Biomass Sustainability Analysis

Summary Report

April 2011

Contents

Photo: Boreal forest: David Dodge, The Pembina Institute; Biomass pellets: OPG

Why use biomass to produce electricity?

To reduce pollution and greenhouse gas emissions and to fight climate change, the Government of Ontario has committed to phasing out the use of coal to produce electricity by the end of 2014.

This has led Ontario Power Generation (OPG) to investigate conversion of its four coal-fired power plants to exclusively use either biomass or natural gas, or to use biomass in combination with natural gas, to fire these plants. Natural gas produces about half the greenhouse gas emissions of coal, and biomass can further reduce emissions if it is sustainably managed as a renewable resource. Biomass for electricity generation can also result in lower emissions of other air pollutants.

OPG coal generating stations, if converted to biomass or natural gas, will produce less electricity than in the past, but will serve a backup role and complement renewable forms of electricity generation like wind and solar.

OPG commissioned this sustainability analysis to determine if biomass sourced from Ontario's forests would be renewable; to better understand the greenhouse gas reduction benefits of biomass; and to estimate the socio-economic benefits that would result from electricity production from biomass. This sustainability analysis examines the potential production and use of two million tonnes of wood pellets per year using biomass from Ontario's Crown forests at four OPG coal plants.

Biomass for energy key findings

- Harvesting of low-grade and residual biomass for electricity production can be done in a way that forest carbon stocks do not systematically decline over a 100-year planning horizon
- Two million tonnes of wood pellets could produce 3.4 billion kilowatt hours of electricity per year — sufficient to power approximately 285,000 homes in Ontario. This can reduce greenhouse gas emissions by 80%, on average, compared to electricity produced by burning natural gas
- Approximately 3,569 full-time jobs can be created from harvesting and using biomass. This would add an average annual contribution of $590 million to Ontario's gross domestic product.

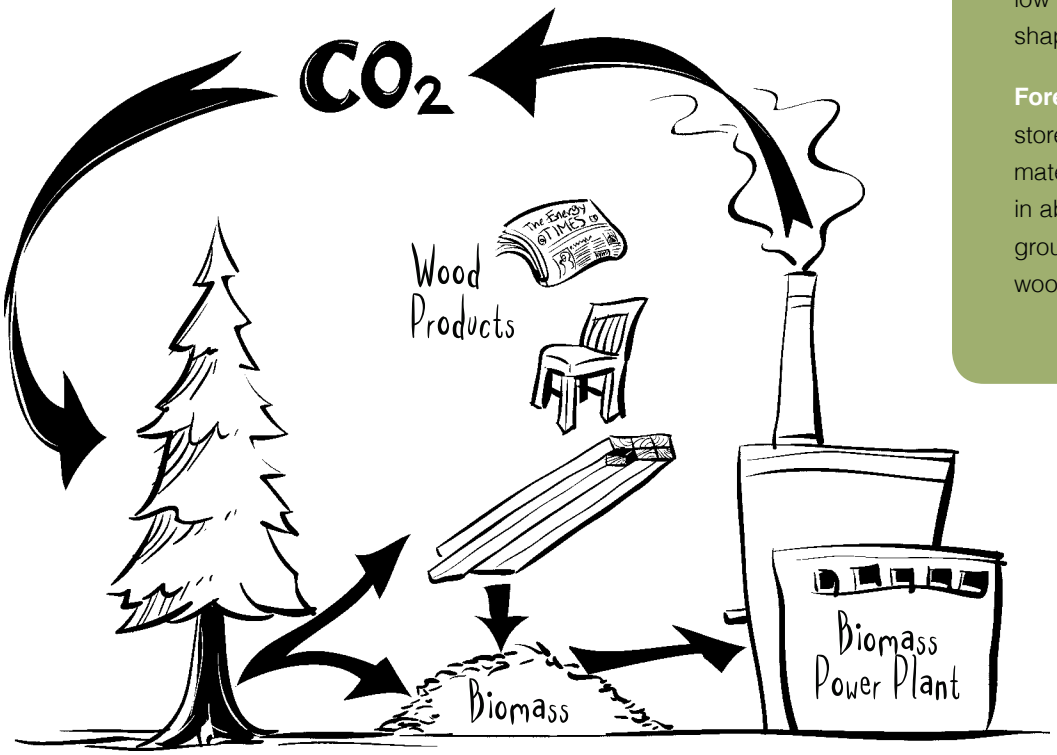
Ontario's Long Term Energy Plan calls for the conversion of the Atikokan Generating Station from coal to wood pellets

What is biomass energy?

Biomass energy is derived from recently-living organic matter. Biomass can come from wood, agriculture waste products or municipal waste, but in the context of producing electricity in Ontario, this study focused on these key sources: sawmill waste, logging residue, low-grade biomass and forest fire salvage wood. Biomass can then be converted to the more convenient form of wood pellet fuel. A network of wood pellet manufacturing plants would be located close to the supply of biomass, creating local jobs and supplying regional power plants. These biomass-powered electricity generation plants would provide a reliable source of renewable power as needed.

Carbon naturally cycles between gaseous compounds (most commonly in the form of carbon dioxide) in the atmosphere and a solid form in plants, animals and soil. Of particular interest to biomass is the cyclic process where carbon dioxide is sequestered through photosynthesis into biomass and then released again to the atmosphere through the natural decomposition or combustion of that biomass.

The biogenic carbon cycle



Biomass dictionary

Biomass: Biological material derived from living or recently-living organisms, including trees, plants and waste materials from the forest; crops and waste from agriculture; and waste from cities and towns.

Wood pellets: Manufactured from biomass sources to provide a low-moisture, efficient-burning fuel to produce heat and energy.

Logging residue or slash: Non-merchantable parts of trees remaining after a forest harvest operation (i.e., tops of trees, limbs, branches, needles/leaves).

