Impact of the biorefinery size on the logistics of corn stover supply: Industrial Sugar Project in Sarnia

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Industrial sugar project in Sarnia

Comet Biorefining signs with Ontario-based farmer’s cooperative to develop sustainable biomass supply chain
March 30, 2016 | Meghan Sapp

A Biomass to Sugar Value Chain: The Digest’s 8-Slide Guide to Canada’s Sarnia biocluster
June 13, 2016 | Jim Lane
The corn stover supply area includes four counties of Lambton, Middlesex, Huron and Kent in Southwestern Ontario.

Counties in Southwestern Ontario. Lambton, Middlesex, Huron and Kent are the major corn growing counties in this region. These counties make up the corn stover supply area in this study.

The proposed cellulosic sugar plant in Sarnia, Ontario
Corn stover availability within the supply area

Harvestable Stover (thousand dry tonnes)

Supply Radius (km)
Research Questions:

- Impact of the biorefinery size on five logistics parameters
  - Size of the supply radius and the harvest area
  - Inventory level and size of the intermediate storage sites
  - Number of daily and annual truckloads
  - Size of the logistics equipment fleet and number of operators to run this fleet
  - Operating costs of the logistics operations and the total delivered cost

Two biorefinery sizes:

- Small-scale (SS): 175 DT/day
- Large-scale (LS): 860 DT/day
Snapshot of the IBSAL model
### Harvest area (ac) and recovered corn stover (DT)

<table>
<thead>
<tr>
<th>Logistics parameter</th>
<th>175 DT/day</th>
<th>860 DT/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual corn stover demand (DT)</td>
<td>63,000</td>
<td>310,000</td>
</tr>
<tr>
<td>Harvest area (ac)</td>
<td>43,470-45,496</td>
<td>194,640-217,590</td>
</tr>
<tr>
<td>Supply radius (km)</td>
<td>50-66</td>
<td>110-140</td>
</tr>
<tr>
<td>Harvestable yield (DT/ac)</td>
<td></td>
<td>1.5-1.85</td>
</tr>
<tr>
<td>Annual harvested corn stover (DT)</td>
<td>75,120</td>
<td>371,800</td>
</tr>
<tr>
<td>Dry matter losses (%)</td>
<td></td>
<td>12-15</td>
</tr>
</tbody>
</table>
Delivered cost at the gate of the cellulosic sugar plant is estimated to be 73.38±1.66 $/DT in 175 DT/day scenario.

Delivered cost at the gate of the cellulosic sugar plant is estimated to be 82.94±2.47 $/DT in 860 DT/day scenario.

Average cost of logistics operations

<table>
<thead>
<tr>
<th>Cost Component</th>
<th>175 DT/day $/DT</th>
<th>860 DT/day $/DT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer replacement</td>
<td>12.05</td>
<td>12.05</td>
</tr>
<tr>
<td>Chop and Windrow</td>
<td>5.84</td>
<td>5.87</td>
</tr>
<tr>
<td>Bale</td>
<td>13.81</td>
<td>13.94</td>
</tr>
<tr>
<td>In-field transportation</td>
<td>7.69</td>
<td>7.65</td>
</tr>
<tr>
<td>Load (Field-side)</td>
<td>2.79</td>
<td>2.73</td>
</tr>
<tr>
<td>Road Transportation</td>
<td>21.89</td>
<td>30.86</td>
</tr>
<tr>
<td>Unload/Load at Intermediate storage</td>
<td>1.94</td>
<td>2.02</td>
</tr>
<tr>
<td>Intermediate storage</td>
<td>5.98</td>
<td>6.49</td>
</tr>
<tr>
<td>Unload at the facility</td>
<td>1.39</td>
<td>1.33</td>
</tr>
<tr>
<td><strong>Delivered cost</strong></td>
<td><strong>73.38</strong></td>
<td><strong>82.94</strong></td>
</tr>
</tbody>
</table>

Note: road transportation includes transportation of bales from corn fields to the facility, from corn fields to the off-site storage sites and from the storage sites to the facility.
Temporary stover inventory at the roadside of corn fields

