Biomass and carbon neutrality

Putting in place an evaluation framework

Workshop discussions and comments synthesis

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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.

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1. Introduction

The first phase of the project 'Biomass and carbon neutrality: putting in place an evaluation framework' was dedicated to analyzing the current state of biomass sectors, including feedstocks quantities produced and different usages of biomass in Canada.

The outcome of this work, presented in a white paper, was used as the starting point for a series of five regional workshops to discuss and exchange on some questions, uncertainties and other elements considered relevant, to paint the most accurate picture of the situation.

The objective of the workshops was to bring together specialists and stakeholders from academia, governments, and industrial sectors that process or use biomass resources, to share knowledge and experiences, and identify elements considered as priorities or as neglected issues in biomass industries.

This report presents the result of the analysis of notes taken during the five workshops and comments received on the white paper.

In the light of this analysis, certain themes stood out by recurring throughout the discussions and workshops, and deserve to be highlighted:

- The need to consolidate priorities across all industries now and on the longer term
- The necessity of harmonizing the prioritisation criteria for biomass uses
- Taking into account other aspects (such as biodiversity, energy security, food security, water security) in addition to net-zero objective
- Community must be part of the process

Notes to reader:

- The ideas mentioned in this report were synthesized and classed in different categories to simplify the presentation and reading of the notes taken during the discussions
- We did not judge or evaluate the ideas, therefore, some ideas in this report might be contradictory
- All the original notes that were collected during the workshops on the online platform are available for download from *the IET's website*

2. Elements to consider for evaluating biomass uses

Themes mentioned by stakeholders and experts concerning the evaluation of biomass uses are listed in Table 1.

Table 1: Themes mentioned by stakeholders and experts concerning the evaluation of biomass uses

Themes	Details
Regional approach	• Ensuring that the capacity of supply of the region is not exceeded is necessary • Reducing distances to markets and the transportation of feedstocks by adapting a regional approach • Risk of de-structuring of the socio-economic fabric if the industry is transformed towards bioenergy production (mainly for forestry) • Adapting an approach by different phases in order to monitor the environmental and economic performance of projects across the value chains
GHG emissions	***Carbon intensity (CI)*** • Evaluating and measuring CI is hard to do • Including CI is crucial while assessing bioenergy uses • Keeping CI of biofuels low needs effort ***Temporality effect*** • Capturing the temporality effect in dynamic LCA studies ***Supply chain emissions*** • Taking into account the whole supply chain emissions • Need for a holistic approach • Increase of emissions due to the effect of long-distance transportation between feedstock collection and production • Decrease of the GHG emissions of the whole supply chain by decarbonizing the transportation • A higher focus on production compared to the end use presently • Methane leakage in the renewable natural gas chain ***Carbon debt*** • Difference between types of feedstocks (transformation residues, end-of-use wood, etc.) • Difference in climate impact of letting wood degrade vs using wood for energy ***Carbon market*** • Integrating the role of carbon markets which are playing an important role ***Negative emissions*** • Specific for certain regions due to geological storage • Considering what are the best applications and markets for negative emissions
Profitability and affordability	• Accounting for all external costs • Need to know the production costs of different types of bioenergy based on the real cost of biomass

Themes	Details
	• Price should not be the only factor • Potential impact of government funding on the markets • Selling internally vs exporting bioenergy • Considering what is the maximum that we can do in terms of production that is economically viable
Alternatives	***Alternative use of the feedstocks*** • Considering if there is a higher value product • Existence of other bioproducts that can be produced with the same feedstocks ***Alternative energy source*** • Replacing the most expensive energy sources • Availability of more options of technologies on the longer term • For RNG: prioritizing the industries where other alternatives do not exist over the residential • Considering what are the alternatives and the way they compare ***Hard to decarbonize sectors*** • Expectation for Clean fuels to play a critical role in 'hard-to-decarbonize' sectors such as industry and medium- and heavy-duty freight • Taking into consideration that some sectors do not have other alternatives for decarbonization • Considering if biofuels are the best solution for heavy duty transport • Considering the options for decarbonization of the aviation, marine and rail sectors
Competition	***Competition for resources*** • Existence of competition mostly for forestry sector and no real competition for other types of biomass such as organic waste ***Competition with other energy sources*** • Competition with non-bioenergy sources ***Competition with Green Chemistry and other non-energy uses*** • Taking into consideration the competition with green chemistry • Existence of competition not only among energy producers but also for other applications of biomass, including bioplastics, mulch, P&P, lumber, etc. • Impact of economy and cost of non-bio alternatives for the determination of the best application ***International competition*** • Higher export demand for certain bioproducts compared to others • Impact of the differences between international and national regulations • Competition with the US for human resources and technologies • Requiring policy support to have a domestic market for biofuels and to not mostly export it

