Global Energy

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1. Introduction

The increasing societal demand for energy has been an important issue since the industrial revolution. Over the last fifty years, the global demand for energy has grown substantially resulting in greater fossil-fuel consumption, with increased atmospheric carbon dioxide (CO_2) concentrations and accelerating climate change (IPCC 2007). Consequently, governments, industries and other parties are seeking to reduce CO_2 emissions to mitigate climate change. Sustainable energy production and consumption systems are important elements in climate-change mitigation. Canada's forest sector is a major consumer of renewable bioenergy and it may become an important supplier of such energy.

This paper examines the impacts of global energy supply and demand on Canadian forests and the forest sector. First, energy supply from Canada's forests is considered in a global context by outlining the interactions between the global situation and the other drivers considered by this project. Second, bioenergy production technologies and the opportunities for bioenergy to become an important product for the Canadian forest sector are discussed. Third, historical trends and forecasts for energy production and consumption at the global level and within Canada are reviewed. Finally, two alternative scenarios for global energy and its impacts on the Canadian forest sector are presented.

2. Canada's Forests and Forest Sector in the Context of Global Energy Supply and Demand

Global energy supply and demand issues affect many aspects of Canadian forestry, as shown by its influence on many of the drivers studied in this project (see Appendix). It interacts very strongly with climate change, ecosystem health, geopolitics and societal values. CO_2 emissions from fossil-fuel-consuming energy production and transport systems have been associated with climate change (IPCC 2007). In addition to the adverse effects of climate change on ecosystems, fossil-fuel emissions may have significant direct, localized ecological impacts. Energy demand and price volatilities will also strongly affect technological development and societal values over the next fifty years as acceptable energy, construction and transport systems with low energy and carbon intensities are developed.

Historically, geopolitics and conflict of resources have been strongly influenced by global energy issues, with many international conflicts having developed over access to energy resources. In addition, trading groups such as the Organization of the Petroleum Exporting Countries (OPEC) have been established to bring together diverse energy-producing countries in an attempt to control the availability and price of energy resources.

Global energy supply and demand issues are likely to exert a moderate influence on forest industry profitability and wood supply/demand. As energy becomes more expensive and price volatility increases, industry profitability may be affected. For example, the profitability of energy-intensive components of the sector, such as mechanical pulping, may decrease. Alternatively, such developments may provide an opportunity for the sector to become a net bioenergy producer. In recognition of this potential, the Canadian forest-products sector has set a target of being carbon neutral by 2015, without the purchase of any emission offsets (FPAC 2007). As energy becomes a more important output of forest-products manufacturing, the balance of wood supply and demand is likely to be affected. At present energy prices, the majority of wood and fibre will continue to flow to higher-value end uses such as lumber, panels and pulp and paper rather than energy. Initially, the drive to produce bioenergy from lignocellulosic materials will use wood-processing and forest residues due to their relatively low cost. If energy prices continue to increase more rapidly than the price of commodity forest products, increased competition between commodity processing and energy end-uses is likely to occur.

Many drivers considered by this project also interact with global energy supply and demand (see Appendix). Climate change and technology will heavily influence the types of energy production systems used over the next fifty years. Societal views on climate change, the associated ecological impacts and acceptable energy production and transport technologies will also influence how CO_2 emissions from energy systems are mitigated. Geopolitical issues, governance and conflict over resources are major motivators for the United States (US) to seek secure supplies of energy, which in turn will have implications for Canadian energy and forest sectors.

3. Bioenergy: technologies and potential supply from Canadian forests

Recently, greenhouse-gas (GHG) emission reduction targets in the Kyoto Protocol, the rising oil price and energy security issues have raised the level of interest in bioenergy (UNECE/FAO 2007). This section describes the major technological platforms used to produce bioenergy, highlights alternative feedstocks, and addresses the potential use of Canada's forests for bioenergy.

Bioenergy production technologies

Three major platforms are used to produce energy from biomass. These platforms are either (Figure 1):

- thermo-chemical;
- biochemical;
- mechanical.

The thermo-chemical conversion platform is comprised of three core processes: combustion, gasification and pyrolysis. The amount of oxygen consumed is greatest in combustion and least in pyrolysis and the ratios of gaseous, liquid and solid products also varies from process to process. Biochemical conversion consists of pretreatment to increase the biodegradability of the substrate and subsequent fermentation to either ethanol or methane/CO_2. Mechanical processing involves crushing oil-containing crops such as canola. Each platform converts

