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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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# Background

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

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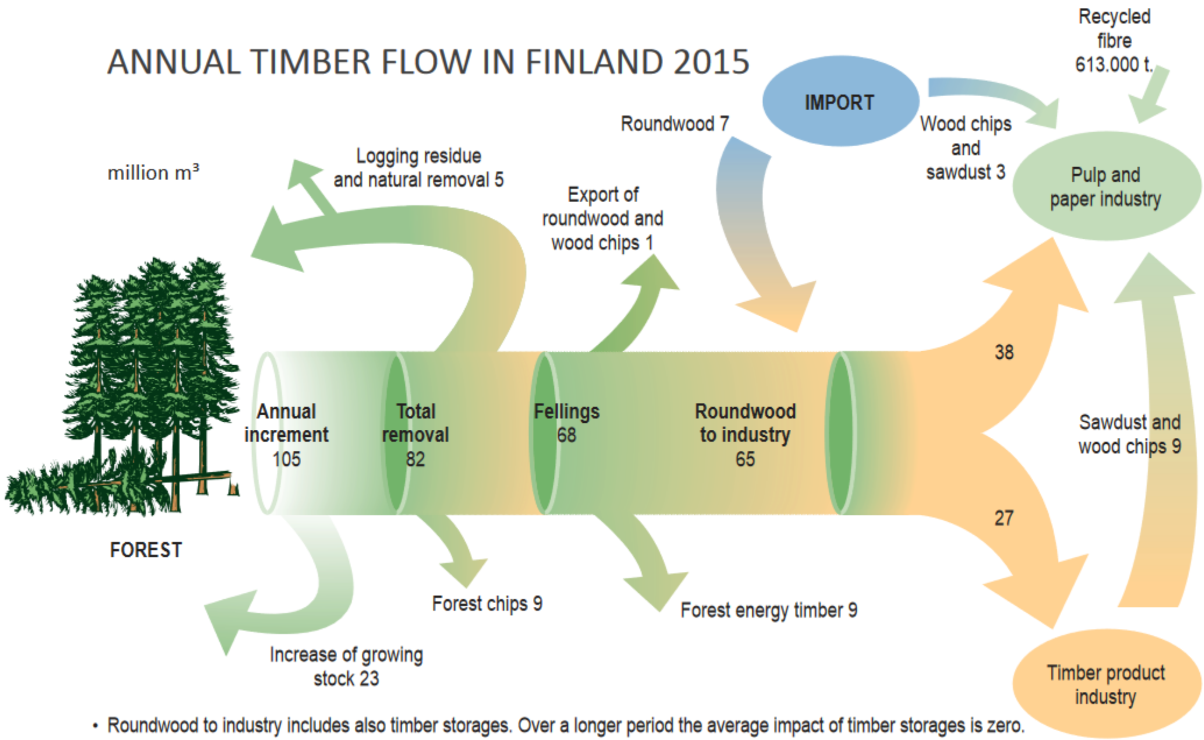
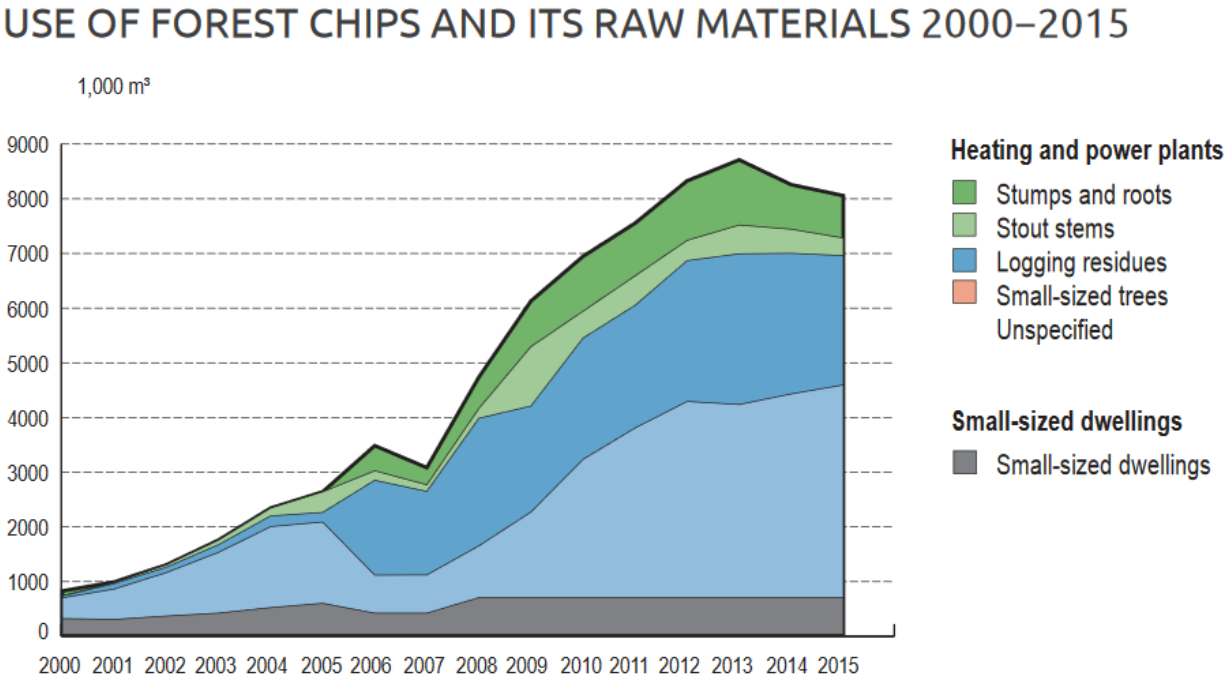



