Overview of Finnish Wood Fuel Supply Chains

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PromoBio
Training Week Finland
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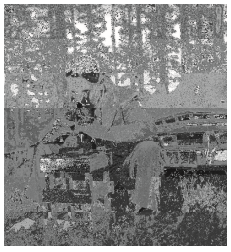
Finnish Forest Research Institute
R&D activities & Forest Energy in Finland

Metla since 1917-

subordinated to the Ministry of Agriculture and Forestry

Staff of Metla in Finland
- approximately 750 employees
- incl. 370 researchers

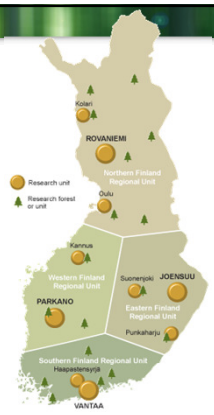
Budget
- ~55 Mio €



Metla 2013

Core activities:
- production and implementation of research results
- knowledge transfer and information services
- research supporting activities
- State authority tasks

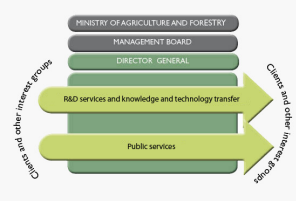
Four Regional Units:
- Southern Finland
- Eastern Finland
- Western Finland
- Northern Finland



Metla 's Mission

Metla builds the future of the forest sector of Finland by producing and disseminating information and know-how for the well-being of society

Research priorities:
• Forest-based enterprise and business activities
• Social impact of forests
• Structure and functioning of forest ecosystems and
• Information data bank on forestry and the forest environment



Metla 's Research

•research is organised into problem-oriented projects and multi-disciplinary research programmes
•150 projects
•large number of projects are jointed national and/or international, in collaboration with universities, research organisations and other R&D organisations

Research Programmes

Forests and water
H2O (2013-2017)

Forest Sector Foresight - project group
MTU (2012 - 2015)

ForestEnergy2020
(2012–2016)
Joint research programme with VTT Technical Research Centre of Finland

Forests and silviculture in the future
MHO (2012–2016)

Renewing wood product value chains and timber procurement solutions
PUU (2009–2013)

Wellbeing from forests
HYV (2008–2013)

LYNET-research programmes
(in finnish)
* Bioeconomy (2011 - 2015)
* Climate change (2011 – 2015)
* Sustainable land use (2011 - 2014)
* Baltic sea (2011 - 2015)

Metla Eastern Finland

Joensuu , Punkaharju and Suonenjoki Units
Centre in Joensuu
Director prof. **Jari Parviainen**
Staff: 200 employees (100 scientists)

Mission
Multidisciplinary approach to promote, regional economic and enterprise activities based on forests and forest products

State authority tasks
- National Forest Inventory
- inspection of plant protection products
- measuring roundwood and sawn timber

Strengths of forest cluster in Joensuu

- **Location:** densely forested area, traditional forest products manufacturing region in Finland
- **Networking:** *Metla* and *University of Eastern Finland - Faculty of Natural and Forest Sciences* located on same campus area; distance to *EFI* and local forestry stakeholders are short
- **EU´s Regional Target Area:** finance of research through rural/regional development structural funds are available
- **Bridge between EU and Russia:** geographically close to Republic of Karelia and Russia

Metla Joensuu 1981

-

Customer manager **Jari Miina**
Staff **130 (incl. 80 researcher)**

Seven research disciplines *lead by a professor/senior scientist*
- forest management planning *(Prof. Mikko Kurttila)*
- silviculture and environmental impacts from forestry *(Prof. Leena Finér)*
- wooden-based biomass and forest technology *(Prof. Antti Asikainen)*
- wood science and technology *(Prof. Erkki Verkasalo)*
- economy of forest enterprices *(Prof. Pekka Ollonqvist)*
- international forestry, especially countries with economies in transition and Russian forestry *(Prof. Timo Karjalainen)*
- forest inventory methodologies and data calculations *(Dr. Kari T. Korhonen)*

