NRC·CNRC

NRC.CANADA.CA

Combined production of biogas and hydrochar from food waste

Laurent Spreutels (Task 37, NTL Canada)

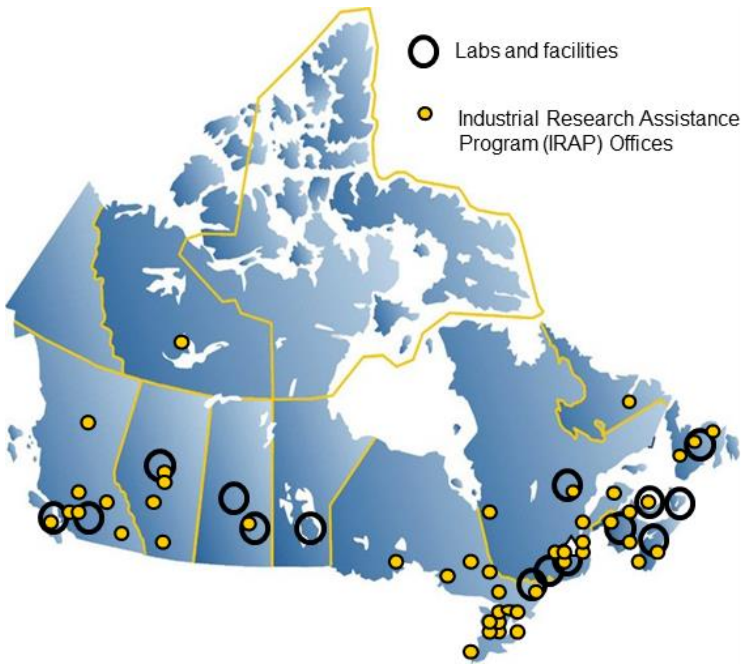
F. Tanguay-Rioux, F. Matteau-Lebrun, F. Ngoundjo

Bioprocess Engineering, Clean Energy Innovation

National Research Council Canada

October 23rd, 2024 – BBEST & IEA Bioenergy Conference – Sao Paulo, Brazil

Overview



Emerging Technologies
- Digital Technologies
- Advanced Electronics & Photonics
- Measurement Science and Standards
- Herzberg Astronomy & Astrphysics
- Security and Disruptive Technologies
- Nanotechnology

Transportation & Manufacturing
- Aerospace
- Automotive and Surface Transportation

Engineering
- Construction
- Clean Energy Innovation
- Ocean, Coastal and River Engineering

Life Sciences
- Aquatic and Crop Resource Development
- Human Health Therapeutics
- Medical Devices

Canada’s premier research and technology organisation (established 1916)

Targeted research and services addressing business and societal needs

Extensive technology expertise supporting Canada’s major economic sectors

Clean Energy Innovation

282

Researchers, engineers and experts in 5 sites across Canada

$37.8M

2023/24 Year-End Expenditures

$11.4M

2023/24 Revenues

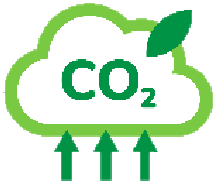
Solutions for Canada's Clean Transition

Clean Energy Innovation - Areas of Focus

Fuel Switching

Electrification

Hydrogen



Carbon Management

GHG emission reduction impact timeline

Near-term — Medium-Term — Longer-Term

R&D Program Map

Advanced Clean Energy (Mid to High TRL)

Industrial Carbon Management (Medium TRL)

Materials for Clean Fuels Challenge (Low TRL)

Advanced Clean Energy (ACE) Program

- Over 65 projects with partners from industry, academia and government
- Focus on mid to high TRL clean energy technologies that can be moved into multiple sectors
- Designed to support priorities of the Government of Canada to meet 2050 targets and fill R&D gaps for industry

1 - Battery Energy Storage

New Battery Critical Materials Initiative

Supporting the emerging battery supply chain

2 - Low Carbon Fuel Switching

Fuel switching using clean fuels produced from waste

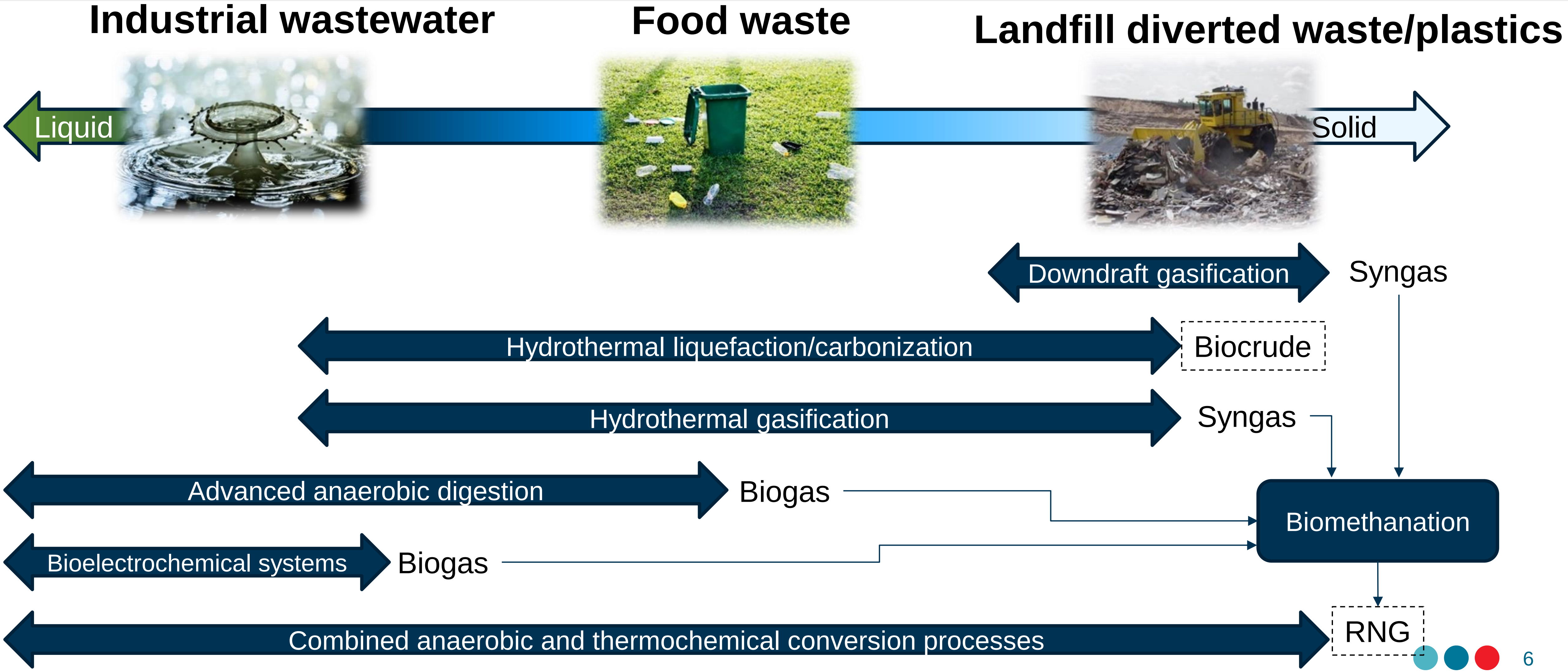
3 - Hydrogen

Supporting the production and distribution of fossil-free hydrogen

4 – Grid Integration

Validation and integration of renewables for grid resiliency

Advanced Clean Energy (ACE) Program
Low Carbon Fuels – Conversion and Upgrading



CONVERSION OF ORGANIC WASTES

Why combining bio and thermo?

