

# Biomass Gasification

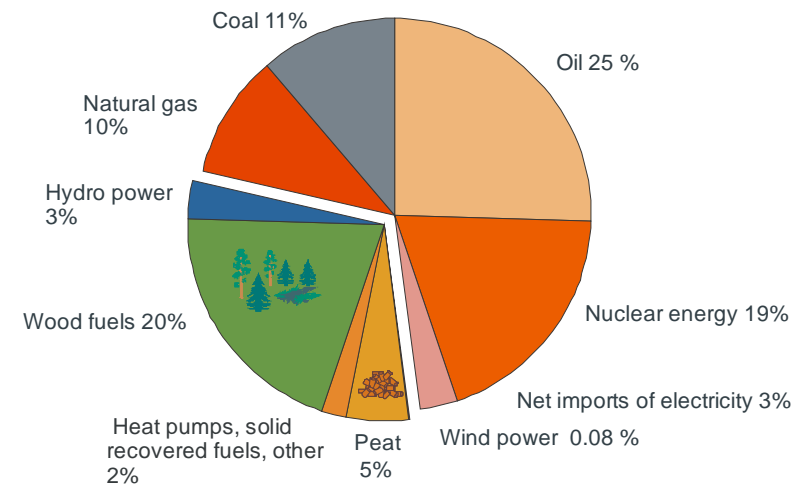
– IEA Task 33 Country Report - Finland



**Ilkka Hannula & Esa Kurkela**  
**16.4.2012 Istanbul, Turkey**

## Characteristics of the energy sector in Finland

- Versatile structure of energy production with high efficiency (30 % of electricity by CHP)
- Indigenous energy sources cover only 1/3 of the energy demand, high share of RES 25 %
- Energy intensive industry covers 50 % of the energy demand
- Open electricity market since late 1990's, lowest electricity prices within the EU
- CO<sub>2</sub> tax on fuels introduced already in 1990's
- Support for bio-power inversely proportional to the price of CO<sub>2</sub> (max. 18 €/MWh)
- Guaranteed price for wind power 83.5 €/MWh for 12 years



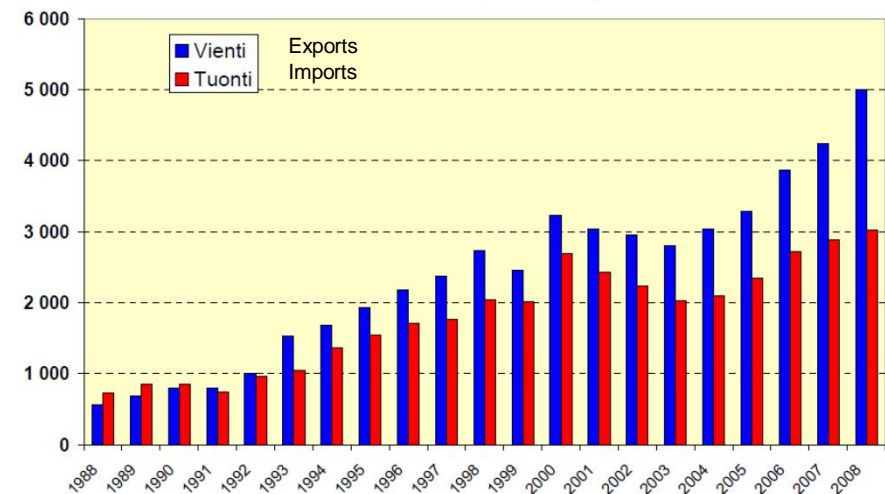
Total energy consumption by energy sources 1 327.7 PJ (368.8 TWh)

