A RENEWABLE ENERGY OPTION

BIOMASS
POWER

THE ENERGY OF **MATTER**

BIOMASS POWER:
THE ENERGY DERIVED FROM ANIMAL OR VEGETABLE MATTER THAT CAN BE CONVERTED INTO ELECTRICITY BY VARIOUS METHODS

CURRENT STATE OF KNOWLEDGE

According to the Intergovernmental Panel on Climate Change, biomass accounted for 10.2% of the world's total output of primary energy (energy that has not undergone any conversion or transformation) in 2008. The International Energy Agency projects that it will be the fastest-growing renewable energy source between now and 2030, providing as much as 30% of the power consumed worldwide by 2050.

In Canada, about 4.4% of the primary energy consumed comes from biomass. It is the second-biggest source of renewable energy, after hydropower.

In Québec, forest biomass is the most frequently used organic matter due to its ready availability and the maturity of the generating method involved.

Cover: Forest biomass storage

Right: Transportation of forest biomass

BIOMASS POTENTIAL

In 2009, biomass generated 27.5 EJ/year (7,639 TWh/year) of primary energy worldwide. While most biomass energy is used to produce heat, it also generates 158 TWh/year of electricity. Canada is the world's seventh-largest producer of primary energy and electricity from forest biomass.

In 2011, Québec's potential forest, agrifood and urban biomass was estimated at 19.5 million tonnes of dry matter, representing gross thermal energy of 334 PJ/year (93 TWh/year). A total of 42% of that energy is already being harnessed. Forest biomass is the most frequently used type, with only slash showing significant potential for power generation. Urban and agrifood biomass has not yet been harnessed as a source of energy to any significant degree, except for cooking oil.

OUTPUT AND COSTS

In a cogeneration (electricity and steam) plant fueled by forest biomass, 30% to 35% of the energy in the solid biomass can be converted into electricity, during the steam cycle. By recovering the heat produced and using it for other purposes, total efficiency can exceed 80%.

LEARN MORE

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From 1999 to 2009, upfront costs for forest biomass in Québec were much lower and more stable than for fuel oil. However, the technical infrastructure required for biomass power costs slightly more than comparable technologies using fossil fuels. The reason: since biomass has a lower energy density than fossil fuels, a larger quantity of raw material and consequently more extensive infrastructure are needed to produce the same amount of electricity.

Harnessing urban and agrifood biomass would be profitable, particularly in terms of avoided landfill costs, which have climbed significantly in recent years.

ADVANTAGES AND DISADVANTAGES

- Relatively low and stable upfront costs for forest biomass
- Continuous source of power, unlike wind and photovoltaic solar power
- Lower energy density than fossil fuels
- Large-scale operations expensive because biomass resources are widely dispersed

Forest biomass storage

- Need to build biomass-fueled cogeneration plants near the resource or near power transmission lines
- Complexity of using urban biomass, particularly because of waste diversity and the need for sorting operations, a variety of processing technologies, etc.

SUSTAINABLE DEVELOPMENT

The main issues associated with generating electricity from forest biomass are the following:

- Reclamation of industrial wood waste, which would otherwise be sent to landfill
- Loss of biodiversity and soil depletion if insufficient slash is left on site
- Production of air contaminants during biomass combustion and transportation (increased trucking of slash)
- Biomass storage impact: contaminant leaching, odor and esthetic nuisances
- Production of end waste (e.g., wood ash) that can be difficult to reclaim due to its metal content

NB: Issues related to the production of biofuel for the transportation industry from urban and agrifood biomass are not discussed in this document.

A **SUSTAINABLE** RESOURCE

Types of biomass in Québec

In Québec, there are three types of biomass with significant energy potential: forest, agrifood and urban biomass. Of these, forest biomass exists in the greatest quantities, with slash still offering significant potential for development.