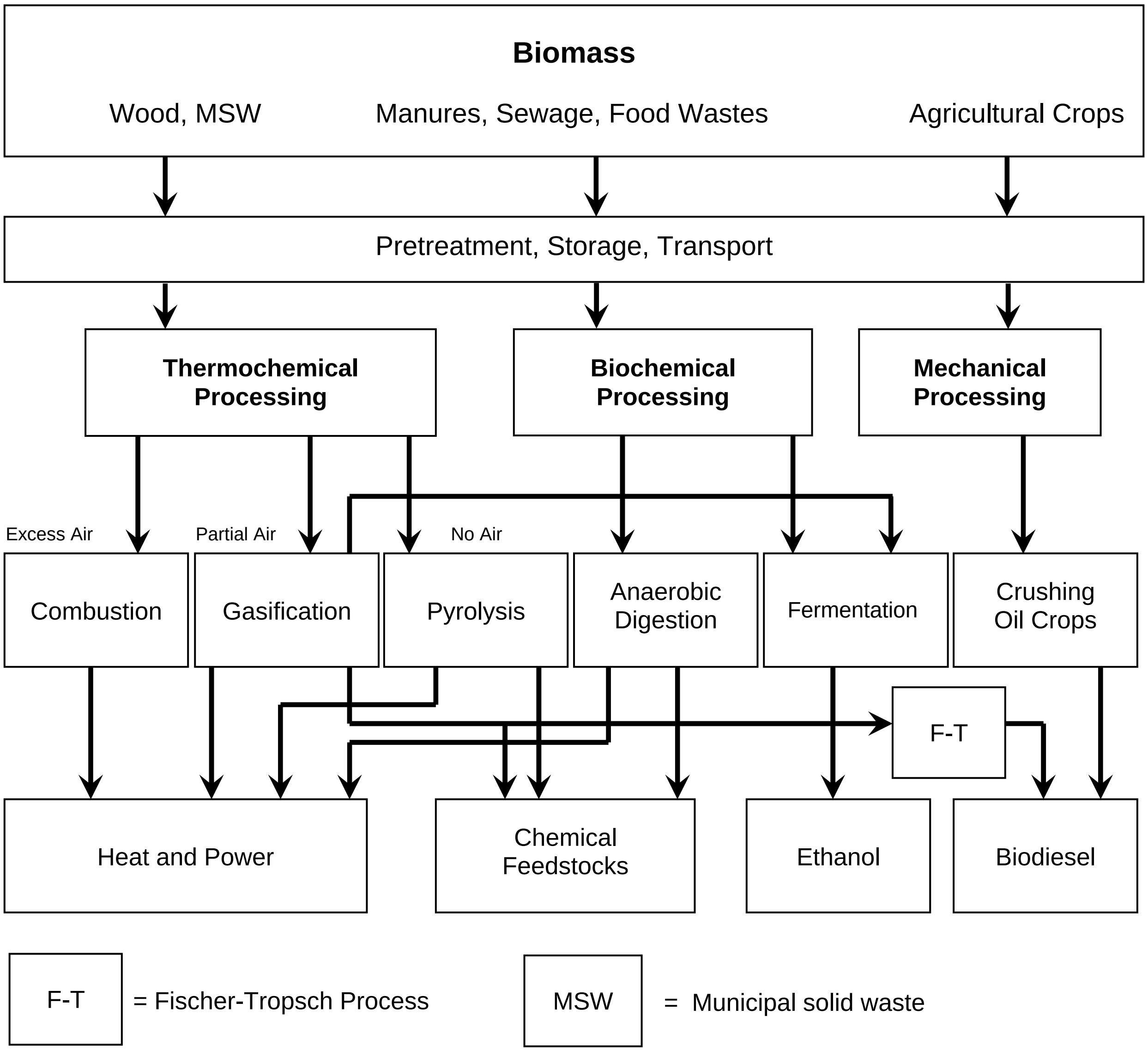

Figure 1. Conversion routes for the production of bioenergy (Adapted from Kaltschmitt and Bridgwater 1997, and IEA 2007).

biomass into heat, power, transport fuels or chemical feedstocks that fulfill a wide range of end uses.

Developed and developing countries differ considerably in their use of bioenergy. Developed nations use most bioenergy for heat and power generation and there is an increasing focus in its use as a liquid transport fuel. In developing countries, most bioenergy is used for heating.

Sources of feedstock: agriculture and forestry

Each bioenergy platform requires a suitable biomass feedstock. To date, most of the commercially successful conversion platforms use agricultural (nonwoody) plants rather than wood-based feedstocks due to the ready accessibility of the oils and carbohydrate polymers. For example, corn is the major feedstock for ethanol production in the US and sugarcane predominates in Brazil. The US has policies to grow its bioenergy supplies and it is targeting an increase from 6 billion gallons of ethanol production in 2006 to 60 billion gallons by 2030 (Roberts et al. 2007). These policies have increased the consumption of agricultural materials for biofuel production, and contributed to substantially higher prices for grains and oilseeds (Klein and LeRoy 2007). Large quantities of grain have also been imported from Mexico with consequent significant increases occurring in Mexican grain and tortilla prices, leading to civil outcry in that country (Sauser 2007).

This type of outcome was expected, as a vibrant bioenergy sector had been predicted to increase both food prices and the competition for land between biomass for energy and food (Brown, 2003; Azar, 2005; WWI, 2007). Recent analyses have revealed a convergence between the markets for fuel, food and wood fibre (Roberts et al. 2007). Although global grain production has doubled over the last forty years, the availability of grain per capita has remained at approximately 320 kg.capita^{-1} since the mid-1970s because the world's population has also approximately doubled over this period (UN 1999). The social, economic and ethical issues associated with diverting food to fuel are major drivers to provide bioenergy from sources of biomass, such as forest residues, that are not suitable as food (Azar 2005).