Low-grade biomass: Trees that are of low quality for wood products due to shape, size, species or other traits.

Forest carbon: The amount of carbon stored in living and dead forest materials. This includes carbon stored in above-ground biomass, below-ground biomass and conventional wood product pools (lumber, paper).

Photo: Roberta Franchuk, The Pembina Institute

Biomass: A renewable resource

Amidst growing concerns about the need to reduce greenhouse gas emissions, Ontario has established programs to support clean, renewable forms of energy. Electricity produced from biomass, sometimes called bioenergy, is another form of renewable energy to meet Ontario's electricity needs.

Biomass is perhaps the oldest source of energy in the world. In 2008 it made up 9.9% of the world's energy use. In many parts of the world, wood is used as a primary source of energy for cooking and heating. In many Scandinavian and some European countries, biomass energy is widely and successfully used, while North America, other parts of Europe and Russia are looking to increase the use of biomass to generate electricity.

If biomass is sourced appropriately it can significantly reduce greenhouse gas emissions, especially when it replaces coal-fired power plants.

Ontario has many potential sources of biomass for energy. The most promising of these are residues from forest logging operations, waste from sawmills, low-grade biomass and non-merchantable forest biomass. In certain areas in Ontario, a portion of the residue from logging operations is currently piled at roadside and burned, which releases stored carbon directly into the atmosphere.

Biomass will likely not be the most important source of electricity generation in Ontario, but it can serve an important role in a cleaner, more renewable energy future.

What makes biomass renewable?

According to the United Nations Framework Convention on Climate Change (UNFCCC), biomass from forest lands is considered "renewable" if one of the following conditions applies:

1 The biomass is originating from land areas that are forests where

- the land area remains a forest; and
- sustainable management practices are undertaken on these land areas to ensure, in particular, that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and
- any national or regional forestry and nature conservation regulations are complied with.

2 The biomass is a biomass residue and the use of that biomass residue in the project activity does not involve a decrease of carbon pools, in particular dead wood, litter or soil organic carbon, on the land areas where the biomass residues are originating from.

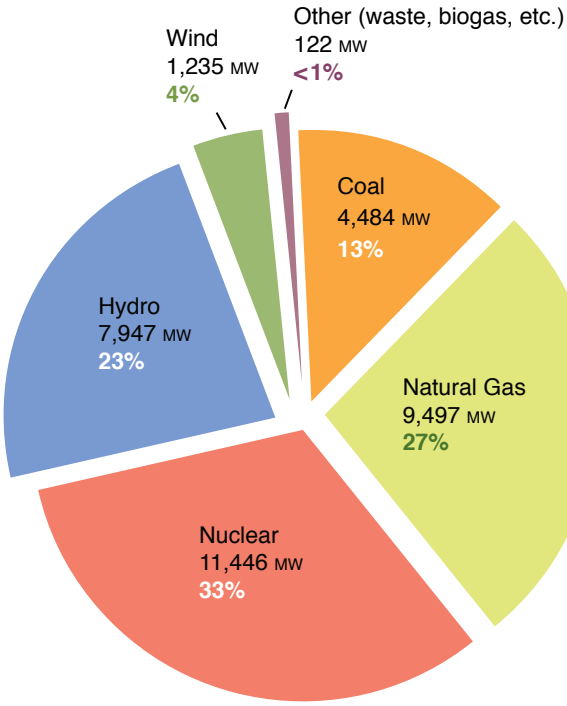
Top source of energy in Sweden

Sweden is a country with a northern climate and a valuable forest industry. The Swedish forest industry is the world's second largest exporter of timber. Biomass supplied 32% of all of Sweden's energy demand in 2009, surpassing oil that year to become the single largest source of primary energy. The country's goal is to get 50% of its total energy from renewable sources by 2020.

Photo: OPG

Biomass storage silos at the Nanticoke Generating Station

Ontario's electricity supply mix



Ontario's 2011 installed electricity generation capacity (MW)

Source: Independent Electricity System Operator (IESO) www.ieso.ca/imoweb/media/md_supply.asp

Advantages of biomass

- ✓ **Renewable** – Sustainably-managed sources of biomass can provide fuel indefinitely.
- ✓ **Readily available** – A significant amount of biomass fuel is available in most regions of North America in the form of agricultural crops and waste, forestry, and municipal waste.
- ✓ **Dispatchable** – A biomass-fired generation plant can increase or decrease electricity production in response to demand. This is an important factor in incorporating a variety of energy sources in the overall system.
- ✓ **Part of the natural carbon cycle** – Drawing energy from biomass utilizes the carbon within the natural carbon cycle. Biomass draws carbon from the atmosphere during its growth cycle and releases carbon when it is combusted.
- ✓ **Local resource** – Biomass energy is typically fuelled by local sources of biomass, creating local economic development opportunities.

Sustainability criteria

Sustainability criteria were used to evaluate the environmental and socio-economic performance of biomass compared to other options.

Harvesting of forest biomass for electricity production must be done in a way that protects ecosystems, reduces greenhouse gas emissions and creates socio-economic benefits.

Environmental criteria

Biomass harvesting from Crown land forests to produce energy must be integrated into existing forest management practices to ensure legislation, regulations, rules and guidelines are sufficient to support a new biomass sector. The following are some of the key environmental criteria that are crucial to continue to monitor.

GHG emissions and forest ecosystem carbon

The greenhouse gas emissions of harvesting and using forest biomass to produce electricity balance the carbon stored in the forest.

Air emissions

Combusting biomass should not lead to increased levels of local and regional criteria air contaminants such as particulate matter, nitrogen oxides or sulphur oxides. The goal is to produce significantly fewer emissions than the coal-fired plants being replaced.