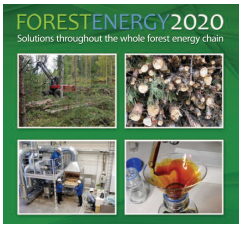
Examples of forest research with wide applications

- enterprise activities in wooden construction
- updated information on roundwood trade, stumpage and delivery prices of roundwood in Finland, Baltic States and Nordic countries
- forecasts on stumpage prices, trade of forest industry products on markets foreign
- Russian forestry, internet service:

  www.idanmetsatieto.fi

Bioenergy Research at Metla

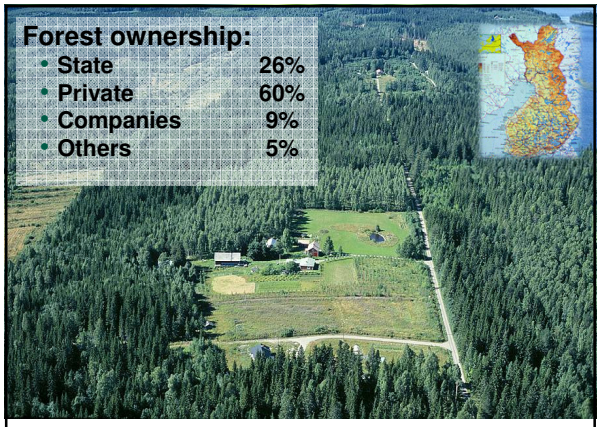
- ForestEnergy2020 research programme
- Joint programme at METLA and VTT
- 10 thematic areas covering the whole span of forest energy value chain
- www.forestenergy2020.org



FINLAND'S FORESTS

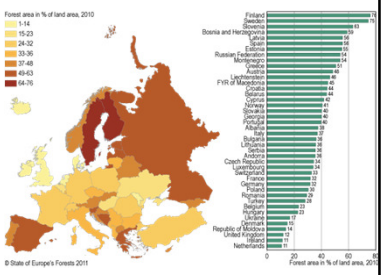
Forest ownership:

- State 26%
- Private 60%
- Companies 9%
- Others 5%



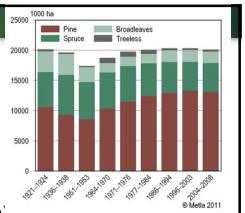
Forests in Finland

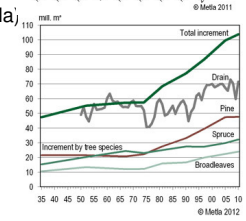
- Forests cover 23 million ha (76%)
- Boreal forests
- Private forest cover 83% of roundwood removal
- Forestry and forest industries account for 6% of the GDP



Intensive Forest Mgmt

- Main tree species
  - Pine (Pinus sylvestris)
  - Spruce (Picea abies)
  - Birch (Betula pubescens/pendula)
- Rotation period 80-120 years
- Forest mgmt
  - Pre-commercial thinning
  - 1-3 thinnings
  - Final felling
  - Soil preparation/Planting





Biomass Availability Estimations

Robert Prinz & Perttu Anttila

Before Establishing a Biomass Fuelled Heating or Power Plant, You Need to Know…

- How much there is feedstock?
- What kind of material is it?
- Where is it located?
- What is the cost of fuel at plant?
- How much of the resource is available?
- How does the availability evolve in time?

-> Plant (or project) level case studies

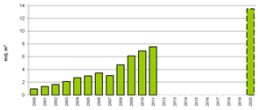
Photo: Juha Laitila

Decision Support for Policy-Makers and Large Market Players

- Ambitious targets for increase of renewables
- EU's 20-20-20 targets
- In Finland 13.5 Mm^3 of forest chips should be used in 2020

-> Large-scale studies at the regional, national, EU and global levels

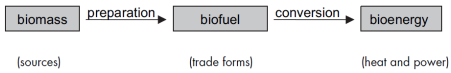
The use of forest chips in Finland and the target for 2020



Ylitalo (2012)

Terms and Concepts

What Is Forest Energy?