Use of lignocellulosic materials for bioenergy production

Woody (i.e. lignocellulosic) feedstocks offer both strategic and environmental benefits over agricultural materials that are used to supply food. The strategic drivers have been outlined above. Recently, the environmental benefits of wood-derived ethanol, methanol and methane over most agriculturally sourced fuels have been demonstrated (Scharlemann and Laurence 2008). The complexity of lignocellulosic polymers and their inaccessibility to enzymes makes them more difficult to use in the biochemical platforms than in the thermo-chemical platforms.

To date, the greatest success using woody feedstocks for energy production has been with wood-processing residuals. Energy is usually produced by combustion and it is generally used directly within the forest-products sector, either for fueling the operation of pulp and paper mills or heating the kilns used to dry lumber in sawmills. However, some wood-processing residues and whitewood are also exported after being processed into wood pellets. The varying price of energy in different parts of the world has enabled wood pellets to be transported substantial distances for bioenergy production. In 2005, for example, the price of electricity in the Netherlands was 31 cents per kilowatt hour (CAD cents.kwh^{-1}) compared to 7.5 CAD cents.kwh^{-1} in British Columbia (BC) (Eurostat 2006). This price differential made it economic to transport wood pellets from BC to the Netherlands where the wood pellets were generally used for co-firing in boilers to produce electricity and their perceived carbon neutrality helped meet emission targets under the Kyoto Protocol. Over the last decade, wood-pellet production in Canada increased significantly to reach 1.5 million tonnes.year^{-1} in 2007 (WPA 2007).

To date, there are no full-scale lignocellulosic ethanol plants operating in North America. However, five commercial-scale projects are presently under construction in the US. One of these plants, with a target production of 1 billion gallons.year^{-1}, is being built in Georgia, US (Roberts et al. 2007). The price for delivered fibre to the plant is forecast to be in the range of US \$40-50.m^{-3} and it will consume about 10.9 million dry tonnes of wood annually (Roberts et al. 2007). If successful, this plant will create an increased demand for residual lignocellulosic materials and, as with many other economic developments, Canada and its forest sector are likely to feel the impacts of US technological innovations.

Canada's forests as a source of bioenergy

Complete use of timber-productive forest resources for bioenergy

Forty-two percent of Canada's 998 million hectares of land (M ha) are forested, and about 25% of the total land area (245 M ha) are considered timber-productive forest containing approximately 343 EJ[1] of energy (Wood and Layzell 2003). In 2006, Canada's primary energy consumption was estimated to be 10.9 EJ, of which about 9.3 EJ were fossil-fuel-derived (section 4 below). Using the 2006 rate of consumption, the standing biomass in the Canadian forest contains sufficient energy to provide about 31 years of Canada's total energy needs, and about 37 years of Canada's fossil-fuel-based energy demand. This analysis assumes that all of Canada's timber-productive forest biomass could be harvested instantaneously and converted to energy with 100% efficiency. Over a 30-40 year period, both energy demand and forest biomass will grow significantly. Models using realistic growth forecasts of both the timber productive forest and fossil-fuel energy demand indicated that this forest resource would be depleted within 31-37 years if used only for energy supply with 100% conversion efficiency. The similarity between this period and that for 'instantaneous' use was due to the relatively similar growth rates forecast for energy demand and forest increment.

Use of Canada's annual harvest for bioenergy only

Canada's forest sector typically harvests about 47.7 Mt C roundwood and about 26 Mt C.yr^{-1} of non-stem biomass for a total harvest of 73.8 Mt C.yr^{-1} (Wood and Layzell 2003). Assuming that 50% of the non-stem biomass was retained on the site to promote sustainability and protect ecosystem integrity (Wood and Layzell 2003), an annual harvest of 60.8 Mt C.yr^{-1} would be achieved, with an energy content of 2.14 EJ.yr^{-1} equivalent to about 23% of Canada's annual energy demand from fossil fuels. The ecological impacts and economic feasibility of removing this material from the forest would require careful assessment and these considerations may result is less non-stem biomass removal.

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[1] The values cited in this report differ from those given in Wood and Layzell 2003. The original values have been amended to correct a mis-calculation regarding the amount of non-stem biomass available.

Northern temperate countries remove typically 12% of the non-stem biomass from the forest site (Mabee et al. 2008). Consequently, about 3.1 Mt $C.yr^{-1}$, equivalent to 0.11 $EJ.yr^{-1}$, of non-stem biomass may be available. Adding this biomass to Canada's roundwood harvest would provide a resource with an energy content of 1.79 $EJ.yr^{-1}$, equivalent to 19% of Canada's annual fossil-fuel consumption. This analysis also assumes that all of Canada's timber-productive forest biomass would be harvested and converted to energy with 100% efficiency.

