

Business from technology

Waste to Energy – Gasification of SRF

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Terminology (1)

- **waste and waste derived fuels**
 - municipal solid waste (MSW)
 - mixed waste
 - household waste
 - RDF/SRF
 - source separated waste
 - biowaste
 - specific fractions: metal waste, glass, paper/board, etc
 - **SRF (Solid Recovered Fuel)**
 - commercial and industrial waste (CIW)
 - **SRF**
 - specific waste fractions: electronic scrap, auto shredder residue (ASR), plastic waste, sewage sludge, etc.

Terminology (2)

- **incineration**

- primary target: reduction of volume of waste instead of landfilling
- product: primarily heat (district heat, process heat)
- limited power production

- **co-firing of waste derived fuels**

- primary target: utilise energy content of waste
- by-processing of waste derived fuels/SRF
- waste derived fuels as secondary fuel
- conventional boiler technology
- special requirements for flue gas cleaning (set by WID Waste Incineration Directive)

Terminology (3)

- **Waste to Energy technologies (WtE)**
 - specially designed for utilisation of waste/waste derived fuels only
 - primary targets: efficient utilisation of energy content of waste and reduction of waste volume
 - high efficiency
 - for power and heat
 - can be based on
 - conventional grate firing
 - fluidised bed combustion
 - gasification
 - other technologies

Driving forces for development of high efficiency WtE technology

- **serious need to improve overall energy production efficiency of waste incinerators**

- **driving forces/regulations**
 - common policy directs to more efficient use of all kind of waste
 - climate change/CO₂ reduction

 - significant needs to reduce landfilling (especially in Europe)
 - sustainability
 - targets to recycle, reuse and utilise waste
 - price of energy
 - etc.

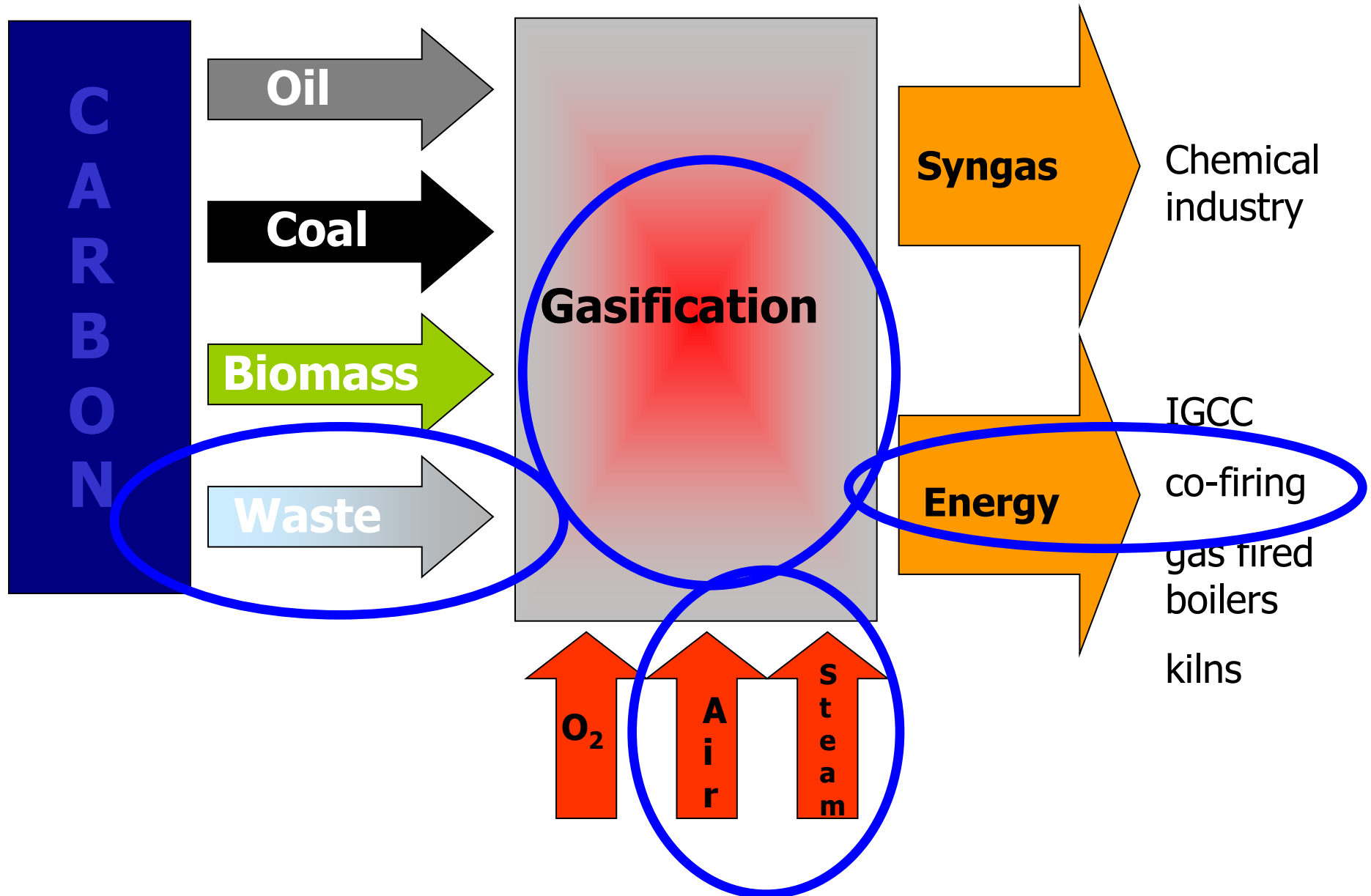
Direct co-firing of waste derived fuels

- **share of co-fired waste restricted by corrosion and deposits**
 - aluminium content
 - chlorine content
 - alkali metal content
 - etc.
- **regulations related to flue gas cleaning**
 - Waste Incineration Directive (WID)/national law is applied
- **primary driving force: savings in fuel cost**

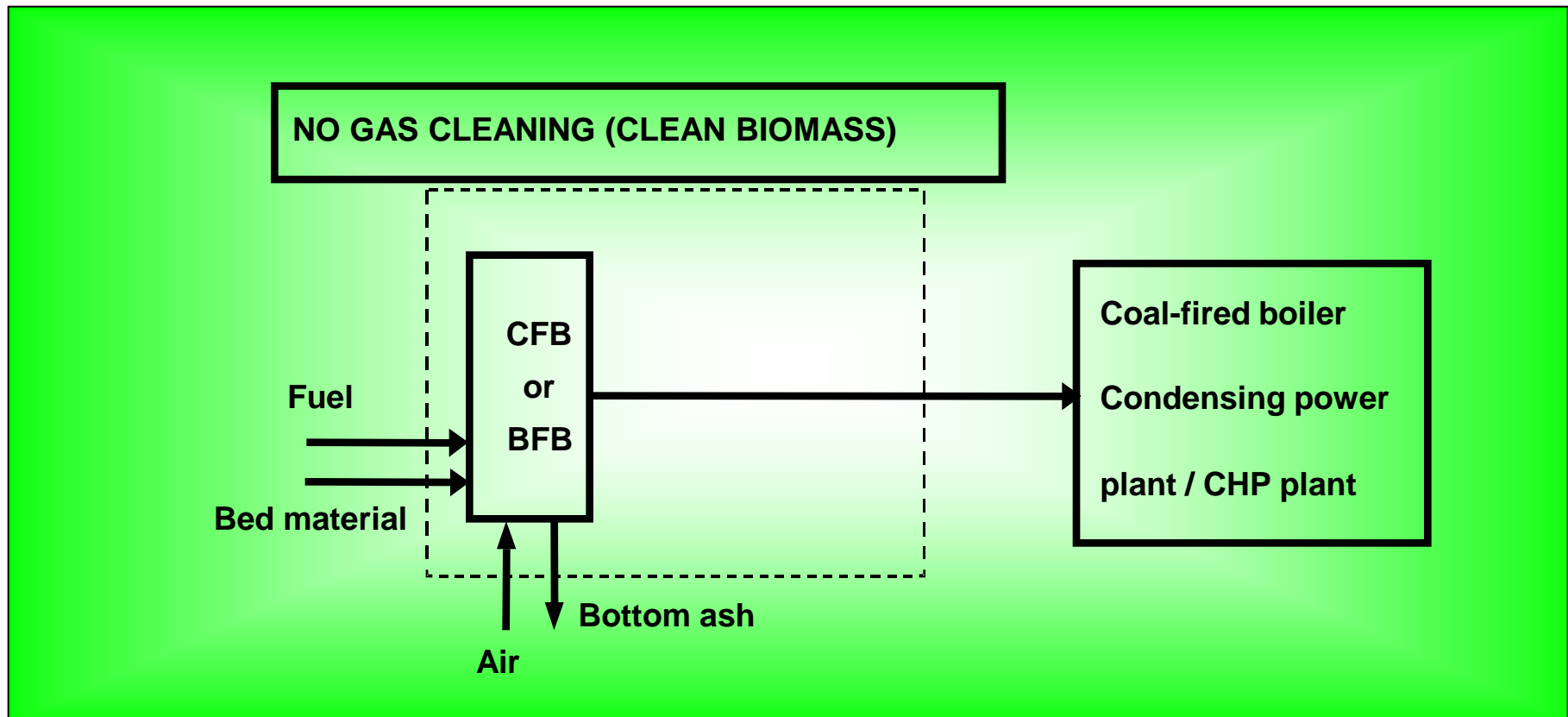
Indirect co-firing of waste derived fuels based on gasification