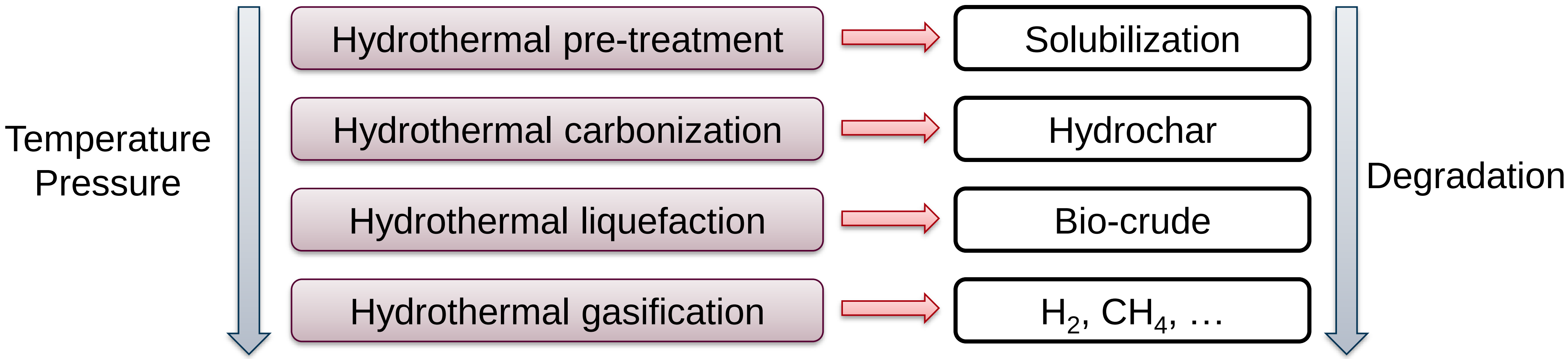
Why it’s challenging?

What can be done to overcome the challenges?

Thermochemical conversion of organic wastes: Hydrothermal processes

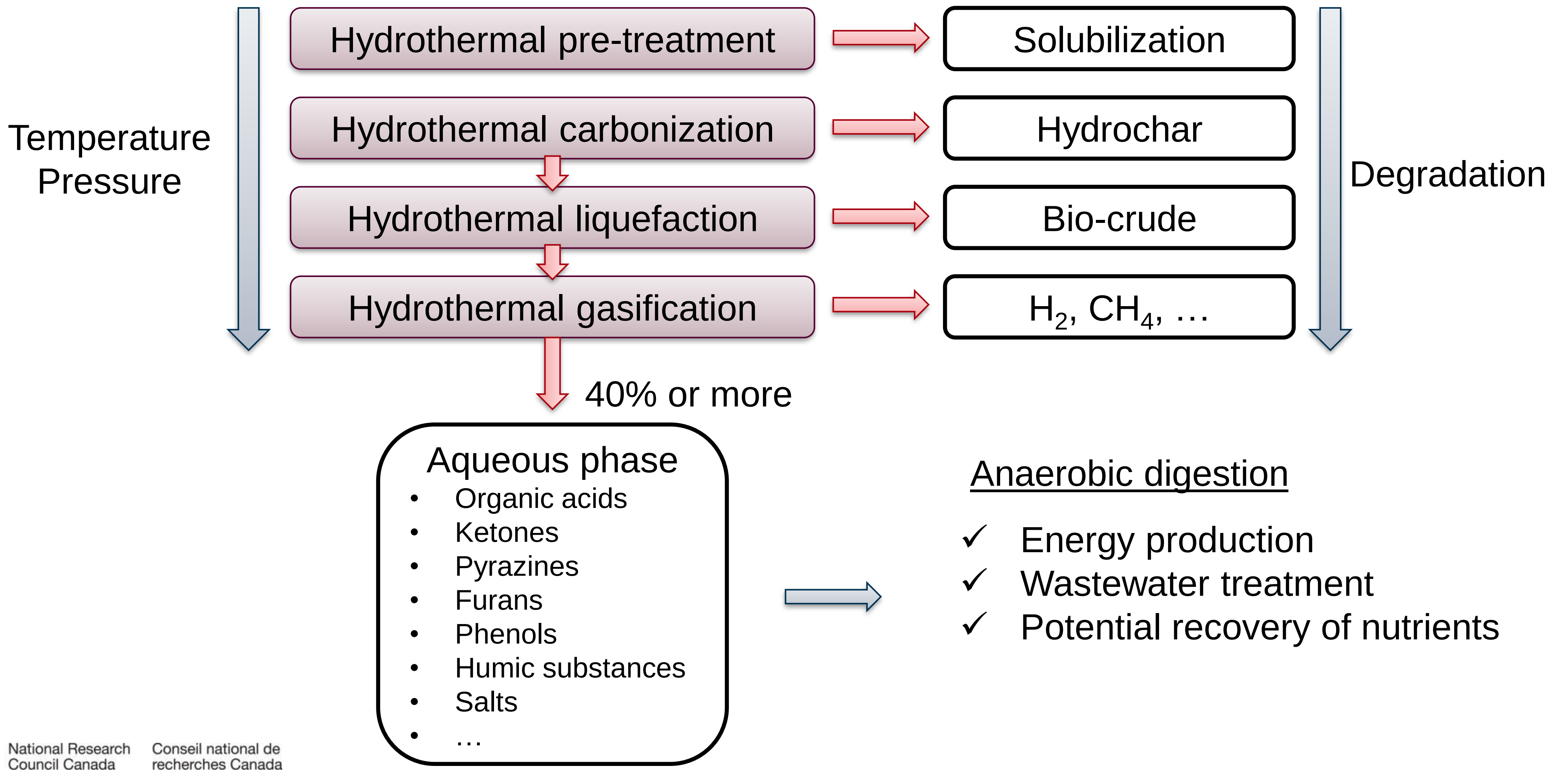
- **Organic wastes are generally wet (70-95% moisture)**
- **Conventional thermochemical processes require energy-intensive drying**

→ Hydrothermal processes



- Aqueous phase reforming
- Wet-air oxidation
- …

Anaerobic digestion of the aqueous phase from hydrothermal processes



Hydrothermal conversion of digestate from anaerobic digestion

Optimization (TEA/LCA)

Organic waste

Anaerobic digestion

Biogas
- CH_4
- CO_2

Digestate
- Organic fertiliser
- Nutrient source
- Very dependent on feedstock
- High moisture

