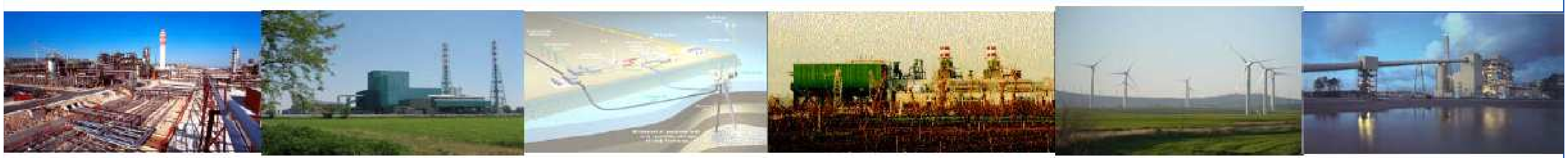
FOSTER WHEELER

BIOMASS GASIFICATION FOR THE PRODUCTION OF SNG: A PRACTICAL ROUTE THROUGH AVAILABLE AND NEW TECHNOLOGIES



R. Domenichini – Director Power Division
Foster Wheeler Italiana

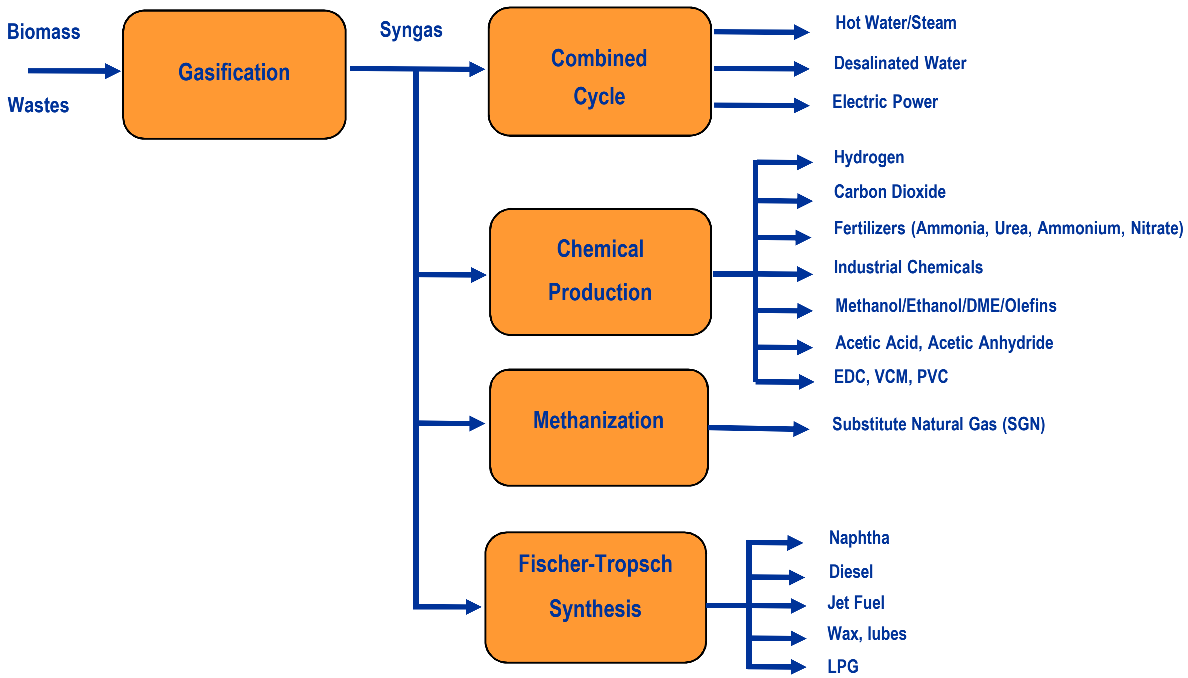
Gasification Technology Conference, November 2010 – Washington (USA)

TOPICS

- Why Biomass Gasification? Why SNG?
- Foster Wheeler CFB Gasification Experience
- Biomass Gasification and Syngas Purification
- Methanation
- Preliminary Economic Evaluation
- Conclusions

WHY BIOMASS GASIFICATION? WHY SNG?

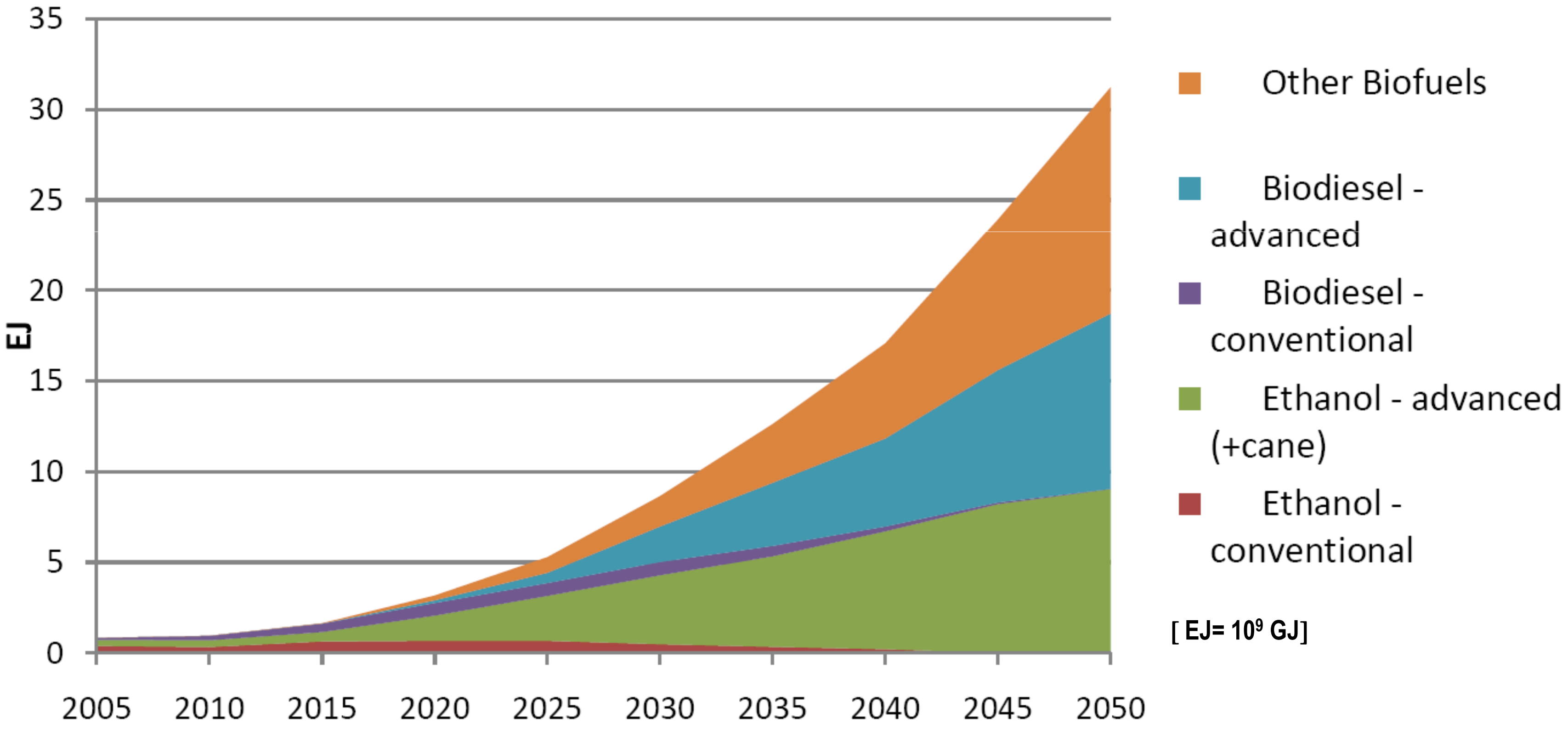
- **Biomass Gasification: the bridge to a green world**
  - Transport fuels
  - Chemical products
  - Heat and power