- waste derived fuels gasified in a separate (fluidised bed) gasifier
- product gas co-fired with coal (or other fuels) in a large scale boiler
- co-firing in a large scale boiler enables benefits of large scale steam cycle, i.e. high power production efficiency

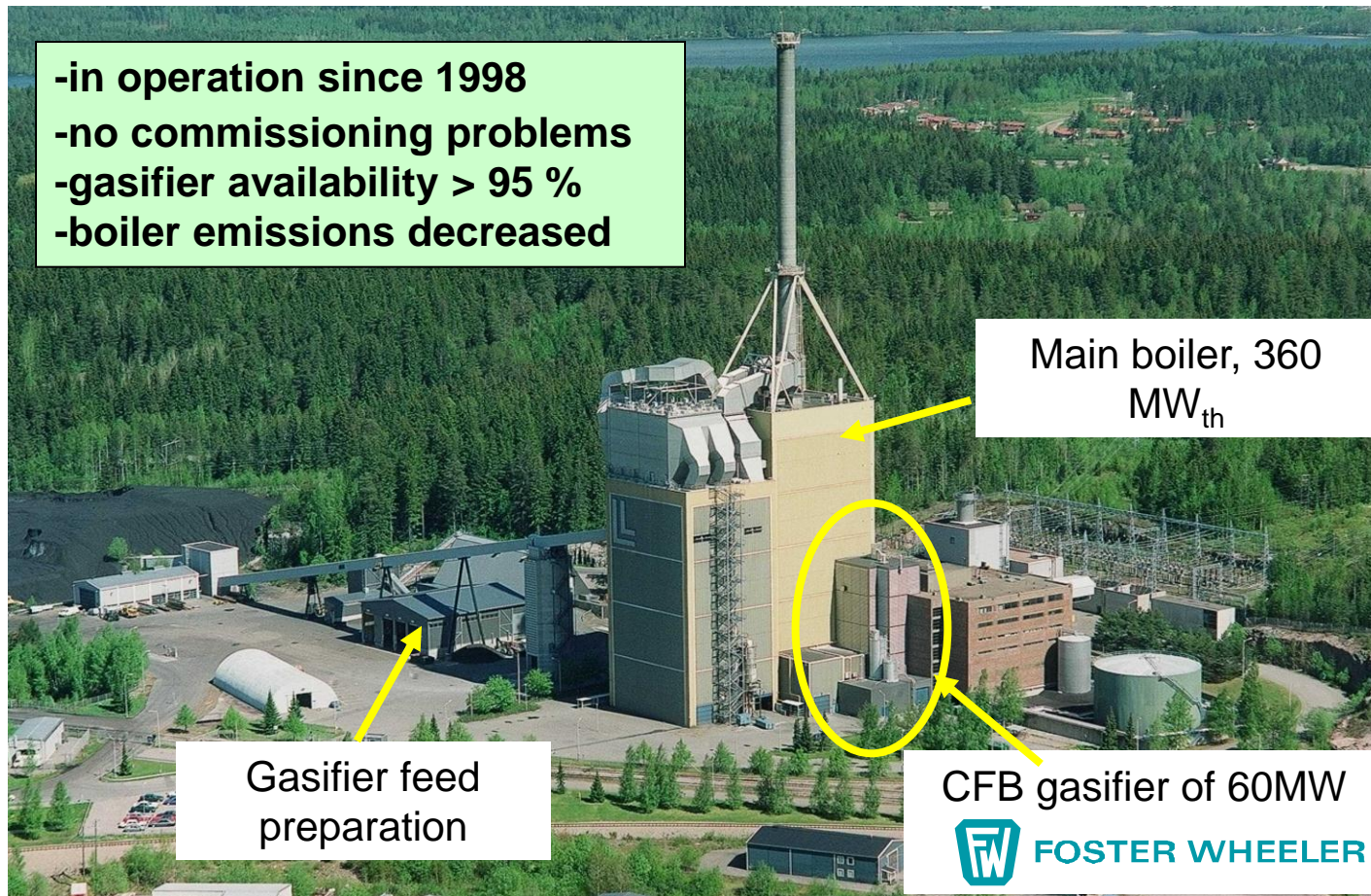
REMARK! Focus of this presentation on gasification technologies with some gas cleaning or with possibility for gas cleaning. Technologies based on two-stage combustion are excluded (Thermoselect, Ebara, Energos, Kobelco, etc.)



Clean biomass (or in some cases clean waste)

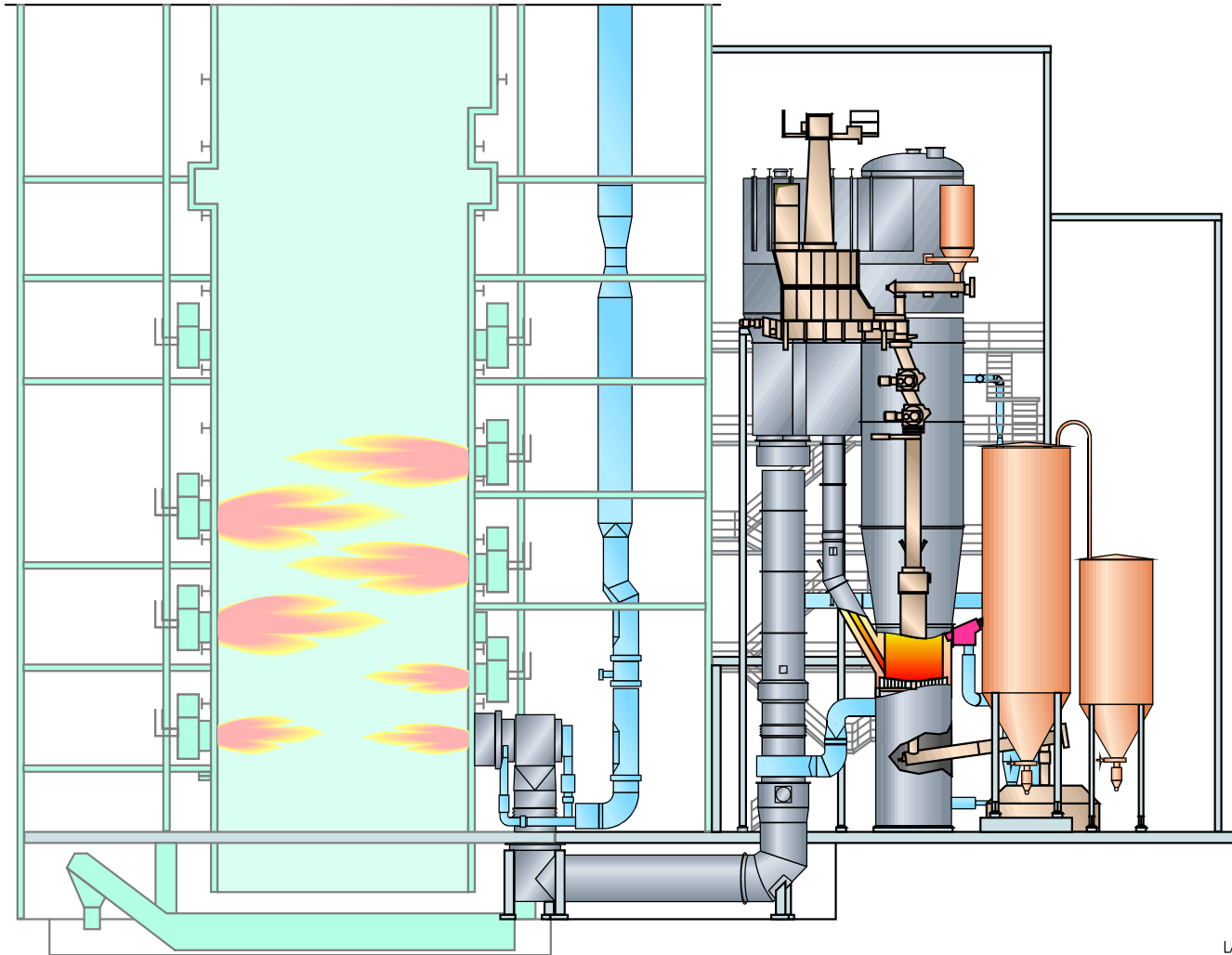


Proven reference: Lahti (Kymijärvi power plant), Finland







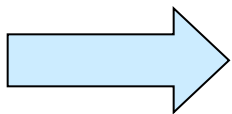
**CFB BIOMASS GASIFIER**
40 - 70 MW_{th}