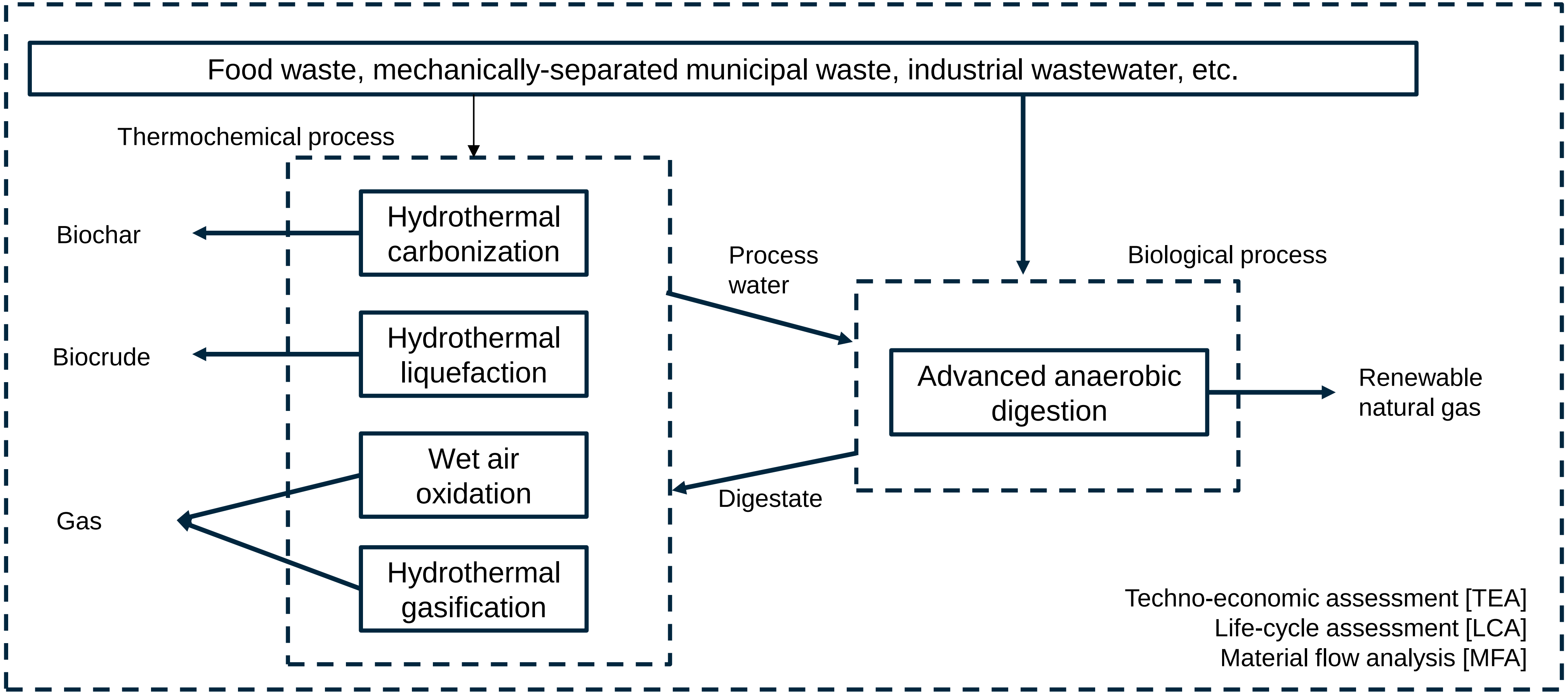
- ✓ Value-added products
- ✓ Additional energy production
- ✓ Heat recovery
- ✓ Degradation of contaminants

Hydrothermal treatment

Integration of HTC and AD for the conversion of challenging waste

HTT-AD project

Integration of thermochemical and biological processes for enhanced conversion of challenging organic wastes into fungible fuels.