- **SNG (Substitute Natural Gas): a practical pathway to final users**
  - Easy connection of production plants to existing natural gas networks

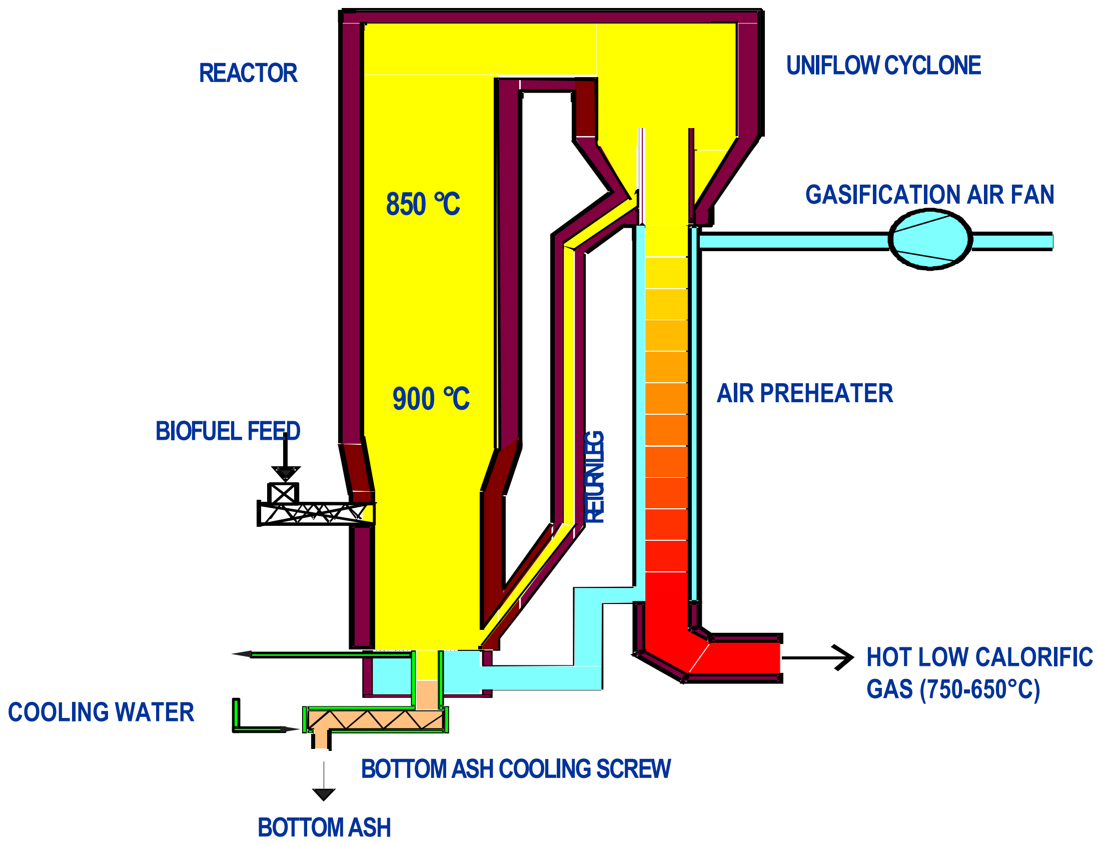
BIOFUELS PRODUCTION PROJECTIONS IN THE BLUE MAP SCENARIO

“BLUE Map” scenario: reduction of energy-related CO_2 emissions by 50% in 2050 (vs 2005 level)



Source: IEA 2010

FOSTER WHEELER CFB GASIFIER



Refractory lined
No heat transfer surfaces

Uniflow cyclone

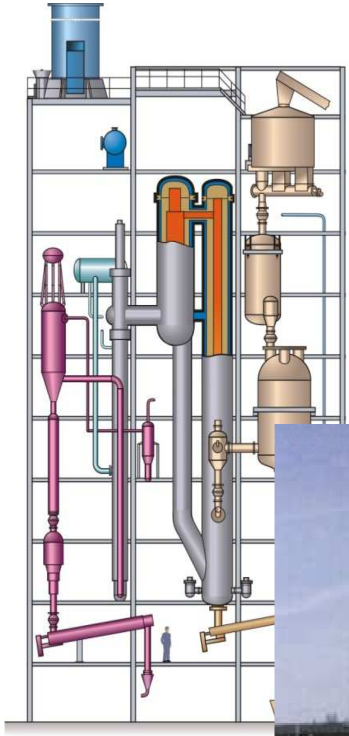
Air preheater integrated into gas duct below cyclone

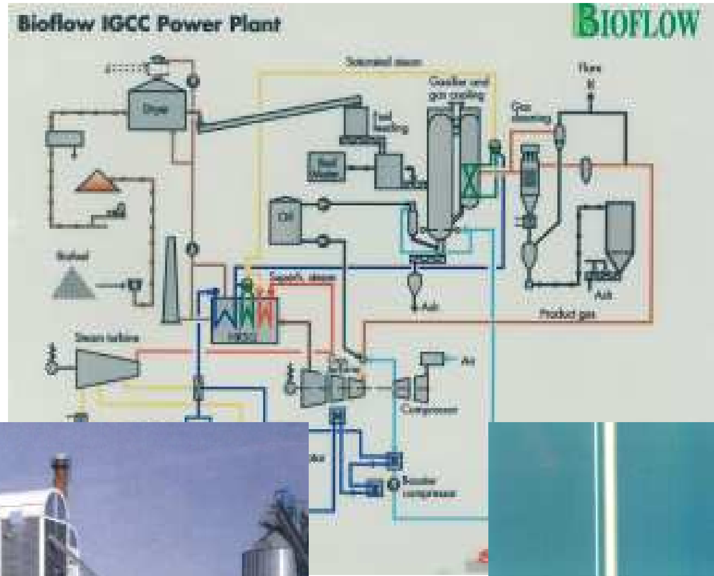
Process conditions according to fuels and applications

