Biomass and carbon neutrality: putting in place an evaluation framework

Current State in Canada

Executive summary

Preliminary version

Institut de l'énergie Trottier and ***Transition Accelerator***

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About the *Institut de l'énergie Trottier* (IET)

The IET was created in 2013 thanks to a generous donation from the Trottier Family Foundation and is based at Polytechnique Montréal. Its mission is to train a new generation of engineers and scientists with a systemic and transdisciplinary understanding of energy issues, to support the search for sustainable solutions to help achieve the necessary transition, to disseminate knowledge, and to contribute to discussions of energy issues. This diversity of expertise allows IET to assemble work teams that are transdisciplinary, an aspect that is vital to a systemic understanding of energy issues in the context of combating climate change.

About the Transition Accelerator

The Transition Accelerator (The Accelerator) exists to support Canada's transition to a net zero future while solving societal challenges. The Accelerator works with innovative groups to create visions of what a socially and economically desirable net zero future will look like and build out transition pathways that will enable Canada to get there. The Accelerator's role is that of an enabler, facilitator, and force multiplier that forms coalitions to take steps down these pathways and get change moving on the ground. Our four-step approach is to understand, codevelop, analyze and advance credible and compelling transition pathways capable of achieving societal and economic objectives, including driving the country towards net zero greenhouse gas emissions by 2050.

Disclaimer

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Background

Biomass resources are expected to play a major role in the transition to net-zero and many studies estimate the potential of biomass feedstocks for the deployment of bioenergy systems in Canada. Even though biomass resources are abundant and renewable, the portion that can be sustainably harvested each year and processed to meet a wide range of societal needs is limited. The recuperation of unmerchantable wood or harvest residues in the forestry and agricultural sectors could also be considered a way to valorize unused residual biomass. Feedstocks could be allocated to various applications, including combustion for heat and power, conversion to bioethanol, biojet fuels, renewable natural gas, biochar, wood composite products, biopolymers, etc. However, the decarbonization pathways of several economic sectors are based on the same types of biomass feedstocks. For example, the decarbonization of the aviation sector and road transportation sectors involved are closely related due to technologies that can produce adjustable fraction of biojet and renewable diesel. Depending on how these projects develop, this competition can either accelerate decarbonization or create important tensions.

With the development of multiple conversion technologies, competing demands from various economic sectors and a limited supply, which pathways would contribute best to carbon neutrality in Canada? The aim of this project is to co-develop, through several exchanges and workshops with stakeholders and experts in this domain, an evaluation and comparison framework for the use of biomass resources in Canada in the context of transition to carbon neutrality by 2050.

