants displaces electricity that would have been purchased from the grid. The amounts of raw biomass and natural gas are accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[2] The biofuel production is not accounted for in 'Total Energy Use'.

[3] The Greenhouse Gas (GHG) emissions of the Agriculture sector are not accounted for in the present Table.

Table C-2: Industrial Sectors - 2020 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq)

Energy Use (PJ)

Sector	Electricity Use		Natural Gas & Natural Gas Liquids Use	Petroleum Use	Coal & Coke Use	Biofuel, Biomass & Waste		Total Energy Use
	Electricity from the Grid	Self Generated Electricity (CHP)[1]				Feedstock Use	Biofuel Production[2]	
Pulp and Paper	30.3	0	17.0	7.2	0	123.9		**178.4**
Forestry and Wood Products	3.5	0	6.2	3.4	0	6.8		**20.0**
Mining and Oil and Gas Extraction	17.1	0	23.3	31.1	7.8	0		**79.4**
Cement	1.8	0	3.2	0.8	9.5	0.5		**15.8**
Smelting and Refining	27.3	0	1.4	1.4	0	0		**30.0**
Food	6.4	0	7.0	3.6	0	0		**16.9**
Machinery, Electronics, Metal Fabrication	10.2	0	11.1	5.7	0	0		**27.0**
All other Manufacturing	24.1	0	26.2	13.5	0	0		**63.9**
Chemical Manufacturing	7.8	0	0.3	0	0	0		**8.1**
Construction	0.0	0	2.1	7.3	0	0		**9.5**
Biofuel Production	3.4	0	0	0	0	7.2	0	**10.6**
Total Industrial	**131.9**	**0**	**97.8**	**74.1**	**17.2**	**138.4**	**0.0**	**459.4**
Agriculture	1.4	0	0.9	12.1	0	0	0	**14.3**
Total	**133.3**	**0**	**98.6**	**86.2**	**17.2**	**138.4**	**0.0**	**473.7**

Greenhouse Gas Emissions[3] (Mt CO_2eq)

GHG Emissions Type								GHG Emissions
Direct GHG Emissions	0	0	5.5	5.3	1.6372314	0		**12.5**
Indirect GHG Emissions	2.2	0	0.8	0.6	0	0		**3.5**
Total	**2.2**	**0**	**6.3**	**5.9**	**1.7**	**0**		**16.0**

Notes and References:

[1] Self generated electricity from Combined Heat and Power (CHP) biomass and natural gas plants displaces electricity that would have been purchased from the grid. The amounts of raw biomass and natural gas are accounted for in 'Total Energy Use', not the

[2] The biofuel production is not accounted for in 'Total Energy Use'.

[3] The Greenhouse Gas (GHG) emissions of the Agriculture sector are not accounted for in the present Table.

Table C-3: Industrial Sectors - 2050 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use		Natural Gas & Natural Gas Liquids Use	Petroleum Use	Coal & Coke Use	Biofuel, Biomass & Waste		Total Energy Use
	Electricity from the Grid	Self Generated Electricity (CHP)[1]				Feedstock Use	Biofuel Production[2]	
Pulp and Paper	44.0	0	24.7	10.3	0	179.8		**258.8**
Forestry and Wood Products	3.7	0	6.6	3.5	0	7.2		**21.0**
Mining and Oil and Gas Extraction	32.6	0	44.4	59.2	14.8	0		**151.0**
Cement	2.2	0	3.8	1.0	11.4	0.6		**19.0**
Smelting and Refining	31.8	0	1.6	1.6	0	0		**35.0**
Food	9.4	0	10.3	5.3	0	0		**25.0**
Machinery, Electronics, Metal Fabrication	7.9	0	8.6	4.4	0	0		**21.0**
All other Manufacturing	61.6	0	66.9	34.5	0	0		**163.0**
Chemical Manufacturing	13.4	0	0.6	0	0	0		**14.0**
Construction	0	0	2.5	8.5	0	0		**11.0**
Biofuel Production	9.0	0	0	0	0	19.0		**28.0**
Total Industrial	**215.7**	**0**	**169.8**	**128.4**	**26.2**	**206.7**	**0.0**	**746.8**
Agriculture	1.6	0	1.0	14.4	0	0		**17.0**
Total	**217.3**	**0**	**170.8**	**142.8**	**26.2**	**206.7**	**0.0**	**763.8**

