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Development for Opportunities for Utilisation of Biomass Residues in the Renewable Sector of Ukraine

Biomass to heat and Power - FIN/UA cases

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BIOMASS

Sulamaa Consulting

ДЕРЖЕНЕРГОЕФЕКТИВНОСТІ

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Background

Wood-based bioenergy is a by-product of sustainable forestry

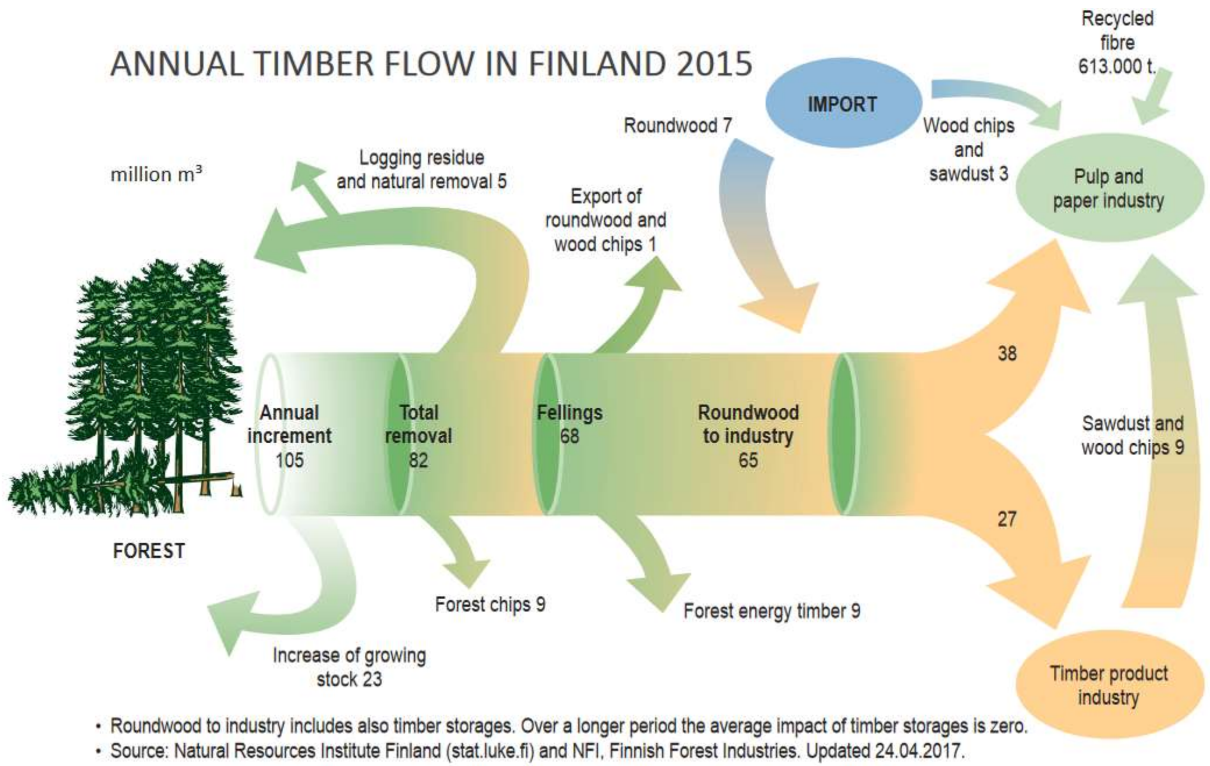
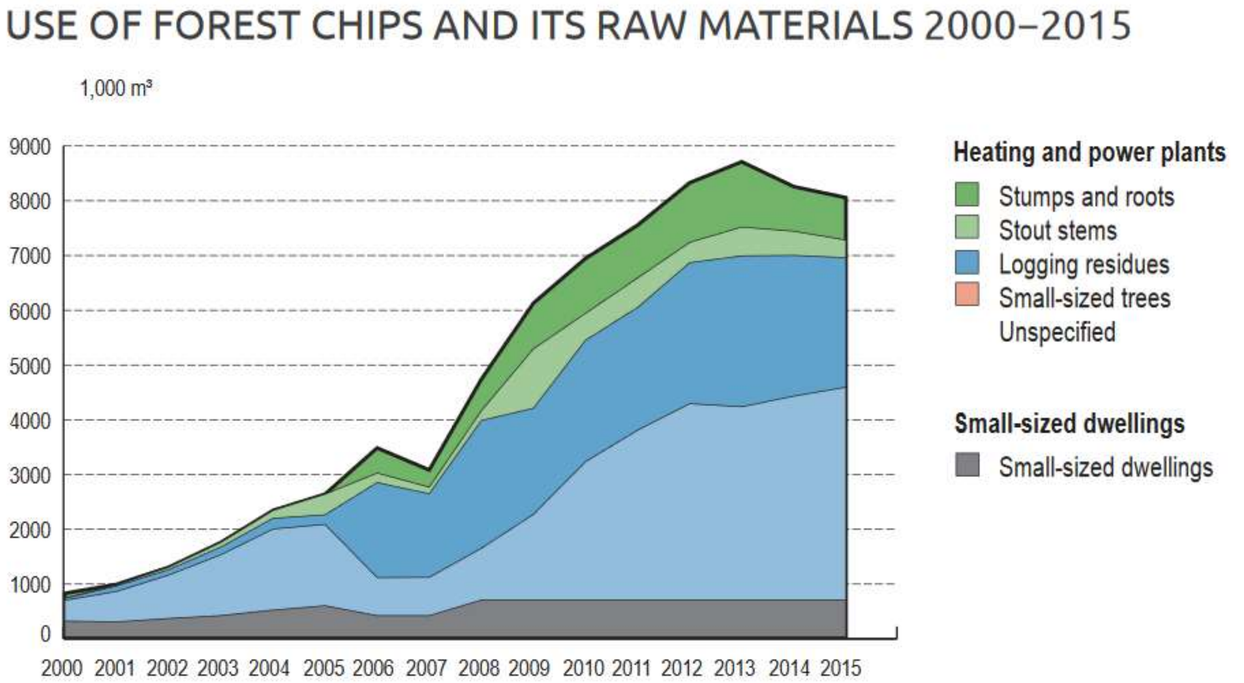