LAHDEN LÄMPÖVOIMA
KYMIJÄRVI POWER PLANT
KYMIJÄRVI, FINLAND

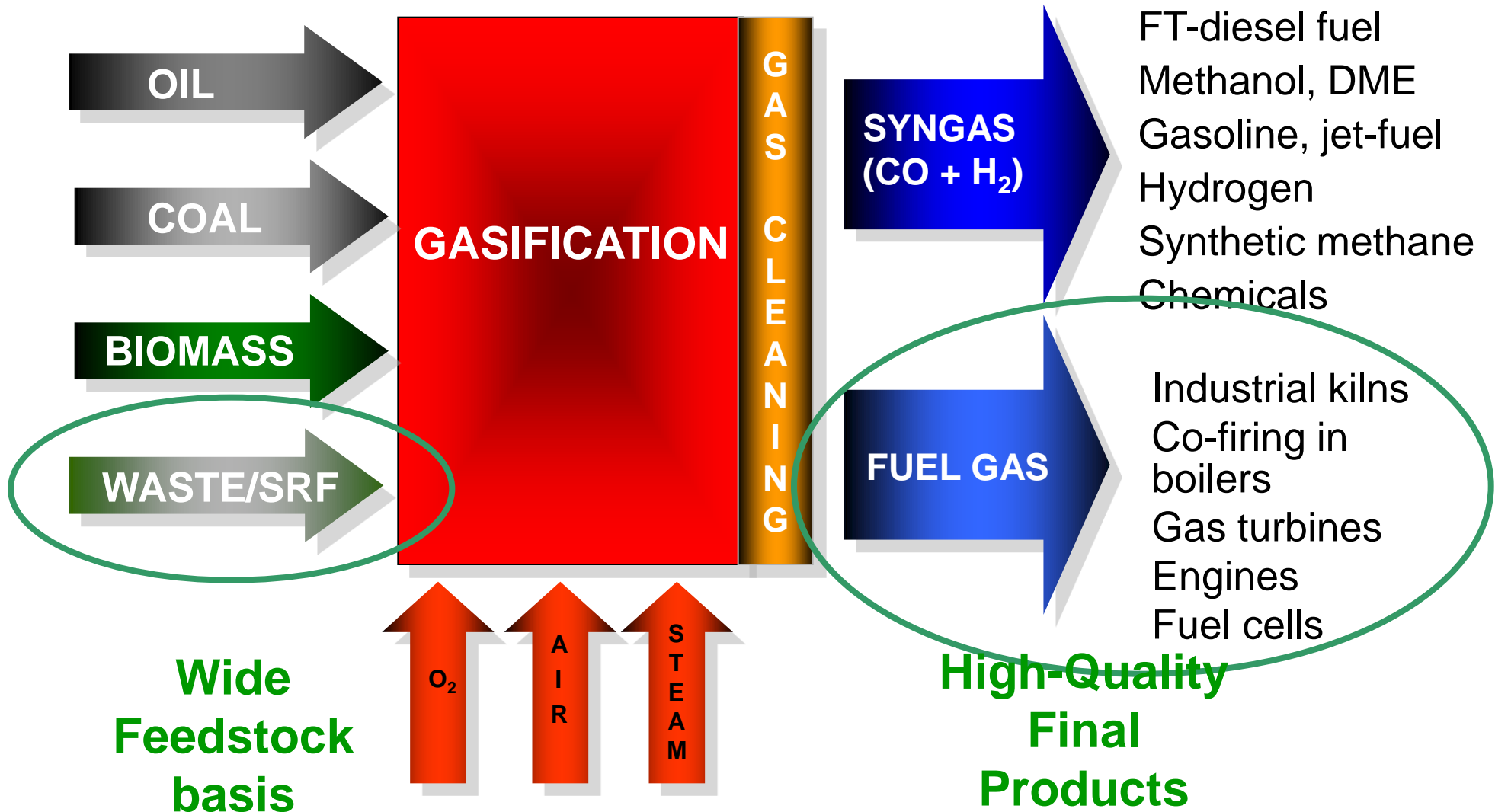
Biomass rich in harmful impurities/waste derived fuels (SRF, high quality RDF)

- Wheat straw: rich in potassium & chlorine
- Demolition wood waste: heavy metals
- **SRF/RDF : heavy metals, chlorine**
- **Plastic waste with some PVC: chlorine**
- **Sewage sludge: heavy metals**

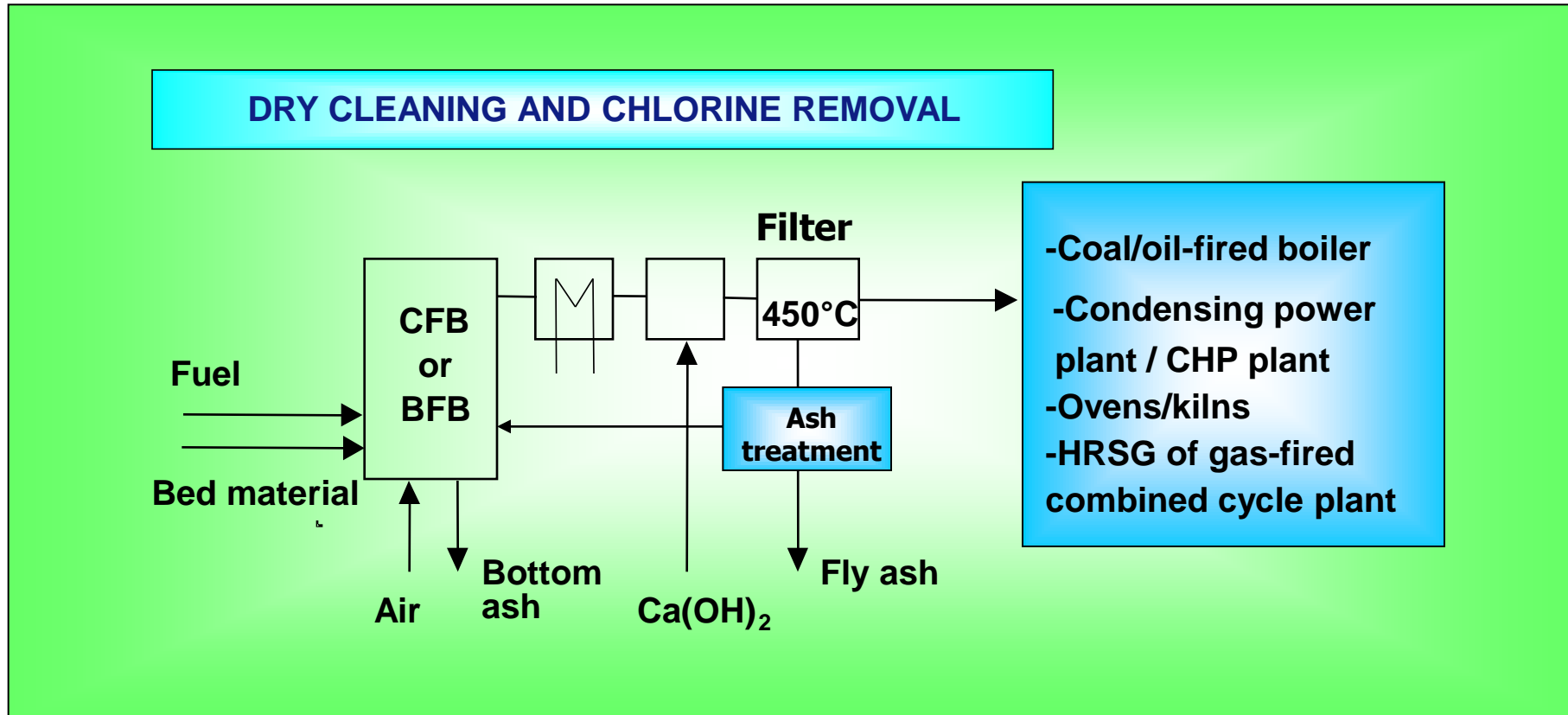
- Emissions
- Boiler corrosion
- Fouling



