Biomasse et carboneutralité

Biomass and Carbon Neutrality

INSTITUT DE L'ÉNERGIE TROTTIER

The Transition Accelerator — L'Accélérateur de transition

Prioritising biomass uses to achieve net-zero target

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Prioritising Biomass Uses to Achieve Net-Zero Target

Biomass and Carbon Neutrality – Mid Term Forum
Organized by Institut de l'Énergie Trottier, **National Arts Centre in Ottawa**
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Outline

Who we are?

Our main research question related to biomass

Our methodology

Multicriteria Analysis

Some results

Questions & Answers

CanmetENERGY in Varennes' Scientific Research

INDUSTRY

$3.5M

38 employees

- Eco-efficient decarbonization of the industrial sector
- Clean fuels production and utilization
- Artificial intelligence for energy efficient process industry
- Advanced CCUS Technologies and Systems
- Technical courses, tools and support for professionals and universities in the field of energy optimization and data analytics

RENEWABLE ENERGY INTEGRATION

$3.5M **30 employees**

- PV assessment and technology development
- Smart grid and microgrid for resilient power systems
- Smart cities and communities
- Transition to high renewable integration on the grid

BUILDINGS

$4.3M **32 employees**

- Renewable heating and cooling systems
- Optimal building operation
- Technical expertise in support to the greening of federal government's operations (GGO)
- Energy systems for northern/remote infrastructures

Disclaimer and Acknowledgments

- Nous souhaitons remercier le Gouvernement du Québec pour son important soutien financier et son apport technique précieux pour la réalisation de cette étude

- The contents of this presentation is for information purposes and do not represent policy positions of the Government of Canada or the Gouvernement du Québec, and do not constitute an approbation of any particular commercial product.
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Québec

Research question: What is the best use of available biomass?

Soil amendment

Kiln

?