Use of Canada's annual harvest for wood products, pulp and paper, and bioenergy

Presently, the majority of the roundwood harvest is used to manufacture forest products, such as lumber, panels and pulp and paper, and this utilization pattern is likely to continue in the near term as the harvest flows to its highest value uses. During manufacturing, some of the roundwood input is converted to bioenergy and a portion ends up as biomass residues. Most bioenergy production occurs in the black liquor recovery process at Kraft mills with 0.3 $EJ.yr^{-1}$, equivalent to 8.55 Mt $C.yr^{-1}$, being produced by Canadian mills in 2006 (Statistics Canada 2008). In addition, energy from biomass residues produced by the Canadian forest products sector accounted for 0.27 $EJ.yr^{-1}$ in 2006 (Statistics Canada 2008) to give a total bioenergy production from woody biomass of 0.57 $EJ.yr^{-1}$ which is equivalent to about 6.2% of Canada's annual fossil fuel consumption.

In addition to the biomass used to generate this energy, the forest products sector produces excess biomass residues. The surplus residues from the sector declined from 4.55 Mt $C.yr^{-1}$ in 1990 to 1.37 Mt $C.yr^{-1}$ in 2004 (McCloy 2005). This decrease was caused by sawmills generating fewer residues per unit of roundwood input (see Technology paper) and the increased use of residues for bioenergy or in products such as wood pellets and medium-density fiberboard. More recently, this trend may have been reversed due to the increased availability of low-quality trees resulting from pest and disease outbreaks and the greater quantity of residues associated with processing this challenging material. Assuming that the 2004 data are still applicable, complete utilization of the surplus residues together with the existing bioenergy production would generate 0.62 $EJ.yr^{-1}$, equivalent to about 6.7% of Canada's annual fossil fuel consumption.

Assuming again that 12% of the non-stem biomass may be removed economically from the site while achieving the goal of sustainable forest management would provide 0.11 $EJ.yr^{-1}$. Adding this value to the 0.62 $EJ.yr^{-1}$ calculated in the paragraph above, Canada could sustainably produce about 0.73 $EJ.yr^{-1}$ without increasing its roundwood harvest or changing industry practice substantially. This is an energy value equivalent to 7.9% of national fossil-fuel use.

Practical constraints

Many of the paragraphs above have assumed an energy conversion efficiency of 100%. The type of bioenergy technology used affects the validity of this assumption. Efficient combustion processes may operate at a thermal efficiency of 75-92% whereas power generation systems may exhibit an electrical efficiency of 20-35%. Many other conversion technologies fall within these bounds. The numbers cited here therefore represent maximum potential values and adjustments should be made based on the efficiency of the energy conversion technology.

Intensification of forest management and application of advanced biotechnologies could increase biomass availability. If intensive silviculture, plant breeding and biotechnology were able to increase the availability of lignocellulosic feedstocks by 50%, this could maintain the scale of the existing forest-products industry and enable bioenergy to supply 2.7 $EJ.yr^{-1}$ or 29% of the national fossil-fuel use in 2006.

4. A Look-back: Trends in Global and Canadian Energy Consumption since 1970

This section considers historical trends in energy demand and production from the following three perspectives:

- Global energy consumption
- Canadian energy consumption
- Energy and the Canadian forest-products industry

Global energy consumption

The global demand for energy has increased by about 60% since 1980 and continues to grow rapidly in response to increased population, economic development and consumptive behaviour (IEA Bioenergy 2007). In 2006, total global energy consumption was 498 EJ (IEA 2007) and fossil fuels met about 86% of this demand (Figure 2). Nuclear power satisfied 6% of global consumption and renewables (i.e. hydro, solar, wind and biomass) accounted for 8%. Fossil fuels have been forecast to continue as the predominant source of global energy over the next twenty years by several agencies (EIA 2008, IEA 2007) despite diminishing oil reserves (Illum 2004). Nuclear and renewable supplies may increase in the future due to intense decarbonization pressures on nations (TCBC 2006). At present, the use of biomass for energy varies greatly between developed and developing nations. In industrialized countries, biomass typically contributes less than 10% to the total energy supplies, while it constitutes 50-90% of the total energy supply in developing countries (IEA Bioenergy 2007).