Image source: forest.fi

Forest based energy in Finland



- The use of forest chips has almost multiplied by ten during the 2000's. finland's goal is that in 2020 the annual use is 13.5 million cubic meters.
- Felled stout timber is made into forest chips, if it has such faults that it cannot be used as timber or pulp wood.
  Such a fault can be decay, for example.
- Source: Natural Resources Institute Finland (stat.luke.fi). Updated 19.4.2016.

Image source: forest.fi

Forest based energy in Finland

SOLID WOOD FUEL CONSUMPTION IN HEATING AND POWER PLANTS IN 2015

FUEL	Solid volume mill.m3	Solid volume share, %	Energy content TWh	Energy content share, %	Users
FOREST CHIPS	**7.35**	**40.2**	**14.68**	**42.1**	**985**
FOREST INDUSTRY BY-PRODUCTS	**10.10**	**55.3**	**18.27**	**52.4**	-
industrial chips	1.02	5.6	2.06	5.9	200
sawdust	2.15	11.8	4.28	12.3	245
bark	6.92	37.9	11.90	34.1	190
other	0.02	0.1	0.03	0.1	3
WOOD PELLETS AND BRIQUETTES	**0.14**	**0.7**	**0.73**	**2.1**	**240**
RECYCLED WOOD	**0.69**	**3.8**	**1.19**	**3.4**	**105**
TOTAL	**18.27**	**100**	**34.87**	**100**	**-**

- The bulk density of 1,150 kg/m3 has been usen in converting pellets and briquettes into solid volume.
- Source: Natural Resources Institute Finland (stat.luke.fi). Updated 21.04.2017.

Image source: forest.fi

Agrobiomasses in Finland

(Sakari Alasuutari/Plugi)

- Current energy use of agrobiomasses 0.5 TWh/a, mainly straw
- Total potential 12 – 22 TWh/a
- Major part of the potential consists of agricultural side products (straw) 10% and dedicated energy crops 50% (Reed canary grass) (Mikkola 2012. peltoenergian tuotanto Suomessa)

FIN Cases:
#1 Imatran Lämpö Oy Virasoja

#2 Imatran Lämpö Oy Rajapatsas

Project #1 Finland: Imatran Lämpö Oy, Virasoja

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- Biomass boiler heat capacity – 36 + 4 MW
- Main fuel – wood chips (from logging residues), bark
- Investment - 15.5 M€
- Energy production:
  - heat - 134495 MWh
  - power – N/A MWh
- Fuel consumption – 154 565 MWh
- Energy efficiency of supply chain including losses in the heat distribution network 83%*

*=heat produced/fuel consumption$_{fuel}$+fuel consumption $_{supply\ chain}$
=> approx 2-3ltr diesel fuel consumed for 1 Mwh$_{fuel}$
=> Energy consumption in the supply chain approx. 0,03MWh$_{diesel}$/Mwh$_{wood\ fuel}$

