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/CO_2 reduction

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

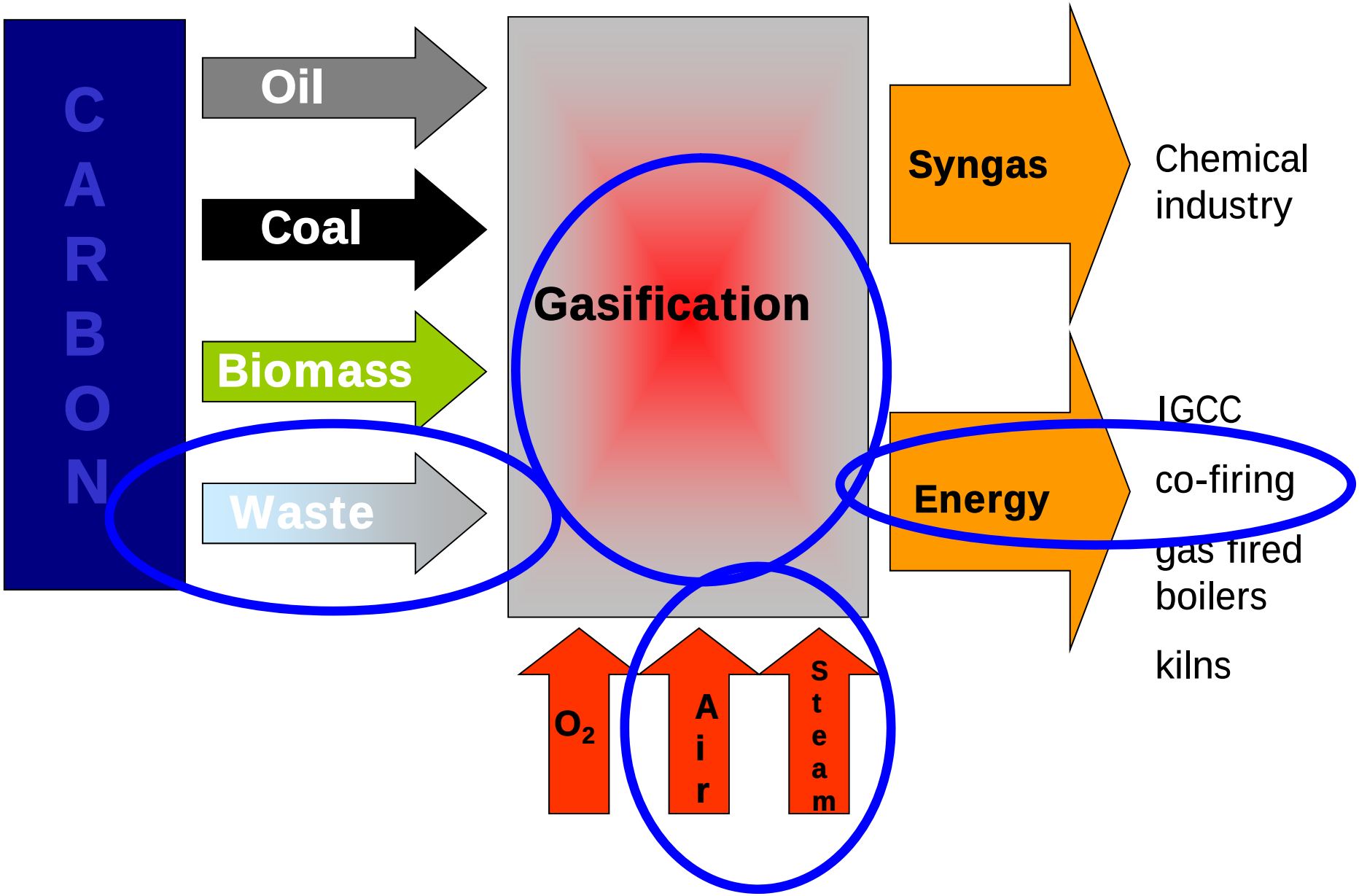
Direct co-firing of waste derived fuels