Pyrolysis oil

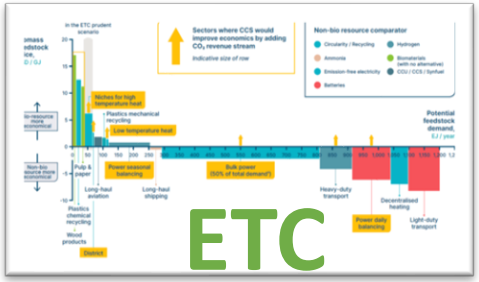
Syngas/ RNG

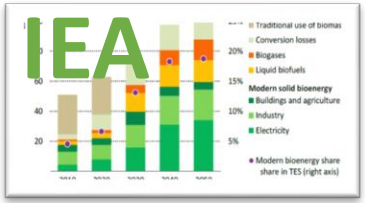
Anode baking

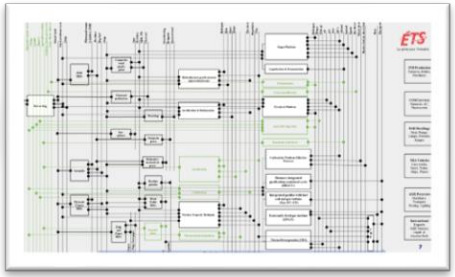
Steelmaking

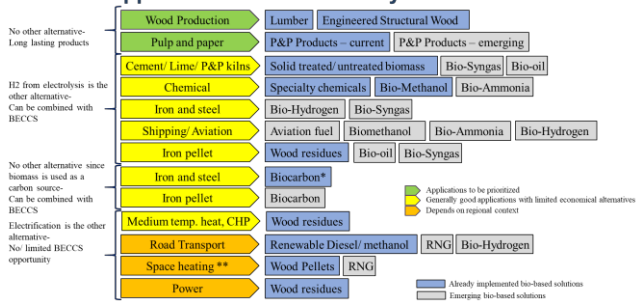
Pelletizing plant

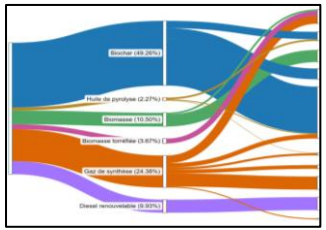
Our approach / methodology

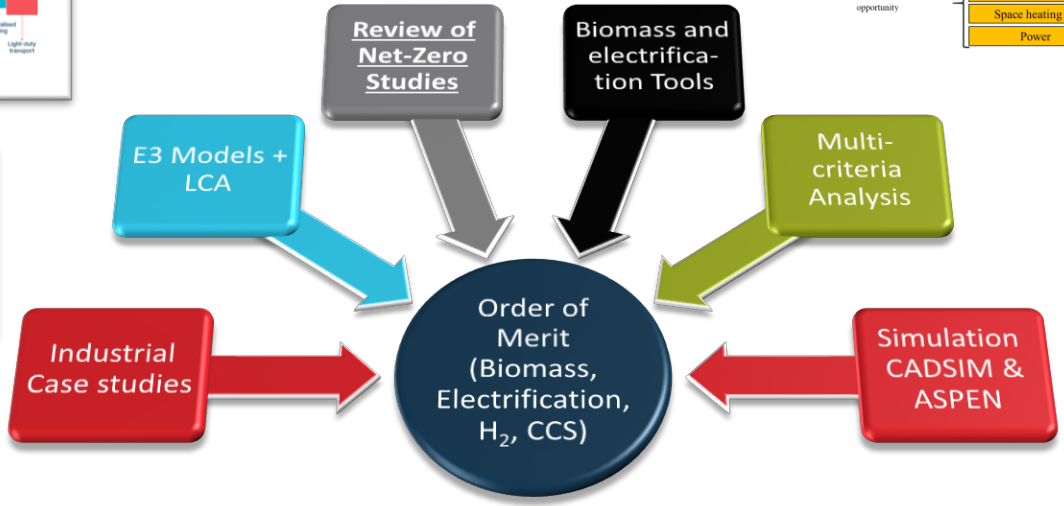








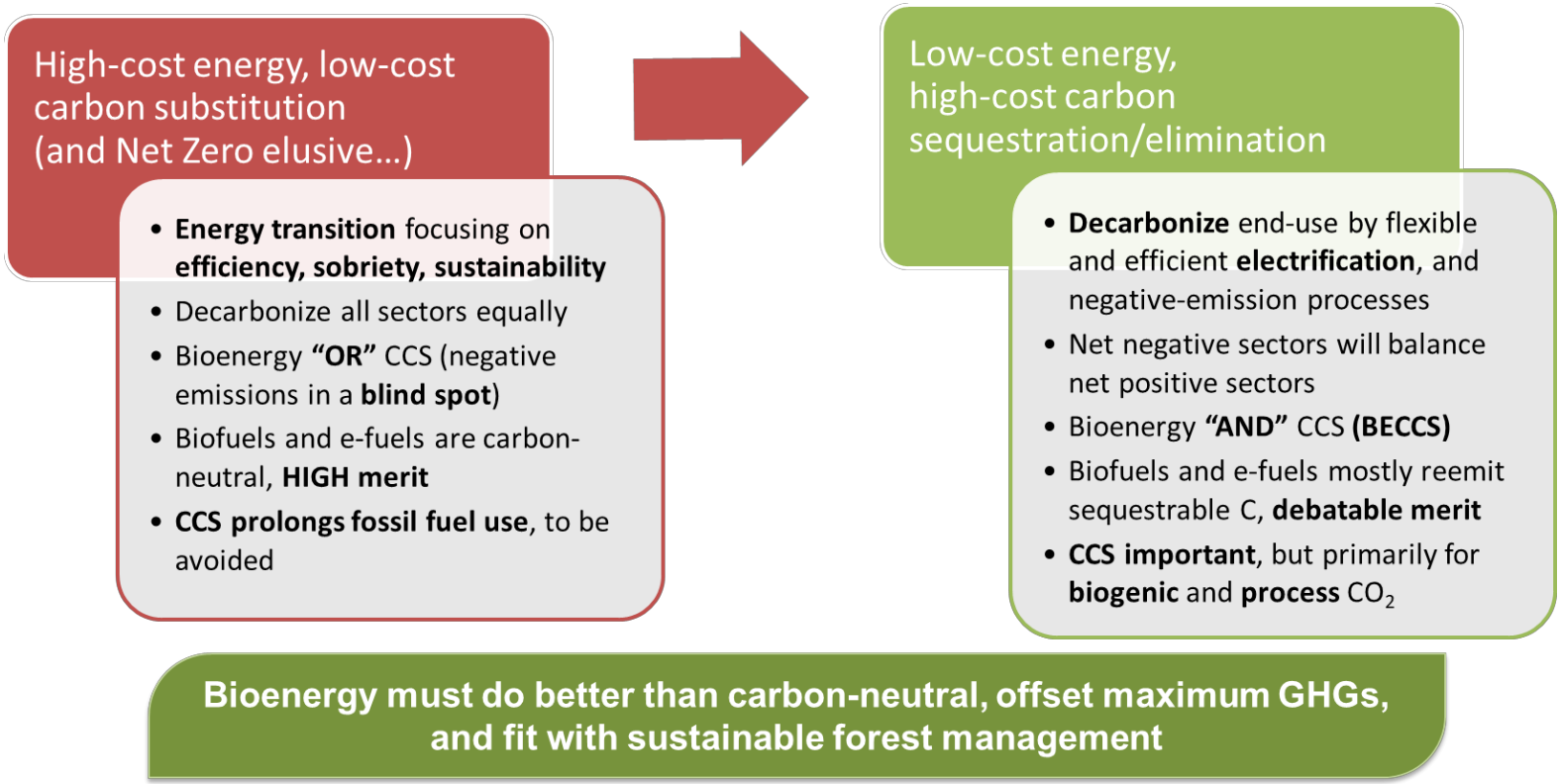




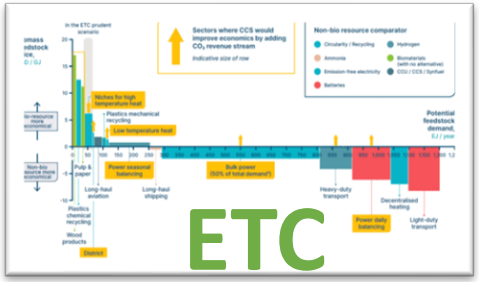
Summary of reviewed studies on Net Zero

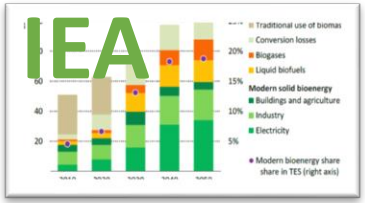
Study	Year	Geography	Pathway optimization	BECCS Modeling	Key concept / differentiator
Princeton	**2020**	**U.S.A.**	**Yes**	**Good**	**Sub-regional detail**
E.P.F.L.	2020	Switzerland	Yes	Good	Carbon flow detail
C.I.C.C.	2021	Canada	No	Poor	Need both “safe bets” and “wild cards”
I.E.A.	2021	World	No	Poor	Realpolitik
E.T.C.	2021	World	No	Discuss	Biomass cost parity
Dunsky/ESMIA	2018/21	Québec	Yes	2021 only	NATEM model
Trottier	2021	Canada	Yes	Good	NATEM model
Oxford	2021	World	No	No	Learning curves
CER	2023	Canada	No	Good	Energy Future 2023-2050
NRCan (internal)	2023	Canada	Yes	Good	NATEM model

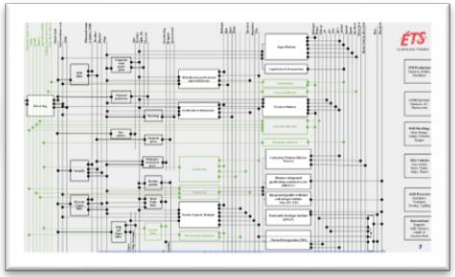
A Paradigm Shift about GHG Emissions

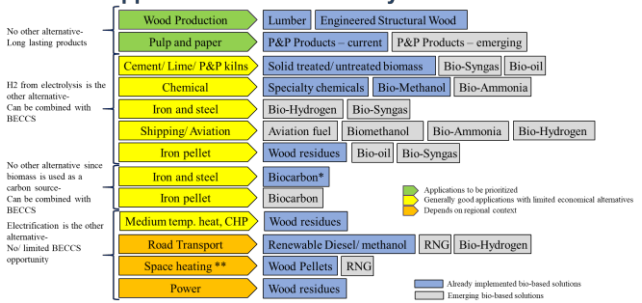


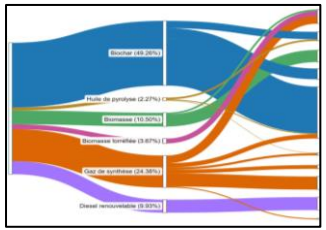
Our approach / methodology











Review of Net-Zero Studies

Biomass and electrifica-tion Tools

E3 Models + LCA

Multi-criteria Analysis

Industrial Case studies

Order of Merit (Biomass, Electrification, H_2, CCS)

