Business from technology

Technologies for bioenergy production for district heat and power

Jouni Hämäläinen, technology manager
VTT, Technical research centre of Finland
e-mail: jouni.hamalainen@vtt.fi Tel.: +358 40 5211066

The Finnish-Russian bioenergy working group excursion 8.-10.6.2010

VTT in brief

Personnel 2700 ■ Turnover 245 M€

Customer sectors

- Biotechnology, pharmaceutical and food industries
- Electronics
- Energy
- ICT
- Real estate and construction
- Machines and vehicles
- Services and logistics
- Forest industry
- Process industry and environment

Focus areas of research

- Applied materials
- Bio- and chemical processes
- Energy
- Information and communication technologies
- Industrial systems management
- Microtechnologies and electronics
- Technology in the community
- Business research

VTT's operations

Research and Development ■ Strategic Research ■ Business Solutions ■ Ventures ■ Expert Services ■ Corporate Services

VTT - Diverse and sustainable energy research

VTT pursues versatile energy research, from nuclear to renewables. Energy economy, energy systems and reduction of emissions also form a crucial part of our energy research.

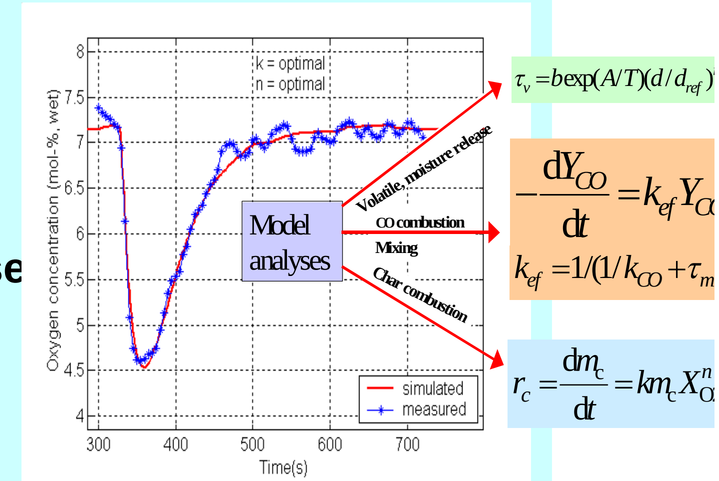
- Provides almost 400 energy experts
- Provides modern experimental facilities, pilot plants and calculation tools
- Synergy with other VTT competencies
- Networks - national & international
- Key focus of technology developments:
  - **Cost-effective and zero-emission heat and power production**
    - Bioenergy - especially combined heat and power (CHP)
    - Wind power – especially for cold climate conditions
    - Nuclear energy – safety, plant life management, nuclear waste management and geological disposal, Generation IV nuclear technologies
  - **Efficient and optimized use of biomass resources**
    - Focus on forest residues and waste
  - **Clean fossil fuels**
    - Carbon Capture and Storage (CCS) in Fluidized Bed Combustion (FBC)
  - **Synthetic fuels for transportation, energy savings through use of electricity in hybrid cars**

Bioenergy chains and fluidized bed combustion - main competence areas

1. **Biomass fuel production, fuel processing and handling technologies**
    - *Fuel production chains for power plants*
    - *Production of biomass fuels on heating plants and small scale use*
    - *International biomass fuel markets in Europe and market development*

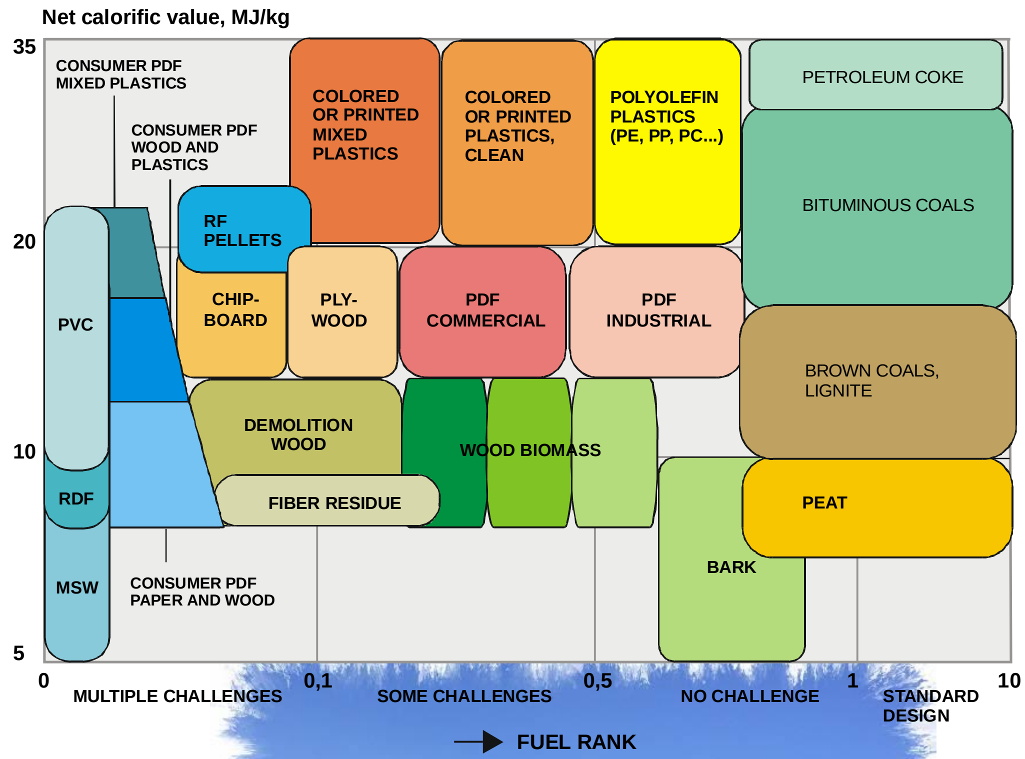
2. **Fluidized bed combustion and multifuel operation**
    - *Fluidized bed combustion characterisation test services*
    - *Challenging fuels and ash chemistry in FB and grate combustion*
    - *Multifuel combustion at power plants*
    - *Process development of air and oxyfuel fluidized bed combustion*

