Fortum's CHP-integrated pyrolysis oil production

October 19, 2013

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Fortum's sustainability approach

Economic

Competitiveness, high performance and responsible business operations generate long-term value and growth

Environmental

Competence in CO_2 free hydro and nuclear and energy-efficient CHP production

Development of new climate and environmentally benign energy systems and solutions

Social

Security of supply of electricity and heat

Good corporate citizenship

Employee wellbeing, development of professional skills

Occupational safety

Responsible business conduct

Sustainability at the core of the strategy:
economic, environmental and social responsibility

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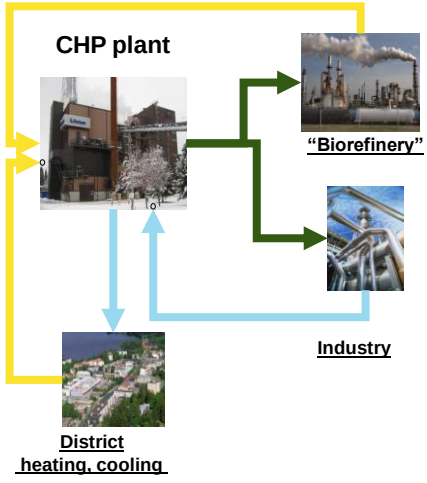
Next generation CHP with integrated concepts

Why is this important?

- Aim for higher power/heat ratio
- Competition in fuels -> fuel flexibility
- Slow growth or decrease of heat loads
- Load factor (4000 -> 8000 hours/a)
- Integrated concepts could provide new business opportunities and products

Examples of integrated concepts
Pyrolysis oil
Torrefaction (bio coal)
Gasification (SNG, traffic fuels, green chemicals)
Ethanol (1st and 2nd generation)
Heat driven cooling
Desalination



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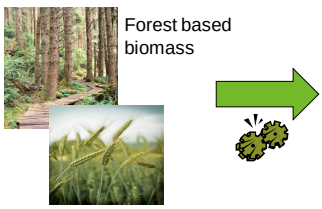
Bio-oil production and final use has clear synergies with low-carbon energy production



Bio-fuels for energy production
= raw materials for bio-oil

CHP power plant

- Power production
- Heat production
- **Bio-oil production**

End use of bio-oil
- CO_2 –neutral heat and steam production

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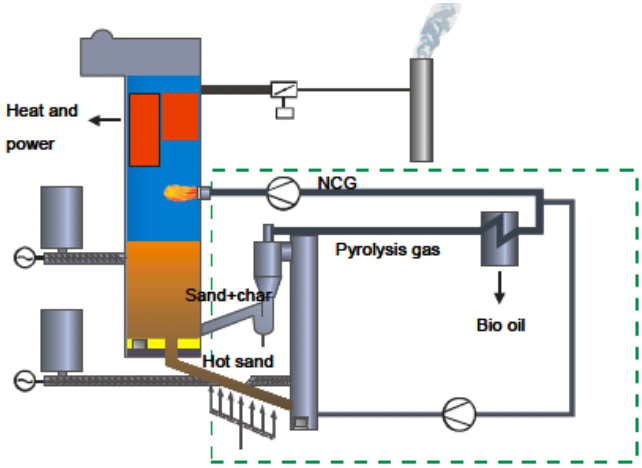
Why to integrate bio-oil production with CHP

- **Savings** in investment costs up to 25-30% compared to stand-alone plant
- Using large bio-fuelled boiler as a "host" gives **synergies with raw material supply** arrangements – in most optimal case same raw material can be used both for bio-oil production and combustion in main boiler
- In case of wet raw materials the **drying process provides additional heat load** for a CHP-unit and boosts profitability through increased electricity output
- **Synergies can be gained in operations** of the integrated plant (24/7 control, monitoring and manning of the plant)

