Profitability of drying wood chips integrated into fuelwood supply

FORMEC 2015, Linz, Austria
Jyrki Raitila, VTT
Background

- Study in Central Finland (2012)
  - Ca. 30 heating plants run by heat entrepreneurs
  - Total output of these plants 20 MW

About 1 Mm$^3$ of wood chips could be dried with unused heating capacity
Supply costs of forest chips
Supply costs 1/3

**Case 1:** Heating plant, annual heat production 5,000 MWh

- Supply chain 1 (**contractor model**): Raw material bought at landing, chipping and transportation separately paid for (chipping with large mobile chipper, transport with 120 m³ truck)
  - Price for whole trees at landing: €13 /MWh
  - Chipping costs: €3.6 /loose-m³
  - Transport costs: €3.6 /km
  - Efficiency of boiler: 78-88% when moisture of wood chips 55-20%
  - Malfunction costs: €120 /each
  - Use of heating oil: €14,000-0 /a (wood chips 55-20%)

- Supply chain 2 (**single supplier model**): Wood chips supplied by one supplier
  - Price of wood chips delivered at plant: €20 /MWh
  - Efficiency of boiler: 78-88% when moisture of wood chips 55-20%
  - Malfunction costs: €120 /each
  - Use of heating oil: €14,000-0 /a (wood chips 55-20%)
Supply costs 2/3

**Case 2: Heating plant, annual heat production 1,500 MWh**

- Supply chain 1 (**contractor model**): Raw material bought at landing, chipping and transportation separately paid for (chipping with tractor powered chipper, transport with tractor – load space 20 m³)
  - Price for whole trees at landing; €25 /solid-m³
  - Chipping costs; €4.5 /loose-m³
  - Transport costs; €2 / loose-m³
  - Efficiency of boiler; 78-88 % when moisture of wood chips 55-20%
  - Malfunction costs; €120 /each
  - Use of heating oil; €5,200- 0 /a (wood chips 55-20%)

- Supply chain 2 (**single supplier model**): Wood chips supplied by one supplier
  - Price of wood chips delivered at plant, €20 /MWh
  - Efficiency of boiler; 78-88 % when moisture of wood chips 55-20%
  - Malfunction costs; €120 /each
  - Use of heating oil; €5,200- 0 /a (wood chips 55-20%)
Supply costs 3/3, €/produced MWh

Case 1
- Transport and chipping costs of wet wood make contractor model more expensive

Case 2
- Raw material and chipping significantly more expensive when wood is wet
Cost difference of dry and wet chips

**Case 1**
- Cost difference between *supply models* max 2.7 €/MWh, if moisture is 55%

<table>
<thead>
<tr>
<th></th>
<th>Contractor model</th>
<th>Single supplier model</th>
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</thead>
<tbody>
<tr>
<td>55% → 20%</td>
<td>€8.9/MWh</td>
<td>€6.8/MWh</td>
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<tr>
<td>45% → 20%</td>
<td>€5.3/MWh</td>
<td>€4.3/MWh</td>
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**Case 2**
- Cost difference between *supply models* max 4.3 €/MWh, if moisture is 55%

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<thead>
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</tr>
<tr>
<td>45% → 20%</td>
<td>€10.2/MWh</td>
<td>€6.2/MWh</td>
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**Conclusion 1:** In contractor model wood chips should not be wet
**Conclusion 2:** You can afford paying more for dry wood chips, €/MWh – pricing based on quality!
**Conclusion 3:** On the other hand, you can afford paying for drying
Drying of wood chips
Drying in a show case dryer

- Built in freight container, drying heat from a wood chip boiler, 40-60 kW output needed (Case 2: 1,500 MWh/ν)

- Calculation parameters:
  - Max drying volume; 2,500 loose-m³/a, 25 m³ each drying batch
  - Needed heat energy – calculated with a model - 445 MWh (55% moisture) ja 268 MWh (45% moisture)
  - Price of heat; €40/MWh (prime cost for entrepreneur) ja €24 /MWh (fuel costs only)
  - Dryer investment; 35,000 €
  - Electricity and maintenance; €1,300 /a
  - Repayment; 10 a
  - Interest; 5%
Moisture of wood chips and boiler efficiency

- In small boilers (<1MW) moisture of wood chips affects the performance of the boiler significantly, particularly when MC is bigger than 35%.
Drying wood chips for sale

- Entrepreneur dries wood chips at a plant he operates
- Enough heat available
- Drying costs based on example:

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<th>Heat price 24 €/MWh</th>
<th>Heat price 40 €/MWh</th>
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</thead>
<tbody>
<tr>
<td>55% → 20%</td>
<td>6.5 €/loose-m³</td>
<td>9.3 €/loose-m³</td>
</tr>
<tr>
<td>45% → 20%</td>
<td>4.8 €/loose-m³</td>
<td>6.6 €/loose-m³</td>
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- To be profitable, dry wood chips should be this much more expensive if sold
Drying wood chips to be used at own plant

- Dry (20%) wood chips needed 2,100 loose-m$^3$
- Profitability of drying was evaluated by net present value (NPV) method
  - NPVs of benefits and costs were compared
  - Annual costs were drying and capital costs
- Benefits (cost savings):
  - Less wood chips are needed, less raw material costs
  - Transportation costs decrease because of smaller volume
  - Chipping cost decrease because of smaller volume
  - Boiler efficiency increases
  - Fewer malfunctions of boiler and feeding system occur
  - Less heating oil (additional fuel) is needed
Profitability of drying in different alternatives

<table>
<thead>
<tr>
<th></th>
<th>Drying heat 40 €/MWh</th>
<th>Drying heat 24 €/MWh</th>
<th>Drying heat 40 €/MWh + storage</th>
<th>Drying heat 24 €/MWh + storage</th>
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</thead>
<tbody>
<tr>
<td>Initial moisture</td>
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<tr>
<td>55%</td>
<td>14,792</td>
<td>-36,170</td>
<td>60,196</td>
<td>-775</td>
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<td></td>
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<td>9,234</td>
<td>-51,738</td>
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<td>46,683</td>
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<td>45%</td>
<td>-8,159</td>
<td>-37,222</td>
<td>19,407</td>
<td>-23,727</td>
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<td></td>
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<td>-9,655</td>
<td>-52,789</td>
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<td>5,894</td>
<td>-25,223</td>
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- Additional storage investment needed if there is no other storage available
- Drying more difficult to make profitable in single supplier model
- Cost of drying heat is crucial for profitability
Effect of increased heat sales

- Possible to dry 400 loose-m$^3$ 'extra', then heat sales could be increased by 300 MWh (due to increased heating value + efficiency of boiler)
  - If heat is sold for €60 /MWh, 18 000 € annual gross income is earned
- In the least profitable option about half of the increased potential (=200 loose-m$^3$) would ensure profitability
- In contractor model drying 50 loose-m$^3$ more would be sufficient
Conclusions

- Heating plants operated by entrepreneurs usually have plenty of unused heating capacity that could be used for drying wood chips or firewood.
- Moisture of wood chips should not fluctuate if most operation costs in the supply chain are based on volumes.
- Basis for 'quality pricing = higher price/MWh for dryer wood chips, win-win possible.