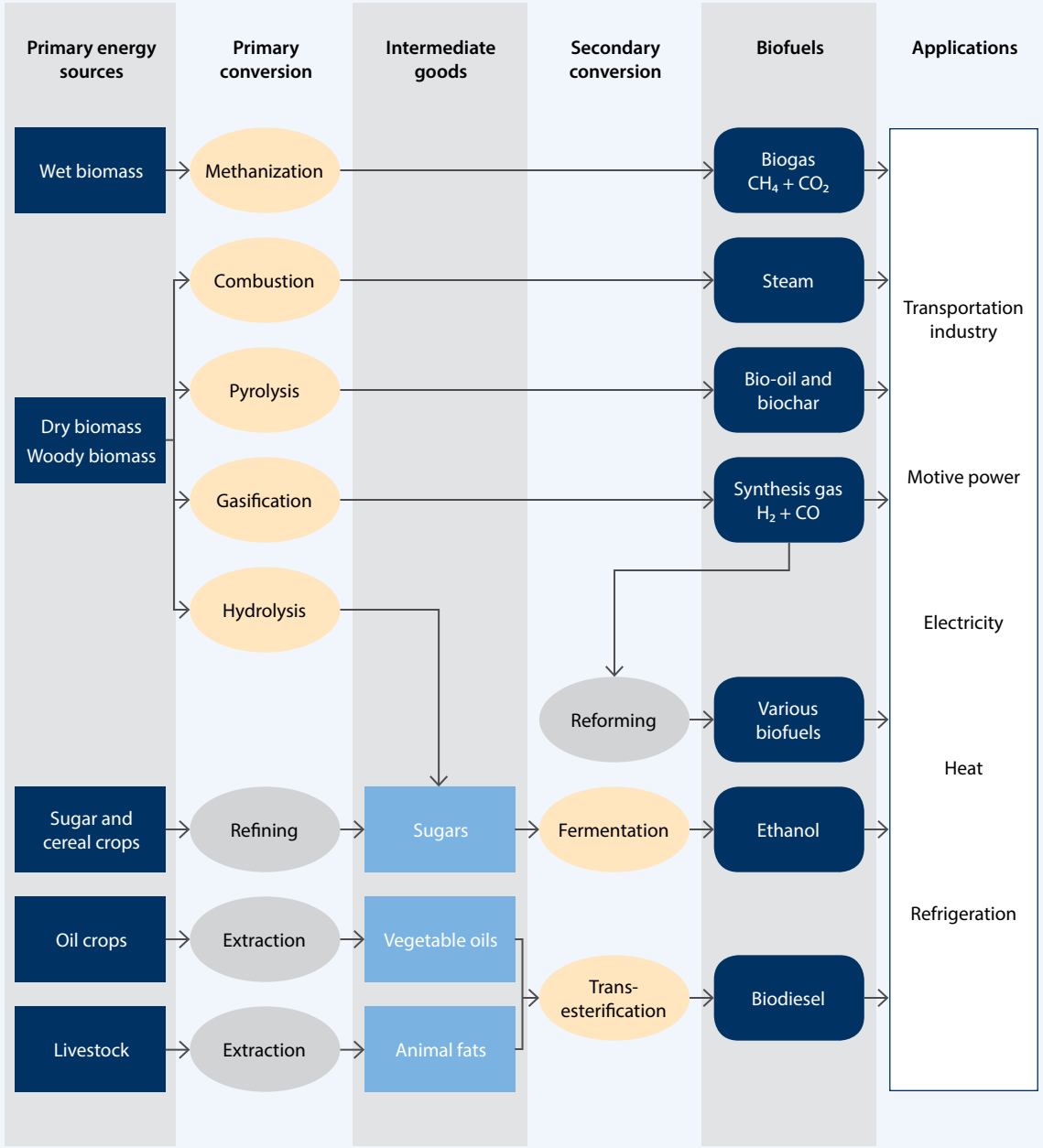
- **Forest biomass** – firewood, wood processing waste (bark, sawdust and shavings, trim ends, edgings, pulp-and-paper plant water treatment sludge) and slash (branches, needles, leaves, trunks and tree tops)
  - To encourage the development of forest biomass as a source of energy, a steady supply of raw materials must be secured. At this time, that supply depends on the quantity of timber harvested by companies with timber supply and forest management contracts.
- **Agrifood biomass** – crops, plant and animal agricultural waste, and waste generated by the agrifood processing industry
  - Crop and livestock forage yields depend on several factors, including weather, soil quality, crop types and the amount of water and fertilizer provided. Since conditions in northern countries are generally less favorable for agriculture than in the tropics, productivity is lower.
  - Growing crops and livestock for food and growing foodstuffs to produce energy are in direct competition. A greater demand for biomass would have a direct impact on supply costs and the availability of the raw materials required to produce this resource.
- **Urban biomass** – municipal water-treatment plant sludge and putrescible organic waste from the residential, commercial and institutional sectors
  - Efforts are under way to make urban biomass processing technologies more efficient. To increase the social acceptability of cogeneration plants in urban settings, information and consultation meetings have to be held with the communities in question.