3. **Modelling of combustion and industrial multiflow processe**
    - *Modelling of combustion processes and emission formation*
    - *Modelling of industrial multifuel flows*
    - *Surface phenomenas at molecular level*



Need to enlarge fuel selection, fuel flexibility

- Environmental issues, lower emissions
- Directives, taxation, emission trading
- Competitiveness, use of lower priced fuels
- Operational flexibility, multifuel operation

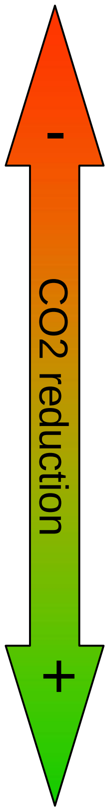


- More challenging fuels will be used

- Needs for combustion and boiler monitoring
    - to support operators
    - to improve operational performance and economy

Use of biomass and waste - cofiring vs. direct combustion

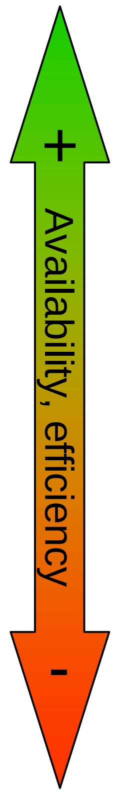
100% Fossil



100% Biomass

- Use of biomass or waste together with peat (or coal)
  - peat ”cleans” the boiler (due to ash behaviour)
  - peat stabilise fuel quality and fuel availabilty
  - alkaline ash in biomass reacts with sulphur originated from peat and reduce SO2 emissions
  - biomass fuels decrease calculated CO_2 emissions
- New plant designed for 100 % biomass fuels
  - need for more expensive plant design (like fuel handling and feeding equipments, larger flue gas mass flow etc.)
  - lower steam parameter to prevent corrosion and ash deposition problems (lower power generation efficiency) or use of special, high cost superheater materials
  - use of special fluid bed materails to prevent bed agglomeration (diapase etc)
  - availability of biomass fuels requirements vs. size of the plant
  - **100% biomass → no CO_2 emissions**

