Enerkem: A waste-to-biofuels solution for China
Bringing clean innovation to reality

Rigorous path to commercialization

- **Testing Phase** (2002-2008)
- **Demo Phase** (2008-2012)
- **Commercialization Phase** (2012-2016)

Enerkem Today

- Varennes, Rotterdam, Barcelona, Minneapolis & UK

- **100+ PATENTS**
- **200+ EMPLOYEES**
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
Building the circular economy and more sustainable energy

Value added greener products to consumers and industries

Post-consumption waste generation

Replacing fossil sources with garbage and low-carbon methanol and ethanol

Converting waste into advanced biofuels and renewable chemicals
# Proprietary thermochemical process

<table>
<thead>
<tr>
<th>Feedstock preparation</th>
<th>Cracking</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>

* Municipal solid waste

![Diagram of the process](image-url)
Unique Feedstock Flexibility

More than 50 feedstock successfully tested in our system

- MSW (Toronto, Sherbrooke, London (UK) and Edmonton)
- Forest biomass (as well as treated wood and C&D wood, both pelletized and chipped)
- Biosolids (dried, from Montreal and from pulp & paper operation)
- Glycerin
- Plastics (various forms: pelletized, shredded, fluffed and mixed)
- Petcoke (Alberta, with 8% humidity and 5-6% sulfur)
- Agriculture biomass (wheat straw, corn stovers)
- More than 25 feedstocks tested successfully in the process
- More than 50 feedstock successfully tested in our system
Municipal Solid Waste (~$215B\(^{(1)}\) Market)

- Global MSW production increasing
- Landfill and incineration taxes and costs also increasing due to stringent permitting and regulations
- Growing prevalence of environmental and circular economy concerns

Communities around the world are seeking alternative waste disposal solutions. Enerkem changing existing landfill and incineration status quo

Biofuels (~$56B\(^{(2)}\) Market)

- Proliferation of new Renewable Fuel Standards including in China (now mandates in 64 countries)
- Focus of mandates is on advanced and cellulosic biofuels (non-edible)
  
  Large capacity gap in market exists today to meet requirements

Enerkem has a significant cost advantage vs. incinerators and landfills

Enerkem is the only proven scalable technology capable of addressing this gap

Strategically Positioned for Exceptional Growth

Upstream & Downstream Markets equivalent to ~2,343 Enerkem Edmonton production lines\(^{(3)}\)
THE CITY OF EDMONTON’S INTEGRATED WASTE MANAGEMENT CENTRE

1. Integrated Processing & Transfer Facility
2. Recycling center
3. Composting center
4. Enrkems biorefinery

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

90% WASTE DIVERSION

Edmonton
Alberta Innovates
Cost-competitive and sustainable solution

**Municipality:**
- Supplies 230,000 tons (bone dry basis) of MSW per year (as available)
- Long-term contract
- Pays tipping fee – attractive compared to status quo
- Suggests sites

**Enerkem:**
- Technology provider and joint venture partner in biorefinery projects – partners with upstream and/or downstream industry
- Converts RDF (SRF) into biofuels and renewable chemicals (ethanol or methanol)
- Works with the waste and municipal partners to optimize MSW sorting into commodities and for site selection
- Manages business risks incl. sale of final product with partners
- Generates net economic benefits in the region with attractive employment and business with local industry & service providers.
NEXT PROJECTS

- Biomethanol facilities in Europe
- Projects under development in Canada and the U.S.
- Major joint venture signed with Sinobioway for 100 Enerkem facilities in China by 2035.
Key success factors

• Predictable and favorable policies and regulations to attract private investment
• Patient capital for financing (long cycle of development vs other industries)
• Right skills and talents at the right moment
• Viable business model not relying on subsidies
• Right partners and strong commercial relationships for feedstock, co-investment, off-take, equipment supply
• Modular manufacturing based on pre-fabricated modules
• Strong IP strategy
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)
Overview of European REDII by 2030 for Enerkem Biomethanol