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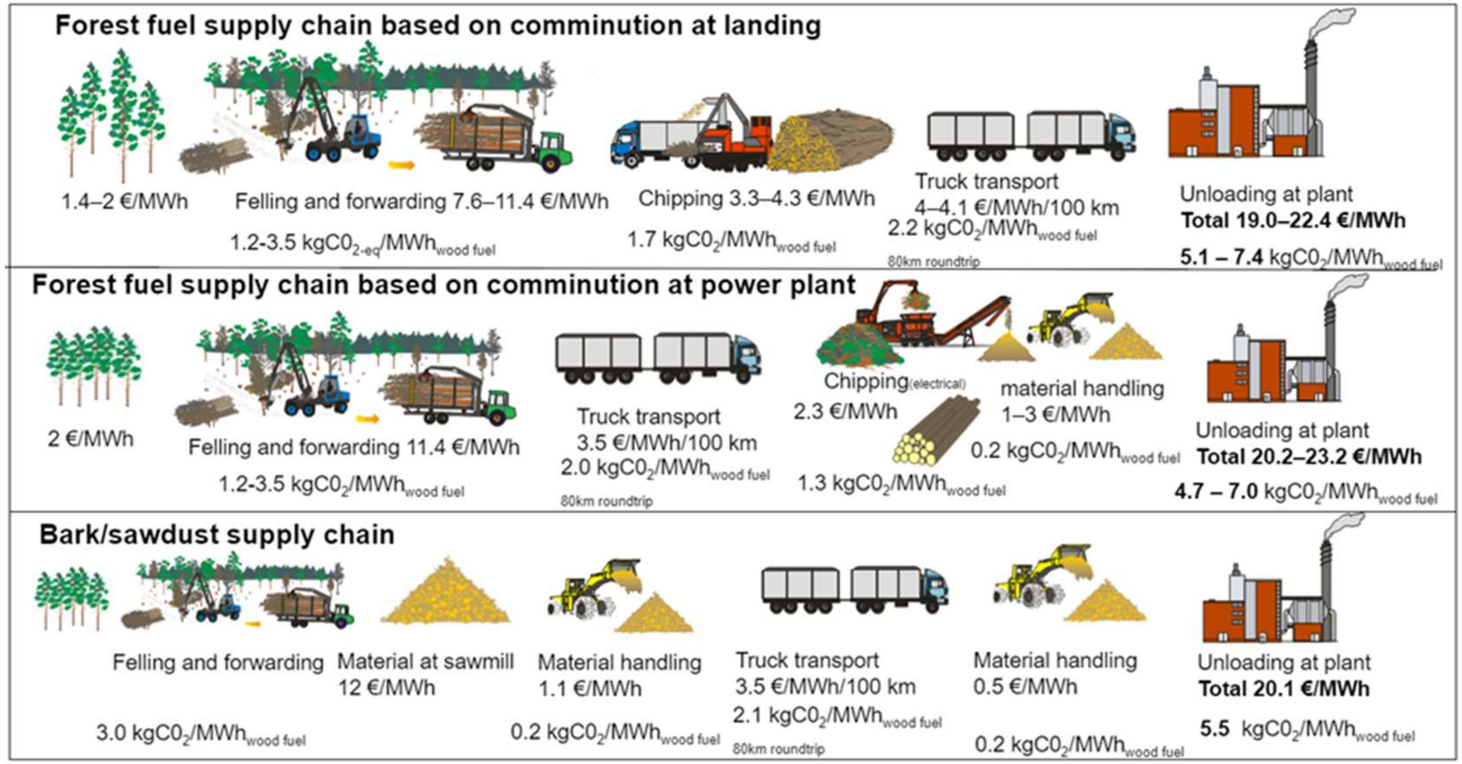
Project #1 Finland: Imatran Lämpö Oy, Virasoja