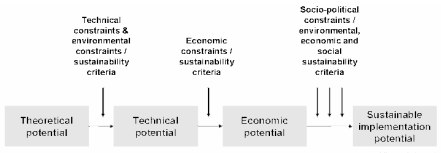


FAO (2004)

- Forest energy = energy produced of woody biomass from forest
- Here we focus on the estimation of the supply potential and availability of the biomass resource
- Forest energy is always bioenergy -> 'Bio' prefix is not necessary!

Types of Potentials

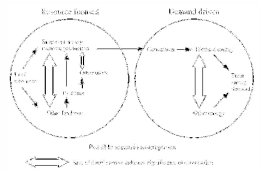
- Determines the approach and methodology
- Depends often on data availability



Vis et al. (2010)

Aspects to Be Considered

- Approach
  - Resource focused
  - Demand driven
  - Integrated
- Timeframe
  - Past
  - Present
  - Future
- Geographical coverage
  - Scope
  - Resolution
- Units
  - Solid-m3, loose-m3
  - Tonne (t)
  - Joule (J), watthour (Wh), tonne of oil equivalent (toe)



Berndes et al. (2003)

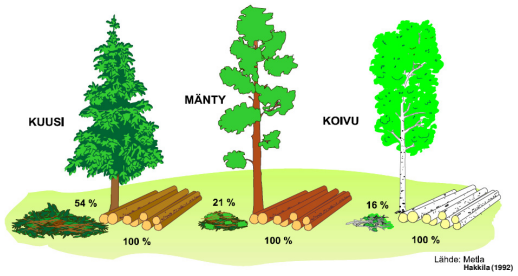
How to harmonise methods?

Biomass Energy Europe

- Biomass Energy Europe (BEE) project produced a handbook for biomass potential estimation (Vis et al. 2010)
- Visit http://www.eu-bee.info/

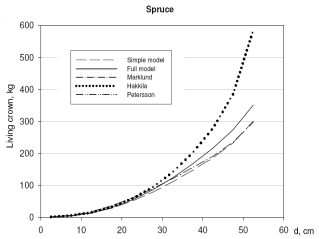
Biomass Models

Tree Allometry



Estimation of Biomass

- Biomass of crown and stump predicted with biomass functions or Biomass Expansion Factors (BEF)
- Explanatory variables may include
  - •tree species
  - •dbh
  - •height
  - •crown length
  - •age
  - •site type
- BEF is a simple version of a biomass function
- BEF converts timber volume to whole tree biomass



Repola et al. 2007

Some Published Models

- Finland
  - Hakkila (1972, 1979, 1991)
  - Repola (2008, 2009)
- Sweden
  - Marklund (1988)
  - Petersson (1999, 2006)
- Comparison
  - Kärkkäinen (2005)
  - Repola, Ojansuu & Kukkola (2007)
- Canada
  - Lambert et al. (2005)
- Europe
  - Zianis et al. (2005)
- Global (IPCC)
  - Penman et al. 2003

An Example of Biomass Models

Norway spruce

Aboveground biomass equations:

Stem wood: $\ln(y_{iti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+14)} + b_2 \ln(h_{ti}) + b_3 h_{ti} + u_k + e_{ti}$

Stem bark: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+18)} + b_2 \ln(h_{ti}) + u_k + e_{ti}$

Living branches: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+13)} + b_2 \frac{h_{ti}}{(h_{ti}+5)} + u_k + e_{ti}$

Needles: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+10)} + b_2 \frac{h_{ti}}{(h_{ti}+1)} + u_k + e_{ti}$

Dead branches: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+18)} + \ln(h_{ti}) + u_k + e_{ti}$

Total (aboveground): $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+20)} + b_2 \ln(h_{ti}) + u_k + e_{ti}$

Belowground biomass equations:

Stump: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+20)} + u_k + e_{ti}$

Roots >1 cm: $\ln(y_{ti}) = b_0 + b_1 \frac{d_{ti}}{(d_{ti}+24)} + u_k + e_{ti}$

Where

y_{ti} = biomass component or total biomass for tree i in stand k, kg
$d_{ti1.3} = 2 + 1.25\ d_{ti}$ (d_{ti} = tree diameter at breast height for tree i in stand k), cm
h_{ti} = tree height for tree i in stand k, m

Repola et al. 2007

Accumulation of Crown Biomass

- Bucking and delimbing height affect accumulation of crown biomass
- Models for relative accumulation

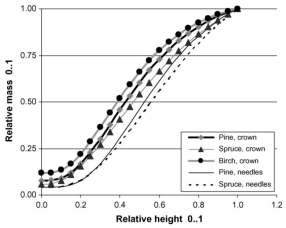


Fig. 6. Estimated relative accumulation of living crown biomass of pine, spruce and birch and accumulation of needle biomass of pine and spruce.

Tahvanainen & Forss 2008

Accumulation of Crown Biomass

Puukohtainen hakkuutähteen kuivamassa (kg) kuusella

Ainespuun latvaläpimitta = 6 cm

	Pituus (m)															
$d_{1.3}$ (cm)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7	10,3	10,5	10,9	11,4	7,7	7,5	7,9	8,2	·	·	·	·	·	·	·	·
8	14,2	14,4	8,4	8,3	8,8	8,6	8,8	9,0	9,3	·	·	·	·	·	·	·
9	18,9	11,1	10,6	10,4	10,5	10,4	10,5	10,6	10,8	11,0	·	·	·	·	·	·
10	15,5	14,3	13,6	13,1	12,9	12,7	12,7	12,8	12,9	13,1	·	·	·	·	·	·
11	20,1	18,4	17,2	16,5	15,8	15,7	15,5	15,5	15,5	15,6	15,8	·	·	·	·	·
12	25,7	23,3	21,6	20,5	19,4	19,3	19,0	18,8	18,7	18,8	18,8	19,0	·	·	·	·
13	32,3	29,0	26,9	25,3	23,6	23,5	23,1	22,7	22,5	22,5	22,5	22,5	22,7	·	·	·
14	40,0	35,8	32,9	30,9	28,6	28,5	27,8	27,3	27,0	26,8	26,7	26,7	26,7	26,9	·	·
15	48,8	43,5	39,9	37,4	34,3	34,2	33,2	32,5	32,0	31,7	31,5	31,4	31,4	31,5	31,6	·
16	58,7	52,3	47,8	44,6	40,8	40,5	39,3	38,3	37,7	37,2	36,9	36,7	36,6	36,6	36,7	36,8
17	69,9	62,1	56,6	52,7	48,0	47,7	46,1	44,9	44,0	43,3	42,9	42,6	42,4	42,3	42,4	42,5
18	·	72,9	66,4	61,7	56,0	55,6	53,6	52,1	50,9	50,1	49,5	49,0	48,8	48,6	48,6	48,6
19	·	84,9	77,1	71,5	64,8	64,2	61,8	60,0	58,6	57,5	56,7	56,1	55,7	55,5	55,3	55,3
20	·	·	88,8	82,2	74,3	73,6	70,7	68,5	66,8	65,5	64,5	63,8	63,2	62,9	62,6	62,5
21	·	·	101,4	93,8	84,7	83,7	80,4	77,8	75,7	74,2	72,9	72,0	71,3	70,8	70,5	70,3
22	·	·	115,0	106,2	95,8	94,6	90,7	87,6	85,3	83,4	81,9	80,8	80,0	79,3	78,9	78,6