- Roundwood to industry includes also timber storages. Over a longer period the average impact of timber storages is zero.
- Source: Natural Resources Institute Finland (stat.luke.fi) and NFI, Finnish Forest Industries. Updated 24.04.2017.

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

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## 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

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(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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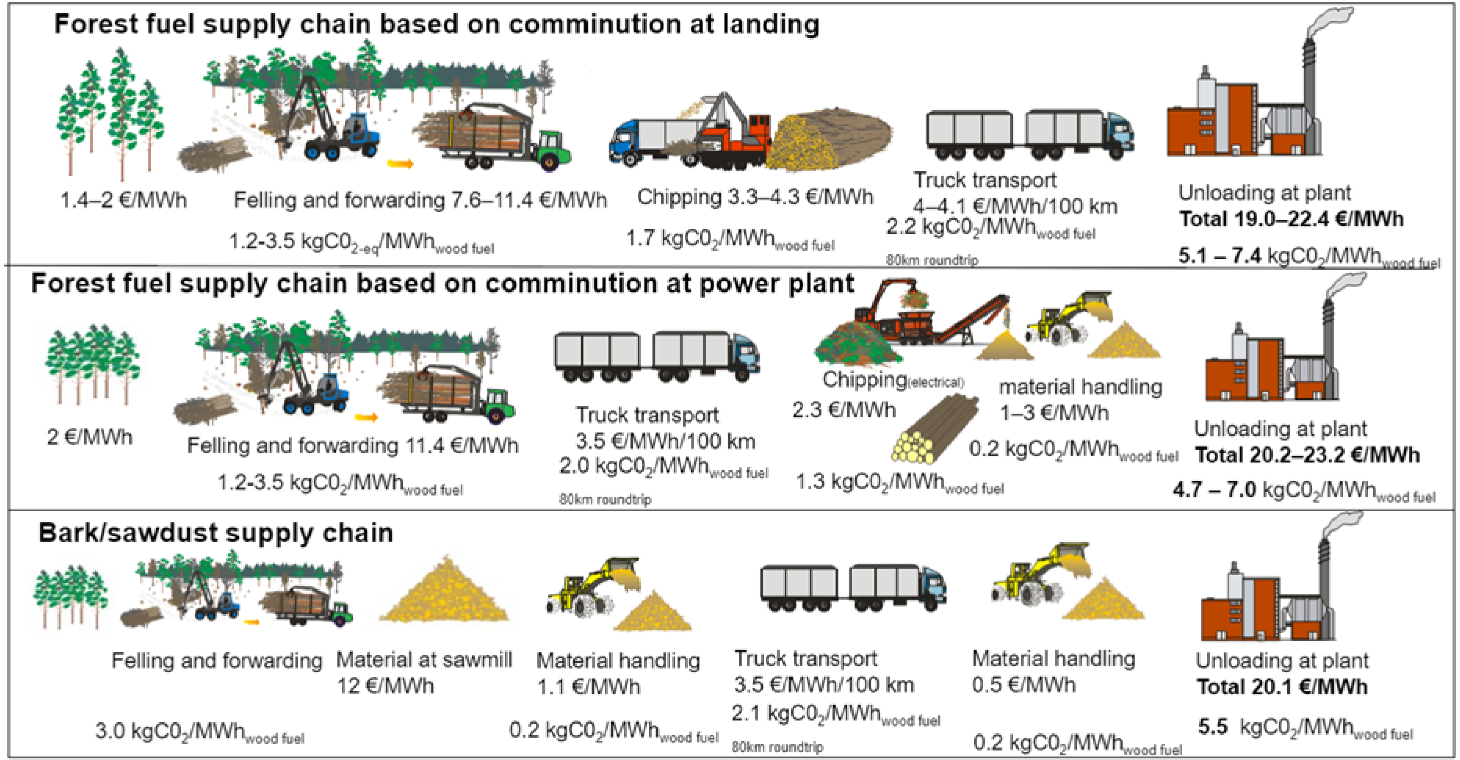
- Biomass boiler heat capacity – 36 + 4 MW
- Main fuel – wood chips (from logging residues), bark
- Investment  - 15.5 M€
- Energy production:
  - heat  -  134495 MWh
  - power –  N/A MWh
- Fuel consumption – 154 565 MWh
- Energy efficiency of supply chain 84%*