Simulation CADSIM & ASPEN

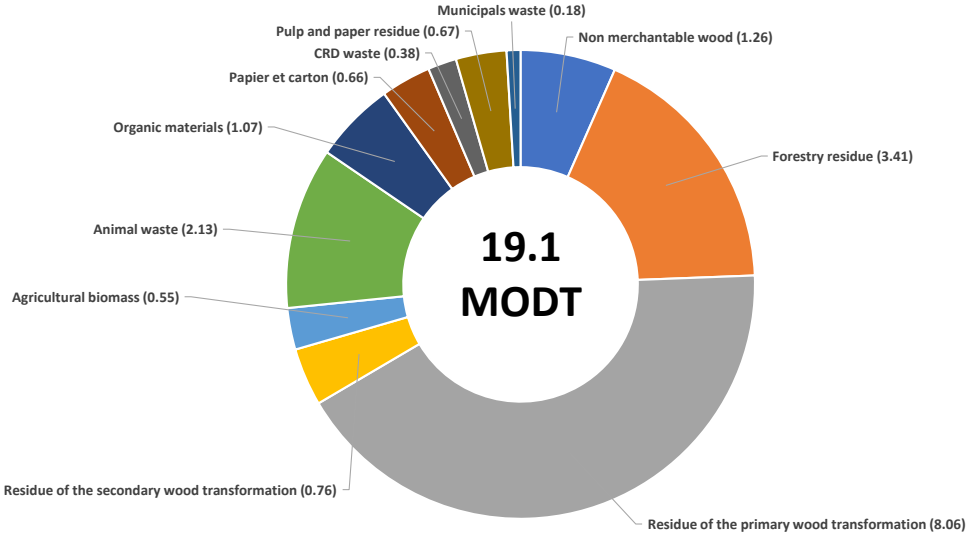
Why a Multi-Criteria Analysis?

- Net zero studies highlighted the importance of biomass in achieving net zero GHG emissions;
- Biomass allocation must be optimised considering its limited quantities;
- Some of the key criteria that can be derived from Net Zero studies include:
  - Existence of an alternative to bioenergy, including process change or electrification;
  - Efficiency relative to electrification, not to fossil fuels;
  - Possibility to not reemit carbon;
  - Compatibility with BECCS over time;
  - Technical constraints and retrofit costs of industrial processes.
- Other biomass allocation approaches do not consider these criteria explicitly;
- Other biomass allocation approaches may not consider the technical and economic challenges associated with bioenergy usage.

Why a Multi-Criteria Analysis?

- The good engineering judgment was added to the study to identify and select the most promising pathways and applications;
  - Difficult to incorporate using other approaches for many industrial processes and pathways.
- In this study, it was not assumed that a given energy source needed to be replaced by its bioequivalent;
- Alternative energy sources were investigated to identify the lowest quality energy source for each industrial applications, and ideally, the one requiring the least processing steps.

Biomass Volume in Quebec



Note 1: Only forest residues and non-merchantable wood are assumed to be not yet exploited;

Note 2 : Around 4.67 million tons of dried biomass per year is available;

Note 3: Residues from primary and secondary wood processing are the most competitive source of biomass, but most of them are already in use.

Note 4: Modification to the current forest value chains will be needed for some bioenergy applications to “free” more saw dust and shavings (higher quality biomass)

Référence: INVENTAIRE DE LA BIOMASSE DISPONIBLE POUR PRODUIRE DE LA BIOÉNERGIE ET PORTRAIT DE LA PRODUCTION DE LA BIOÉNERGIE SUR LE TERRITOIRE QUÉBÉCOIS, Rapport WSP, 2021