Source: Energystatistics 2010

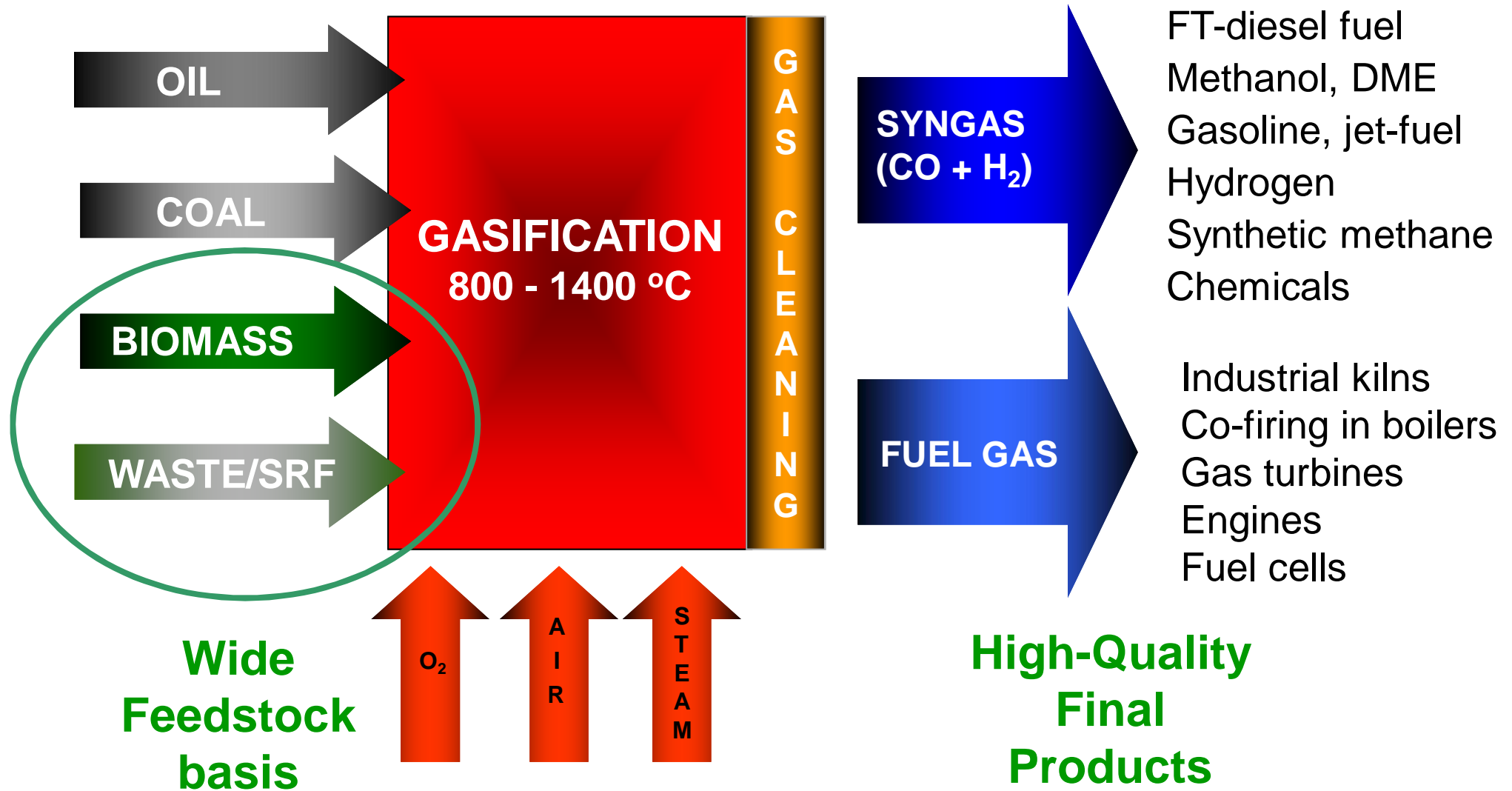
Eija Alakangas, VTT

## Background of the strategic choices of the energy research at VTT

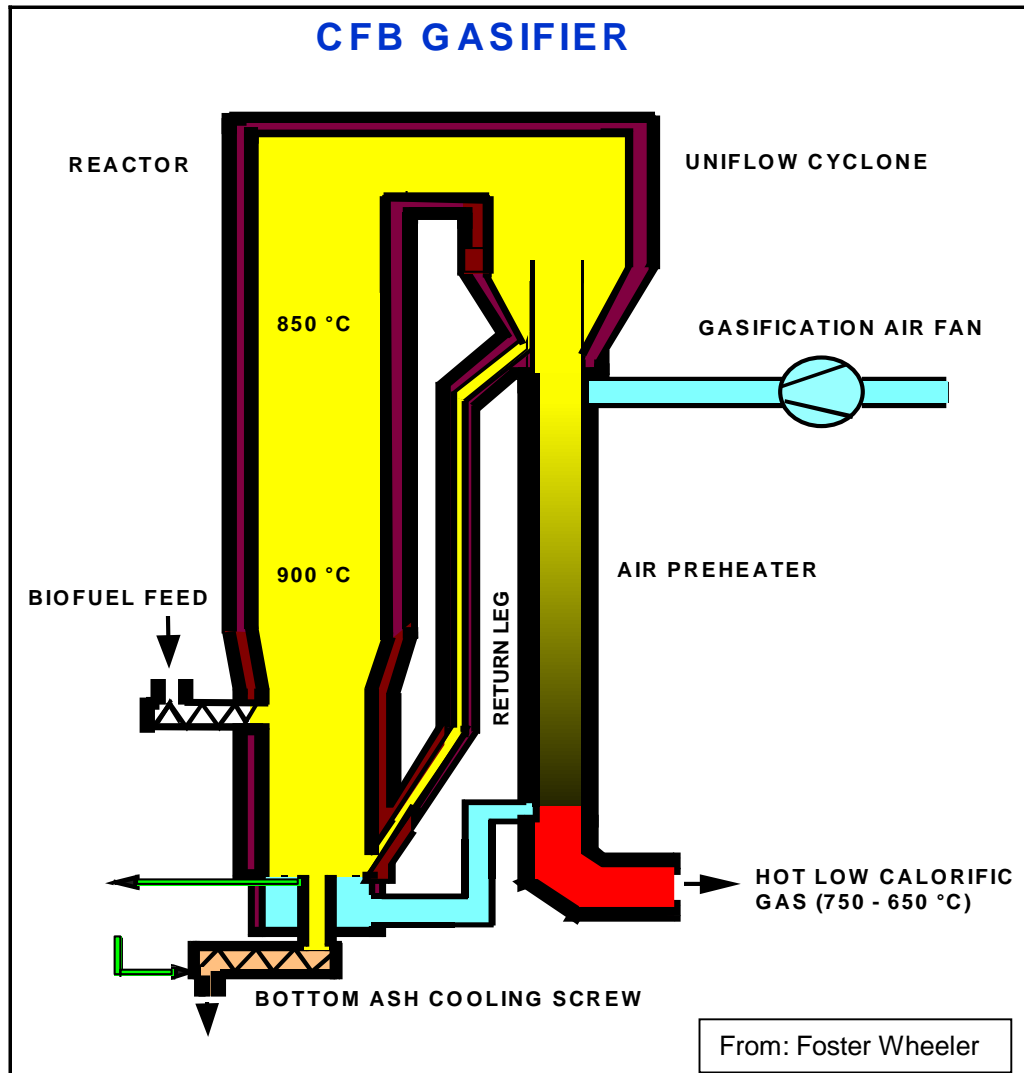
- Challenges of the global energy sector: combating climate change, replacing limited and more expensive fossil fuels with renewable resources, demand for energy efficiency
- Mandatory targets for greenhouse gas emissions, energy efficiency and RES in Europe by 2020
- Climate and energy strategy in Finland
  - Nuclear power for base load
  - Increased use of RES, especially bioenergy and wind
  - Improved energy efficiency
- Energy technology has reached 7.6% of the exports, one of the highest shares in the world and the growth is also aimed at in the future



Exports and imports of the energy technology in 1998-2008 in Finland, million euros. Source: The Research Centre of the Finnish Economy, 2009.



## Atmospheric-pressure CFB/BFB gasification for kilns and boilers



- Commercial lime-kiln gasifiers were constructed in 1980's by Ahlström
- New development by Foster Wheeler in 1990's for boiler applications
- Gasifiers are now offered by
  - Andritz-Carbona
  - Foster Wheeler
  - Metso Power
- Feasible in size range 15-150 MW

### VTT's role and activities

- IPR on gas reforming for clean gas applications
- support for industrial projects
- R&D on gas filtration, heavy metal removal and fuel characterisation

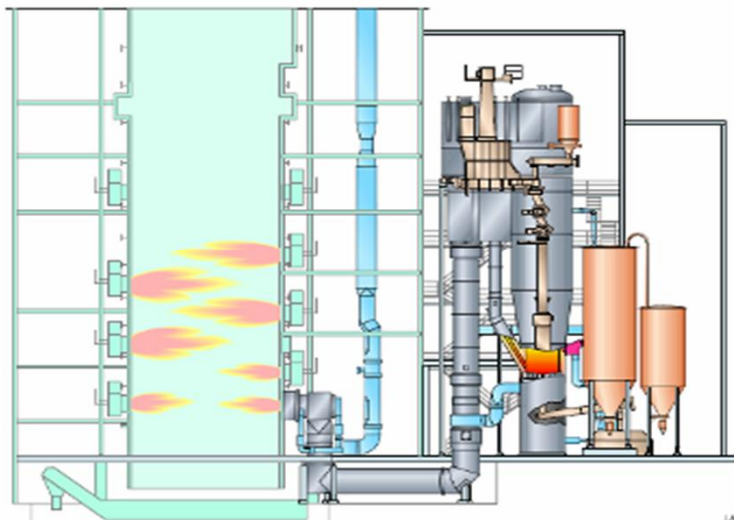
# Efficient utilisation of wastes and biomass residues in existing power plants

a cost-effective way to reduce CO<sub>2</sub> emissions of power plants

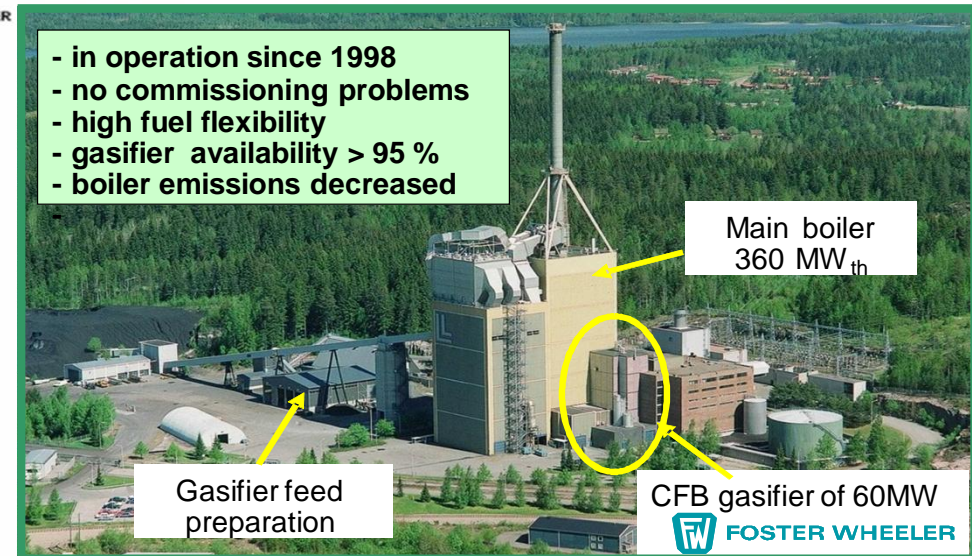


From: Foster Wheeler

CFB BIOMASS GASIFIER  
40 - 70 MW<sub>th</sub>



LA-GEN LAMPOKKA  
KEMIAN TEKNINEN  
KESKUS OY



- in operation since 1998
- no commissioning problems
- high fuel flexibility
- gasifier availability > 95 %
- boiler emissions decreased