*=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$_{wood\ fuel}$

# Project #1 Finland: Imatran Lämpö Oy, Virasoja

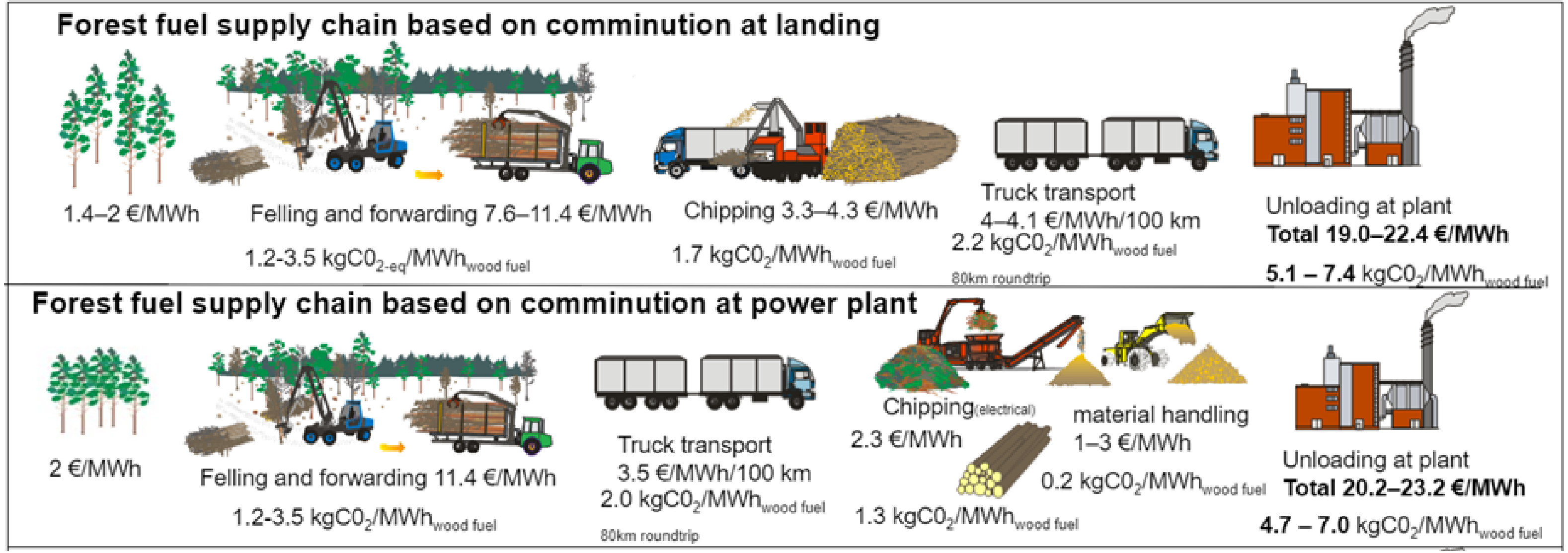


# Project #2 Finland: Imatran Lämpö Oy, Rajapatsas

- 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 80 %