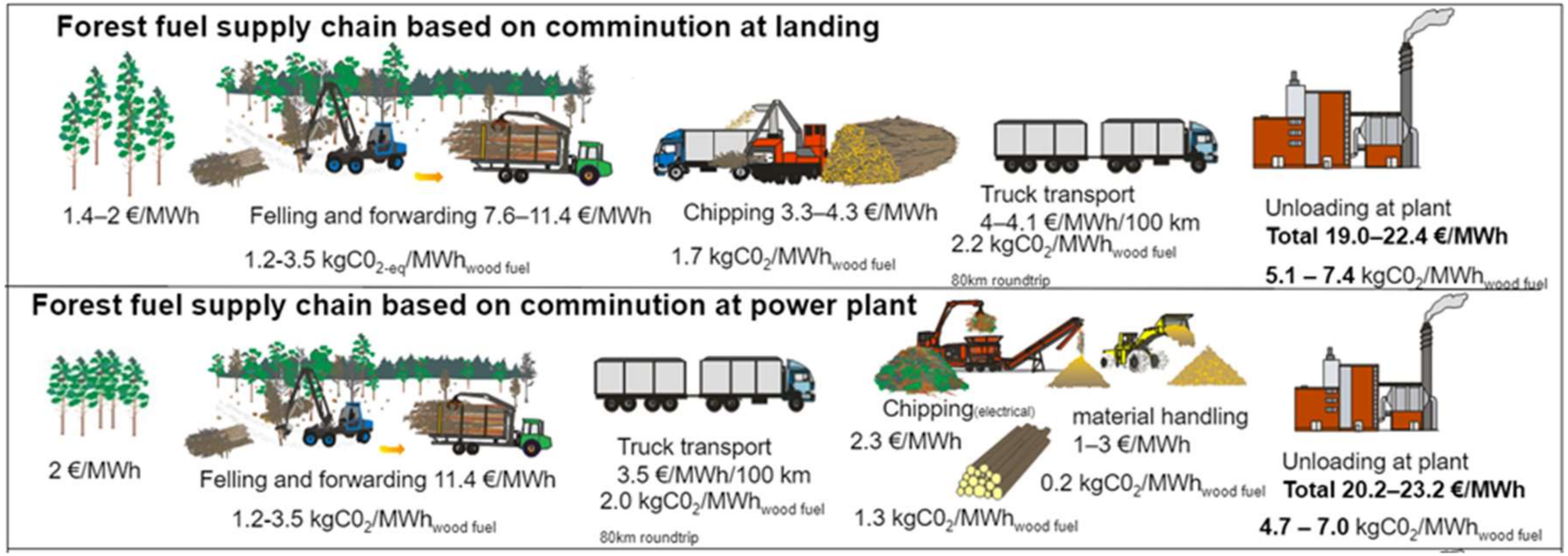


Project #2 Finland: Imatran Lämpö Oy, Rajapatsas

- Biomass boiler heat capacity – 4 MW
- Main fuel – wood chips
- Investment - 2.6 M€
- Energy production:
  - heat - 18 871 MWh
  - power – N/A MWh
- Fuel consumption – 22 894 MWh
- Energy efficiency of supply chain including losses in the heat distribution network 80 %
- A flue gas condenser investment will be made in the near future

*=heat produced/fuel consumption$_{fuel}$+fuel consumption $_{supply\ chain}$
=> approx 2-3ltr diesel fuel consumed for 1 Mwh$_{fuel}$
=> Energy consumption in the supply chain approx. 0,03MWh$_{diesel}$/Mwh$_{wood\ fuel}$

Fuel supply chain costs and emissions

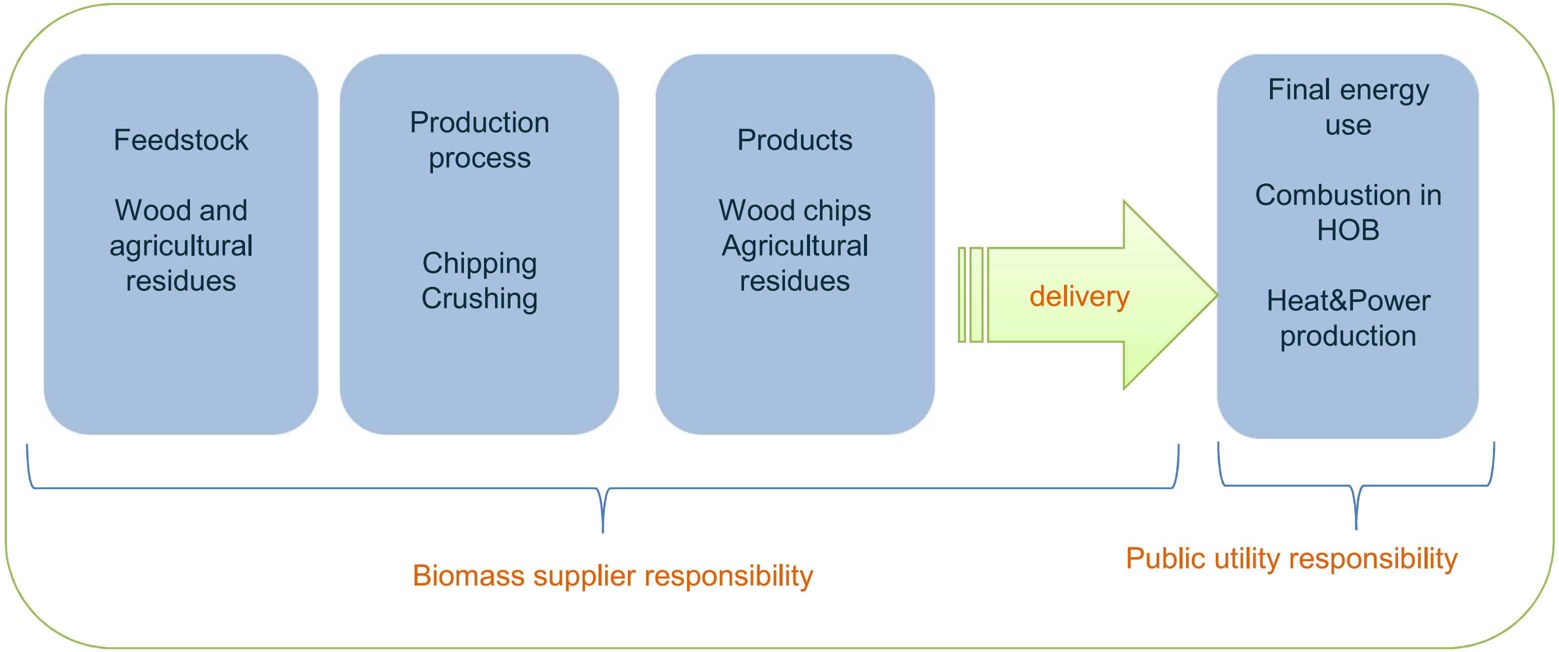


UA Cases:
#1 Biomass CHP installation of public utility Miskteplovodenergia
#2 Biomass HOB installation of private company LLC Ukteplo

Project #1 Ukraine: Biomass CHP installation of public utility Miskteplovodenergia

- Biomass boiler heat capacity – 15 MW
- ORC unit power capacity – 1,6 MW
- Main fuel – wood chips
- Investment - 12,2 mill $
- Loan (WB) - 9.6 mill $
- Energy production:
  - heat - 44 706 MWh
  - power – 7 160 MWh
- Fuel consumption – 69 548 MW (23 kt)
- Energy efficiency of supply chain – 77%