Cold start up appr. 15-18 hours
Refractory lining heat up rate 50...70 C/h

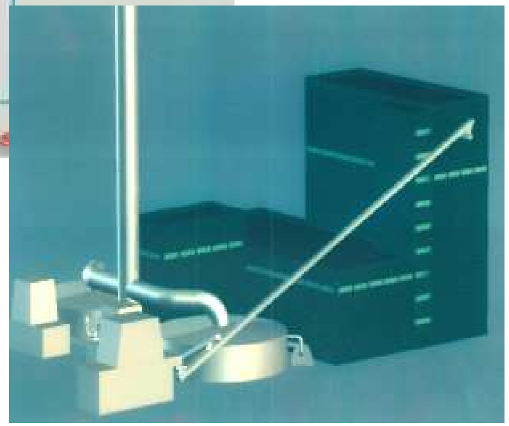
Long History
(originally developed end 70's/beginning 80's) → **Recent commercial applications** → **New developments in progress**

PRESSURIZED GASIFICATION OF BIOMASS - VÄRNAMO AND ÄÄNEKOSKI





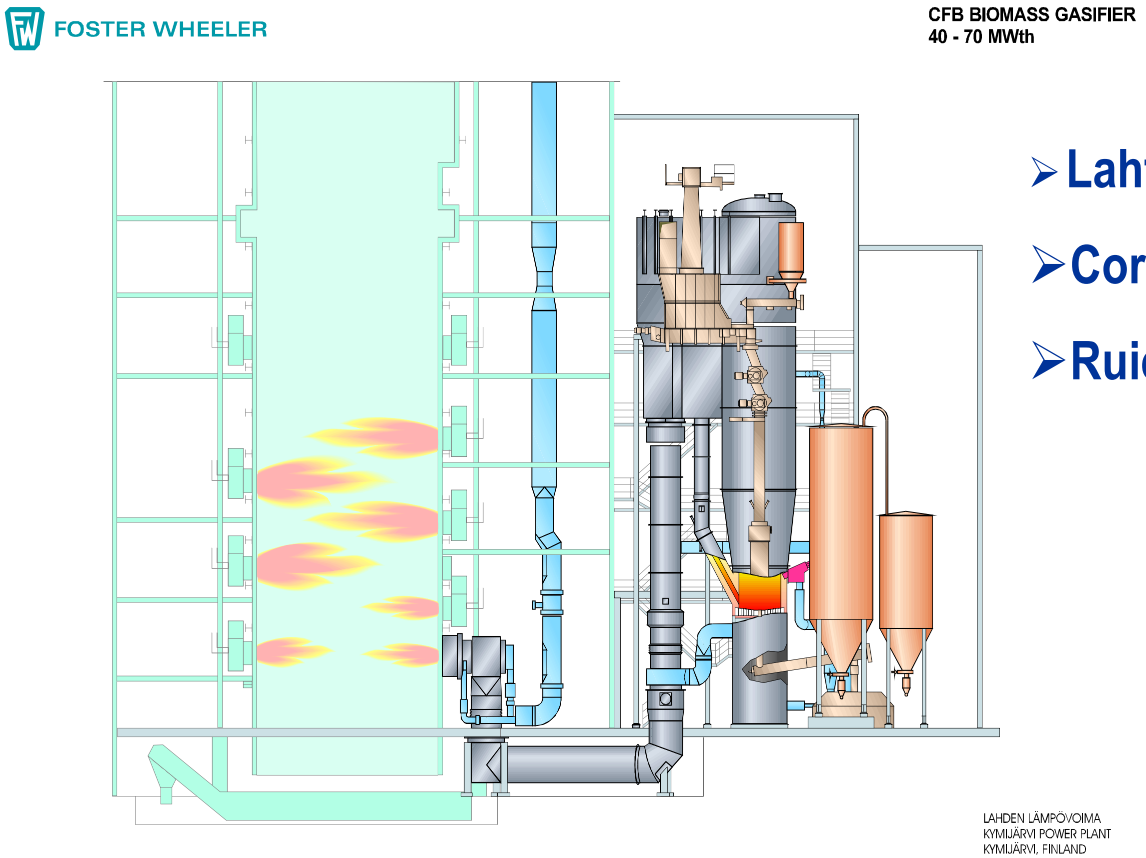
Äänekoski Technical and Feasibility Study



Värnamo IGCC Demonstration Plant

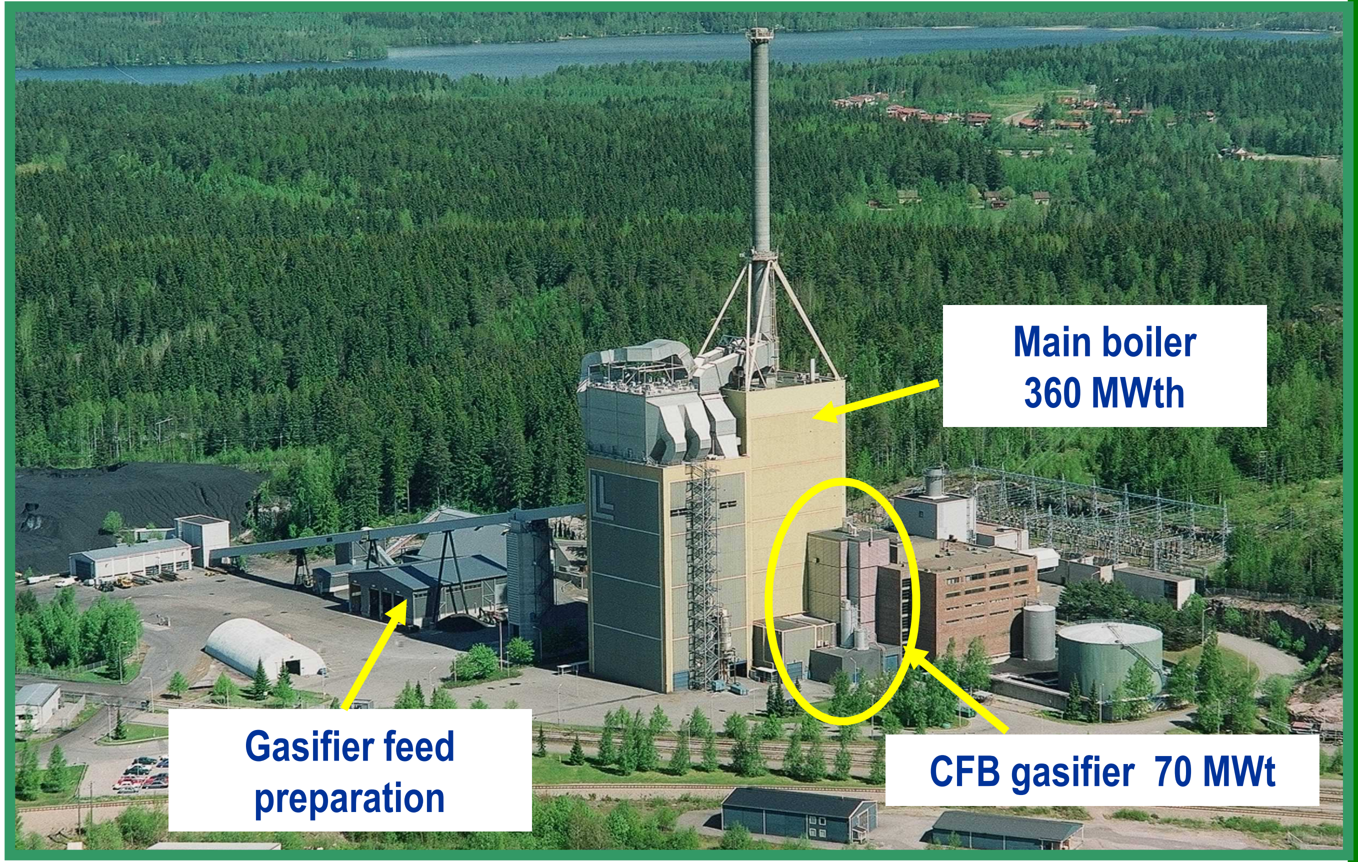
- Airblown Gasification of wood chips
- Gasification pressure temperature: 18 bar g/950°C
- Electrical/Thermal power output: 6 MWe/9MWth
- Efficiency: 32% (el)/83% (overall)