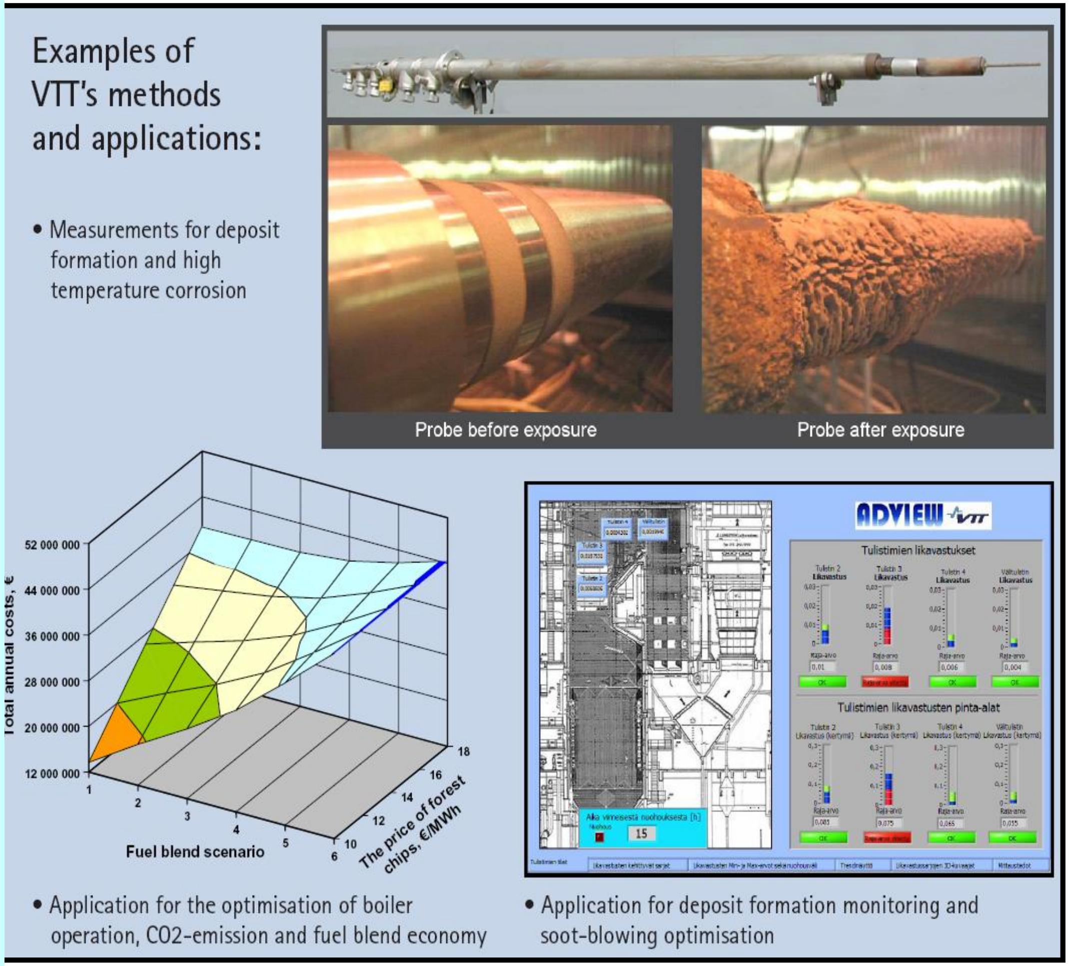
100% Fossil



100 % Biomass

Challenges of biomass and waste derived fuels

- Development of **monitoring, diagnostic and calculation methods** to optimize multifuel operation at power plants
  - On-line monitoring of ash deposition
  - Long-term measurements of corrosion characteristics
  - Methods for process analysis to improve plant operation (availability and reliability)
  - **Currently in semicommercial application**, installed on several power plants by VTT
  - New innovations and patents on analysis of fluid bed behaviour and on-line measurement of heat transfer inside the furnace

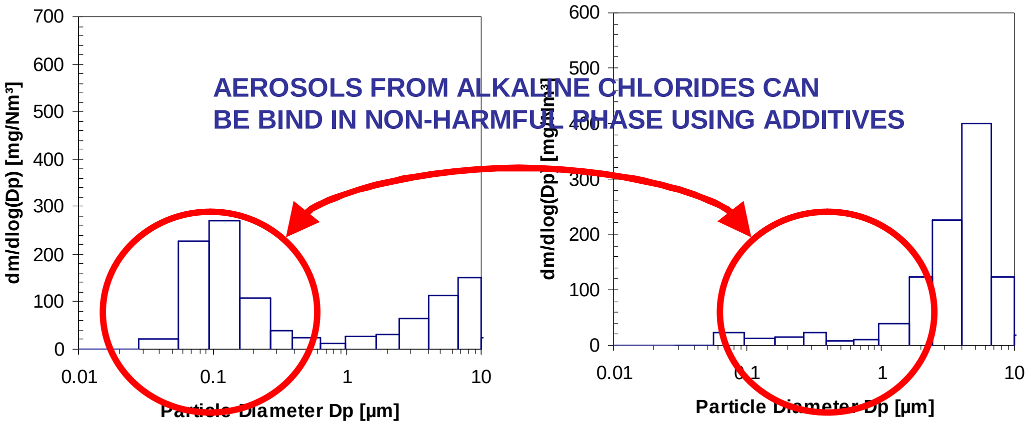


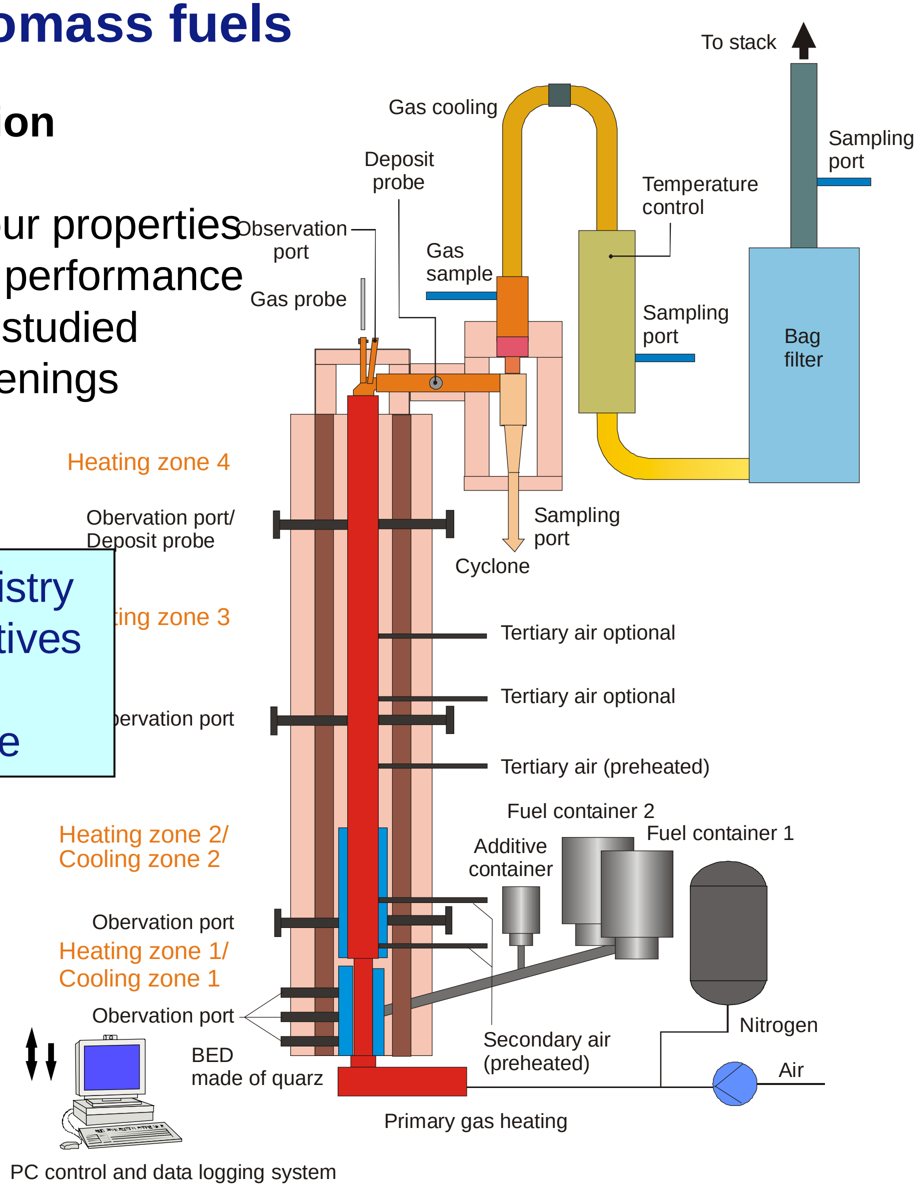
Biomass combustion – R&D related to ash behaviour chemistry Key issue for biomass fuels