Main boiler  
360 MW<sub>th</sub>

Gasifier feed  
preparation

CFB gasifier of 60MW  
FOSTER WHEELER

## New CFB gasification plants are in commissioning/under construction

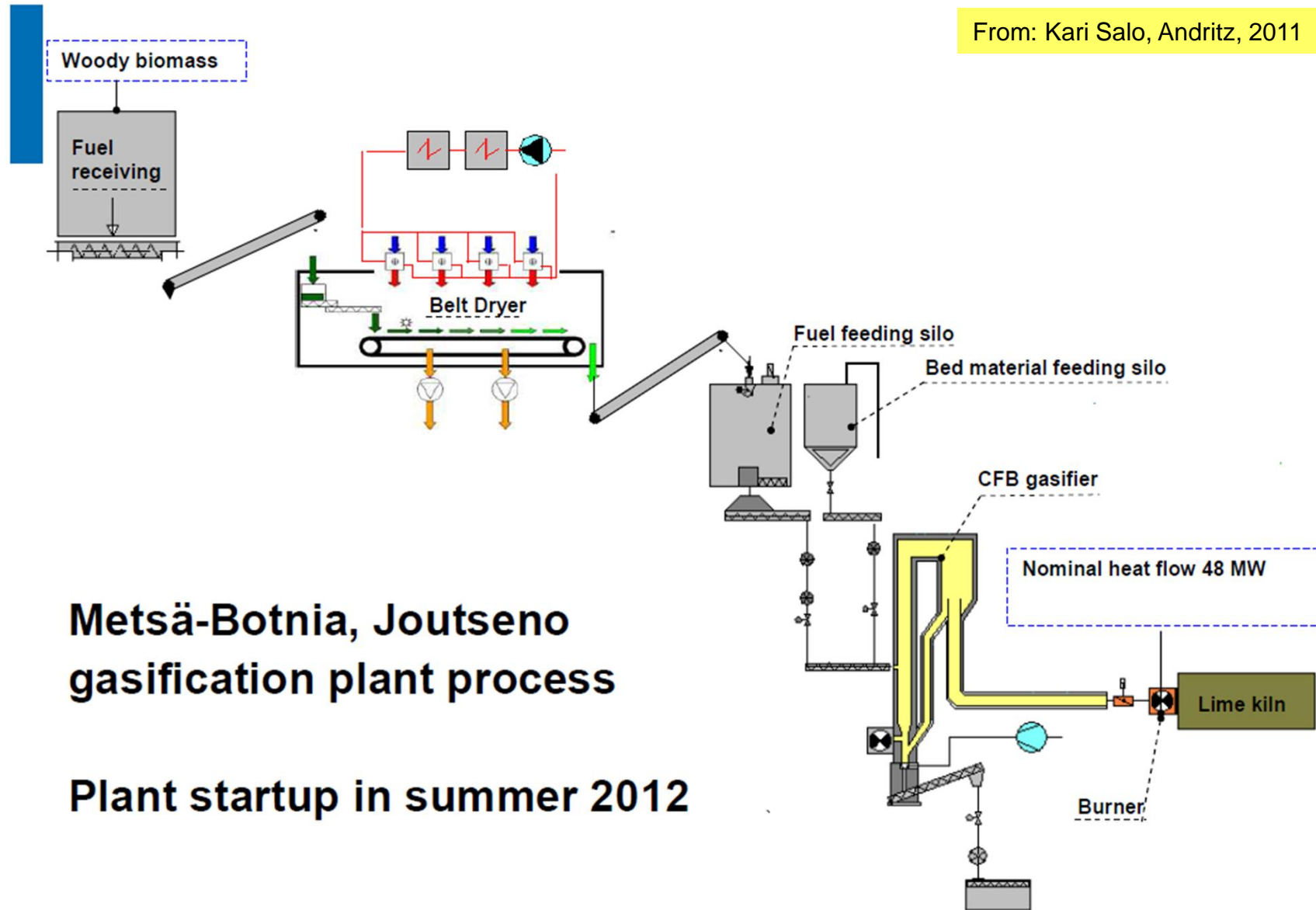
- two new gasifiers (2x80 MW) at Lahti waste-to-energy plant (supplier: Metso)
- one large gasifier (140 MW) in Vaasa (supplier: Metso)
- lime kiln gasifier (48 MW) at Joutseno (supplier Andritz)
- lime kiln gasifier (12 MW) at Varkaus was returned to air-blown operation mode after successful test campaigns for Neste Oil and Stora Enso (Foster Wheeler)

From: Kari Salo, Andritz, 2011

## Metsä-Botnia, Joutseno gasification plant for lime kiln



From: Kari Salo, Andritz, 2011



**Metsä-Botnia, Joutseno  
gasification plant process**

**Plant startup in summer 2012**



From: Ville Hankalin, Metso  
Nordic Bioenergy 2011, Jyväskylä

## Metso's Gasification Projects

### Vaskiluodon Voima – Substituting Coal for Biomass in a PC boiler

- 140 MW<sub>th</sub> gasifier adjoined to the existing 560 MW coal-fired power plant
- PC boiler in operation since 1982
- Coal consumption  
400,000 – 500,000 t/a
- Enables to replace up to 40 percent of coal
- Production capacity
  - electricity 230 MW
  - district heating 170 MW
- Vaskiluodon Voima's total investment ~40 MEUR