COMBINATION OF BIOMASS GASIFICATION AND PC BOILER COMBUSTION



- Lahti, Finland (70 MWt) since 1998
- Corenso, Finland (50 MWt) since 2001
- Ruien, Belgium (50 MWt) since 2002

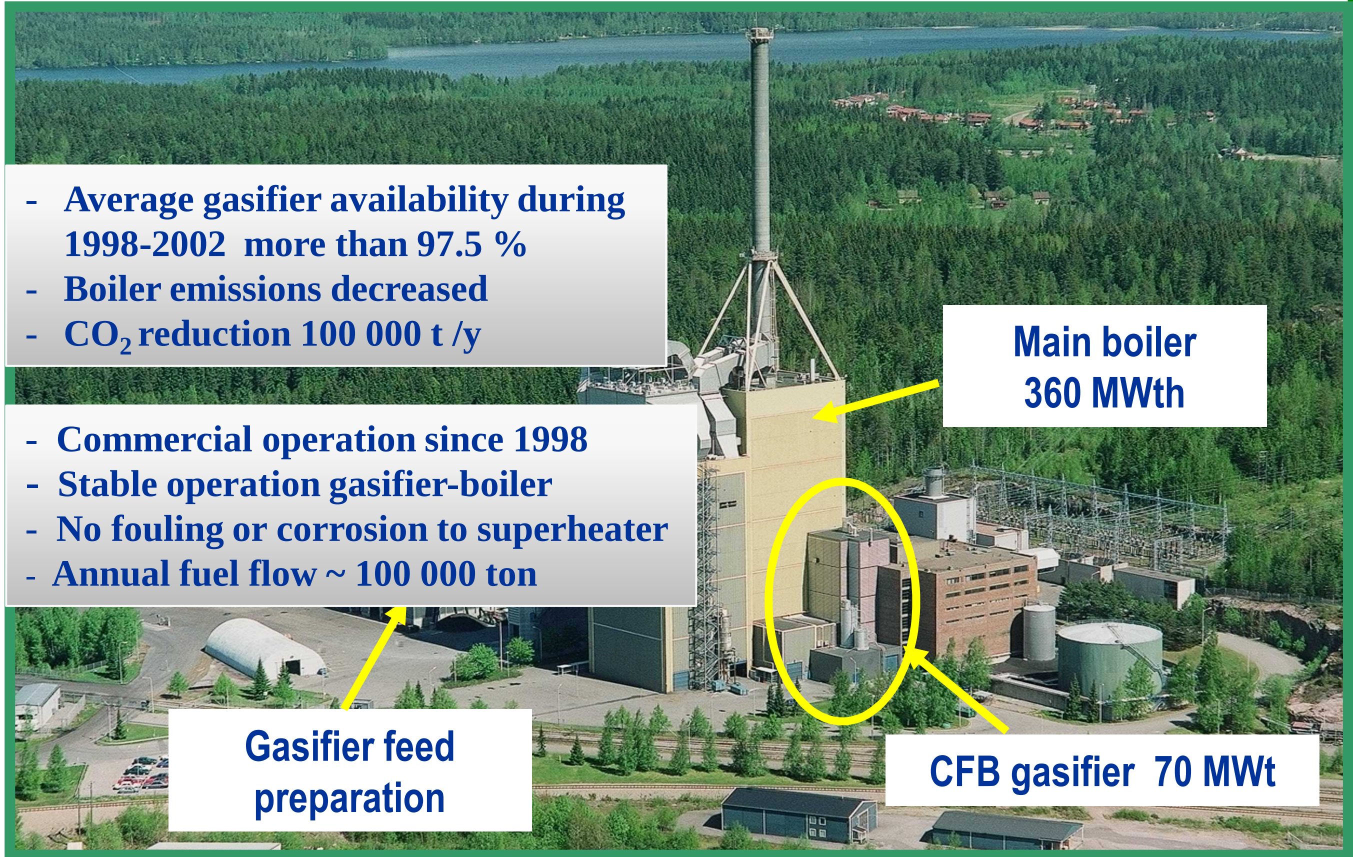
LAHTI OPERATING EXPERIENCE



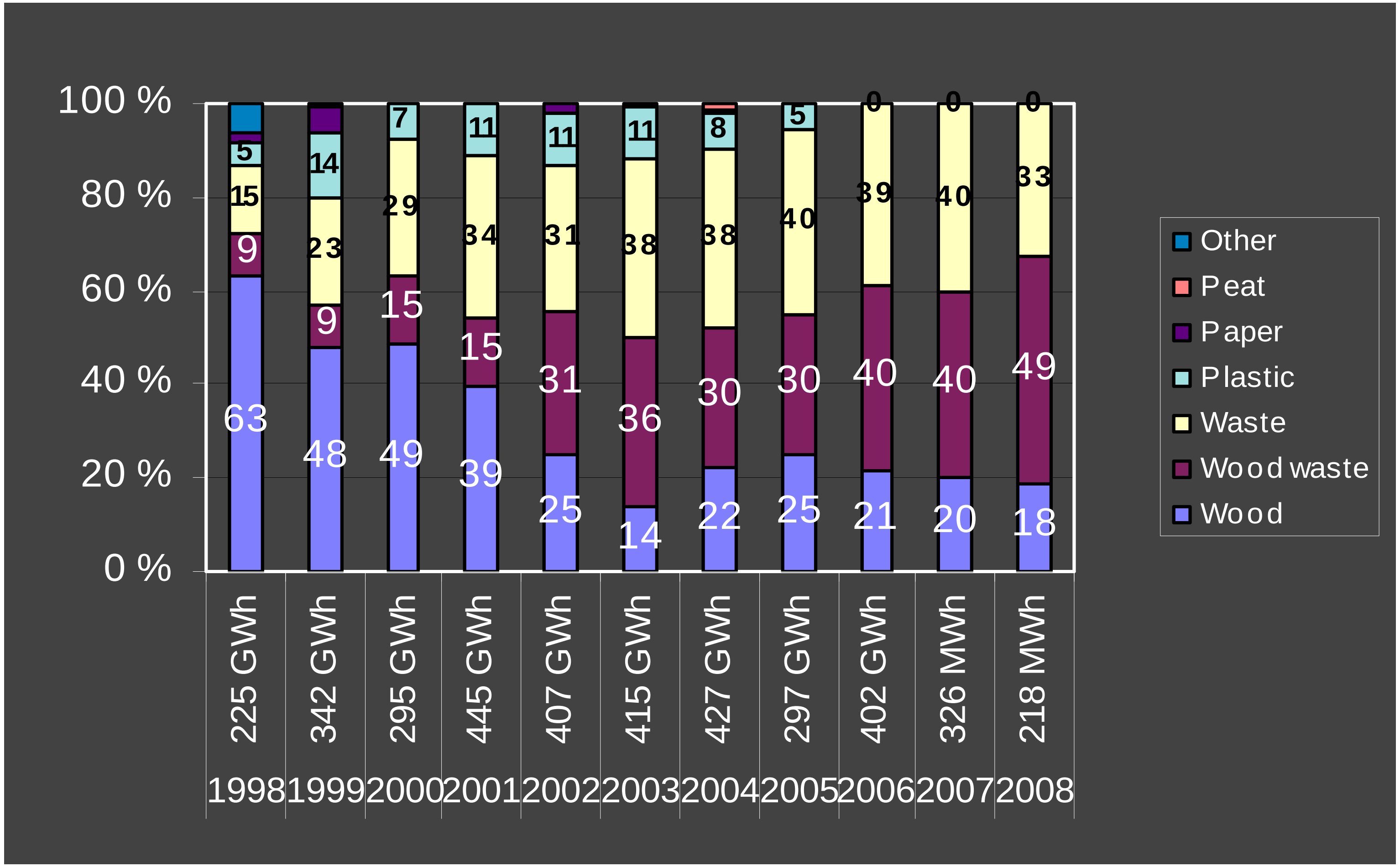
LAHTI OPERATING EXPERIENCE

- Average gasifier availability during 1998-2002 more than 97.5 %
- Boiler emissions decreased