An important R&D area for understanding combustion chemistry with biomass and waste derived fuels

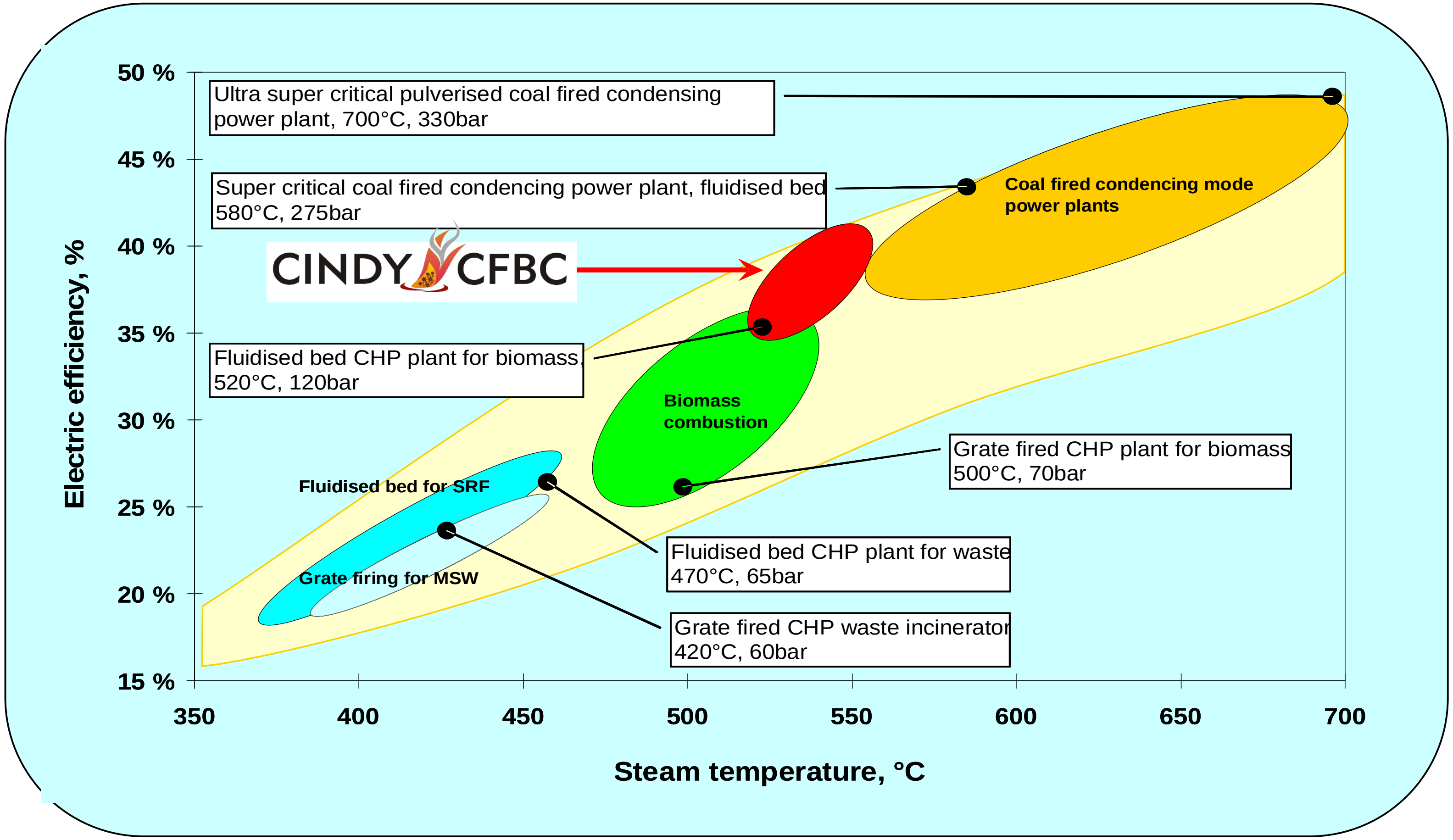
- Biomass and waste fuels has challenging ash behaviour properties that need to be understand to design boilers with high performance
- Characterisation of fuel combustion behaviour can be studied in pilot scale fluidized bed facility. BFB with 30 kW, openings for gas and solid sampling at different locations on combustion path