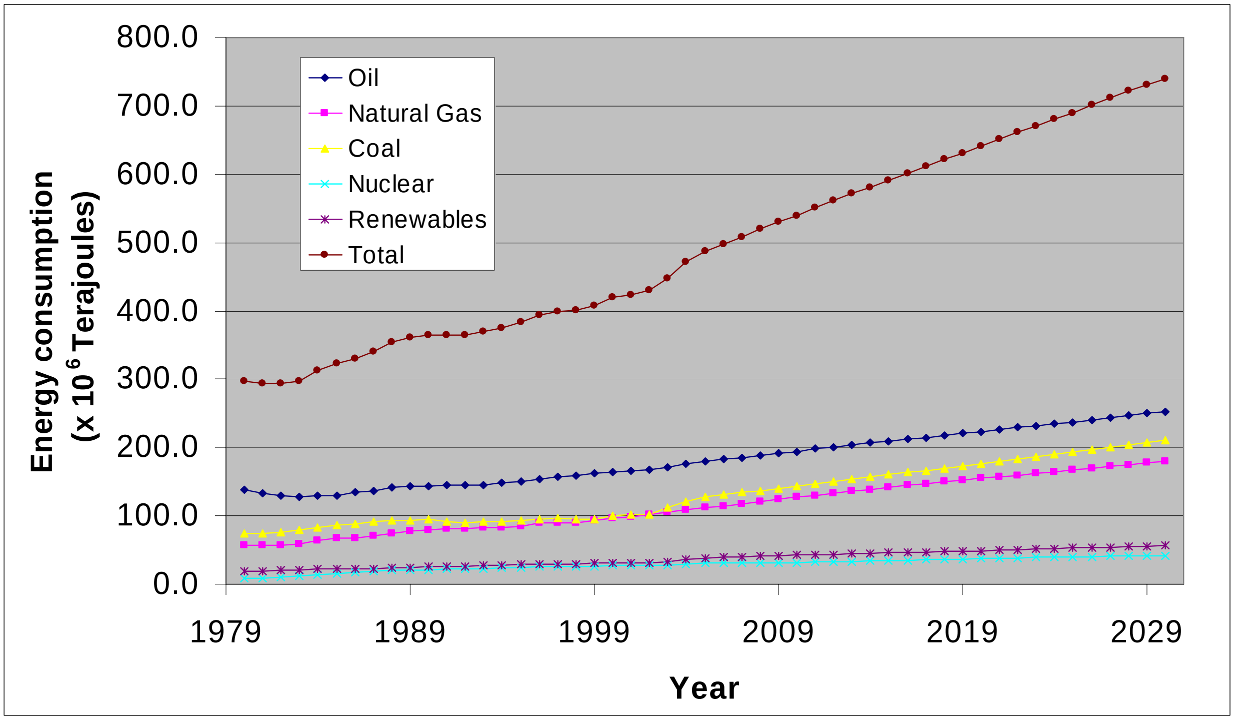

Figure 2. Historical and forecast global energy consumption (EIA 2007).

Canadian energy consumption

Canada has an energy-intensive economy and its per-capita energy consumption of 0.34 $TJ.capita^{-1}$ (Statistics Canada 2008) has been about 50% greater than the average value for G-8 countries (IEA 2004a). Canada's total energy demand increased 218% from 3.20 EJ in 1961 to 10.2 EJ in 1997 which supported a 261% growth in GDP within the period (Figure 3). In 2006, Canada's total energy consumption was estimated to be 10.9 EJ (Statistics Canada 2008).

Canada's energy supply infrastructure is heavily dependent upon fossil fuels, with about 85% of the energy consumed originating from this fuel source. Renewable energy and nuclear power play minor, but increasingly important, roles. Between 1958 and 2002, Canada's consumption of non-fossil fuels increased from 13% to 16%.

Crude oil has been the largest contributor to the Canada's energy mix and its input increased by 137% from 1.60 EJ in 1961 to 3.80 EJ in 1997. The proportion of energy obtained from natural gas and coal increased 526% and 145% respectively over the same period. Energy from hydro sources grew 235% from 0.37 EJ in 1961 to 1.25 EJ in 1997. Energy from wood waste and residual wood made the smallest contribution to the total energy mix with a 156% growth from 0.23 EJ to 0.59 EJ in 1961 and 1997 respectively.