Greenhouse Gas Emissions[3] (Mt CO_2eq)

GHG Emissions Type								GHG Emissions
Direct GHG Emissions	0	0	9.5	9.2	2.48881	0		**21.3**
Indirect GHG Emissions	8.7	0	1.4	1.0	0.1	0		**11.1**
Total	**8.7**	**0**	**10.9**	**10.2**	**2.5**	**0**		**32.4**

Notes and References:

[1] Self generated electricity from Combined Heat and Power (CHP) biomass and natural gas plants displaces electricity that would have been purchased from the grid. The amounts of raw biomass and natural gas are accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[2] The biofuel production is not accounted for in 'Total Energy Use'.

[3] The Greenhouse Gas (GHG) emissions of the Agriculture sector are not accounted for in the present Table.

Table C-4: Industrial Sectors - 2020 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq)

Energy Use (PJ)

Sector	Electricity Use		Natural Gas & Natural Gas Liquids Use	Petroleum Use	Coal & Coke Use	Biofuel, Biomass & Waste		Total Energy Use
	Electricity from the Grid	Self Generated Electricity (CHP)[1]				Feedstock Use	Biofuel Production[2]	
Pulp and Paper	30.3	1.5	11.3	4.9	0	133.9		**180.4**
Forestry and Wood Products	3.9	0	6.2	2.7	0	7.2		**20.0**
Mining and Oil and Gas Extraction	25.0	2.8	13.2	16.7	4.1	0.8		**59.8**
Cement	1.4	0.4	6.0	0.8	6.6	0.5		**15.4**
Smelting and Refining	27.3	0	1.4	1.4	0	0		**30.0**
Food	6.6	0	7.0	2.5	0	0		**16.1**
Machinery, Electronics, Metal Fabrication	10.2	0	11.1	5.7	0	0		**27.0**
All other Manufacturing	37.0	0	12.4	6.6	0	10.0		**66.0**
Chemical Manufacturing	7.8	0	0.3	0	0	0		**8.1**
Construction	0.0	0	2.1	7.3	0	0		**9.5**
Biofuel Production	12.8	0	0	0	0	27.0	22.4	**39.8**
Total Industrial	**162.2**	**4.6**	**71.0**	**48.7**	**10.7**	**179.4**	**22.4**	**471.9**
Agriculture	4.6	0	0.9	12.1	0	6.8	6.3	**24.3**
Total	**166.7**	**4.6**	**71.8**	**60.8**	**10.7**	**186.2**	**28.7**	**496.2**

Greenhouse Gas Emissions[3] (Mt CO_2eq)

GHG Emissions Type								GHG Emissions
Direct GHG Emissions	0	0	4.0	3.5	1.015029	0		**8.5**
Indirect GHG Emissions	1.5	0.0	0.6	0.4	0.0	0.0		**2.4**
Total	**1.5**	**0**	**4.5**	**4**	**1**	**0**		**10.9**

Notes and References:

[1] Self generated electricity from Combined Heat and Power (CHP) biomass and natural gas plants displaces electricity that would have been purchased from the grid. The amounts of raw biomass and natural gas are accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[2] The biofuel production is not accounted for in 'Total Energy Use'.

[3] The Greenhouse Gas (GHG) emissions of the Agriculture sector are not accounted for in the present Table.

Table C-5: Industrial Sectors - 2050 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use		Natural Gas & Natural Gas Liquids Use	Petroleum Use	Coal & Coke Use	Biofuel, Biomass & Waste		Total Energy Use
	Electricity from the Grid	Self Generated Electricity (CHP)[1]				Feedstock Use	Biofuel Production[2]	
Pulp and Paper	44.0	6.0	2.0	1.0	0	219.8		**266.8**
Forestry and Wood Products	5.1	0	6.6	0.7	0	8.6		**21.0**
Mining and Oil and Gas Extraction	64.0	11.0	3.8	1.6	0	3.2		**72.6**
Cement	0.6	1.6	15.2	1	0	0.6		**17.4**
Smelting and Refining	31.8	0	1.6	1.6	0	0		**35.0**
Food	10.2	0	10.3	1.1	0	0		**21.6**
Machinery, Electronics, Metal Fabrication	7.9	0	8.6	4.4	0	0		**21.0**
All other Manufacturing	113.0	0	11.6	6.9	0	40.0		**171.5**
Chemical Manufacturing	13.4	0	0.6	0	0	0.1		**14.1**
Construction	0	0	2.5	8.5	0	0		**11.0**
Biofuel Production	46.5	0	0	0	0	98.3	89.8	**144.8**
Total Industrial	**336.7**	**18.6**	**62.6**	**26.9**	**0**	**370.7**	**89.8**	**796.8**
Agriculture	14.4	0	1.0	14.4	0	27.1	25.0	**57.0**
Total	**351.1**	**18.6**	**63.6**	**41.2**	**0**	**397.8**	**114.8**	**853.8**