Using the knowledge generated in ash behaviour chemistry VTT has patented a method based on combustion additives to change ash behaviour chemistry → lower deposition, lower corrosion risk. Method currently in commercial use





CINDY CFBC®: DOUBLING THE ELECTRIC EFFICIENCY IN WASTE-TO-ENERGY by utilising the capability of coal ash to adsorb and chemically react with the waste-originated salts. This results in a complete absence of halogen salts in the combustion gases wherefrom the energy can be recovered with electric efficiency of 41%.

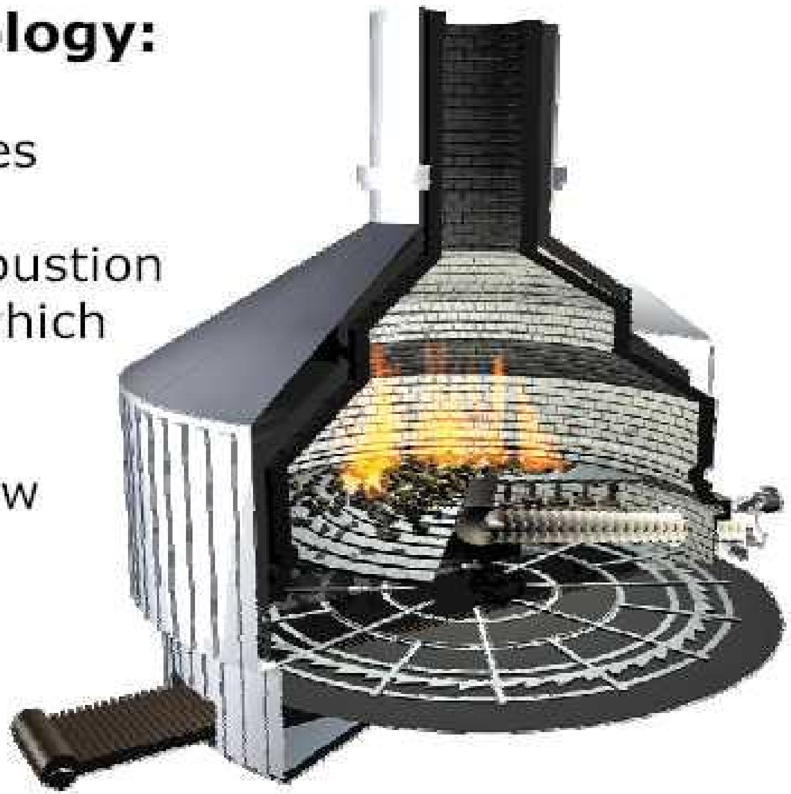


Combined heat and power production in small scale

Wärtsilä - BioGrate™

BioGrate™ Combustion Technology:

- Rotating conical grate
- Several (4 - 10) combustion zones
- Zone controlled primary air inlet under the grate for complete combustion
- Fuel feeding from centre bottom which don't disturb combustion process
- Under grate wet ash removal
- Designed for wet fuels up to 65%-w
    - Long lifetime
    - Reliable operation
    - High efficiency combustion
    - Low emissions