- CO_2 reduction 100 000 t /y

- Commercial operation since 1998
- Stable operation gasifier-boiler
- No fouling or corrosion to superheater
- Annual fuel flow ~ 100 000 ton



LAHTI GASIFIER FUELS

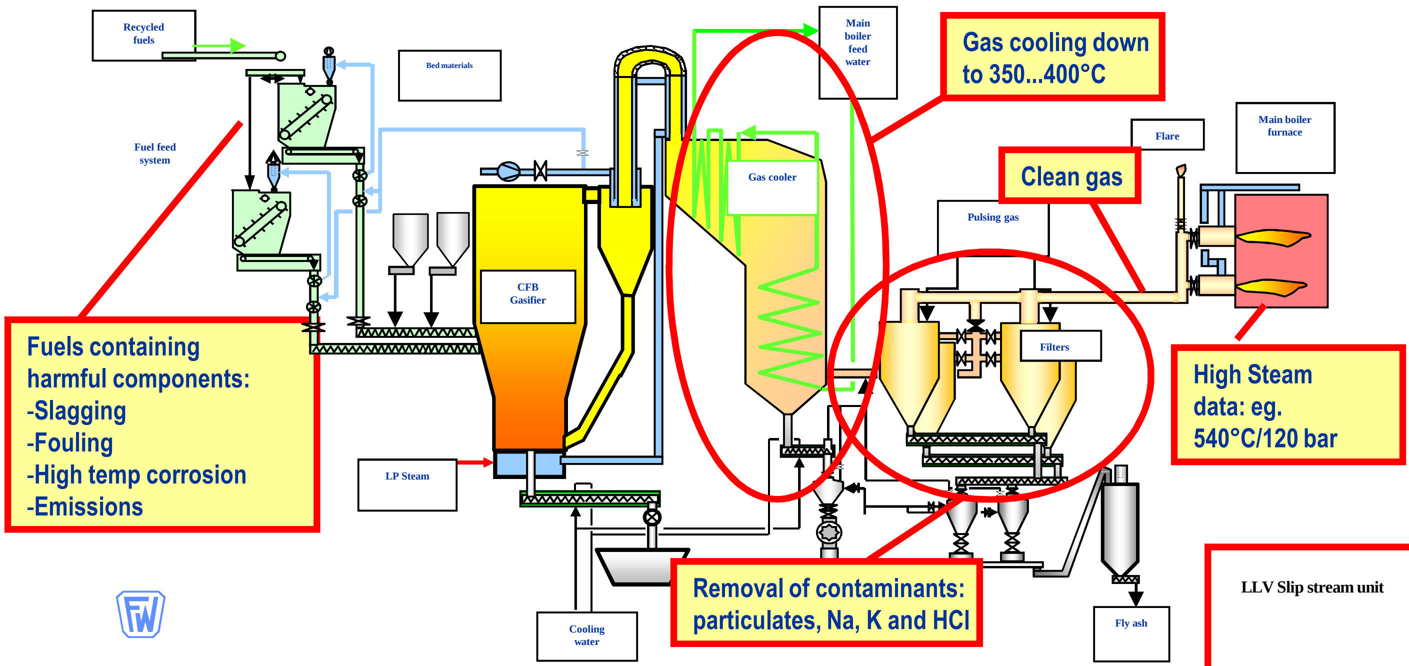


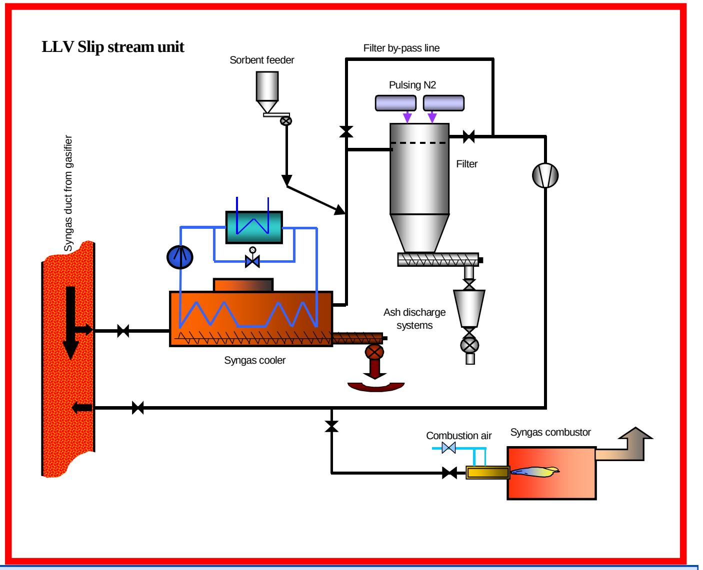
REF = Recycled Fuel; In-origing classified waste based fuel consisting of paper, plastics, cardboard, wood, etc.

