Biomass and Carbon Neutrality

Putting in place an evaluation framework

Current State in Canada

Executive summary

December 2024

INSTITUT DE L'ÉNERGIE TROTTIER
The Transition Accelerator
L'Accélérateur de transition

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The list of stakeholders and experts that participated in the workshops and/or provided comments regarding the preliminary version of the white paper is in Appendix 10.

Linguistic revision and translation

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About the Institut de l'énergie Trottier (IET)

The creation of the IET was made possible, in 2013, thanks to an exceptional donation from the Trottier Family Foundation to Polytechnique Montréal. Since then, the IET has been involved in every energy debate in the country. At the source of major collective reflections, the team mobilizes knowledge, analyzes data, popularizes issues and recommends fair and effective plans. All this while contributing to academic research and training. Its independence gives it the neutrality essential to the collaborative approach it advocates, facilitating work with the players most likely to advance the energy transition, while allowing it to be freely critical when relevant.

As the initial ten-year mandate came to an end, the Trottier Family Foundation decided to renew its confidence in the IET and made a new donation. Given the scope of the IET's activities and its status as a key player, it was decided to extend its mandate. The team will thus be able to continue offering science-based advice and enriching societal dialogue, in order to advance the way we produce, convert, distribute and use energy.

About the Transition Accelerator

The Transition Accelerator (the Accelerator) is a pan-Canadian charity organization that works with others to solve societal challenges through positive, transformational system change. 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 reach it. 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.

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Canada

Disclaimer

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Background

Given that biomass resources are expected to play a major role in the transition to net-zero, many studies have estimated 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 and 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 biofuels, renewable natural gas, biochar, wood composite products, biopolymers, and so on. However, the decarbonization pathways of several economic sectors are based on the same types of biomass feedstocks, which could lead to competition. For example, the decarbonization of the aviation sector and road transportation sectors involved are closely related through the technologies that can produce adjustable fractions of biojet and renewable diesel. Depending on how these projects develop, this competition could either accelerate decarbonization or create significant tensions.

With the development of numerous conversion technologies, competing demands from various economic sectors and a limited supply, which pathways would best contribute 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.

This report presents an overview of the current situation in Canada regarding the production of both biomass feedstocks and bioproducts. The analysis was performed 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 for both energy and non-energy usages. This first analysis enables us to identify some key uncertainties tied 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 with a view to receiving comments from a wide variety of perspectives including industries, academia, governments, Indigenous communities, and non-profit organizations, to achieve the end objective of co-constructing an evaluation and comparison framework for biomass usages in a net-zero future.