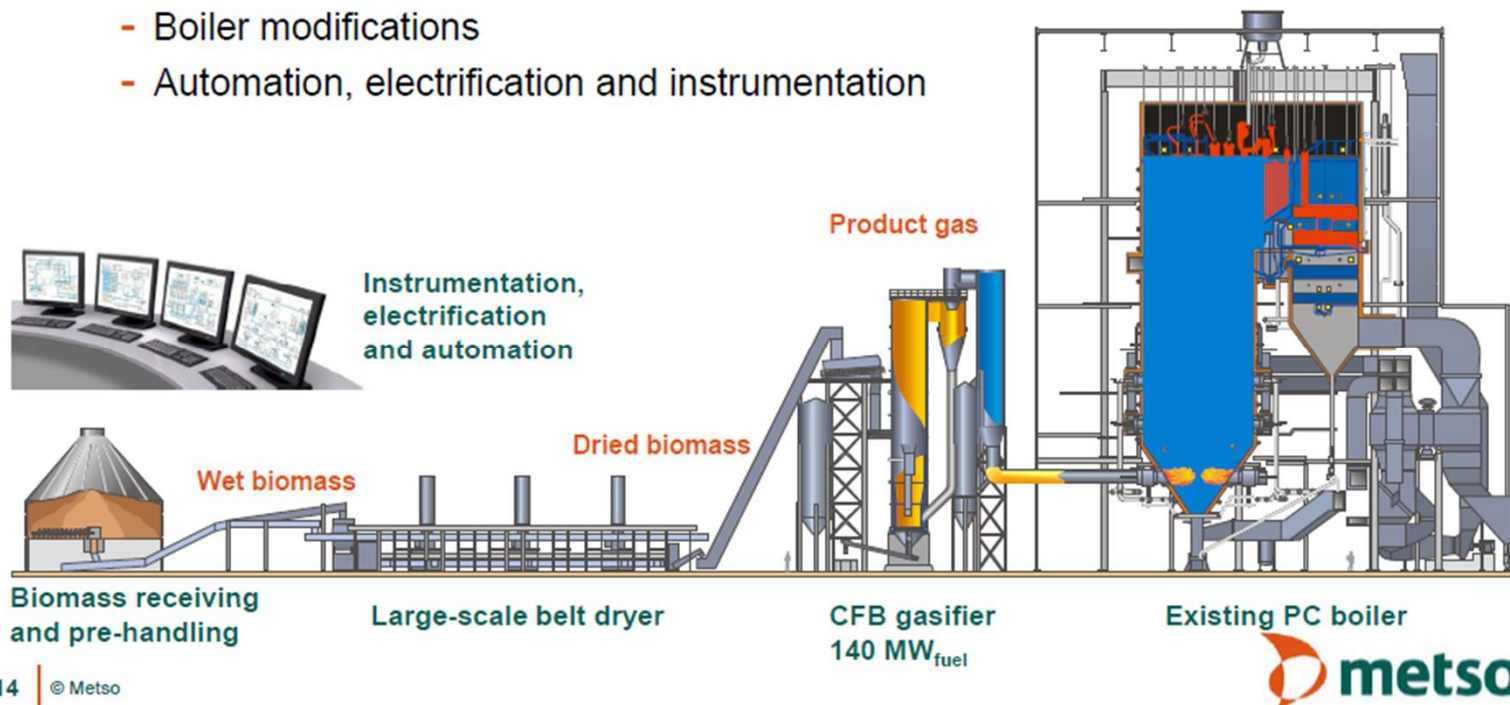


# Metso's Gasification Projects

From: Ville Hankalin, Metso  
Nordic Bioenergy 2011, jyväskylä

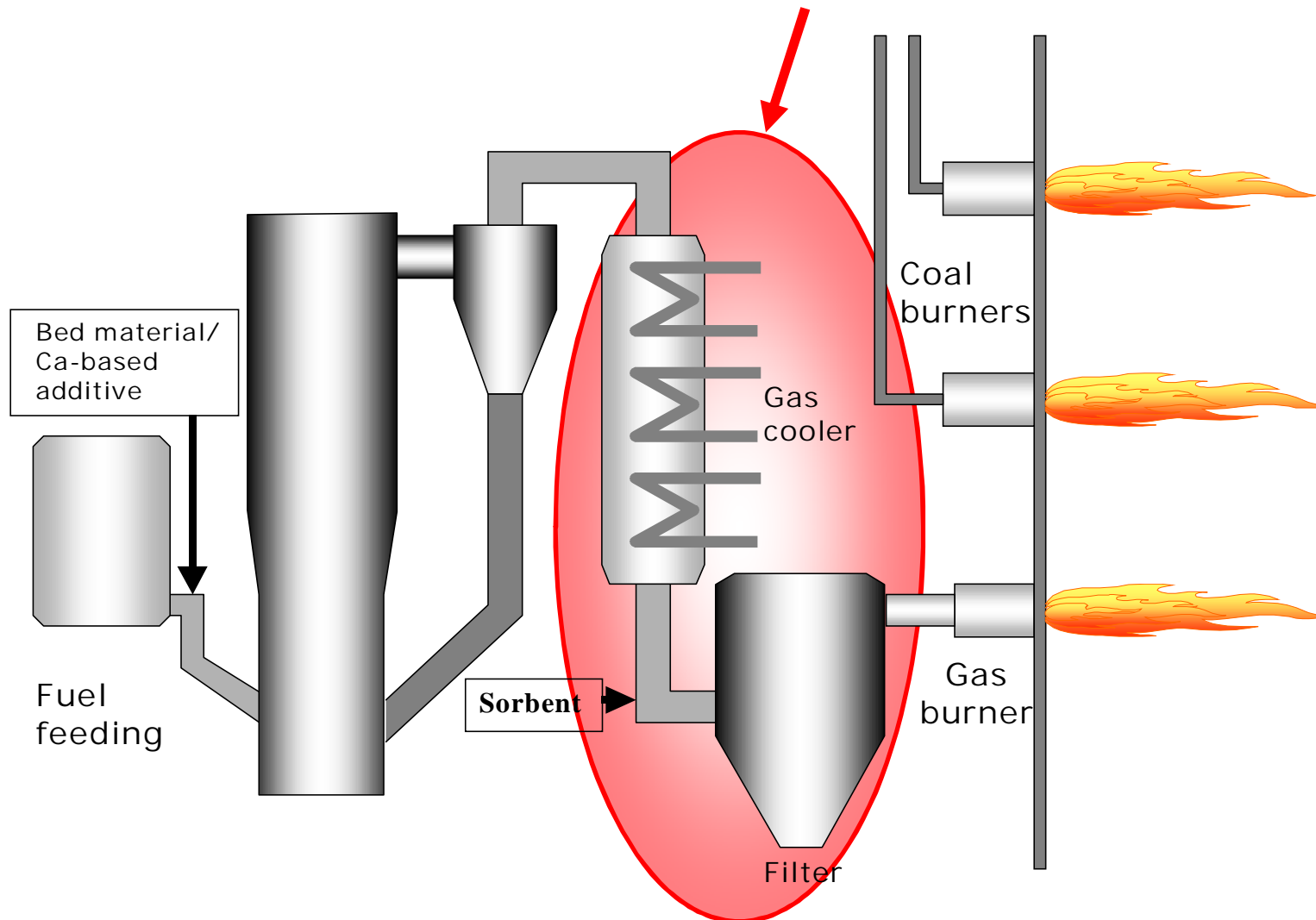
## Vaskiluodon Voima – Substituting Coal for Biomass in a PC boiler

- Metso's scope
  - Fuel receiving and handling
  - Drying
  - Gasification
  - Boiler modifications
  - Automation, electrification and instrumentation



# Gas cleaning: gas cooling followed by filtration

developed at VTT since late 1990's





## LahtiStreams IP (Advanced Integrated Waste Management and WtE Demonstration)

( Lahti Energia/FI , VTT/FI, L&T/FI, Dong Energy/DK, FZK/D; total budget 23.5 M€ )

- **Demonstration** of complete advanced waste management chain including:

- > waste processing
- > material recovery
- > SRD/RDF production
- > **advanced high efficiency WtE plant**
- > further treatment of ashes

- **R&D** of
- waste processing and material recovery
  - improved hot gas cleaning
  - advanced ash treatment
  - new gasification based high efficiency WtE technologies

From: Ville Hankalin, Metso  
 Nordic Bioenergy 2011, jyvaskyla

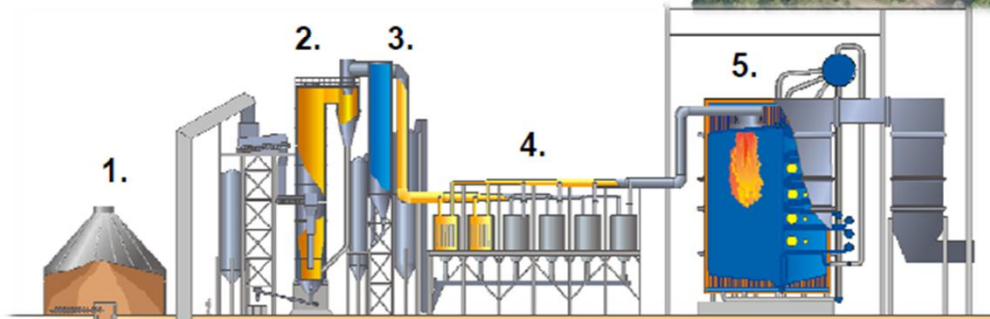
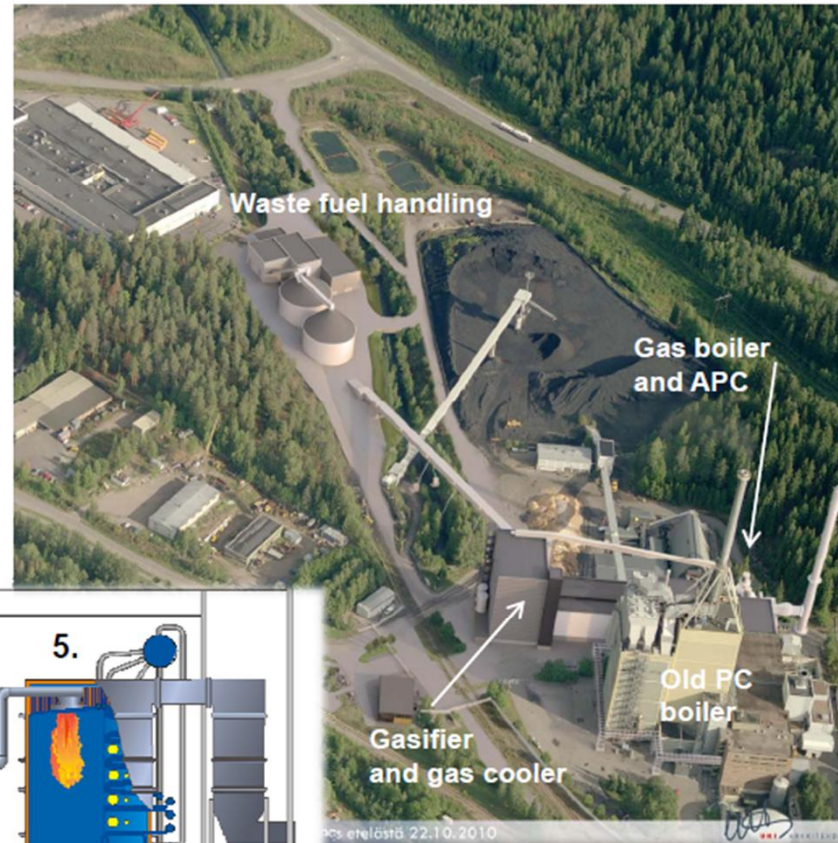
# Metso's Gasification Projects

## Lahti Energia – Gasification Power Plant

2 x 80 MW<sub>th</sub> gasifiers  
 Waste-derived fuel  
 50 MW<sub>e</sub> & 90 MW<sub>heat</sub>