COMBINATION OF BIOMASS GASIFICATION AND PC BOILER COMBUSTION

- Lower environmental emissions
- Better fuel flexibility
- Possibility to use local fuel (biomass, REF, plastics, etc.) resources in high efficiency steam cycle (say 120 bar, 540°C vs 40 barg, 400°C)
- Low investment and operation costs
- Utilization of existing power plant capacity
- Only small modifications to the main boiler
- High plant availability: gasification unavailability does not cause a power output reduction.

CLEAN GAS CONCEPT FOR DIFFICULT FUELS (REF / RDF, straw, agrobiofuels, etc.)





Pilot plant in operation at Lathi
(total operating hours 3300, years 2003/2004)

FUTURE APPLICATIONS: ULTRA CLEAN GAS DEVELOPMENT FINNISH APPROACH

PHASE 1 - UCG Development Program / 2004 – 2006

- Targeted to optimize the gasification process and gas conditioning&cleaning process to meet the requirements for the Fischer-Tropsch fuels, SNG and other synthesis gas utilization technologies
- Led by VTT; other partners FWE Oy, Neste Oil, Vapo, Andritz, Technical University of Helsinki, StoraEnso, UPM, M-Real, Metsä-Botnia, PVO
- Testing performed by VTT with various test facilities (pressurized and atmospheric)

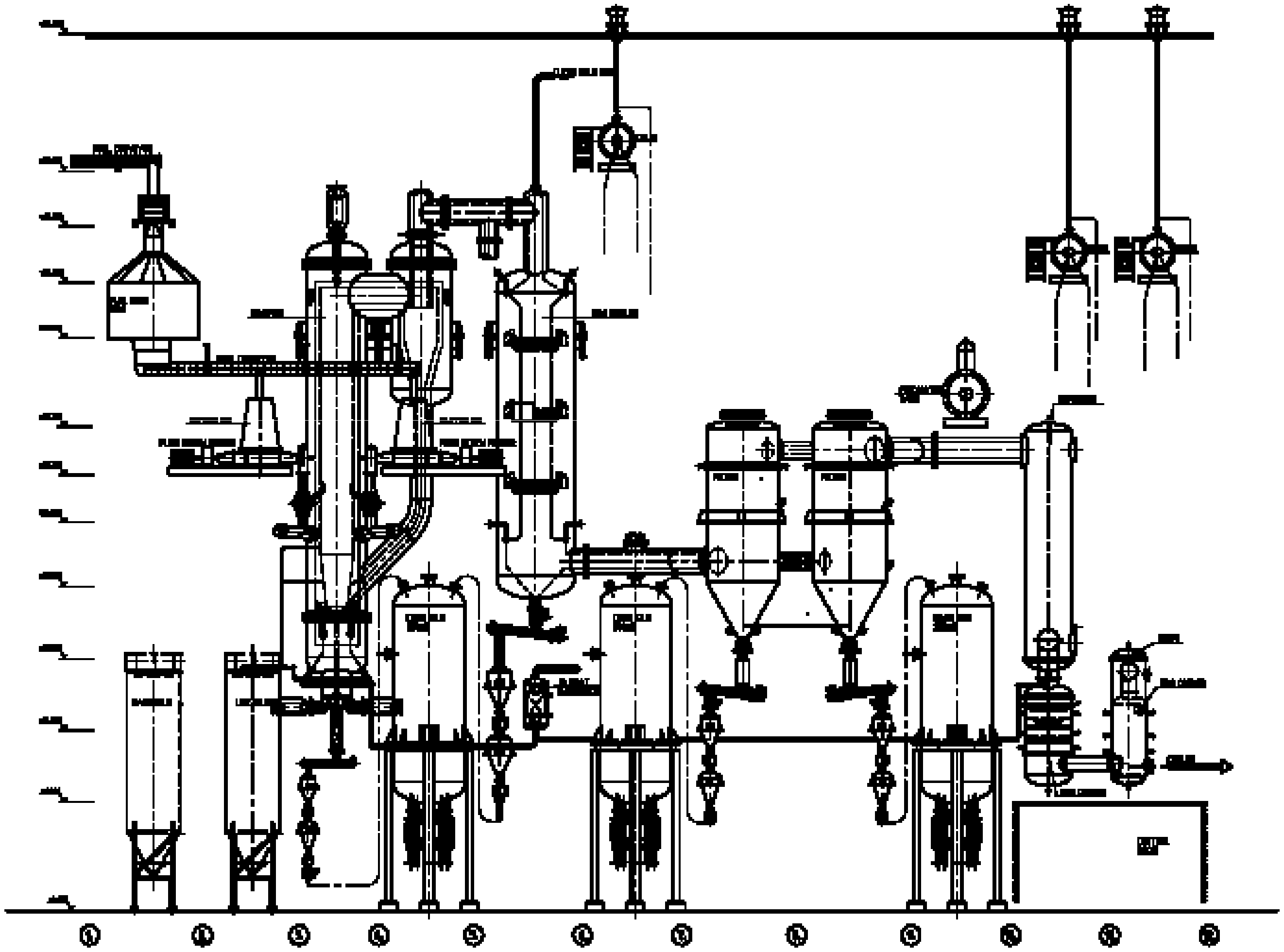
PHASE 2 - Long term industrial demonstrations

- NSE-FWEOy testing going on in Varkaus, Finland (2009-2011) with VTT as the main R&D partner

ULTRA CLEAN GAS CONCEPT

- Optimised pressurised oxygen-steam fluidised-bed gasification process (FW scope)
- Wide range of feedstocks: woody biomass, agrobiomass, peat, waste derived fuels
- Optimised gas reforming, dirty shift and ultra cleanup
- Liquid biofuel production integrated to pulp and paper industries

CFB GASIFICATION ISLAND (280 MWt)



SYNGAS QUALITY FOR BIOMASS GASIFICATION

	Entrained Flow	Circulating Fluidized Bed
Methane content	< 0.5%	5-7%
Tar content	~ 0	10^4 mg/Nm^3 max

Tar: organic compounds with boiling temperature higher than benzene (80°C).