- **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**

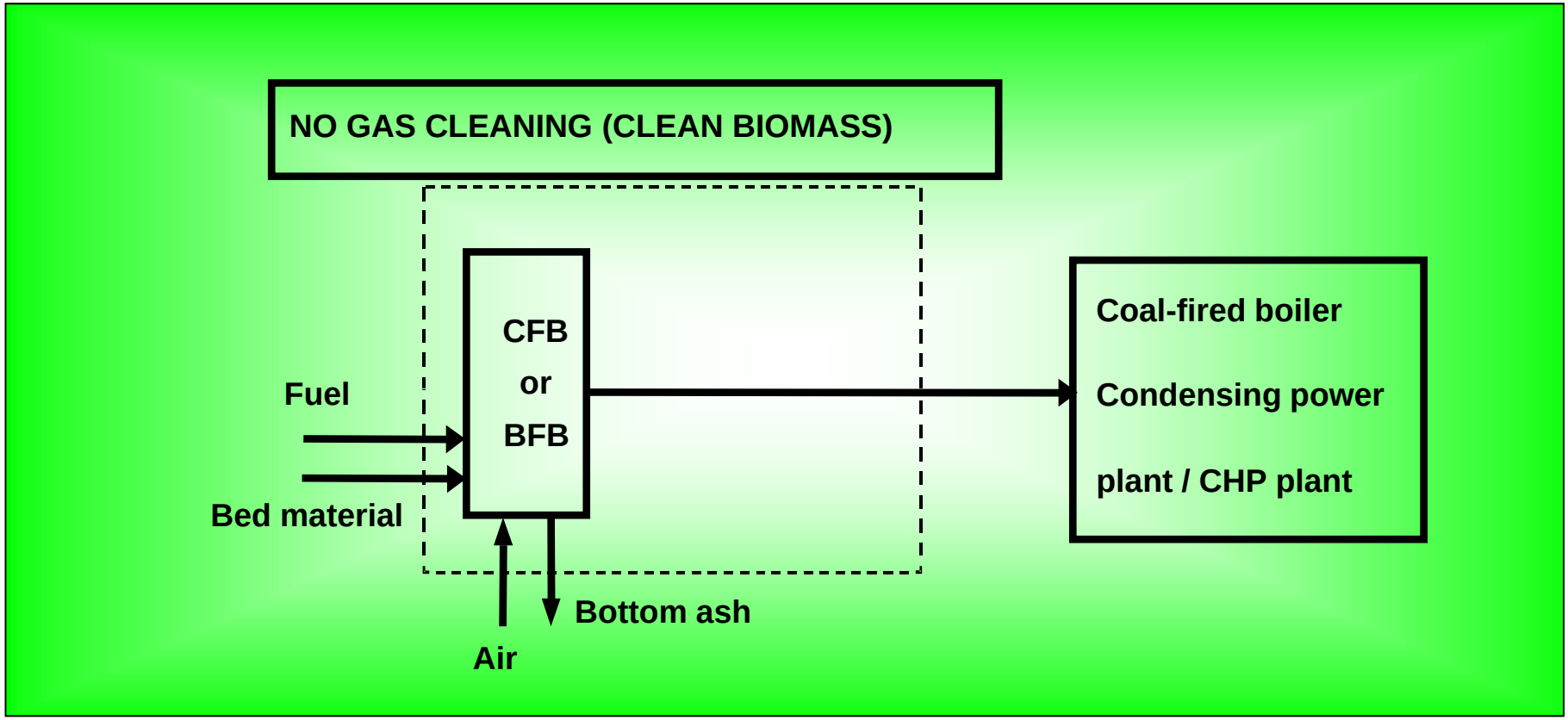
Indirect co-firing of waste derived fuels based on gasification