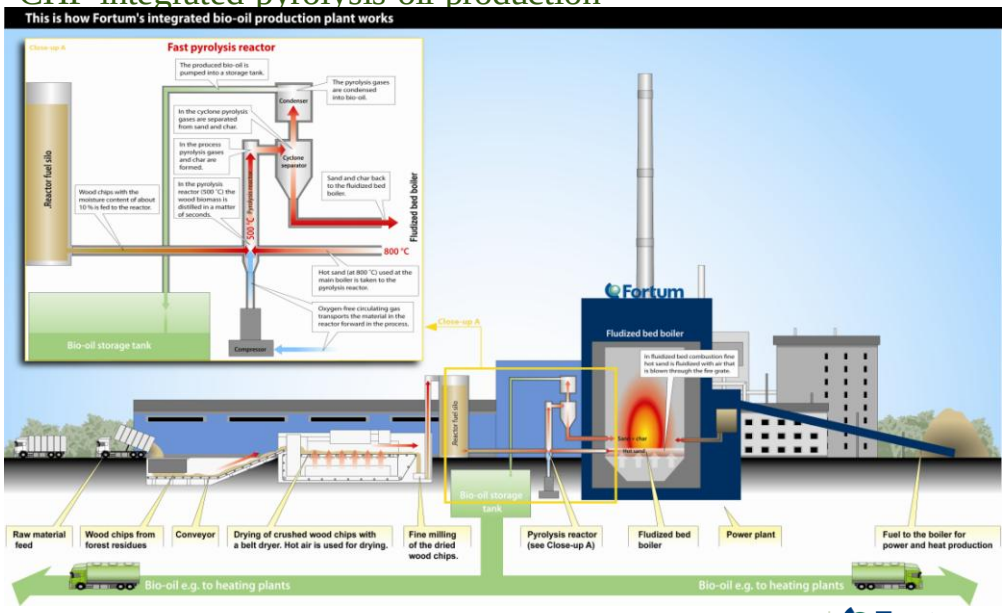
How do you produce pyrolysis oil

Bio-oil can be produced in power plants which can combust bio-fuels and sufficient raw material supply



- Hot sand of a fluidized bed boiler is utilized as media for heat transfer
- Crushed and dried biomass is "pyrolysed in ~500 C temperature in a boiler-integrated reactor in oxygen-free circumstances
- Production gas will be condensated to bio-oil
- Sand and the remaining coke will be returned to boiler where coke is burned to get heat and power
- Also uncondensed gases are fully utilized in power and heat production

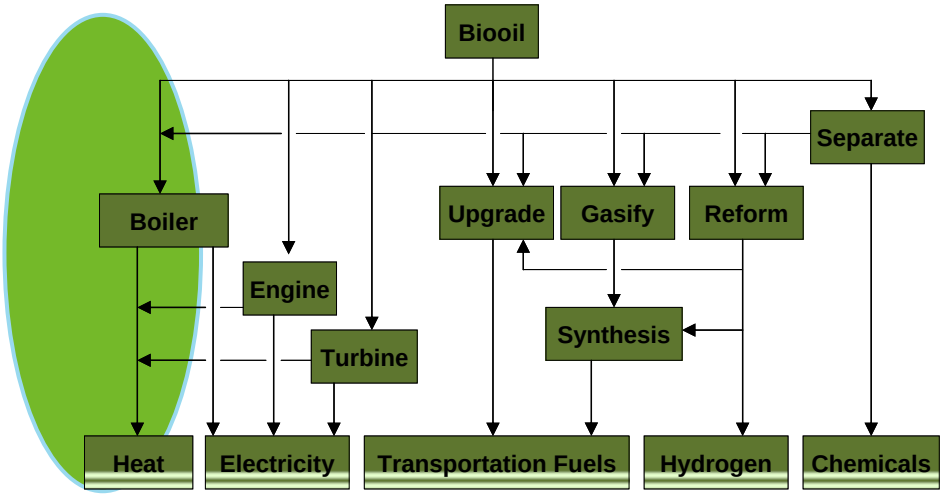
CHP-integrated pyrolysis oil production



Pyrolysis oil – a domestic alternative for fossil oils

- Bio oil is produced from biomass like forest residues and other forest industry by-products
- Energy density of bio oil is high compared to unprocessed biomass
  - Bio oil can be economically transported longer distances to be utilised in heat and steam production
  - Heating value of bio oil is about half compared to fossil oils
- Bio oil can be used for replacing heavy fuel oil
- In the future bio oil can be a raw material for carbon lean chemicals and traffic fuels

Pyrolysis oil has several potential future applications



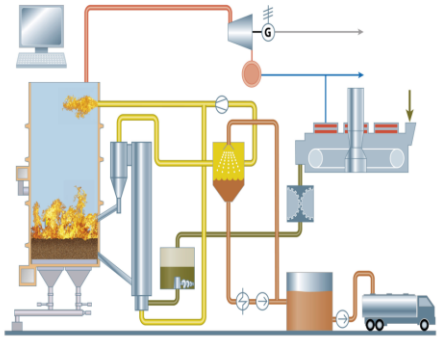
Source: Biomass Pyrolysis, IEA Task 34 Booklet

Pyrolysis oil – from R&D to production

- Fortum, Metso, UPM and VTT have developed together a pyrolysis process which is integrated to fluidized bed boiler
- In pilot phase bio oil has been produced in Metso laboratory and the oil has been tested in Fortum's Masala heating plant
- Fortum's Joensuu power plant was selected as a proper demo site
- The experimental results were encouraging, and in February 2012, Fortum decided to implement commercial-scale demonstration of investment in Joensuu
- On September 23rd, 2013 the Global District Energy Climate Awards organization awarded Fortum for its investment project using fast pyrolysis technology to produce bio oil with a special award for innovation
- In October 2013 Fortum and the local Finnish energy company Savon Voima Oyj have signed the first commercial contract on bio-oil delivery. Fortum's sustainable bio-oil will replace heavy and light fuel oil in Savon Voima's heat production