Themes	Details
	• For bioethanol: Cost-competitiveness with US bioethanol and reliance on imports
Food security	• Food insecurities in Canada already exist and are a main challenge • Ensuring that bioenergy development does not contribute to the decrease of food security • Shifting the focus back to food security and not only on feedstock supply for biofuels due to international conflicts • Being careful that the demand for biofuels does not impact the price of vegetable oils and corn for food • Ensuring that food security and energy needs are both prioritized • Consider if the sustainability of the food system is being impacted
Supply chain	***Current socio-economic structure*** • Risk of de-structuring the socio-economic fabric if the industry is transformed towards bioenergy production (mainly for forestry) ***Possible synergies between biomass industries*** • Synergies between the production of biofuels and bioproducts • Contributing to the structure of a supply chain and minimizing the losses at different steps of the chain ***Vertical integration*** • Better predictability with vertical integration
Feedstocks	***Availability*** • Uncertainty around the availability of feedstocks (e.g., harvest residuals) ***Waste and by-products*** • Taking into consideration if the feedstock is a by-product or not • Minimizing waste and converting waste into a product and finding other markets for byproducts • Need for co-digestion of different feedstocks in order to make the biogas project profitable (manure, agriculture and municipal organic residues) ***Inconsistent quality*** • Importance of feedstock quality when we talk about biomass
Land use	***Land use change*** • Considering the impact of agriculture land use for biofuels production ***Indirect land use change (iLUC)*** • Huge impact on the GHG emissions and carbon intensity by iLUC • Considering the land surface that would be needed to fulfill the demand ***Marginal lands*** • Harvesting biomass on extended riparian buffer strips: issues of costs and water quality • Mitigating the risk of marginal lands being taken over by efficiency improvements

Themes	Details
Flexibility of production	• Flexibility of technologies in responding to the market and the demand in a similar way that oil refineries can • Existence of several opportunities for upgrading biocrude to biofuels: Industries producing biocrude could decide who to sell it to and therefore to which end use. • Production of renewable diesel and SAF via HEFA technology: Flexibility of the platforms and potential for production of what is required with a slight increase in CAPEX. It's up to policy designs to prioritize well and the producers will follow.
Value for the ecosystem	***Carbon value*** • Considering all the socio-economic elements and making the optimal use of investment to achieve/contribute to net zero ***Beyond the carbon benefit*** • Looking at the value for the ecosystem and beyond the carbon benefit (clean water and clean air) ***Air pollution*** • Considering the air pollution that results from biomass combustion ***Biodiversity*** • Importance of taking into consideration the possible impact on biodiversity ***Water use*** • Considering the impact of water use
Natural disturbances	• Ensuring security and accommodation for challenges related to natural disturbances such as drought or floods • Importance of controlling the increase in wildfires
Technologies	***Availability of the technology*** • Prioritizing biomass relative to the technology that is available ***Conversion process improvement*** • Thinking of the potential improvements for conversion processes while comparing fuels • Taking into consideration the energy yield • Taking into consideration the carbon efficiency of the conversion processes ***Requirement for other inputs*** • Taking into consideration the energy required to produce bioenergy • Considering which other inputs are needed to produce certain biomass products
Time horizon	• Considering the time horizon that we are looking at • Considering projections of technology advancements and new markets on the longer term
Multicriteria optimisation	• Getting inspired from the 3 'R's: Reduce, reuse, recycle • Analyzing surface used per energy produced per type of energy source

3. Risks and uncertainties

Risks and uncertainties mentioned by stakeholders and experts concerning biomass use for energy and non-energy purposes are listed in Table 2.