- SS Scenario
- LS Scenario

Inventory level (dry tonnes)

Oct-Week2, Oct-Week3, Nov-Week1, Nov-Week2, Nov-Week3, Nov-Week4, Dec-Week1, Dec-Week2, Dec-Week3, Dec-Week4, Jan-Week1, Jan-Week2, Jan-Week3, Jan-Week4, Feb-Week1

- SS Scenario: 53,064
- LS Scenario: 5,001
Stover inventory at intermediate storage sites

- SS Scenario
- LS Scenario

Inventory level (dry tonnes)

- Oct-Week2
- Nov-Week1
- Dec-Week1
- Jan-Week1
- Feb-Week1
- Mar-Week1
- Apr-Week1
- May-Week1
- June-Week1
- July-Week1
- Aug-Week1
- Sep-Week1
- Oct-Week1

- 52,304
- 244,790
Based on the maximum observed inventory in the intermediate storage sites, approximately 47 and 235 acres of land would be required to hold 100,095 bales and 468,462 bales in the SS scenario and LS scenario, respectively.
Number of truckloads- 175 DT/day scenario

Delivered truckloads to the facility
Delivered truckloads to the intermediate storage sites

Number of daily truckloads

Oct-Week2, Nov-Week2, Dec-Week2, Jan-Week2, Feb-Week2, Mar-Week2, Apr-Week2, May-Week2, Jun-Week2, July-Week2, Aug-Week2, Sep-Week2, Oct-Week4, Nov-Week4, Dec-Week4, Jan-Week4, Feb-Week4, Mar-Week4, Apr-Week4, May-Week4, June-Week4, July-Week4, Aug-Week4, Sep-Week4
Number of truckloads- 175 DT/day scenario

10 and 26 truckloads would be delivered to the biorefinery and the intermediate storage sites on a daily basis, respectively. Overall, the annual truckloads delivered to the biorefinery and the intermediate storage sites are estimated to be 3,564 and 2,679, respectively.
Number of truckloads - 860 DT/day scenario

- Delivered truckloads to the facility
- Delivered truckloads to the intermediate storage sites
47 and 116 truckloads would be delivered to the biorefinery and the intermediate storage sites on a daily basis, respectively. Overall, the annual truckloads delivered to the biorefinery and the intermediate storage sites are estimated to be 16,839 and 12,828, respectively.
Logistics Equipment Pool

- 53ft flatbed trailer truck: 70
- Telescopic bale loader: 28
- Tractor (185-220 hp): 38
- Collector/stacker: 22
- Square baler: 16
- Cornstalk shredder: 22

175 Dt/day: 9

860 DT/day: 16, 22, 22, 70, 28
## Logistics Equipment Pool

<table>
<thead>
<tr>
<th>Logistics Equipment Pool</th>
<th>175 DT/day</th>
<th>860 DT/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of equipment</td>
<td>34</td>
<td>196</td>
</tr>
<tr>
<td>Total economic value ($)</td>
<td>5,505,000</td>
<td>32,280,000</td>
</tr>
<tr>
<td>Number of operators to run this pool of equipment</td>
<td>26</td>
<td>156</td>
</tr>
</tbody>
</table>

### Equipment Breakdown

- **175 DT/day**
  - Tractor (185-220 hp): 9
  - Collector/stacker: 6
  - Square baler: 7
  - Cornstalk shredder: 5
  - Telescopic bale loader: 2

- **860 DT/day**
  - Tractor (185-220 hp): 38
  - Collector/stacker: 22
  - Square baler: 16
  - Cornstalk shredder: 22
  - Telescopic bale loader: 11
Conclusions

- The differences in the logistics parameters are not necessarily proportional to the differences in the size of the biorefineries.

- The characteristics of the supply area and local conditions play a key role in the structure of the corn stover logistics system for both facility size scenarios.

- The size of variations in the logistics parameters in the LS scenario was observed to be large than the SS scenario.

- The magnitude of the logistics parameters in the LS and SS scenarios reveals the complexity of the management of the logistics system in a large-scale biorefinery.
Acknowledgment

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