Greenhouse Gas Emissions[3] (Mt CO_2eq)

GHG Emissions Type								GHG Emissions
Direct GHG Emissions	0	0	3.5	1.9	0	0		**5.4**
Indirect GHG Emissions	3.1	0	0.5	0.2	0	0		**3.8**
Total	**3.1**	**0**	**4.0**	**2.1**	**0**	**0**		**9.2**

Notes and References:

[1] Self generated electricity from Combined Heat and Power (CHP) biomass and natural gas plants displaces electricity that would have been purchased from the grid. The amounts of raw biomass and natural gas are accounted for in 'Total Energy Use', not the amount of co-generated electricity (to prevent double counting).

[2] The biofuel production is not accounted for in 'Total Energy Use'.

[3] The Greenhouse Gas (GHG) emissions of the Agriculture sector are not accounted for in the present Table.

Appendix D

Transportation Sector Tables

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Table D-1: Transportation Sectors - 2010 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use *(from the grid)*	Petroleum Products Use	Biofuel Use	Total Energy Use
Licensed Pax vehicles				
Cars & SUV's	0	99.5	0	**99.5**
Pick-ups, Vans	0	47.5	0	**47.5**
Other household vehicles	0	3	0	**2.6**
Ferries	0	3.8	0	**3.8**
Buses and Other Non-electric Public Transit	0	5.6	0	**5.6**
Electric Public Transport	0.5	0	0	**0.5**
Subtotal Licensed Pax Vehicles	**0.5**	**159.0**	**0**	**159.5**
Gateway				
Rail	0	14.1	0	**14.1**
Marine	0	71.4	0	**71.4**
Air	0	24.8	0	**24.8**
Trucking	0	3.9	0	**3.9**
Passenger Vehicles	0	3.5	0	**3.5**
Subtotal Gateway	**0**	**117.7**	**0**	**117.7**
Domestic Commercial				
Light commercial	0	26.3	0	**26.3**
Freight Trucks	0	22.3	0	**22.3**
Transient Commercial	0	6.9	0	**6.9**
Coastal Vessels	0	8.9	0	**8.9**
Off road equipment & propane	0	7.1	0	**7.1**
Subtotal Domestic Commercial	**0**	**71.5**	**0**	**71.5**
Total	**0.5**	**348.2**	**0**	**348.7**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type				GHG Emissions
Direct GHG Emissions Factor	*0*	*72,000*	*0*	
Indirect GHG Emissions Factor	*9,107*	*7,500*	*20,800*	
Direct GHG Emissions	0	25.1	0	**25.1**
Indirect GHG Emissions	0.0	2.6	0	**2.6**
Total	**0.0**	**27.7**	**0**	**27.7**

Table D-2: Transportation Sectors - 2020 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)				
Sector	**Electricity Use** *(from the grid)*	**Petroleum Products Use**	**Biofuel Use**	**Total Energy Use**
Licensed Pax vehicles				
Cars & SUV's	0	117.7	3.6	**121.3**
Pick-ups, Vans	0	56.2	0.2	**56.4**
Other household vehicles	0	2.9	0.2	**3.1**
Ferries	0	4.2	0.6	**4.8**
Buses and Other Non-electric Public Transit	0	7.4	0	**7.4**
Electric Public Transport	0.6	0	0	**0.6**
Subtotal Licensed Pax Vehicles	**0.6**	**188.4**	**4.6**	**193.6**
Gateway				
Rail	0	15.9	1.2	**17.1**
Marine	0	60.2	4.2	**64.3**
Air	0	42.2	0.2	**42.4**
Trucking	0	4.1	0.4	**4.5**
Passenger Vehicles	0	4.2	6.8	**11.0**
Subtotal Gateway	**0**	**126.6**	**12.7**	**139.4**
Domestic Commercial				
Light commercial	0	31.1	1.4	**32.5**
Freight Trucks	0	24.6	0.3	**24.9**
Transient Commercial	0	7.6	0.3	**7.9**
Coastal Vessels	0	8.6	0.4	**9.0**
Off road equipment & propane	0	8.3	0	**8.3**
Subtotal Domestic Commercial	**0**	**80.1**	**2.4**	**82.5**
Total	**0.6**	**395.1**	**19.8**	**415.5**