Soil quality and forest site productivity

Biomass harvesting should not lead to soil degradation. Soil fertility, organic matter, nutrients and pH must be maintained and soil erosion must be minimized.

Hydrology and water quality

Biomass production should not lead to contamination or depletion of water resources. Riparian buffers and wetlands are respected and pesticides are restricted to comply with integrated pest management practices.

Biodiversity and terrestrial habitat

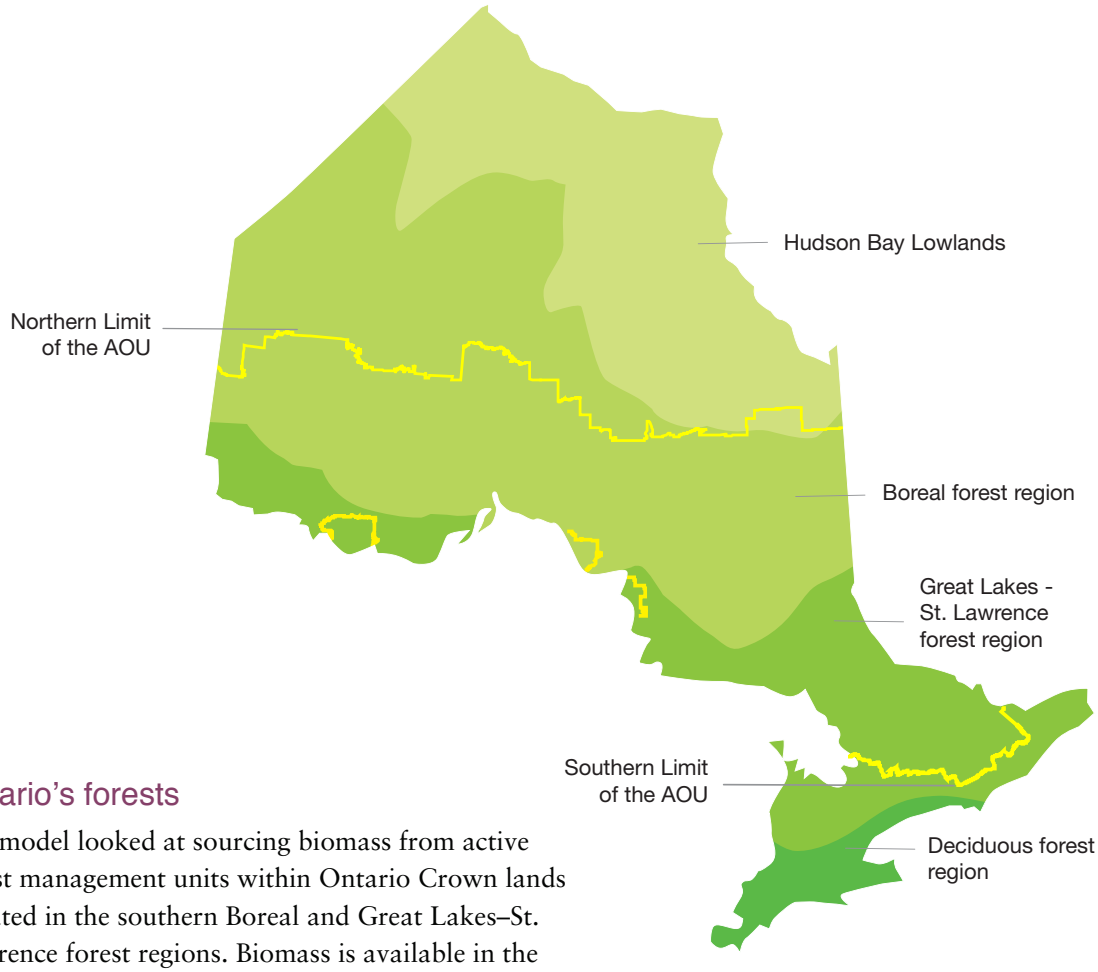
Wildlife habitat and rare, threatened or endangered species or ecosystems must be protected. The ecological functions and integrity of the forest should be maintained.

The Nanticoke Generating Station in Southern Ontario.

Photo: OPG

The Area of Undertaking (AOU) and forest regions in Ontario

Source: As adapted from Ontario Ministry of Natural Resources



Ontario's forests

The model looked at sourcing biomass from active forest management units within Ontario Crown lands situated in the southern Boreal and Great Lakes–St. Lawrence forest regions. Biomass is available in the form of sawmill waste, logging residue, harvesting of low-grade biomass and post-fire salvage wood.

Socio-economic criteria

Well-being of workers and local communities

A biomass sector should create new employment opportunities in the community, improve income and education and reduce poverty levels. Employee competence is enhanced by training and supervision.

Economic indicators

The biomass sector should contribute to gross domestic product and the economic well-being of a community. The financial benefits from the sector are equitably shared by businesses, landowners, employees and government.

Aboriginal peoples' rights

Aboriginal people should have the authority to control biomass operations on their lands. Aboriginal peoples' rights must be respected on their traditional lands including full and meaningful consultation in the development of policies and legislation governing forest management and biomass operations.

Community engagement

Meaningful public participation in forest management planning and biomass operations should be designed to respect the rights of others to use lands and not be adversely affected. Conflicting land uses are addressed and no irreparable harm is inflicted on heritage, cultural, recreational or tourist values.