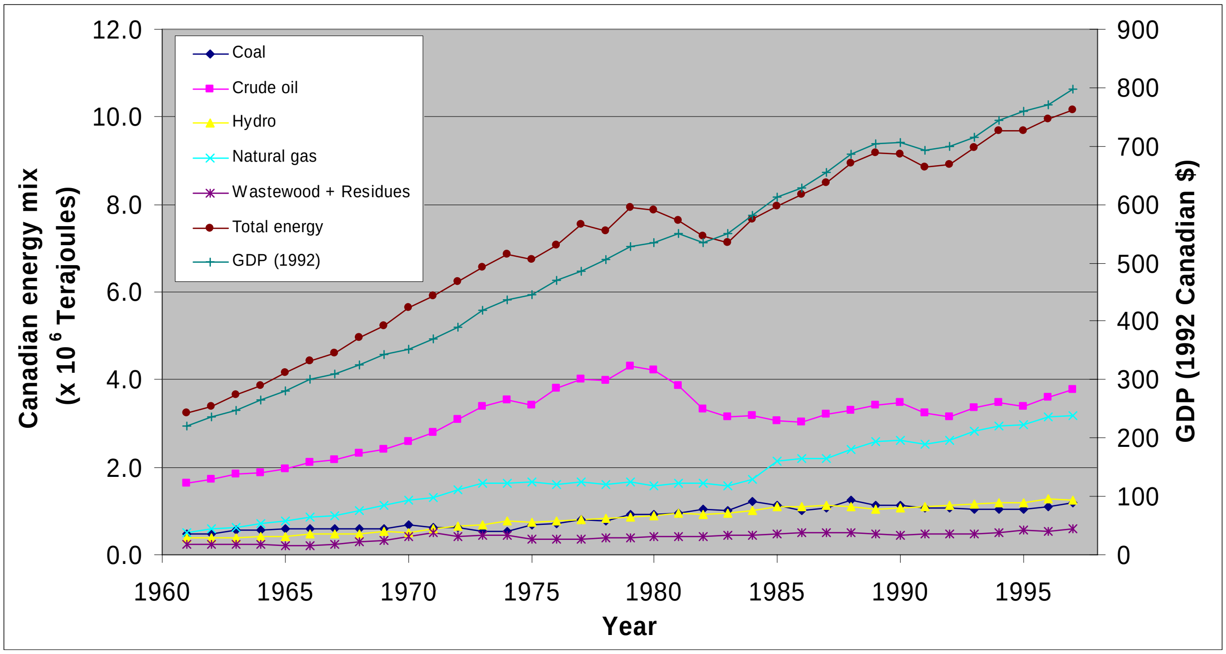

Figure 3. Canadian energy mix and GDP. (Statistics Canada, 2008)

Energy and the Canadian forest products industry

Total energy consumption in the Canadian forest-products sector increased by 14% from 0.377 EJ in 1978 to 0.439 EJ in 2004 (Statistics Canada 2008). The pulp and paper industry has historically dominated energy consumption within the sector. It accounted for 84% of the total energy used in 2004 and the wood-products manufacturing sector accounted for 16%. However, since 1990, wood-products manufacturing has steadily increased its share from 10 to 16% of the total while the pulp-and-paper industry's share has dropped proportionally.

The use of bioenergy in the Canadian forest sector has increased by 159% over the last forty years. Energy-efficient technologies such as biomass cogeneration, and combined heat and power (CHP) are penetrating the marketplace to complement the black-liquor combustion processes used in kraft pulp mills (TCBC 2006). Biorefineries that use biomass in an optimal manner to derive revenue from a wide range of fuels and chemicals are presently under development and they offer the some potential to rejuvenate the forest-products sector.

5. Existing scenarios for energy supply: Global, North American and Canadian contexts

Global energy scenarios predict an increasing contribution of fossil fuels to the medium- and long-term fuel mix (IEA 2004b; IEA 2007, EIA 2008). The World Energy Outlook 2004 forecasted that by 2030 coal would account for 22% of the world energy supply; natural gas 23%; nuclear, 5% and hydro and renewables would together contribute 14%. Crude oil is forecast to remain the principal fuel in the global energy mix and its consumption is predicted to increase 36% by 2030 (IEA, 2004b; IEA 2007). Canada is expected to face an increasing demand from the US for oil from the oil sands (NEB, 2007). Significant environmental challenges have to be addressed as part of the oil-sands development (Soderbergh et al. 2007).

The International Energy Agency (IEA) developed a World Alternative Policy Scenario to test the implications of decarbonization measures (IEA 2004b). Even this relatively low-carbon-intensity scenario forecast that fossil fuels would account for the largest share of the primary fuel mix in 2030 in North America (TCBC 2006). North American energy developments are important because US consumption patterns influence Canadian energy developments. Oil's share of the region's energy supply was predicted to increase marginally in both reference and alternative scenarios (Figure 4). Natural gas, the second largest energy source, was forecast to increase to slightly over 25% of supply in both reference and alternative scenarios. Coal, the third largest energy supply, was expected to decrease from 22% of supply in 2002 to either 18% or 15% in 2030 in the reference and alternative scenarios respectively. Hydro and other renewables, which together constituted the fourth dominant supply, were forecast to increase from 7% of supply in 2002 to 8.5 -12% depending on the scenario. Nuclear power, the final component in North America's energy mix, was projected to decrease from 8.5% of supply in 2002 to between 6 - 6.5% in 2030.

Canada's National Energy Board recently presented three scenarios for energy demand to 2030 (NEB 2007). In all scenarios, the demand for petroleum products increased significantly compared to a 2004 baseline. The percentage contributions of electricity and gas were forecast to decrease slightly. The remaining category, 'biofuels and emerging energy', met 5-8% of the energy demand, depending on the scenario. For comparison, this category met 6% of the demand in 2004. Fossil fuels are therefore expected to continue as the main source of energy in Canada over the next few decades. While there are forces at play to ensure that fossil fuels will continue to underpin economic growth, intensified decarbonization pressures will also arise from society's changing environmental values (TCBC 2006).