Räisänen 2010

Accumulation of Crown Biomass

Puukohtainen hakkuutähteen kuivamassa (kg) kuusella

Ainespuun latvaläpimitta = 10 cm

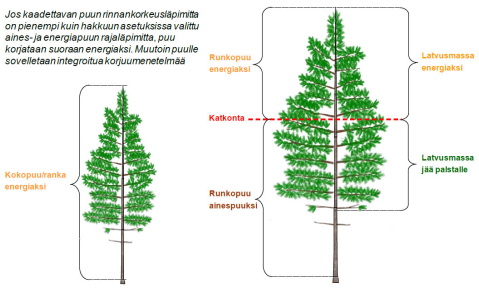
+114%

	Pituus (m)															
$d_{1.3}$ (cm)	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
7	10,3	10,5	10,9	11,4	12,3	12,5	13,0	13,7	·	·	·	·	·	·	·	·
8	14,2	14,4	14,8	15,3	16,2	16,6	17,2	18,1	18,9	·	·	·	·	·	·	·
9	18,9	19,0	19,4	20,0	20,9	21,3	22,4	23,3	24,3	25,2	·	·	·	·	·	·
10	24,6	24,5	24,9	25,5	26,3	27,2	28,3	29,4	30,5	31,7	·	·	·	·	·	·
11	31,4	31,1	31,3	31,9	32,6	33,9	35,0	36,3	37,6	27,5	28,5	·	·	·	·	·
12	39,3	38,6	38,7	25,7	25,3	26,0	26,4	27,0	27,7	28,4	29,2	30,1	·	·	·	·
13	48,5	47,3	30,7	29,8	28,8	29,3	29,5	29,8	30,2	30,7	31,3	32,0	32,7	·	·	·
14	58,8	38,7	36,4	35,0	33,2	33,7	33,5	33,6	33,8	34,1	34,5	35,1	35,7	36,4	·	·
15	70,6	46,1	43,1	41,0	38,5	38,9	38,4	38,2	38,2	38,3	38,6	39,0	39,5	40,0	40,7	·
16	60,6	54,7	50,7	48,0	44,6	44,9	44,1	43,6	43,3	43,3	43,4	43,7	44,0	44,5	45,0	45,6
17	71,6	64,3	59,3	55,8	51,5	51,7	50,5	49,7	49,2	49,0	48,9	49,0	49,2	49,6	50,0	50,5
18	·	75,0	68,9	64,6	59,3	59,3	57,7	56,5	55,8	55,3	55,1	55,0	55,1	55,3	55,7	56,1
19	·	86,8	79,4	74,2	67,8	67,6	65,6	64,1	63,1	62,3	61,9	61,6	61,6	61,7	61,9	62,3
20	·	·	90,9	84,7	77,2	76,8	74,3	72,4	71,0	70,0	69,4	68,9	68,7	68,7	68,8	69,0
21	·	·	103,4	96,1	87,4	86,7	83,7	81,4	79,6	78,4	77,4	76,8	76,4	76,3	76,2	76,4
22	·	·	116,9	108,4	98,3	97,4	93,8	91,0	88,9	87,3	86,2	85,3	84,8	84,4	84,3	84,3

Räisänen 2010

ComBio Tool

Jos kaadettavan puun rinnankorkeusläpimitta on pienempi kuin hakkuun asetuksissa valittu aines-ja energiapuun rajaläpimitta, puu korjataan suoraan energiaksi. Muutoin puulle sovelletaan integroitua korjuumenetelmää



Pasanen 2010

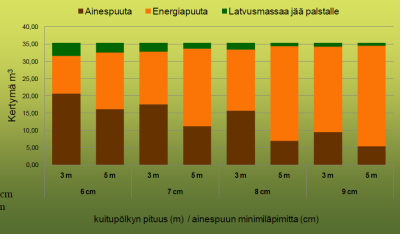
ComBio Tool

Esimerkki: männikön ensiharvennus

Puuston lähtötiedot:
- 1833 runkoa/ha
- ppa 20,5 m²/ha
- keskiläpm 12,5 cm
- keskipit. 11 m

Harvennuksen jälkeen
- 1233 runkoa/ha
- ppa 15,9 m²/ha
- keskiläpm 13,0 cm
- keskipit. 11,5 m

ComBio -asetukset
- aines- ja energiapuun raja (d1.3) 6 cm
- ainespuun minimiläpimitta: 6 - 9 cm
- pölkyn pituudet 3m ja 5m