Biomass Availability – by Type and by Administrative Region

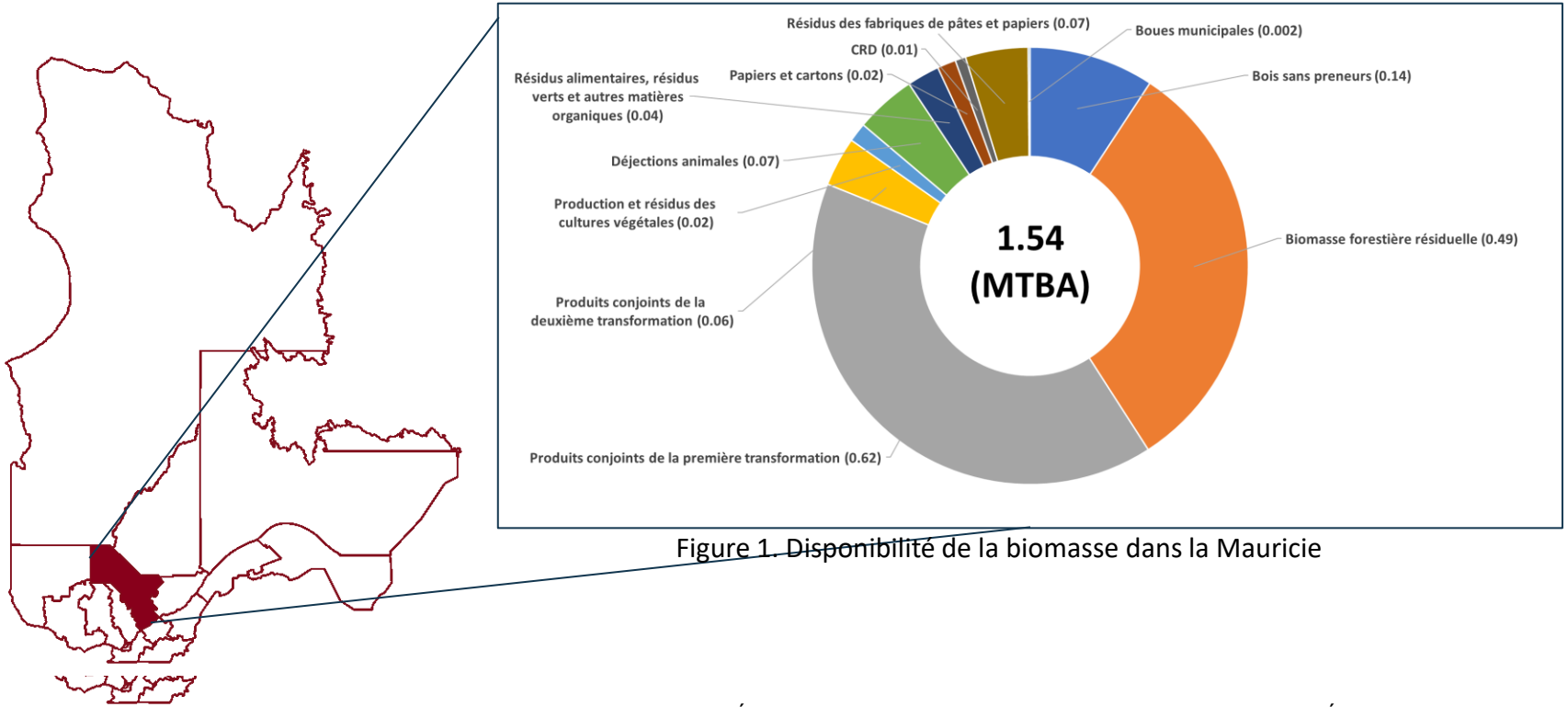
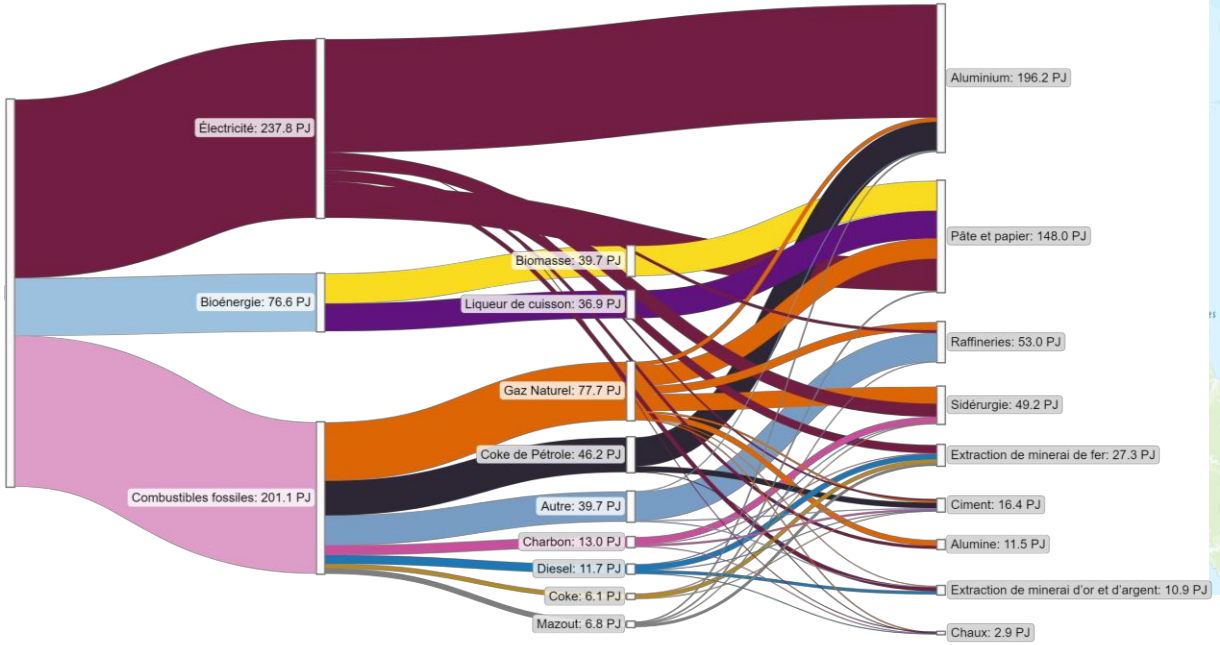
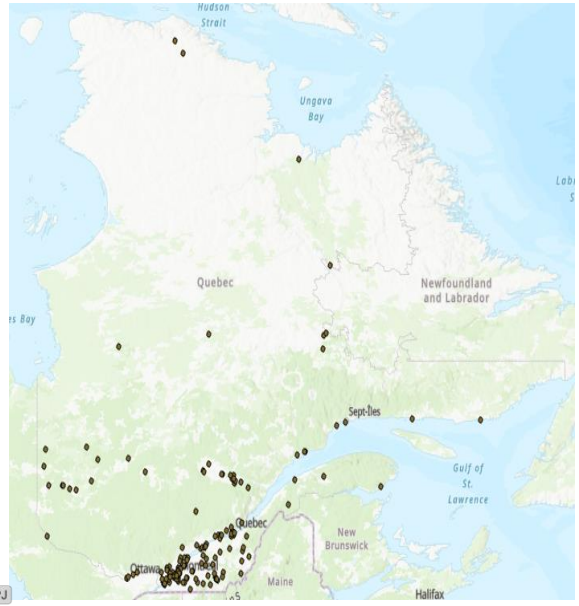


Figure 1. Disponibilité de la biomasse dans la Mauricie

Référence: INVENTAIRE DE LA BIOMASSE DISPONIBLE POUR PRODUIRE DE LA BIOÉNERGIE ET PORTRAIT DE LA PRODUCTION DE LA BIOÉNERGIE SUR LE TERRITOIRE QUÉBÉCOIS, Rapport WSP, 2021