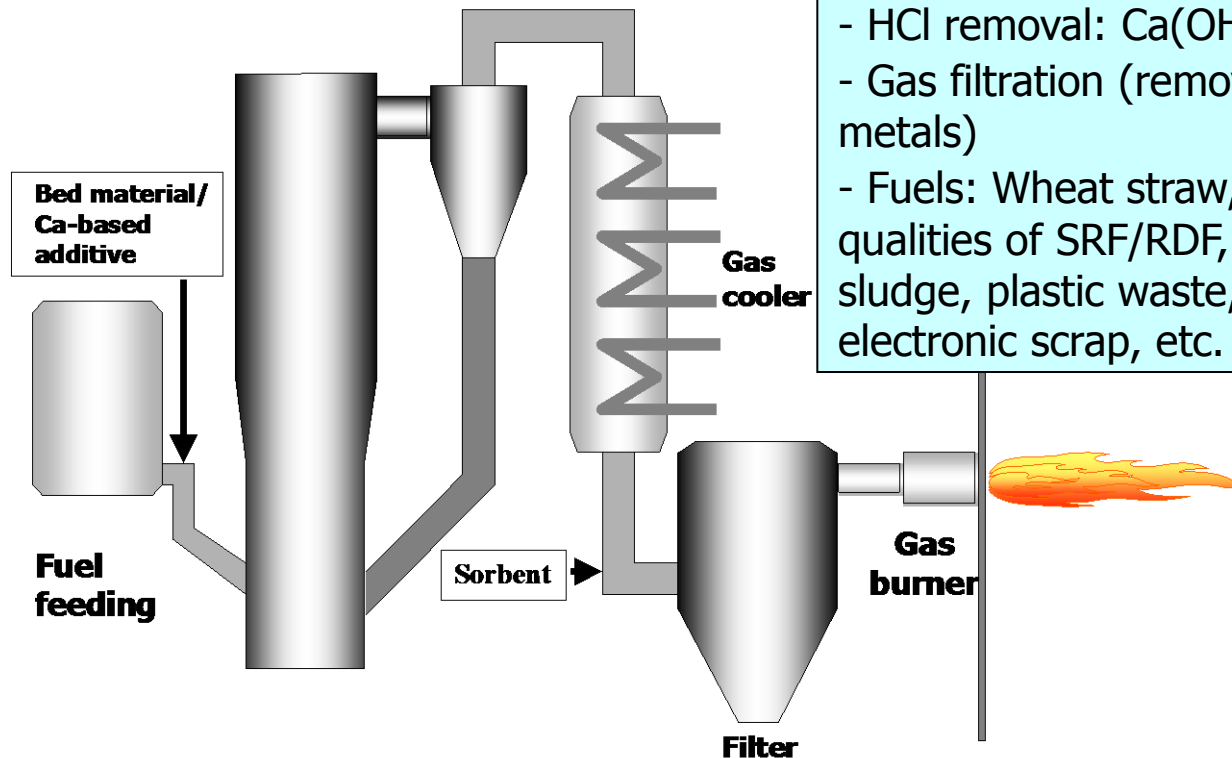
Gasification + Gas Cleaning + Co-firing



Biomass rich in harmful impurities/waste derived fuels



Gasification & gas cleaning R&D at VTT



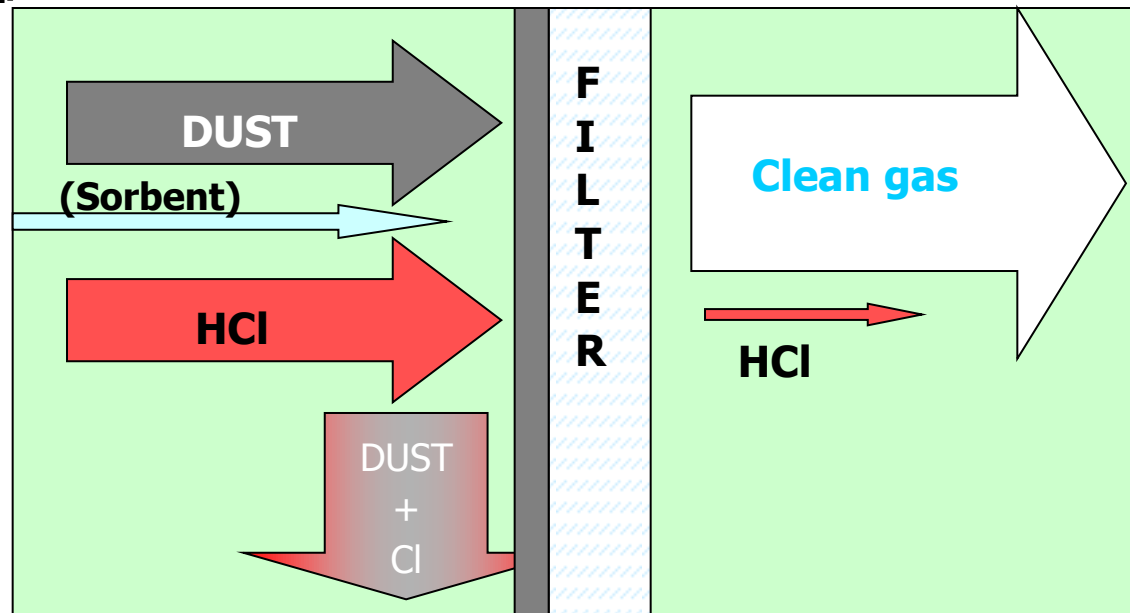
- Air blown CFB gasification (+BFB + Fixed Bed)
- Gas cooling to 350-500°C
- HCl removal: $\text{Ca}(\text{OH})_2$ + inherent Ca, Na, K
- Gas filtration (removal of ash, alkali metals, heavy metals)
- Fuels: Wheat straw, demolition wood, several qualities of SRF/RDF, industrial wastes, sewage sludge, plastic waste, Auto Shredder Residue, electronic scrap, etc.



Removal of chlorine & heavy metals

■ Chlorine removal

- especially when SRF/RDF is gasified
 - target: residual HCl concentration 100..200 ppm (v)
 - inherent alkali metals
 - sorbent injection ($\text{Ca}(\text{OH})_2$) if needed
 - filtration at 350...500°C
-
- efficient enough
 - low cost



Removal of chlorine & heavy metals

- **Removal of heavy metals**
 - gas cooling (350...500°C)
 - condensation of vapour phase metals
 - filtration
 - target set by WID

- most of metals can be captured easily
 - below 450...500°C
 - Cd, Pb, Zn
 - exception: Hg

Chlorine removal

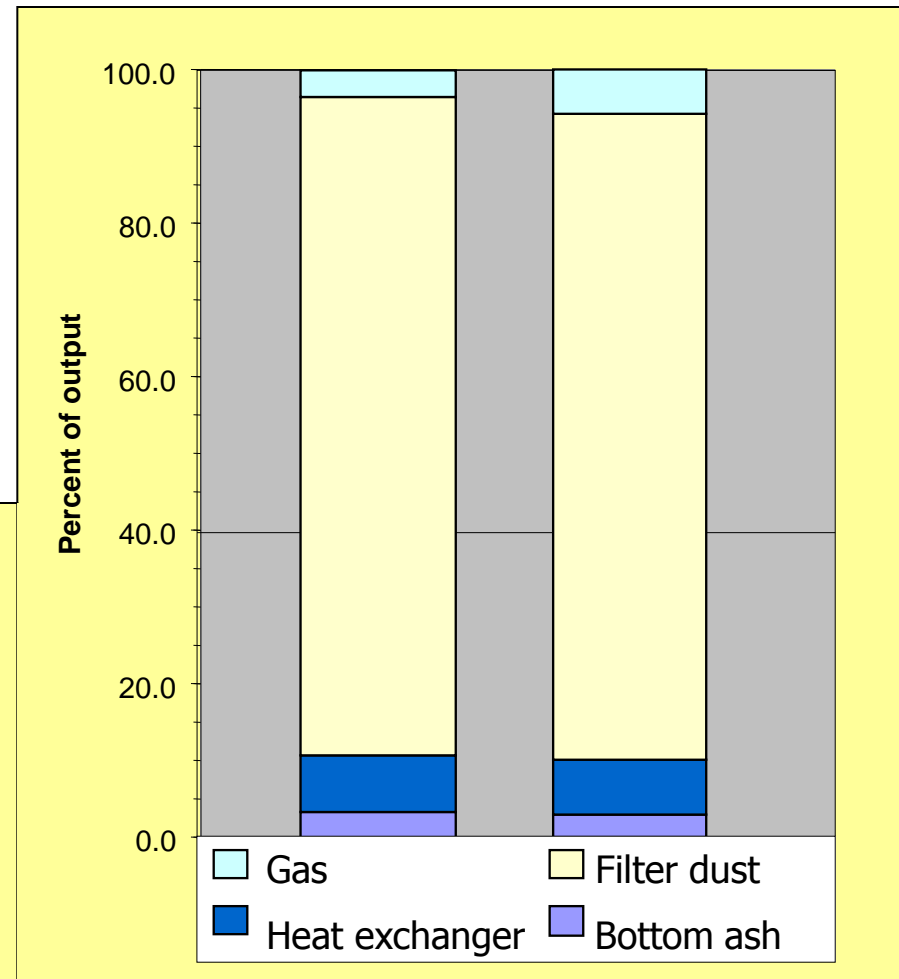
- 60...95 % efficiency typical
- high Na & K content => no need for additional sorbent
 - wheat straw
 - some waste materials