1. Fuel handling
2. Gasifier
3. Gas cooling
4. Gas filter
5. Gas boiler and flue gas cleaning

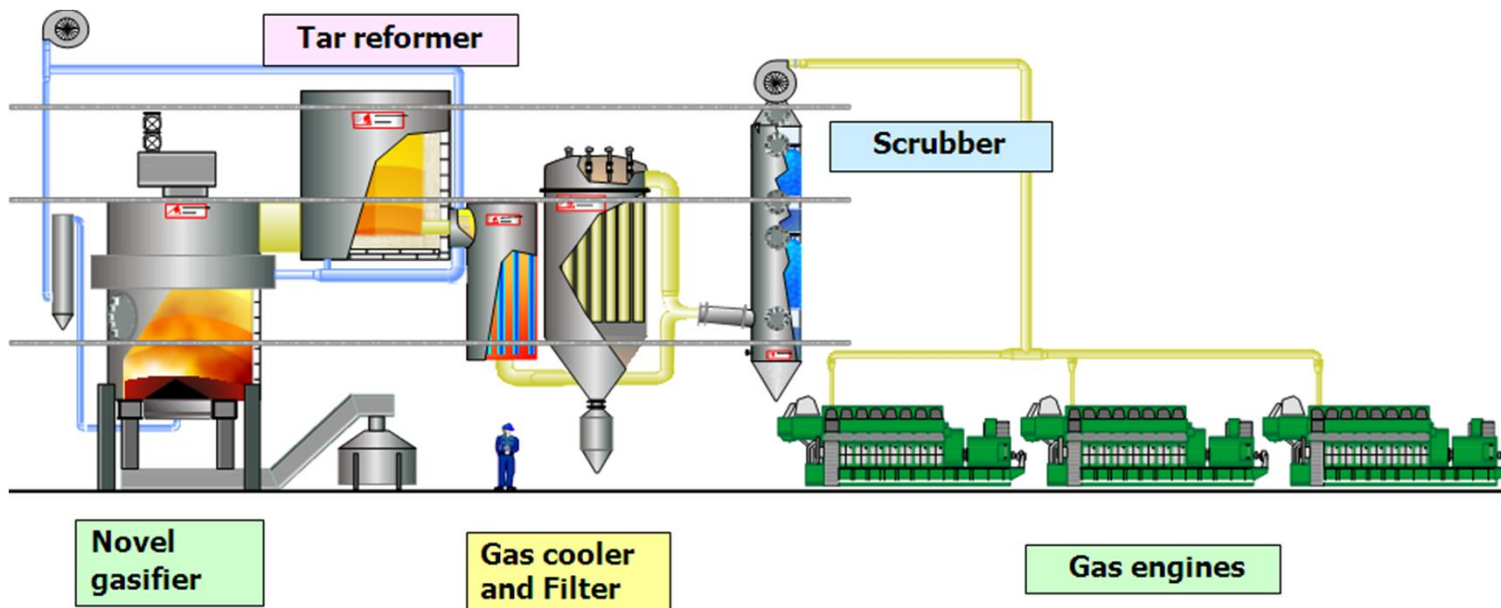
Start-up April 2012  
 Total investment 157 M€



Architecture study of the plant

# High-Efficiency Power from Biomass

- IGCC based on pressurised fluidised-bed gasification and hot filtration
  - pilot-scale R&D by VTT in 1990's for large scale of 30 – 150 MWe
  - new interests due to increasing need for green power
- Gasification coupled to engines for small-scale plants 0.1-5 MWe
  - VTT's Novel gasifier development in early 2000
  - Gas reforming know-how was licenced to Carbona and their Skive plant
  - Support to SME companies in "farm-scale" power



Biomass IGCC  
Demonstration Plant,  
Värnamo, Sweden

# Downdraft gasification for the Small-Scale

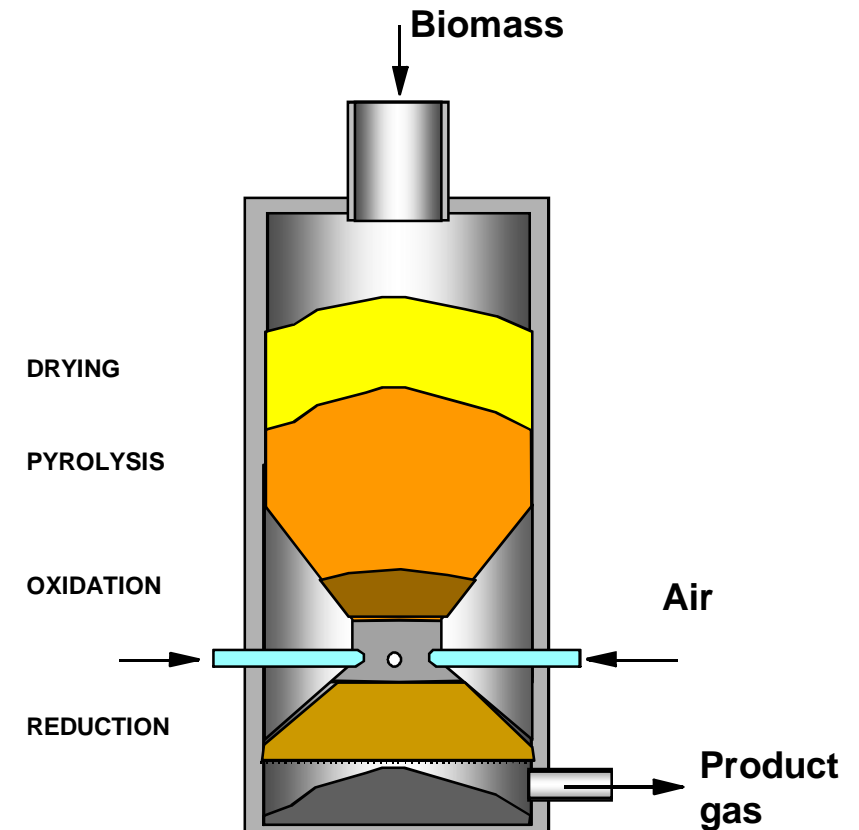
- originating from II World War wood/charcoal gasifiers

## Downdraft fixed bed gasifier:

- ◆ several developers since II world
- ◆ suitable only to high-quality fuels
  - 10 - 100 mm in size
  - moisture < 25 %
  - no ash sintering tendencies
- ◆ limited to smallest size < 1-3 MW<sub>fuel</sub>
- ◆ poor carbon conversion

## Advantages:

- low tar content and simple gas cleaning
- low investment cost and easy to operate
- suitable to small gas engines < 300 kWe (preferably naturally aspirating)



**SME companies are developing small-scale gasifiers for gas engines in Finland aiming to 100 – 500 kWe (at least 5 different companies)**

**New R&D project at VTT with five SME companies is planned for 2012**

- Global technology review
- Preliminary R&D on a couple of new ideas
- Support for SME developers

## Gasification based small scale CHP development in Finland

- Downdraft gasifier followed by gas purification and gas engine
- Dried wood chips as fuel

### Gasek

- Power output 50 kW, heat output 100kW
- R&D site in Reisjärvi
- Contact: [info@gasek.fi](mailto:info@gasek.fi)



COMPANY

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SOLUTIONS

GASEK CHP PLANTS

GASEK CHP PLATFORM

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## CLEAN PERFORMANCE



GASEK's CHP (Combined Heat and Power) plant is a combined unit for generating electricity and heat, which is well suited, for instance, for small and medium sized businesses as well as for energy generation in remote communities. We deliver our power plants on the turn-key basis.

### Volter

- Power output 30 kW, heat output 80 kW
- Three plants in Oulu region
- Contact: [jarno.haapakoski@volter.fi](mailto:jarno.haapakoski@volter.fi)

Sources: [www.gasek.fi](http://www.gasek.fi), [www.volter.fi](http://www.volter.fi)

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### CHP-PLANT

The container-packed CHP-plant produces, for example, enough electricity and heat for the annual needs of a farm or an entire small housing estate.

Electricity is produced by gasifying wood chips. Waste heat from the process can be used in hydronic underfloor heating, preheating of air-conditioning or domestic water, for example.

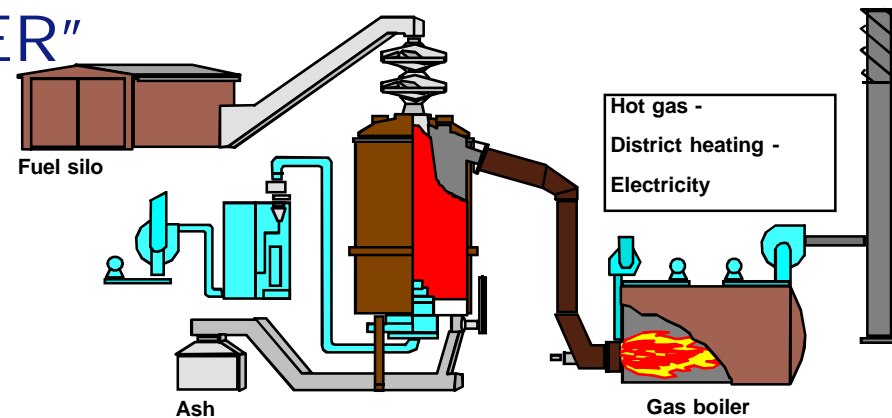
Your CHP-plant can be landscaped to match your own surroundings.