Greenhouse Gas Emissions (Mt CO_2eq)				
GHG Emissions Type				**GHG Emissions**
Direct GHG Emissions Factor	*0*	*72,000*	*0*	
Indirect GHG Emissions Factor	*16,340*	*7,500*	*20,800*	
Direct GHG Emissions	0	28.4	0	**28.4**
Indirect GHG Emissions	0.0	3.0	0.4	**3.4**
Total	**0.0**	**31.4**	**0.4**	**31.8**

Table D-3: Transportation Sectors - 2050 Reference Case - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq)

ENERGY USE (PJ)				
Sector	**Electricity Use** *(from the grid)*	**Petroleum Products Use**	**Biofuel Use**	**Total Energy Use**
Licensed Pax vehicles				
Cars & SUV's	0	172.2	14.6	**186.8**
Pick-ups, Vans	0	82.5	0.6	**83.1**
Other household vehicles	0	3.7	0.9	**4.6**
Ferries	0	5.4	2.3	**7.6**
Buses and Other Non-electric Public Transit	0	12.8	0	**12.9**
Electric Public Transport	0.8	0	0	**0.8**
Subtotal Licensed Pax Vehicles	**0.8**	**276.4**	**18.5**	**295.7**
Gateway				
Rail	0	21.4	4.7	**26.1**
Marine	0	26.5	16.7	**43.2**
Air	0	94.4	0.8	**95.2**
Trucking	0	4.7	1.7	**6.4**
Passenger Vehicles	0	6.5	27.1	**33.5**
Subtotal Gateway	**0**	**153.4**	**50.9**	**204.4**
Domestic Commercial				
Light commercial	0	45.5	5.6	**51.0**
Freight Trucks	0	31.5	1.3	**32.8**
Transient Commercial	0	9.7	1.1	**10.8**
Coastal Vessels	0	7.6	1.8	**9.3**
Off road equipment & propane	0	11.7	0	**11.7**
Subtotal Domestic Commercia	**0**	**105.9**	**9.8**	**115.7**
TOTAL	**0.8**	**535.7**	**79.2**	**615.8**

GREENHOUSE GAS EMISSIONS (Mt CO_2eq)				
GHG Emissions Type				**GHG Emissions**
Direct GHG Emissions Factor	*0*	*72,000*	*0*	
Indirect GHG Emissions Factor	*40,453*	*7,500*	*20,800*	
Direct GHG Emissions	0	38.6	0	**38.6**
Indirect GHG Emissions	0.0	4.0	1.6	**5.7**
TOTAL	**0.0**	**42.6**	**1.6**	**44.3**

Table D-4: Transportation Sectors - 2020 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use *(from the grid)*	Petroleum Products Use	Biofuel Use	Total Energy Use
Licensed Pax vehicles				
Cars & SUV's	2.0	78.2	9.5	**89.7**
Pick-ups, Vans	0.7	37.3	4.6	**42.6**
Other household vehicles	0	2.6	0.4	**3.0**
Ferries	0	3.8	0.6	**4.4**
Buses and Other Non-electric Public Transit	0	5.9	1.1	**7.0**
Electric Public Transport	1.8	0	0	**1.8**
Subtotal Licensed Pax Vehicles	**4.4**	**127.8**	**16.3**	**148.5**
Gateway				
Rail	2.5	12.9	1.5	**16.9**
Marine	0	72.9	3.4	**76.3**
Air	0	23.2	0.8	**24.0**
Trucking	0	4.1	0.2	**4.3**
Passenger Vehicles	0	4.2	0.3	**4.5**
Subtotal Gateway	**2.5**	**117.3**	**6.2**	**126.0**
Domestic Commercial				
Light commercial	0.5	22.9	3.2	**26.7**
Freight Trucks	0	17.6	0.6	**18.2**
Transient Commercial	0	7.0	0.3	**7.3**
Coastal Vessels	0	8.0	0.9	**8.9**
Off road equipment & propane	0	7.1	1.2	**8.3**
Subtotal Domestic Commercia	**0.5**	**62.6**	**6.2**	**69.3**
Total	**7.5**	**307.7**	**28.7**	**343.9**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type				GHG Emissions
Direct GHG Emissions Factor	*0*	*72,000*	*0*	
Indirect GHG Emissions Factor	*9,107*	*7,500*	*20,800*	
Direct GHG Emissions	0	22.2	0	**22.2**
Indirect GHG Emissions	0.1	2.3	0.6	**3.0**
Total	**0.1**	**24.5**	**0.6**	**25.1**