Methods of harnessing biomass energy

The methods used to produce energy with biomass vary depending on the type of biomass and its intended use. In Québec, the combustion of solid biomass is a common practice; biomethanization and gasification are also interesting avenues to explore.

- **Combustion of solid biomass** – Combustion is a thermochemical process that produces direct heat. Woody biomass is made up of forestry or agrifood waste: bark, branches, straw, sawdust, wood pellets, etc. Used as fuel for boilers, hot air furnaces or wood stoves, this primary energy source provides hot water, hot air or steam. The steam can then be used to generate electricity, among other purposes.

BIOMASS POWER AND APPLICATIONS



In Québec, some businesses and hospitals use biomass to generate electricity that they use for their own purposes or sell to other consumers.

- **Biomethanization** – Biomethanization is a process for stabilizing organic matter through fermentation, without the presence of oxygen. The biogas produced is composed of methane and carbon dioxide and may contain traces of other gases depending on the substrate used. It can be produced in a bioreactor, with a retention time of 1 to 50 days. It can also be extracted from landfills, where it is produced naturally over 10 to 40 years. This combustible gas is used to generate heat and/or electricity.

  In Québec, some companies produce biogas to meet their own energy needs. Municipal water treatment plants and some landfills with the proper facilities also generate electricity.

- **Gasification** – Gasification is a process that produces combustible gas by reacting solid or liquid fuel with a gasification agent such as air or oxygen, at atmospheric pressures. The biomass is entirely or partly transformed into a combustible gas, chiefly under the effect of heat. This gas is composed primarily of hydrogen and carbon monoxide, along with minute quantities of methane, carbon dioxide and tar. Gasification takes place in a gasifier as a dry process, or in a digester as a wet process.

  The combustible gas can be used to power a boiler to produce steam or a turbine or generator to produce electricity. It can also be used in cogeneration and as a raw material in a chemical reforming process to produce liquid biofuels.

  There are no biomass gasification plants in Québec.