- **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**

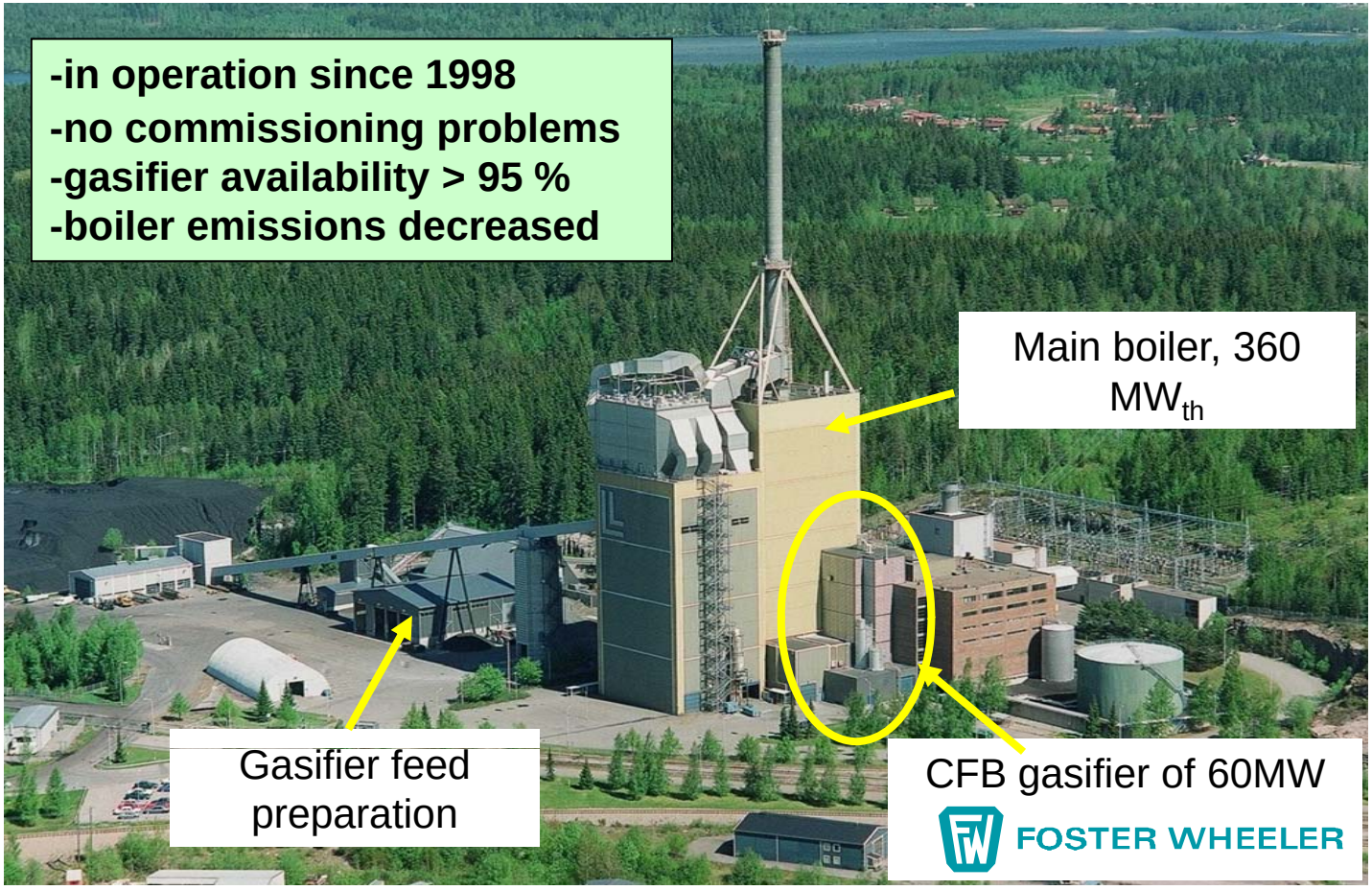
REMARK! **Focus of this presentation on gasification technologies with some gas cleaning or with possibility for gas cleaning. Technologies based on two-stage combustion are excluded (Thermoselect, Ebara, Energos, Kobelco, etc.)**


CARBON
Oil
Coal
Biomass
Waste
Gasification
Syngas
Energy
Chemical industry
IGCC
co-firing
gas fired boilers
kilns
O2
Air
Steam

Clean biomass (or in some cases clean waste)