Fuel supply chain



Fuel supply chain costs and emissions

Fuel supply chain based on old garden comminution at garden

Volume: 2000 t
5560 MWh

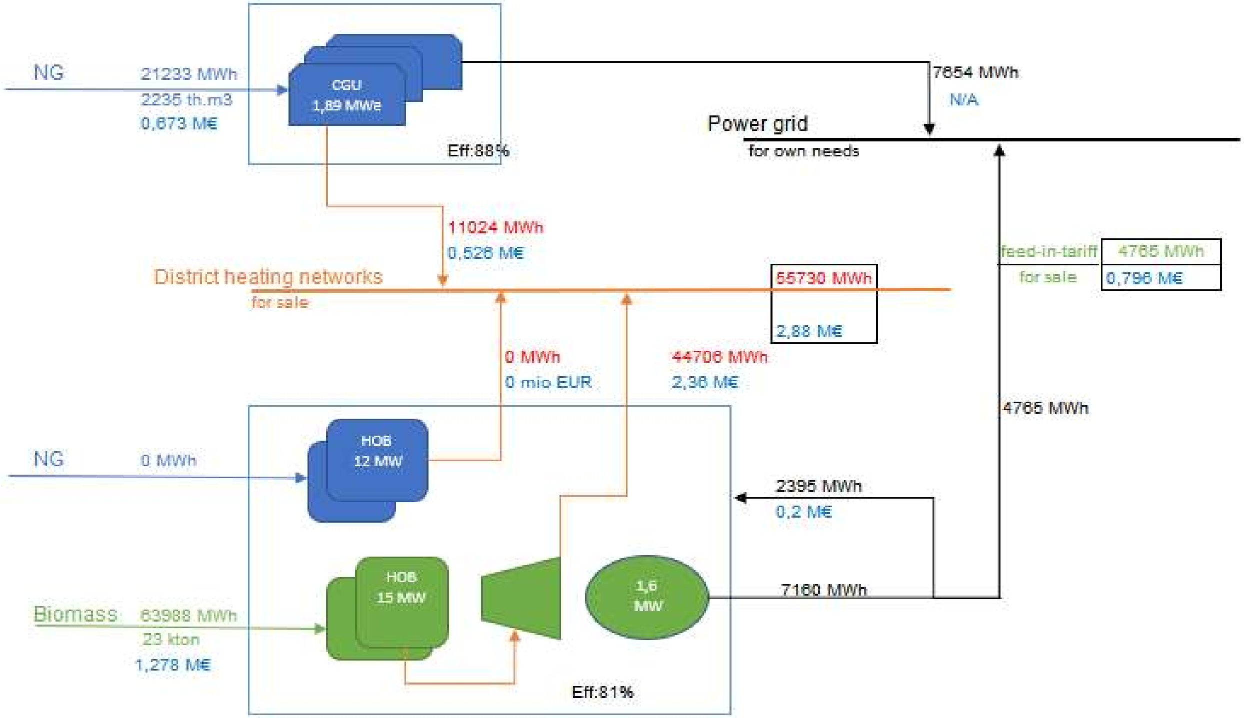
RAW material	Felling	Chipping	Transportation	Total:
- €/MWh	5,33 €/MWh	3,64 €/MWh	1,212 €/MWh 4,85 €/MWh 100km	16,0 €/MWh
Motor fuels consumption and emissions CO2				
0 kg/MWh	0 kg/MWh	1,97 kg/MWh	0,86 kg/MWh	2,83 kg/MWh
0 kg CO_{2e}/MWh	0 kg CO_{2e}/MWh	6,5 kg CO_{2e}/MWh	2,8 kg CO_{2e}/MWh	9,4 kg CO_{2e}/MWh

Fuel supply chain from forest residues and firelogs based on comminution at forest

Volume: 23 017 t
63 988 MWh

RAW material	Felling	Chipping	Transportation	Total:
3,2 €/MWh	5,3 €/MWh	3,6 €/MWh	0,823 €/MWh 1,267 €/MWh/100km	20,0 €/MWh
Motor fuels consumption and emissions CO2				Total:
0 kg/MWh	0 kg/MWh	2,0 kg/MWh	0,5 kg/MWh	2,5 kg/MWh
0 kg CO_{2e}/MWh	0 kg CO_{2e}/MWh	6,5 kg CO_{2e}/MWh	1,8 kg CO_{2e}/MWh	8,3 kg CO_{2e}/MWh