Energy and GHG Mapping of the Quebec Industrial Sector



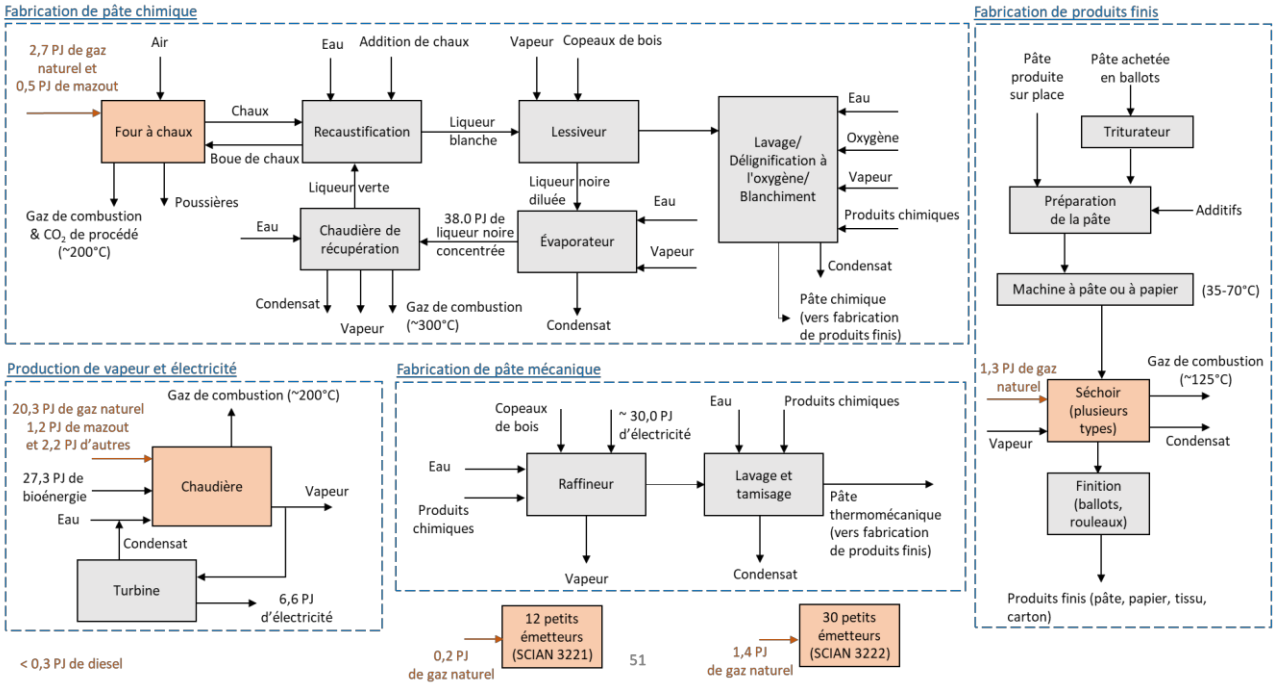


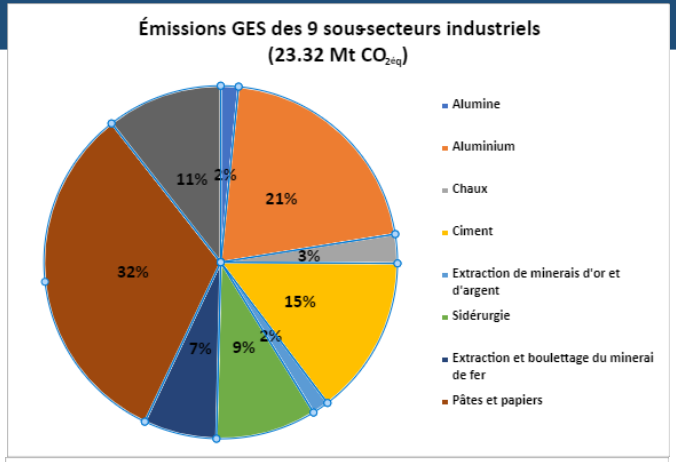
77 industrial plants

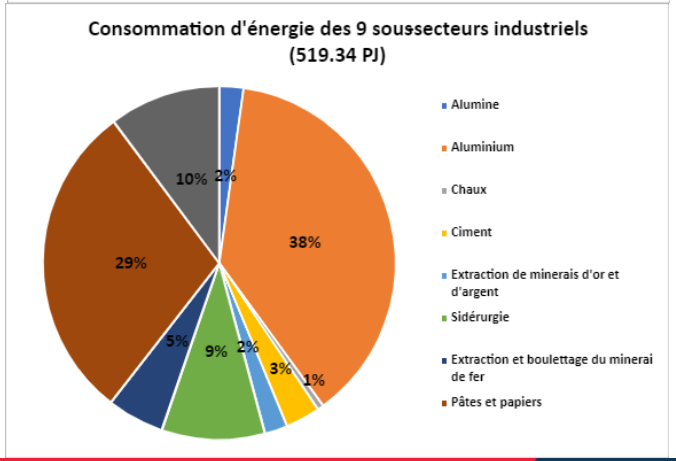
Accounts for 70% of emissions and 67% of industrial energy consumption in Quebec including petroleum coke and process coal.

Pâtes et papiers – Estimations obtenues par simulation

Cartographie énergétique des procédés et des sous-procédés industriels



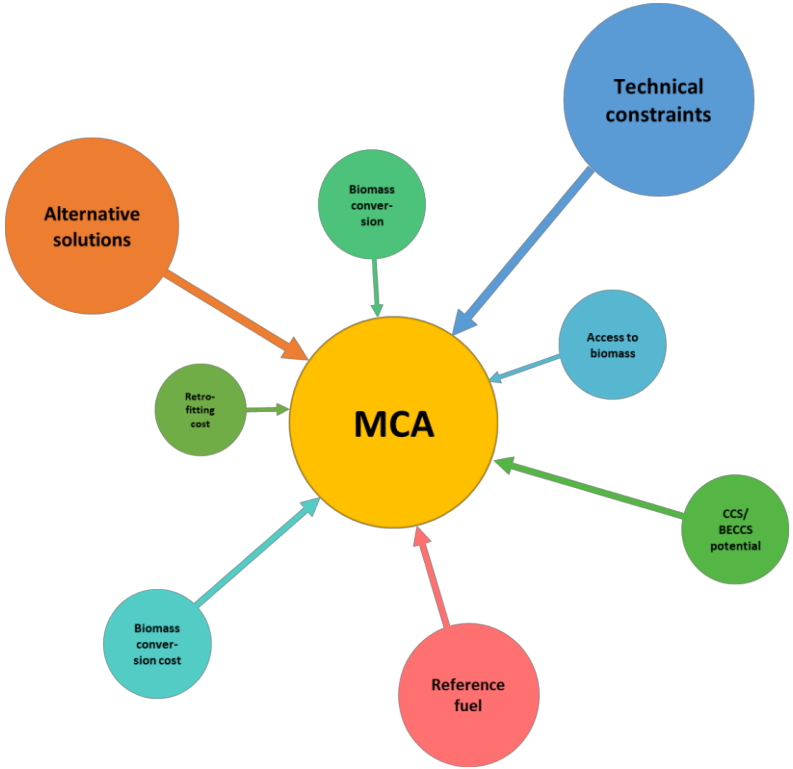

Émissions GES des 9 sous-secteurs industriels
(23.32 Mt $CO_{2éq}$)
11%
2%
21%
3%
32%
15%
7%
9%
2%
Alumine
Aluminium
Chaux
Ciment
Extraction de minerais d'or et d'argent
Sidérurgie
Extraction et boulettage du minerai de fer
Pâtes et papiers


Consommation d'énergie des 9 sous-secteurs industriels
(519.34 PJ)
10%
2%
38%
29%
5%
9%
2%
3%
1%
Alumine
Aluminium
Chaux
Ciment
Extraction de minerais d'or et d'argent
Sidérurgie
Extraction et boulettage du minerai de fer
Pâtes et papiers


Alumine
Aluminium
Raffineries
Ciment
Extraction or et argent
Sidérurgie
Extraction du fer
Chaux
Pâtes et papiers

Multi-Criteria Analysis – Bioenergy

- The aim of this analysis is to **maximize the reduction of GHG emissions in industrial facilities**, while taking into account technical and economic constraints;
- The criteria were identified with the help of experts and a thorough review of net-zero studies (e.g., Dunsky/ESMIA);
- Agricultural applications are excluded;
- The weight given to each criterion **can be modified** in the tool developed to perform a sensitivity analysis;
- **Results**: Potential industrial needs far exceed resource availability