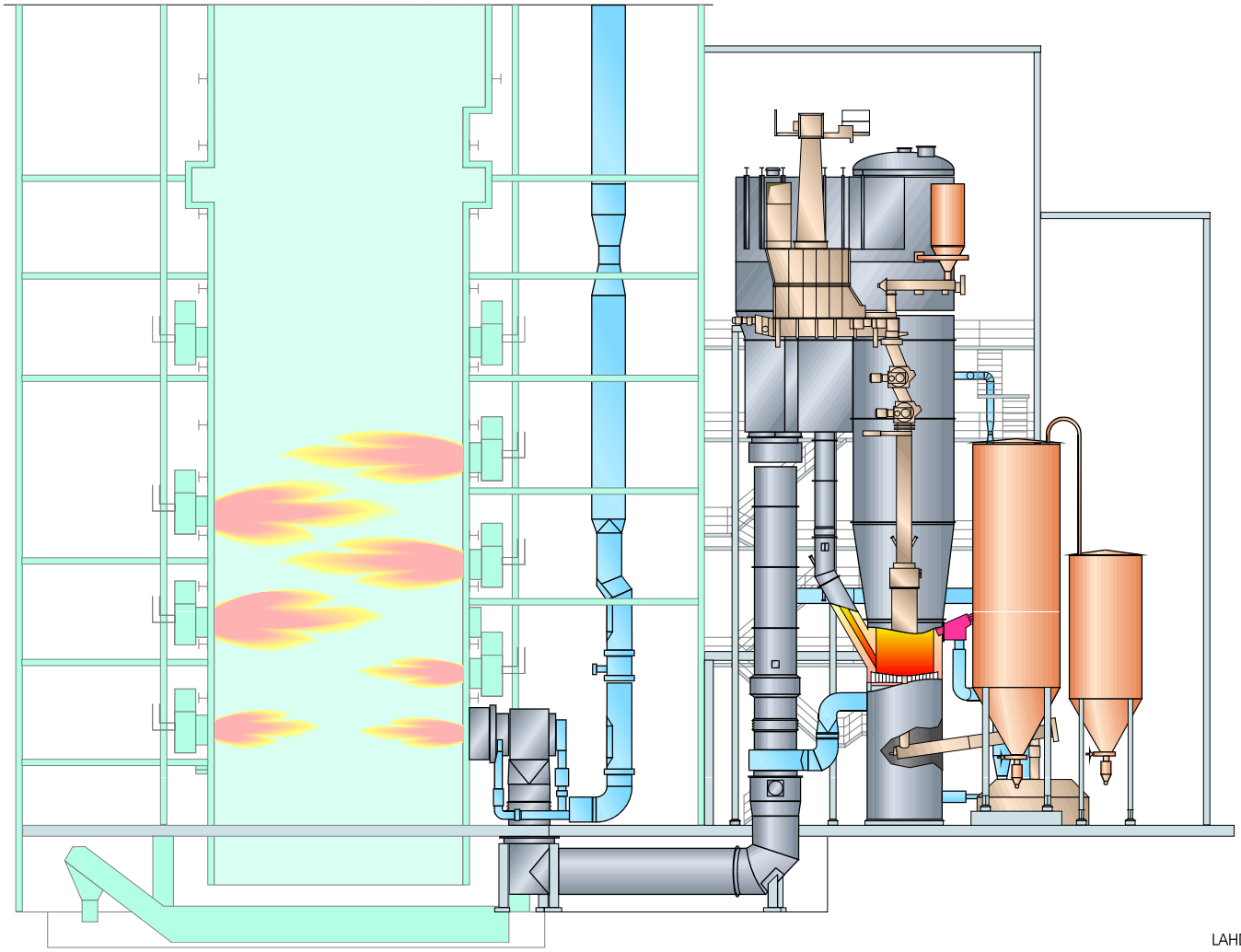
Proven reference: Lahti (Kymijärvi power plant), Finland