Courtesy of Wärtsilä

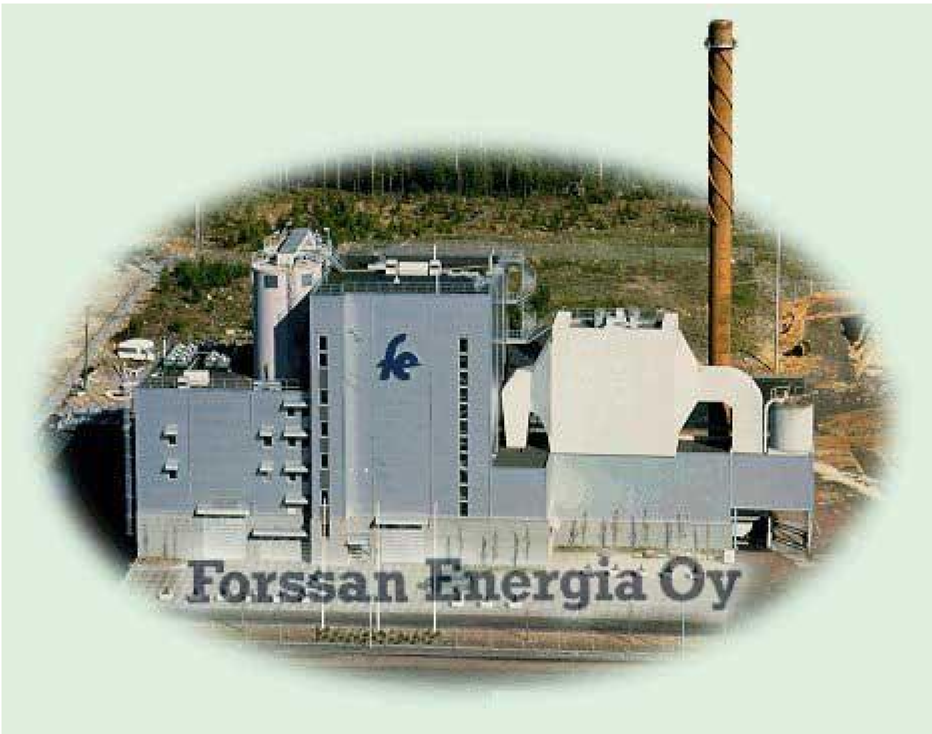
WÄRTSILÄ

Combined heat and power production in medium scale

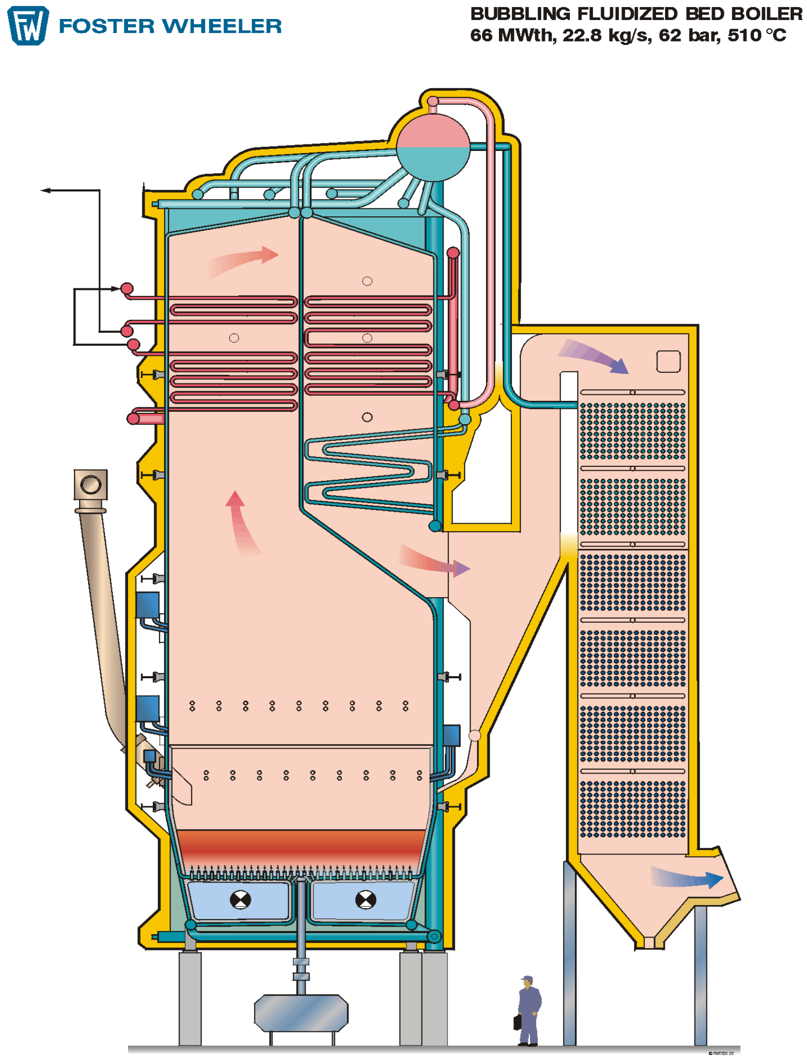
Forssan Energia Oy, Finland

22.8 kg/s, 62 bar, 510°C 66 MW_{th}

Fuel: Demolition Wood, forest residue, REF



Courtesy of Forssan Energia Oy and Foster Wheeler Energia Oy

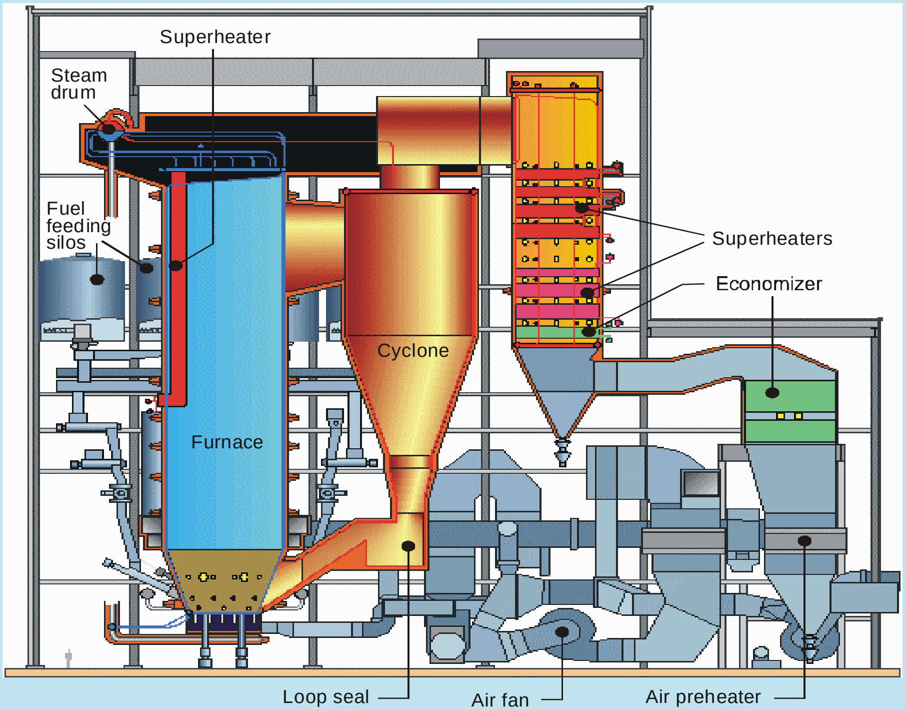


Combined heat and power production in large scale

The size of the units will increase up to 600-800 MW_e