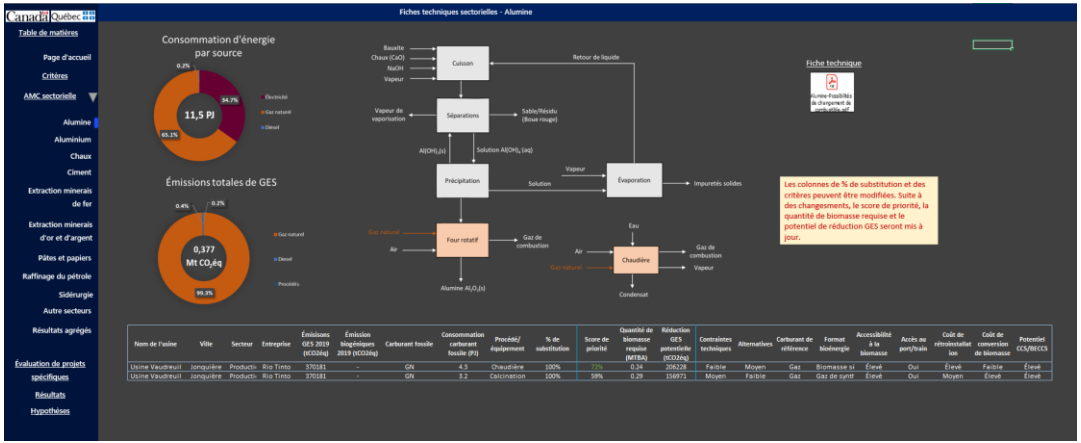


Multi-Criteria Analysis – List of projects at a plant level

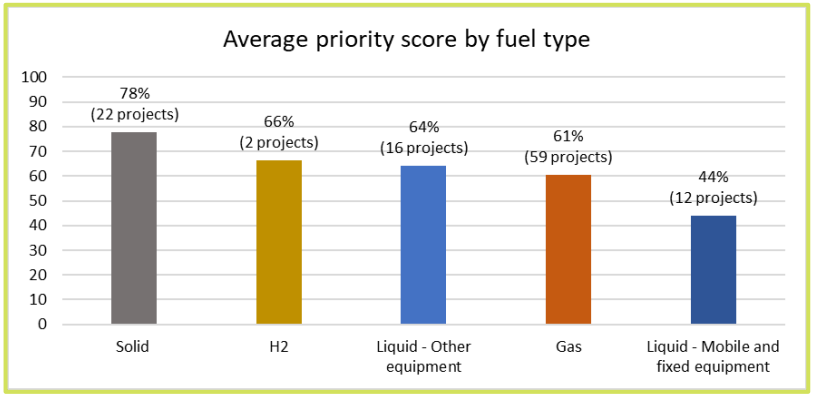
Project #	Facility name	Facility city	Sector	GHG emisisons 2019 (tCO2e)	Fuel switching %	Sub process/equipment	Primary fuel	Bioenergy alternative
1	Raffinerie Jean-Gaulin	Lévis	Raffineries de pétrole	1,331,211	100%	Boiler	Gas	Dried biomass
2	Usine de Bouletage de Port-Cartier	Port-Cartier	Extraction de minerais de fer	1,328,490	100%	Boiler	Liquid	Dried biomass
3	Usine de Bouletage de Port-Cartier	Port-Cartier	Extraction de minerais de fer	1,328,490	100%	Pelletizing furnace	Liquid	Bio-oil
4	Usine de Bouletage de Port-Cartier	Port-Cartier	Extraction de minerais de fer	1,328,490	100%	Mobile/fixed equipments	Liquid	Ren. Diesel
19	Usine de Bouletage de Port-Cartier	Port-Cartier	Extraction de minerais de fer	1,328,490	100%	Pelletizing furnace	Solid	Bio-char
5	Fibrek SENC	St-Félicien	Usines de pâte chimique	1,169,284	100%	Boiler	Gas	Dried biomass
6	Fibrek SENC	St-Félicien	Usines de pâte chimique	1,169,284	100%	Lime kiln	Gas	Syngas
7	Usine de La Tuque	La Tuque	Usines de carton	1,158,077	100%	Boiler	Gas	Dried biomass
8	Usine de La Tuque	La Tuque	Usines de carton	1,158,077	100%	Lime kiln	Gas	Syngas
9	Domtar Usine de Windsor	Windsor	Usines de papier (sauf le papie	1,143,261	100%	Boiler	Gas	Dried biomass
10	Domtar Usine de Windsor	Windsor	Usines de papier (sauf le papie	1,143,261	100%	Lime kiln	Gas	Syngas
108	Cascades Groupe Tissu Lachute, une division de Casc	Lachute	Usines de papier (sauf le papie	11,905	100%	Boiler	Gas	Dried biomass
109	Fabrication région Est, Sherbrooke	Sherbrooke	Usines de papier (sauf le papie	11,594	100%	Boiler	Gas	Dried biomass
110	Centrale d'Obedjiwan	Obedjiwan	Production d'électricité à parti	10,287	100%	Generator	Liquid	Dried biomass
111	Rosario Poirier inc.	St-Alphonse	Sawmills (except shingle and shake mills)		100%	Mobile/fixed equipments	Liquid	Ren. Diesel

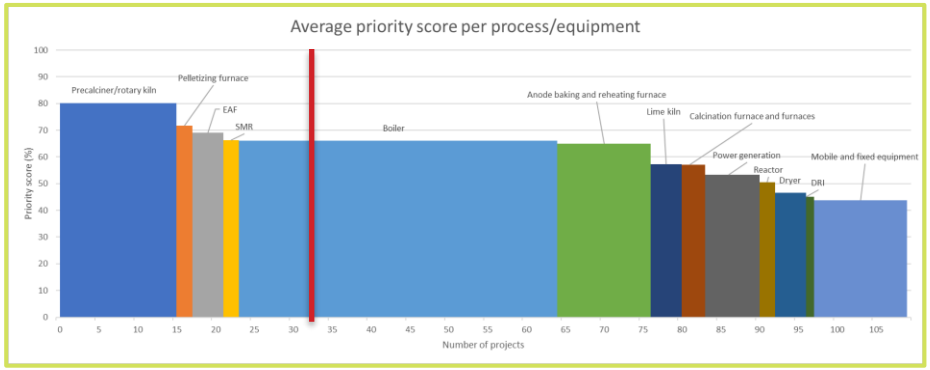
Multi-Criteria Analysis – Tool developed

- Excel based tool that allows the user to qualitatively evaluate and rank different bioenergy projects
- Objective considered: Maximize GHG reduction in industrial facilities while considering technical and economic constraints
- Bloc-flow diagrams present the process and energy use in each equipment/process.