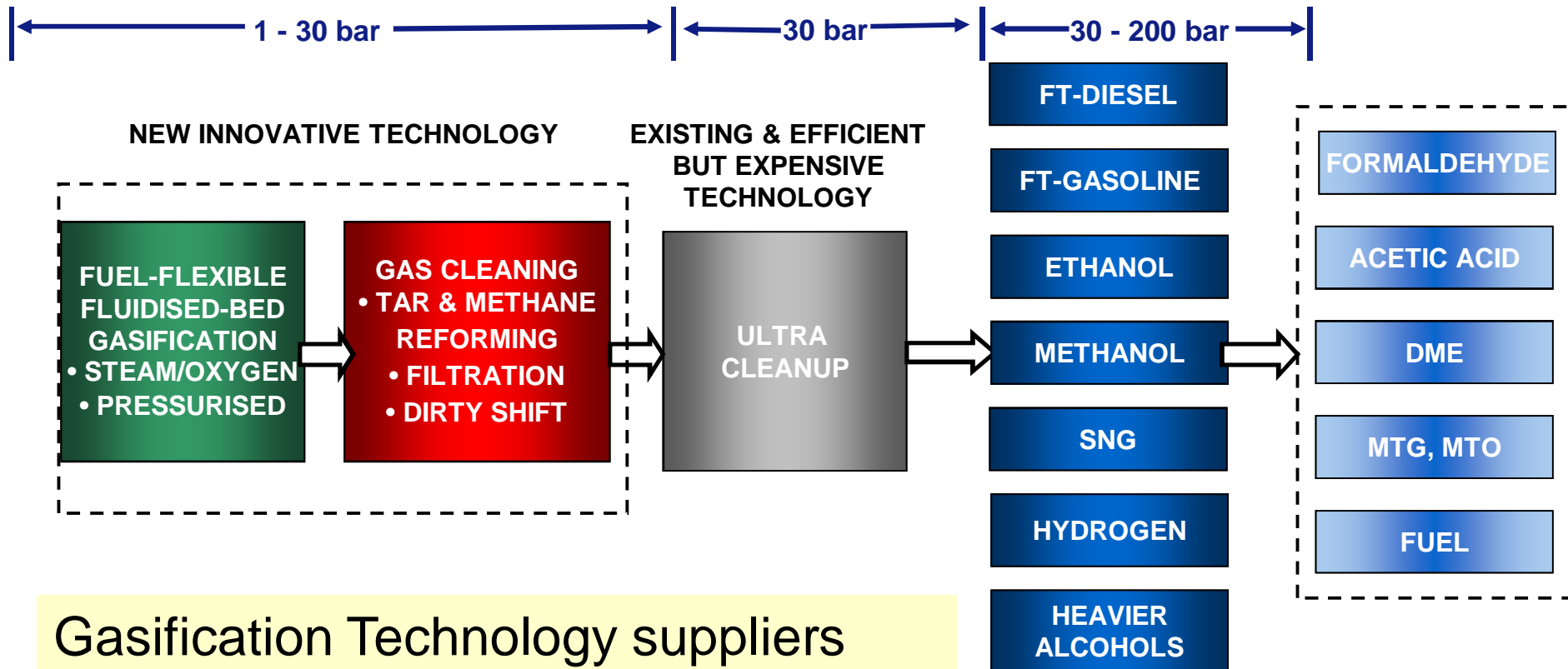
## UPDRAFT GASIFIER "BIONEER"

- developed in 1980's, 10 plants
- for boilers and kilns, 5 MW scale
- tar containing gas
- high carbon conversion
- robust, flexible, fully automated
- Novel version in operation at Kokemäki



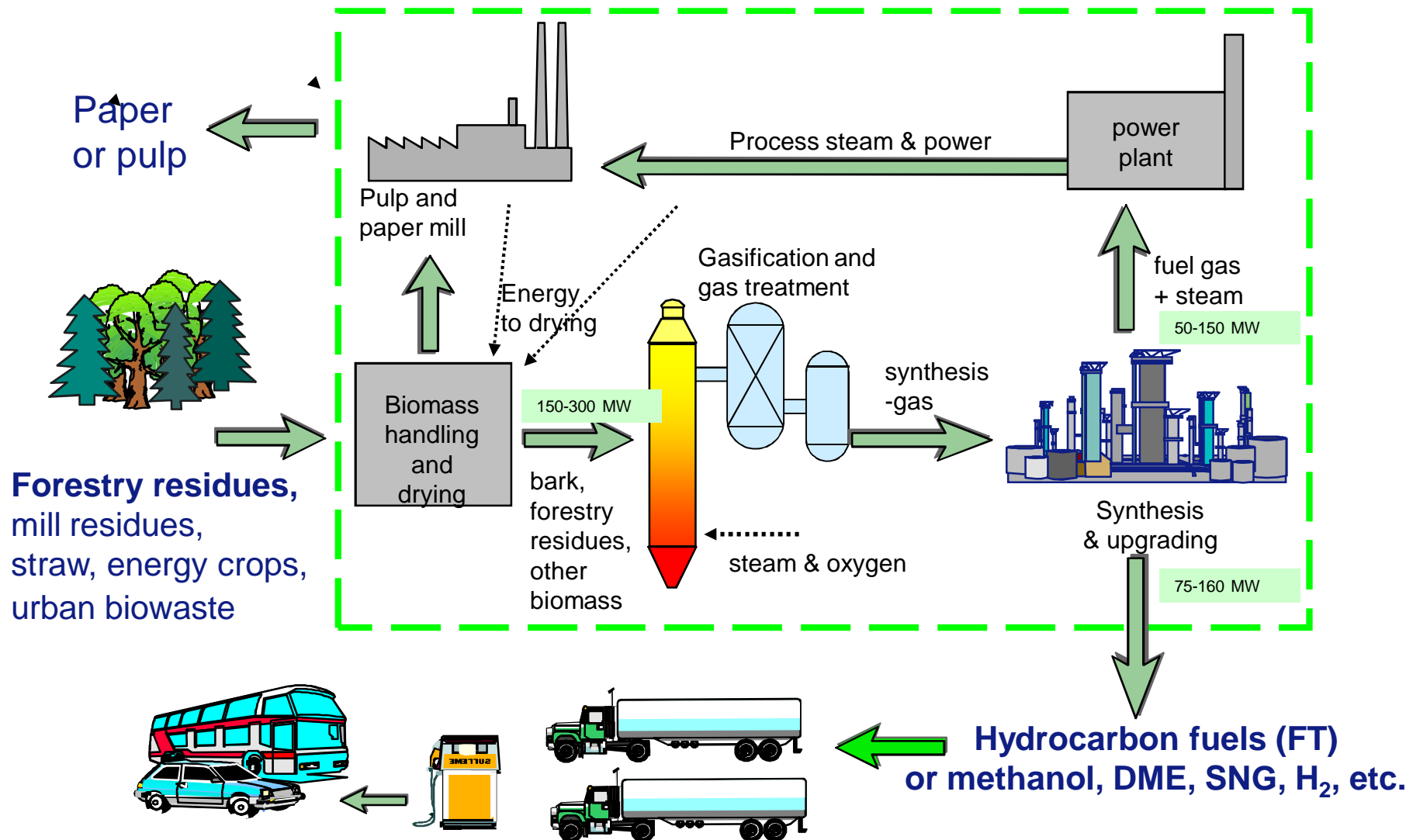
5 MW district heating plant, Jalasjärvi, Finland,  
in operation since 1987

## Gasification route to different products



Gasification Technology suppliers  
**Andritz-Carbona, Foster Wheeler**  
 and **Metso** have also several studies  
 and R&D&D projects abroad

# Syngas Route to Biofuels – Integrated Concept Studied at VTT's UCG-project in 2004-07



## Biorefinery BTL Demonstration Plans in Finland

- Three consortiums are presently planning second-generation BTL biorefineries in Finland
- The planned capacities are 100 000 – 200 000 ton/a of diesel
- EU's NER300 funding has been applied - decisions expected at the end of 2012
- Overall investment costs in order of € 400 - 800 million?

- Very large-scale is needed to achieve positive economics?
- First plants will be more expensive than mature technology?