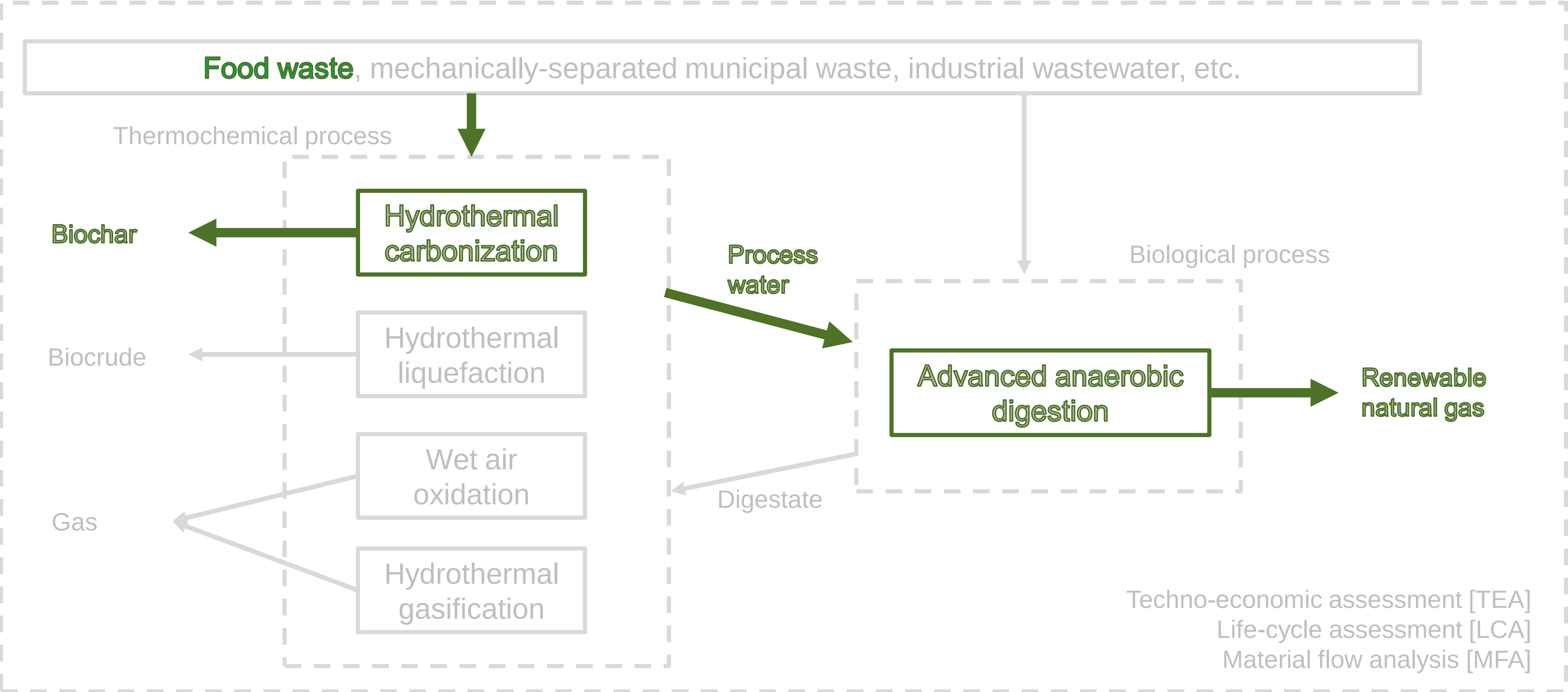


National Research Council Canada / Conseil national de recherches Canada

Case study #1 – HTC + AD

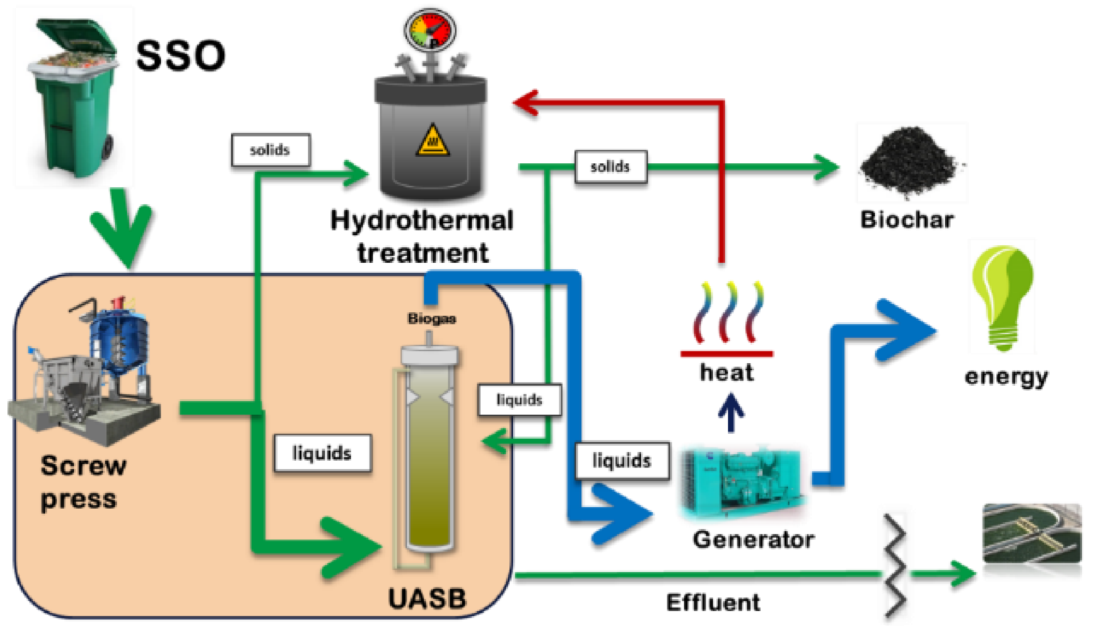
HTT-AD project

Integration of thermochemical and biological processes for enhanced conversion of challenging organic wastes into fungible fuels.



Case study #1 – HTC + AD
CH4 production from liquid fractions

- Food waste is only partially biodegradable in AD
- Operation at low organic load (accumulation of VFAs at high load)



Converting the solid and liquid fractions separately

- ✓ Reduce size of the AD for food waste treatment → high rate digester
- ✓ Increase energy production
- ✓ Reduce contamination issues

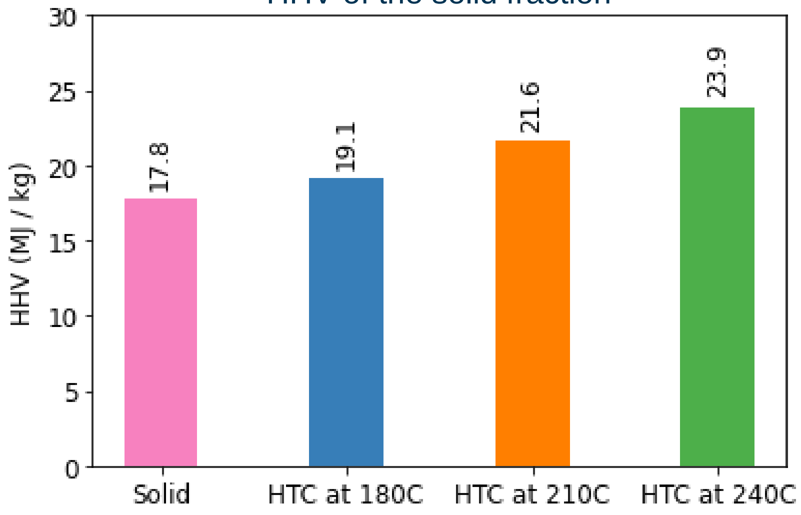
Tanguay-Rioux et al. (2024). *Assessment of the Feasibility of Converting the Liquid Fraction Separated from Fruit and Vegetable Waste in a UASB Digester*. Bioengineering.

Case study #1 – HTC + AD
CH4 production from HTC process water

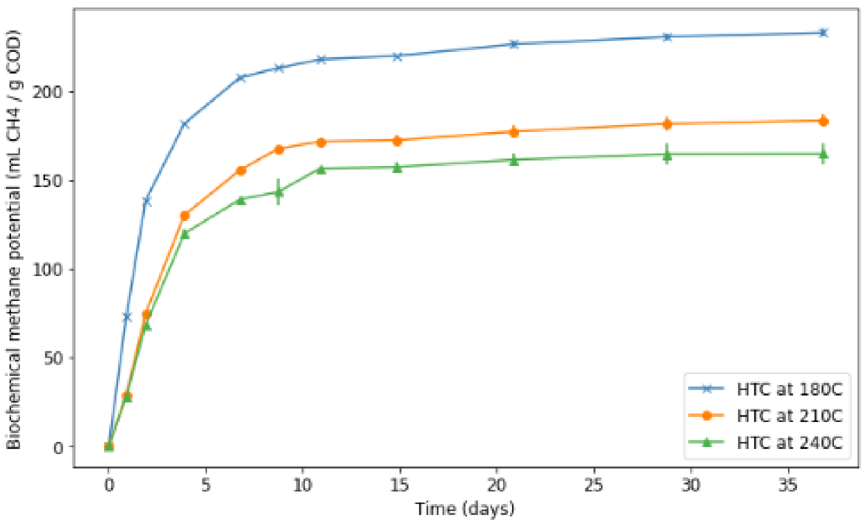
Hydrothermal carbonization of the solid fraction of food waste and conversion of the process water by AD