Heavy tar (boiling temperature > 350°C)

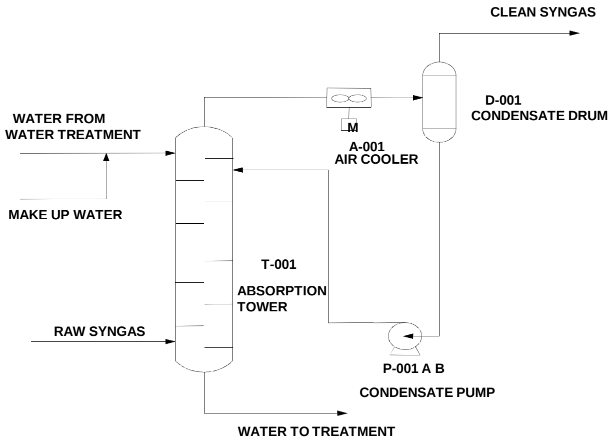
→ **Potential fouling of heat exchangers, filters, adsorbents, etc.**

Light tar (i.e. phenol, naphthalene)

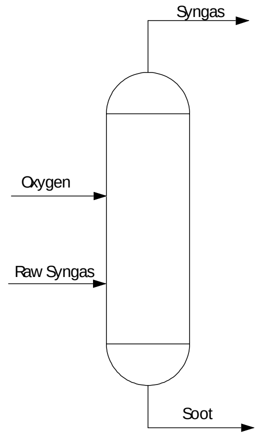
→ **Condensate contamination**

SYNGAS PURIFICATION: TAR Removal Options

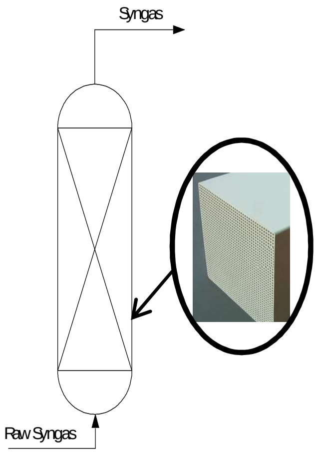
AQUEOUS SCRUBBING



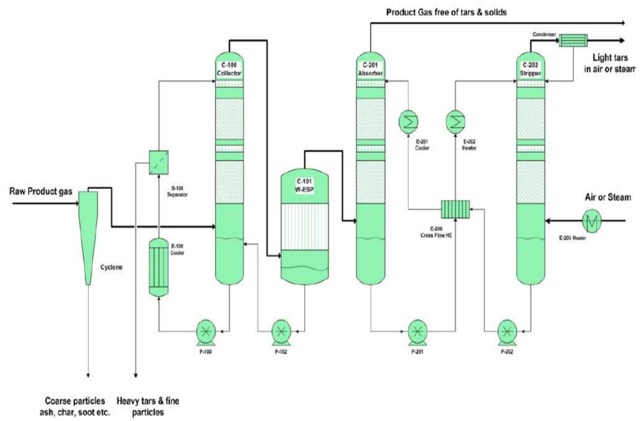
THERMAL CRACKING



CATALYTIC CRACKING



OIL SCRUBBING



Source: http://www.renewableenergy.nl/

SYNGAS PURIFICATION : TAR REMOVAL OPTIONS

Process	Advantages	Disadvantages	Risk
Aqueous Scrubbing	▪ Good efficiency ▪ Smooth and trouble-free operation	▪ Tars pass from gas to liquid phase ▪ High Capex for WWT ▪ Dew point T remains high	▪ Tar condensation at unit outlet
Thermal Cracking	• Complete removal • Chemical energy remains in syngas	▪ Soot formation ▪ High Capex ▪ Low thermal efficiency (product used to provide heat)	▪ None
Catalytic Cracking	• Potential complete removal • Chemical energy remains in syngas • Composition of product gas can be adjusted	▪ Soot formation ▪ Catalyst consumption and cost ▪ Catalyst disposal due to Ni	▪ Coke formation and catalyst deactivation ▪ Low references
Oil Scrubbing	• Stability and availability • Chemical energy remains in syngas (tars recycle) • High efficiency	▪ Scrubber/Stripper to remove NH_3, HCl, H_2S ▪ High level of filtration at high temperature	▪Naphtalene in the clean syngas: test required