Several sites have been investigated by companies



## NSE Biofuels JV company owned by Neste Oil and Stora Enso



### Development partners

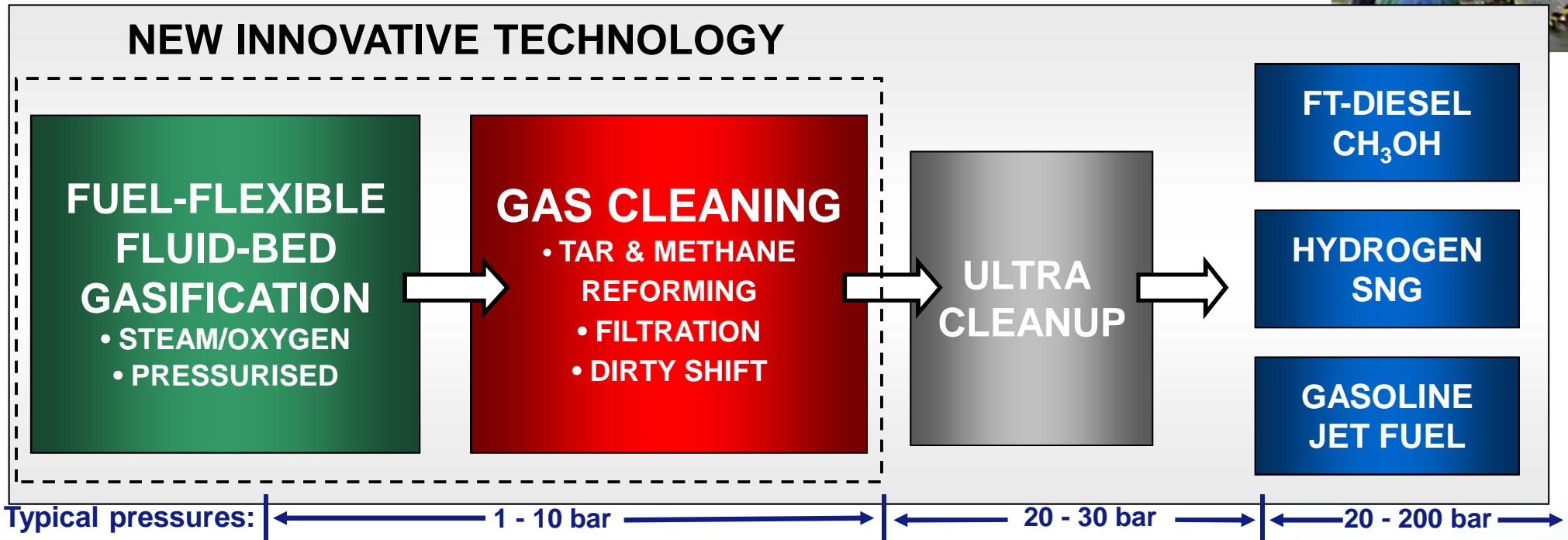
Research & piloting partner	
Gasification supplier	
Process engineering	NESTE JACOBS   NESTE OIL
Feedstock procurement	 storaenso
Sustainability	NESTE OIL  storaenso
Upgrading, distribution	NESTE OIL

From: V.Jokela, NSE presentation at IEA gasification seminar, Piteå, 2011



# Gasification and Gas Cleaning Process

- developed and tested at VTT on 0.5 MW scale
- ca. 4000 operating hours with different wood residues



- GASIFIER TARGETS**
- NO ASH-RELATED PROBLEMS
  - SIMPLE DESIGN AND HIGH RELIABILITY
  - HIGH C-CONVERSION TO GAS+TARS
  - LOW OXYGEN CONSUMPTION

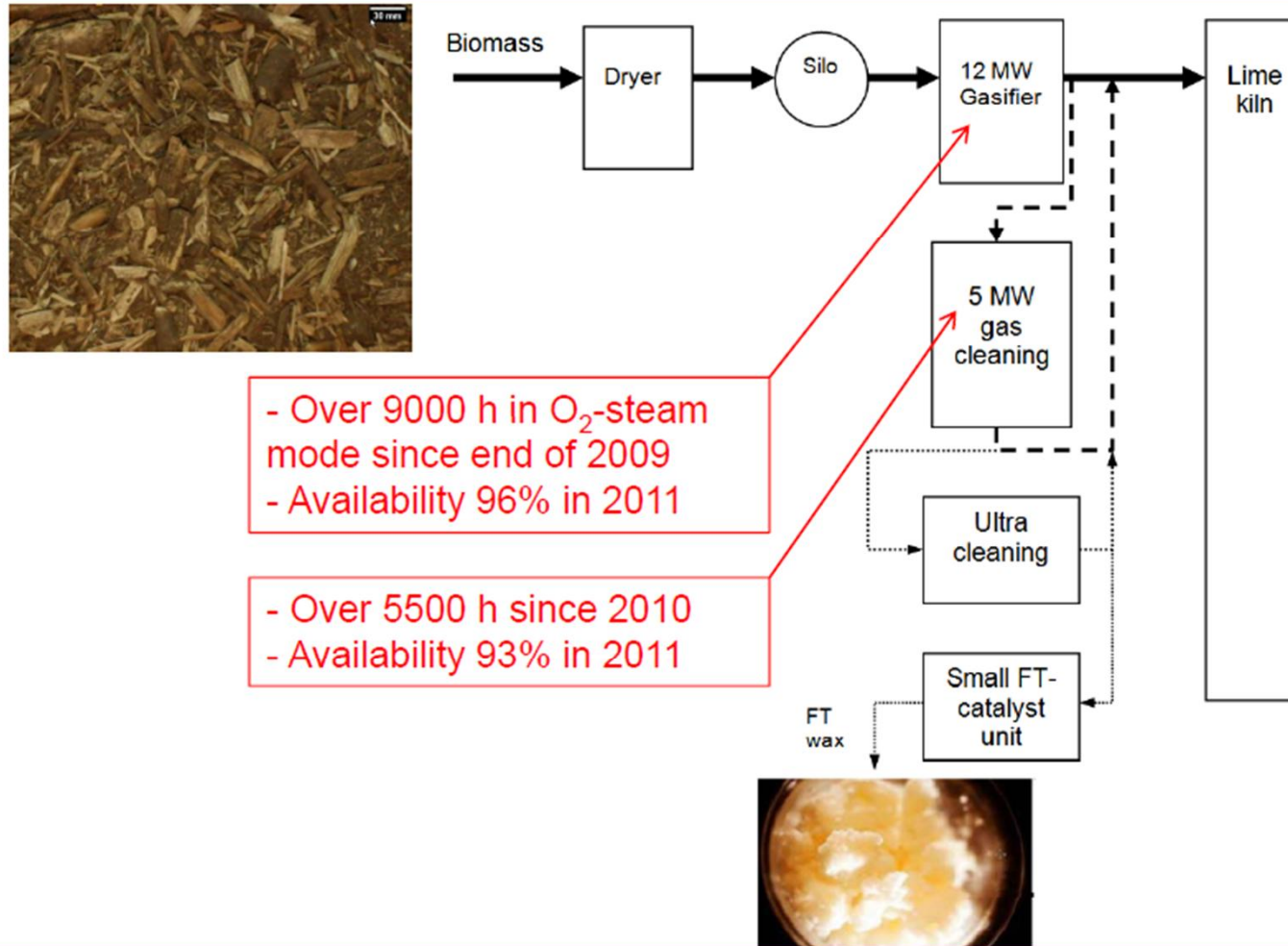
- GAS CLEANING TARGETS**
- COMPLETE TAR DECOMPOSITION
  - 60-80% METHANE REFORMING
  - H<sub>2</sub>/CO RATIO SUITABLE TO FT-SYNTHESIS



