A RENEWABLE ENERGY OPTION

BIOMASS POWER

THE ENERGY OF **MATTER**

WHAT IS BIOMASS POWER?

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

Cover: Forest biomass storage

Right: Transportation of forest biomass

CURRENT STATE OF KNOWLEDGE

The main advantage of generating power from biomass is the fact that the carbon released during the process (whether to produce electricity, biofuels, renewable natural gas, etc.) is biogenic, because it is produced by photosynthesis from CO_2 that is already in the air.

From 2010 to 2017, biomass accounted for roughly 7.5% of all energy consumed in Québec (Delisle, 2019, p. 55). In 2019, over 163 petajoules (PJ) of this type of renewable power was generated in the province (Whitmore and Pinaud, 2020, p. 7). Forest biomass is the most frequently used organic matter due to its ready availability. In 2016, nearly 3.11 million anhydrous metric tonnes (AMT) of biomass were used to produce electricity through cogeneration in Québec (Baril, 2017).

BIOMASS POTENTIAL

Québec's supply of forest, agrifood and urban biomass available for use in power generation is estimated at 10 million tonnes, representing gross thermal energy of 174 PJ (48 TWh). Slash (forestry waste consisting of tree trunks, crowns and branches) offers the greatest potential, at nearly 6.5 million anhydrous metric tonnes (MNRF, 2009, p. 9). Since some of the slash is already used to maintain soil fertility during harvesting, among other things, approximately 4.4 million tonnes can be reclaimed as a source of energy, corresponding to 84 PJ of thermal energy (23 TWh). By comparison, in 2018, the pulp and paper industry used primarily timber (nearly 1.55 million AMT) and wood chips (nearly 4.9 million AMT) as energy sources (Delisle, 2019).

OUTPUT AND COSTS

In a biomass-fueled cogeneration plant (which simultaneously produces electricity and thermal power in the form of steam), 30% to 35% of the energy in the solid biomass is converted into electricity. By recovering the heat released and using it for various purposes, total efficiency can reach 80%.

The price of biomass power depends on many factors. However, its generating cost per unit of energy can be determined based on the delivered cost of biomass and its heating value. For example, if the delivered forest biomass costs $100/AMT and has a heating value (LHV) of 18 gigajoules (GJ) per anhydrous metric tonne (or 5 kWh/kg), the generating cost is $5.55/GJ (or $0.02/kWh). 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 power. The cost of the infrastructure required to generate power from biomass is therefore greater than for fossil fuels.

Using agrifood and urban biomass to produce energy is also cost-effective, because it avoids incurring landfill costs, which are constantly rising.

Forest biomass storage

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
- Need to build biomass-fueled cogeneration plants near the resource or power transmission lines
- Complexity of using urban biomass as a result of waste diversity, which requires sorting operations, a variety of processing technologies, etc.

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

LEARN MORE

- Types of biomass in Québec
- Methods of harnessing biomass energy
- Québec's biomass potential
- Climate change and air quality
- Life cycle assessment
- Ecosystems and biodiversity
- Health and quality of life
- Land use
- Regional economy
- Social acceptability

SUSTAINABILITY

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
- Ethical questions surrounding the production of agrifood biomass used to generate power rather than feed livestock
- Decrease in available farmland for growing human food, intensification of soils and use of pesticides
- The generation of energy from crops grown for that purpose requires extreme vigilance. If these crops replace crops grown for food, the latter will have to be grown elsewhere, potentially leading to deforestation with significant environmental repercussions.