BFB gasification

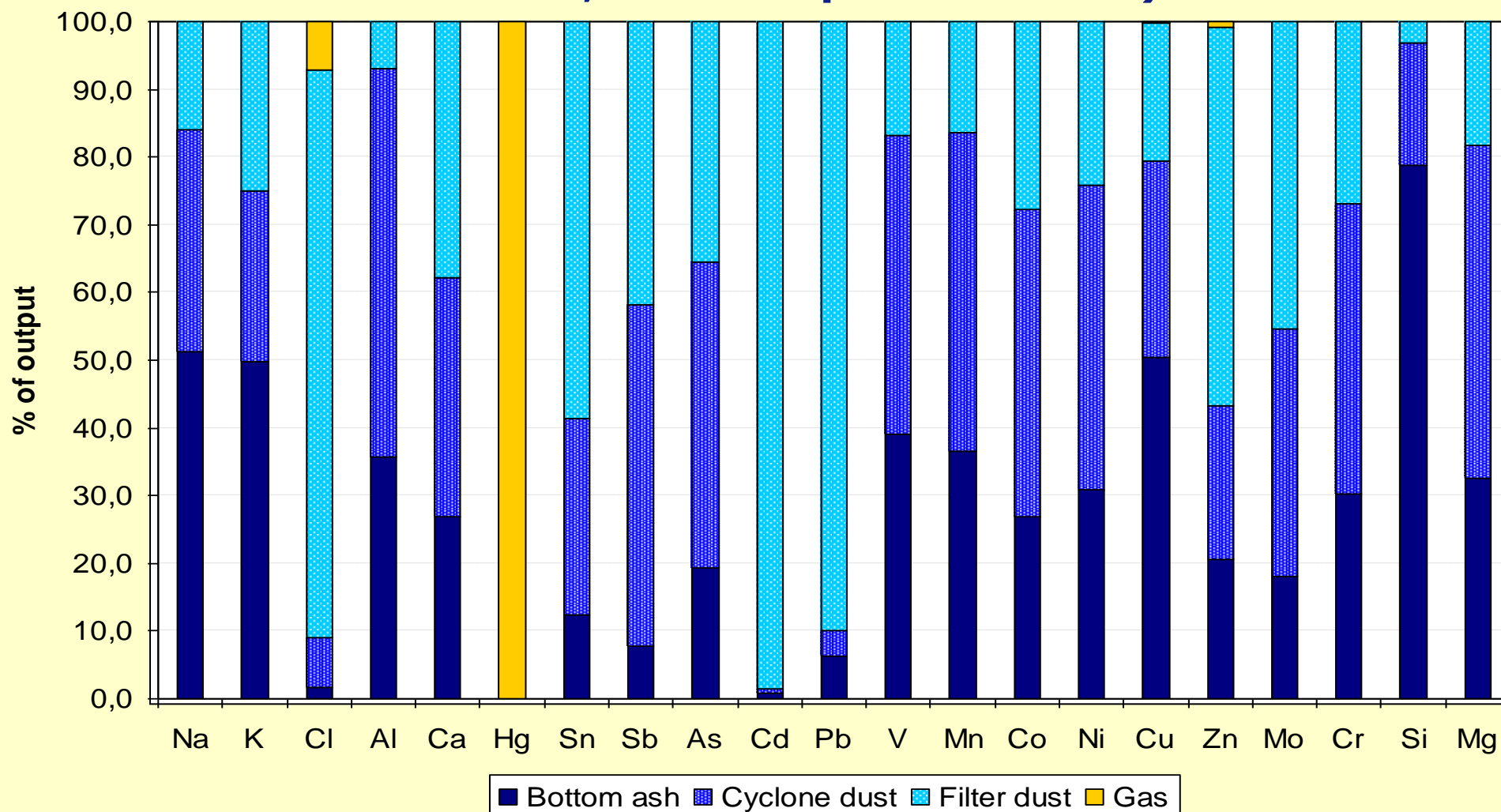
SRF pellet

Ceramic fabric filter (FB-900)

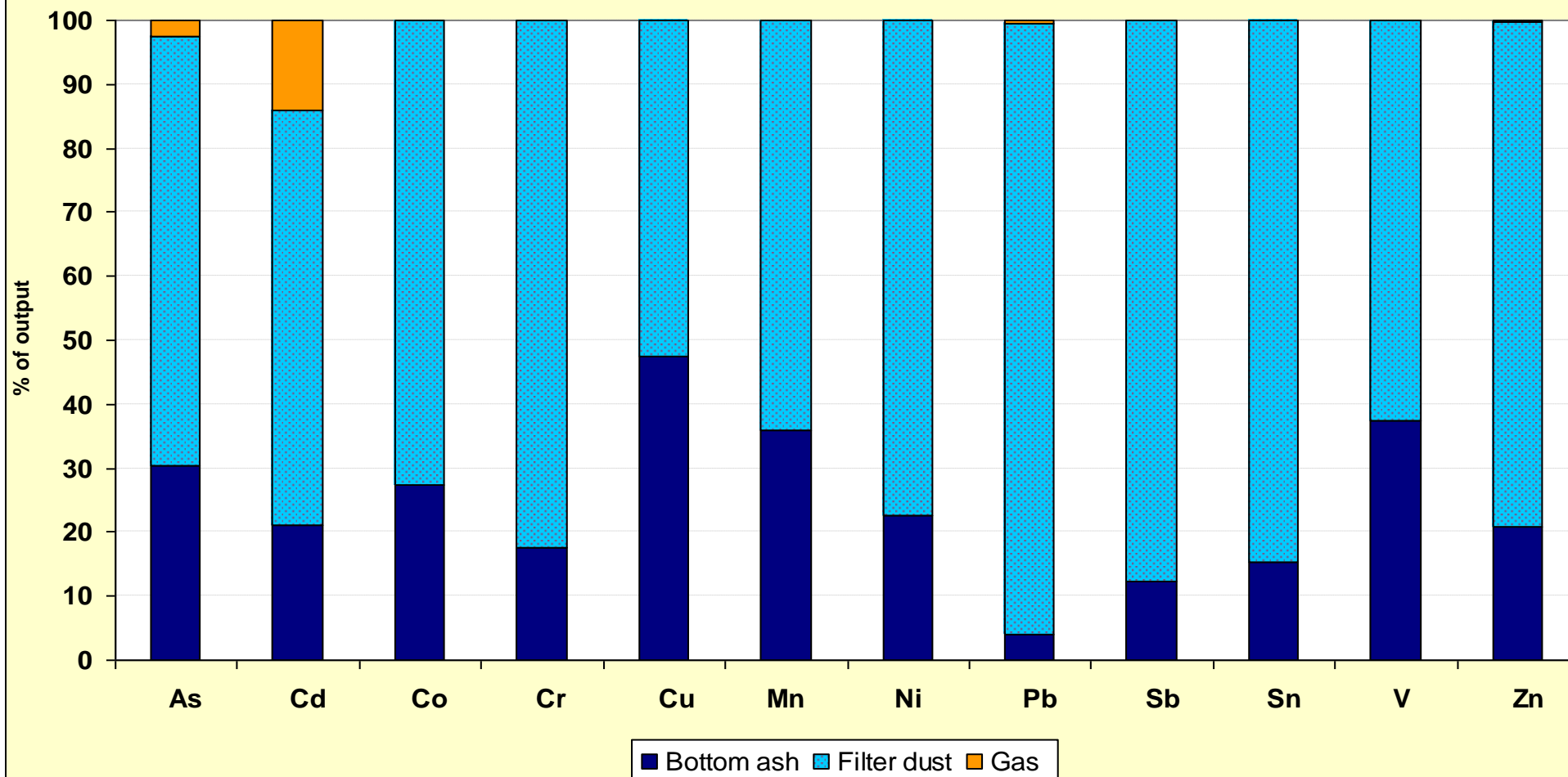
Filtration at 410-420°C



Fuel: SRF ; Ceramic fabric filter (3M FB-900); Cyclone temperature 700-750°C; filter temperature 395°C)



Fuel: SRF pellets; Rigid ceramic fibre filter (Tenmat); filter temperature 500°C)