- Demonstration at a lab-scale

HHV of the solid fraction



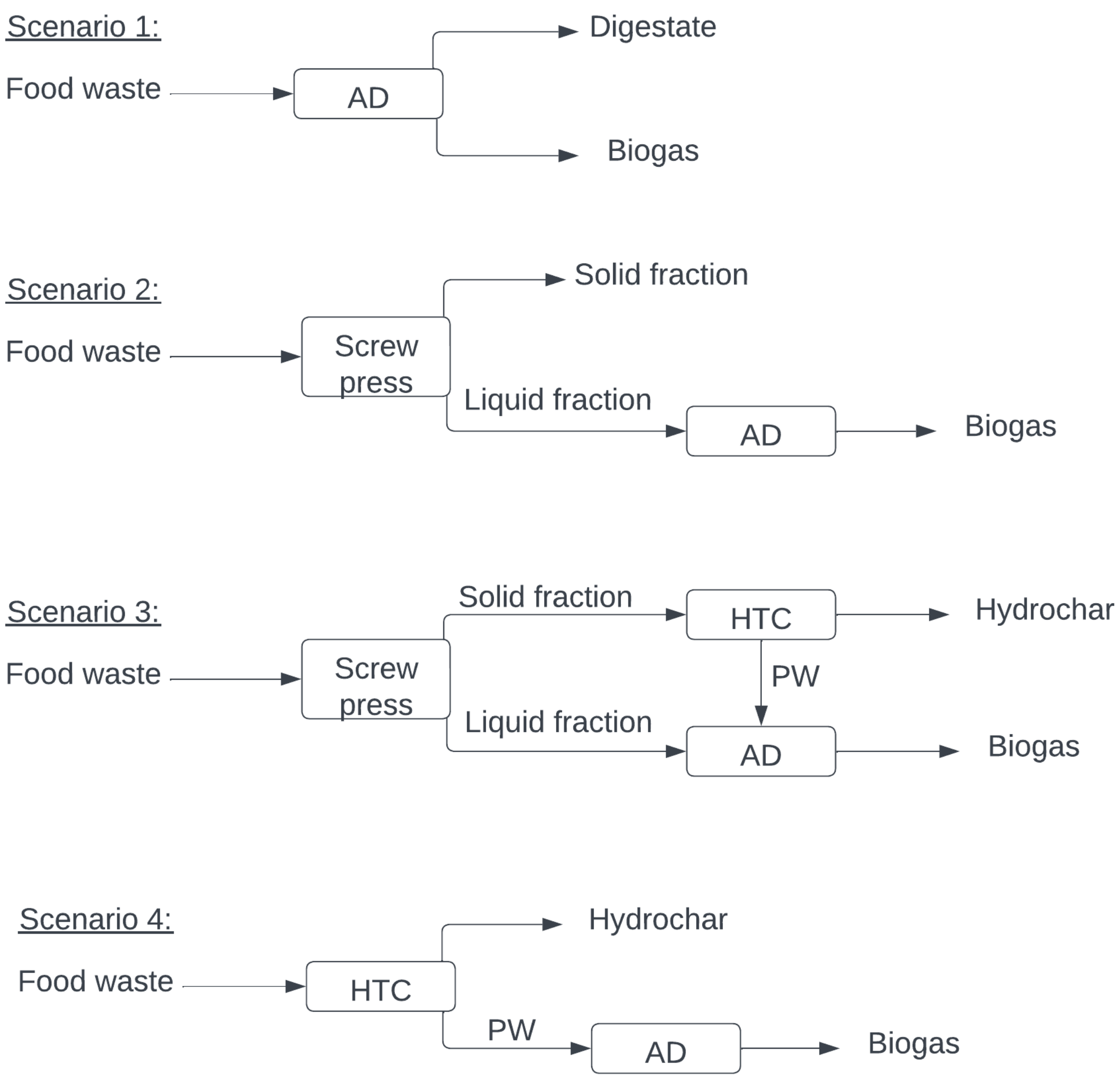
BMP of the liquid fraction



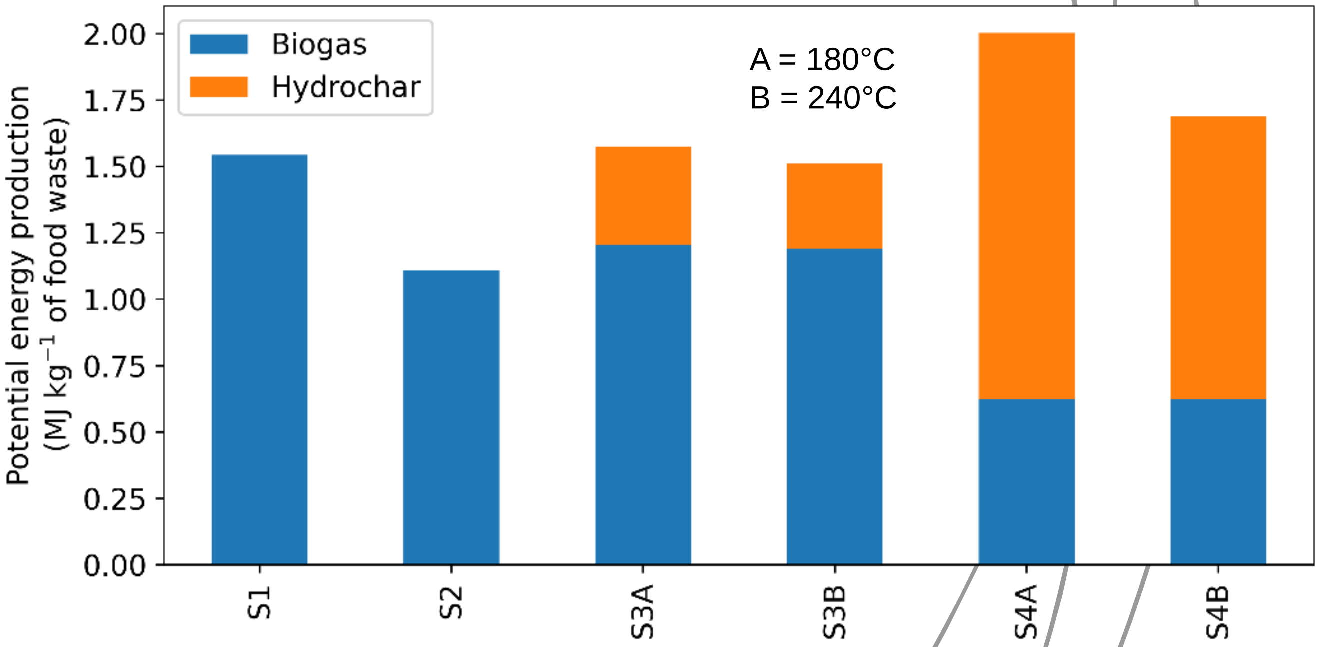
→ Inverse effect of temperature on hydrochar and process waters

→ 50% hydrochar, 40% process water, 10% gas

Case study #1 – HTC + AD
Comparing different scenarios



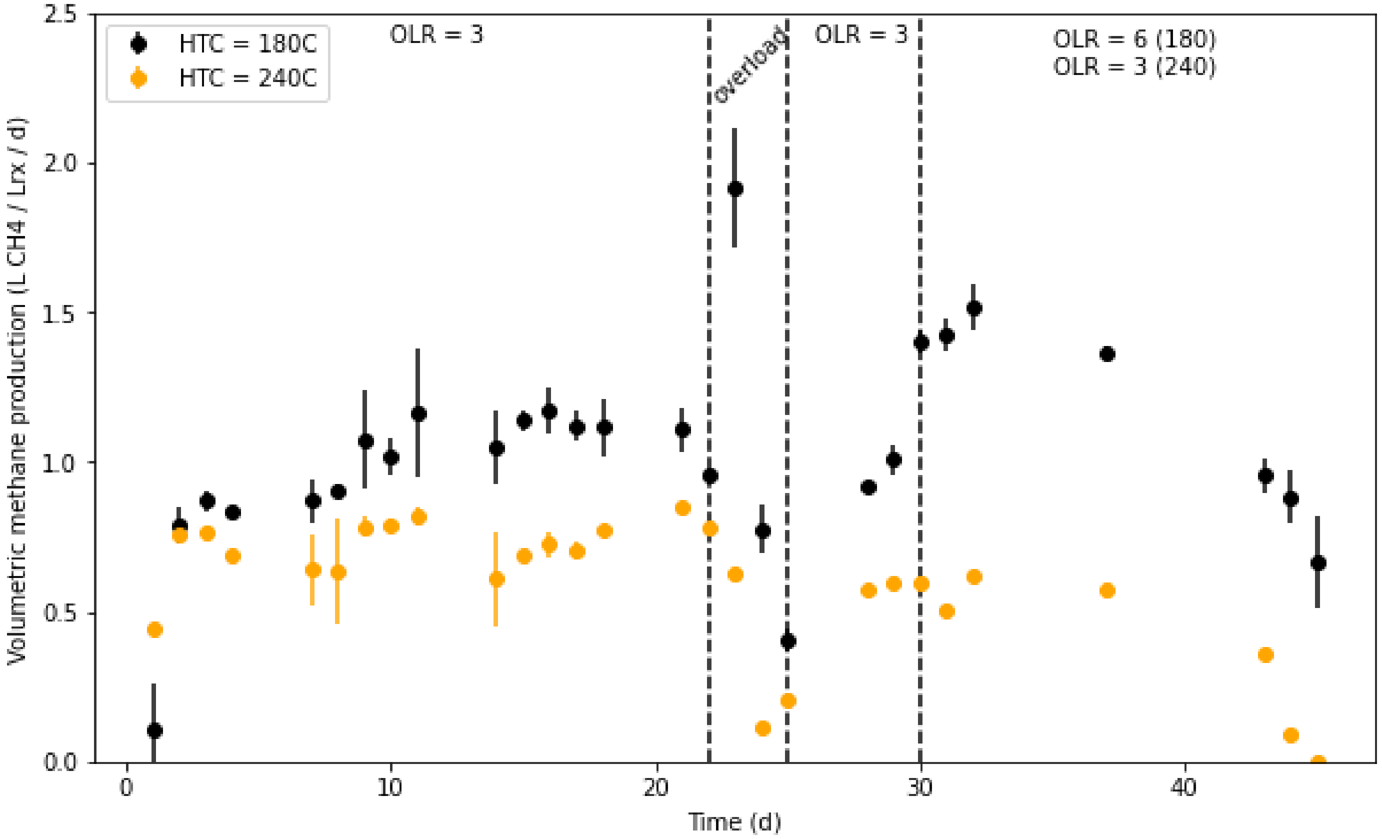
Potentially recoverable energy according to the scenarios of food waste conversion



