

State of art fluid bed gasifiers and
boilers for biomass and wastes

IEA Bioenergy / Task 33
Fluidized bed conversion of
biomass and waste

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Skive, Denmark

Juhani Isaksson /Valmet

Overview

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- Valmet FB technology offering
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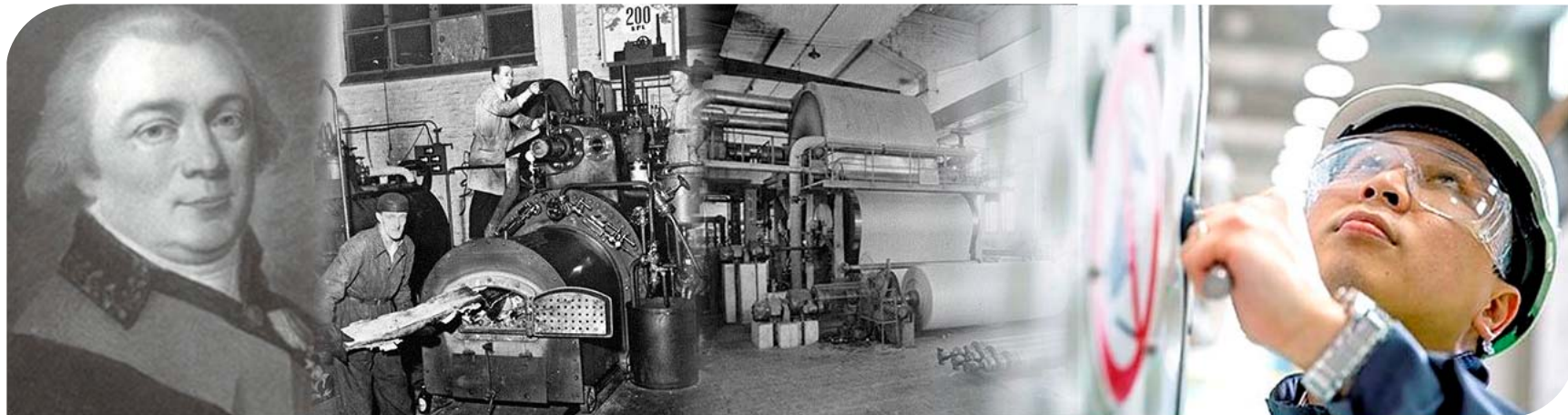
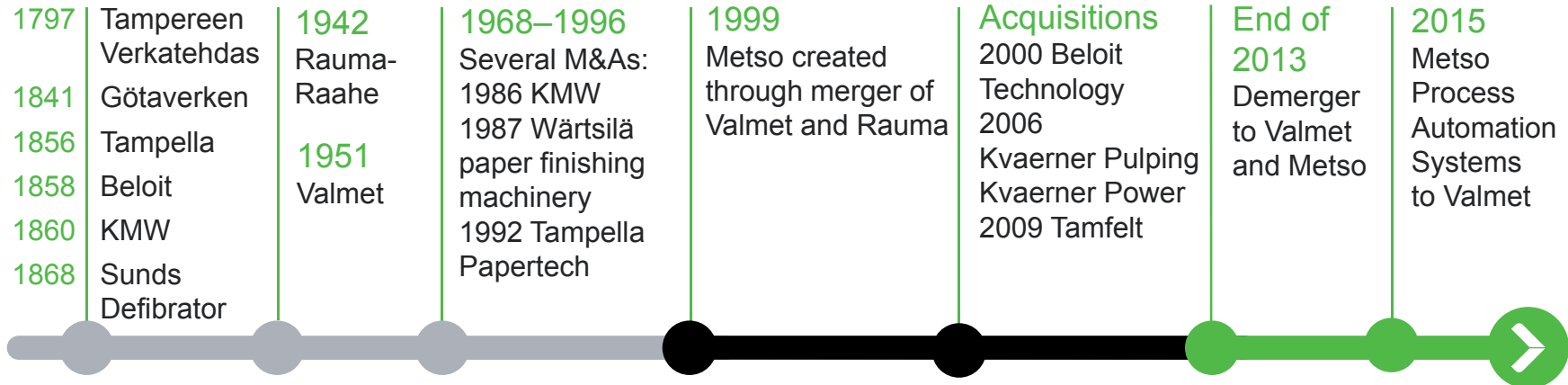
Valmet

Leading process technologies,
automation and services for the pulp,
paper and energy industries

Valmet 

220 years of industrial history in 2017

From cloth making to high-tech processes



Our offering by business line

Paper

- Recycled fiber lines
- Tailor-made board and paper machines
- Modularized board and paper machines
- Tissue production lines
- Modernizations and grade conversions
- Standalone products

Pulp and Energy

- Complete pulp mills
- Sections and solutions for pulp production
- Multifuel boilers
- Biomass and waste gasification
- Emission control systems
- Biotechnology solutions e.g. for producing bio fuels

Services

- Spare parts and consumables
- Paper machine clothing and filter fabrics
- Rolls and workshop services
- Mill and plant improvements
- Maintenance outsourcing
- Services energy and environmental solutions

Automation

- Distributed control systems
- Quality control systems
- Analyzers and measurements
- Performance solutions
- Process simulators
- Safety solutions
- Industrial Internet solutions



Focus in customer benefits

Valmet - Summary

- Unique and market's widest offering including process technology, automation and services for pulp, paper, energy industries.
- 12,000 professionals serving global customer base
- One of the world's 300 sustainability leaders
- Net sales EUR 2.9 billion
 - Services EUR 1,163 million
 - Automation EUR 290 million
 - Pulp and Energy EUR 826 million
 - Paper EUR 647 million
- Vision to become the global champion in serving our customers



Comprehensive Offering for Energy Customers



- Biomass to Energy, Waste to Energy and Multifuel solutions
 - Fuel handling systems
 - Boiler islands, modularized power plants and heating plants
 - Air pollution control systems
- Products and Technologies
 - Circulating fluidized bed boilers (CYMIC) and Bubbling fluidized bed boilers (HYBEX)
 - Biomass and waste gasification
 - Oil and gas boilers, waste heat recovery boilers
- Rebuilds and conversions
 - BFB conversions, capacity increases and lower emission levels
- Services

Facts

- Solutions for demanding fuels: biomass, waste and multifuel
- Multifuel capabilities
- Wide capacity range
- From-Fuel-to-Stack solutions
- Large installed base

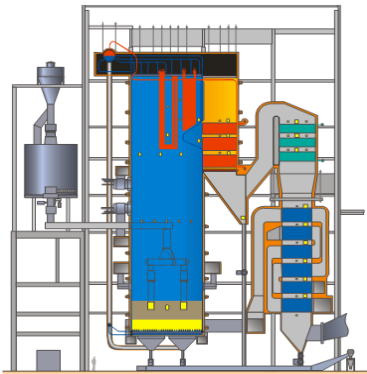
Results

- High fuel flexibility gives economic advantage and security
- Replacement of fossil fuels
- Reducing CO₂ emissions economically
- Minimum emissions

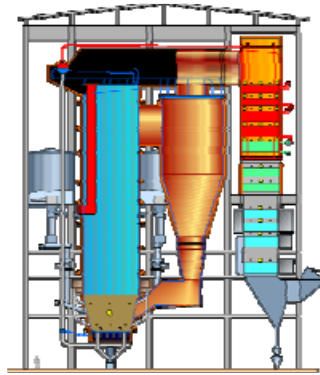
Valmet solutions for biomass and waste

Products for combustion and conversion

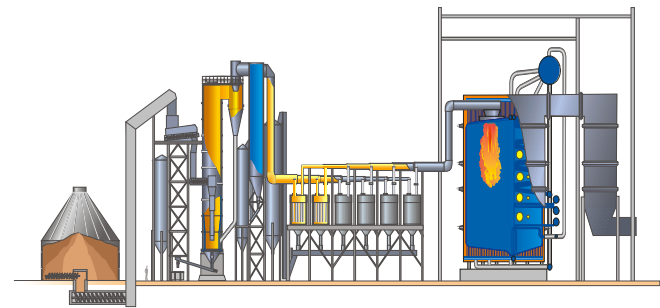
HYBEX BFB



CYMIC CFB



CFB Gasifier



BioPower



Bio oil



Black pellets



Valmet DNA DCS



Valmet HYBEX BFB boiler

Fuel flexibility

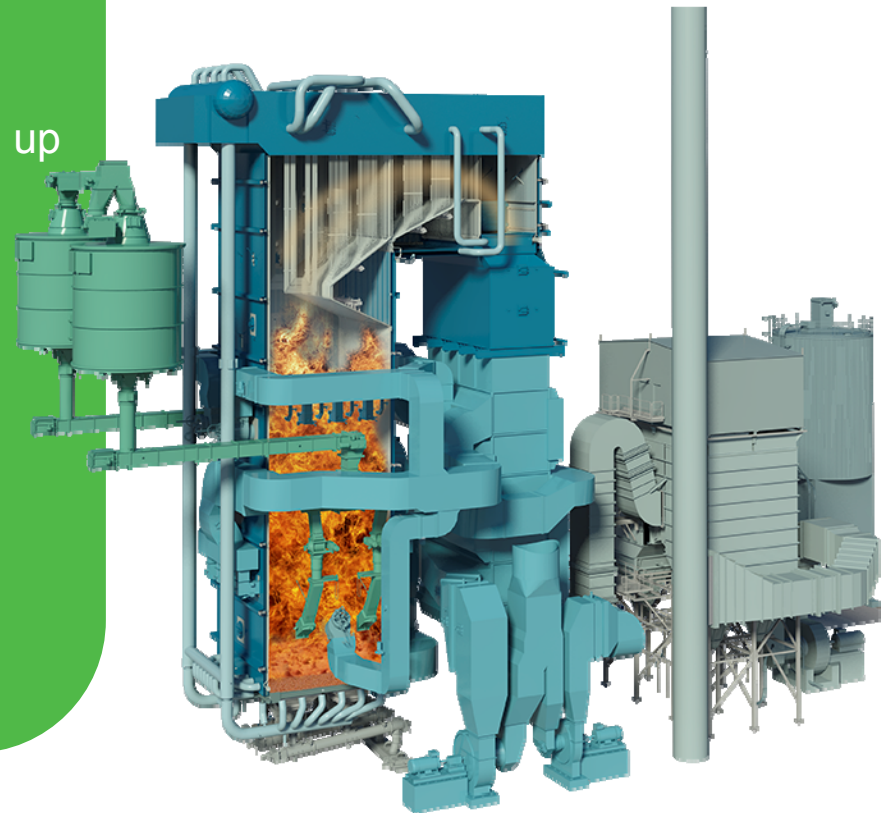
- Possible to use very different kind of fuels in same boiler
- LHV ..514.. MJ/kg
- Combine firing and back up with oil/gas up to 100 % MCR