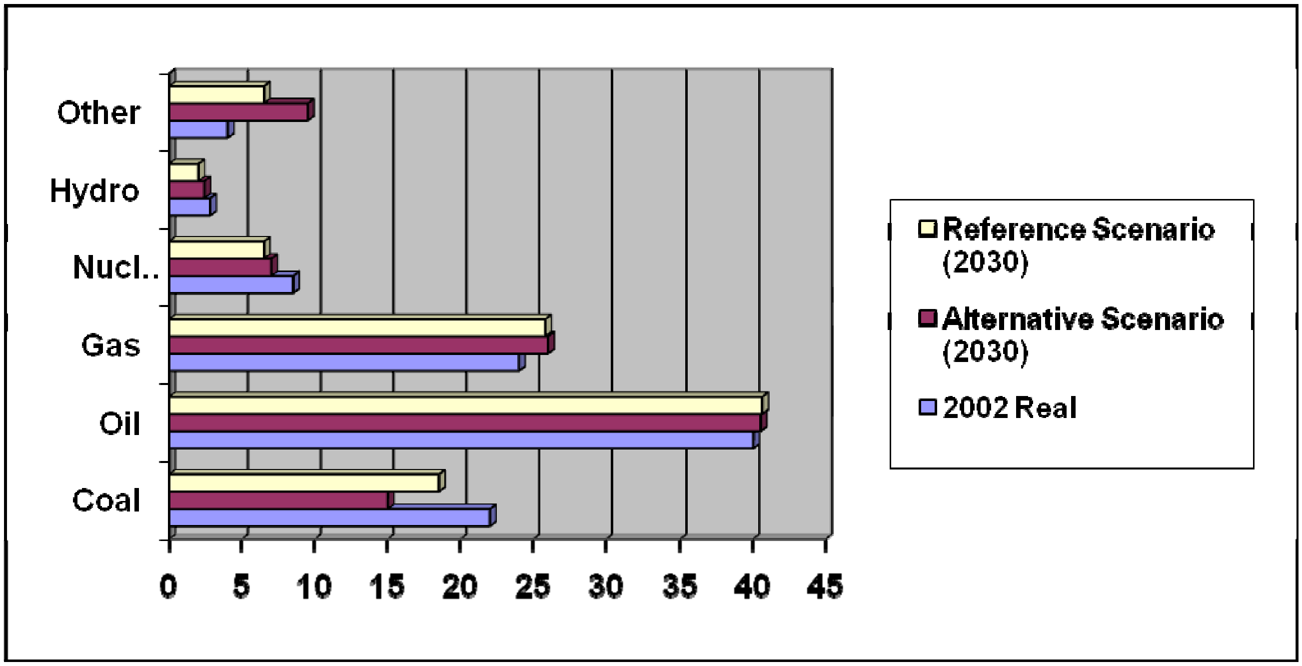

Figure 4. North American Primary Energy Mix (per cent) (World Energy Outlook 2004).

All of these scenarios show that renewables, and especially bioenergy, are expected to be a minor contributor to both North America's and Canada's future energy supply. However, despite the small total contribution to the national energy supply, strategic drivers will result in ongoing efforts to use forest materials for bioenergy production. Future technological developments and rates of commercialization will determine whether Canada and the world will follow a path where renewable energies are utilized to their fullest extent or whether gains in energy efficiency and carbon sequestration will allow fossil fuels to continue to dominate the energy supply for another century, as forecast in several scenarios (TCBC 2006).

6. A Look-ahead: Future Scenarios for Energy's Impact on Canada's Forests to 2050

This paper considers two scenarios for bioenergy and its impacts on Canadian forests:

1. Low forest bioenergy, where negligible fibre is extracted from Canada's forests for the provision of energy; and

2. High forest bioenergy, where all economically available forest resources are used to satisfy energy demands.

Low forest bioenergy

In this scenario, Canadian forestry operates to sustain both communities and forest ecosystems. Relatively small-scale timber extraction occurs to provide livelihoods for value-added manufacturers and artisans. Residues from manufacturing are used to provide energy for the local industry and community. Harvesting residues are largely left within the forest to decay, thus recycling nutrients and providing habitat. Canada's energy supply is satisfied largely by ready access to fossil fuels and nuclear power with bioenergy from forest resources providing a negligible contribution. Technological advances enable the mitigation of the CO_2 emissions from fossil-fuel plants and the safe disposal of nuclear fuel wastes so that these energy production systems have socially acceptable environmental impacts. Energy prices remain low to moderate in real terms.

High forest bioenergy

In this scenario, real energy prices rise substantially and energy is an important product for the Canadian forest sector. Highly productive forest areas are intensively managed to maximize fibre production and as much fibre as possible is extracted from the forests. Minimal amounts of residue are left within the forest and at the road side. Technology is developed to densify and transport both green and woody biomass economically from harvesting sites and roadsides to manufacturing plants. The fibre supply flows to its most profitable use and a much broader suite of products is manufactured than in 2008. Concern over the security of food supplies has resulted in the widespread use of lignocellulosic materials for bioenergy. Technological breakthroughs enable the economic conversion of lignocellulosic materials to a diverse range of fuels and biomaterials and large biorefineries have become an important part of the forest-products sector. Advanced products that replace petrochemically derived plastics are manufactured. Liquid fuels derived from wood provide an important component of Canada's transport fuel needs. Still, bioenergy continues to make a minor contribution to Canada's total energy supply.

7. Conclusions

Global primary energy demand is projected to increase substantially over the next thirty years. Fossil fuels are forecast to dominate the global energy supply for a substantial period, with oil remaining the single largest fuel source in the global energy mix.

Presently, renewable energy accounts for 8% of global energy consumption. Future decarbonization pressures arising from climate change, energy security and environmental concerns may increase this value. These pressures have already contributed to an increase in the global grain-ethanol and biodiesel production. The social, economic and ethical issues associated with diverting food to fuel will continue to be major drivers to provide bioenergy from biomass sources, such as forest residues, that are not directly used for food supply.