Multi-criteria Analysis Results – Bioenergy

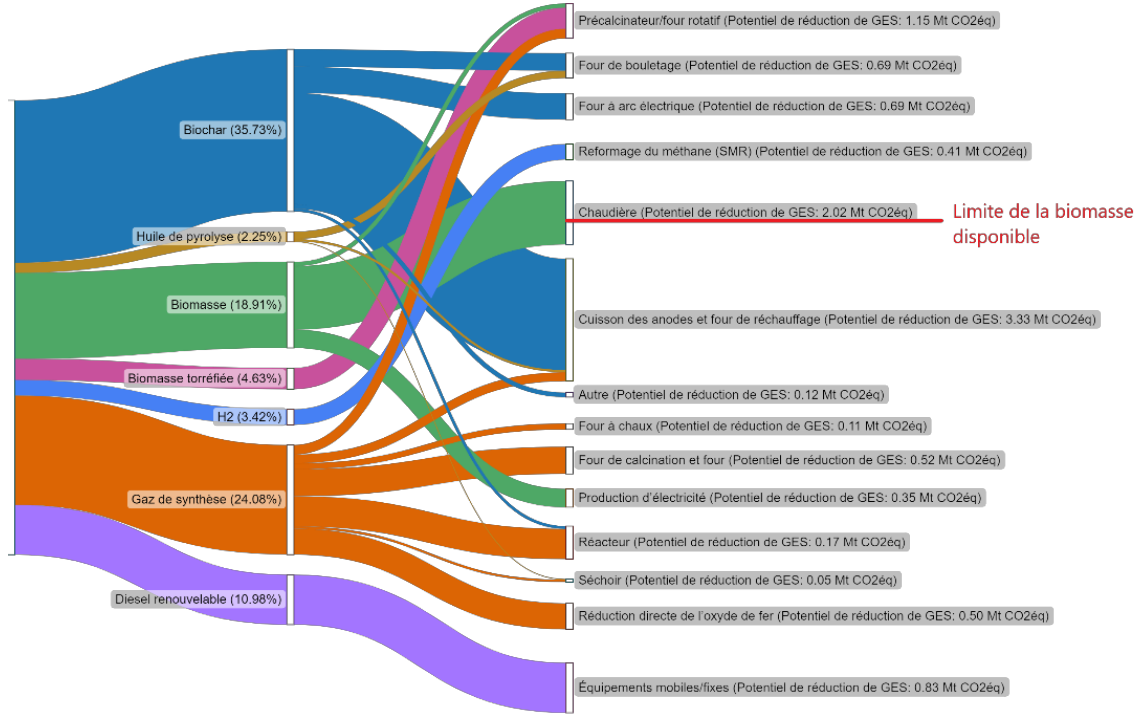




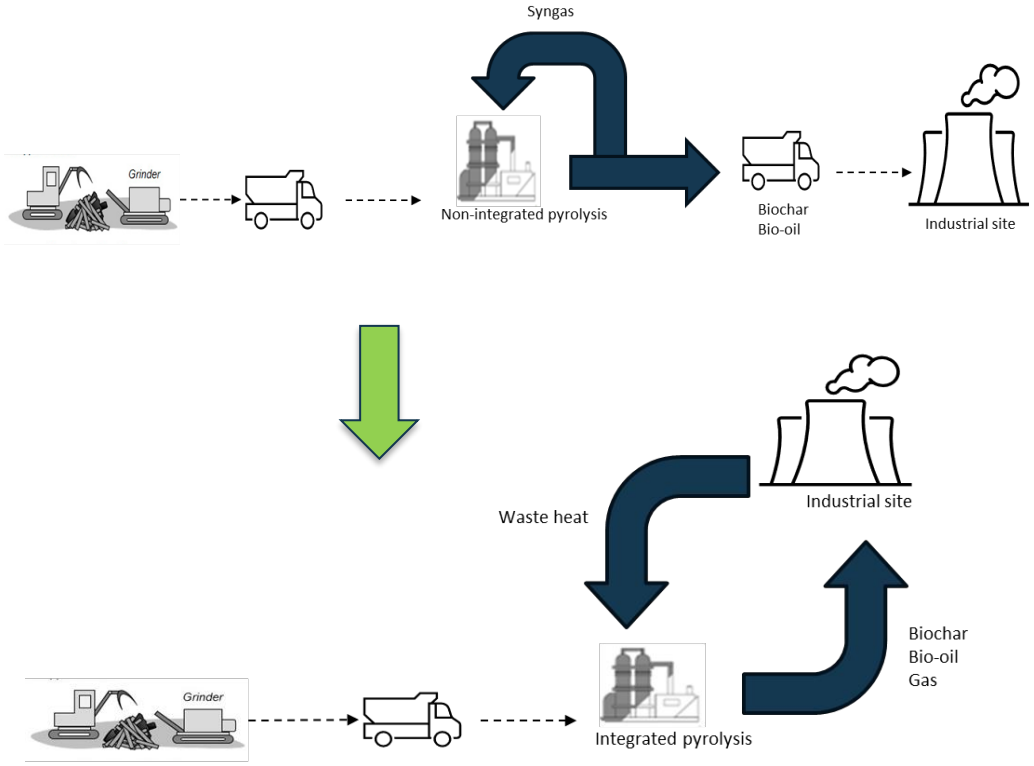
- Calciners and rotary kilns are the processes/equipment with the highest average priority score, followed by processes requiring biocarbon.
- Boilers account for the largest number of projects, and apply to various sectors such as pulp and paper, iron and steel, oil refineries, etc.
- Lower-priority projects mainly aim at replacing fossil fuels used in mining equipment with renewable diesel.
- Projects related to the production of bioenergy in solid or H_2 form have a higher priority score.

Multi-Criteria Analysis Results – Bioenergy (continued)