Readyness for CO_2 capture required in the future

Circulating fluidised-bed boiler plant



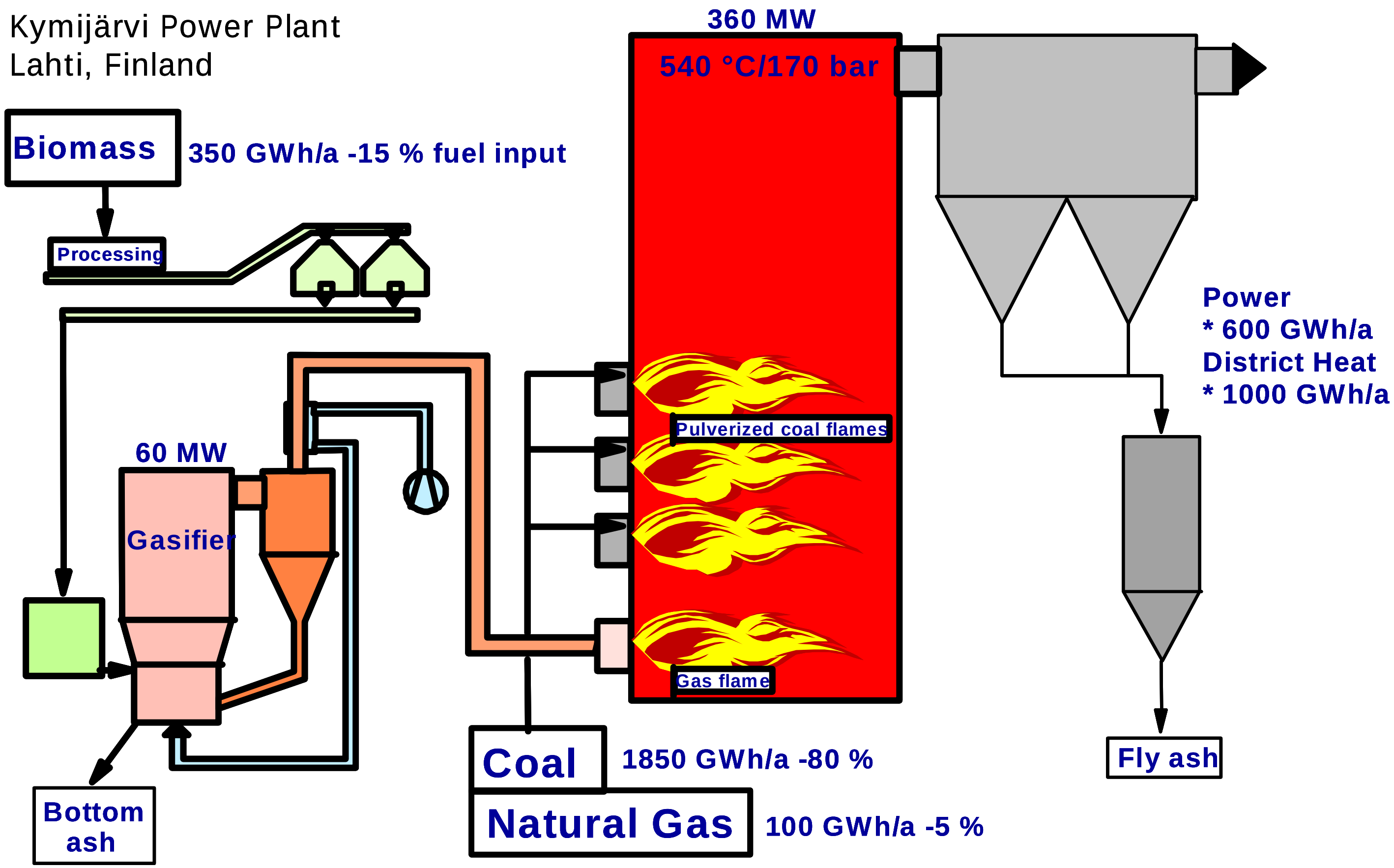
Plant	Oy Alholmens Kraft Ab	
Supplier	Kvaerner Pulping Oy	
Commissioning	2001	
Fuels (annual share)	Peat	45%
	Wood fuels	45%
	Coal and oil	10%
Thermal power	550 MW	
Live steam	194 kg/s, 165 bar, 545 °C	
Boiler efficiency	92%	
Plant output	Electricity	240 MW
	Process heat	100 MW
	District heat	60 MW
Emission limits	SO_2	70 mg/MJ
	NO_x	50 mg/MJ
	Particles	30 mg/m^{3}n