Methodology of the sustainability analysis

A systems approach: Life cycle assessment

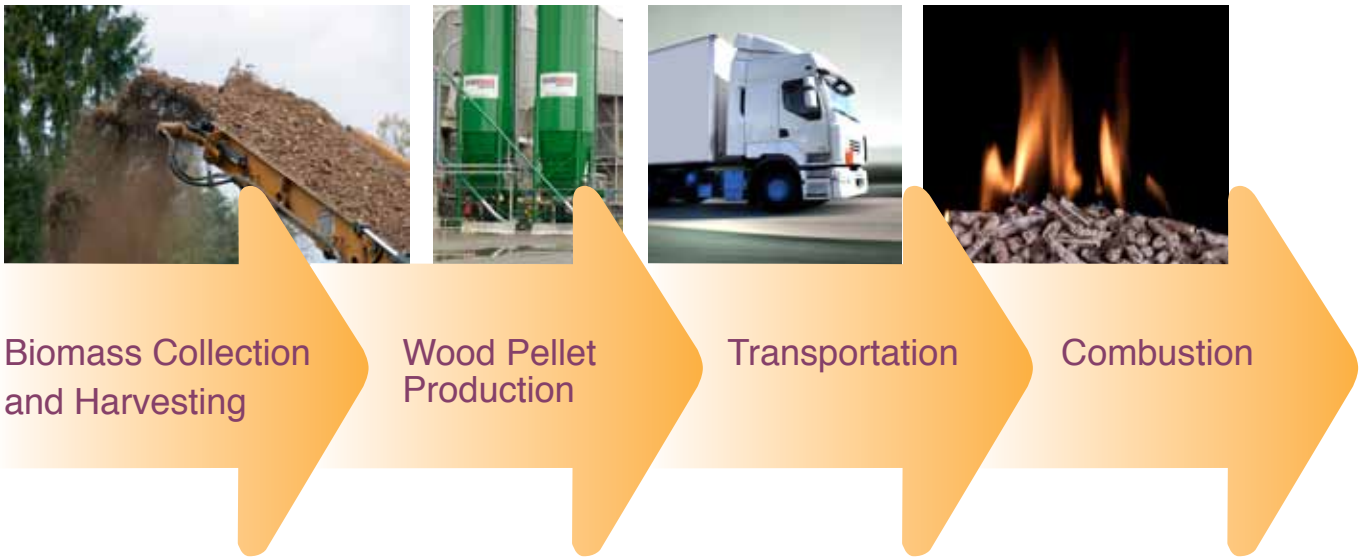
The Pembina Institute used a suite of tools and advice from a technical advisory committee to test the benefits and impacts of adding a biomass energy industry to Ontario's existing forestry industry.

A life cycle assessment tool and Ontario's Provincial Impact Assessment Model were used to estimate net greenhouse gas emissions from the harvest, manufacture, transport and combustion of wood pellets. The analysis compared the impacts of adding a 2 million tonne wood pellet industry to an assumed future forestry industry.

The data came from the spatial forest modelling system that covers the Crown forests in Ontario's Boreal and Great Lakes–St. Lawrence forest regions. The spatial modelling system also enabled a view of the socio-economic impacts of introducing biomass to forest-dependent communities. The socio-economic impacts were assessed using two key data sources from Statistics Canada: a socio-economic model based on 2006 Household Survey data, and Ontario economic multiplier data.

The primary environmental factors analyzed were the forest carbon stock and impact on greenhouse gas emissions. Forest carbon models, life cycle greenhouse gas emissions, and several scenarios were looked at to test a future with and without a biomass sector.

Photo illustration by The Pembina Institute, photos by iStock and OPG



Forest management practices and carbon

A critical assumption in the modelling for this analysis is that sustainable harvest practices in Ontario do not allow forest carbon to decline. This constraint would likely impact the timing, location and type of harvesting currently conducted. The analysis did not assess Ontario's curent forestry practices, and is only focused on the relative impact of adding a wood pellet industry.

Accurately accounting for carbon flows

To accurately compare the biomass option against natural gas, a model was developed to account for changes in forest carbon and life cycle emissions over a 100-year time period. The model combined the Ontario Ministry of Natural Resources' Provincial Impact Assessment Model and the Canadian Forest Service's Carbon Budget Model with the Pembina Institute's life cycle emissions calculator. The model calculates the periodic change in atmospheric greenhouse gas emissions from both the natural gas case and the biomass case.

Socio-economic factors

Given the importance of the socio-economic impacts of energy choices, our analysis evaluated the following impacts on forest-dependent communities:

- Employment benefits
- Median and individual family income
- Educational attainment
- Value of housing
- Proportion of out-migration from a community
- Unemployment
- Additions to sector-based and provincial GDP

A number of key assumptions were made for modelling purposes:

- Only forest lands currently managed for forest harvesting were used as sources of biomass
- High-grade timber volumes (i.e., high-value hardwood and softwood sawlogs) were not considered to be a viable biomass resource for wood pellet production
- Low-grade timber volumes (i.e., trees that are not suitable for lumber or pulp) were assumed to be a viable biomass resource where existing markets are not utilizing these volumes
- Forest carbon cannot systematically decline
- Medium to long-term decaying dead organic matter pools were constrained from declining
- Habitat and stand distribution requirements (based on stand types and ages) of Ontario's Landscape Guidelines were complied with
- Annual harvest rates from the current forest industry were 15 million cubic metres for the first five years, then 20 million cubic metres for the remaining 95 years
- Biomass resource use prioritization was determined to be: 1) sawmill waste from existing operations, 2) logging residues in the Boreal and Great Lakes–St. Lawrence regions, 3) low-grade timber volumes in the Boreal, 4) low-grade timber volumes in the Great Lakes–St. Lawrence, and 5) post-fire salvage
- 50% of logging residues were assumed to remain on site to maintain soil nutrient quality and biodiversity
- Current practice for logging residue in the Boreal is to pile and burn a portion of the logging residue at roadside, whereas residues in the Great Lakes–St. Lawrence forest are left in the forest
- Average wood pellet combustion efficiency is 32%.