Table 2: Risks and uncertainties mentioned by stakeholders and experts concerning biomass use

Themes	Details
Decision-making	• Risk of taking decisions in silo that neglect the interdependencies in the biomass sectors • Current challenge of availability of evidence-based analysis
Investments	***Investing in new industries*** • Race to invest in new industries and lack of investment in existing industries • Growth of industries due to subsidies • Concern for technology lock-in through current decisions for investments in new technologies • Need of long-term commitment from agricultural producers and buyers to deblock funding • Lack of a large margin of improvement for the cost of production of RNG from agricultural residues ***Feedstocks*** • Uncertainty if investments in bioenergy are taking into consideration the feedstock availability • Potential change of cost of biomass depending on the demand
Policy and regulations	• Challenges related to the role of different levels of government (federal, provincial and municipal) • Policies being based on a national level and not compatible to smaller regions and certain provinces • Danger of having prescriptive policy • Risk of inconsistent policy signals • Risk due to lack of long-term planning • Different policies with visions that do not necessarily converge • Impact of tax credits on the export/import dynamic with the US (e.g., Canadian biodiesel mostly exported, and Canadian demand is met through imports from the US)
Unintended consequences	• Risk of possible unintended consequences of new systems
Social acceptability	• Challenge for the logistics and land use for new bioenergy projects
Carbon price	• Predictability and clarity in the carbon price is important • Exportation of resources and products due to more advantageous policies abroad

Themes	Details
	• Risk of policy change: paying a price for biogenic carbon in the future
Carbon accounting and reporting	• Improvements in carbon accounting methodology for bioenergy • Impact of carbon emission reporting on the export demand for bioproducts • Uncertainty in the possible future changes to biogenic carbon accounting practices
Environmental attributes and carbon markets	• Owning the environmental attributes with the commodity when purchasing RNG • Accuracy of measurements and versatility of carbon credits • Instability of the carbon market • Avoiding double counting of GHG emissions reduction • Uncertainty in how much relies on the role of carbon credits
Past failures	• More precaution due to past failures in bioindustries
Decrease in demand for liquid fuels	• Decrease in the current consumption of gasoline and diesel due to electrification and other decarbonization pathways • Risk of decrease on the longer term of current estimated demand
Construction cost	• Uncertainty if the construction cost would be an obstacle for project development in provinces such as Quebec
Scaling up bioenergy systems	• Uncertainty on the potential capacity to scaling up facilities to get economies of scale • A lot of promising technologies are still in pilot or demonstration scales • Challenge for businesses to do things at scale • Need for massive industrial transformations
Arbitration	• Uncertainty on how to decide what the best use of biomass is
Role of bioenergy in the whole energy system	• Uncertainty on the percentage of bioenergy in the Canadian energy portfolio in the future
Market development	• Risk of market crystallization by the first project developed: taking over the resources in a certain region • Necessity of subsidies for market development • Limitation of the market to couple big players • Opportunities to valorize by-products • Risk of unbalancing the existing chain and existing models of production and exportation • Cost of connexion to the gas network for RNG producers • Challenge for RNG projects due to the size and configuration of the gas pipelines

4. Suggestions for action

Key suggestions shared by stakeholders and experts concerning the biomass use for energy and non-energy purposes are listed in Table 3.

Table 3: Suggestions by stakeholders and experts for action

Suggestions
Evaluation of the demand for bioenergy • Evaluation of the potential demand for bioenergy of different sectors (industries, road transport, marine, aviation) based on the current consumption and then showing what it represents in relation to current bioenergy production and availability • Having a right assessment of feedstocks to enable industries to make the most appropriate decisions when planning their energy supply portfolio • Comparison of the demand from domestic market and international market • Comparing biomass sectors adequately and avoiding wasting investments on inefficient systems
Actions related to governance role • Need an integrated plan for natural resources management • Collaboration between sectors • Need of independent entities (agencies) for bioenergy • Proposition of having a committee for attribution of biomass, by getting inspired with how it is done in the electricity sector (attributing capacity for certain projects) • Need to change the volumetric mandate into carbon intensity reduction target • Sharing risk and reducing cost volatility • Government interfering to limit the allocation of resources to one player
No regret sectors • Identifying the no regret sectors for bioenergy • Identifying the priorities for bioenergy for each province • Identifying which usage would have a higher value and not only economical
Right set of regulations and policies • Putting in place the right set of regulations and policies to help financial levers for adoption of technologies and enabling the economies in communities • Need for Canada to be more competitive: government policies can change the current landscapes • Ability of compliance credits to kick start the bioeconomy if they give it to certain projects • Including biofuel facilities in the Clean Technology Investment Tax Credit and/or Clean Manufacturing Investment Tax Credit • Contracts for difference as the way forward with policies • Cap on emissions in combination with carbon tax • Using feedstocks in an optimal way and balancing food security and environmental sustainability