Courtesy of Metso Power Oy

Efficient utilisation of wastes and biomass residues in existing power plants

cost-effective way to reduce CO_2 emissions of power plants

Kymijärvi Power Plant
Lahti, Finland



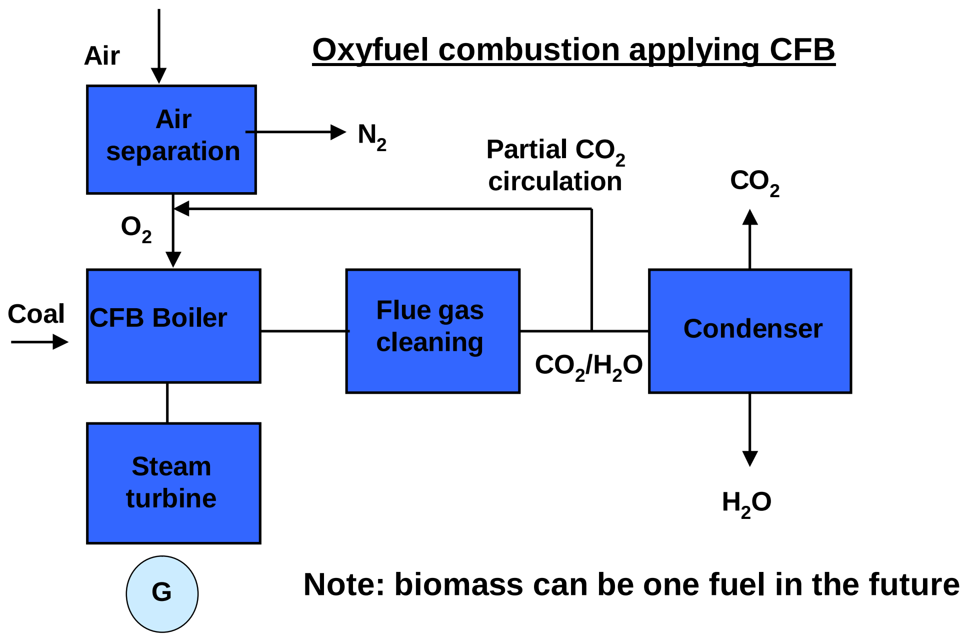
Analyses of fuel supply chain - ForPower - References
Case Bialystok, POLAND, 2005

- The target of the study was a 100 MW CHP plant in North-East Poland aiming to retrofit old coal-fired boiler to biomass boiler applying bubbling FB technology.
- The aim of the study was to evaluate:
  - Availability of forest fuel
  - Possibilities and economy of modern forest fuel harvesting in polish conditions
  - Economy of retrofit for energy production using biomass forest fuels
- Co-operation with Polish forest authorities
- The studied forest fuel materials were:
  - logging residue from final fellings
  - small tree from thinnings.

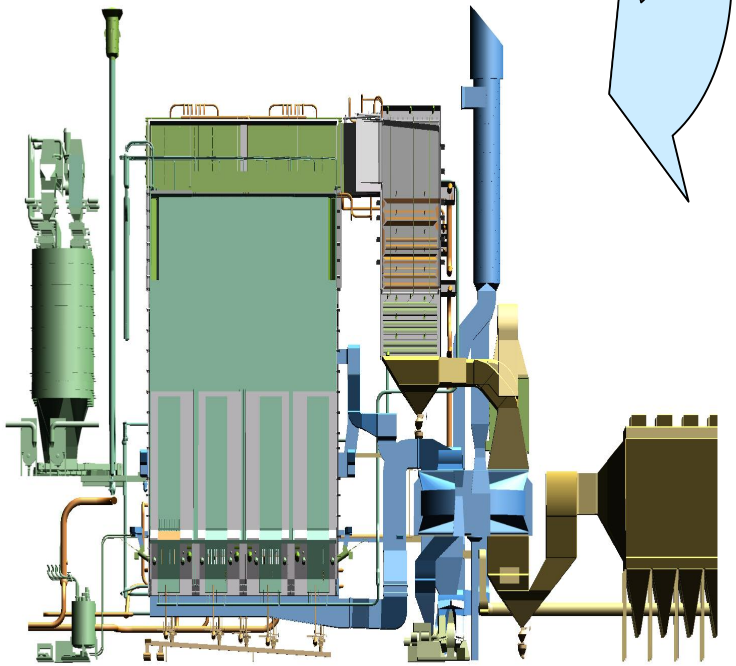
Pictures: VTT

Future concepts developed at VTT together with industry: fluidized bed combustion technology applying oxyfuel combustion

- Research activities for development of **advanced CFB technology**
  - Increasing the efficiency (lower fuel consumption, less emissions)
  - Sizing up CFB's up to 600 to 800 MWe
- **Zero emission** power generation technology based on oxyfuel combustion
  - Combustion in O_2/CO_2 atmosphere + CO_2 capture



Note: biomass can be one fuel in the future



VTT creates business from technology

Futher information:
Jouni Hämäläinen, e-mail: jouni.hamalainen@vtt.fi
Tel: +358405211066