Table D-5: Transportation Sectors - 2050 Electrification Scenario - Energy Use (PJ) **and GHG Emissions** (Mt CO_2eq) 254.052

Energy Use (PJ)

Sector	Electricity Use *(from the grid)*	Petroleum Products Use	Biofuel Use	Total Energy Use
Licensed Pax vehicles				
Cars & SUV's	7.9	14.3	38.2	**60.4**
Pick-ups, Vans	2.7	6.8	18.3	**27.8**
Other household vehicles	0	3	1.7	**4.3**
Ferries	0	3.8	3	**6.3**
Buses and Other Non-electric Public Transit	0	6.7	4	**11.1**
Electric Public Transport	5.5	0	0	**5.5**
Subtotal Licensed Pax Vehicles	**16.2**	**34.1**	**65.1**	**115.4**
Gateway				
Rail	10.0	9.1	6.1	**25.2**
Marine	0	77.5	13.7	**91.1**
Air	0	18.4	3.2	**21.6**
Trucking	0	4.7	0.8	**5.5**
Passenger Vehicles	0	6.5	1.1	**7.6**
Subtotal Gateway	**10.0**	**116.1**	**25.0**	**151.0**
Domestic Commercial				
Light commercial	2.1	12.8	12.8	**27.8**
Freight Trucks	0	3.6	2.4	**5.9**
Transient Commercial	0	7.3	1.3	**8.6**
Coastal Vessels	0	5.3	3.6	**8.9**
Off road equipment & propane	0	7.0	4.7	**11.7**
Subtotal Domestic Commercia	**2.1**	**36.0**	**24.7**	**62.9**
Total	**28.3**	**186.2**	**114.8**	**329.3**

Greenhouse Gas Emissions (Mt CO_2eq)

GHG Emissions Type				GHG Emissions
Direct GHG Emissions Factor	*0*	*72,000*	*0*	
Indirect GHG Emissions Factor	*9,107*	*7,500*	*20,800*	
Direct GHG Emissions	0	13.4	0	**13.4**
Indirect GHG Emissions	0.3	1.4	2.4	**4.0**
Total	**0.3**	**14.8**	**2.4**	**17.4**