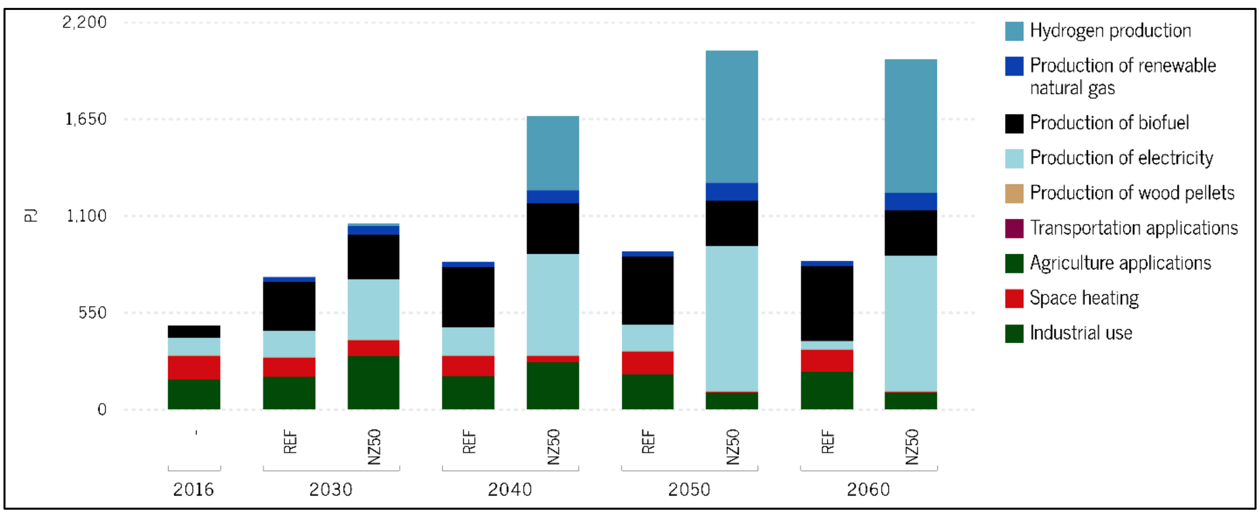
In the full report, we present an overview of the current situation in Canada concerning the production of both biomass feedstocks and bioproducts. The analysis was done by searching for publicly available information in the literature on quantities of biomass resources in Canada and the existing commercial or emerging technologies that are being developed worldwide to convert biomass resources to many valuable products including both energy and non-energy usages. This first analysis allows us to identify some key uncertainties related to the use of biomass resources in the context of transition to net-zero. This report will be shared with stakeholders and experts in the domain to receive comments from a wide variety of perspectives including industries, academia, governments, indigenous communities, non-profit organizations, for the end objective of co-constructing an evaluation and comparison framework for the biomass usages in a net-zero future.

1. Overview

Bioenergy has been traditionally one of the main energy sources for humans and its use continued to expand with modern technologies to include numerous applications and a large variety of biomass feedstocks. In a context of transition to a net-zero future, bioenergy is occupying a significant place in scenarios of future energy mixes and is expected to play an important role in the decarbonization of many sectors including transportation, space heating and industrial use.

1.1. The Net-Zero Challenge

Most recent Canadian energy modelling studies, projecting transition to a net zero future in 2050, include bioenergy in the resulting scenarios (Canadian Climate Institute 2021; IEA 2021; Langlois-Bertrand et al. 2021). In the IET Canadian Energy Outlook 2021 (Figure 1), the production of bioenergy increases rapidly before 2030 for net-zero scenario, with a particularly important contribution to the decarbonization of the transportation sector (biofuels), electricity generation with carbon capture and storage (BECCS) and industrial use. This narrow role is due to the lack of alternatives for producing negative emissions and to the blending mandates for biofuels. Such use is limited, however, by biomass availability, competing non-energy applications and the remaining emissions associated with its use (Langlois-Bertrand et al. 2021).



Source: (Langlois-Bertrand et al. 2021)
Note: REF is the reference scenario using no constraining GHG reduction targets. NZ50 is a scenario which imposes a net-zero emissions target on total CO_2e by 2050, and a 40% reduction target by 2030, with respect to 2005.

Figure 1: Primary biomass usages in net-zero scenarios of the Canadian Energy Outlook published by IET in 2021

Bioenergy can be produced from biomass resources from three key sectors: forestry, agriculture, and urban/rural waste. Figure 2 shows the type of biomass resources that were included in net-zero scenario of the IET Canadian Energy Outlook. Based on a rich set of technologies, the quantity of forest waste that is used for bioenergy remains significant until 2060 in all net-zero scenario; however, the use of agricultural crop residues grows rapidly and reaches more than 30% of the total biomass sources in 2050. Other sources of biomass, such as dedicated culture, municipal organic waste, landfill gas, soya, canola and fatty residues, also contribute to the energy mix in these scenarios.

