Torrefied Pellet Production - Comparison of some Forestry Industry Integration Opportunities to Stand-Alone Plants

A European R&D Project funded within the Seventh Framework Programme by the European Commission

Bioenergy from Forest Conference
15-18.9.2014

Vesa Arpiainen (VTT), Carl Wilén (VTT), Esa Sipilä (Pöyry Management Consulting Ltd.)
Outline

- **Task 3.4**: Torrefaction process optimisation/integration
- **Parent processes and integrates**: Modern sawmill and modern pulp mill
- **Stand-alone plants**: European plants and overseas plant
- **Key bases of production cost estimate**
- **Summary of production costs of torrefied pellets**
- **Breakdown of production costs of alternatives**
- **Conclusions**
TORREFACTION

TASK 3.4: TORREFACTION PROCESS OPTIMISATION/INTEGRATION

INVOLVED PARTNERS: VTT, ECN, CENER, UMU AND TOPELL

SUBCONTRACTOR: PÖYRY MANAGEMENT CONSULTING LTD
Parent processes and integrates: Modern sawmill

- Modern sawmill - timber product from soft wood 250,000 solid m³/a

Alternative 1:
- New sawmill and new torrefaction plant integrate, 231,600 t/a torrefied pellets
- Common biomass (bark, sawdust) boiler (35 MWₜₜ) for hot water generation (belt dryer for biomass drying at torrefaction plant)
- Wood chips from sawmill (39 MWₜₜ) are utilized as a raw material in torrefaction plant
- Additional forest fuels (136 MWₜₜ) are also utilized as a raw material for torrefaction plant

Alternative 2:
- Existing sawmill with a new torrefaction plant integrate, 101,100 t/a torrefied pellets
- New biomass boiler (bark) for torrefaction plant (12 MWₜₜ)
- Wood chips and sawdust are not utilized as a raw material of torrefaction plant
- Forest fuels (77 MWₜₜ) are utilized as a raw material for torrefaction plant
Parent process: Modern saw mill - main mass and energy flows, production 250 000 m³ sawn timber from soft wood
Parent processes and integrates: Modern Nordic pulp mill

- Modern Nordic pulp mill, soft wood pulp 600,000 dry t pulp/a

Alternative 5:

- Pulp mill and new torrefaction plant integrate, 407,200 t/a torrefied pellets

- The extra bark from pulp mill is used as a boiler fuel (45 MW\textsubscript{th}) of torrefaction plant (belt dryer for biomass drying at torrefaction plant)

- The pulp mill serves local electricity (50 €/MW\textsubscript{e}) for the torrefaction plant for grinding of torrefied biomass and for pelletising operation

- Forest fuels (299 MW\textsubscript{th}) are utilized as a raw material for torrefaction plant

- The same integration savings concerning logistics, personell (75% of stand-alone plant costs) and maintenance costs (75% of stand-alone plant costs) as in the sawmill case are assumed
Parent process: Modern Nordic soft wood pulp mill - main mass flows from soft wood

Wood

- 173 ton/h dry
- 346 ton/h total

Digesting and Washing

- 184 t/h tot
- 145 t/h dry

Bark

- 8.3 ton/h

Black Liquor

- 949 ton/h total
- 148 ton/h dry

Evaporation

- 1580 m³/h

Water

- 1580 m³/h

Water effluent

- 1375 m³/h

Bleaching

- ClO₂, NaOH, CO₂, H₂SO₄, MgSO₄, etc

Recovery Boiler

- Steam used internally

Causticising and Lime kiln

- Bleached Pulp

- 75 ton/h dry
- 83 ton/h total

O₂ - bleaching

- 815 ton/h total
- 82 ton/h dry

Drying

- 949 ton/h total
- 148 ton/h dry
- 184 t/h total
- 145 t/h dry

Note: All process internal flows are not shown in the slide.

Source: www.bioref-integ.eu Public report: D4total

This project has received funding from the European Union’s Seventh Programme for research, technological development and demonstration under grant agreement n° 282826
Stand alone-plants: European plants and overseas option

Base Case:
- Reference plant, 72,800 t/a torrefied pellets
- The feedstock price of wood has stabilised in the Nordic countries to a level of 18-25 €/MWh
- Price of forest residues used in the cost estimate is 18 €/MWh (< 150 MWth)

Alternative 8:
- A large scale European torrefaction plant, 500,000 t/a torrefied pellets
- Price of forest residues used in the cost estimate is 20 €/MWh (>150 MWth)

Alternative 9:
- A large scale overseas torrefaction plant, 500,000 t/a torrefied pellets
- In overseas regions the price variation is significantly larger, range from 10 to 20 €/MWh
- Price of wood used in the cost estimate is 15 €/MWh
Stand alone-plants: Price of wood

Pulpwood costs, delivered at plant, in selected regions 2013, in m$^3$ sob (solid over bark)
Source: Sipilä, E., Biomass as feedstock for gasification, Presentation at AEL Biomass gasification seminar, 29 October 2013, Tampere (in Finnish)
# Key bases of production costs estimate