High performance

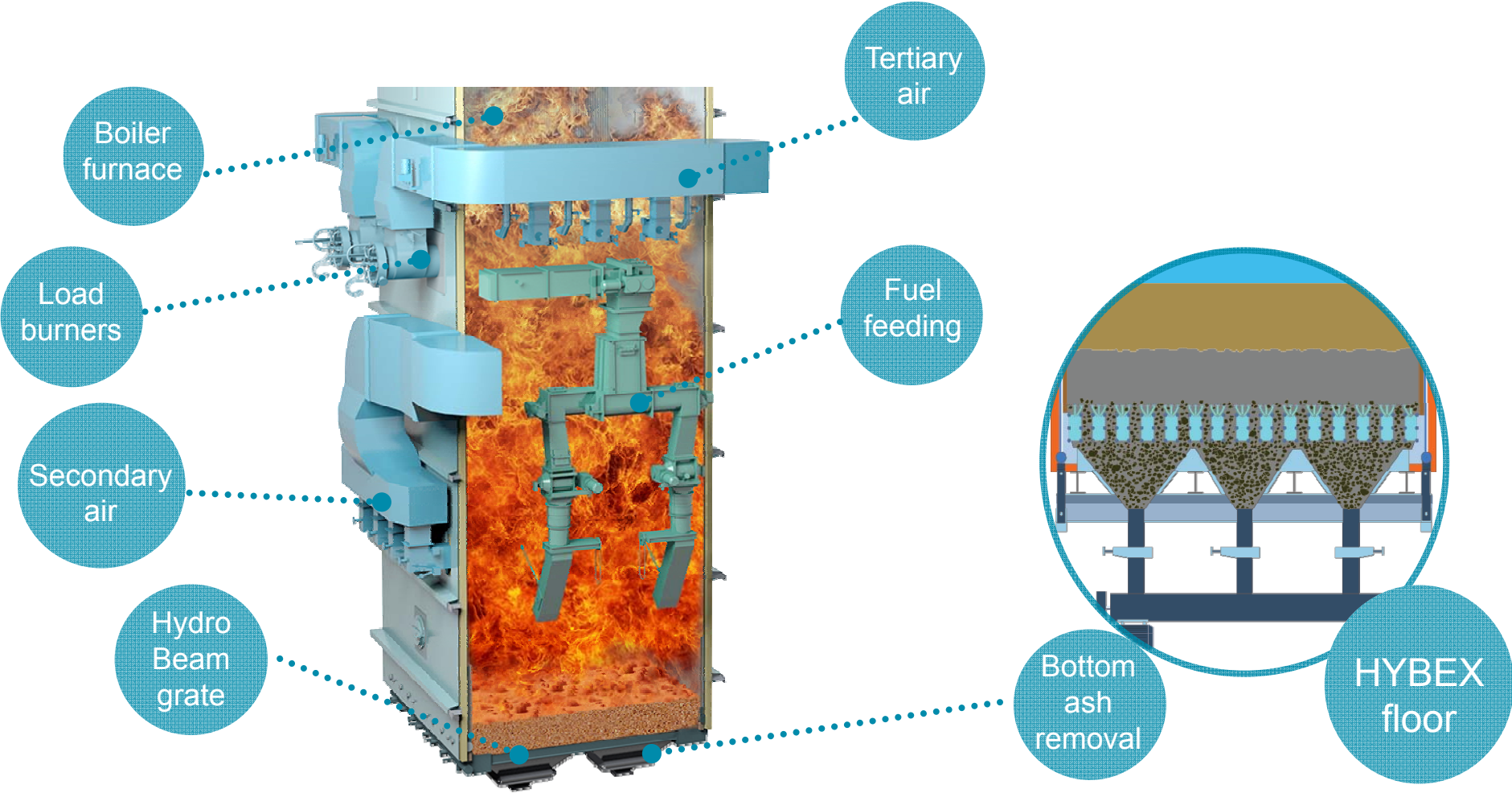
- High combustion efficiency
- Low flue gas emissions
- Excellent reliability

References

- Plant size 10-100 MW_e
- Over 190 references



HYBEX BFB boiler technology



HYBEX boiler plant

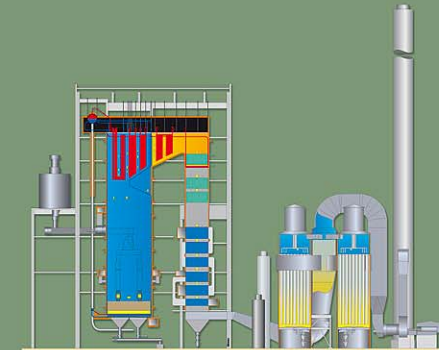
Dalkia Factory, 41 MWe Biomass power plant

HYBEX Bubbling Fluidized Bed (BFB) boiler

Steam 124 MW_{th}, 47 kg/s, 119 bar, 520 °C

Fuels Bark, sawdust, wood chips, sludge, forest residue, recycled wood

Flue gas cleaning with fabric filter



Valmet fuel handling and storage

Fuel receiving station 1 000 m³/h

Storage 15000 m³ A-frame

Fuel to boiler 300 m³/h

Valmet DNA automation system



Gainesville Renewable Energy Center, FL, USA

HYBEX boiler

Steam 292 MWth, 117 kg/s, 112 bar, 540°C

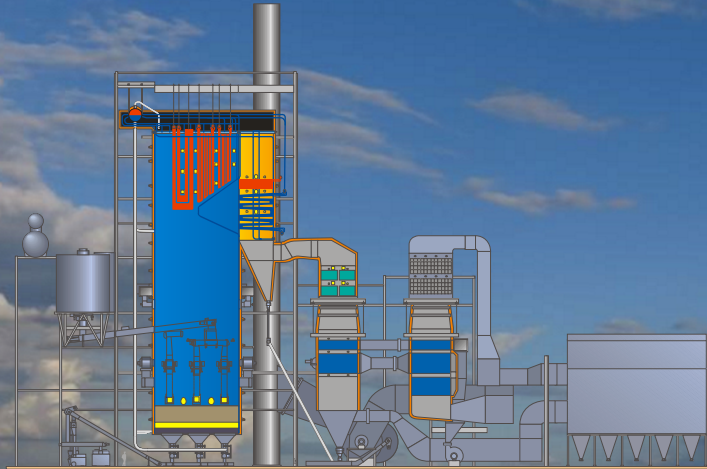
Net electrical output 100 MWe

Biomass fuels

Ultra low emission

- Baghouse filter with additives

- Clean side catalyst



Asnaes ASV6

Contract signed 6/17

Start up 12/19

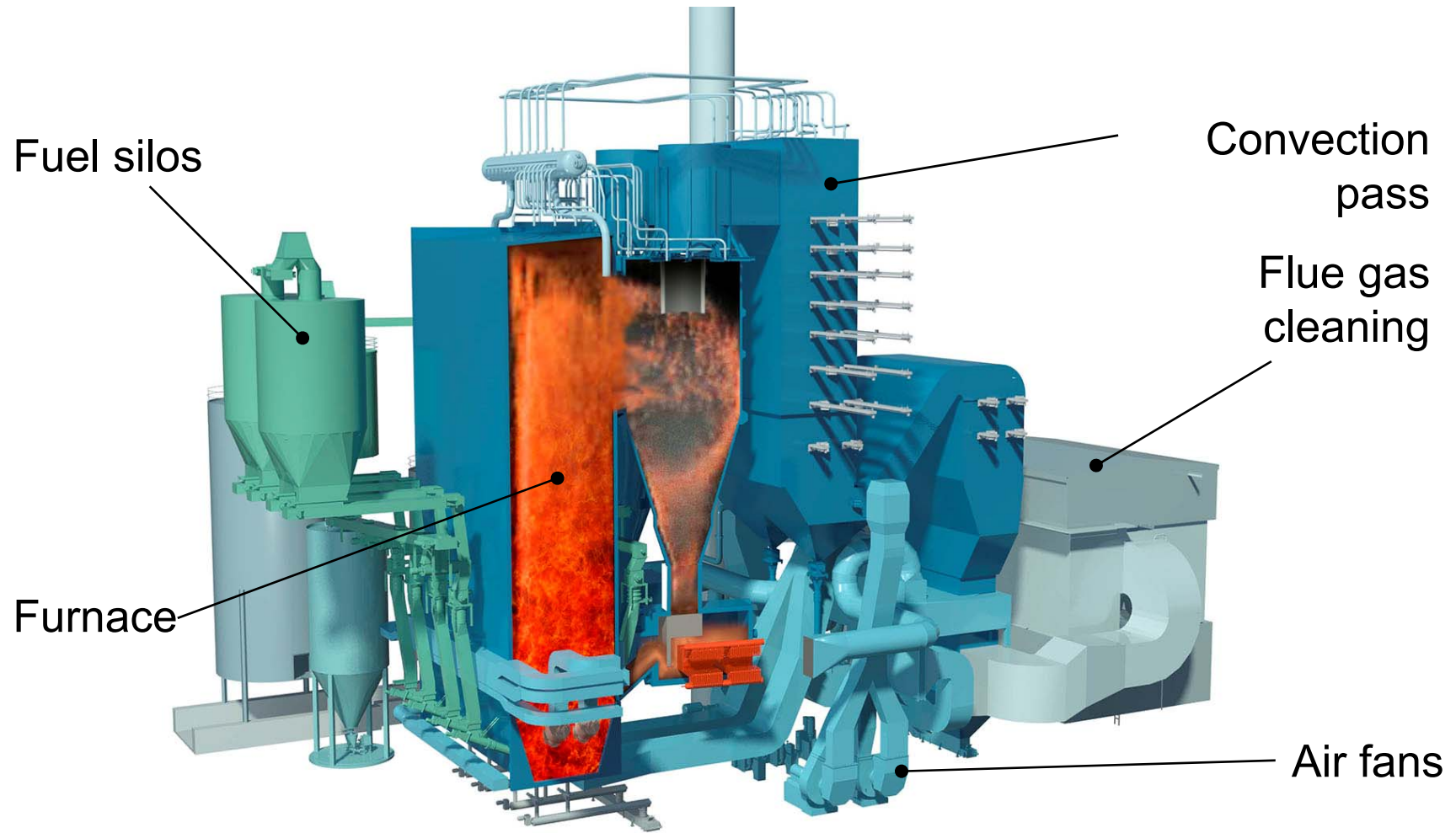
Steam flow 50 kg/s
Steam temperature 540 °C
Steam pressure 100 bar(g)
Full superheating 70-100 % MCR
Boiler operational area 30...100 % MCR
SNCR for NOx reduction
Sulphur feeding for corrosion reduction