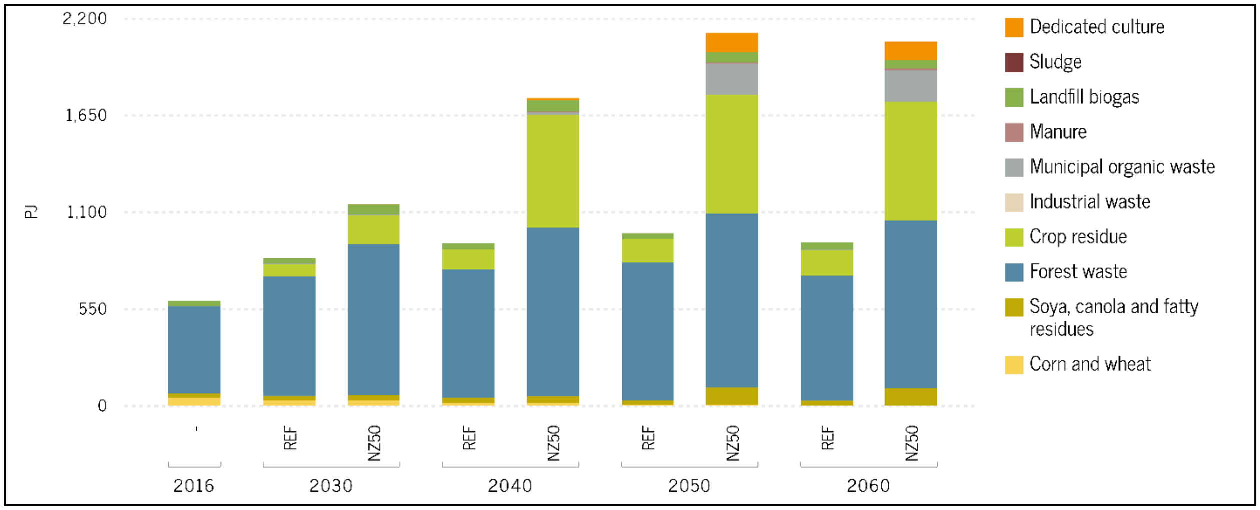


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Figure 2: Bioenergy sources, shown by type, in net-zero scenarios of the Canadian Energy Outlook published by IET in 2021

1.2. Current Situation in the Biomass Sectors

The objective of this report is to summarize the key data and information from the literature that is related to the quantities of Canadian biomass resources and to present the current situation concerning the harvest, production and collection of biomass resources in the agricultural, forestry and urban/rural waste sectors. The data search was done primarily from the data published by the government of Canada through the different platforms including Statistics Canada, Environment and Climate Change Canada and Natural Resources Canada. However, for the information that was not available through these platforms, the data was collected from published reports, scientific articles, industry websites, etc.

Table 1 shows the summary of the quantities produced in Canada of different biomass feedstocks and bioproducts. The data for each type of feedstock are presented further in the report.

Table 1: Summary of the quantities of the major biomass feedstocks and bioproducts produced in Canada per year

Description		Quantities produced per year	Energy content (PJ)	Carbon stock potential value @ \$65/t CO_2 (billion \$)	Carbon stock potential value @ \$170/t CO_2 (billion \$)
Biomass feedstocks					
Forestry sector	Wood volume harvested	143 million m^3	1,216	2 to 11	6 to 29
	Logging residues *	21 Mt *(dry)*	390	1 to 2	3 to 6
Agricultural sector	Cereal crops	64.5 Mt	1,035	3 to 6	9 to 16
	Oilseed crops	25.3 Mt	729	1 to 2.5	3 to 7
	Corn stover *	13 Mt *(dry)*	234	-	-
	Straw and other harvest residues *	34 Mt *(dry)*	544	-	-
	Animal manure	21.4 Mt *(dry)*	146	-	-
Urban and rural waste	Wood and wood products	2.8 Mt	52	-	-
	Other organic waste	9.4 Mt	47 to 110	-	-
Bioproducts					
Solid biofuels	Wood pellets	3.5 Mt	59	-	-
Liquid biofuels	Bioethanol	1,642 million litres	35	-	-
	Renewable diesel	0	0	-	-
	Biodiesel	431 million litres	15		
	Biocrude and bio-oil			-	-
	Biomethanol			-	-
	Biojet	0	0	-	-
Biogas and RNG		-	22	-	-
Biohydrogen		0	0	-	-
Non-energy usages	Softwood lumber	56 million m^3	476	-	-
	Structural panels	9 million m^3	85	-	-
	Hardwood lumber	0.9 million m^3	7	-	-
	Wood pulp	14.3 Mt	221	-	-
	Other (e.g., food & feed, biochar)	-	-	-	-

* Rough estimates for these biomass resources and precision are needed.

