Large scale forest biomass supply for energy – lessons learned in Finland and Sweden

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CENBIO days

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Storyline

• History of forest energy, the s-curve
• Harvesting technology for
  – Logging residues
  – Small trees
  – Stumps
• Challenges in logistics: water and seasonality
• Forest energy, environment and carbon cycle
• Predicting the future of forest energy
S-curve for forest energy

% of resource used/ Technology readiness

infancy    expansion    maturity

Logging residues
Thinning wood
Stumps
S-curve for forest energy

% of resource used/ Technology readiness

infancy  expansion  maturity

Finland  Sweden  Norway
Finland and Sweden, harvestable potentials
(datasets and methods differ)
Bioenergy is wood energy

- Biogas, agro
- Traffic fuel, waste and agro
- Traffic fuel, wood based
- Pellets
- Forest chips and firewood
- Sawmill byproducts
- Black liquor

TWh

2012 2020

31.3.2014
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Finland – small trees, Sweden – logging residues, 2011
Use of forest chips, 2012

![Bar chart showing the use of forest chips in Finland and Sweden in 2012. Finland has a total of 8 million m³/a, with contributions from stumps (green), logging residues (red), and small trees (blue). Sweden has a total of 7 million m³/a, with contributions from stumps (green) and logging residues (red).](chart.png)
Logging residue balance

Low annual cut

Average annual cut

High annual cut

m³/km²/vuos

- 0
- 1 - 20
- 21 - 40
- 41 - 60
- 61 - 80
- 81 - 100
- 101 - 120
- 121 - 160
- 161 - 200
- 201 - 300

METLA
Small tree balance

Delimbed stem harvest  Whole tree harvest  Integrated harvest

Maps showing the distribution of small tree balance across different regions in Finland.
Stump balance

High annual cut  Average annual cut  Low annual cut
Technological learning

Cost reduction of unrefined wood residues in Sweden 1975-2003

\[ y = 38.588x^{-0.2258} \]

\[ R^2 = 0.9756 \]
Harvesting systems for final fellings
Logging residues - trends

- More efficient forwarding (SWE, FI)
- ’Green’ forwarding (SWE)
- Drier, cleaner material (SWE, FI)
- Less tractor-chipping (SWE)
- Chipper truck and loose residue systems expand (SWE)
- Chipping at roadside (FI)
- Saturating supply volumes (SWE, FI)
The logging costs of whole-trees, delimbed energy wood and whole-tree bundles

Logging cost, €/m³ = Cutting + Forwarding
Cutting removal 1500 trees per hectare
The harvesting cost of chips at the plant, €/m³

Harvesting cost at the plant = Cutting (d_{1,3} = 8 cm) + forwarding 300 m + chipping + transporting 50/15 km
The chipping productivity of whole-trees & delimbed energy wood

- Chipping productivity per effective working hour, m³/h
  - Whole-trees: 55 m³/h
  - Delimbed longwood: 67 m³/h

- Average volume of the grapple load, m³
  - Whole-trees: 0.33 m³
  - Delimbed longwood: 0.49 m³

Grapple load volume in chipping, m³

Diagram showing the comparison between whole-trees and delimbed longwood in terms of chipping productivity and grapple load volume.
Harvesting system for early thinnings

Delimbed stems procurement chain from thinnings with chipping at the plant
Small trees – trends

- Strongly increasing volumes (FI+SWE)
- Less simple felling heads (SWE)
- CTL heads with multi stem cutting+delimbing (FI)
- Larger machines (FI+SWE)
- ’Energy thinning’ (FI+SWE)
- Compaction through rough delimbing (SWE)
- Slightly larger trees (FI+SWE)
- Continuous felling/accumulation?
Stump wood

+ Largest unrealized potential
+ Easy storing
+ Excellent fuel properties
+ No nutrient loss
+ Low ecological value

- Difficult harvesting
- Soil contaminations
- Bulkiness & handling
Stump wood - trends

- Evident learning curve (FI+SWE)
- Pre-crushing may solve transport, handling and contamination problems (FI+SWE)
- Use saturating? (FI economy, SWE certification)
Stump harvesting, growth and nutrients

Impacts on growth c.a. 35 year after harvest

Growing stock, m³/ha

Tree species

Pine

Spruce

All

Stump harvest
Reference
Stump harvesting, growth and nutrients

Nutrient status c.a. 35 years after harvest

- **N (humus+soil)**
- **Ca (humus)**
- **K (humus)**
- **Mg (humus)**
- **P (humus)**

- Stump harvest
- Reference

kg/ha
Impacts to forest ecosystem

• Logging residues & stumps
  – Impacts similar as by clearcut, soil preparation + regeneration
    • Ground water and runoff waters
    • Hg mobilization
    • Surface vegetation (residue harvest increases species number, as raspberry does not invade the site)
    • Ground flora and fauna (in total stump harvest fauna reduced)
  – On 30% of clearcuts, residues are harvested (FI)
  – On 10% of clearcuts, stumps are harvested (FI)
Net increase of carbon stock in the Finnish forests 1990-2010

Cumulative carbon in harvested forest chips since 1990

Cumulative increase of carbon storage since 1990
Net carbon binding increases

(Kallio et al. 2012, Metla)

2007 harvest level
25 TWh bio CHP
25 TWh bio CHP + 7 TWh traffic fuels
Overcoming the fuel demand variation: Precision supply

- Transportation distances: Where to storages are?
- Storage volumes: Quantity in each spot
- Spatial clusters: Grouping of storages in operational units
- Use of drying models for predicting moisture contents

Improved tactical planning

Right material at the right time to the right place
Energy production over the year

Pronounced seasonal variation

Variation of fuel demand

Quantity

Quality

J. Windisch, K. Väätäinen, P. Anttila, A. Asikainen, J. Laitila, L. Sikanen
BEST seminar, 19.2.2014
Challenges during peak times

Quantity

Limited fleet capacity

Quality

Moist raw material
Machine utilisation over the year
50% increase of supply capacity in peak period
Trucks are growing in volume and weight

– 60 tonne trucks in use for several decades
– 76 tonne trucks allowed on roads in Finland from 1.10.2013
– 90 tonne trucks have been tested in Sweden and
– 110 tonne trucks are now tested in Finland
Conclusions

• Learning by doing verified also in forest energy
• Logging residue supply saturating, small tree supply still growing
• Fuel quality management in focus
• Reduction of seasonal variation main logistical challenge
• Larger trucks are coming
The future

• Wood-based oil production really taking off
• Coal and wastes difficult to compete against
• Security of supply becoming more important
• GHG mitigation’s role becoming less important
• Future growth: Integrated industrial concepts
  – CHP+Oil
  – Fibres+Oil+CHP
• Economic sustainability of forest energy must be improved