SITA

FOSTER WHEELER

CFB BIOMASS GASIFIER
40 - 70 MWth



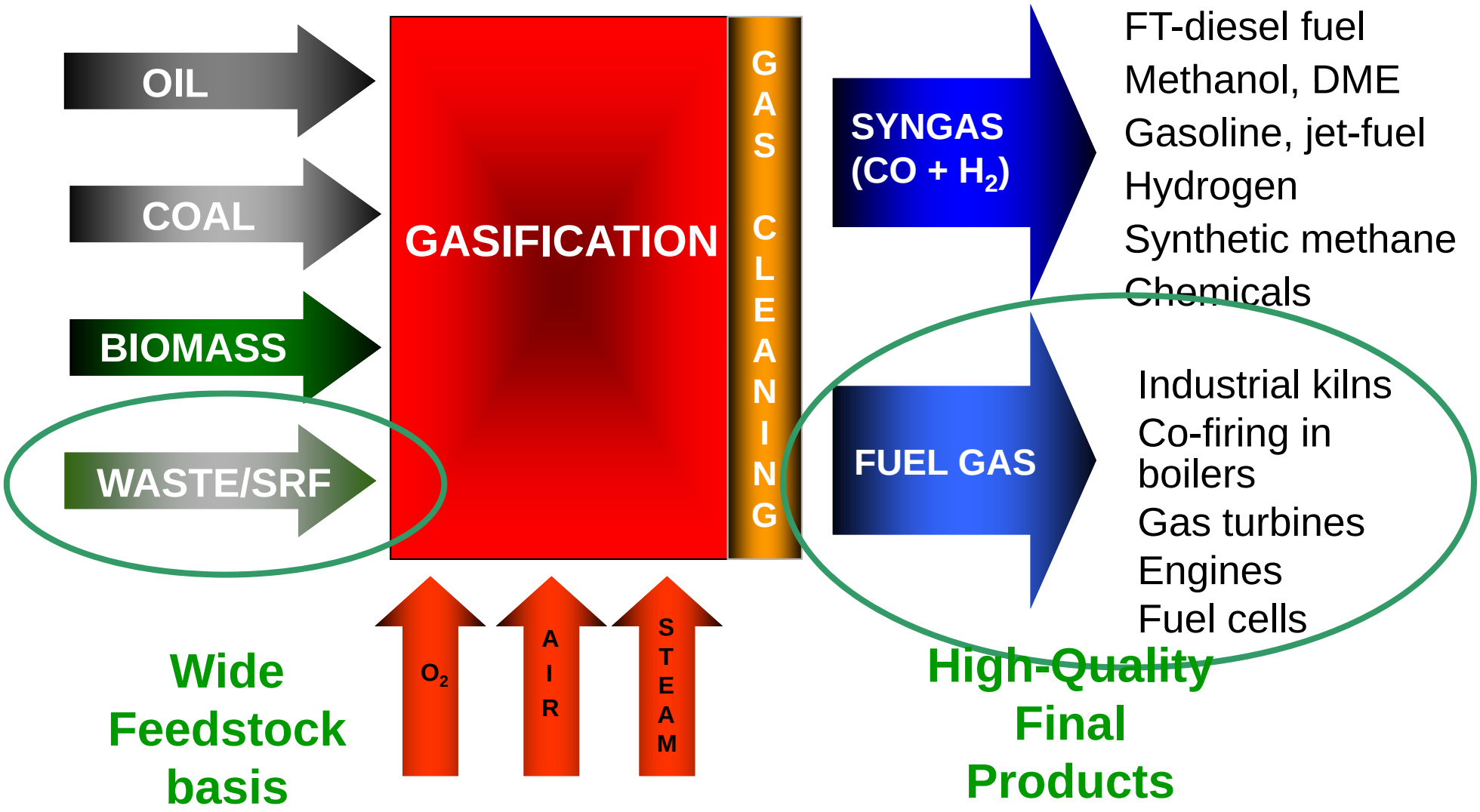
LAHDEN LÄMPÖVOIMA
KYMIJÄRVI POWER PLANT
KYMIJÄRVI, FINLAND

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

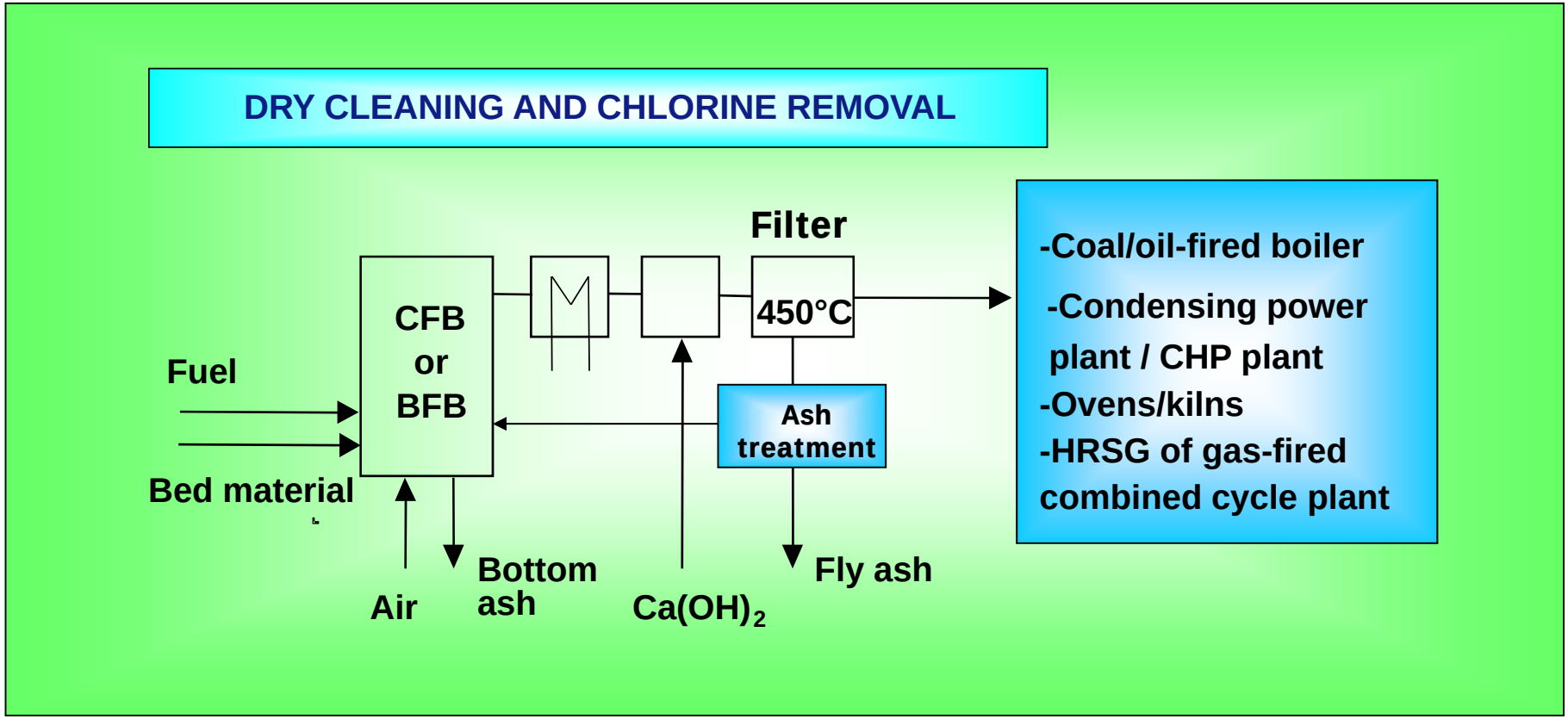
- Wheat straw: rich in potassium & chlorine
- Demolition wood waste: heavy metals
- **SRF/RDF : heavy metals, chlorine**
- **Plastic waste with some PVC: chlorine**
- **Sewage sludge: heavy metals**