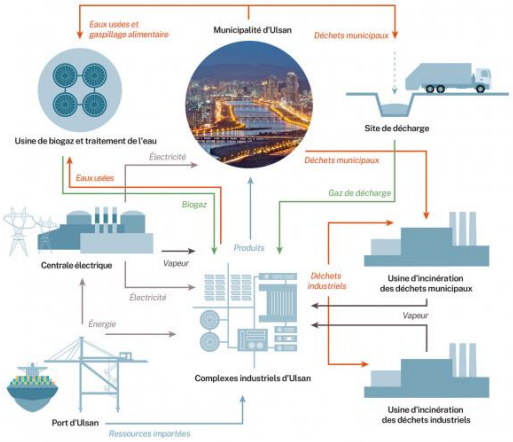
16 MODT



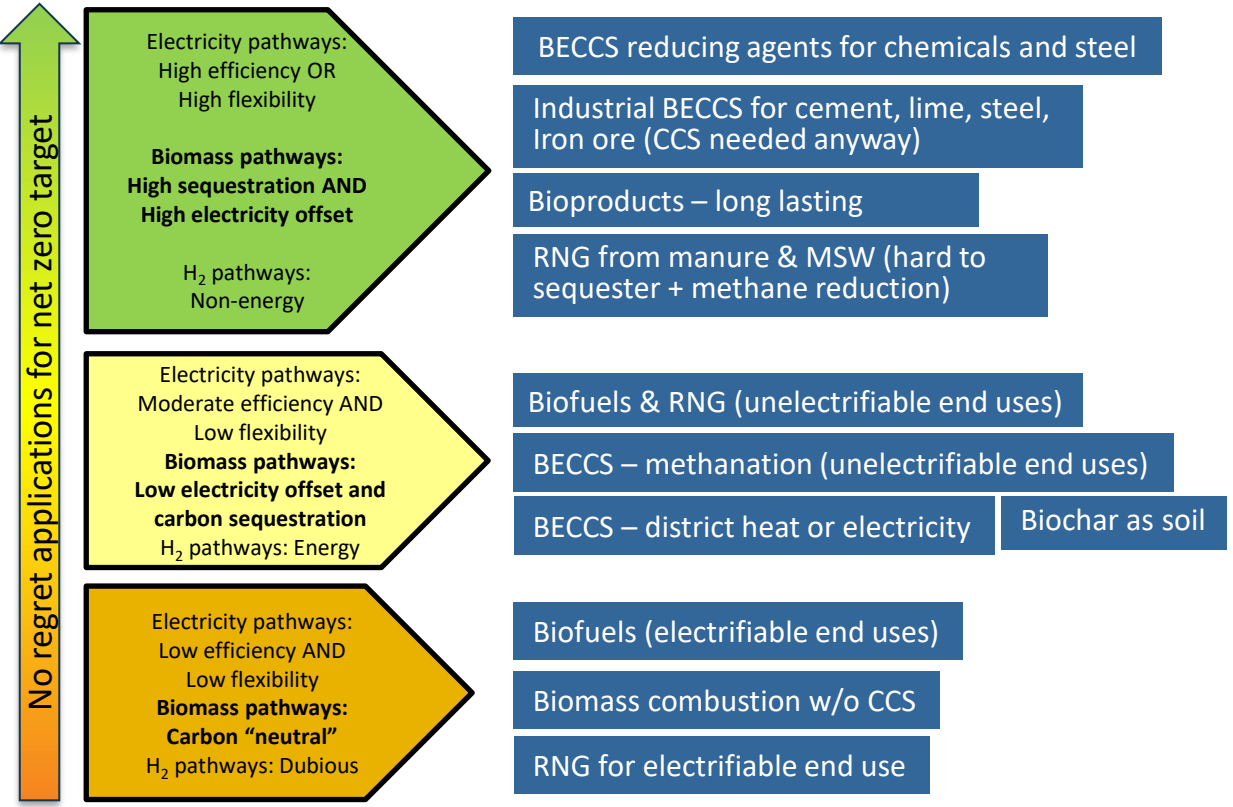
Biomass valorization through energy integration with industrial sites



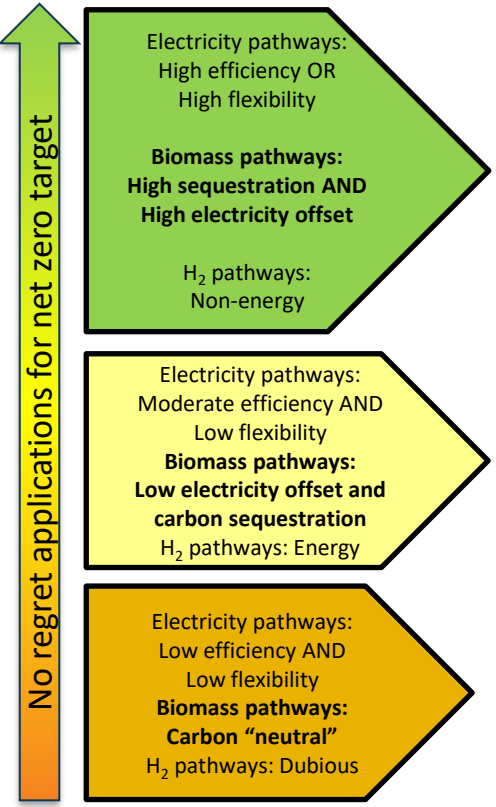
- Higher overall energy efficiency
- Possibility of using gaseous products from the bioenergy plant on an adjacent industrial site
- Lower cost (on a large scale as part of a long-term contract)
- Lower GHG emissions from biofuel production and transportation



Consensus Order of Merit for 2050 – Biomass



Consensus Order of Merit for 2050 – Biomass and Electricity



H_2 and BECCS as reducing agents for chemicals and steel

Industrial BECCS for cement, lime, steel, Iron ore (CCS needed anyway)

Bioproducts – long lasting

RNG from manure & MSW (hard to sequester + methane reduction)

High efficiency electro-technologies

Intermittent electric boilers & furnaces (curtailed renewables only)

Intermittent electrolysis (curtailed renewables only)

Electric heat pumps

Biofuels & RNG (unelectrifiable end uses)

BECCS – methanation (unelectrifiable end uses)

BECCS – district heat or electricity

Biochar as soil

Boilers & furnaces – continuous, high temp

H_2 for seasonal CHP

H_2 for long haul transportation

Biofuels (electrifiable end uses)

Biomass combustion w/o CCS

RNG for electrifiable end use

Boilers & heaters – coincident peaks, low temp

Continuous electrolysis

H_2 for heat (electrifiable end uses)

H_2 for CCU when CO_2 sequestrable

Biomass | Electrification | Green H_2

Conclusion

- CanmetENERGY in Varennes and the Gouvernement du Québec modelled decarbonization options from an *energy systems* perspective, to help guide heavy industrial CO_2 emitters
  - Combine different methods (case studies with industry, E3 models, MCA, etc.) to refine “order-of-merit” information (*pathway arbitrage* between bioenergy, hydrogen, electrification etc.) on different time scales, and subsequently to roadmap efficient and “no regret” pathways to industrial decarbonation

- Key lessons around bioenergy
  - The bioenergy projects identified for the industrial sector could require up to 16 MTBA. However, only 4.7 MT of dried biomass are currently available;
  - According to the analysis, projects producing bioenergy in solid and gaseous form gain greater merit for maximizing GHG reductions, especially when carbon sequestration is a co-benefit;
  - Projects allowing biogenic carbon sequestration reduce the amount of electricity needed for net-zero
  - Electrification should be favored where the technology is available, cost-effective, and energy efficient

Québec

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