Fuel mixture for Asnaes ASV6

- Forestry woodchips:
 - Whole trees without roots
 - Stemwood
 - Logging residues
 - Chemically untreated wood by-products and residues
- Woodchips like fuels
 - Whole trees without roots
 - Stumps/roots
 - Bark (from forestry operations)
 - Segregated wood from gardens, parks, roadside maintenance, vineyards, fruit orchards and driftwood from freshwater
- Straw – future fuel



Valmet CYMIC boiler plant



CYMIC CFB for demanding biomass

Fuel flexibility

- From high heating value and high ash fuels to high moisture fuels
- Coal and biomass cofiring possible

Superior performance

- Low emissions - good sulphur removal
- High reliability

Possibility for loop seal superheater

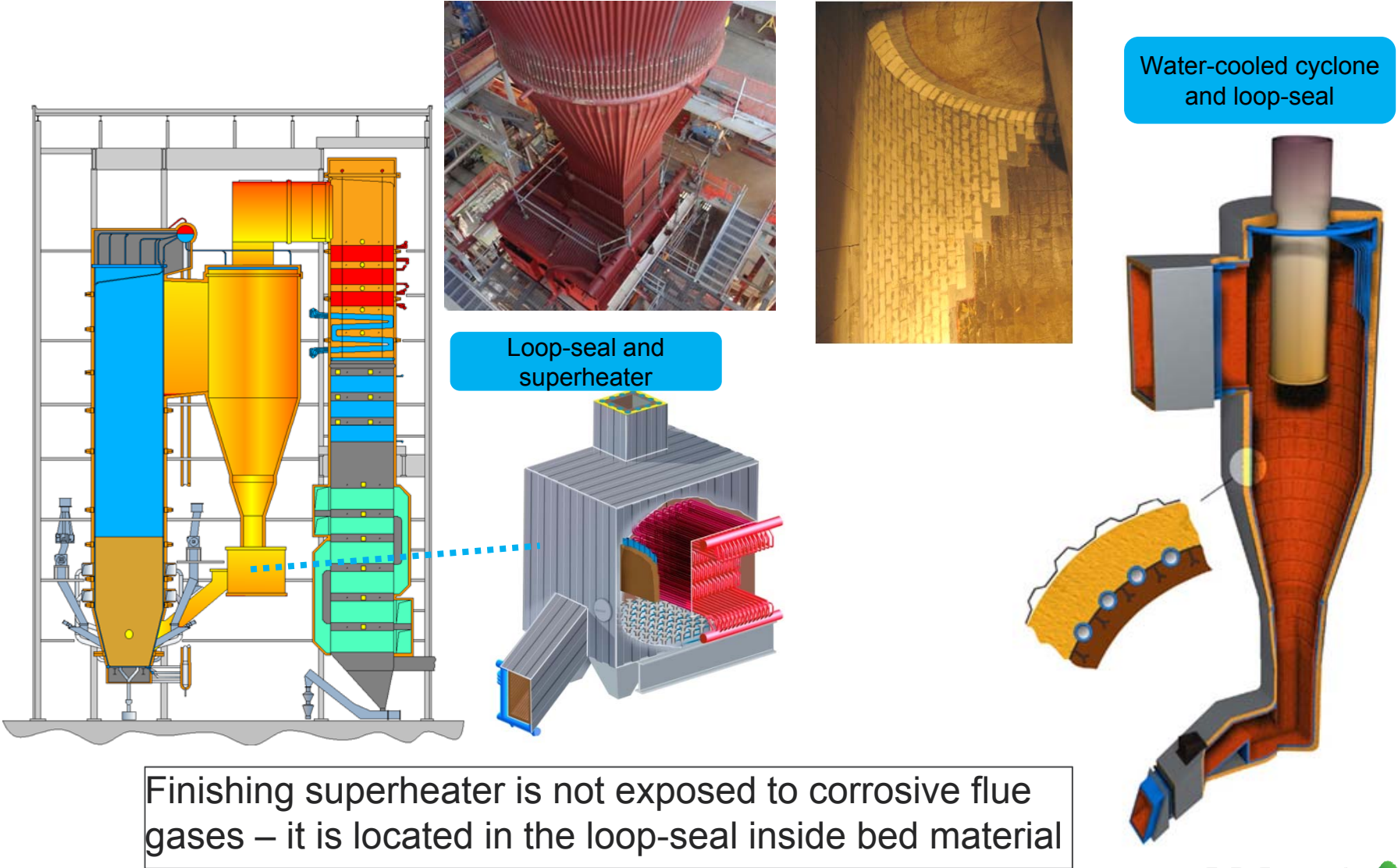
- High steam parameters and high electrical efficiency with demanding fuels

References

- Up to 300 MW_e (1000 MW_{th})
- More than 80 references



CYMIC demanding biomass application



Valmet's CFB boiler technology

Fuel experience (totally >90 references)

COAL BASED FUELS

LOW CALORIFIC FUELS



	Number of units
Bark	3
Peat	16
Sludge	2
Wood waste	17
Wood chips	2
Forest residue	4

- Bituminous coal 40
- Sub-bituminous coal 2
- Brown coal (lignite) 1
- Pet coke 5
- Gob (bituminous coal waste) 5
- Culm (antracite mining waste) 1

OTHER FUELS

- RDF (= Refuse Derived Fuel) 6
- TDF (=Tire Derived Fuel) 8
- OCC (paper recycling) reject 3