- Emissions
- Boiler corrosion
- Fouling

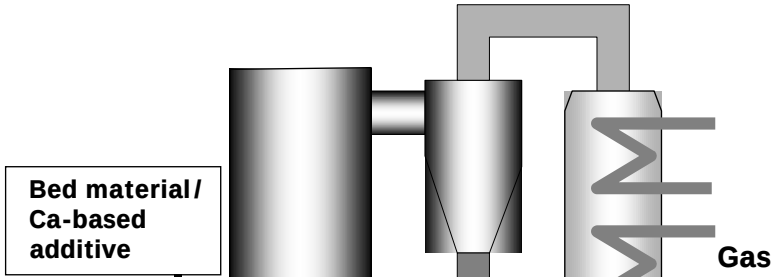
→ **Gasification + Gas Cleaning + Co-firing**


OIL
COAL
BIOMASS
WASTE/SRF
GASIFICATION
GAS CLEANING
SYNGAS (CO + H2)
FUEL GAS
FT-diesel fuel
Methanol, DME
Gasoline, jet-fuel
Hydrogen
Synthetic methane
Chemicals
Industrial kilns
Co-firing in boilers
Gas turbines
Engines
Fuel cells
O2
AIR
STEAM
Wide Feedstock basis
High-Quality Final Products