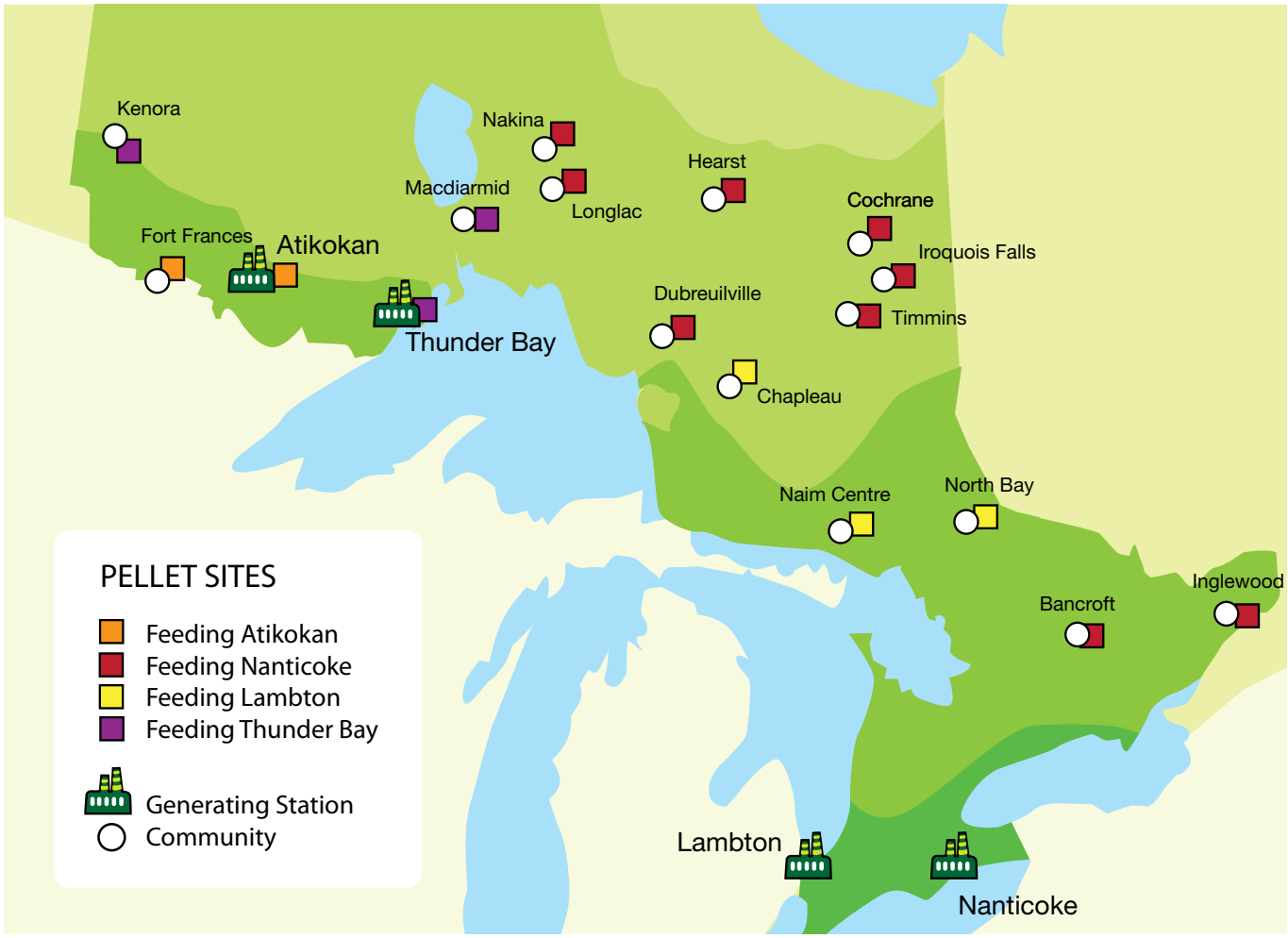
Biomass sources and wood pellet manufacturing

To supply 2 million tonnes of wood pellets to the power plants each year, the analysis assumed 17 pellet plants would be located across Ontario. By optimizing the distribution of the pellet plants across the forest region and drawing on the regional supplies of biomass, the costs of hauling and wood pellet transportation can be optimized. The hauling of the biomass from forest management units to pellet plants was modelled using trucks, and the transportation of pellets to the generating stations was modelled using rail and truck.

A life cycle activity map was created to define and quantify emissions from the harvesting, wood pellet production, biomass transportation and use of biomass to generate electricity.

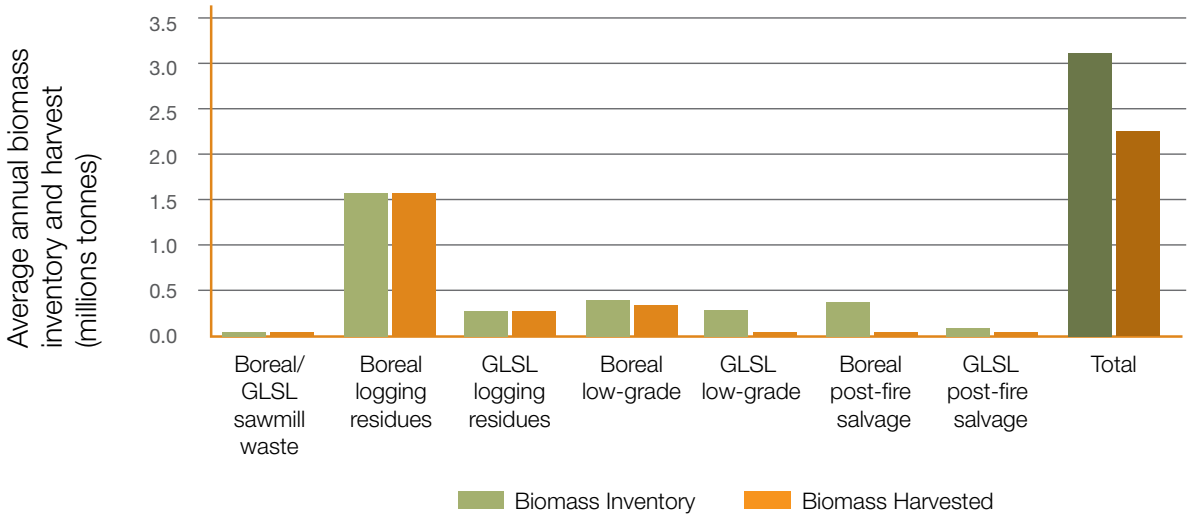
The Ontario Provincial Impact Assessment Model was used to examine how a range of variables, including annual harvest rates, sourcing biomass resources and position of pellet plants, impact forest carbon and emissions over time.