*=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

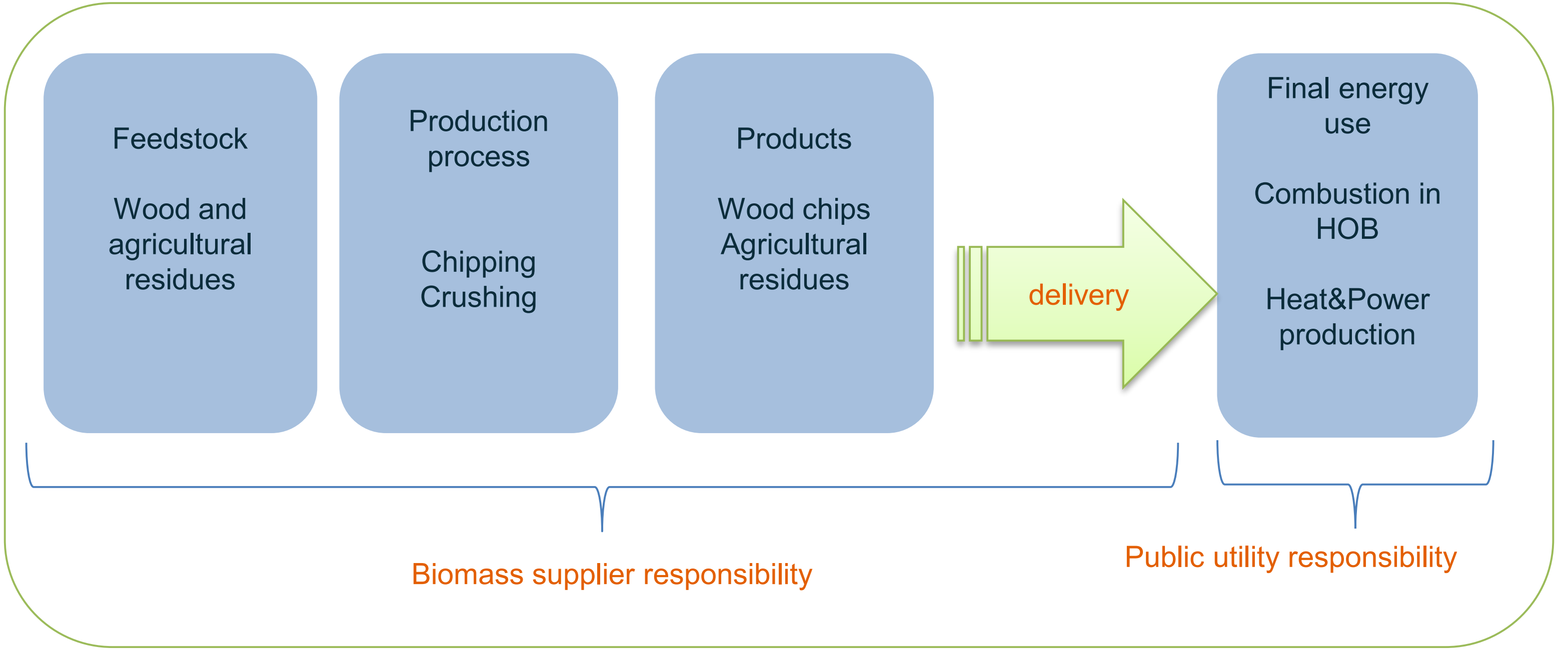


# UA Cases:
# #1 Biomass CHP installation of public utility Miskteplovodenergia
# #2 Biomass HOB installation of private company LLC Ukteplo