Biomass rich in harmful impurities / waste derived fuels



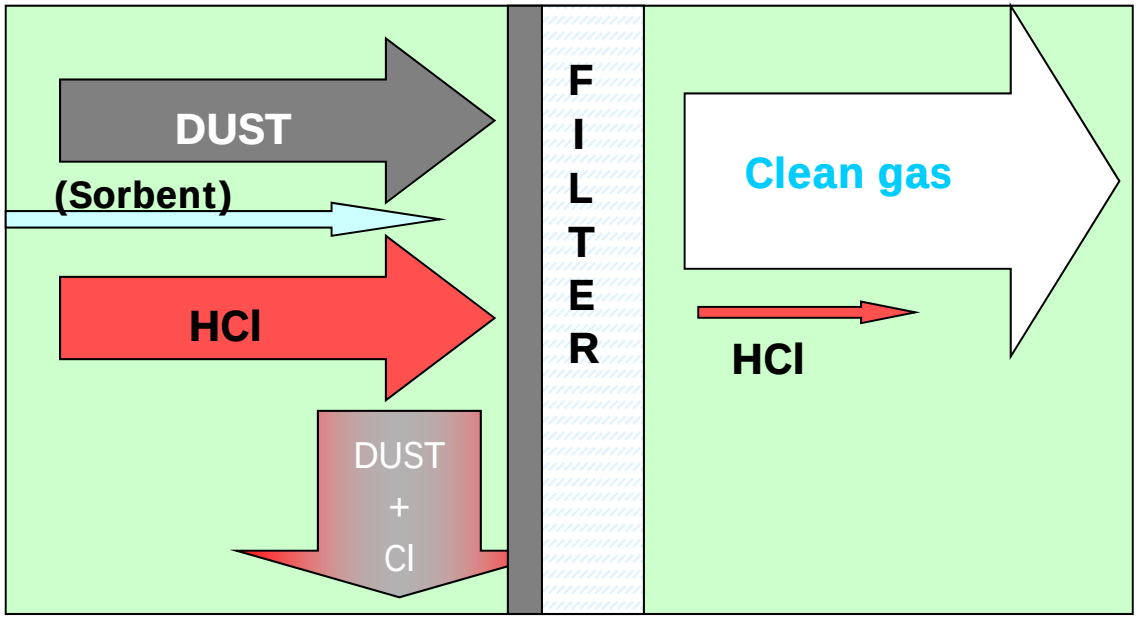
Gasification & gas cleaning R&D at VTT



- Air blown CFB gasification (+BFB + Fixed Bed)
- Gas cooling to 350-500°C
- HCl removal: $Ca(OH)_2$ + 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 ($Ca(OH)_2$) 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

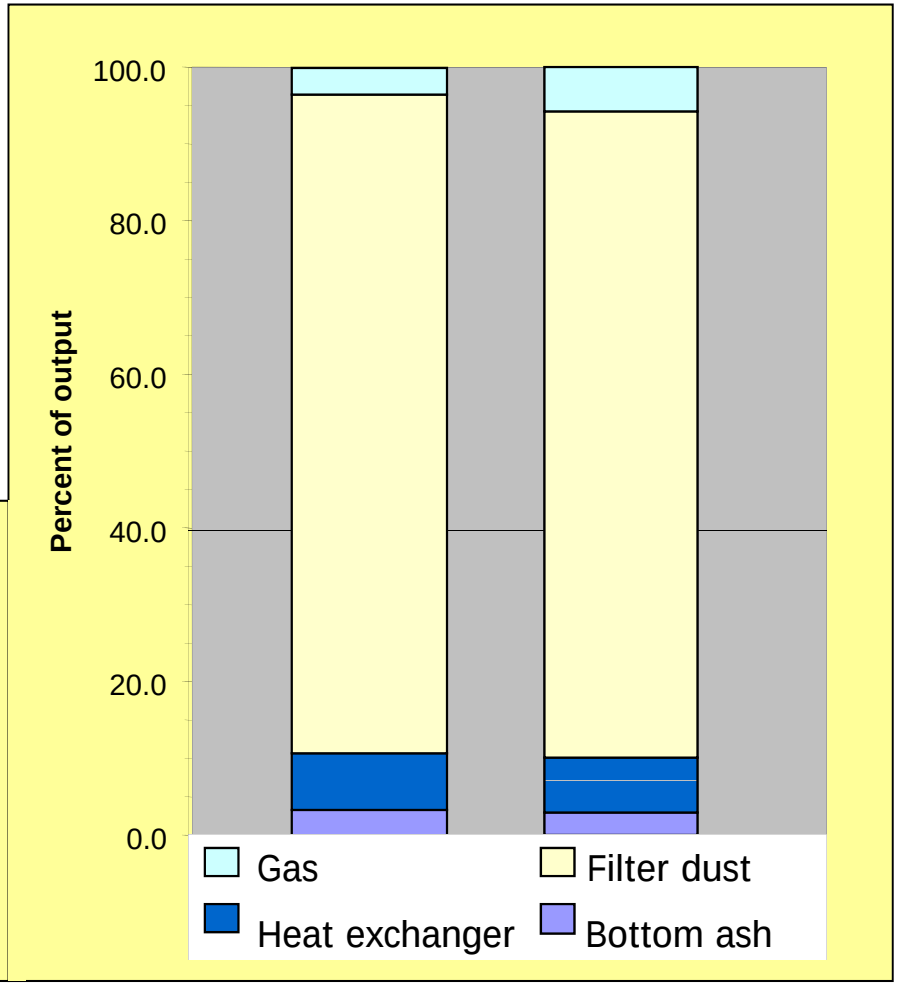
- **60…95 % efficiency typical**
- **high Na & K content => no need for additional sorbent**
  - **wheat straw**
  - **some waste materials**