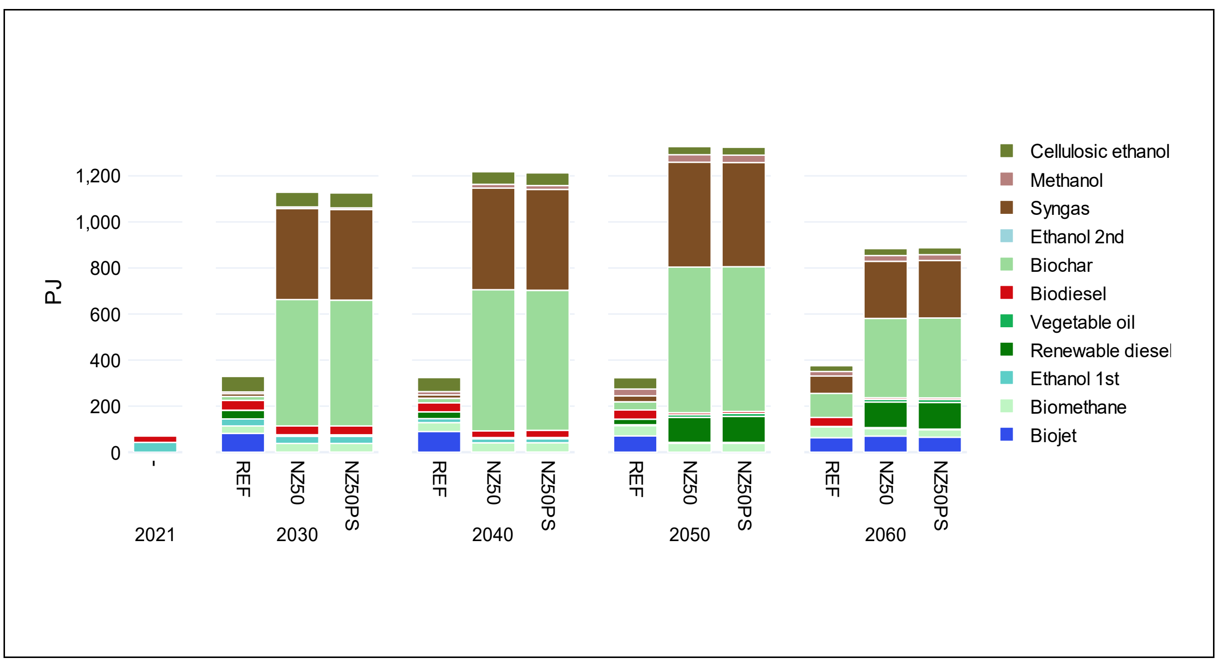
1. Overview

The use of bioenergy, traditionally one of the main energy sources for humans, has continued to expand with modern technologies to encompass numerous applications and a wide variety of biomass feedstocks. In a context of transition to a net-zero future, bioenergy occupies 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, buildings heating and industrial use.

1.1. The Net-Zero Challenge

The most recent Canadian energy modelling studies projecting transition to a net-zero future in 2050 include bioenergy in their resulting scenarios (Canadian Climate Institute 2021b; IEA 2021; Langlois-Bertrand et al. 2024). In the IET Canadian Energy Outlook 2024 (Figure 1), the use of bioenergy increases rapidly before 2030 for net-zero scenarios, for the decarbonization of the transportation sector, industrial use and in large part to produce negative emissions with biochar and bioenergy coupled with carbon capture and storage (BECCS). This narrow role is due to the lack of alternatives for producing negative emissions and to the blending mandates for biofuels. Such use is however limited by biomass availability, competing non-energy applications and the remaining emissions associated with biomass use (Langlois-Bertrand et al. 2024).

Figure 1: Primary biomass usages in net-zero scenarios

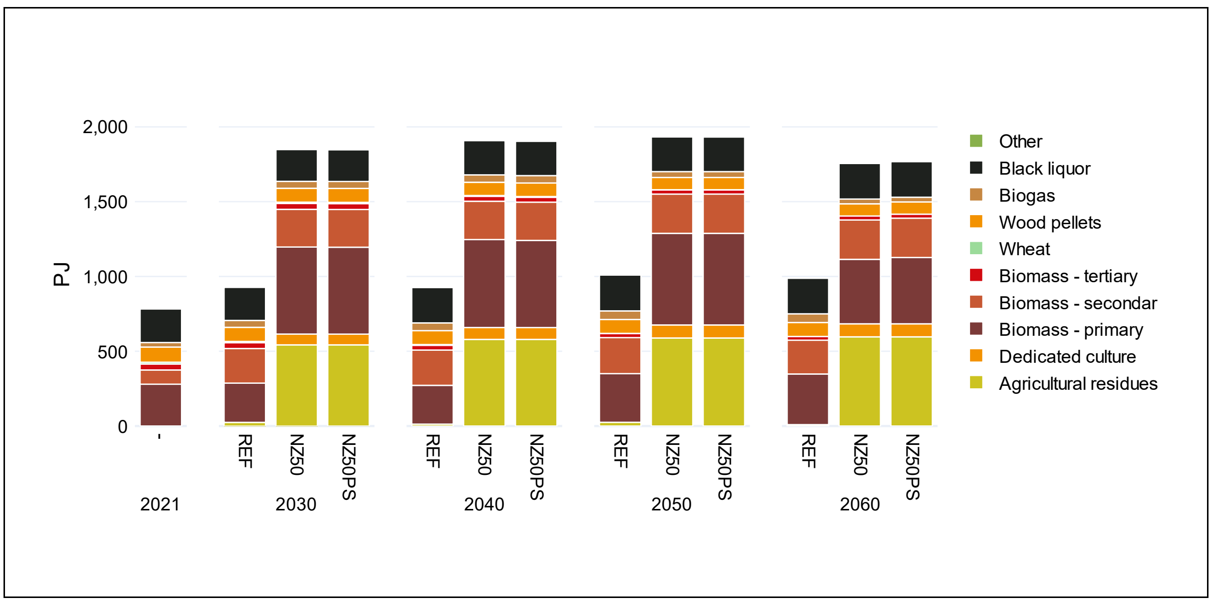


Source: Langlois-Bertrand et al. 2024.

Note: REF is the reference scenario using no constraining GHG reduction targets. NZ50 is a scenario that imposes a net-zero emissions target on total CO_2e by 2050, and a 40% reduction target by 2030, with respect to 2005. NZ50PS is a scenario identical to NZ50 except for cost projections for nuclear SMRs, which are higher.