Tanguay-Rioux F. et al. (2024). *Conversion of the solid fraction of food waste separated by a screw press using an integrated hydrothermal carbonization and anaerobic digestion process.* Waste Management

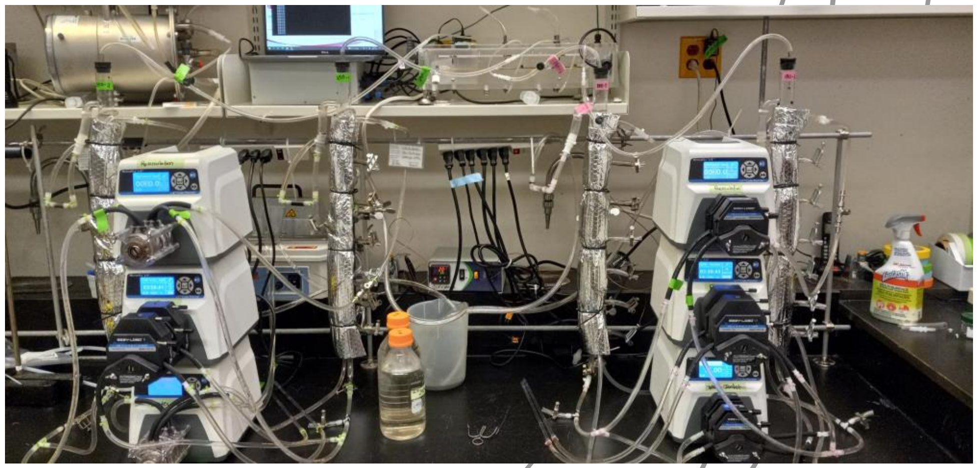
Case study #1 – HTC + AD
What happens in continuous digester?

- Continuous conversion of process waters in a UASB



HTC temperature (180°C vs 240 °C)

- Higher methane production @ 180°C
- Higher tolerance to overload @ 180°C
- Accumulation of inhibiting compounds, both cases

