Design and Economics of an Advanced Biomass Processing Depot - Case Study in Southern Quebec

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Bécancour Waterfront Industrial Park
(Québec, Canada)
Bécancour Waterfront Industrial Park
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### Centralized vs. Decentralized Supply Chain

<table>
<thead>
<tr>
<th>Centralized</th>
<th>Decentralized</th>
</tr>
</thead>
</table>
| **Corn stover fields**  
Collection  
Storage | **Corn stover fields**  
Collection  
Storage |
| | **Depots**  
Grinding  
Pretreatment  
Densification  
Hydrolysis  
Coprodcts use |
| **Biorefinery**  
Grinding  
Pretreatment  
Hydrolysis  
Fermentation  
Distillation  
Coprodcts management  
Distribution | **Biorefinery**  
Fermentation  
Distillation  
Distribution |
Materials & methods

Location criteria

Animal distribution

Availability ag feedstock

Availability urban feedstock
Depending on farmer participation, decentralized performance can be 16% to 42% more efficient than centralized configurations.

A decentralized network with several small depots tends to reduce the average impedance as biomass availability increases.

This is due to the transport savings related to a denser and more connected network.
Inputs - Specificity & logistics

24 k DMg y⁻¹
Harvest area: Corn residue
Purchase; Harvesting; Collection; Storage; Transport; Nutrients; Handling; Pre-treatment

12 k DMg y⁻¹
Urban and ag organic waste
Negative cost; Transport; Handling; Storage; Pre-treatment
Local circular design

- **Corn Stover**: 24 k DMg y⁻¹
- **Enzyme**: 1.2 k DMg y⁻¹
- **Sugar**: 7.5 k DMg y⁻¹
- **Hemicellulose**: 12 k DMg y⁻¹
- **Lignin**: 5.5 k DMg y⁻¹
- **Animal waste**: 3.3 k DMg y⁻¹
- **Urban Organic waste**: 8.6 k DMg y⁻¹
- **BioCH₄**: 2.2 M Nm³ y⁻¹
- **Digestate**: 11 k DMg y⁻¹
# Total Capital Investment

## 2011 US Dollars

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>A000 Land</td>
<td>$700,000</td>
</tr>
<tr>
<td>A100 Handling, Storage and Utilities</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>A200 Pretreatment &amp; Hydrolysis</td>
<td>$2,500,000</td>
</tr>
<tr>
<td>A300 Enzyme</td>
<td>$300,000</td>
</tr>
<tr>
<td>A400 Biogas &amp; Wastewater Installation</td>
<td>$2,900,000</td>
</tr>
</tbody>
</table>

Total Inside battery limits (ISBL) $7,600,000

Total Direct Costs (TDC) $19,400,000

Indirect Costs $11,700,000

Fixed Capital Investment (FCI) $31,000,000

Total Capital Investment (TCI) $32,600,000
Costs & Revenues

**REVENUE DIVISION ($US 2011)**

- Sugar: $5,732,587 (59%)
- CNG bioCH4: $1,170,233 (12%)
- Avoided GHG emission: $1,116,153 (12%)
- Animal feed: $751,461 (8%)
- Digestate: $145,690 (2%)
- Lignin: $112,116 (1%)

**COST DIVISION ($US 2011)**

- Cost of Feedstock: $1,147,503 (18%)
- Transport Input: $402,393 (6%)
- Transport Output: $370,680 (6%)
- Personnel Costs: $821,928 (13%)
- Pre-treatment costs: $970,427 (15%)
- Enzyme Production: $47,723 (1%)
- Biogas production: $487,531 (7%)
- Maintenance, Property insurance & Tax: $446,005 (7%)
- Annual Depreciation: $674,373 (10%)
- Loan Interest Payment: $153,397 (2%)
- Government taxes: $132,424 (2%)
CO$_2$e avoided, reduced or stored

1. 2nd G sugar: -6,600 tCO$_2$e/yr
2. BioCH4: -6,300 tCO$_2$e/yr
3. Lignin use: -6,900 tCO$_2$e/yr
4. Good agricultural practices: -31,200 tCO$_2$e/yr
5. Efficient transport & decentralized SC: -350 tCO$_2$e/yr

TOTAL: -51,500 tCO$_2$e/yr
Over 30 years: 1.5 M tCO$_2$e
# Economic Analysis

The Net Present Value (NPV) is calculated using the formula:

$$ NPV = \sum_{t=1}^{n} \frac{CF_t}{(1 + IRR)^t} - I_0 = 0 $$

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inside battery limits (ISBL)</td>
<td>$7,600,000</td>
</tr>
<tr>
<td>Fixed Capital Investment</td>
<td>$31,000,000</td>
</tr>
<tr>
<td>Equity</td>
<td>40%</td>
</tr>
<tr>
<td>Loan Interest</td>
<td>6%</td>
</tr>
<tr>
<td>Interest rate</td>
<td>10%</td>
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<tr>
<td>Income Tax Rate</td>
<td>27%</td>
</tr>
<tr>
<td>Sugar Production Rate (MMlb/yr)</td>
<td>16.8</td>
</tr>
<tr>
<td><strong>Net Present Worth</strong></td>
<td>$0</td>
</tr>
</tbody>
</table>

## Minimum Sugar Selling Price

- **US$ (2018) /lb** $0.384
- **US$ (2018) /Metric tonne** $846
US retail price of dextrose ($US 2018)

Minimum Sugar Selling Price: **38.4 ¢**

Conclusions

1. Economy
   - Value creation and profit at regional scale
   - Diversification of farmers' incomes
   - New local circular business model

2. Social
   - Jobs creation in agri-business
   - Creating a common shared vision among stakeholders

3. Environment
   - Closed-loop bioresource system
   - Reduction of greenhouse gas emissions
   - Bio-based chemical building block