Number of units



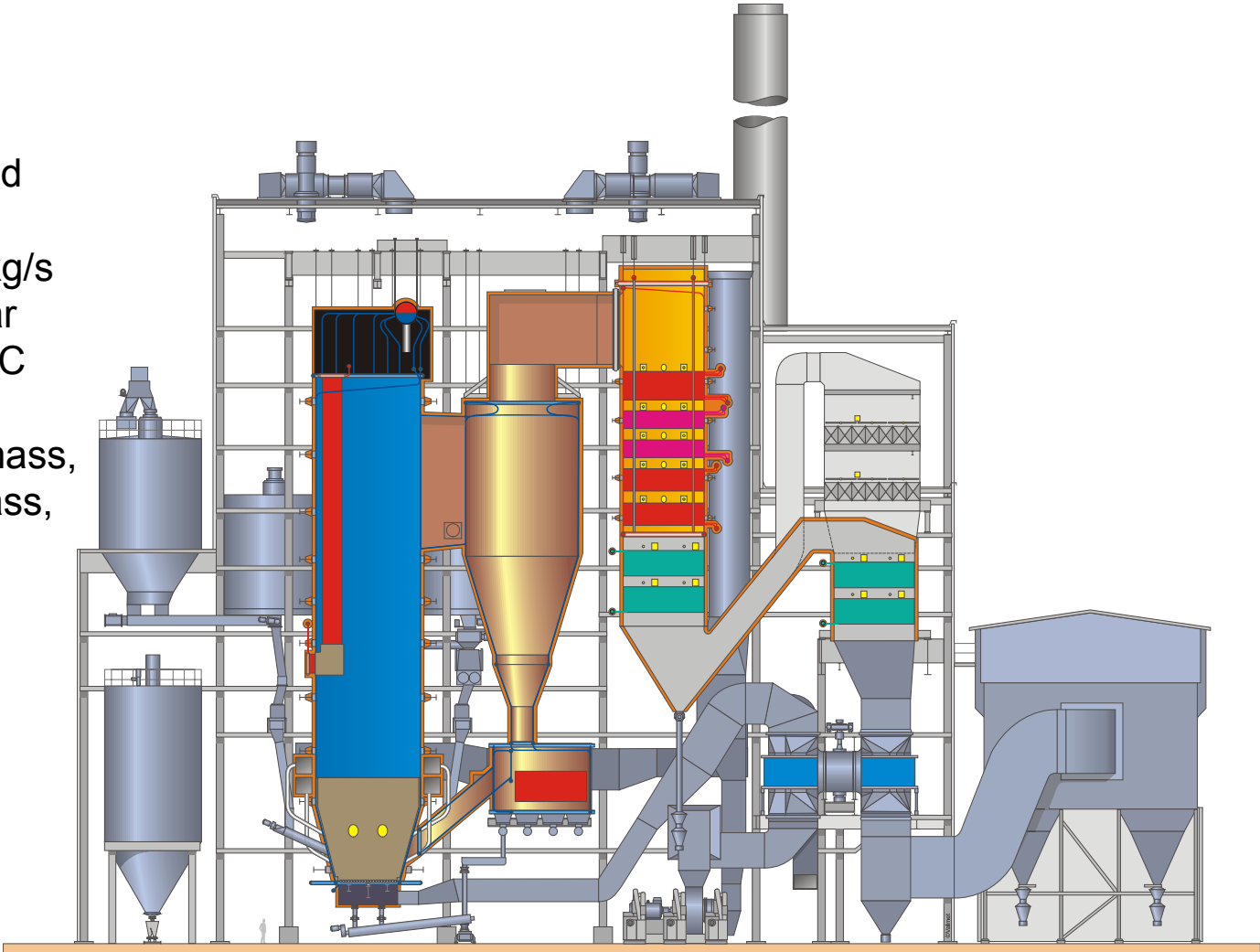
CYMIC reference

TSE, Naantali, Finland

Steam 144 / 130 kg/s
164 / 44 bar
555 / 555 °C
390 MW_{th}

Fuels: Wood biomass,
agro biomass,
peat, coal,
SRF

Start-up 2017

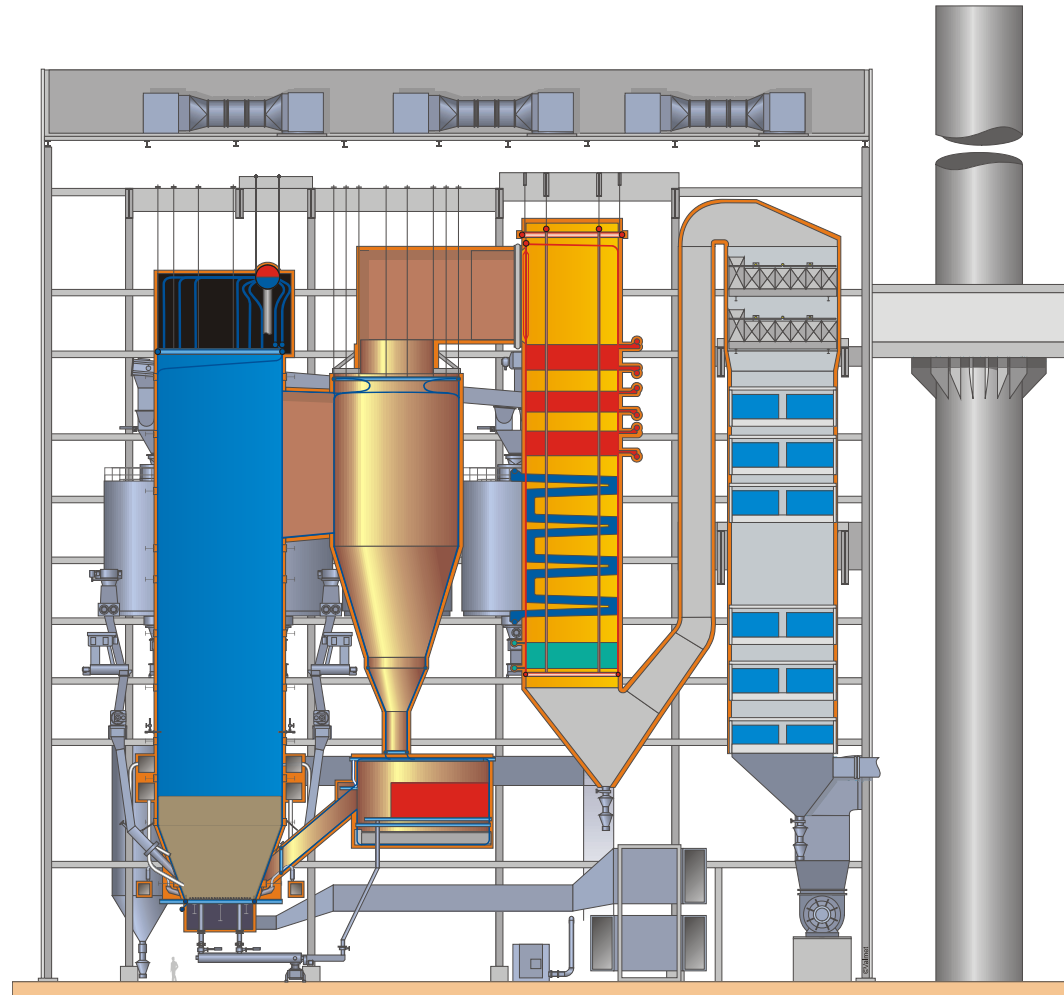


CYMIC boiler

Circulating Fluidized Bed (CFB) technology

HOFOR Energiproduktion A/S
Copenhagen, Denmark

- Steam 184 kg/s
140 bar (g)
560 °C
459 MW_{th}
- Remarks Wood chips
- Start-up 2019