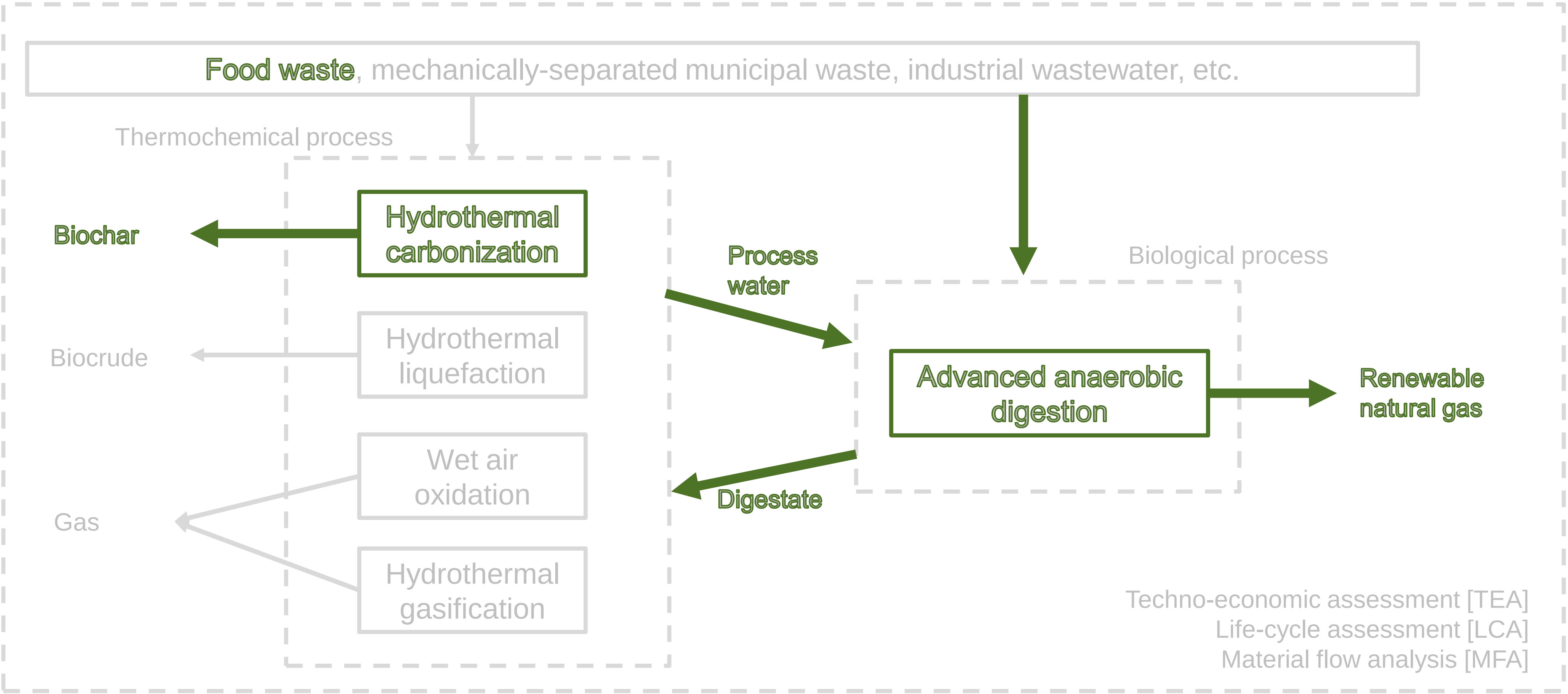


National Research Council Canada
Conseil national de recherches Canada

Case study #2 – AD + HTC + AD

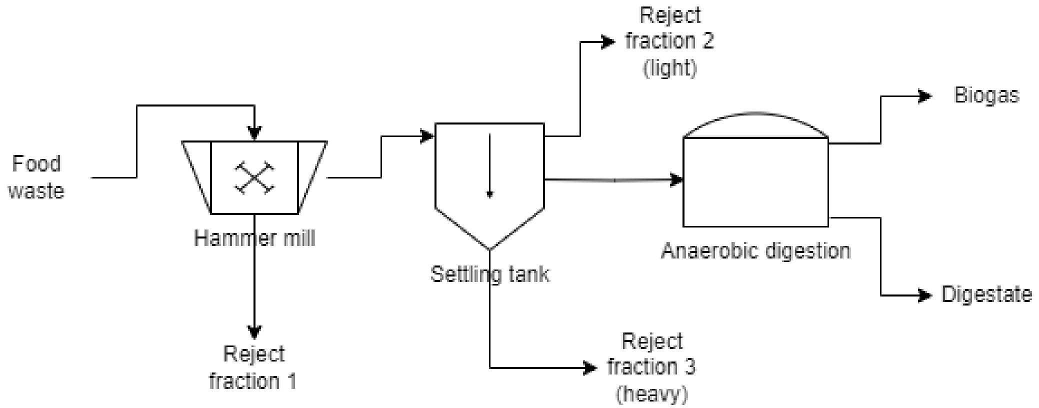
HTT-AD project

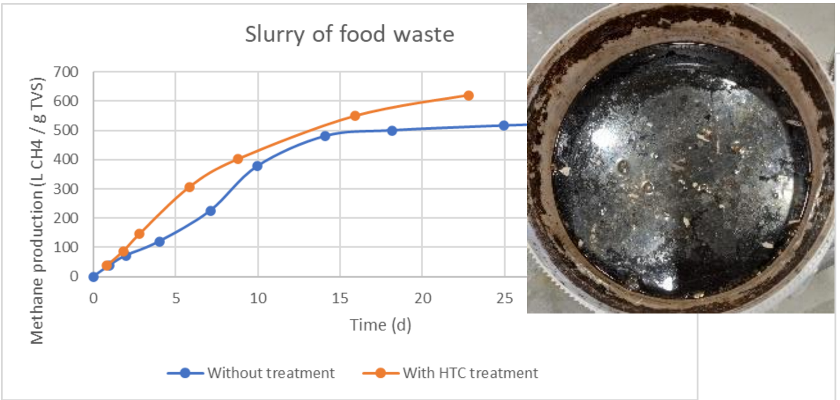
Integration of thermochemical and biological processes for enhanced conversion of challenging organic wastes into fungible fuels.

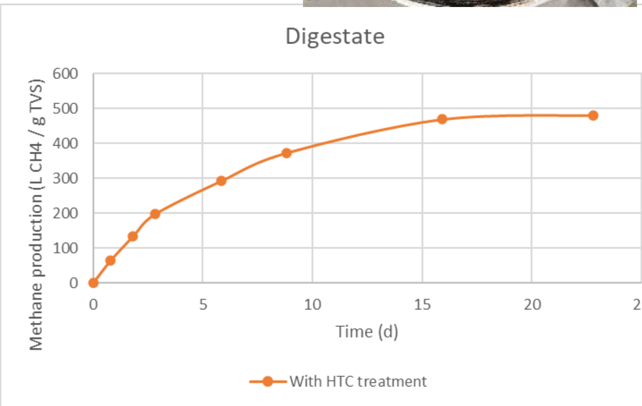


Case study #2 – AD + HTC + AD
Effect of HTC on digestate and CH4

HTC as a way to improve CH_4 production from AD and decrease waste



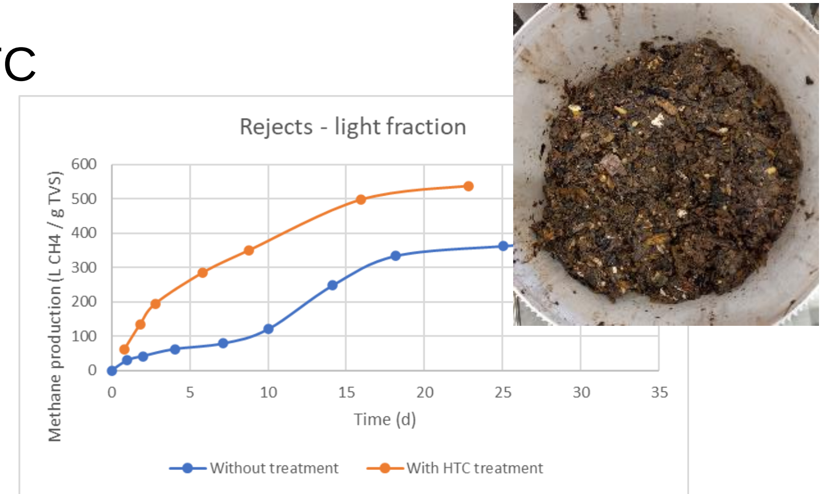


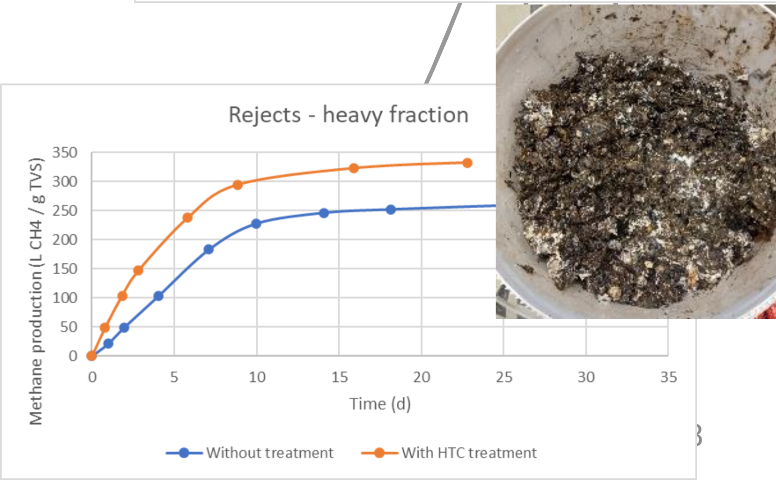


→ Conversion of the reject fractions by HTC

→ Recirculation of PW in the digester

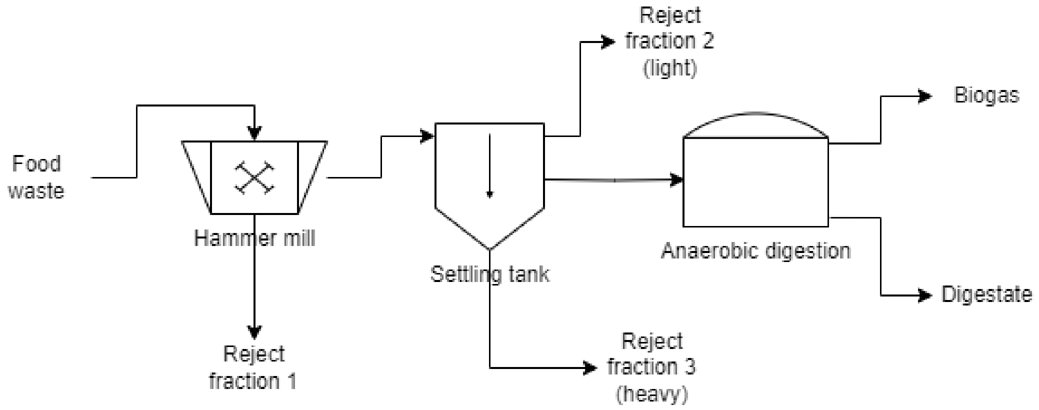
→ Reduction of losses by 50% (landfilling)