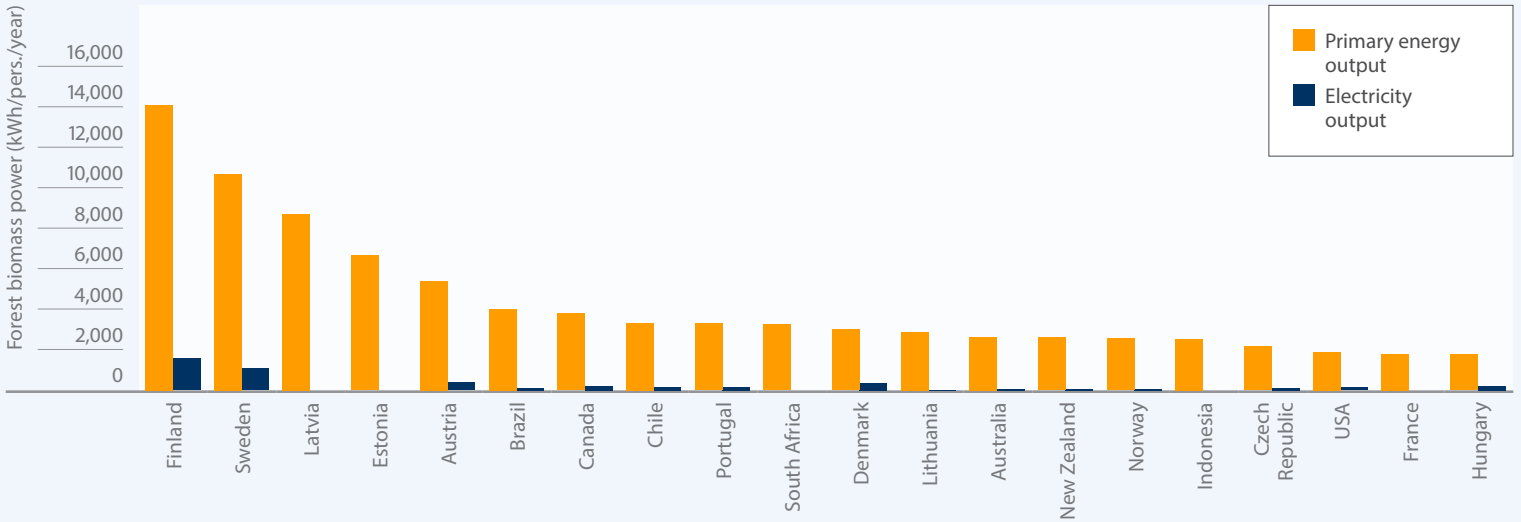
Use of forest biomass – 2009

- Primary energy output:[1] 7,660 TWh_{th}/year (27,576 PJ/year)
- Electricity output: 158 TWh_e/year

1. Primary energy: Energy present in the natural resource and that has not undergone any anthropogenic conversion or transformation.

NB: th subscript: thermal energy or power; e subscript: electrical energy or power.

PRIMARY ENERGY AND ELECTRICITY OUTPUT AROUND THE WORLD – 2009



Québec's biomass potential

QUÉBEC'S BIOMASS POTENTIAL – 2011

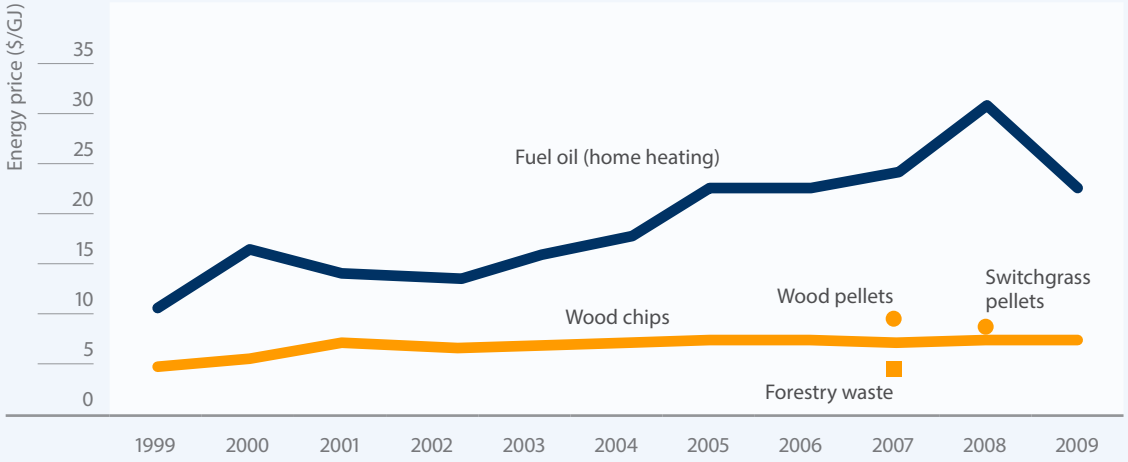
BIOMASS	TOTAL GROSS POTENTIAL		ALREADY DEVELOPED POTENTIAL		
	QUANTITY (DMT/year)	ENERGY (PJ_{th}/year)	QUANTITY (DMT/year)	ENERGY[1] (PJ_{th}/year)	
Forest biomass					
Firewood (residential)	2,771,850	52.00	2,771,850	52.00	(100%)
Wood processing waste	2,380,000	44.96	2,107,000	39.84	(89%)
Slash	4,430,000	83.95	0	0	(0%)
Pulp and paper waste	915,172	15.63	560,910	9.93	(63%)
Spent liquor	3,018,750	37.10	3,018,750	37.10	(100%)
Agrifood biomass					
Cereal crop waste	1,835,940	30.77	0	0	(0%)
Perennial energy crops[2]	868,000	14.79	0	0	(0%)
Livestock manure	2,069,659	32.12	0	0	(0%)
Animal carcasses	7,803	0.20	0	0	(0%)
Slaughterhouse waste	160,935	3.88	0	0	(0%)
Cooking oil	60,000	2.21	29,500	1.09	(15%)
Lactoserum	81,600	1.10	820	0.011	(1%)
Urban biomass					
Municipal water-treatment plant sludge	223,796	2.66	undet.	undet.	undet.
Putrescible household waste	669,665	12.24	0	0	(0%)
Total	**19,493,177**	**333.63**	**8,468,050**	**139.63**	**(42%)**