- **≥32% Renewable Energy**
  - (To be achieved at EU level)

- **≥14% in Transport**
  - (Minimum binding mandate for fuels suppliers)

- **7% crop-based biofuels (CAP)**
  - Cap based on 2020 consumption
  - Min. GHG threshold set at 65% for facilities starting operations after 1/1/2021
  - Sustainability criteria to meet
  - Phase-out of palm oil by 2030

- **3,5% waste-based; new technologies**
  - (annex IX part A; incl. MSW)
  - (MINIMUM; binding mandate)

- **1,7% waste-based; mature technologies**
  - (annex IX part B; incl. used cooking oil for biodiesel)
  - (CAP)

Other Options to meet transport mandate:
- 1. Recycled carbon fuels (fossil waste-based; GHG threshold TBD)
- 2. Electric Vehicles (Evs) (4 multiplier)
- 3. Aviation fuels (1.2 multiplier)
- 4. Marine fuels (1.2 multiplier)
- 5. Rail fuels (1.5 multiplier)

Note: Multipliers are optional except for EVs

- Electricity
- Heating/Cooling
- Transport

- **Eligible/Approved solutions to meet transport mandate under REDII**
  - Mandate: 0.2% by 2022, 1.5% by 2025 and 3.5% by 2030
  - Double counting measure allowed
  - Min. GHG threshold set at 65% for facilities starting operations after 1/1/2021
  - (Baseline scenario for gasoline is increasing. Will therefore compare ourselves to a more polluting fuel which gives us an advantage.)

- **Double counting measure allowed**
  - Min. GHG threshold set at 65% for facilities starting operations after 1/1/2021

* Final adoption (procedural step) expected in October 2018
Plant Design, Procurement, Manufacturing & Supply Chain

- BioMethanol lines made up of 90 modules
- BioEthanol lines made up of 105 modules
- 90% modularized
- ~20 tested modules suppliers
- 40 of our 200+ employees are dedicated to procurement activities
- Modules contracts are on a fixed-priced basis with delivery liquidated damages
- ~80%-90% of costs are firmed-up & “de-risked” prior to construction phase
Developing other products as part of R&D program

<table>
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<tr>
<th>Chemical building blocks in Enerkem’s synthesis gas</th>
<th>Product</th>
<th>Global Market Size</th>
<th>Current Market Prices (1)</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>Acrylic Acid</td>
<td>&gt;$14 billion&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>$2,300+ / MT</td>
<td>Industrial Coatings, Paints, Fiber</td>
</tr>
<tr>
<td>H&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Acetic Acid</td>
<td>&gt;$4.3 billion&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>$450+ / MT</td>
<td>Solvents, Pesticides, and Coatings, Chemical Intermediate</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Ethyl Acetate</td>
<td>~$1.5 billion&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>$1,700+ / MT</td>
<td>Coatings, Solvents, Ink</td>
</tr>
<tr>
<td></td>
<td>Butanol</td>
<td>&gt;$2.4 billion&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>$1,400+ / MT</td>
<td>Solvent, Chemical Intermediate, Fuel</td>
</tr>
<tr>
<td></td>
<td>Propanol</td>
<td>&gt;$3.5 billion&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>$1,900+ / MT</td>
<td>Fuel Additive, Plastic Intermediate, Solvents</td>
</tr>
<tr>
<td></td>
<td>Dimethyl Ether (DME)</td>
<td>&gt;$4.8 billion&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>$450+ / MT</td>
<td>Fuel, Aerosol Propellant</td>
</tr>
<tr>
<td></td>
<td>Jet / Diesel Fuel</td>
<td>&gt;$640 billion&lt;sup&gt;(3)&lt;/sup&gt;</td>
<td>$5.0 / Gallon</td>
<td>Fuel</td>
</tr>
</tbody>
</table>

Sources: 1) ICIS, in USD, 2) ICIS, Company estimates 3) Argus DeWitt
Thank you

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www.enerkem.com