Bioenergy can be produced from biomass resources from the following three key sectors: forestry, agriculture, and urban/rural waste. Note: REF is the reference scenario using no constraining GHG reduction targets. NZ50 is a scenario that imposes a net-zero emissions target on total CO2e by 2050, and a 40% reduction target by 2030, with respect to 2005. shows the type of biomass resources that have been included in the IET Canadian Energy Outlook net-zero scenarios. Based on a rich set of technologies, the quantity of forest waste used for bioenergy remains significant until 2060 in all net-zero scenarios. However, the use of agricultural crop residues grows rapidly before 2030. Other sources of biomass, such as dedicated culture, municipal organic waste, landfill gas, also contribute to the energy mix in these scenarios.

Figure 2: Bioenergy sources by type in net-zero scenarios



Source: Langlois-Bertrand et al. 2024.

Note: REF is the reference scenario using no constraining GHG reduction targets. NZ50 is a scenario that imposes a net-zero emissions target on total CO_2e by 2050, and a 40% reduction target by 2030, with respect to 2005. NZ50PS is a scenario identical to NZ50 except for cost projections for nuclear SMRs, which are higher.

1.2. Current Situation in the Biomass Sectors

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

Table 1 summarizes the quantities of different biomass feedstocks and bioproducts produced in Canada per year. The data for each type of feedstock are presented further in this report. No attempt was made to estimate the technical potential of the resources cited in this report for any type of biomass usage. However, the aim is to provide a clear overview of biomass resources in Canada, including those that are currently used for food, feed and construction, and the current production of major bioproducts.

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 (G\$)	Carbon stock potential value @ \$170/t CO_2 (G\$)
Biomass feedstocks					
Forestry sector	Wood volume harvested	143 Mm^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)*	185 to 401	-	-
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	65	-	-
Liquid biofuels	Bioethanol	1,750 M litres	41	-	-
	Renewable diesel	1,210 M litres	44	-	-
	Biodiesel	416 M litres	15		
	Biocrude and bio-oil	-	-	-	-
	Biomethanol	-	-	-	-
	Biojet	0	0	-	-
Biogas and RNG		-	22	-	-
Biohydrogen		0	0	-	-
Non-energy usages	Softwood lumber	56 Mm^3	476	-	-
	Structural panels	9 Mm^3	85	-	-
	Hardwood lumber	0.9 Mm^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: The list is not exhaustive. Only the quantities of the main categories of biomass for which values are available are presented in this table.
The values for the quantities of biomass used for food and feed are not included in this table, as they are not available.
This report offers references and additional data regarding the values in this table, in the corresponding sections.

Erreur ! Source du renvoi introuvable., **Erreur ! Source du renvoi introuvable.** and **Erreur ! Source du renvoi introuvable.** present the conversion factors used to estimate the energy content of the biomass resources in Canada. The method used to estimate the biogenic carbon stock value is set out in Section 5.4 of this report.

1.3. Uncertainties and Concerns

Many uncertainties remain about the integration of bioenergy systems in a net-zero future. The uncertainties and concerns respecting bioenergy raised in the literature primarily focus on the availability and sustainability of biomass resources, competition with essential non-energy usages such as food and animal feed, technology development and costs, supply chain emissions, assumption of the 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 inassessing bioenergy's role in a net-zero future:

(a) *Land use*: It is recognized that the capacity of the managed forest and agricultural lands to supply biomass in a sustainable manner is limited. How will the increase in bioenergy demand impact 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 bioproducts producers*: With limited feedstock availability and a rising demand for its use from different energy and non-energy producers, what will be the basis of the arbitration for the best usage? For example, many facilities have announced the production of renewable diesel and sustainable aviation fuel (SAF) in the near future in Canada. However, the producers' decision 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 in 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 entire system?

(d) *Alternatives:* If a specific 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 be the alternative destiny of that resource? What is the best way to compare options to ensure a complete assessment of the climate effects of the entire system put in place?

(e) *Assumption of carbon neutrality:* Bioenergy is often assumed to be carbon neutral since the biogenic carbon 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 "carbon parity 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 stock large quantities of carbon until it is released into the atmosphere through harvest and use for energy or their natural decomposition. At present, the carbon stock has no 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:* Under UNFCCC countrywide reporting guidelines, CO_2 emissions from biomass combustion are not reported in the energy sector in order to avoid double counting the emissions that have already been reported in the land use, land-use change and forestry sector. How does the fact that emissions are counted at the place of harvest rather than according to combustion impact the sustainable practices of the reporting countries?

2. References

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