OPG generating stations and wood pellet manufacturing locations



Location of Ontario Power Generation's four generating stations and modelled locations of the 17 pellet plants across the Boreal and Great Lakes–St. Lawrence forest regions.

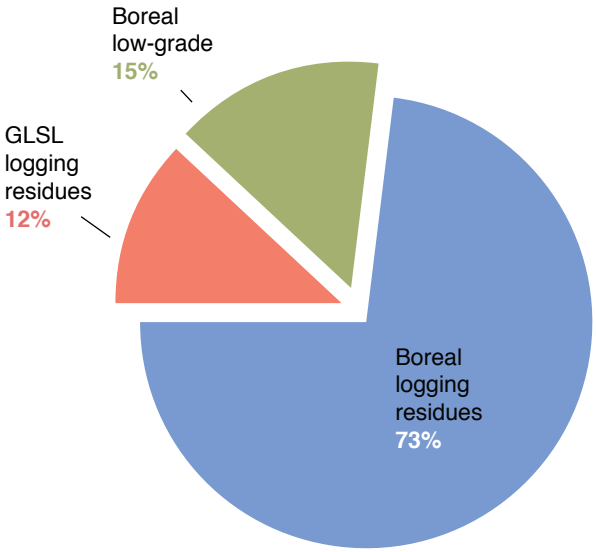
Optimized supply of biomass



Biomass inventory and harvest amounts for each biomass source used to supply 2 million tonnes of pellets.

Sawmill waste is the best choice for a source of biomass, but at the defined harvest rates sawmill waste was already allocated to pulp and paper mills. As a result, manufacturers supplying wood pellets to OPG would get most of the required biomass feedstock from logging residues. Approximately 73% of the biomass would come from Boreal logging residues and 12% from Great Lakes–St. Lawrence logging residues. The remaining 15% of the biomass supply comes from low-grade biomass from the Boreal forest, primarily white birch sourced from clear-cut harvesting operations.

Sources of biomass



Average percentage of biomass harvested to meet 2 million tonne annual requirement.

Photo: OPG

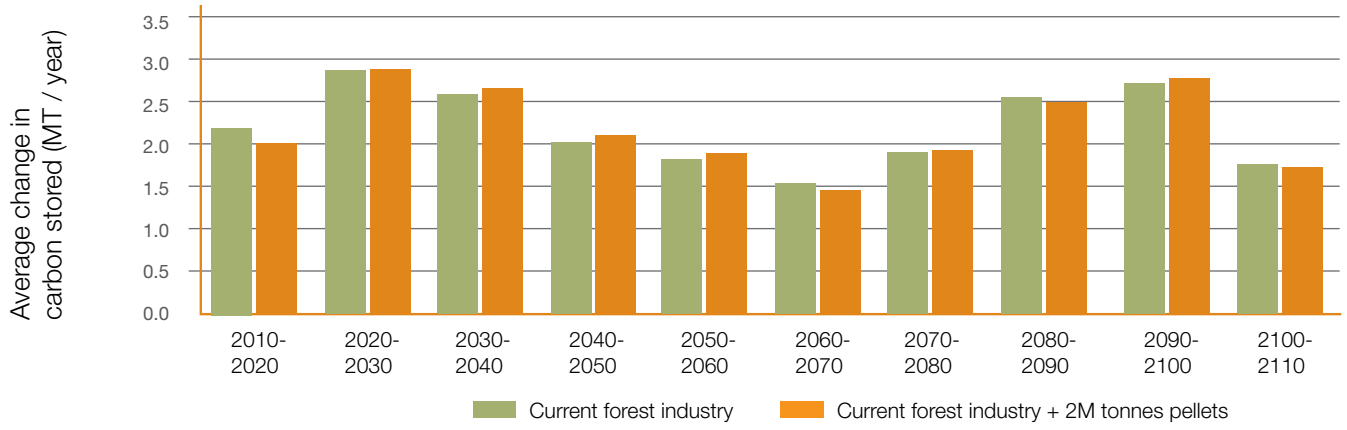
Findings of the sustainability analysis

The analysis concludes that it is feasible to source 2 million tonnes of wood pellets from forest biomass to produce electricity in Ontario.

Carbon in the forest

Forest carbon modelling shows that adding a new 2 million tonne wood pellet industry to existing forest operations does not significantly alter forest growth over the 100-year planning horizon. There is an initial drop in the carbon stored in the forest, reflective of the initial biomass harvesting. By introducing a forest management constraint of not allowing forest carbon to decline over the 100 years, the total carbon stored in the forest increases in both the projected forest industry scenario and the wood pellet scenario. The modelling shows that a 2 million tonne wood pellet industry could be added to an existing forest industry without causing total forest carbon to systematically decline.

Changes in forest carbon from adding 2M tonnes of pellet production



The change in total forest carbon stored (above-ground carbon, below-ground carbon and product pools) for the projected forest industry and projected forest industry plus 2 million tonnes of wood pellets.