Appendix E

Flow Diagram Assumptions

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Appendix E

Flow Diagrams Assumptions

- Co-generation of heat and power by the industrial and commercial sectors accounted for in the sector themselves (not in 'Electric Power'). As a result, the biomass used for co-generation is accounted for in the Biomass-to-Industrial and Biomass-to-Commercial flows (not in the Biomass-to-Electric Power flow);
- No Natural Gas-to-Transportation flow in the 2010, 2020, and 2050 diagrams; natural gas used for pipeline transportation is accounted for within the 'Industrial' sector;
- No Petroleum-to-Commercial flow in the 2010, 2020, and 2050 diagrams; petroleum products used by commercial fleets are accounted for within the 'Transportation' sector;
- We assumed no use of petroleum by the 'Residential' sector in 2020 and 2050;
- Imports and/or exports of biomass and petroleum products are not shown in the diagrams due to missing trade data. "Net" biomass and "Net" petroleum product flows are shown (local production + imports – exports);
- Each sector's useful energy and lost energy ratios are assumed constant overtime. Ratios based on 2006 performance: 71%, 71%, 61% and 20% of useful energy for the 'Residential', 'Commercial', 'Industrial' and 'Transportation' sectors, respectively. In reality these ratios are expected to improve over time;
- Electricity mix assumptions:
  - 13% generation losses and 13% transmission and distribution losses;
  - No coal power generation;
  - Petroleum-to-Electric Power assumed constant at 1 PJ in all the reference cases and electrification scenarios (to account for remote diesel generators); and
  - Natural gas-to-Electric Power: the reference cases use values from MKJA (2009) (29 P, 39 PJ, and 117 PJ for 2010, 2020, and 2050 respectively); in the electrification scenarios it is assumed that natural gas power generation remains constant at 29 PJ;
  - <u>2010 Reference case</u>
    - Biomass-to-Electric Power: NRCan (2005)[1] states that "almost all the >650 MW of provincial woody biomass electric generating capacity is used internally by pulp and paper mills." Therefore, we only allocated the Williams Lake Woodwaste Plant (~60MW) to 'Electric Power' generation (other plants are accounted for in the 'Industrial' sector). Williams Lake consumed 600,000 tonnes of "green wood" whose energy content is 10,900 MJ/tonne. Therefore, the Biomass-to-Electric Power flow is 7 PJ;
    - Other Renewable-to-Electric: 3 PJ, from MKJA (2009); and
    - Hydro-to-Electric Power: balance between the total energy supply required by 'Electric Power' and the other flows calculated above.
  - <u>2020 and 2050 reference cases; 2020 and 2050 electrification scenarios</u>
    - The incremental power capacity other than the one generated with natural gas is assumed to be generated as follows:
      20% Biomass;
      40% Hydro; and
      40% from other renewable (geothermal, wind, tidal and waves).

      Note: the resulting power generation increments are consistent with the potential generation resources options identified by BC Hydro[2] with the exception of biomass. The biomass potential in the BC Hydro study is considered to be conservative since it only includes biomass residues.

[1] Natural Resources Canada (NRCan), Canadian Forest Service, Brad Stennes, 2005, Biomass Energy Opportunities from Large-Scale Forest Disturbances. Victoria, BC: July 11.
[2] BC Hydro, 2009, BC Hydro Potential Generation Resource Options (part of BCUC Long-Term Electricity Transmission Inquiry).

Appendix F

References

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No.	Name of Document or Report	Author	Date	Classification
1	Housing Market Information	Canada Mortgage and Housing Corporation	Feb-10	Residential
2	Survey of Household Energy Use (SHEU) - 2007	NRCan	2007	Residential
3	British Columbia Housing Starts for Urban Areas and Communities	Canada Mortgage and Housing Corporation	2006	Residential
4	Typical Home & Water Heating Costs	Manitoba Hydro	2006	Residential
5	Residential Capacity Modeling for LRSP Review	Metro Vancouver	2006	Residential
6	Survey of Household Energy Use (SHEU) - 2003	NRCan	2003	Residential
7	Average Residential Electricity Consumption	Hamilton Hydro Inc.	Undated	Residential
8	Commercial and Institutional Consumption of Energy Survey	NRCan	2007	Commercial
9	Real Estate Development Industry	Industry Canada	2003	Commercial
10	Commercial and Institutional Building Energy Use	NRCan	2003	Commercial
11	Commercial Solar Water Heating Systems	NRCan	undated	Commercial
12	BC Pulp Exports	BC Progress Board	2009	Industry
13	British Columbia Oil and Gas 2009 Yours to Explore	Ministry of Energy, Mines and Petroleum Resources	2009	Industry
14	Biodiesel Utilization: Update on Analytical Techniques, May 2009	U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy	2009	Industry
15	Shale Gas in North America Emerging Supply Opportunities	Canadian Society for Unconventional Gas	2008	Industry
16	Tracking the Sun II: The Installed Cost of Photovoltaics in The US from 1998-2008	Lawrence Berkeley National Laboratory	2008	Industry
17	North American Industry Classification System (NAICS) - Canada	Statistic Canada	2007	Industry
18	Biodiesel Energy Balance	Dept. Biological and Agricultural Engineering, University of Idaho	2005	Industry
19	Canada and British Columbia Pulp and Paper Production 1994-2005	BC Stats	2005	Industry
20	Benchmarking the Energy Consumption of Canadian Underground Bulk Mines	NRCan	2005	Industry
21	Benchmarking the Energy Consumption of Canadian Underground Bulk Mines	NRCan / CIPEC	2005	Industry
22	Canada, a Big Energy Consumer: A Regional Perspective	Statistic Canada	2005	Industry
23	Profile of British Columbia's Manufacturing Sector	BC Stats and CMA	2004	Industry
24	A Review of Energy Consumption & Related Data Canadian Cement Manufacturing Industry, 1990 to 2001	CIEEDAC	2003	Industry
25	Energy Cost Reduction in the Pulp and Paper Industry – An Energy Benchmarking Perspective	NRCan	2002	Industry

