Forest bioenergy supply chains: Maximising benefits, mitigating impacts

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Mobilising forest biomass

Forest inventory England

<table>
<thead>
<tr>
<th>Managed</th>
<th>756 kha</th>
</tr>
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<table>
<thead>
<tr>
<th>Coppice + standards</th>
<th>39 kha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Understocked &amp; overgrazed</td>
<td>45 kha</td>
</tr>
<tr>
<td>Overstocked broadleaved</td>
<td>77 kha</td>
</tr>
<tr>
<td>Neglected + Chalara threat</td>
<td>57 kha</td>
</tr>
<tr>
<td>Moribund conifer</td>
<td>61 kha</td>
</tr>
<tr>
<td>Remaining unmanaged</td>
<td>261 kha</td>
</tr>
</tbody>
</table>

Forest inventory Canada

<table>
<thead>
<tr>
<th>Forest land</th>
<th>396 million ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed area</td>
<td>226 million ha</td>
</tr>
<tr>
<td>Disturbance</td>
<td>19 million ha</td>
</tr>
<tr>
<td>Harvested area</td>
<td>0.78 million ha</td>
</tr>
<tr>
<td>annual area affected by wildfire</td>
<td>1.5 – 4.5 million ha</td>
</tr>
<tr>
<td>annual area affected by (pests, cumulative)</td>
<td>17-20 million ha</td>
</tr>
</tbody>
</table>
Getting the balance right?

E.g. By 2060:
- Requires 2,000 ha per year from now until 2060
- Afforested lands also managed - additional biomass supply

Accumulated average change vs. 'Do nothing'

Production:
- 800,000 t/yr

CO₂ per area cumuli

1 21 41 61 81 101 121 141 161

- Managed forest
- Disturbed forest taken into management
- Disturbed forest
Energy from forest residues

https://www.canadianbiomassmagazine.ca/combustion/filling-the-gap-1665
GHG emissions from forest and sawmill residues
GHG emissions from forest and sawmill residues

**Graph**

- **Forest residues**
  - Drying with biomass: 0.1
  - Drying with diesel: 23.9
  - Drying with electricity: 10.9
  - High losses: 40.1
  - Drying with biomass: 40.7
  - Drying with diesel: 16.2

- **Sawmill residues**
  - Drying with biomass: 0.1
  - Drying with diesel: 23.9
  - Drying with electricity: 10.9
  - High losses: 40.1
  - Drying with biomass: 40.7
  - Drying with diesel: 16.2

**Legend**
- Direct soil emissions
- Energy conversion
- Transport (land)
- Transport (transatlantic)
- Pellet processing
- Wood production

**Note**
- The graph and table provide detailed data on GHG emissions from various stages of forest and sawmill processes.
Dry Matter Losses and Greenhouse Gas Emissions from Wood Chip Storage Piles

The Experiment: Two Wood Chip Heaps

**Heap Built on Grass**
- Sampled a commercial heap ‘cheap and cheerful’
- No weighbridge available – estimated ~ 200 tonnes
- Dimensions: 5m high, 9 m wide, 10 m sampling area
- Cut in March

**Heap Built on Cement**
- On Rothamsted site
- Weighbridge onsite = 84 tonnes
- Dimensions: 4m high, 9 m wide, 12m sampling area
- Cut in April- leafier material

**GHG Emissions**
Probes inserted into heap at 2 depths

**Dry Matter & Temperature**
Bagged samples with known chip quantity and temperature recorder
Dry Matter Losses and Greenhouse Gas Emissions from Wood Chip Storage Piles

Dry Matter Losses – Whole Heap

Whole Stack: Lost 21% of dry matter
- Estimated LHV wet chip (50%): 7.8 GJ t⁻¹
- Estimated LHV of mixed samples (43% m.c): 9.1 GJ t⁻¹
- Energy loss: 1.6 GJ/tonne stored, or Energy in/out ratio: 0.8
  - If it dried to 25% it would have gained 1.5 GJ t⁻¹

LCA Study:
If used for heat to displace natural gas this loss would:
- Increase whole-supply chain GHG emissions by 23%
- Increase the land area required to provide the same unit of energy by 26%
Dry Matter Losses and Greenhouse Gas Emissions from Wood Chip Storage Piles

GHG Emission Results: \( \text{CH}_4 \) vs. \( \text{CO}_2 \)

**Heap on Grass**

- **Aerobic**
- **Anaerobic**
- Respiration slows

**Heap on Cement**

- Carbon Dioxide
- Methane Control
- Methane

**CH\(_4\) peaks after CO\(_2\) peak** — indication of anaerobic decomposition phase

Methane generation is not constant — most occurring within 2 week period
GHG emissions from forest and sawmill residues
Energy from waste wood

https://www.ukconstructionmedia.co.uk/news/sustainability-demands-see-increase-in-waste-wood-recycling/
GHG emissions from waste wood

- Emissions significantly higher than reference options, due to N$_2$O formation during combustion
- Highest savings (>90%) when replacing large-scale coal
- Emissions/savings from Grade B similar to Grade A pellets
- Removing some of the uncertainties, especially related to urea resins and N$_2$O formation could bring savings in line with untreated waste wood
- Only savings from Grade D when replacing electricity from high carbon feedstocks
- Grade A most suitable for domestic application, with significant savings
Conclusion forest residues

- Mobilising effect can improve carbon stocks and net GHG reductions, but depends on management practices
- Forest biomass can deliver significant GHG emission reductions
- BUT various emission uncertainties
- Management of storage could be one of the key issues and significantly affect overall supply chain emissions
- Fuel mix varies
- Need to verify the actual level of emissions for different supply chains
- Reference usually related to a specific counterfactual
- Uncertainties need to be considered when bioenergy is included in emission budgets to stay within climate change targets.
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