Enerkem biorefineries: setting a new global standard in biofuels, chemicals and waste management
Enerkem at a glance

- MSW-based biofuels and renewable chemicals producer
- World’s first full-scale commercial MSW biorefinery beginning operations in Edmonton, Alberta
- $400M invested to date to move from R&D to commercial stage
- 200 employees
- New alternative to landfilling and incineration
The Enerkem solution

**Feedstock**
- Municipal Solid Waste

**Process**
- Syngas
- Proprietary Thermochemical Technology

**Products**
- Ethanol / Methanol
- Renewable Chemicals
- Power Generation

**Markets**
- Transportation Fuels
- Solvents, Polymers, Coatings, Plastics, Adhesives

- Product cost competitive with those derived from fossil-based feedstocks

- 10 year history – Largest operating demo plant in cellulosic ethanol

- Approximately 1.3B MT\(^{(1)}\) of trash generated per year globally

End Products Flexibility
Benefits of using waste as feedstock

ENVIRONMENTAL

• Reduces GHG emissions
• No land use impact
• Sustainable alternative to landfilling
• Complementary to recycling
• Fuel produced close to point of consumption/feedstock (limited transportation)

ECONOMIC

• Most inexpensive feedstock (typically no cost)
• Abundant resource
• Readily available and collected
• Available in all regions (urban and rural)
Alternative to landfilling and traditional WTE

Helping increase waste diversion to 90%
Large market potential

Large market potential

**MSW IN THE WORLD**

85% TO LANDFILL

1.3 BILLION METRIC TONS OF MSW GENERATED PER YEAR

548 MILLION METRIC TONS OF MSW SUITABLE FOR ENERKEM’S TECHNOLOGY PLATFORM

THE POTENTIAL: 329 BILLION LITRES' USING ENERKEM (87 B GALLONS)

- Ethanol and biomethanol as well as ethanol are used as a transportation fuel blend in many EU states and China
- Unique opportunity in EU and China
Cost-competitive and sustainable solution

**Municipality:**
- Supplies 100,000-400,000 tons of MSW per year (long-term contract)
- Pays tipping fee – attractive compared to status quo
- Suggests sites

**Enerkem:**
- Invests approx. $100-200M to build, own and operate the biorefinery
- Converts RDF into 10 to 40 MMGPY of biofuels/biochemicals
- Works with the city to optimize MSW sorting into commodities and for site selection
- Manages business risks incl. sale of final product
- Creates high-quality jobs:
  - 610 direct/indirect during construction
  - 152 direct/indirect (permanent) during operation (for 1 X standard Enerkem system of 10 MMGPY)
- Generates $C65 M/year in net economic benefits in the region (for 1 X standard Enerkem system of 10 MMGPY)
An efficient “carbon-recycling” process

<table>
<thead>
<tr>
<th>Feedstock preparation</th>
<th>Gasification</th>
<th>Cleaning and conditioning process</th>
<th>Catalytic synthesis and product purification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sorting, shredding, drying (if required) and feeding</td>
<td>Conversion of carbon-rich residues into synthetic gas</td>
<td>Primary syngas purification</td>
<td>Conversion of chemical-grade syngas into final renewable products</td>
</tr>
</tbody>
</table>

![Diagram of the carbon-recycling process](Image)

*Municipal solid waste*
Unique partnership with the City of Edmonton

- Leader in waste management practices
- Edmonton Waste Management Centre
  - North America’s largest collection of modern, sustainable waste processing and research facilities
  - 233-hectare site
- Enerkem selected as part of a thorough selection process involving over 100 technology providers
City of Edmonton’s Integrated Waste Management Centre

1. Integrated Processing and Transfer Facility
2. Recycling center
3. Composting center
4. ENERKEM biorefinery

Recycled ➡ 20%
Composted ➡ 40%
Biofuels ➡ 30%
Landfill ➡ 10%

Waste diversion = 90%
World’s first commercial MSW-to-biofuels and chemicals facility

ENERKEM ALBERTA BIOFUELS

Capacity: 38 million litres per year (i.e. 1 X standard Enerkem system)
Feedstock: 25-year agreement with City of Edmonton for 100,000 dry tonnes of MSW per year
Products: Biomethanol, cellulosic ethanol
Benefits of the Enerkem Alberta Biofuels facility

Economic

• An investment of >$100M
• High-quality jobs: 150 direct and indirect permanent jobs\(^1\)
• 610 direct and indirect jobs\(^2\) during construction
• Increases annual net economic spending in the local area by $65 million
• Helps diversify Alberta economy

\(^1,2\): Based on an independent economic impact analysis conducted by Doyletech using their EconWin model
Benefits of the Enerkem Alberta Biofuels facility

**Energy**

- Diversifies energy basket
- Contributes to meeting provincial Renewable Fuel Standard
  - Enerkem’s production will represent ~10% of required ethanol production
- Positions Alberta at the forefront of clean technology and advanced biofuels
- Creates synergies with petrochemical sector and research institutions
Benefits of the Enerkem Alberta Biofuels facility

Environmental/Social

• Solves a waste problem and avoids methane emissions
• Reduces GHG emissions by 60% when compared to gasoline
• Can become a model for municipalities around the world
Bringing the model to reality

Rigorous path to commercialization
Next facility: VANERCO

First advanced biofuels facility in Canada to be co-located with a conventional biofuels production facility

Capacity: 38 million litres
(1 standard Enerkem system \(\rightarrow\) possibility to add more systems)

Feedstock: Non-recyclable/non-compostable urban waste
(industrial, commercial, institutional, construction, etc.)
Using waste as a feedstock for the chemical industry

Waste-to-Chemicals public-private partnership in Europe

![Diagram showing waste-to-chemicals process with partners AkzoNobel, Enerkem, Air Liquide, AVR, CleanTech Delta, Port of Rotterdam, Gemeente Rotterdam, and province Zuid Holland.](image)
Target growth areas for global partnerships

- Strategic partnerships with leading industrial groups
- Selection based on market attractiveness:
  - public policies
  - tipping fees
  - proximity to petrochemical infrastructure
  - population
Renewable chemicals for everyday products

<table>
<thead>
<tr>
<th>Chemical building blocks in our syngas</th>
<th>Product Family</th>
<th>Applications</th>
</tr>
</thead>
</table>
| CO                                    | Alcohols       | • Transportation fuels  
|                                        |                | • Solvents for pesticides and coatings  
|                                        |                | • Pharmaceuticals  
|                                        |                | • Polymers  
|                                        |                | • Cosmetic products  
|                                        |                | • Plastics  
|                                        |                | • Textiles  
| H₂                                    | Acrylates      | • Architectural and industrial coatings  
|                                        |                | • Plastics  
|                                        |                | • Adhesives  

Renewable Methanol
Next projects

• Biomethanol facilities in Europe
• Projects under development in Canada and the U.S.
• MOUs in China and other regions of the world
Thank you

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