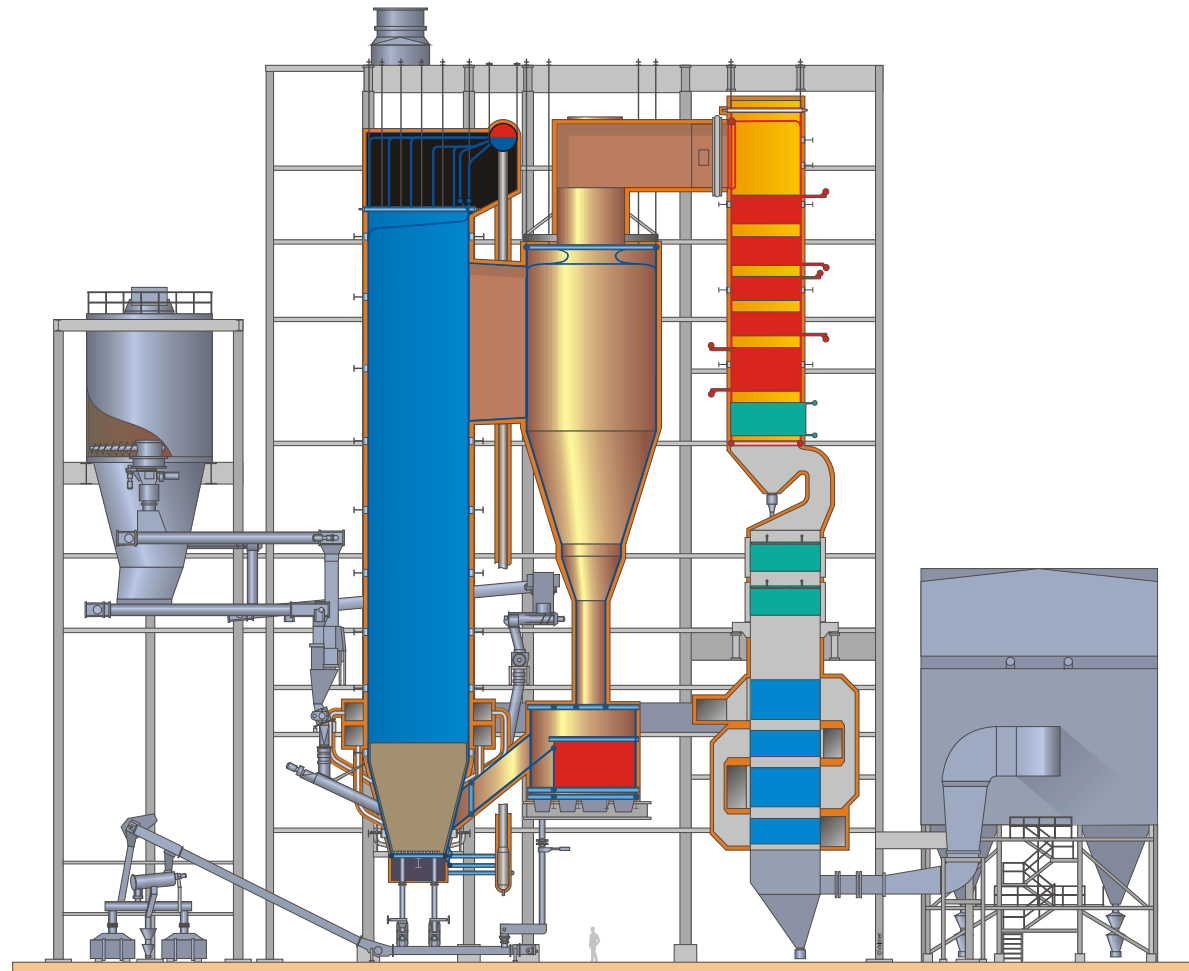


CYMIC boiler

Circulating Fluidized Bed (CFB) technology

JFE Engineering Corporation
Ofunato Power Inc.
Ofunato
Japan

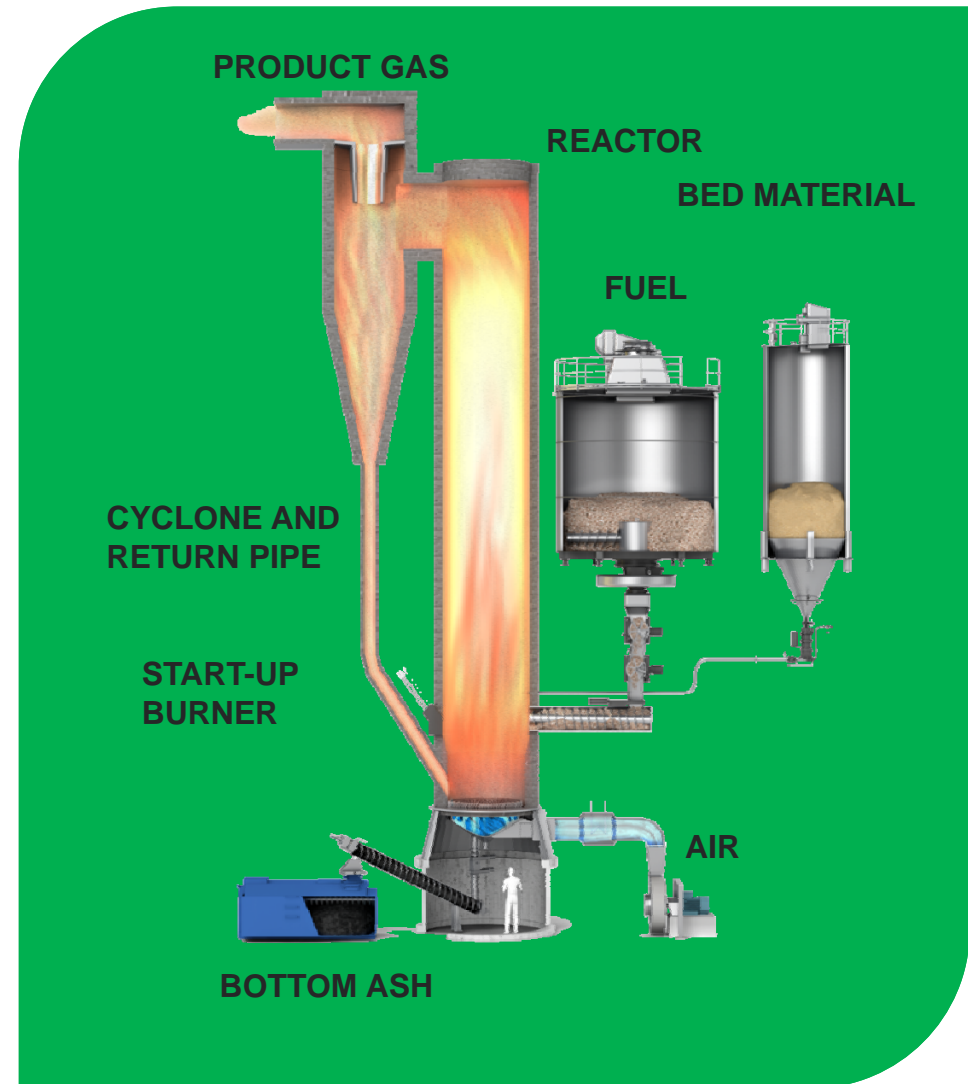
- Steam 65/57 kg/s
142/27 bar
557/540 °C
185 MW_{th}
- Remarks PKS, EFB, coal
- Start-up 2019



Valmet CFB Gasifier

Large scale process equipment to turn biomass, waste and other reactive solid fuels into gas.

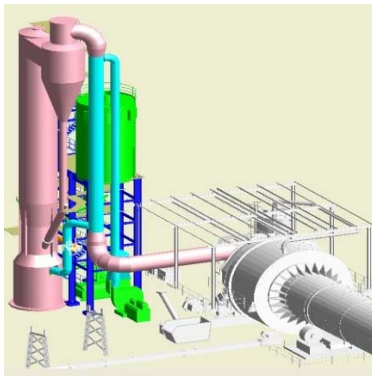
- Rugged steel frame
- Self standing structure
- Prefabricated refractory
- Fuel feed with air lock
- 100 % redundant systems for fuel and ash handling



Valmet CFB Gasifier - application

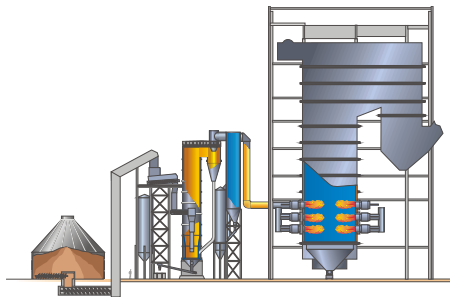
Product gas for industrial kilns

- Woody biomass, bark, peat and waste
- 20 – 110 MW_{fuel} units
- Typically includes a dryer
- Dusty product gas
- References for Limekilns
- Other types of kilns also possible



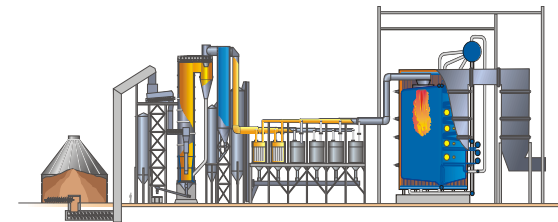
Product gas for power boilers

- Woody biomass, bark, peat and waste
- Superior electrical efficiency
- **Existing boilers**
- 50 – 300 MW_{fuel} units
- If needed, can include a dryer
- Gas cleaning as needed



Product gas from waste for power production

- Waste-derived fuel
- 50 – 150 MW_{fuel}
- High electrical efficiency
- Typically a new gas boiler (existing boiler is also an option)



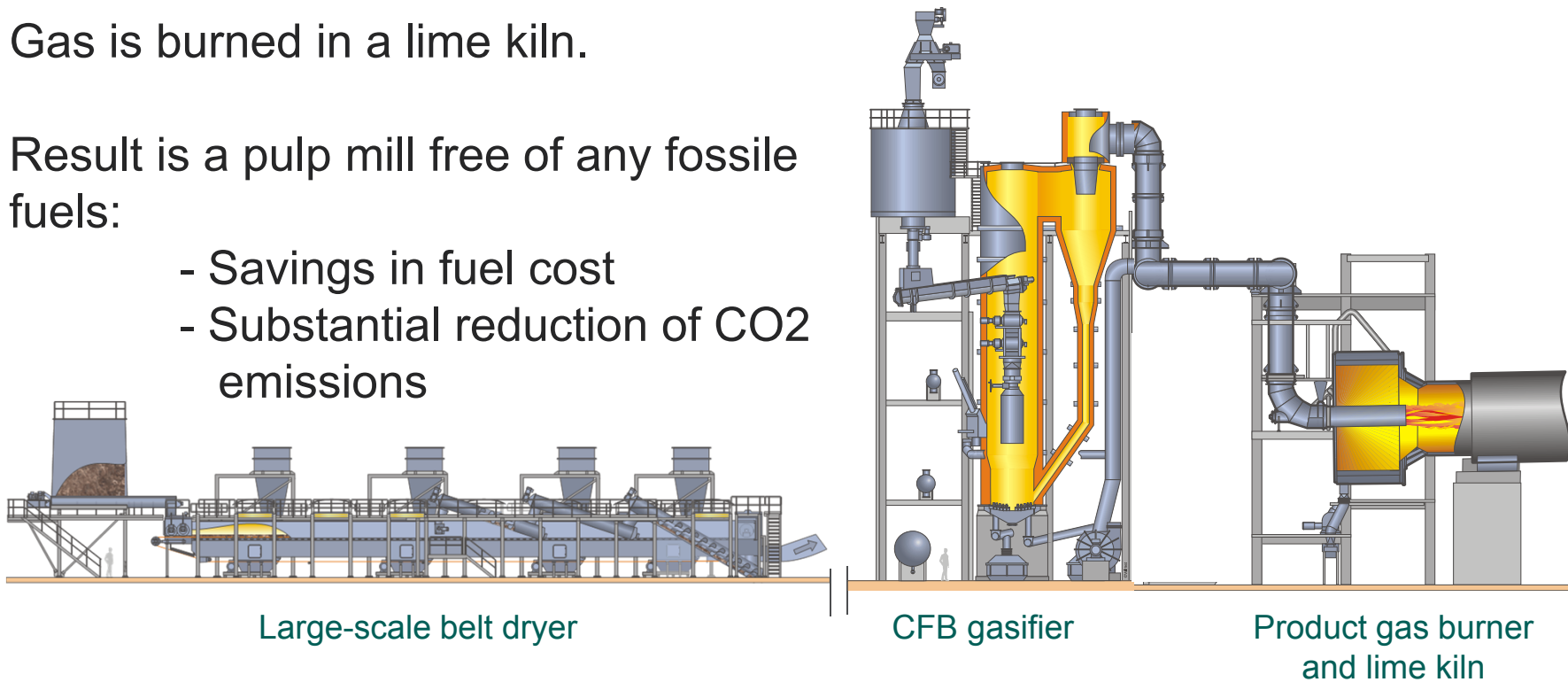
Lime kiln fuel substitution

Dried fuel is converted to bio-gas in the gasifier.

Gas is burned in a lime kiln.

Result is a pulp mill free of any fossile fuels:

- Savings in fuel cost
- Substantial reduction of CO₂ emissions



Lime Kiln Gasifiers



Chenming Huanggang, China, 2018
(Under construction)

Application: Lime kiln
Gasifier 50 MW
Dryer evaporation 12 ton/h



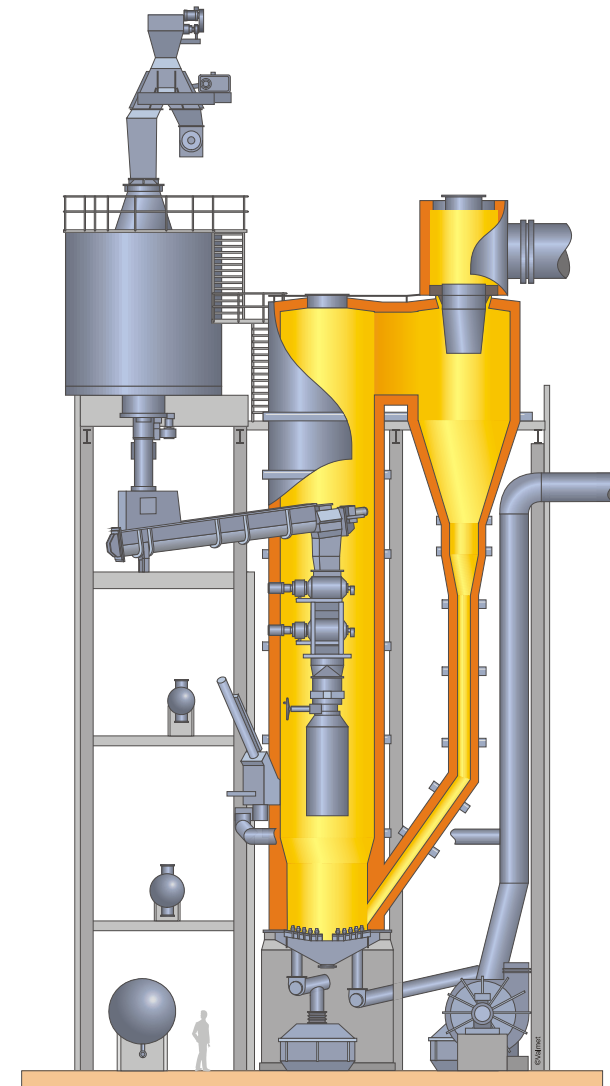
Metsä Fibre Äänekoski, Finland, 2017
(Under commissioning)

Application: Lime kiln
Gasifier 87 MW
Dryer evaporation 23 ton/h



APP OKI, Indonesia, 2017
(Under commissioning)

Application: Limekiln
Gasifier 2 x 110MW
Dryer evaporation 2 x 19 ton/h



OKI 2 * 110 MW CFB Gasifiers for Lime Kilns

Lime kiln

- 2* 1250 tpd lime kiln
- 5.5x140m
- 2 * 110 MW burner (oil & biogas)

CFB Gasification Plant

- Gas power: 2 * 110MW
- 15.4 tph dry fuel
Birch, Pine and Spruce bark as fuel
- Dryer: 40-65% → 8-12% bark

Initial operation ongoing.