NB: DMT/year: dry metric tonnes per year – AMT/year (also used): anhydrous metric tonnes per year. In the forestry industry, the expressions "kiln dried" (anhydrous) and "air dried" (±8% moisture) are also used. th subscript: thermal energy or power.

1. The percentages shown in parentheses indicate the proportion of biomass already used in relation to the total potential.
2. Plants grown on shorelines and marginal land.

Price comparison

**PRICE COMPARISON:
FOREST BIOMASS VS. FUEL OIL
IN QUÉBEC**



NB: Transportation costs must be added to biomass costs.

Climate change and air quality

No matter which generating method is used, air emissions are one of the main environmental impacts of biomass power. Leaving aside the energy required to collect, transport and process the raw materials, generating energy from biomass saves about as much greenhouse gas as burning fossil fuels produces. The CO_2 ultimately produced does not contribute to the greenhouse effect because it comes from the CO_2 contained in the atmosphere. On the other hand, the CO_2 produced by burning fossil fuels and released into the atmosphere does contribute to the greenhouse effect since it comes from the carbon contained in the earth's crust.

Air emissions are subject to a number of regulations governing the use of biomass. For wood heating, for instance, the city of Montréal prohibits the installation of non-certified fireplaces or woodstoves that burn anything other than wood pellets, natural gas or propane. The Communauté métropolitaine de Montréal, for its part, authorizes only the use of virgin wood.

Life cycle assessment

When its entire life cycle is considered, the environmental footprint of biomass power is generally slightly greater than that of other renewable energy options, but considerably less than that of fossil-fuel-based thermal options. Ultimately, that smaller impact is due to the superior efficiency of the combined heat/electricity output and to the reclamation of industrial wood waste, which would otherwise go into landfills.

Comparing Power Generation Options and Electricity Mixes: the full report is available in French only.

Ecosystems and biodiversity

Harvesting biomass in logging areas must be regulated to maintain forest biodiversity and productivity and preserve soil and water quality.

Slash plays an important role in forest ecosystems. Like fertilizer, it enriches soil and helps regulate its acidity. Removing slash to produce energy could have a significant impact on the renewal of sensitive forest cover like jack pine growing on coarse sand.

Health and quality of life

Burning forest biomass may be harmful to human health because it can create smog, which is composed of fine particles suspended in the atmosphere. Burning urban biomass can release metals and other pollutants into the air, which can also be harmful to human health and the environment.

Local or regional biomass development can reduce the need for transporting raw materials, mitigating the impact on health and the environment.

Land use

Harnessing biomass as a power source requires infrastructure that can fit easily into industrial areas. However, generating operations may lead to an increase in road traffic. In addition, using biomass that would otherwise be buried can avoid having to open new landfills.

Regional economy

Biomass development can lead to significant savings by eliminating the need to destroy or bury large quantities of waste. Biomass power helps secure the supply of thermal and electrical energy and strengthen energy security. The extra power sold to customers or local distributors is a new source of revenue, helping ensure the company's long-term survival.

With the raw material scattered across Québec, local economic spinoffs are significant. Building biomass-processing plants and biomass-fueled cogeneration plants can stimulate regional development, while building a full-fledged biomass power industry can give new impetus to job creation and training and help keep skilled workers in the regions.

Social acceptability

The social acceptability of biomass development projects is determined by various factors. They include the following:

- The benefits of reducing waste for the community, along with the associated environmental impact
- Proper operation of biomass processing plants and biomass-fueled cogeneration plants

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