Suggestions
Energy efficiency • Making investment in industries conditional on the introduction of energy management systems to reduce their energy use • Considering an approach based on improving the energy productivity to reduce the energy demand
Carbon intensity • Standardizing the carbon intensity measurement and evaluation
Need more data regarding the Canadian biomass inventory • Having more data for biomass quantities and inventories
Indigenous communities engagement • Including the perspective of Indigenous communities
Roadmaps and regulatory frameworks • Putting in place decarbonization roadmaps • Providing regulatory frameworks to ensure food security • Monetizing environmental attributes • Demonstrating the impact of carbon price and the competitivity of renewable bioenergy with fossil fuels

5. Challenges related to the agricultural sector

Stakeholders shared what they consider as big challenges in the agriculture sector. Among the challenges that distinguish the agriculture sector from the forestry sector, are the reliability of supply, role of producers in determining what types of crops would be produced and the role of food security in the discussions around the development of bioenergy projects. The challenges mentioned by stakeholders are presented in Table 4.

Table 4: Challenges mentioned concerning the agricultural sector

Themes	Details
Reducing GHG emissions	• Interdependencies between agriculture and industries: biomethanisation is one of the few solutions to reduce emissions in the agriculture sector
Seasonality and uncertainty of yearly scenarios	• Seasonality of crop residues • Uncertainty of the farmers on their yearly scenario • Need to support producers through the volatility of the markets • Planification of crops depending on the market and the demand: there will be variability based on the economics • Trust issue from the producers side due to changing policies • Existence of a lot of good innovative technology, but if it is not profitable, it wouldn't work • Uncertainty on how to increase the resiliency of the agricultural sector • Ability to wait and then sell the products when the price is better • Need for producers to sell the totality of their products
Fertilizers	• Need for substituting current fertilizers • Lower cost of synthetic fertilizers • Leaving crop residues on the field has a benefit of reducing fertilizer costs • Importance of digestate quality produced from anaerobic digestion as a fertilizer
Soil health	• Uncertainty of the available quantities of crop residues and the sustainability of their removal from the fields • Need for alternatives to sustain soil health if residues are removed from the fields in high quantities • Impact of digestate application on soil health
New types of emerging crops	• Concern for producing new types of crops (e.g., camelina which is not a major food crop). There are challenges for acceptance by producers. • Potential use of Camelina as a cover crop, which could lead to incremental revenues • Need for less fertilizer for production of Camelina which could displace canola as a feedstock for biofuels

Themes	Details
	• Necessity for producers to be sure about what to grow and managing the risks with new crop regimes and with uncertainty of prices • Informing producers on possibilities of diversifying crops to meet both food and energy needs and providing them with incentives • Extreme volatility of crop markets
Increase in demand for oilseed and grain crops	• Uncertainty if the demand would exceed Canadian production capacity with the increase in the use of Canola for different fuels • Uncertainty on how much more could be harvested from cereal and oilseed crops • Uncertainty on how the increase of crops use for fuels would change the land use
Water use	• Water use being a big challenge • Accounting for the availability of water for use by the agricultural sector
Economy of scale	• Challenge for economy of scale with using agriculture residues like straw • Challenge for using straw as a feedstock on a continuous basis
Changes in current practices	• Necessity of changing current practices due to emissions related to agriculture • Impact of diversifying crop production on the increase of resilience of the system in terms of soil health and biomass production • Cost of changing current agricultural practices (e.g., land conversion from annual to perennial crops, intercropping, shoulder season crops) • Potential of using hemp for bioproducts instead of more traditional products
Agricultural residues	• Inconsistent quality of feedstocks • Technical difficulties for the collection of agricultural residues from the fields • High cost of collection and transportation of agricultural residues • Possibility of producing pellets from agricultural residues and storing them
International demand	• Exposure to risk from international markets due to high export demand for canola and biofuels • Uncertainty around the exportation of canola oil while the domestic demand is high • Potential for exporting canola meal
Climate change impact	• Risk of drought and impact on agricultural crops and residues availability
Risk and prices volatility	• The amount of risk that biomass producers can take depends on risk mitigation and risk sharing mechanisms put in place as well as policy support • High volatility in grain prices and impact of developments in the US market • Possibility for producers to wait until the price is right to sell their products • Risk of decrease of the need for bioenergy with other future technologies

Themes	Details
Production capacity	• Uncertainty on the maximum production potential by using canola crops • Limited quantities for used cooking oil • Uncertainty on the benefits of energy plantations on marginal lands
Case of Atlantic Canada	• Lack of crops supply and food production in the agriculture sector in Atlantic Canada • Need to aggregate the resources in the agriculture sector due to the risk of not having enough supply for bioenergy projects • Potential for growth of the agricultural sector

6. Challenges related to the forestry sector

Stakeholders shared what they consider as big challenges in the forestry sector. Main challenges mentioned by stakeholders concerning the forestry sector are listed in Table 5.