A SUSTAINABLE **RESSOURCE**

Types of biomass in Québec

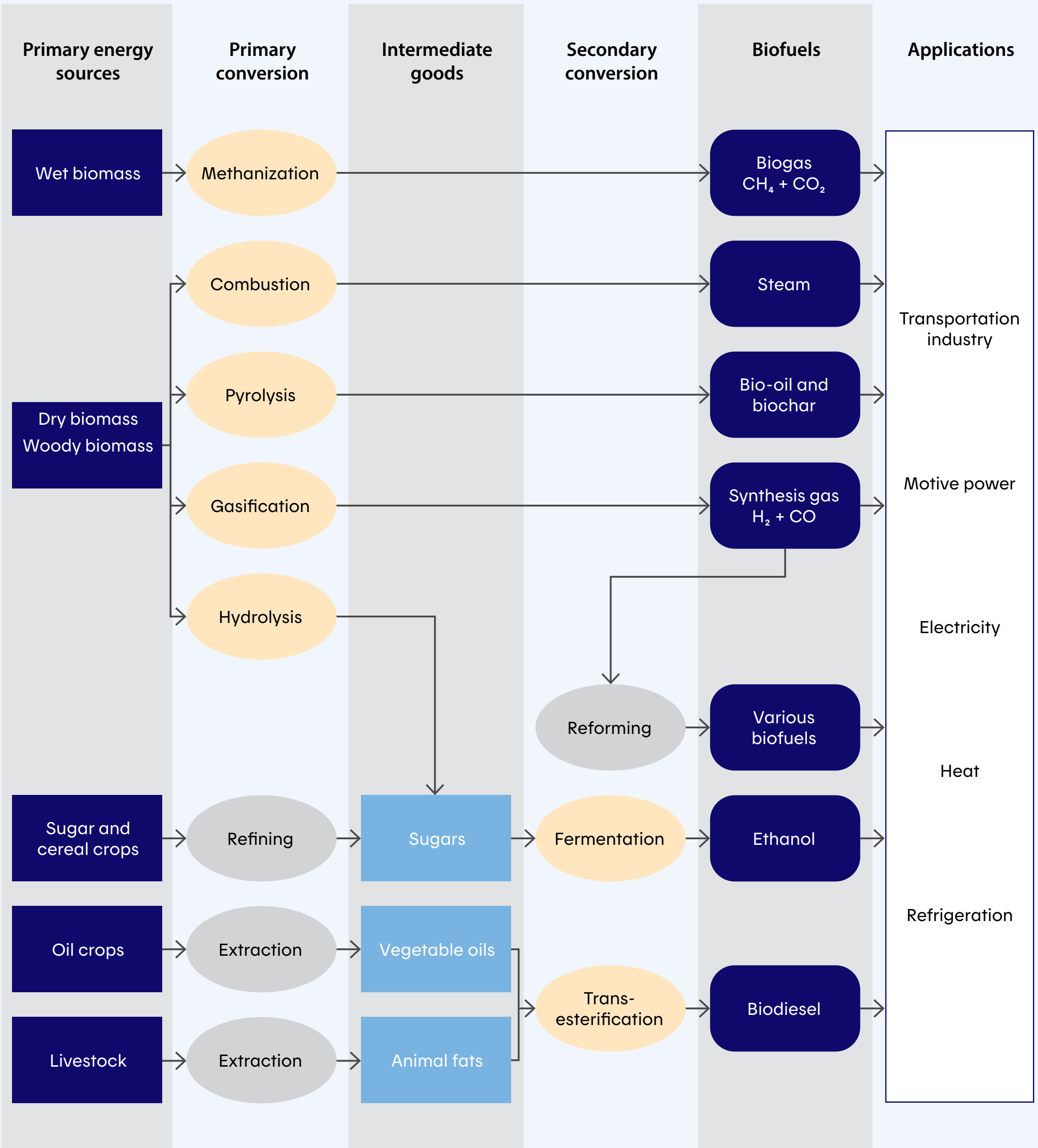
In Québec, there are three types of biomass with significant energy potential: forest, agrifood and urban biomass. Of these, forest biomass exists in the greatest quantities, with slash still offering significant potential for development.

- **Forest biomass** – firewood, wood processing waste (bark, sawdust and shavings, trim ends, edgings, pulp-and-paper plant 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. That supply depends on the quantity of timber harvested by companies holding timber supply and forest management contracts.
- **Agrifood biomass** – crops, plant and animal agricultural waste, as well as 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.
  - Producers of food biomass used to generate power are in direct competition. A greater demand for biomass has a direct impact on supply costs and the availability of raw materials.
- **Urban biomass** – municipal sludge and putrescible organic waste from the residential, municipal, commercial and institutional sectors
  - Efforts are under way to make urban biomass processing technologies more energy efficient. To increase the social acceptability of cogeneration plants in urban settings, information and consultation meetings must be held with the communities in question.