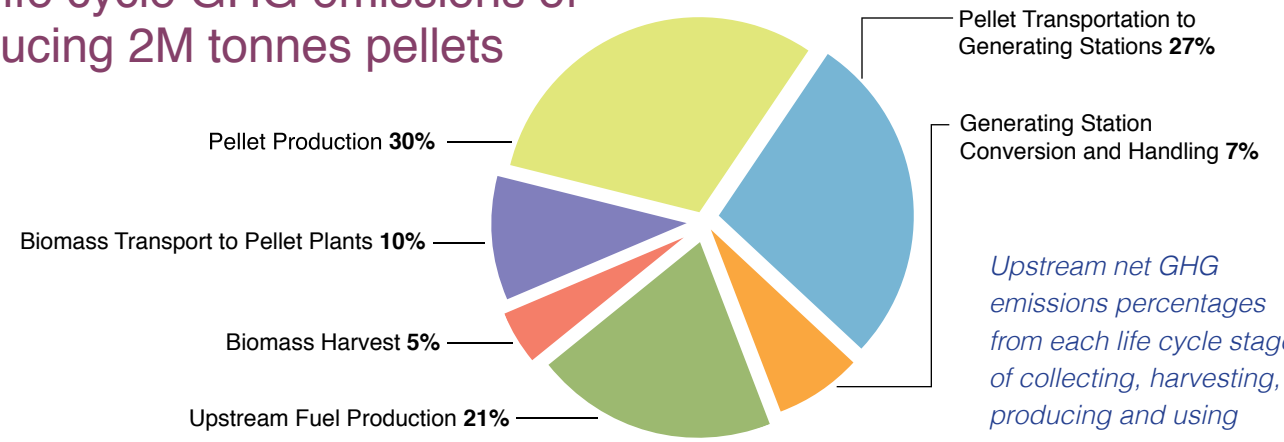
Net life cycle emissions — Biomass vs. natural gas

The majority of the upstream life cycle greenhouse gas emissions from harvesting, transporting and producing wood pellets come from wood pellet transportation and wood pellet production. The net life cycle emissions are calculated by adding the total upstream life cycle greenhouse gas emissions to the greenhouse gas emissions from the change in the forest carbon.

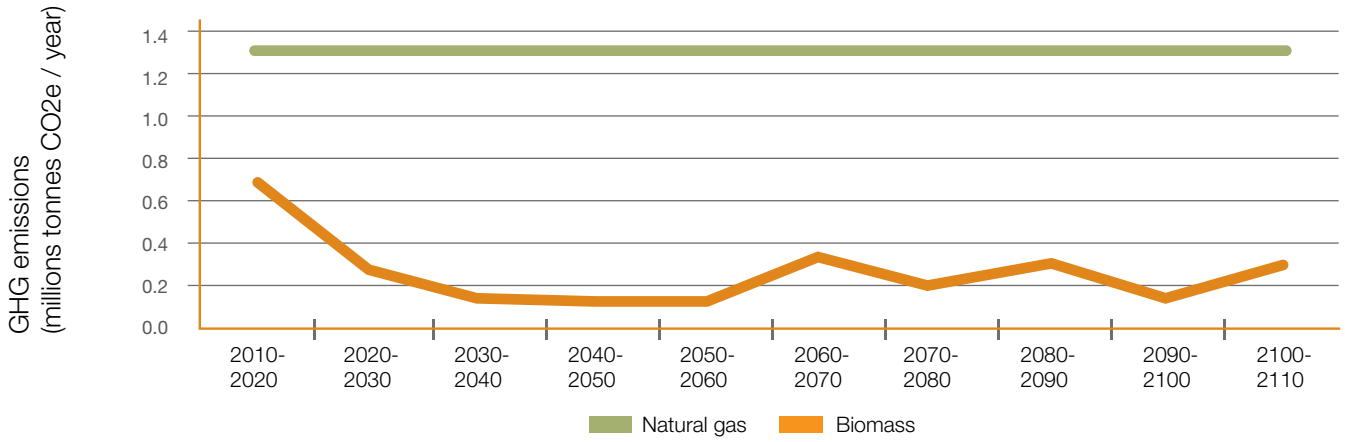
The analysis compared the difference in net greenhouse gas emissions between wood pellet fired electricity and natural gas-fired electricity. Over the 100-year analysis, greenhouse gas emissions are initially high because of the initial removal of biomass from the forest carbon stock which is combusted and released to the atmosphere. The wood pellet electricity system is not without greenhouse emissions, but over the entire 100-year analysis the wood pellet system has significant greenhouse gas benefits compared to natural gas. Averaged over the period, there is an 80% reduction in greenhouse gas emissions for biomass compared to the base case of natural gas electricity.

If sustainable forest management practices manage total carbon, a wood pellet energy system could play a role in a provincial greenhouse gas reduction strategy. A biomass energy program can also contribute to OPG's sustainable development strategy by reducing emissions through fuel switching and spurring local economic development in forest-dependent communities.

Net life cycle GHG emissions of producing 2M tonnes pellets



Upstream net GHG emissions percentages from each life cycle stage of collecting, harvesting, producing and using wood pellets.



Generating electricity from biomass can reduce greenhouse gas emissions on average by 80% compared to natural gas. Net greenhouse gas emissions are initially high because of the first harvest, and then the greenhouse gas emissions fluctuate as the forest transitions over time.

Socio-economic

Adding a wood pellet industry to Ontario's forestry and energy systems will create jobs and economic growth, especially in northern communities. Compared to the baseline of natural gas imported from outside Ontario, the domestic supply of biomass for energy boosts Ontario's GDP.