Challenges that distinguish the forestry sector from other types of biomass include are the risk of disrupting the industry structure with new types of projects, the impact of wildfires on supply of biomass, the flexibility of forest management practices, the increase of demand for housing construction and the uncertainty around the upcoming changes in practices aiming to increase the resilience of forests.

Table 5: Challenges mentioned concerning the forestry sector

Themes	Details
Forest productivity	• Need to increase forest productivity: in some Nordic countries, forest productivity is higher that in north America • Potential to change forest management practices and to adapt according to the type of demand for feedstocks • Change in forest management practices could impact the quantities considered currently available • Potential impact of demand for bioenergy on certain zones of Crown lands that are not being cut because of quality of logs and species
Transportation of logging residues	• It is a challenge to transport logging residues on long distances • Need to maximize the collect of forest biomass to optimize transportation cost
Standards on forest residues	• Current standards concerning logging residues need to be reviewed
Adaptation of wood transformation industries	• Need to change forest management practices to increase resiliency of the forests, and wood transformation industries need to adapt accordingly as well as regulations • Lack of agility in the current system • Uncertainty of the potential impact on supply levels of changes in forest management practices
Price of biomass feedstocks	• Variability of cost of biomass due to harvest, condition and pretreatment conditions • Potential change in price of forest residues due to higher demand
Current structure of the forest industries	• Risk of de-structuring the industry with new types of bioenergy projects • Primary harvest industry is essential since different industries cannot harvest at the same time and place • Codependences (e.g., pulp and paper and cogeneration) • Control of the competition for biomass and the end use of logging residues by holders of license for harvesting

Themes	Details
Need of increasing housing constructions	• Potential impact on wood supply due to a growing need for building houses in Canada • Challenge of timber availability for housing construction
Impact of natural disturbances	• Importance of land use management to better protect communities from wildfires • Potential increase in supply of biomass due to thinning practices that aim to increase forest resiliency • Higher value for bioenergy use of wood affected by wildfires compared to non energy uses • Uncertainty of the impact of wildfires and diseases on wood supply
Competition for forest biomass	• Need for reviewing the allowable annual cut with the increase of competition for feedstock • Difference in competition depending on the region and province • Consideration of forest biomass to be abundant or not • Concern for harvesting primary forests • Uncertainty about the role of wood waste for RNG production
Impact on GHG emissions	• Taking into consideration the difference in GHG emissions for wood degradation in nature compared to energy use • Limitations of the approach of emissions accounting in the LULUCF sector concerning the bioenergy use of Harvested Wood Products and being able to distinguish if old growth forests are being harvested
Crown lands vs private lands	• Need for distinguishing challenges between crown lands and private lands and differences among provinces • Considering if some private forests are underutilized
BECCS and negative emissions	• Dependence of BECCS development on the geology for storing carbon and being region-specific • High cost of electricity from biomass and higher difficulty to increase its use with potential price increase • Challenge for biomass supply for a large capacity BECCS plant • Help of smart policies to overcoming the challenges for BECCS deployment • High capture rate and well understood technology that could be deployed • Uncertainty for the economic viability of BECCS
Wood pellets	• Focusing on using pellets more locally instead of exporting • Existence of more power generation plants in Canada than cogeneration, which has a better efficiency
Standards for biomass boilers	• Canadian manufacturers specialize in large biomass boilers and have not broadly manufactured smaller units • Challenge for sale of small-scale biomass boilers in Canada due to unacceptance of European standards • Limiting the use of wood pellets for heating

7. Challenges related to the urban and rural waste sector

Stakeholders shared what they consider as big challenges in the urban and rural waste sector. The challenges mentioned by stakeholders are presented in Table 6.

Table 6: Challenges mentioned concerning the waste sector

Themes	Details
End-of-use wood	• Challenge of using end-of-use wood due to problems of separating waste • Challenges with the quality of feedstocks that cannot respond to the demand of industries • Need for a better structure of the sector of recuperation of wood from construction, renovation and demolition (CRD) sites to account for all waste being generated
Differences across provinces	• Different policies for recycling across provinces • Challenge of accounting for waste on a national level which might not provide a good picture • Anaerobic digestion is less used in the Atlantic region and organic residues are being sent to landfills (e.g., in New Brunswick)
Composting vs waste-to-energy	• Composting organic waste being a current practice that competes with waste-to-energy novel applications
Projects using municipal solid waste (MSW)	• Interesting feedstock to use • Many challenges including cost of production and duration of contracts while calling for projects

8. Challenges related to labour

Many stakeholders agreed that the lack of skilled workers for bioenergy projects is an existing issue and would affect the bioenergy sectors. However, this issue is not specific for this sector. Other responses received concerning the challenges related to labour are presented in Table 7.