APP OKI under construction in 2016



OKI – The Gas line it is not so small



Äänekoski – Latest Kiln & CFB Gasifier delivery in Finland

Lime kiln

- 1200tpd lime kiln 5.5x140m
- 87 MW burner (oil & biogas)
- Stationary CB cooler
- ESP

CFB Gasification Plant

- Gas power: 87MW ~ 15.4 tpd dry fuel
- Birch, Pine and Spruce bark as fuel
- Dryer: 40-65% → 8-12% bark

Initial operation ongoing.



Metsä Fibre Äänekoski – also the burner is quite massive





Kymijärvi
Waste
Gasification
Plant

Kymijärvi II - Waste Gasification plant

Highest efficiency for Energy-from-Waste, *1 million* tons processed (Sept 2016)

- World's largest waste gasification power plant in operation
- Processes 250 ktpa of waste fuels (RDF & contaminated wood) to produce:
 - 50 MW of electricity
 - 90 MW of district heat
 - CHP efficiency of 87,5 %
 - Total investment ~ 160 M €
- 30,000+ operating hours since commissioning
- Over 1 million ton of processed waste (August 2016)

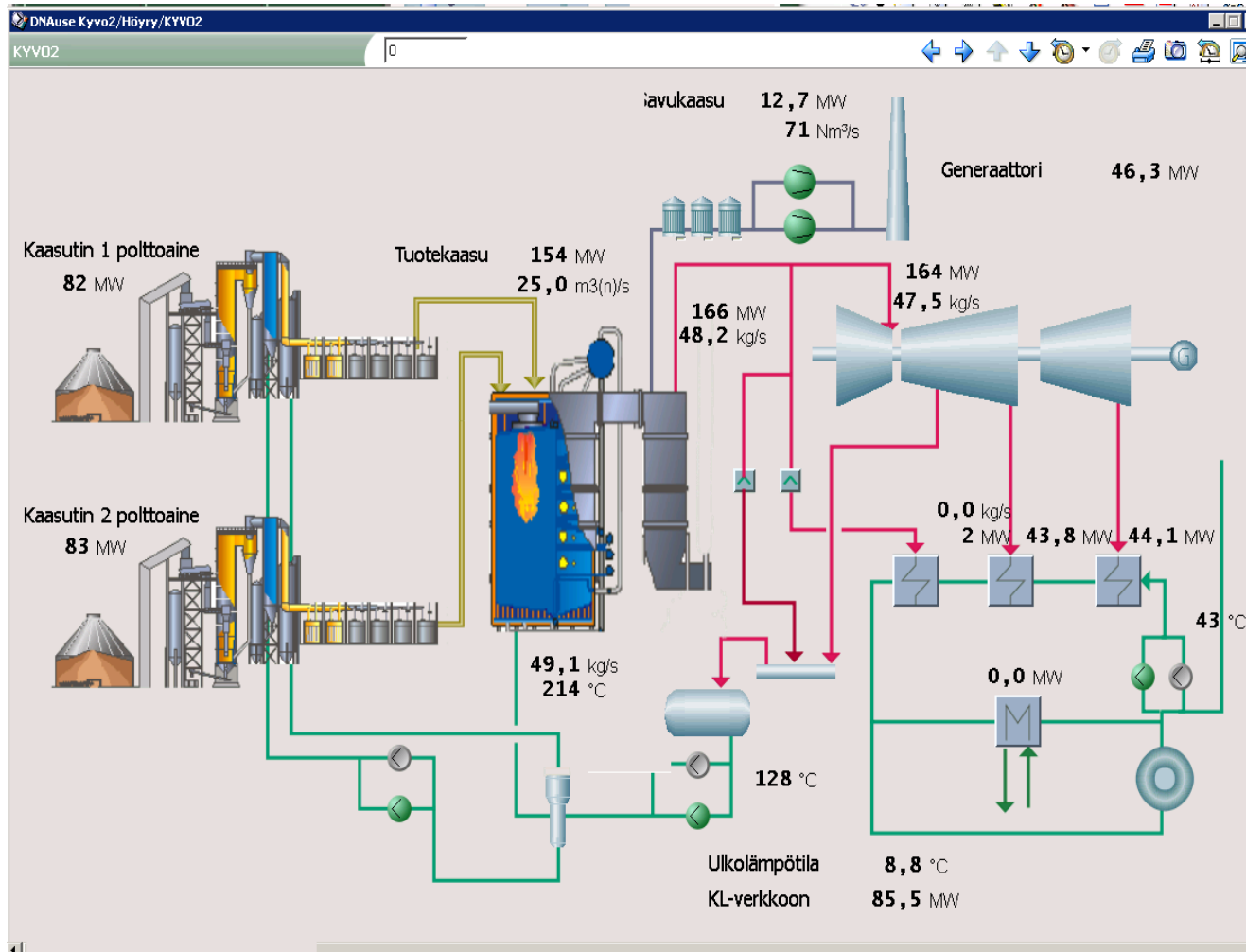
Lahti Energia, Lahti, Finland
Start-up 2012