Notes: This list is not exhaustive. Only the major categories with known quantities are included in this summary. Food & Feed are major biomass usages and are not included in this table since the total quantities are unknown.

1.3. Uncertainties and Concerns

There are many uncertainties related to the integration of bioenergy systems in a net-zero future. Uncertainties and concerns related to bioenergy in the literature mainly include the availability and sustainability of the biomass resources, competition with essential non-energy usages such as food and animal feed, technology development and costs, supply chain emissions, assumption of "carbon neutrality" of biomass and the accounting rules for GHG reporting of bioenergy emissions in the United Nations Framework Convention on Climate Change (UNFCCC) (Bentsen 2017; Cowie et al. 2021).

The following is a list of the main uncertainties and concerns identified so far while assessing bioenergy role in a net-zero future:

(a) ***Land use:*** It is known that the capacity of the managed forest and agricultural lands to supply biomass in a sustainable manner is limited. How will the increase of bioenergy demand impact the forest management practices, the dedication of agricultural lands to biofuel production and the increase of biomass residues recuperation from harvested lands?

(b) ***Competition for the same resources by different energy producers*:** With limited feedstock availability and a rising demand for its use by different energy producers, on which basis will the arbitration for the best usage occur? For example, many facilities announced the production of renewable diesel and sustainable aviation fuel (SAF) in the near future in Canada, however, the decision of producers to focus on increasing the production of either renewable diesel or SAF would depend on the economics and the existence of proper incentives (Allan, Goldman, and Tauvette 2023).

(c) ***Supply chain emissions:*** The increase of bioenergy demand for different applications will require the implementation of supply chains in different regions. How will the harvest, processing and transportation of biomass impact the net GHG emissions of the whole system?

(d) ***Alternatives:*** If a certain bioenergy usage is not put in place, what will the alternative energy source be? Or, if a certain type of biomass residue is not collected and used for bioenergy, what will the alternative destiny of that resource be? What is the best way to compare options to ensure a complete assessment of the climate effects of the whole system that is put in place?

(e) ***Assumption of "carbon neutrality":*** Bioenergy is often assumed to be carbon neutral since biogenic carbon that is being emitted at the time of combustion, was previously sequestered or will be again during regrowth of the biomass resources. An important factor to consider in this assumption, is the temporality of these emissions which is referred to in the literature as “carbon debt” and “payback time.” How is the temporality of the climate effects of bioenergy systems taken into consideration in planning for a net-zero future by 2050?

(f) ***Negative emissions:*** Burning biomass for energy followed by recapturing and storing the carbon is one of the few ways to produce negative emissions. Technologies that lead to negative emissions will be necessary to reach net zero in the absence decarbonization solutions for all sectors in Canada by 2050. How—and where—will these technologies be prioritized in the upcoming years?

(g) ***Value of biogenic carbon stock*:** Biomass resources are stocking large quantities of carbon until it gets released to the atmosphere through harvest and use for energy. Presently, the carbon stock does not have a price value unless carbon offset credits are attributed. The carbon pricing system for emissions does not apply to bioenergy based on the assumption of carbon neutrality. If the current system were to be reevaluated, what would the carbon stock value be now, and by 2050?

(h) ***Reporting for bioenergy emissions:*** In the UNFCCC countrywide reporting, CO_2 emissions from biomass combustion are not reported in the energy sector in order to avoid double counting of the emissions which are already reported in the “land use, land-use change and forestry sector.” How does this approach of counting emissions at the place of harvest instead of combustion impact the sustainable practices of the reporting countries?

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