Table 7: Challenges mentioned by stakeholders concerning labour

Themes	Details
Training workers for new skills and technologies	• Issue of finding skilled workers can be managed during the period of planification for new projects • Training is needed for new types of technologies (anaerobic digestors) • Training is needed for workers that have similar skills set required for bioenergy projects to transition from other industries, especially if other industries would be disappearing due to changing demand • Biomass sectors, such as forest management, are labor-intensive and could be impacted by policy changes
Competition with other sectors	• Attracting more skilled workers is necessary and costly and would be a challenge for many biomass sectors • Shortage of workers is more an issue in rural areas compared to urban areas. However, biomass projects are creating jobs which may drive the economic development of in rural areas. • Challenges to offer competing salaries with other industries such as the oil and gas sector • The cost for construction in Canada is high and that impacts the cost for labour too

9. Comments on the preliminary version of the white paper

Stakeholders and experts shared comments and suggestions regarding the preliminary version of the white paper that was shared. Major comments on the strengths and weaknesses of the paper and suggestions received, during the workshops and by email, for improvement of the paper are presented in Table 8. Note that we also received corrections on specific, phrases or paragraphs in the paper that will help us to correct the preliminary version and prepare the final version of the white paper.

Table 8: Comments and suggestions received from stakeholders and experts concerning the preliminary version of the white paper

Comments received	
Strengths	• Comprehensive report with quantitative information • Interesting approach concerning the discussion about the limit of the resources • The section of list of uncertainties and concerns • Essential base to fuel the discussions for the development of plans and frameworks

Weaknesses	• Some data are not very recent
	• The report provides a good pan-canadian vision. However, it is hard to do an evaluation with a Canadian relevance. Adding regional assessments was suggested.
	• Data missing:
	  ○ Mill waste quantities
	  ○ Information about Hemp biomass, specially in Alberta
	  ○ The current markets and use of agricultural crops and residues
	  ○ Economic viability of different sectors
	• It is not mentioned in the report the water use in all of the energy production processes
	• Urban and rural waste opportunities need further discussion
	• The wood pellet section is short and could a bad perception about this sector
	• Quantifying the value of biogenic carbon would not get a lot of traction

Comments received	
Suggestions	• Hold an annual update of the report in order to make recent data and information available to all and to propose measures to achieve carbon neutrality • Regional assessment needs to be done in the report • Include precise and clear recommendations for decision-makers in the final version of the report • Add a definition for sustainable biomass resources • Consider adding a section on carbon neutrality of biomass, especially forest biomass. May need to explain the concept and present various perspectives for clarity and insight. • Add information about how the evaluation framework will be used • Add more information about policy and regulations • Add more information about non-energy use of biomass • Add a section about the Life Cycle Assessment for different biomass sources and usages • Add a Sankey graph showing the resources, conversion and usage from the data of Figures 1 and 2 • Add the risks and uncertainties for each of the bioenergy sectors • Add data about the surfaces of agricultural lands currently used, marginal or abandoned • Add more information about Wildfires mitigation and land use • Add the challenges related to specific provinces, sector by sector • Add a section about Green Chemistry • Add the Technology Readiness Level (TRL) of the different technologies • Map technologies with corresponding biomass resources • Add some end use application/sectors • Assessment of availability and supply of non-used biomass • Add if there is a better biomass alternative for the products • Add the aspect of logistics: How much of the biomass is available considering the logistics to collect and transport the feedstocks? • Cost of biomass collection and transport: What is economically viable? • Product markets: More explanation about the forestry products markets • Add a larger analysis on the carbon market • Consider using the term ‘residuals’ instead of ‘waste’ for agriculture and forest biomass for example because in a lot of cases it is used and not really wasted • Include difference of soils in different regions • Add more explanation about the forest products markets • Talk about the concept of Climate Smart Forestry (examples from Sweden and Finland)