Climate Act
Award
2012



Valmet Waste Gasification

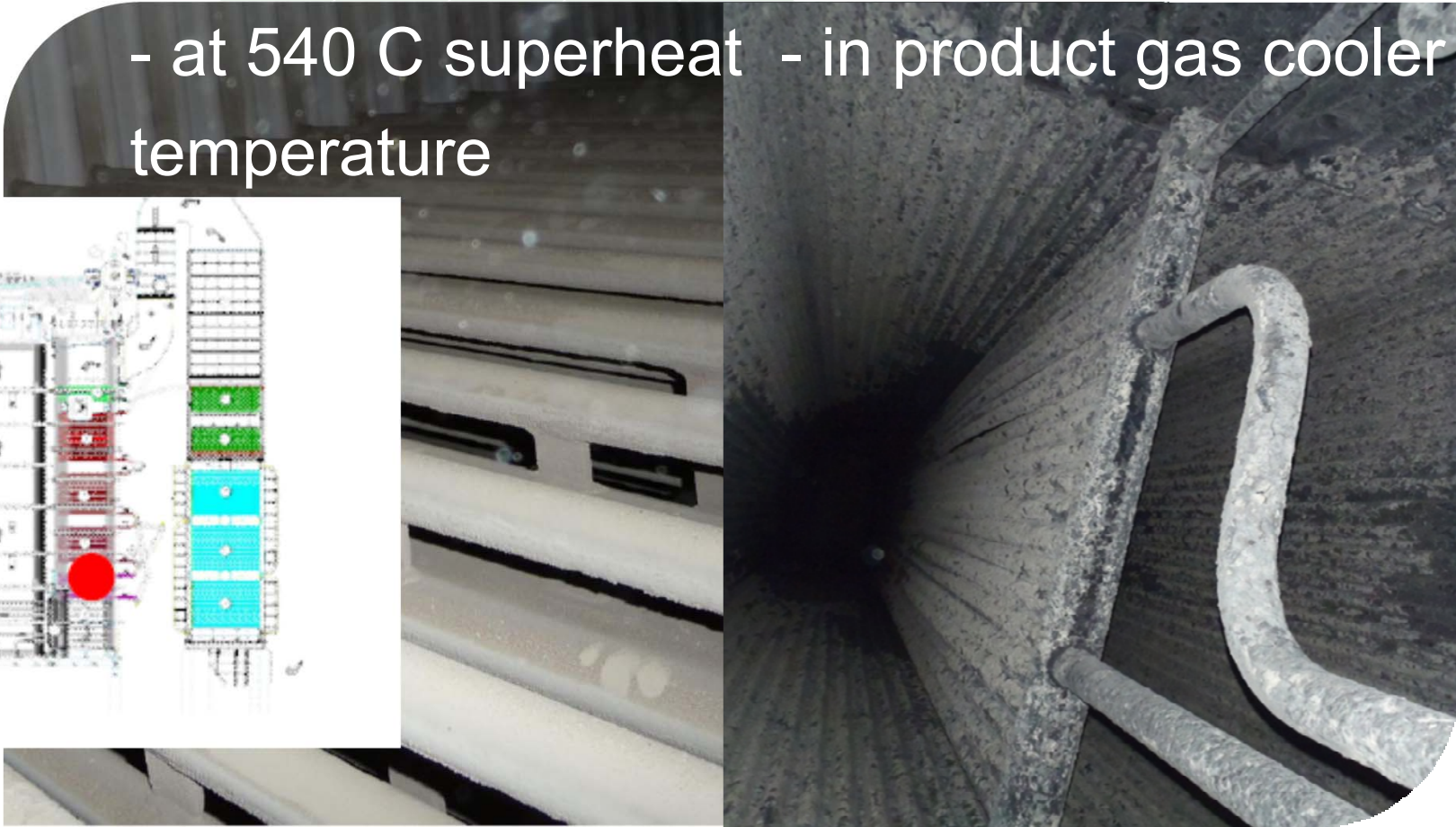
Commercially operating plant



Valmet Waste Gasification

No Corrosion after 30 000 hours

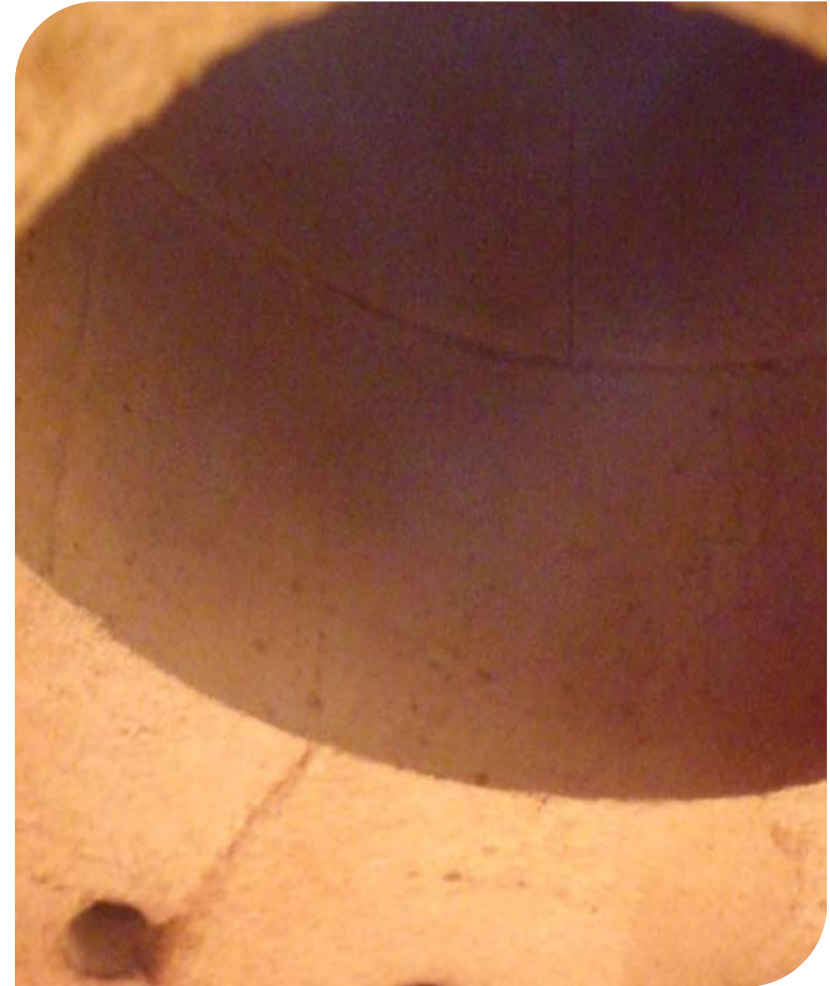
- at 540 C superheat - in product gas cooler temperature



Valmet waste gasification

Experiences

- Stable and easy to control
- Capacity achieved with a clear margin
- Tolerates fuel variation with a margin
- Compliance with WID (also with 2 s 850 °C)
 - No need for support fuel
- No corrosion detected (30 000 hrs)
- Availability challenges during the first year
 - Hot gas filtration was the major challenge
 - Operational routines required learning
 - Availability now improved up to the target level

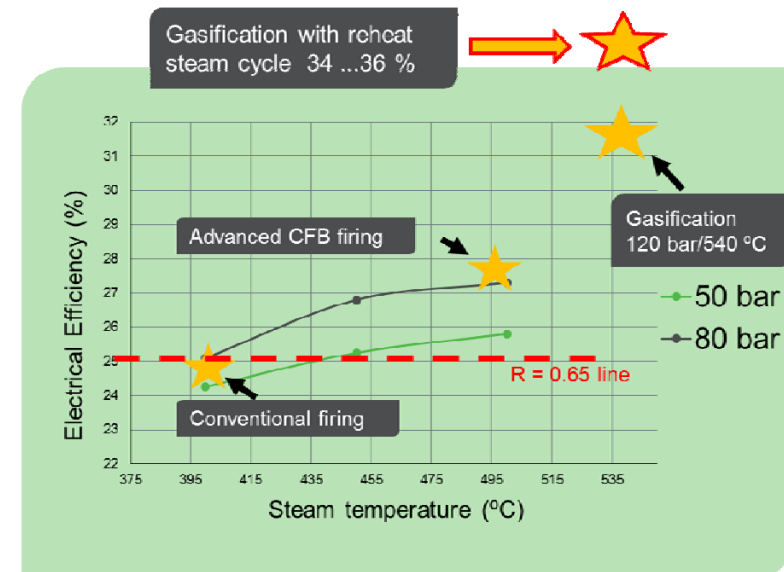


Valmet waste gasification

Next steps

1. Corrosion is not limiting the steam cycle selection:
 - Reheat cycle is possible
 - New boiler concept under evaluation
 - Some 40 - 50 % electricity yield (25 % =>36 %) compared to convectional solution can be reached !
2. Improved reliability with double hot gas filter concept.

	Gross electrical efficiency (%)	Net electrical efficiency (%)
CHP plant (0,2 bar back pressure)	29 – 32	27 -30
No reheat steam cycle (540 C / 120 bar)	32 -34	30 -32
Reheat steam cycle (540 C/140 bar/540 C/ 30 bar)	36 -38	34 -36





Fossil Fuel
Replacement -
Vaskiluodon
Voima

Vaskiluodon Voima - Valmet gasification plant

View of the plant before the fuel conversion

The Vaskiluoto 2 -unit

- 560 MW_f coal fired boiler
- Pulverized fuel firing
- Benson design
- 185 bar/540 °C +
43 bar/ 570 °C

Output capacity

- 230 MW_e
- 175 MW CHP heat

Commissioning of the unit

- Boiler 1983
- Turbine plant 1998

Production

- Electric power 0.9 – 1.7 TW_h/a
- District heating to municipal
net 450 GW_h/a



Vaskiluodon Voima

Fluidized bed gasification was selected

Low investment

- Only minor modifications were needed for the boiler
- Investment budget 40 M€ for 140 MW fuel replacement capacity

Low operational cost

- Local forest biomass could be utilized
- Peat as back up fuel
- Low parasitic power consumption
- High-efficiency bio => electricity

Safe solution

- Fall back option secured
 - **Possible to keep the original coal firing capacity on-line**