Socio-economic impacts of wood pellet production and utilization in Ontario

New full-time jobs created:

Forest-dependent communities	3,249
Rest of Ontario	320
Total new full-time jobs	3,569
Annual additional GDP to Ontario:	$590 million/ year

Ontario biomass at a glance

- Harvesting of biomass for electricity production can be done in a way that forest carbon stocks do not systematically decline over a 100-year planning horizon. Ontario-sourced wood pellets meet the UNFCCC definition of *renewable* biomass.
- Two million tonnes of wood pellets could produce 3.4 billion kilowatt hours of electricity per year — sufficient to power approximately 285,000 homes in Ontario. This can reduce greenhouse gas emissions by 80%, on average, compared to electricity produced by burning natural gas.
- Ontario has a renewable supply of biomass available from logging residues and low-grade wood sufficient to supply 2 million tonnes of wood pellets annually for electricity production.
- There are a variety of biomass sources for wood pellet production in Ontario, each with unique impacts on forest carbon, life cycle greenhouse gas emissions and costs. The priority biomass sources are sawmill waste, logging residues, low-grade wood and post-fire salvage wood.
- Approximately 3,569 full-time jobs will be created, 91% of which will be in forest-dependent communities.
- A wood pellet sector will add an average annual contribution of $590 million to Ontario's GDP.

Further research

The analysis conducted provides preliminary sound evidence that, from the perspective of greenhouse gas emissions and socio-economic benefits, there are real advantages to utilizing Ontario-sourced biomass residues to produce electricity in Ontario. At the same time, additional research is vital to further improve the decision-making process. It will be important to engage key stakeholders to gather additional feedback. It will also be valuable to conduct a variety of sensitivity analyses to test the assumptions and parameters of the models developed in this work.

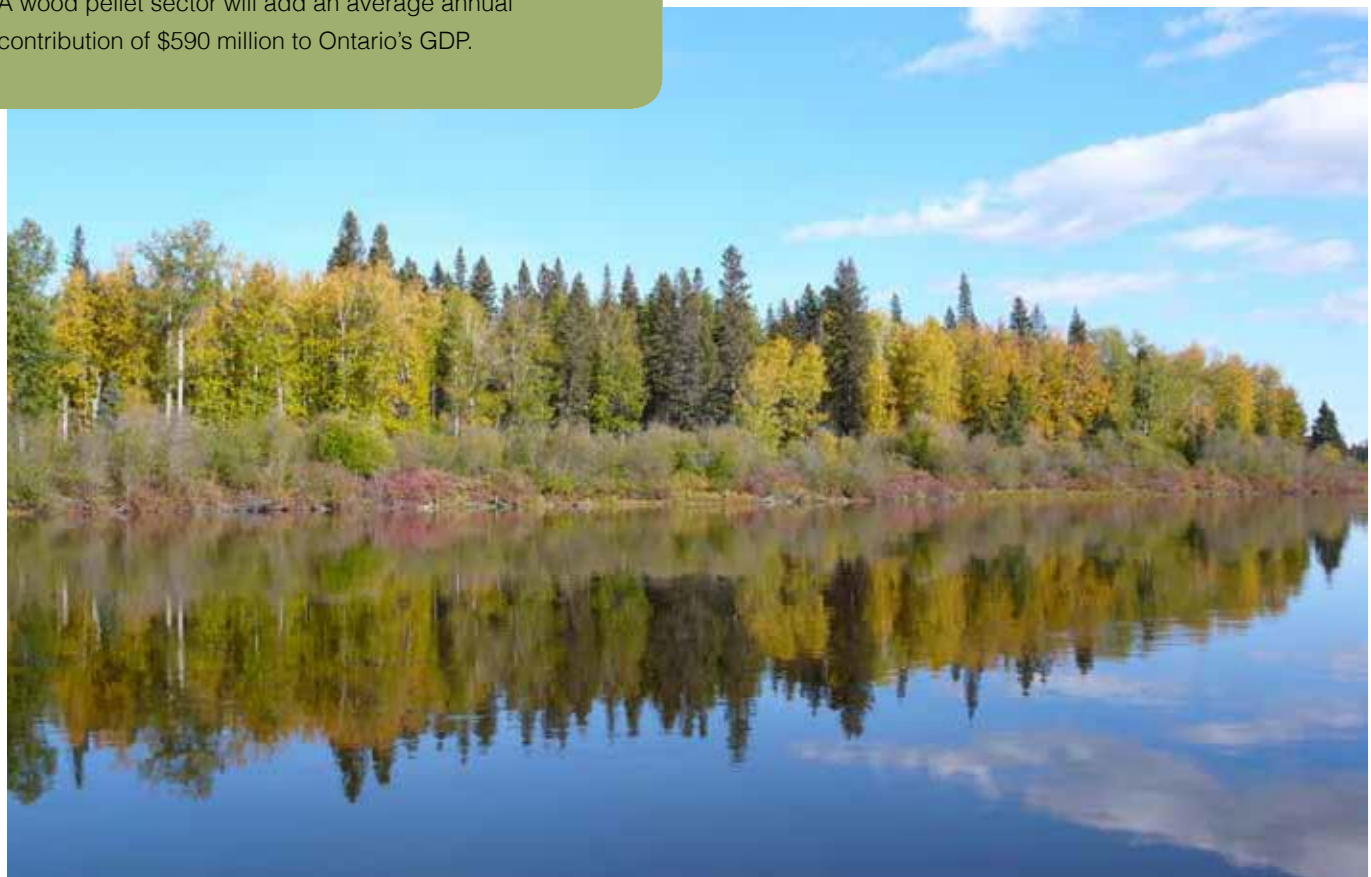


Photo David Dodge, The Pembina Institute

For more information

You can download a copy of the full report on biomass sustainability at:
www.opg.com/power/thermal/repowering/

- OPG Thermal Repowering Program — www.opg.com/power/thermal/repowering/
- IEA Bioenergy Task 32 — www.ieabcc.nl/
- Canadian Bioenergy Association — www.canbio.ca/canbio.php

This factsheet was developed by the Pembina Institute (www.pembina.org) for Ontario Power Generation (www.OPG.com).

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