Pyrolysis project in Jelgava

- Pyrolysis project – integrated part of Jelgava biomass CHP plant
- Planned production amount of bio-oil in Jelgava – 40 thousands t/year
- Planned investment amount – 27 MEUR
- Considering eligibility of the project to apply for **NER300 program in the category** «Lignocellulose to intermediate solid, liquid or slurry bioenergy carriers via pyrolysis»
- Possibility to implement the project in two CHP plants simultaneously – in Estonia and in Latvia



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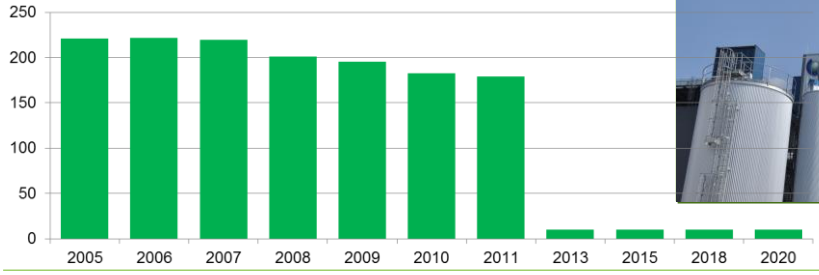
Turn-around in Jelgava district heating system

- Previous production was 100% natural gas based, using boiler houses from 70`s.
- Fortum total **investment during 2008-2013 totals ~ 90 M€,** including:
  - DH **network renovation**; interconnection of two DH systems under river and **replacement of all heat production** units, including **BioCHP** *(combined heat and power plant)* based on wood chips.
  - First and largest project of such kind in Latvia.



CO2 emissions from heat production CO2/kWh

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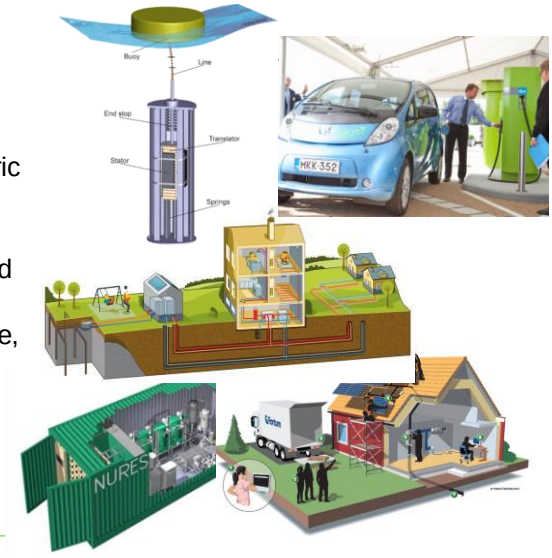
R&D aspiration is to enable a sustainable CO_2-free future for Fortum

- Wave power to commercial use
- Pyrolysis oil one step towards aspiration to become a carbon free power and heat producer
- Advancing a rapid adoption of electric vehicles
- New solutions to district heating
- Decentralised energy production and smart grids
- Increased nuclear safety and lifetime, nuclear CHP
- NURES product to remove radioactivity from liquids



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Fortum a forerunner in sustainability

- **Dow Jones Sustainability World Index**
  - Included for ten consecutive years
  - Fortum the only Nordic power and heat company
- **Carbon Disclosure Leadership Index**
  - Fortum globally third best company in the utility sector 2012
  - Fortum the only Nordic power and heat company
- **SAM Sustainability Yearbook**
- **STOXX® Global ESG Leaders indices**
- **oekom**
- **OMX GES Sustainability Finland Index**
- **Storebrand SRI**

Dow Jones Sustainability Indexes Member 2012/13

CARBON DISCLOSURE PROJECT

Member 2012/2013 STOXX ESG LEADERS INDICES

Corporate Responsibility Prime rated by oekom research

OMXSUSTAIN NASDAQ OMX INDEX OMX GES SUSTAINABILITY FINLAND

BEST IN CLASS environmental and social performance STOREBRAND SRI

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Fortum's recent investments in the Baltics in local fuel based CHPs

Tartu, Estonia bio/peat CHP 25 MWel/50 MWth in operation since 2009
Total investment 75 MEUR

Klaipeda, Lithuania WtoE CHP 20 MWel/50 MWth in operation since May 2013
Total investment 130 MEUR

Pärnu, Estonia bio/peat CHP 23 MWel/45 MWth in operation since 2010
Total investment 80 MEUR

Jelgava, Latvia bio CHP 23 MWel/45 MWth in operation since September 2013
Total investment 70 MEUR

Thank you!