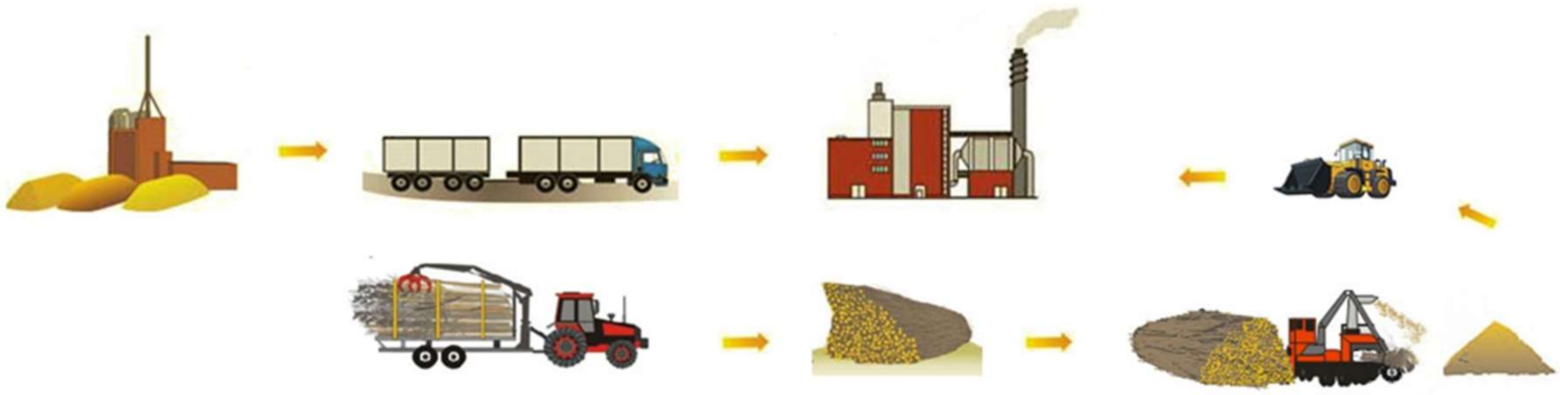
Flow chart for energy production



Project #2 Ukraine: Biomass HOB installation of private company LLC Ukteplo

- Biomass boiler heat capacity –10,5 MW
- Main fuel – wood chips
- Investment - 4 mill $
- Energy production:
  - heat - 32 564 MWh
  - power – 0 MWh
- Fuel consumption –38 300 MW (15 kt)
- Energy efficiency of supply chain –81 %

Fuel supply chain



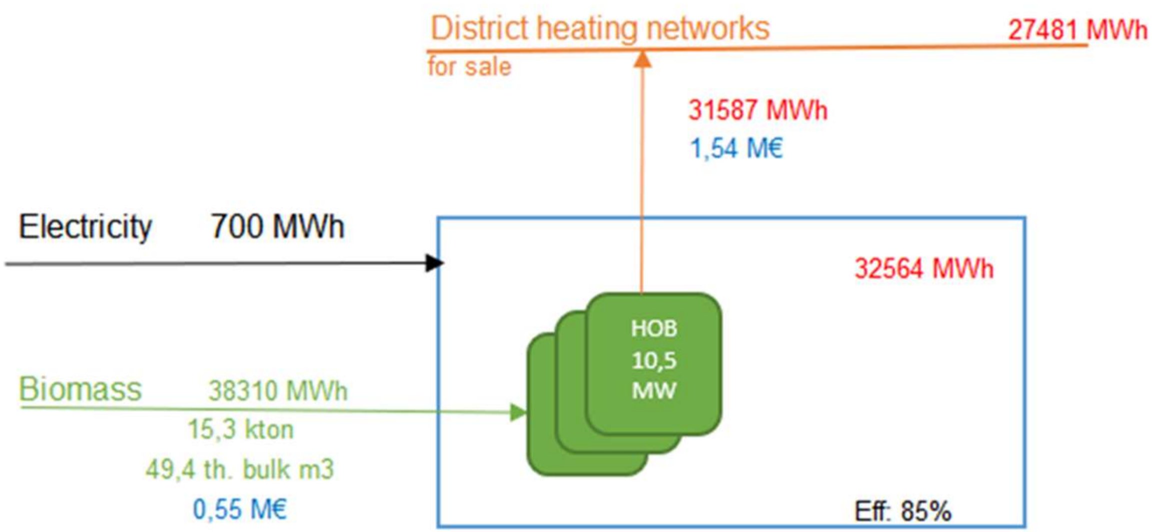
Fuel supply chain costs and emissions

Fuel supply chain from sawmill residues based on chipping at HOB site

Volume: 15 321 t; 38 304 MWh

	RAW material	Felling and forwarding	Sawmill residues transportation	Chipping	Handling	Total
Cost	0 €/MWh	0,0 €/MWh	6,3 €/MWh	1,741 €/MWh	4,34 €/MWh	**12,4 €/MWh**
Motor fuels consumption and emissions CO_2	0 kg/MWh	0 kg/MWh	0 kg/MWh	0,4 kg/MWh	1,6 kg/MWh	**2,00 kg/MWh**
	0 kg CO_{2e}/MWh	0 kg CO_{2e}/MWh	0 kg CO_{2e}/MWh	1,2 kg CO_{2e}/MWh	5,4 kg CO_{2e}/MWh	**6,6 kg CO2e/MWh**
Electricity consumption and emission CO_2	0 kWh.e/MWh	0 kWh.e/MWh	0 kWh.e/MWh	0,0 kWh.e/MWh	18,3 kWh.e/MWh	**18,3 kWh.e/MWh**
	0 kg CO_{2e}/MWh	0 kg CO_{2e}/MWh	0 kg CO2e/MWh	0,0 kg CO_{2e}/MWh	20,1 kg CO_{2e}/MWh	**20,1 kg CO2e/MWh**