Examples of gasification and gas cleaning test trials at VTT

**Gas cleaning
by filter:**

- particles
- chlorine
- heavy metals

Test trial Year/Week	Gasifier	Gasifier fuel	Filter/operation temperature
1999/21	CFB	Wood chips	Bag filter (FB 900)/345-360°C
1999/24	CFB	SRF	Bag filter (FB 900)/360-370°C
1999/35	CFB	SRF	Bag filter (FB 900)/360°C
1999/38	CFB	SRF	Bag filter (FB 900)/450-460°C
2000/44	CFB	Coal+PVC	Bag filter (FB 900)/395°C
2000/20	CFB	SRF	Bag filter (FB 900)/410°C
2000/23	CFB	SRF	Bag filter (FB 900)/445°C
2000/36	CFB	Recycled PE+PP	Bag filter (FB 900)/395°C
2000/38	CFB	SRF+wood pellets	Bag filter (FB 900)/393°C
2001/11	CFB	Recycled PE+PP	Bag filter (FB 900)/400°C
2001/20	CFB	Coal+recycled PE+PP	Bag filter (FB 900)/395°C
2001/48	BFB	SRF	Bag filter (FB 900)/380-400°C
2001/50	BFB	SRF	Bag filter (FB 900)/390-410°C
2002/07	BFB	SRF	Bag filter (FB 900)/400-420°C
2002/10	BFB	SRF	Bag filter (FB 900)/400-420°C
2002/23	CFB	Dried sewage sludge	Bag filter (FB 900)/400°C
2002/42	CFB	Sewage sludge+wood chips	Bag filter (FB 900)/350°C
2002/50	BFB	Wood waste	Bag filter (FB 900)/370°C
2003/10	BFB	SRF	Bag filter (FB 900)/360-390°C
2003/23	CFB	Demolition wood	Rigid ceramic fibre filter/500°C
2003/23	CFB	SRF	Rigid ceramic fibre filter/500°C

Gasification & gas cleaning example:

Fuel Contaminants CFB gasification (70 % RDF/30% wood)	ppm-wt (d.b.)
Ca	12290
Hg	0.10
Sn	11
Sb	14
As	3.0
Cd	2.1
Pb	47
V	4.7
Mn	110
Co	5.3
Ni	8
Cu	340
Zn	224
Mo	<5
Cr	50
Si	12300
Mg	1250
Cl	4700

SRF+wood waste

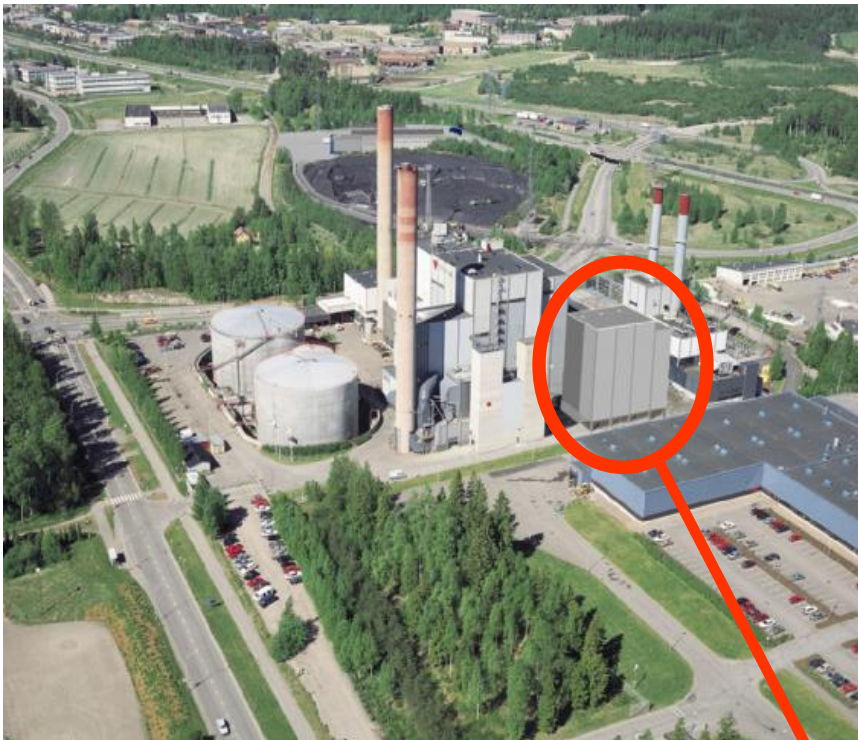
**Air blown CFB
gasification &
dry gas cleaning
at 395°C**

Cleaned gas	
Na, ppm(m)	0,0
K, ppm(m)	0,0
Cl, ppm(m)	109,0
Al, ppm(m)	0,0
Ca, ppm (m)	0,0
Hg, ppm(m)	0,025
Sn, ppm(m)	0,0
Sb, ppm(m)	0,0
As, ppm(m)	0,0
Cd, ppm(m)	0,0
Pb, ppm(m)	0,024
V, ppm(m)	0,0
Mn, ppm(m)	0,0
Co, ppm(m)	0,0
Ni, ppm(m)	0,0
Cu, ppm(m)	0,11
Zn, ppm(m)	0,51
Mo, ppm(m)	0,0
Cr, ppm(m)	0,0
Si, ppm(m)	0,0
Mg, ppm(m)	0,0

Power production efficiency

CHP plant:

SRF to power 30...35 %



Gasifier

Condensing power plant:

SRF to power 35...40 %



(planned projects, not implemented)

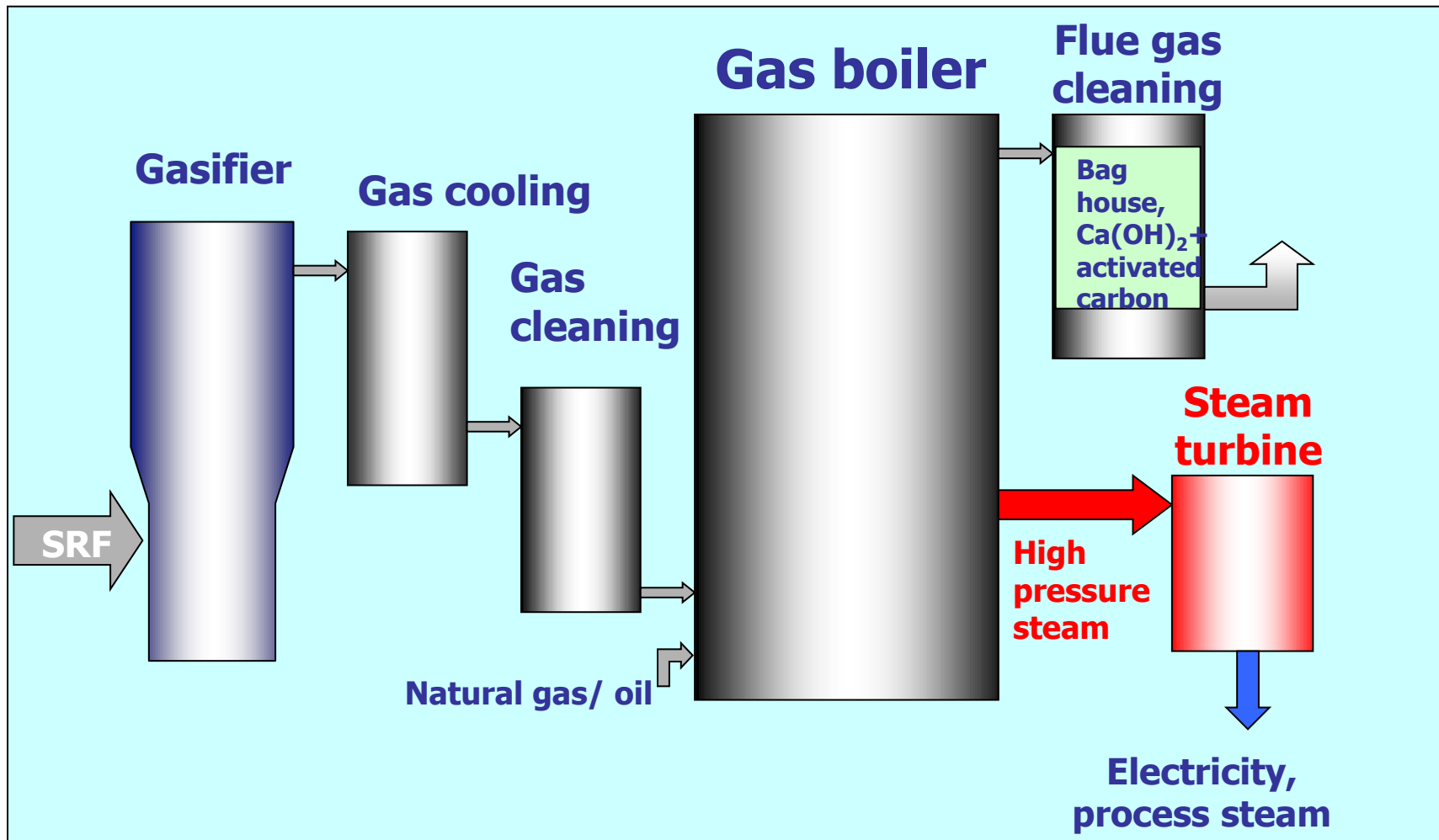
Gasification based WtE technology

- Fluidised bed gasification of SRF/RDF
- Product gas cleaning (dry scrubbing)
- Removal of (corrosive) Cl and ash components (metals)
- Clean gas fired in a gas fired boiler
- No fouling or corrosive impurities