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26	Energy Consumption Benchmark Guide: Cement Clinker Production	NR CAN / CIPEC	2001	Industry
27	Guide to Energy Efficiency in Aluminum Smelters	NRCan	1998	Industry
28	Bioenergy Conversion Factors		Undated	Industry
29	Electrification Roadmap (US)	Electrification Coalition	2009	Transport
30	Cost Comparison of Transportation Modes (Skytrain, Bus, Trolleys, etc.)	UBC School of Architecture and Landscape Architecture	2009	Transport
31	YVR Passengers 1992-2009	Vancouver International Airport	2009	Transport
32	Volvo Cars Electrification Strategy	Volvo	2009	Transport
33	BC Ferries Fuel Consumption Reduction Plan	BC Ferries	2008	Transport
34	British Columbia's Economy: Then and Now (Motor Vehicles per Capita)	BC Statistics	2008	Transport
35	Vision for the Future of the Greater Vancouver Gateway	Gateway Council	2008	Transport
36	Commuting in Metro Vancouver – Journey to Work - Bulletin	Metro Vancouver	2008	Transport
37	Evaluating the Impact of Advanced Vehicle and Fuel Technologies in the US Light Vehicle Fleet	MIT - Thesis	2008	Transport
38	A Transportation Strategy for Metro Vancouver - Transport 2040	TransLink	2008	Transport
39	Transportation In Canada - Overview Addendum (tables and figures)	Transport Canada	2008	Transport
40	Plug-in Electric Hybrid Vehicles - Position Statement	IEEE	2007	Transport
41	Canadian Vehicle Survey - Summary Report	NR CAN	2007	Transport
42	New Motor Vehicle Sales: 2006 in Review	Statistic Canada	2007	Transport
43	Guide to Diesel Idling Reduction	US EPA and NY State Energy R&D Authority	2006	Transport
44	Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower Oil	Natural Resources Research, Vol. 14, No. 1	2005	Transport
45	Canadian Vehicle Survey: Quarterly – October 1 to December 31, 2005	Statistic Canada	2005	Transport
46	Estimates of vehicle-kilometres for Canada by type of vehicle and jurisdiction	Statistic Canada	2005	Transport
47	National Transportation Statistics	U.S. Department of Transportation	2002	Transport
48	National Private Vehicle Use Survey — October 1994–September 1996	NRCan	2000	Transport
49	BC Transit Vancouver Operating Statistics	Statistic Canada	Undated	Transport
50	Resources Development Task Group	Green Energy Advisory Task Force	2010	All Sectors