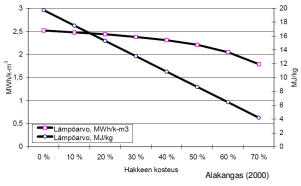


Pasanen 2010

Conversion to Other Units

- If tons are not the desired unit, a conversion needed
- Other frequently used units
  - •m^3
  - •MWh
- Basic densities and net calorific values from literature

Net calorific heating value of forest chips as a function of moisture



Alakangas (2000)

Project-level Assessments

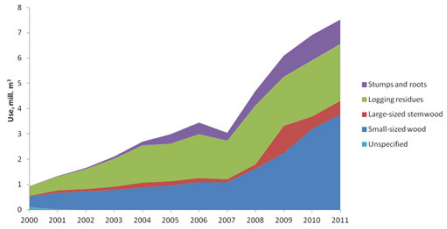
Resource-Focused Cost-Supply Method

- based on forest resource data
  - tree & plot level data
  - stand-level data
  - regional data
- varies in time and space
- biomasses estimated with biomass models or factors
- constraints for wood production and procurement
- road network

Photo: Jutta Kuure

- available data varies case by case -> you have to play with what you have!

Origin of Forest Chips in Finland



Logging Residues from Final Fellings

- crown biomass
  - branches
  - leaves / needles
- stemwood loss
  - defected wood
  - under-sized tops
  - small-sized stems
- mostly spruce

Photo: J. Laitila

Stumps from Final Fellings

- stumps
- coarse roots
- mostly spruce

Photo: J. Laitila

Defected Stemwood

- large-sized
- mostly imported

Photo: P. Anttila

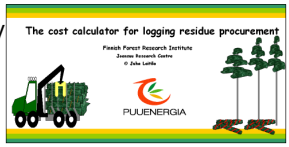
Small Trees from Young Forests

- delimbed stemwood
- whole trees
- ”pulp wood”
- mostly broadleaved, but also pine and spruce

Photo: J. Laitila

Procedure

1. Decide upon the supply chains to be compared
2. Estimate how much energy wood available
3. Calculate transportation distances
4. Calculate costs of each working phase
5. Present the results



Constraints Reduce Availability
An Example of Small Tree Potential

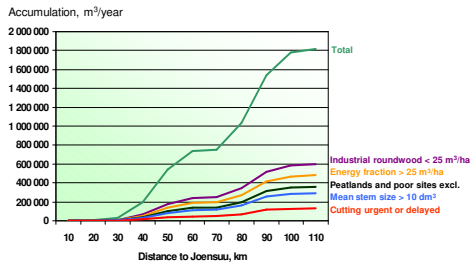
Theoretical potential

Constraints:

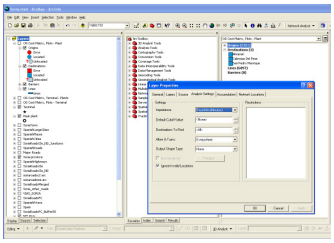
- **Accumulation of industrial roundwood, max. 25 m³/ha**
- **Accumulation of energy fraction, min. 25 m³/ha**
- **Peatland stands and stands on mineral soil with site poorer than *Myrtillus*-type were excluded**
- **Minimum for mean stem size, 10 dm³**
- **Suggested cutting is urgent or delayed**

Estimated technical potential

Effect of Constraints

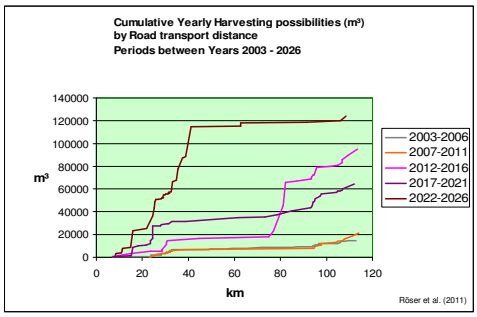


Transport Distances

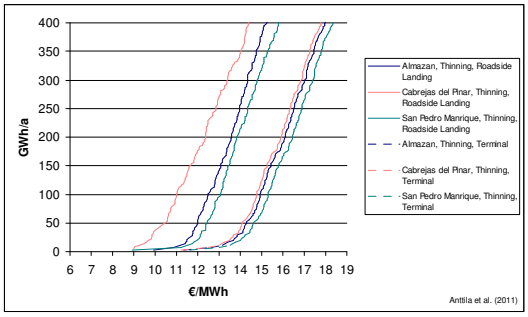


- Calculated in GIS via real road network
- From each supply site to the plant

Example of Results (Wick, Scotland)