Flow chart for energy production



Biomass to heat and power, Cases #1 and #2: Observed similarities, differences and suggestions for development

Case #1 Energy balance of fuel supply chain

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Name	Virasoja	MTVE	Units
Install capacity	36 +4	15	MW
Total volume of biomass	67 476	23 017	t
	154 565	69 548	MWh
Diesel consumption		205	t
		2432	MWh
Total energy production	148 973	51 866	MWh
heat	148 973	44 706	MWh
power	-	7 160	MWh
Power for own consumption	3475	2 395	MWh
Useful energy balance	145 473	48 958,1	MWh
% of primery energy	94,1%	77%	-

Case #1 CAPEX and OPEX

Name	Virasoja	MTVE	Units
Install capacity	36+4	15	MW
heat production	148 973	44 706	MWh
power production	-	7 160	MWh
Biomass CHP CAPEX, incl. VAT	15,5	12,2	Mio €
OPEX, excl. VAT:			
Biomass	2,632	1,278	Mio €
Maintenance costs	0,115	0,003	Mio €
Repairing costs	0,089	0,017	Mio €
Personnel costs	0,300	0,176	Mio €
Own cost of:			
- electricity	-	0,083	€/kWh
- heat	22,6	42,8	€/MWh
Revenue, excl.VAT	7,3	2,6	Mio €

Case #1 Technical Key Performance Indicator

Name	Virasoja	MTVE	Units
Raw materials consumption	67 476	23 017	t/year
Raw materials consumption	154565	63 988	MWh/year
Losses	5595	-	MWh/year
Power produced	-	7 160	MWh/year
Heat produced	148 973	44 706	MWh/year
Internal power consumption	3 475	2 395	MWh/year
Boiler Efficiency	96,4%	85%	%
CO_2 emissions		17 279	t.CO_{2e} /year

Case #2 Energy balance of fuel supply chain

Name	Rajapatsas	LLC Ukteplo	Units
Install capacity	4	10,5	MW
Total volume of biomass	8 562	15 321	t
	22 894	38 304	MWh
Diesel consumption		76,7	t
		910	MWh
Total energy production	18 871	32 564	MWh
heat	18 871	32 564	MWh
power	-	-	MWh
Power for own consumption	352	700	MWh
Useful energy balance	18 852	30 953	MWh
% of primery energy	82,3%	81%	-

Case #2 CAPEX and OPEX

Name	Rajapatsas	LLC Ukteplo	Units
Install capacity	4	10,5	MW
heat production	18 871	32 564	MWh
power production	-	-	MWh
Biomass CAPEX, incl. VAT	2,6	3,556	Mio €
OPEX, excl. VAT:			
Biomass	0,465	0,466	Mio €
Maintenance costs	0,018	0,073	Mio €
Repairing costs	0,006	0,019	Mio €
Personnel costs	0,050	0,053	Mio €
Own cost of:			
- electricity	-	-	€/kWh
- heat	20,31	20,832	€/MWh
Revenue, excl.VAT	1,022	1,286	Mio €

Case #2 Technical Key Performance Indicators

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Name	Rajapatsas	LLC Ukteplo	Units
Raw materials consumption	8562	15 321	t/year
Raw materials consumption	22894	38 304	MWh/year
Heat production	18871	32 564	MWh/year
Internal power consumption	352		MWh/year
Boiler Efficiency	82,3 %	85%	%
CO_2 emissions	Not available	6 417	t.CO_{2e} /year

The similarities, contrasts and differences in the practices used in Finland and Ukraine

Article	Ukraine	Finland
Share of forest (Woodiness)	16,5%	74%
Forest area	10,6 mil ha	23 mil ha
Felling area	445 th. ha/a	1 850 th. ha/a
Volume of timber harvesting	20 mil m^3	70 mil m^3
Number of forestry owners	Private – 0 State -543	Private forestry – 600 000 State forestry – 25% of land area
Main wood fuel feedstocks	Wood waste and fuel wood	Logging residue, delimbed small diameter stems, Non-commercial stem wood, bark, sawdust
Methods of harvesting wood residue	manual	Mechanized, minor share manual in special sites with sensitive soil or other special conditions
Main place of waste/chips processing/production	At the woodworking enterprises, at the CHP / boiler room	Roadside storages near cutting sites for logging residue. For delimbed stem and other stemwood also grinding at CHP/terminal is a feasible option

The similarities, contrasts and differences in the practices used in Finland and Ukraine

Article	Ukraine	Finland
Main residue/waste grinding technology	Stationary wood chippers and low-productivity mobile chippers	High productivity truck mounted mobile chipper
Typical moisture content	35-45%	45- 60%
Typical net weight load capacity - cargo weight	Lightweight (up to 10t) or mediumweight (up to 25t)	up to 30km small scale tractor - up to 25 t net load) and heavy > 30km distance (35-45 t net load)
Methods of quality control controlling the volume of delivery and quality of wood fuel and fuel raw materials	Weight control, Moisture control	Weight control for each delivered load, quality control - sampling of each load, quality certificates,
The average wood chips market price, EUR/MWh incl. VAT:		
- Feedstock	0-3,2	1,4-2
- Felling	5,3-7	7,6-11
- Chipping	3,6	3,3-4,3
- Transportation	0,82-2	3-5
Total	**12-22**	**20-25**
Diesel fuel price	0,9-1 EUR/lt	1,45 EUR/lt