## PROCESSES CHAIN OF THE VARKAUS TEST PLANT

From: Sami Kokki,  
Foster Wheeler

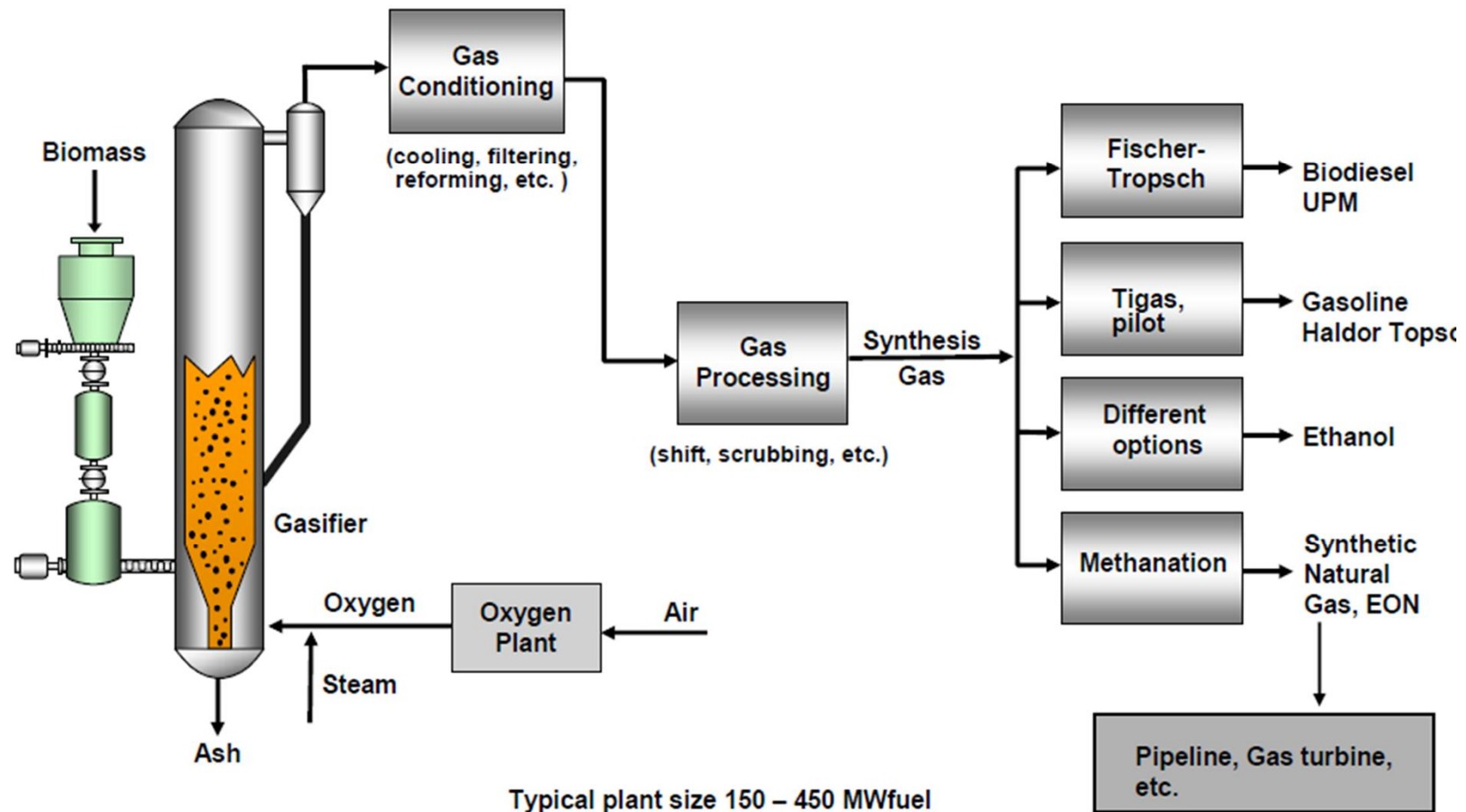
Nordic Bioenergy 2011, Jyväskylä, 6.9.2011



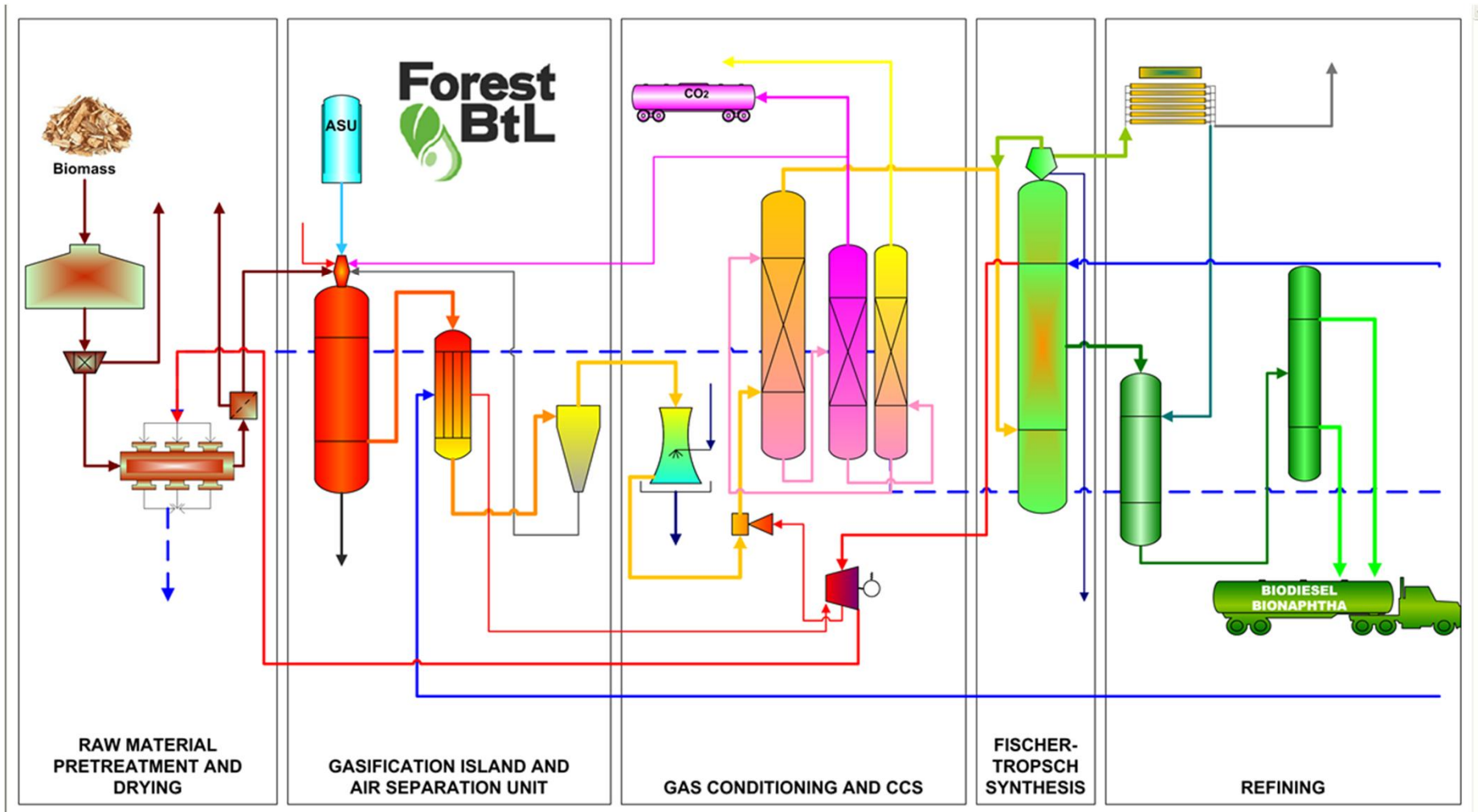
# Synthesis gas for transportation fuels and SNG

ANDRITZ Carbona active projects

From: Jim Patel,  
Andritz-Carbona, 2011









## Biomass-to-Syngas R&D at VTT

### ▪ 2G 2020 BIOFUELS 2012 – 2014

- **Pilot-scale R&D** on improved steam/O<sub>2</sub> gasification and indirectly heated gasification alternatives
- **Simplified final gas** cleaning for once-through-type synthesis
- Heat integration alternatives
- Industrial support from Andritz-Carbona, Foster Wheeler, Fortum, NSE Biofuels and UPM – further R&D for the industrial D&D projects

### ▪ PRODUCTION OF SNG OR H<sub>2</sub> FROM BIOMASS 2011-14

- Evaluation of process alternatives – less capital intensive and suitable to smaller size than BtL plants
- **Pre-competitive R&D on gasification and gas cleaning**
- Wide industrial support in the Vetaani-project

### ▪ US-CO-OPERATION PROJECT ON EVALUATION OF GASIFICATION-BASED SYSTEMS 2011-12

- Ilkka Hannula as **visiting scientist at Princeton University**
- **Evaluation of US development projects**
- Aspen modelling of selected concepts and technologies

### ▪ NORDSYNGAS: 2010-14

- **Nordic University co-operation:** Luleå, Piteå, Sinteff, VTT
- Fundamental aspects of pressurised gasification
- System studies related to integrated plants to pulp and paper industries

### ▪ GASIFICATION REACTIVITY 2011 – 2014

- **Fundamental research** with Åbo Akademi and Jyväskylä University
- Funded by Finnish Academy

## 2G Biofuels and RES-Infra of VTT

- VTT will move and reconstruct its pyrolysis and gasification test facilities to a new industrial site at Espoo
  - Design and construction in 2012 – 13
  - Commissioning in 2013-14
  - Testing activities continue at present site in Otaniemi until end 2013
- Main test facilities:
  - Flash pyrolysis pilot plant and bench-scale pyrolysis facilities
  - Dual fluidized-bed steam gasification pilot plant
  - High-pressure O<sub>2</sub>-blown/air-blown gasification PDU plant
  - Atmospheric-pressure CFB gasification pilot plant for waste fuels
  - Bench-scale gasification and gas cleaning equipment
  - Synthesis testing in slip streams and with simulated gases

### 2G Biofuels R&D project

7.2 M€ - 3 a, incl. ca 1 M€ for test facilities

VTT RES-Infra

5.5 M€

investment