<table>
<thead>
<tr>
<th>Cost</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Feedstock costs</strong></td>
<td></td>
</tr>
<tr>
<td>Forest residues up to 150 MW\textsubscript{th}</td>
<td>18 €/MWh</td>
</tr>
<tr>
<td>Forest residues over 150 MW\textsubscript{th}</td>
<td>20 €/MWh</td>
</tr>
<tr>
<td>Bark</td>
<td>16 €/MWh</td>
</tr>
<tr>
<td>Sawdust</td>
<td>16 €/MWh</td>
</tr>
<tr>
<td>Wood chips (sawmills)</td>
<td>18 €/MWh</td>
</tr>
<tr>
<td>Plantation wood in south</td>
<td>15 €/MWh</td>
</tr>
<tr>
<td><strong>Heat</strong></td>
<td></td>
</tr>
<tr>
<td>Hot water</td>
<td>20 €/MWh\textsubscript{th}</td>
</tr>
<tr>
<td>Low pressure steam</td>
<td>25 €/MWh\textsubscript{th}</td>
</tr>
<tr>
<td><strong>Electricity</strong></td>
<td></td>
</tr>
<tr>
<td>Without transfer costs</td>
<td>50 €/MWh\textsubscript{e}</td>
</tr>
<tr>
<td>With transfer costs</td>
<td>60 €/MWh\textsubscript{e}</td>
</tr>
<tr>
<td><strong>Labour</strong></td>
<td></td>
</tr>
<tr>
<td>Cost, including payroll overheads</td>
<td>55 €/manhour</td>
</tr>
<tr>
<td><strong>Cost factors</strong></td>
<td></td>
</tr>
<tr>
<td>Annual capital charges factor</td>
<td>0.1175 (10% interest, 20 a)</td>
</tr>
<tr>
<td>Cost for start up, interest during construction</td>
<td>21% of plant investment</td>
</tr>
<tr>
<td>Scale-up exponent</td>
<td>0.7</td>
</tr>
<tr>
<td>Maintenance, insurance, taxes</td>
<td>4% of total investment</td>
</tr>
<tr>
<td><strong>Operational times</strong></td>
<td></td>
</tr>
<tr>
<td>Stand-alone plants</td>
<td>8 000 h/a</td>
</tr>
<tr>
<td>Sawmill and pulp mill integrates</td>
<td>8 000 h/a</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>CEPI-Index value 584.6</td>
</tr>
</tbody>
</table>

The economic assessment was carried out mainly based on VTT and Pöyry Management Consulting Ltd in-house information. The assessment of investment costs is based on a number of feasibility studies and budget offers of commercially available equipment and components.
## Summary of the production costs of torrefied pellets

<table>
<thead>
<tr>
<th></th>
<th>Base Case</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
<th>Alternative 5</th>
<th>Alternative 8</th>
<th>Alternative 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant capacity, t torrefied pellets/a</td>
<td>72 800</td>
<td>231 600</td>
<td>101 100</td>
<td>407 200</td>
<td>500 000</td>
<td>500 000</td>
</tr>
<tr>
<td>Production costs of pellets, M€/a</td>
<td>19.3</td>
<td>48.8</td>
<td>24.3</td>
<td>82.5</td>
<td>104.2</td>
<td>87.6</td>
</tr>
<tr>
<td>Production costs of pellets, €/t</td>
<td>265</td>
<td>211</td>
<td>240</td>
<td>203</td>
<td>208</td>
<td>175</td>
</tr>
<tr>
<td>Production costs of pellets, €/MWh</td>
<td>43</td>
<td>34</td>
<td>38</td>
<td>33</td>
<td>34</td>
<td>29</td>
</tr>
<tr>
<td>Market price of wood pellets, €/MWh (PIX Pellet Nordic Index, 2012)</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Price compared to base case, %</td>
<td>100</td>
<td>79</td>
<td>91</td>
<td>76</td>
<td>79</td>
<td>66</td>
</tr>
<tr>
<td>Price compared to market price, %</td>
<td>145</td>
<td>115</td>
<td>126</td>
<td>111</td>
<td>114</td>
<td>96</td>
</tr>
</tbody>
</table>

- **Stand-alone plants**
- **Integrates**
Breakdown of production costs of alternatives, €/MWh

<table>
<thead>
<tr>
<th>Production costs (€/MWh)</th>
<th>Base Case</th>
<th>Saw mill integrates</th>
<th>Pulp mill Integrates</th>
<th>Big stand-alone plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material costs</td>
<td>231 600 t/a</td>
<td>407 200 t/a</td>
<td>500 000 t/a</td>
<td></td>
</tr>
<tr>
<td>Capital costs</td>
<td>72 800 t/a</td>
<td>101 100 t/a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed operating costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other variable operating costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overseas transport costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This project has received funding from the European Union’s Seventh Programme for research, technological development and demonstration under grant agreement n° 282826
Conclusions

- The integration of torrefaction plant to sawmill is especially favourable if a new combined plant is constructed (Alternative 1: 231,600 t/a torrefied pellets, below 80% of base case plant costs)

- The pulp mill integrate can according this estimate produce pellets with about the same price than new sawmill integrate (Alternative 5: 407,200 t/a torrefied pellets, below 80% of base case plant costs)

- Benefits are foreseen in energy integration (power and heat, especially in drying process), in feedstock logistics, in biomass handling and preparation as well as in other common infrastructure benefits

- There are certainly benefits especially on wood procurement, logistics and transportation costs, storage and handling at the plant, and savings in other commodities that may not have been fully implemented in this assessment

- More exact case specific assessments will be needed
thank you very much for your attention

Public report (Sector D3.2):
Report on optimisation opportunities by integrating torrefaction into existing industries

www.sector-project.eu

Additional material:
Wilén, C. et.al. 2014, Wood torrefaction – market prospects and integration with the forest and energy industry, VTT Technology 163.


Additional information on SECTOR project:
info@sector-project.eu
URL: www.sector-project.eu