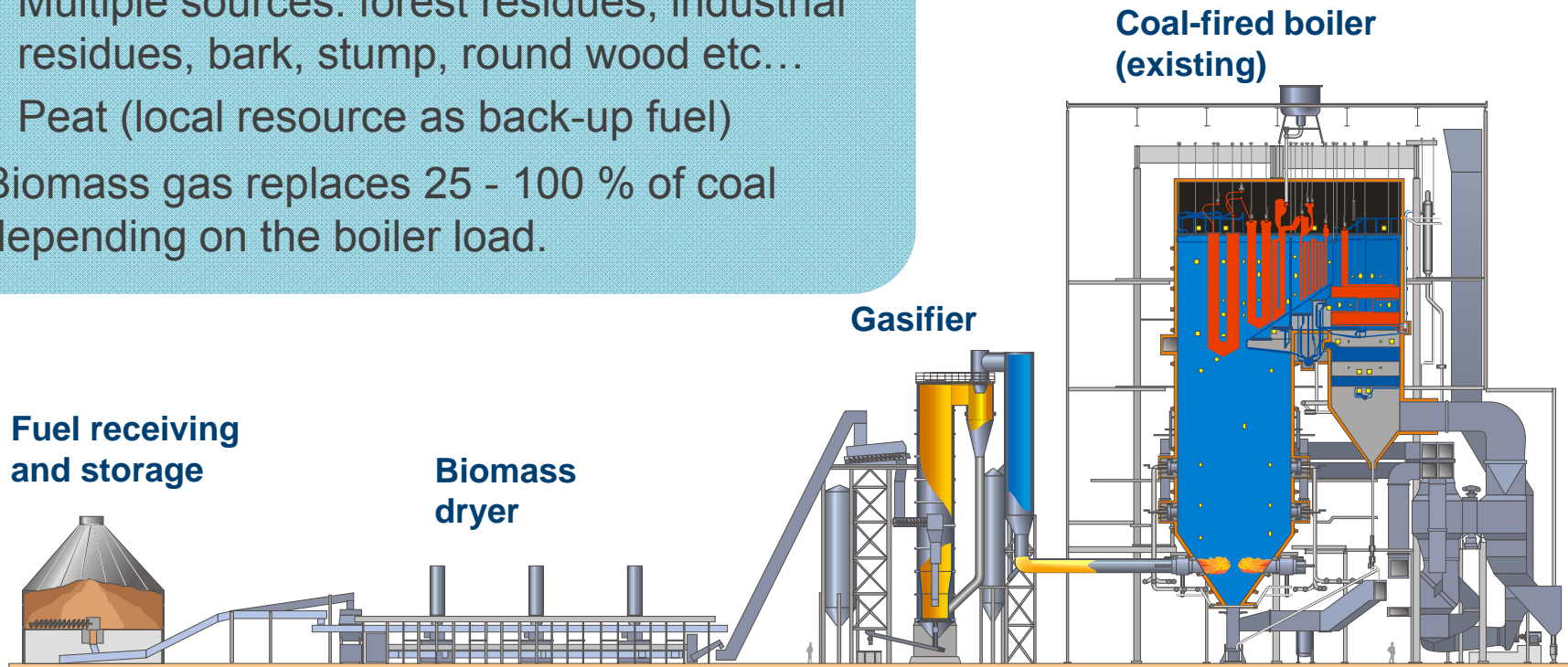


Vaskiluodon Voima - Valmet gasification plant

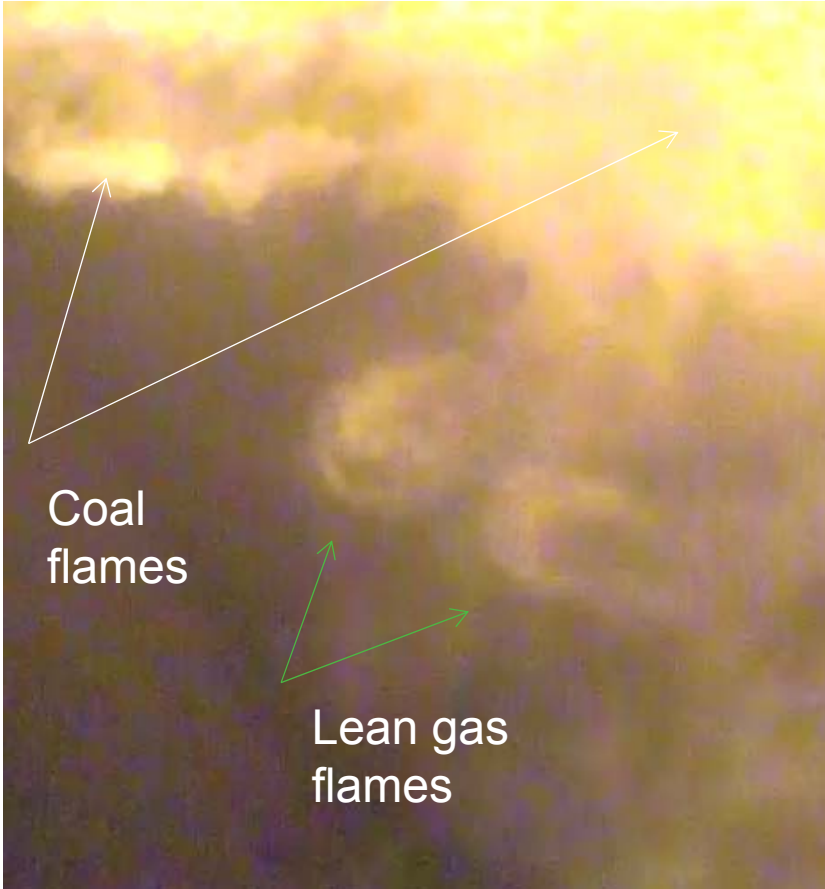
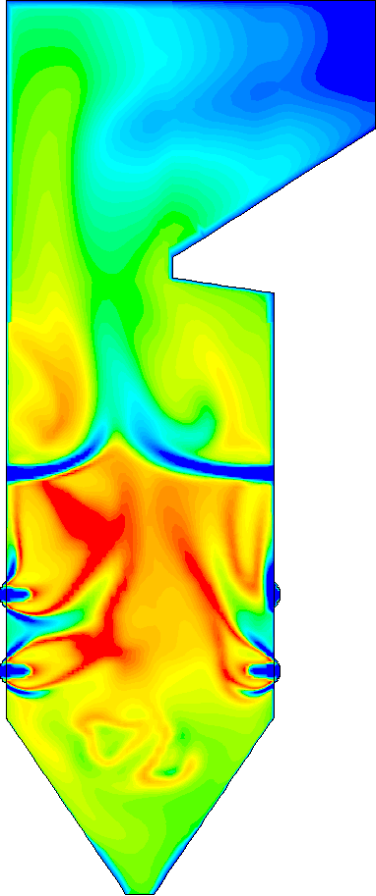
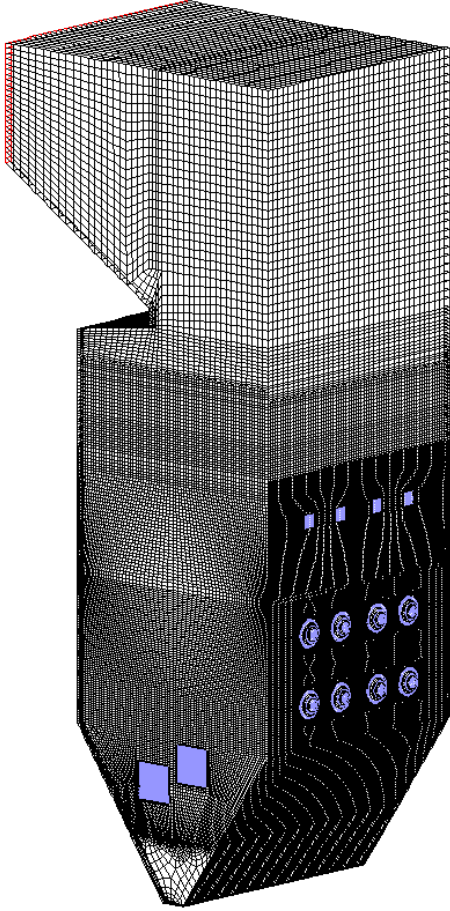
Biomass feed 140 MW

- Chipped or crushed wood biomass
- Multiple sources: forest residues, industrial residues, bark, stump, round wood etc...
- Peat (local resource as back-up fuel)

Biomass gas replaces 25 - 100 % of coal depending on the boiler load.



Co-firing coal and lean gas



Operational experience during the first 3 years

Summary

- The plant has met all design criteria
 - Availability first year 97% => the following year 99% and 98 %
 - Today 20,000 h of operation
 - Design capacity met (exceeded)
 - CO, SO₂ and NO_x emissions reduced
- Plant responds promptly and consistently and is easy to operate
- No lining failures of corrosion/erosion in gasifier. Erosion in fuel yard equipment.
- The fuel drying process operates well
- The gasifier helps to reduce 230,000 tn/a of CO₂ emissions
- Main boiler operated with gasifier only



Summary

The Vaasa biomass gasifier

“We are very pleased with the final results of this project and would like to thank all our suppliers for the fine co-operation!”

Matti Tiilikka – Vaskiluodon Voima

- A major, cost effective power plant fuel conversion from coal to wood biomass
- Short implementation time
- Existing, pulverized fuel fired boiler was utilized with minimal changes
- Thermal integration utilizes low temperature heat from the power plant for fuel drying
- Up to 40% fuel to power efficiency for wood biomass in a condensing mode

New Challenges – New Options




European
Commission

Circular Economy & Waste to Energy

Jorge DIAZ DEL CASTILLO
European Commission
DG Environment



The 2016 Communication on WtE

1 aim, 5 strands

- **Aim:** "Extract more energy from less waste"
- **Strands:**
 - Seeking synergies with EU Strategies and Policies
 - Optimisation of the energy efficiency in processes
 - Tapping on waste-derived fuels
 - Harnessing existing capacities in the EU
 - Waste Hierarchy – clarification of role of WtE and justification for departure from the hierarchy

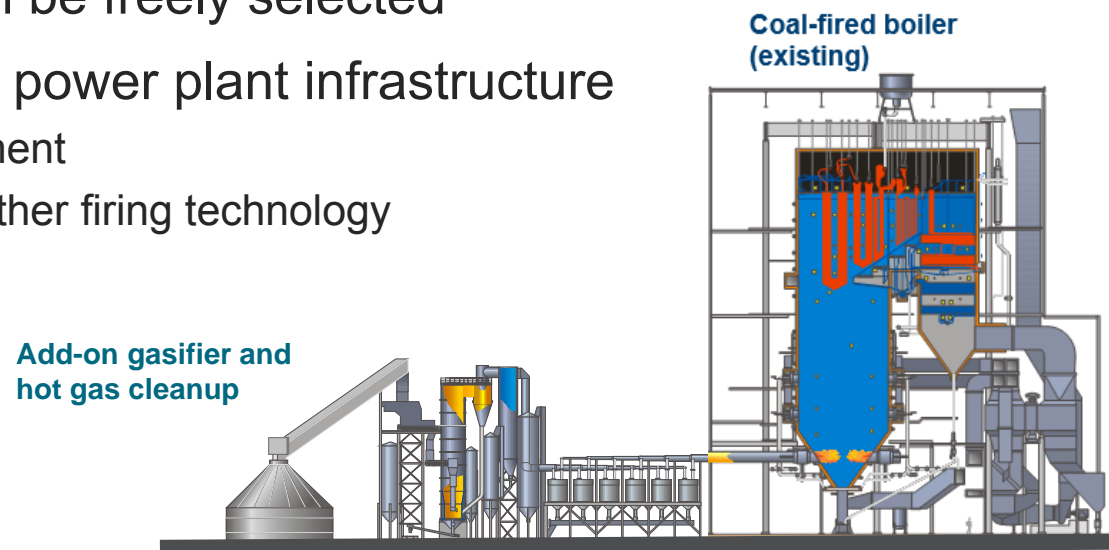
Valmet CFB Gasifier

- A New Concept for Co-firing RDF / SRF

Combines positive experiences from Lahti and Vaskiluoto =>

Co-firing of cleaned gas from waste gasification in an existing boiler

- Minimum impact on boiler operation, corrosion, ash quality and emissions
- Highest electrical efficiency from waste to electricity (up to 40 % +)
- Waste firing capacity can be freely selected
- Utilization of the existing power plant infrastructure
 - Minimum additional investment
 - Boiler can be PC, CFB or other firing technology



COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

The role of waste-to energy in the circular economy

“[...]Using the most energy-efficient waste-to-energy techniques

- Where waste-to-energy processes are opted for, there is a need to **ensure that the most efficient techniques are used: this maximises their contribution to the EU’s climate and energy objectives.** The Commission study estimates that if proven techniques and supporting measures are properly implemented, the amount of energy recovered from waste could rise by 29 % to 872 PJ/year, using exactly the same amount of waste as feedstock. This shows the potential for energy efficiency improvements. The **Commission study found that the best proven techniques to increase energy efficiency for the four waste-to-energy processes below were as follows:**



Brussels, 26.1.2017
COM(2017) 34 final

– co-incineration in combustion plants: gasification of solid recovered fuel (SRF) and co-incineration of the resulting syngas in the combustion plant to replace fossil fuels in the production of electricity and heat;

[...]”



Thank you

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