Fossil fuels are also forecast to dominate North America's energy supply for the next thirty years although hydro and other renewables have been predicted to increase their share of the region's energy mix from 7% in 2002 to between 8.5–12% in 2030. As the United States dominates

Canada's fossil-fuel exports, future US energy-supply strategies are likely to influence Canada's energy situation significantly.

Canada's forests contain sufficient energy to provide about 37 years of Canada's fossil fuel-derived energy demand, assuming that the total forest resource was harvested and converted to energy at 100% efficiency. Presently, energy from biomass accounts for about 6.2% of Canada's annual fossil fuel consumption. If the current roundwood harvest and 12% of the non-stem biomass were converted to energy with 100% efficiency, it could displace 19% of the national fossil-fuel consumption. More practically, if this roundwood harvest and non-stem biomass were used to sustain the current forest-products industries and used to produce bioenergy, 7.9% of the national fossil-fuel use could be satisfied. Intensification of forest management practices and advanced biotechnologies could increase these values. Application of realistic energy production efficiencies would reduce these numbers.

There are strong strategic drivers to use forest-derived materials for bioenergy production and energy is expected to become an increasingly important co-product for the forest sector. It may become a major product in the long term, especially if energy prices continue to increase at a rate greater than those of commodity wood products.

In a low-forest-bioenergy scenario, a minimal amount of fibre is extracted from the forest, predominantly to meet local community needs. Forest bioenergy plays a negligible role in Canada's energy mix. The high-forest-bioenergy scenario combines intensive forest management, and high rates of fibre and residue extraction with advances in biorefinery technology. These developments position bioenergy as an important economic contributor for the sector and the forest meets a significant proportion of Canada's transport fuel needs.

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Appendix

Table 1: Influences of global energy on other drivers.

Driver	**How Global Energy Affects the Driver**
Climate Change	CO_2 emissions from energy production facilities and transport systems that use fossil fuels are important contributors to climate change. Measures to mitigate climate change will result in a major interaction between energy production and climate change.
Wood Supply/Demand	Moderate influence. Energy will become an increasingly important co- or dominant product of forest products manufacturing.
Geopolitics	Major interaction. The drive to secure access to oil has had created significant geopolitical disturbances in the past. Such events are likely to recur.
Technology	Strong interaction. Technological developments will have a major influence on global energy supply and consumption.
Governance	Moderate influence.
Aboriginal Empowerment	Little direct influence.
Ecosystem Health	Significant influence. Global energy exerts a profound influence on ecosystem health.
Conflict over Resources	Strong influence. The drive to secure energy supplies has traditionally been a source of conflict, which may be expected to continue. In addition, there are conflicts in some provinces between land used for energy development and forestry.
Societal Values	Significant. As the nations confront decisions about energy supply options and the most appropriate technologies, societal values will be affected.
Demographics	Negligible influence.
Industry profitability	Moderate. As energy becomes more expensive, it may affect industry profitability in two ways. It could decrease the profitability of energy intensive components of the sector, such as mechanical pulping. Alternatively, it will provide an opportunity for the sector to become a net bioenergy producer and possibly improve the profitability of the sector.

Table 2: Influences of other drivers on global energy.

Driver	How the Driver May Affect Global Energy
Climate Change	Strong interaction. Pressures to mitigate and adapt to climate change will drive the development of non-fossil fuel energy supplies and technologies for mitigation CO_2 emissions from fossil fuel energy plants.
Wood Supply/Demand	Moderate interaction. As concerns grow over the use of crop derived carbohydrates for fuel, there will be pressure to develop biofuels based on woody materials. Initial indications are that the availability of suitable wood supplies will constrain the amount of biofuel that may be produced.
Geopolitics	Significant interaction. Geopolitics has traditionally had a strong effect on the availability of fossil fuel derived energy. As the world moves to a more carbon constrained economy, geopolitical issues may be expected to continue to exert an important influence.
Technology	Strong influence. The development of novel technologies to produce energy from forest based materials and to mitigate the effects of emissions from fossil fuel consuming energy plants will have a major influence on the global energy situation.
Governance	Strong interaction. Energy policies play a major role is development of bioenergy systems and renewable/green technologies.
Aboriginal Empowerment	Minor influence.
Ecosystem Health	Moderate influence. Provisions to ensue healthy ecosystems may constrain access to important fossil fuel and renewable energy sources, especially those that rely upon plant materials.
Conflict over Resources	Significant influence. Conflict for resources may substantially limit access to fossil fuel and renewable energy sources, especially those that rely upon plant materials.
Societal Values	Significant influence. The acceptability of different energy sources to society is likely to affect the large scale implementation of some advanced energy technologies, as occurred previously with nuclear energy. Societal values will also contribute to determining the energy intensity of a nation's future.
Demographics	Significant influence. Population and its age distribution are important parameters affecting the energy intensity of a nation.

Industry Profitability	Minor influence.