SYNGAS PURIFICATION AND METHANATION

Shift and Acid Gas Removal

Syngas composition adjusted by partial shift to facilitate methanation

Physical washing to remove sulphur, followed by adsorption and guard reactor

Methanation catalysts require a very low (a few ppb) sulphur content

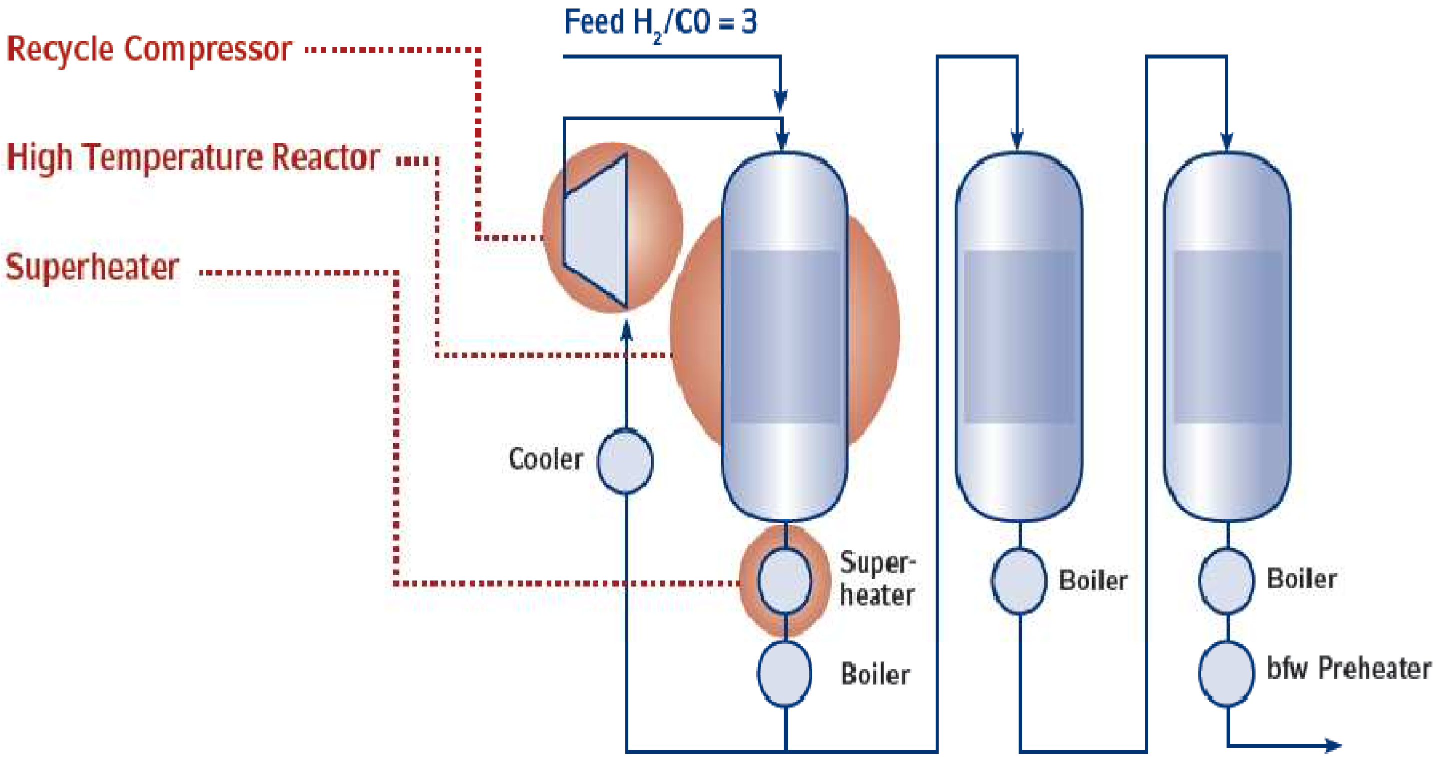
Benzene/Toluene less than 5 ppm

Methanation

$$CO + 3H_2 \Rightarrow CH_4 + H_2O$$

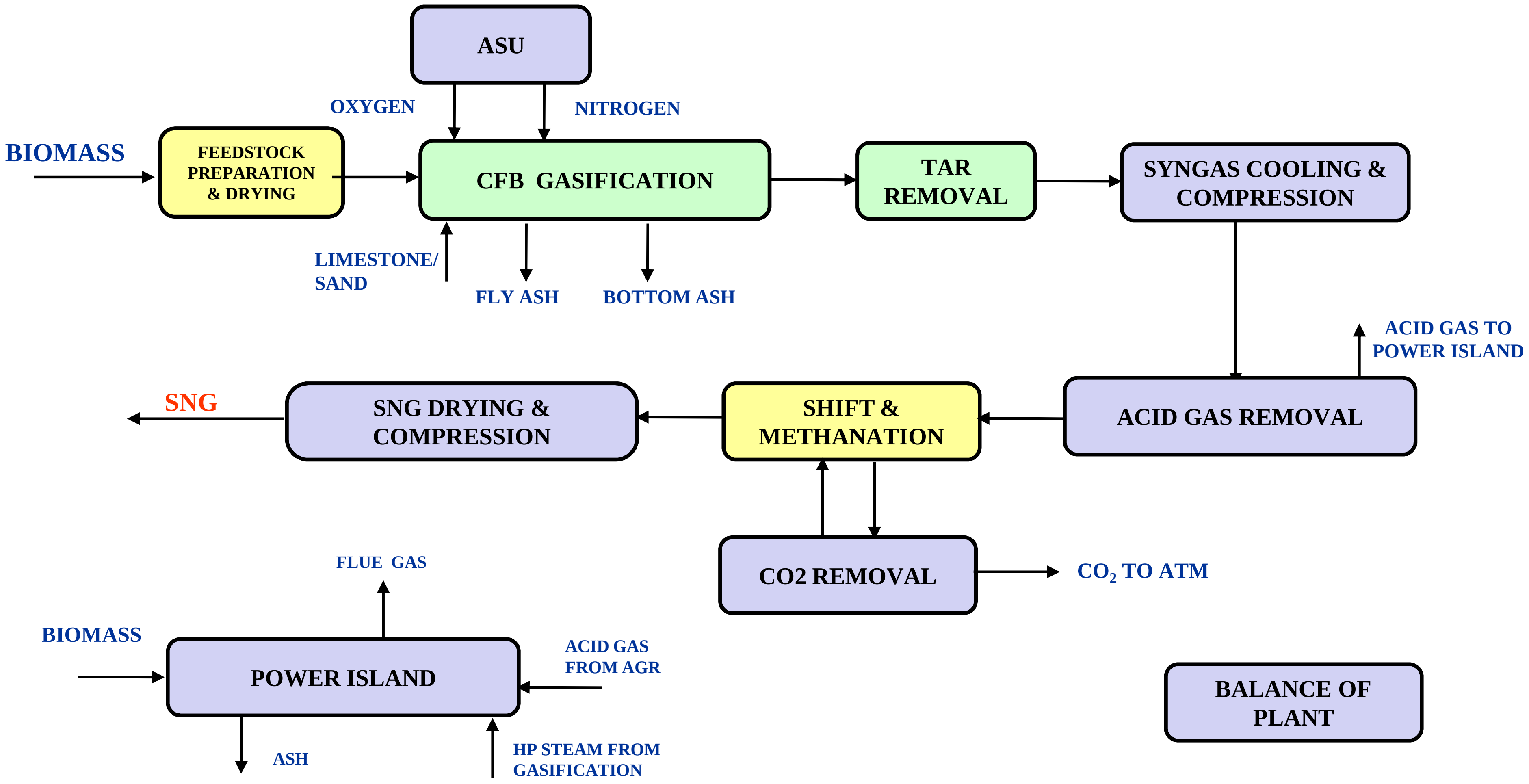
Highly exothermic reaction : 3 to 4 fixed bed catalytic/adiabatic intercooled reactors

METHANATION



Biomass Gasification for the production of SNG

BLOCK FLOW DIAGRAM



PRELIMINARY ECONOMICAL EVALUATION

TECHNICAL DATA

Feedstock: Wood chips and forest residues limited amount of back pellets/demolition wood

Flowrate	94 t/h as received
Inlet thermal power	280 MWt
Outlet thermal power (SNG)	170 MWt
SNG produciton efficiency	60.8%
SNG LHV	33,900 kJ/Nm^3

ECONOMICAL DATA

Total Investment Cost	280 MM Euro
O&M Cost	76 MM Euro/year
SNG Production cost	0.8 €/Nm^3

Basis for SNG cost estimate:

Biomass price:	70 €/t
Electric power:	50 €/MWh
IRR:	10%
Plant life:	25 years
Location:	Central Europe

IEA GHG R&D economic standards applied

CONCLUSIONS

- The economical evaluation shows that investment fundings, tariff incentives and/or Carbon taxation are required to make such projects economically viable

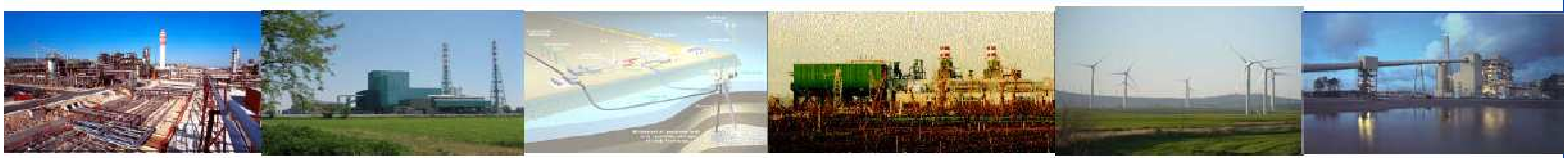
- CFB biomass gasification in association with syngas purification and SNG production is a promising technology, expected to demonstrate high thermal efficiency, good CAPEX and OPEX in comparison with competing technologies

- Some applied technologies need to reach a complete technical maturity: numerous R&D&D activities, also supported by National and European funds, are in progress

- Foster Wheeler is strongly committed to develop and demonstrate both the CFB biomass gasification and the SNG technology

- Foster Wheeler has developed a SNG production technology together with Süd Chemie (a major catalyst supplier).

THANK YOU



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