Comments received	
	• Overall, when listing companies and facilities, be sure to indicate when the lists are exhaustive vs. not. In many cases, only a few projects are highlighted, but it is not clear to the reader on what basis these projects were selected. • Include a heat map of how accessible carbon in biomass is would be great • There could be an additional paragraph on the use of hog fuel boilers in pulp and paper mills, highlighting the general trade-off between the costs of pelletizing and the labour intensity of operating boilers on raw biomass. This trade-off tends to favour raw biomass at larger scales and pellets at smaller scales. The current use of hog fuel for the production of industrial steam represents a significant fraction of current solid biofuel usage. • Include information on the market residuals • The term 'carbon neutrality' in the title can be confusing between the significance of biomass being carbon neutral and 'net zero objective'. Consider changing the title from 'carbon neutrality' to 'Net Zero'. • Which markets are the most promising? • Include information about the efficiency if the different bioenergy processes • Prepare a map of the value chains and include business models • Add the profitability of projects • Add a list of all national protocols for offset credits • Add references for all values in the report and specify how the references were chosen for the values in Table 1 • Add 'biomass affected by fire and insects' as biomass resource in Table 1 • Add a discussion around the emerging competition between carbon-neutral and carbon-negative pathways and the risk that investing in carbon-neutral pathways becomes counterproductive as it crowds out the best potential for negative emissions • In the LULUCF section, make a clearer distinction between what is in each component (anthropogenic and natural disturbance) vs the rules for being moved from one to the other and vice versa • Take a deeper look at the transportation of biomass in forestry and agriculture (GHG emissions and cost) • Add information about the economic viability of specific sectors • Add 'Policy and Regulations' to the list of uncertainties and concerns • Add relevant initiatives happening abroad to the section of programs related to biomass use • Add more information and details about the agricultural residues • Add information about BECCS facilities • Forest management, including harvest levels, falls under provincial/territorial jurisdiction. It would be beneficial to have a sub-section on that topic, as it sets the limit on how much forest biomass can be harvested.

Comments received	
	• Add granular data of land use and land types in Canada considering the impact of location of harvest on the emissions • Need to add Clean Energy for Rural and Remote Communities in the list of programs and policies in Canada • Add a more in-depth analysis concerning the landfill sites • Economic impact assessment should be done for each crop type • Need to add the aspect of food security and to reflect the current situation in the report • Add information about land use change regulations • Add references for existing models suggesting optimal biomass allocation based on various criteria • Add data about the internal use of biomass by sawmills and pulp and paper industries • Energy efficiency to use less quantities of biomass and keep it for other uses • Add an analysis for the ratio of possible diversion of crops (by region and year)

Appendix.1. List of participants

Table 9: List of stakeholders and experts who attended the workshops or provided comments on the white paper

Last Name	First Name	Organization
Adetona	Adekunbi	Canadian Forest Service, Natural Resources Canada
Aghabararnejad	Milad	CanmetENERGY in Varennes, Natural Resources Canada
Alward	Jonathan	Atlantica Centre for Energy
Beaumier	Louis	Institut de l'énergie Trottier
Bédard	Serge	CanmetENERGY in Varennes, Natural Resources Canada
Bédard	André	Quebec Wood Export Bureau
Bélanger	Normand	Fonds de solidarité Bioénergie (Fonds FTQ Bioénergie)
Bernier	Daniel	Union des producteurs agricoles
Bourdages	Alain	Produits forestiers Résolu
Bourque	Jean-Pierre	Ministère des Ressources naturelles et des Forêts
Brewin	Dan	Plant Protein Alliance of Alberta
Broda	Joey	FortisBC
Byatt	Justin	Forest Operations and Development Branch, Government of New Brunswick
Chenel	Jean-Philippe	Consortium de recherche et innovations en bioprocédés industriels au Québec
Clark	Dylan	Pacific Institute for Climate Solutions
Dagher	Roberta	Institut de l'énergie Trottier
Dickie	Chris	ResearchNB
Down	Sam	HEMPALTA
Downing	Melissa	Alberta and National Cattle Feeders' Association
Drevet	Tarra	The Simpson Centre
Durany	Gabriel	Plan A Capital
Edom	Éloïse	Institut de l'énergie Trottier
Ell	Wendy	Glacier FarmMedia
Mohammadi	Hana Fateme	University of British Columbia
Finet	Jean-Pierre	ROEÉ
Foxall	Ryan	BC Ministry of Energy, Mines and Low Carbon Innovation
Gagnon	Bruno	Canadian Forest Service, Natural Resources Canada
Gagnon	Yves	Université de Moncton
Germain	Louis	Conseil de l'industrie forestière du Québec (CIFQ)
Ghatala	Fred	Advanced Biofuels Canada
Goodison	Andrew	Canfor
Goulet	Nicole	Ontario Power Generation

