Forest Industry Biorefinery
Fischer-Tropsch Synthesis Integration to a Mill Site

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Introduction

This work illustrates the importance of process integration to the profitability of the forest industry biorefinery, which produces renewable diesel by the FT process.

- Politically the call is to increased use of bioenergy and biofuels.
  - The demand and cost of energy is increasing.
  - Climate change appears to be progressing.
- Forest industry has potential for success in this emerging market.
  - “3F: Food Fuel Fibre”
  - New business opportunities via integration to mill sites.
On-going projects, Examples

• Woody biomass is already used in Germany by CHOREN to produce SunDiesel.
• NSE Biofuels (Stora-Enso, Neste Oil) opened a gasification & Fischer-Tropsch (FT) synthesis plant in demonstration scale at the Varkaus pulp mill to produce syncrude.
• UPM together with Carbona/Andritz and GTI is pursuing the gasification of forest residues to produce syncrude.
• Xynergo has initiated collaboration with CHOREN to produce of second generation biofuels in Norway.
• Chemrec is building a demonstration plant in Piteå to combine black liquor gasification with DME synthesis.
• Weyerhaeuser explores the Lignol’s proprietary biorefining technology.
Integrated forest industry biorefinery

- Building a feasible renewable diesel production plant requires a source of low-cost feedstock, industrially proven technology as well as efficient plant and energy integration.
- The most logical and promising feedstock is forest residues.
- Pulp mills use a lot of wood and have access to harvesting the forest residues.
- Pulping process and renewable diesel production can utilize different fractions of the forest biomass.
- The FT-synthesis step yields significant amounts of by-product heat.
- Energy integration with a pulp mill or a pulp and paper mill, can significantly improve the economical feasibility.
Common infrastructure

- Existing integrated feedstock procurement and harvesting chain
- Integrating production of electricity, process water and oxygen, waste water treatment and solid waste handling with a pulp and paper mill means major savings.
- Magnitude of cost savings depends on common departments.

Figure Source: UPM, 3rd BTLtec, Göteborg, 13-14 October 2008
# Investment comparison

<table>
<thead>
<tr>
<th></th>
<th>Stand-alone plant</th>
<th>Integrated plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mill water</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Pre-treatment</td>
<td>67</td>
<td>37</td>
</tr>
<tr>
<td>Gasification</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Gas treatment</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>FT synthesis</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Effluent water treatment</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Power distribution</td>
<td>8</td>
<td>8</td>
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<tr>
<td>Common departments</td>
<td>66</td>
<td>6</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
<td><strong>396</strong></td>
<td><strong>291</strong></td>
</tr>
<tr>
<td>Administration</td>
<td>32</td>
<td>23</td>
</tr>
<tr>
<td>Contingencies</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td><strong>TOTAL MEUR</strong></td>
<td><strong>450</strong></td>
<td><strong>330</strong></td>
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</tbody>
</table>
Profitability of biofuel production

• The profitability of the integrated biorefinery is most significantly affected by the selling price of its main product, the FT crude.
• The price of electricity also affects the profitability as the Biorefinery consumes significant amount of electricity.
• Integrated forest biorefinery can utilize the byproducts of the renewable diesel production.
• Excess heat and tail gases are valuable.
Sensitivity of profitability

Profitability is sensitive to.....

FT crude selling price
Electricity price
Investment cost
Forest residues price

IRR, %

% - change

-20 -10 0 10 20
Utilizing surplus energy for extra income

- Of available energy less than half is converted to FT liquids
- Some of the energy can be captured as tail gases
- More heat can be captured as process heat (steam)
Utilizing surplus energy for extra income

- FT liquid is responsible for most of the income
- Some additional income can be realized by replacing natural gas
- If plant requires additional heat (steam) then more extra income can be realized
Maturity and reliability of operation

- Gasification reactors have been in operation at least since 1920s.
- Fischer-Tropsch synthesis is also commonly known and has been in industrial use for decades.
- Drying and pre-treatment of biomass are commercial.
- Forest residues are, however, most likely unclean (NPE) and contain a lot of sand and other unwanted substances.
- Large scale biomass gasification and processing have not yet been operated.

Dr. Hans Tropsch
www.fischer-tropsch.org
Open questions

- The reforming and conditioning of the raw synthesis gas is perhaps still the most uncertain part of the production process.

- Some of the questions still to be answered are:
  - How to control the high dust load, dust fouling of the surfaces and catalyst poisoning in the autothermal reforming?
  - How to solve the problems concerning the durability of the hot gas filter materials?
  - How to control the process interruptions, when for example catalyst has been poisoned?
Environmental issues

- Solid wastes of the renewable diesel production process need to be treated.
- If treated with pulp mill wastes, economics of scale can be achieved.
- Char from the gasification reactor can be used as a fuel for pulp mill power boiler.
- NCG treatment system can handle possible gases.
Waste water

- The composition and amount of the waste waters from the Fischer-Tropsch synthesis need to be studied carefully.
- Waste waters most probably contain some dissolved products and droplets of waxes.
- These components are likely to cause problems in the conventional waste water treatment of the pulp mill.
- Further study about the waste water composition and treatment needs to be done.
Burning VOC

• Biomass materials have a very high volatile content.
• VOC-emissions created during storing of the biomass and especially from the drying step. Some of the dryer types enable the collection and recovery of the VOC gases.
• Collected VOCs can be burned in a power boiler.
Conclusions

- Forest industry with ready access to forestry residues and woody biomass may very well be in the lead in the production of the second generation lignocellulosic biofuels.
- Forest industry and its actors should contribute to finding the best solutions for energy efficient pulp and paper mills as well as for advanced integrated production plants.

Logging residues can be used to produce biofuels for energy production (StoraEnso)