Methods of harnessing biomass energy

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

BIOMASS POWER AND APPLICATIONS



Combustion of solid biomass

- Combustion is an exothermic process, meaning that it releases heat. Woody biomass is made up of agrifood or forestry waste, such as bark, branches, straw, sawdust, wood pellets, etc. Used as fuel for boilers, hot air furnaces or wood stoves, this primary energy source produces hot water, hot air or steam. The steam can then be used to generate electricity, among other purposes.
- 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 combustible 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, or extracted from landfills, where it is produced naturally over 10 to 40 years. It is used to generate heat and/or electricity.
- In Québec, some companies produce biogas to meet their own energy needs. A number of municipal water treatment plants and landfills equipped with biomethanization systems also generate electricity.

Gasification

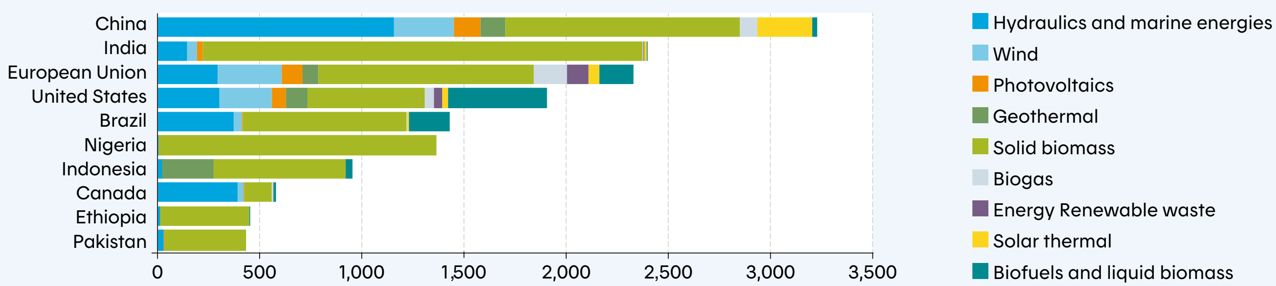
Gasification is a thermochemical conversion process that produces combustible gas from solid fuel. The process involves the partial combustion of the solid in the presence of air or pure oxygen. Part of the solid burns, and the heat generated results in a thermal degradation of the part that hasn't burned.[1] Gasification produces a combustible gas composed primarily (in the dry process) of hydrogen, carbon monoxide and CO_2, along with small quantities of methane and tar.

1. In the case of a pyrolysis process, thermal degradation occurs in the absence of air or oxygen: an external heat source must therefore be provided.

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 to produce commodity chemicals and liquid biofuels. For example, forest biomass can be used to produce synthetic liquid hydrocarbons or alcohols such as methanol. It can even be used to produce synthetic methane. Because the carbon released during biomass gasification is biogenic, the combustible gases produced in this manner are carbon neutral or at least release very little GHG over their life cycle.

There are no commercial biomass gasification plants in Québec, but there are plans on the drawing board.

THE TOP TEN PRODUCERS OF RENEWABLE ENERGY IN THE WORLD[a] – 2017 (TWh)



a) For non-OECD countries, solid biomass data are estimates. Given their significant weight in renewable energies, rankings should therefore be taken with caution.
Sources: © AIE All rights reserved, Renewables Information (2019 final edition); Eurostat.

Québec's biomass potential

QUÉBEC'S BIOMASS POTENTIAL – 2011

TYPE	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	4,400,000	83.60	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	1,800,000	34.20	0	0 (0%)
Perennial energy crops[2]	870,000	16.50	0	0 (0%)
Livestock manure	2,100,000	31.50	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	985,000	17.40	0	0 (0%)
Total	**19,774,906**	**342.94**	**8,488,830**	**139.971 (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.

Climate change and air quality

No matter which generating method is used, air pollution is 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 pollution from biomass use is regulated by a number of authorities. For wood heating, for instance, the city of Montréal prohibits the installation of non-certified fireplaces and 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.

Ecosystems and biodiversity

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

Slash plays a critical role in forest ecosystems. Like fertilizer, it enriches soil and helps regulate its acidity. Excessive collection of slash to produce energy could have an adverse effect on the renewal of sensitive forest cover, such as 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 requires infrastructure that can fit easily into industrial areas. However, that infrastructure can lead to an increase in road traffic. In addition, reclaiming biomass can avoid having to bury tonnes of plant or animal waste and consequently the need 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 also 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 found 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 spur 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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