Example of Results (Soria, Spain)



Regional Assessments

Advanced Spatially Explicit Method

Biomass Energy Europe

Remote Sensing Based Assessment of Forest Energy Potentials in Finland

Perttu Anttila, Aleksi Lehtonen, Jukka Mustonen & Paula Puolakka
Finnish Forest Research Institute (Metla)

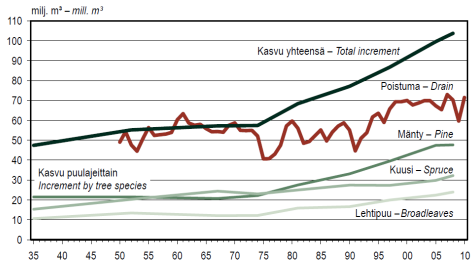
Conference on Biomass Energy Potential Assessments
Brussels, November 8

BEE project is funded by the European Commission under the Framework Programme 7
FP7 GRANT AGREEMENT N° 213417

Biomass Energy Europe

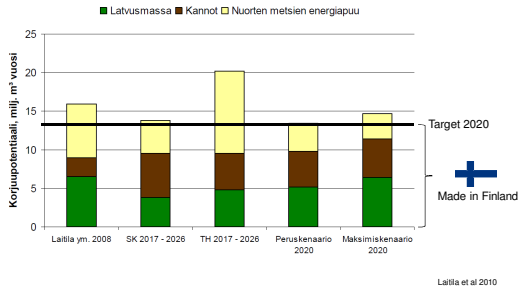
National Assessments

Use of wood fuels can be increased sustainably



Lähde: Metsäntutkimuslaitos – *Source: Finnish Forest Research Institute*

Techno-Economical Potential of Forest Chips in Finland



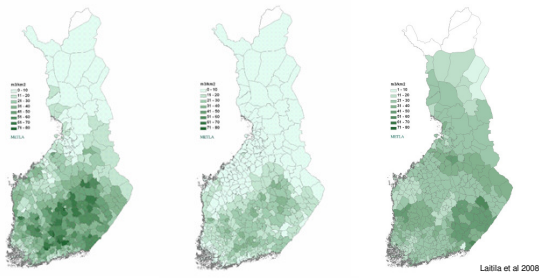
Laitila et al 2010

Spatial Distribution of Potential

Logging residues from final fellings

Spruce stumps from final fellings

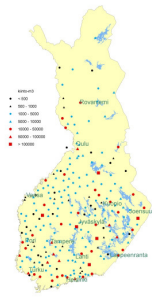
Energy wood from young forests



Laitila et al 2008

Spatial Distribution of Demand

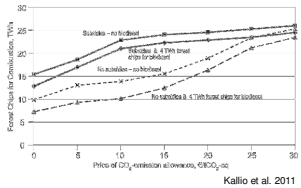
- Demand concentrated on population centres



Spatial Market Model

By municipality

- Demand and supply of energy produced from fuels
- Endogenous supply, demand, and prices of forest chips
- Exogenous roundwood harvests
- Transports are essential cost factor for forest chips !!



Kallio et al. 2011

Forest Biomass Resources in Finland in 2020

- Biggest problem not the technical availability, but the supply cost and logistics

Photo: Jutta Kuure

International Assessments

Forest Energy Resources in the EU

EUwood – Potentials for Increased Growth and Utilization of Tree-based Biomass in the EU

Dr Perttu Anttila

ENERWOODS Thematic Day
Denmark
19 June 2012

Global Potential of Modern Fuelwood

Present fellings
25% of surplus forest growth

Anttila et al. 2009

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Finnish Wood Fuel Supply Chains