Last Name	First Name	Organization
Gulab	Sabrina	The Simpson Centre
Guy Adegbidi	Hector	Université de Moncton Campus d'Edmundston
Harvey	Jacques	J Harvey Consultant & Associés inc
Hays	Fred	AB Beef
Hoffmann	Ron	SixRing
Holowaychuk	Will	Alberta Canola
Ishaque	Hanan	The Simpson Centre
Jazinaninejad	Mona	University of New Brunswick
Kehoe	Steve	BMO
Khennache	Lylia	Airex Énergie
Kiro	Ruth	Pollution Probe
Laframboise	Amélie	Ville de Montréal
Landry	Mathieu	Climate Change Secretariat, Government of New Brunswick
Langlois - Bertrand	Simon	Institut de l'énergie Trottier
Lee	Jason	Environment and Climate Change Canada
levesque	Jonathan	Biomass Solution Biomasse
Lhermie	Guillaume	The Simpson Centre
Liu	Daniel	Natural Resources Canada
Locoh	Ayaovi	Institut de l'énergie Trottier (IET)
Maghzian	Ali	University of British Columbia
Mambo	Tatenda	The Simpson Centre
Marois-Mainguy	Olivier	Ministère de l'Agriculture, des Pêcheries et de l'Alimentation
Mathis	Chris	Viable Solutions
McGee	Michael	BioEnterprises
McKell	Brittany	HEMPALTA
Meisser	Janay	UFA Co-Operative Ltd.
Moss	David	Telus Agriculture
Moss	Riley	TC Energy
Mousseau	Normand	Institut de l'énergie Trottier
Afzal	Muhammad	University of New Brunswick
Müssenberger	Frank	Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs
Naylor	Simon	Viridis Environnement
Niet	Taco	Simon Fraser University
Paré	Benoit	Centre de traitement de la biomasse de la Montérégie
Pauer	Stefan	Clean Energy Canada
Pinault	Eric	Université de Québec à Montréal
Prodan	Hugh	Bio Alberta
Rancourt	Emmanuelle	Vision Biomasse Québec - Nature Quebec

Last Name	First Name	Organization
Sanguinetti	Lucia	The Simpson Centre
Sebaa	Nazim	Association des consommateurs industriels de gaz
Sharma	Mahima	Forest Products Association of Canada
Sieppert	Jackie	School of Public Policy, University of Calgary
Sokhansanj	Shahab	University of British Columbia
Sorenson	Brian	Canary Biofuels
Tauvette	Geoff	Canadian Council for Sustainable Aviation Fuels
Thellen	Philippe	Ministère de l'Économie, de l'Innovation et de l'Énergie (MEIE)
Thiffault	Evelyne	Université Laval
Thomson	Ian	Advanced Biofuels Canada
White	Troy	BioComposites Group
Whitmore	Johanne	HEC
Wiskar	Shawn	The Simpson Centre
Wolinetz	Michael	Navius Research
Wong	Tammy	Ontario Power Generation
Xie	Sheng	Natural Resources Canada
Zhu	Hui	UBC Clean Energy Research Centre
Zuleta	Liliana	Emissions Reduction Alberta

Appendix.2. Workshops structure and schedule

Discussions in all workshops were structured according to the order and themes below (with some slight variations between workshops).

Introduction and presentation

- Context and objectives of the workshop
- What we know so far on biomass usage in Canada

Discussion 1 – Current state report

- Comments on the shared report, its strengths and weaknesses
- Discussion on gaps, uncertainties, and overlooked issues or sectors

Discussion 2 – Supply

- Discussion on what could impact biomass supply and how to avoid any strain on resources

Discussion 3 – Economic viability/profitability

- Discussion on internal and external factors influencing biomass industries
- What is currently overlooked in the development of new value chain?

Plenary session

- Feedback from the breakouts and discussions on challenges related to Net-Zero
- What should be taken into consideration in an evaluation framework?
- Next steps

Notes from discussions were taken on a collaborative platform. The MIRO platform was accessible to all participants and notes were added to the online whiteboards by any person who wished to contribute.

Dates and locations of workshops:

- 26 September 2023 in Montreal, Quebec
- 10 October 2023 in Fredericton, New Brunswick
- 24 October 2023 in Calgary, Alberta
- 27 October 2023 in Vancouver, British Columbia
- 7 November 2023 in Toronto, Ontario