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51	BC Hydro Annual Report 2009 - Electricity Sales	BC Hydro	2009	All Sectors
52	BC GDP by Industry - NAICS Aggregations	BC Statistics	2009	All Sectors
53	British Columbia Population Projections - 2009 to 2036	BC Statistics	2009	All Sectors
54	British Columbia Employment by Detailed Industry, Annual Averages	BC Stats	2009	All Sectors
55	Metro Vancouver - Population Estimates	Metro Vancouver	2009	All Sectors
56	World Refining Capacity	petroleum-economist	2009	All Sectors
57	Energy statistic Handbook	Statistic Canada	2009	All Sectors
58	Peak (Oil) Liquids Production	Toyota	2009	All Sectors
59	History of Prius Development	Toyota USA	2009	All Sectors
60	Sustainable Prosperity	University of OTTAWA	2009	All Sectors
61	World Petroleum Consumption	US EIA	2009	All Sectors
62	British Columbia Manufacturing Shipments - Statistics Canada, CANSIM Table 304-0015	BC Statistics	2008	All Sectors
63	Establishment Counts by Employee Size, 2000 – 2008, and Location Counts by Employee Size, 2008	BC Stats	2008	All Sectors
64	Transmission Technology Roadmap	BCTC	2008	All Sectors
65	Harvesting California's Renewable Energy Resources	Center for Energy Efficiency and Renewable Technologies	2008	All Sectors
66	Wood Pellet Raw Material From British Columbia	Finnish Technology Agency	2008	All Sectors
67	BC Bio-Energy Strategy	Government of British Columbia	2008	All Sectors
68	Photovoltaic Technology status prospects Canadian Annual Report 2008	Natural Resources Canada	2008	All Sectors
69	California Green Innovation Index	Next 10	2008	All Sectors
70	Design Recommendations for the WCI Regional Cap and Trade Program	Western Climate Initiative	2008	All Sectors
71	Oil and Gas Production and Activity in British Columbia	Ministry of Energy, Mines and Petroleum Resources	Feb-07	All Sectors
72	Climate Action Plan	British Columbia Document	2007	All Sectors
73	The Need for a BC Wood Energy Strategy	Forintek	2007	All Sectors
74	Endless Energy	Globe Foundation	2007	All Sectors
75	Regional Energy Partnerships for a Sustainable & Prosperous Future	Gollub - Global Economic Development ICF	2007	All Sectors
76	Outlook for Electricity Markets	NEB	2007	All Sectors
77	Electricity Exports and Imports	NEB	2007	All Sectors
78	Renewable Energy in BC	IPPBC	2006	All Sectors
79	The Future of Geothermal Energy	MIT	2006	All Sectors
80	Report: The State of Energy Efficiency in Canada	Office of Energy Efficiency	2006	All Sectors

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81	Energy Consumption and supply in British Columbia: A Summary and Review	Canada Industrial Energy End-Use, Data and Analysis Centre, Simon Fraser University	Aug-05	All Sectors
82	Simulating Advanced Vehicles Introduction Decisions (AVID): Structure and Coefficients	Center for Transportation Research, Energy Systems Division, Argonne National Laboratory	2005	All Sectors
83	Presentation: Cost Curves	Energy Analysis Office (EAO) & National Renewable Energy Laboratory (NREL)	2005	All Sectors
84	Energy Efficient Buildings	Government of British Columbia	2005	All Sectors
85	Energy & Mines Ministers Conference - Statistics and Supporting Information	Joint Ministerial	2005	All Sectors
86	Combined Heat and Power	NRCan	2005	All Sectors
87	Distributed Bio-Oil Reforming	NREL	2005	All Sectors
88	Ocean Energy: Global Technology Status, Opportunities and Challenges for Canada	Powertech Labs Inc	2005	All Sectors
89	Metering, Communication and Control Technologies for Micro-Generation	University of Sussex	2005	All Sectors
90	Energy Consumption and Supply in British Columbia: A Summary and Review	CIEEDAC	2004	All Sectors
91	A Review of Existing Cogeneration Facilities in Canada	CIEEDAC	2004	All Sectors
92	PV Grid Connected Market Potential under a Cost Breakthrough Scenario	Navigant Consulting	2004	All Sectors
93	Heating and Cooling With a Heat Pump	NRCan	2004	All Sectors
94	Biodiesel in British Columbia Feasibility Study Report	WEDC	2004	All Sectors
95	Conservation Potential Review	BC Hydro	2003	All Sectors
96	Net Metering	US EPA	2000	All Sectors
97	Demand and Supply Outlook	BC Hydro	Various	All Sectors
98	Green Energy Studies for British Columbia	BC Hydro	Various	All Sectors
99	Solar Power In Canada	CANSIA	Various	All Sectors
100	Wood Pellets (BC)	Wood Pellet Association of Canada	Various	All Sectors
101	BC Stats - data bases		Various	All Sectors
102	Statistics Canada - databases and census		Various	All Sectors
103	NRCan - databases		Various	All Sectors
104	US Energy Information Administration - databases		Various	All Sectors
105	Barriers to Increased Bioenergy Use in Canada and Some Solutions	Canadian Bioenergy Association	undated	All Sectors
106	Assessment of the Potential for Low Temperature Geothermal Energy and Aquifer Thermal Energy Storage (ATES) Systems in the Western Canadian Sedimentary Basin	Earth Sciences SFU	undated	All Sectors
107	British Columbia: Electricity Sector in this Decade	M. Jaccard	undated	All Sectors
108	Ground-source Heat Pump Analysis	Retscreen	undated	All Sectors