# 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 |

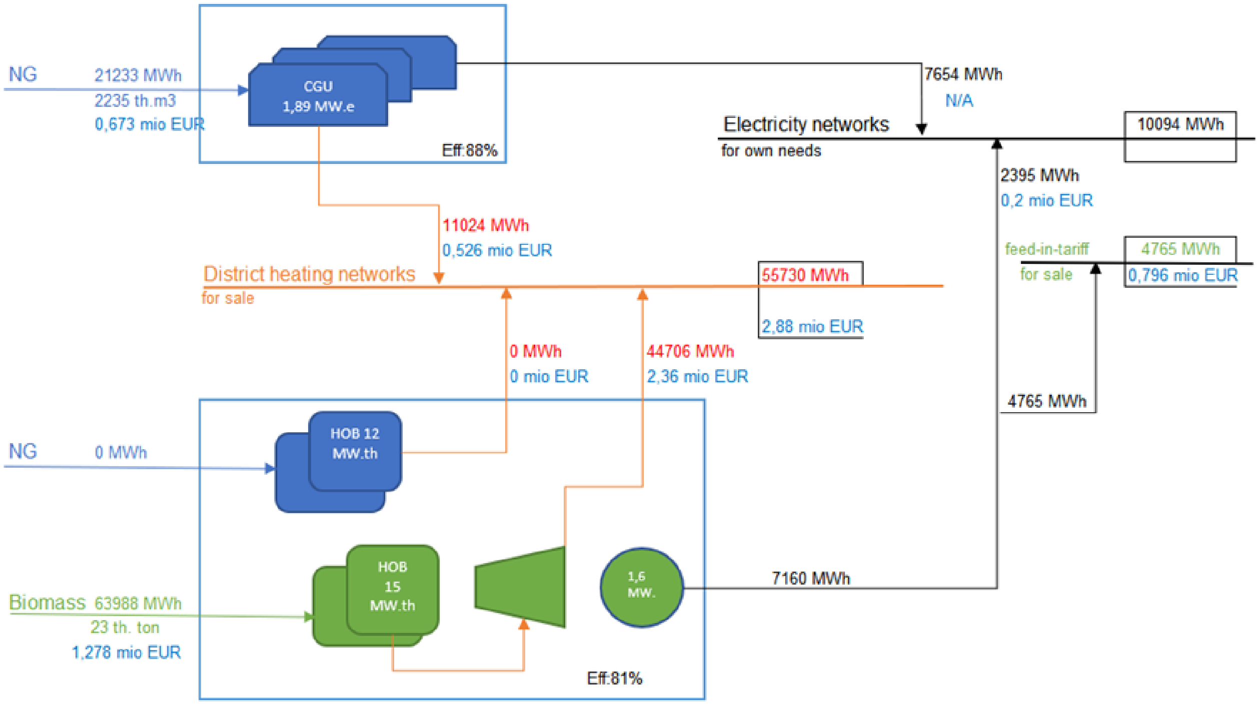

| RAW material | Felling | Chipping | Transportation | Total: |
|---|---|---|---|---|
| - €/MWh | 5,33 €/MWh | 3,64 €/MWh | 1,212 €/MWh<br>4,85 EUR/MWh 100km | 16,0 €/MWh |
| **Motor fuels consumption and emissions CO2** | | | | |
| **0 kg/MWh** | 0 kg/MWh | 1,97 kg/MWh | 0,86 kg/MWh | 2,83 kg/MWh |
| 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 |


| | | | | |
|---|---|---|---|---|
| 3,2 €/MWh | 5,3 €/MWh | 3,6 €/MWh | 0,823 €/MWh<br>1,267 EUR/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 |