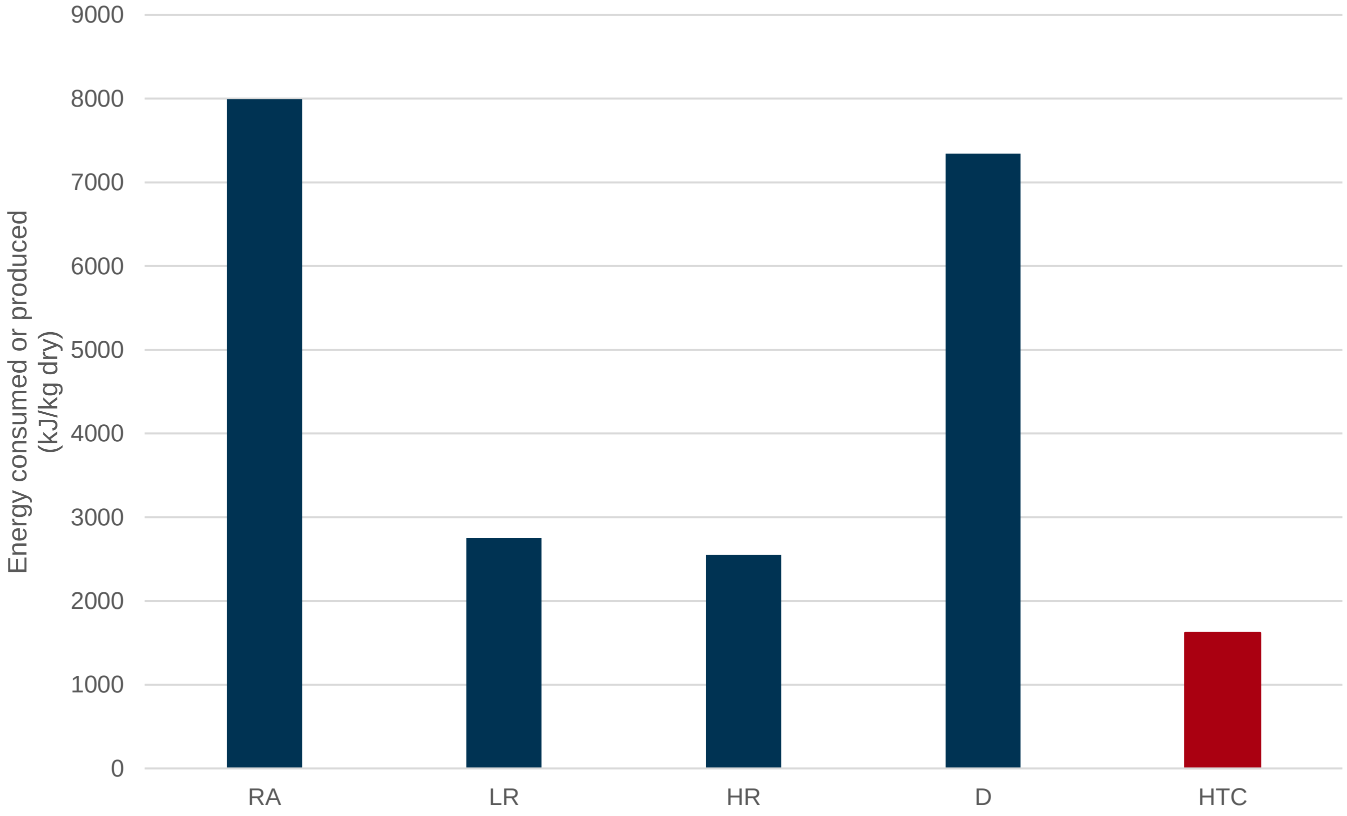


Case study #2 – AD + HTC + AD
Effect of HTC on digestate and CH4 - Energy

HTC as a way to improve CH_4 production from AD and decrease waste



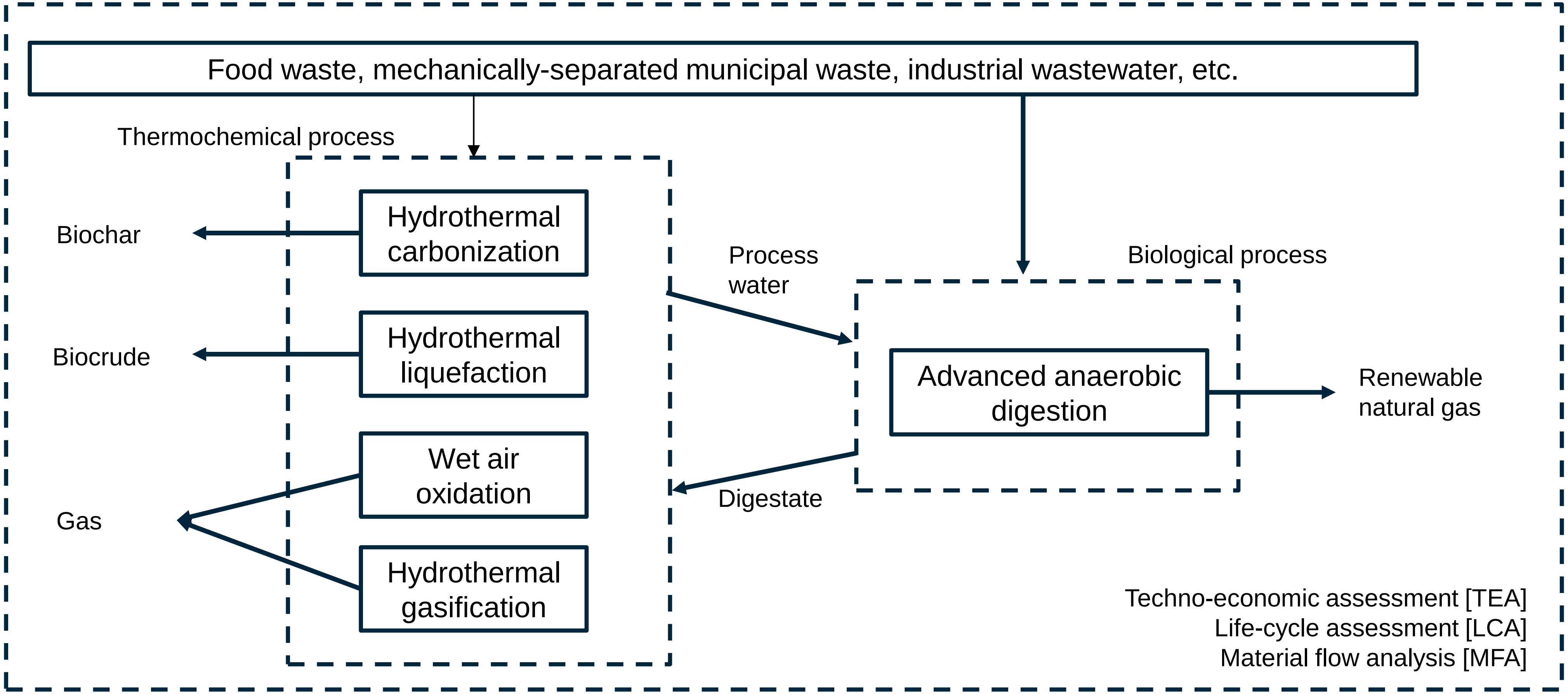
→ Potential positive gain in energy



Integration of HTC and AD for the conversion of challenging waste

HTT-AD project

Integration of thermochemical and biological processes for enhanced conversion of challenging organic wastes into fungible fuels.



Conclusion

- **Combining HTT and AD makes sense and is possible.**
- **Trade-off between hydrochar and CH4 production.**
- **Two main factors influencing the performance of HTC-AD:**
  - Temperature of HTC → composition of PW and hydrochar quality
  - Composition of substrate → composition of PW
- **Continuous AD tests showed that monitoring and control of microbial population and metabolites is important to ensure stable operation.**
- **Overall, next steps should include multilevel analysis (from metagenomic to LCA)**

THANK YOU

Laurent Spreutels, PhD
Team Leader – Bioprocess Engineering
Clean Energy Innovation
National Research Council of Canada
6100 av. Royalmount, Montréal, Québec, Canada, H4P 2R2
Laurent.Spreutels@cnrc-nrc.gc.ca