=> High steam parameters

- High power production efficiency
- Feasibility well competitive compared to conventional incineration (mass burning)
- Fulfills gas cleaning requirements set by WID

Gasification + Gas cleaning + Gas fired boiler + Flue gas cleaning



Metso's Gasification Projects

Lahti Energia – Gasification Power Plant

2 x 80 MW_{th} gasifiers

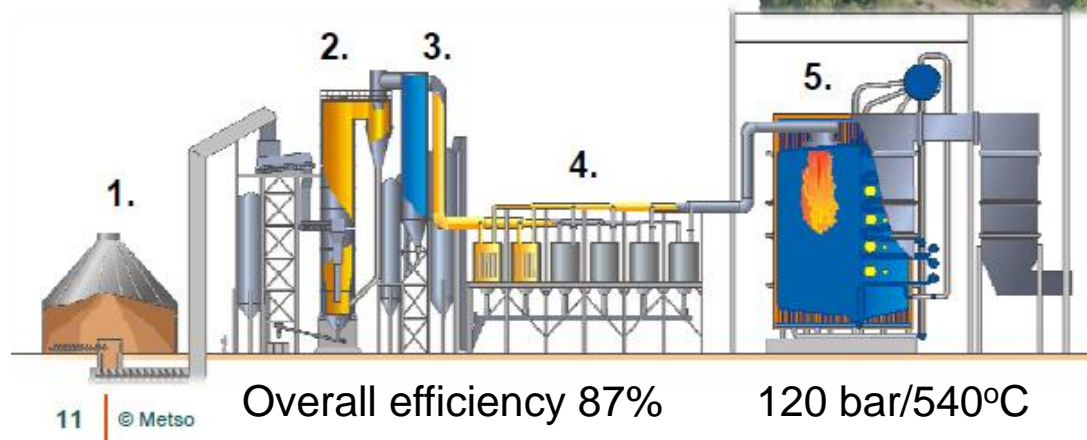
Waste-derived fuel

50 MW_e & 90 MW_{heat}

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

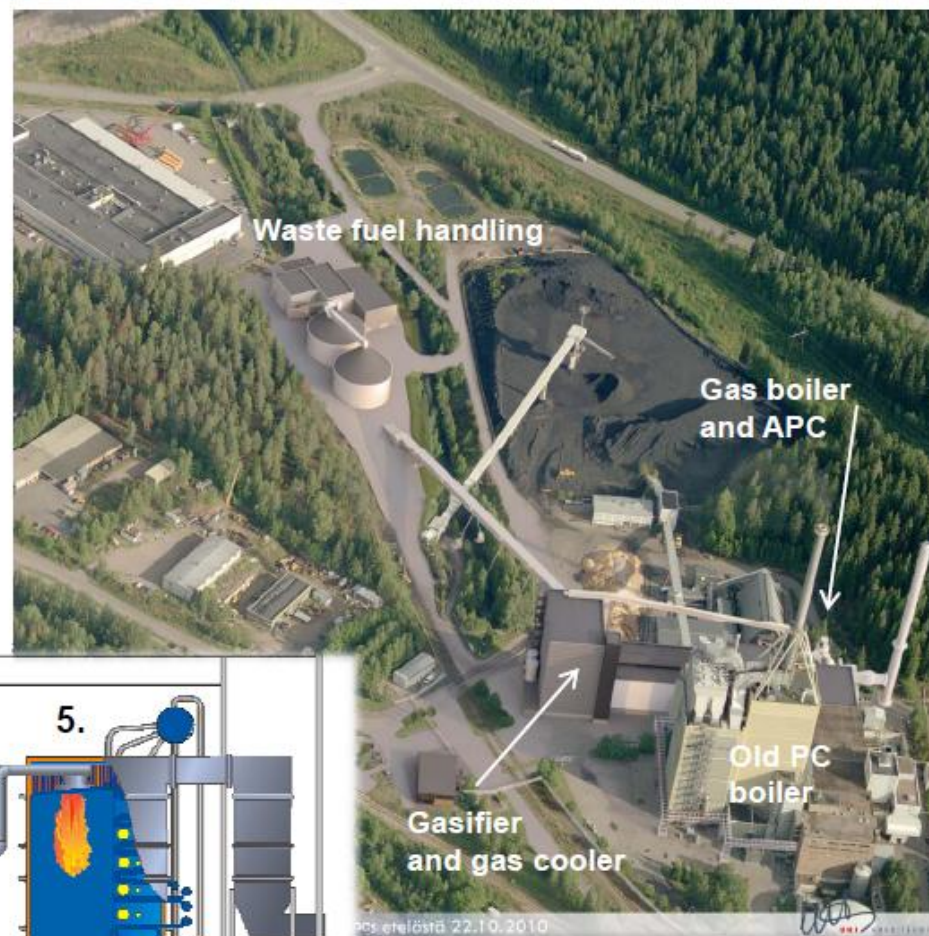
Start-up April 2012

Total investment 157 M€



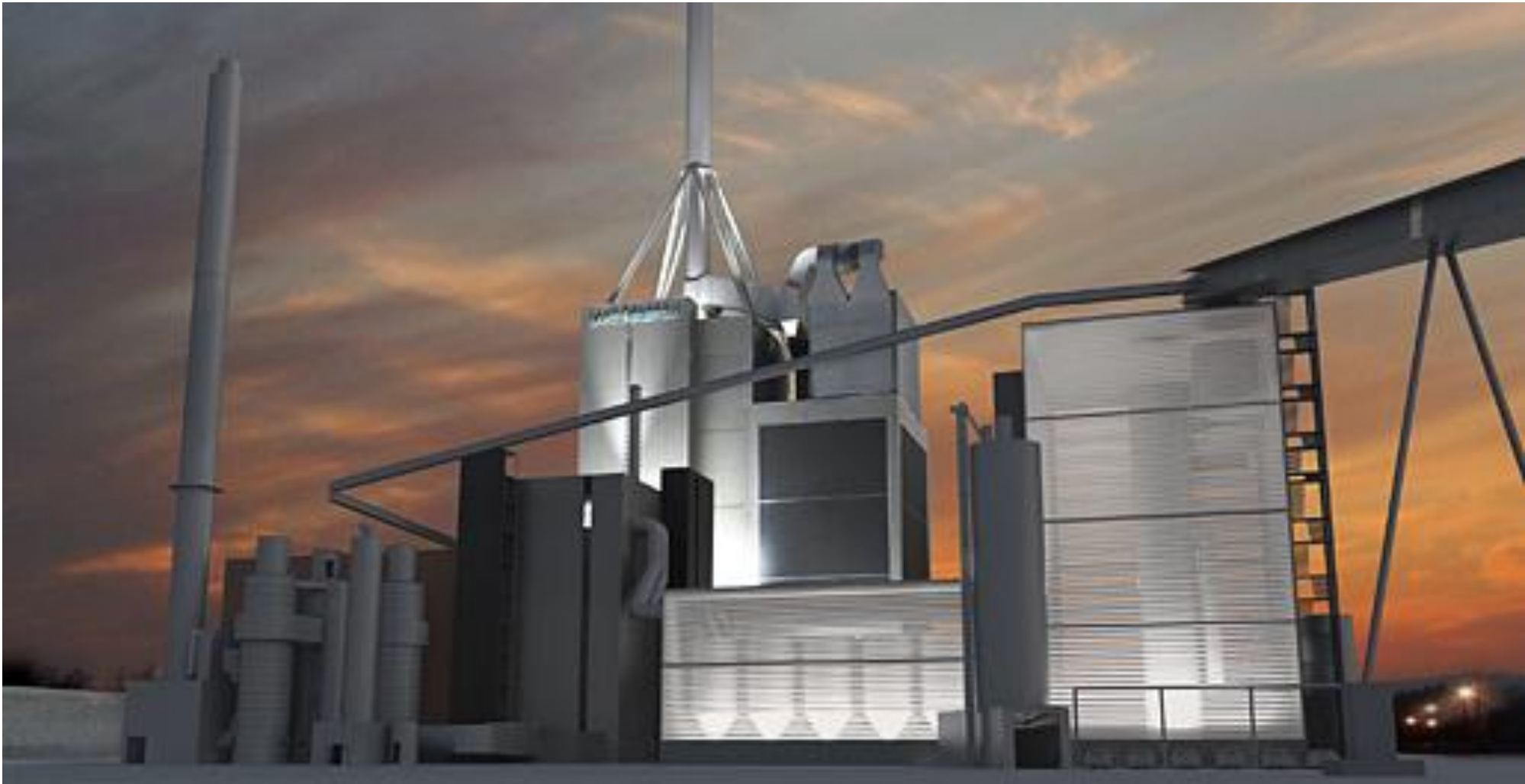
Overall efficiency 87%

120 bar/540°C



Architecture study of the plant

An artist's view on the new Lahti Energia WtE plant

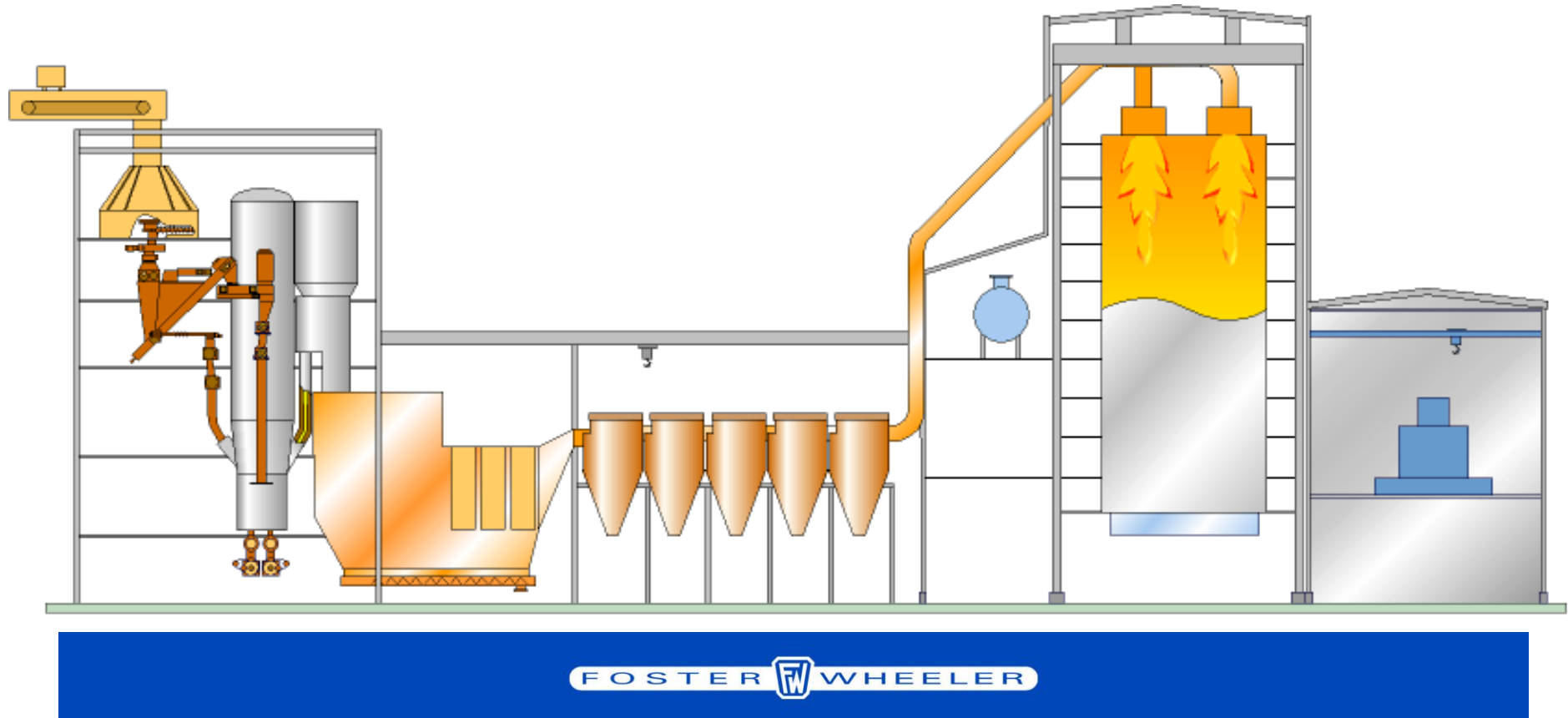


Lahti Kymijärvi power plant construction site (20.10.2011)

(<http://www.roskatenergiaksi.fi/kamerat/kamera-1>)



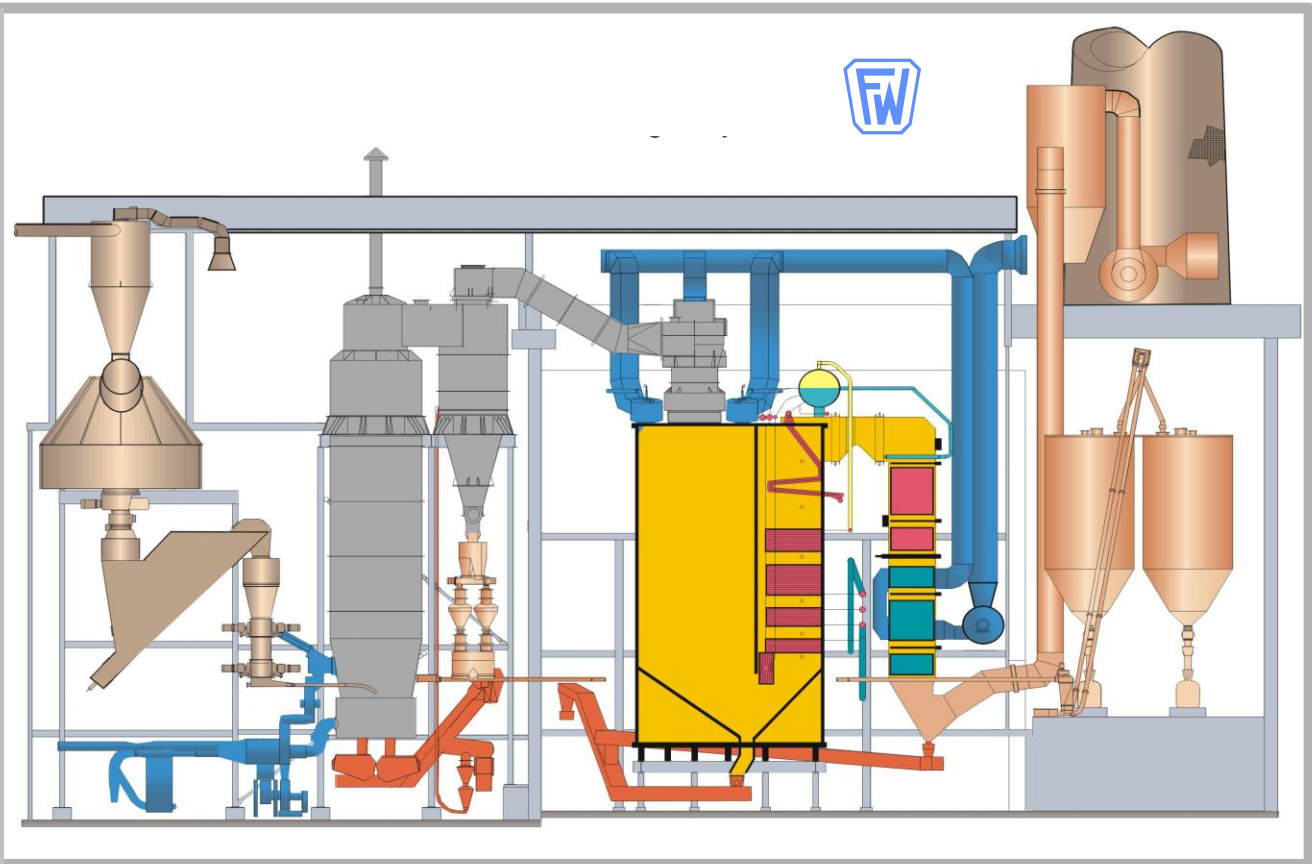
Foster Wheeler design for gasification based WtE plant



Special application: Corenso gasifier in Varkaus, Finland

- at a recycling plant for multi-material packaging
- 50 MW gas to boiler, 2100 t/year aluminium for re-use
- in operation since autumn 2001, now 12 500 hours
- developed by VTT & Foster Wheeler Energia Oy, constructed by Foster Wheeler

**Plastic reject material
with 10 % aluminium**



Summary

- Fluidised bed gasification followed by efficient gas cleaning enables very efficient utilisation of the energy content of SRF and other waste derived fuels
- Efficient gas cleaning usually necessary in order to remove harmful impurities (chlorine, alkali metals, heavy metals, ash)
- Produced gas can be utilised very efficiently in different applications
 - co-firing with other fuels (gas, oil, coal, peat)
 - replacing of fossil fuels in industrial kilns
 - as a single fuel in gas fired boiler

Learn more about gasification based high efficiency WtE technologies

- **visit LahtiStreams project web site**

www.lahtistreams.com

**(Advanced WtE technologies -
seminar in Lahti, Finland, in May 2012)**



**VTT creates business from
technology**