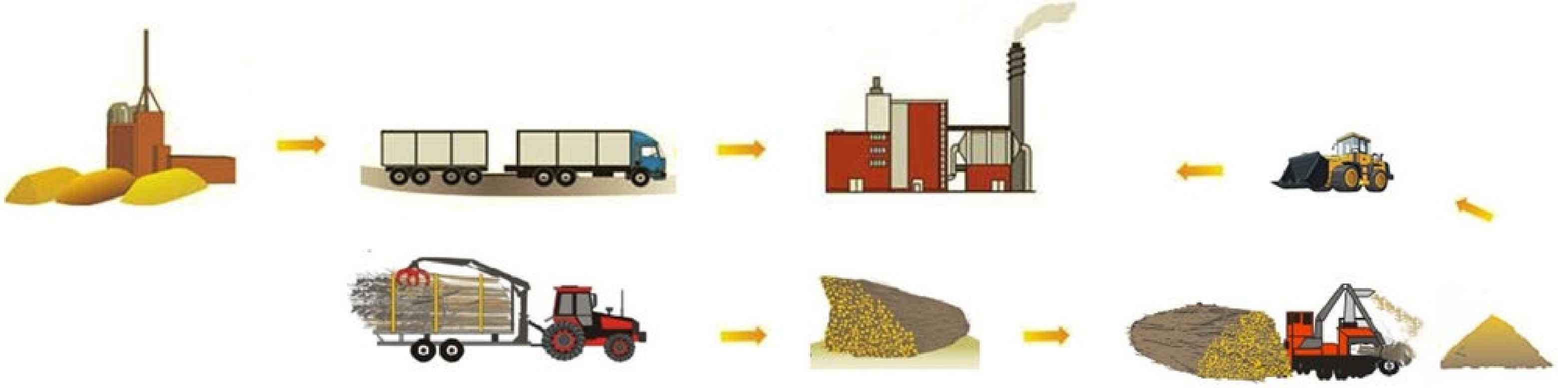
# Flow chart for energy production



# 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



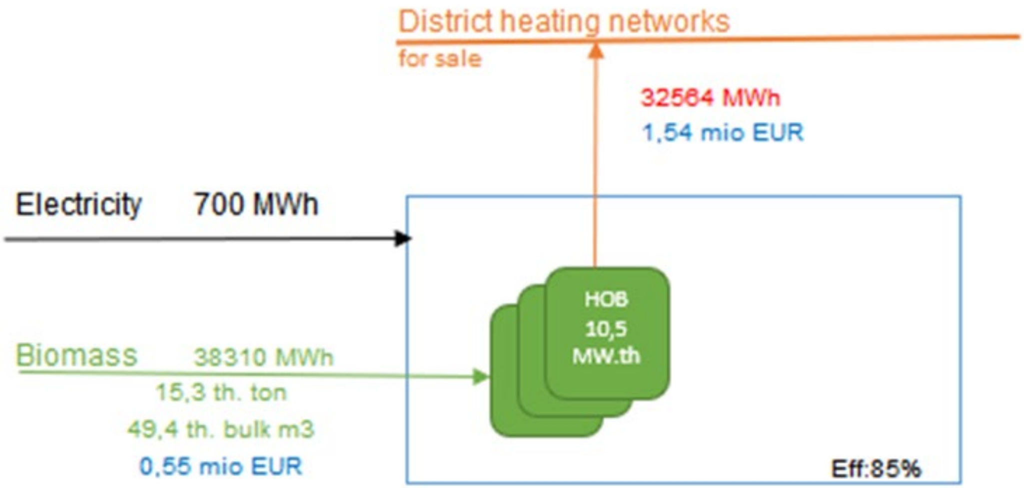
# Fuel supply chain costs and emissions

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

Volume: 15 321 t
38 304 MWh

| | | | Truck transport | Unloading at plant | |
|---|---|---|---|---|---|
| 6,3 EUR/MWh | 0,0 EUR/MWh | 0,0 EUR/MWh | 1,741 EUR/MWh | 4,34 EUR/MWh | **12,4 EUR/MWh** |
| **Motor fuels consumption and emissions CO2** | | | | | |
| 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 CO2** | | | | | |
| 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

| 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 | 3500 | 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 | ? | 0,176 | 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

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| 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 | 3 500 | 2 395 | MWh/year |
| Boiler Efficiency | 94,1% | 85% | % |
| $CO_2$ emissions | | 17 279 | t.$CO_{2e}$ /year |

# Case #2 Energy balance of fuel supply chain

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| 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 | 18,63 | 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 | 0,342 | 1,286 | Mio € |

# Case #2 Technical Key Performance Indicators

VTT

| 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 | 18,63 | | 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

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| 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<br>State -543 | Private forestry – 600 000<br>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

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| 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,<br>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

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- **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

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- 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?

# beyond
## the obvious

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