Benchmark analysis of case studies between BAT and Ukrainian practices

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Estimate Gap Impact = likelihood*impact

Impact	Neglible 1	Minor 2	Moderate 3	Significant 4	Severe 5
Very likely/common 5					
Likely/rather common 4					
Possible 3					
Unlikely 2					
Very unlikely 1					

	Solid biomass
	Production process (Gap impact = 20). No special high productivity equipment for chipping wood residues to provide large quantities of raw materials for powerful energy objects.
	Product (Gap impact = 20). High price of wood chips from firewood. Produced thermal energy can be not competitive with traditional fuels (gas).
	Heat/Power generation and product (Gap impact = 25). The lack and high cost of special equipment for burning of wet fuel and bark.
	Final energy distribution (Gap impact = 20). High level of state regulation of heat and electric energy production and limited level of projects profitability.
	Heat final use (Gap impact = 12). Problems with grid connection, seasonal consumption of thermal energy, lack of a clear state policy and support for waste and renewable energy consumption.

Benchmark analysis of case studies between BAT and Ukrainian practices

Value chain step	Feedstock	Production process	product	Transport	Heat/Power generation	Final energy distribution
BAT in FIN	Residue collected from spruce dominated final felling areas	Chipping at roadside with heavy duty truck mounted chippers	Even particle size, moisture content/impurities/market value/Standards for quality	Transport of chips with a trucks with 45 ton load capacity	Receiving/feed to process/combustion	Power grid/DH grid
UA practice	Not common	On-site shredding with small shredders, mobile shredding services, waste disposal at lower timber landing	High moisture and ash content, deferent particle size	Transportation by trucks - 6-10 t net load capacity	Direct combustion, steam cycle	Power grid/DH grid

Benchmark analysis of case studies between BAT and Ukrainian practices

Value chain step	Feedstock	Production process	product	Transport	Heat/Power generation	Final energy distribution
Gaps/bottlenecks	Lack of information, lack of technology, high manual labor costs, low productivity, limited access	No special equipment for chipping	Low quality as fuel	No wood roads, need for off-road transport	No special equipment for combustion of moist fuel, Lack of a large number of powerful consumers	Tariffs and profitability state regulation, high competition with traditional fuels (gas), grid connections
Gap impact*	16 (4x4)	20 (4x5)	25 (5x5)	12 (4x3)	25 (5x5)	20 (5x4)
Recommendation	Publish information on harvesting and volume of harvesting waste, oblige forestry to collect waste, set targets for the use of forestry waste	Increase forestry financing to upgrade the technical status and production of new products or increase production	Quality must meet consumer requirements and equipment available	Need to construct forest roads, to use trailers with a net loading of more than 20 tons	Installation of new equipment for wet fuel combustion, use of heat energy utilizers	set national and regional targets for the share of RES in heat and electricity, introduce incentives for the use of wood and agriculture residues, grid connection

The value chain steps with most important gap impacts

- **Production process (Gap impact -20).** No special high productivity equipment for chipping wood residues to provide large quantities of raw materials for powerful energy objects.
- **Product (Gap impact -20).** High price of wood chips from firewood. Produced thermal energy can be not competitive with traditional fuels (gas).
- **Heat/Power generation and product (Gap impact -25).**. The lack and high cost of special equipment for burning of wet fuel and bark.
- **Final energy distribution (Gap impact -20).** High level of state regulation of heat and electric energy production and limited level of projects profitability.
- **Heat final use (Gap impact -20**). Problems with grid connection, seasonal consumption of thermal energy, lack of a clear state policy and support for waste and renewable energy consumption.

Conclusions

- Biomass transport efficiency is a key challenge, load sizes are two times larger in Finland
- Mechanized forestry and high-efficiency technology is a key to cost-effective forest fuel supply
- Long (wood) biomass transport distances are a challenge in K-Podilsky
- Short heating season is a big challenge in UA
- Relatively low gas prices are an economic challenge for new investments

Conclusions

- Low heat tariff and weak state support for heat production in UA
- High price for feedstock is a big challenge in UA (High price of wood chips from firewood)
- Lack of a large number of powerful consumers
- No special equipment for moist fuel combustion
- Problems with grid connection
- High level of state regulation of heat and electric energy production and limited level of projects profitability

Conclusions

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- The direct comparison of a case against another does not reveal all bottlenecks.
- In Finland bioenergy – especially wood based heat and power – is a result of a determined and multi-dimensional long term development covering sustainability in social, environmental and economical level.
- Also it has been a matter of political will – certain forestry practises that aim at wood fuel production have received subsidies and a support mechanism has been available for wood fuel use in heat and power production
- For the future the key question is how CO_2 emissions from biomass will regarded. Is BIO-CO_2 equivivalent to the CO_2 that is formed when fossil fuels are burned?

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beyond
the obvious

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