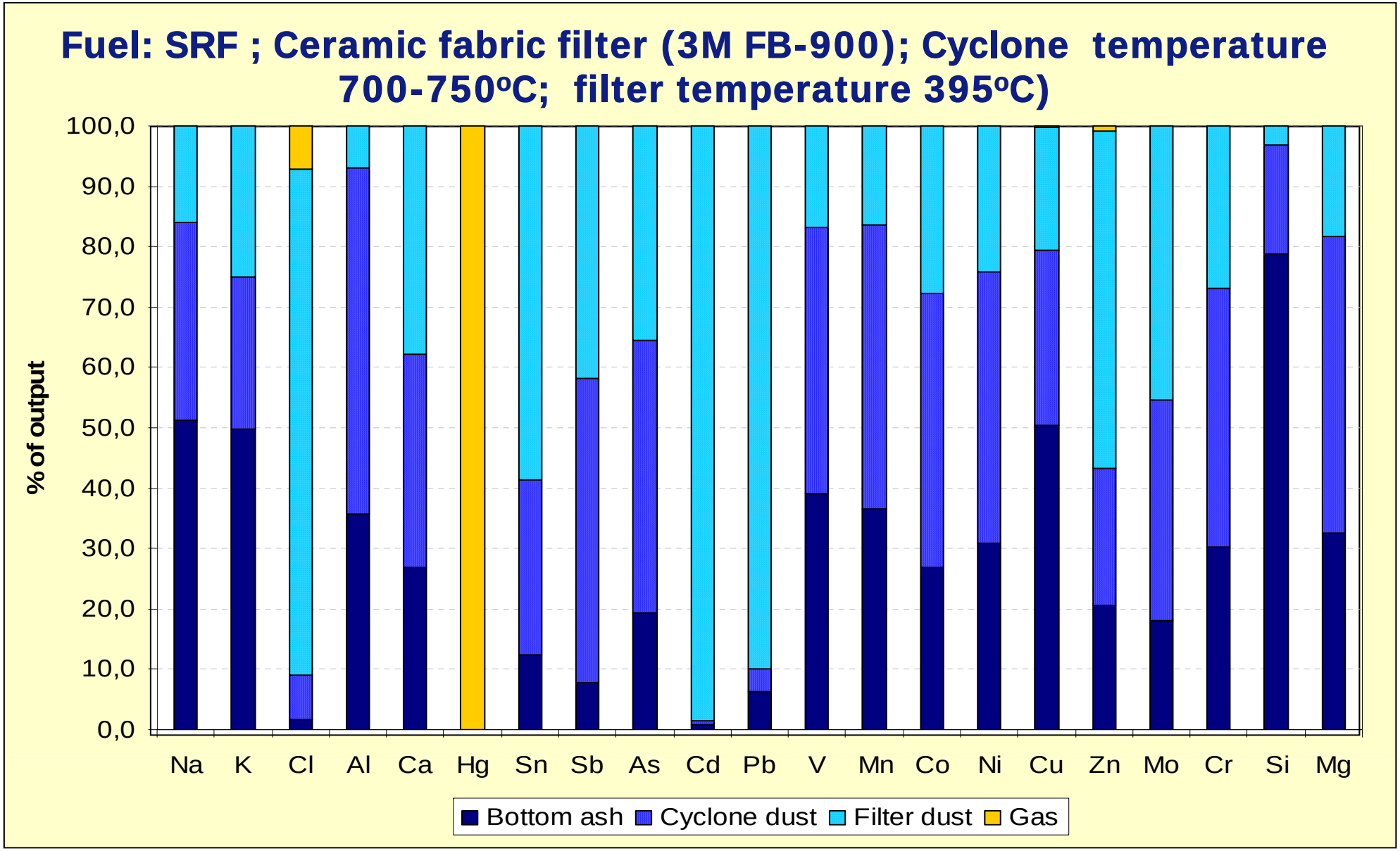
BFB gasification

SRF pellet

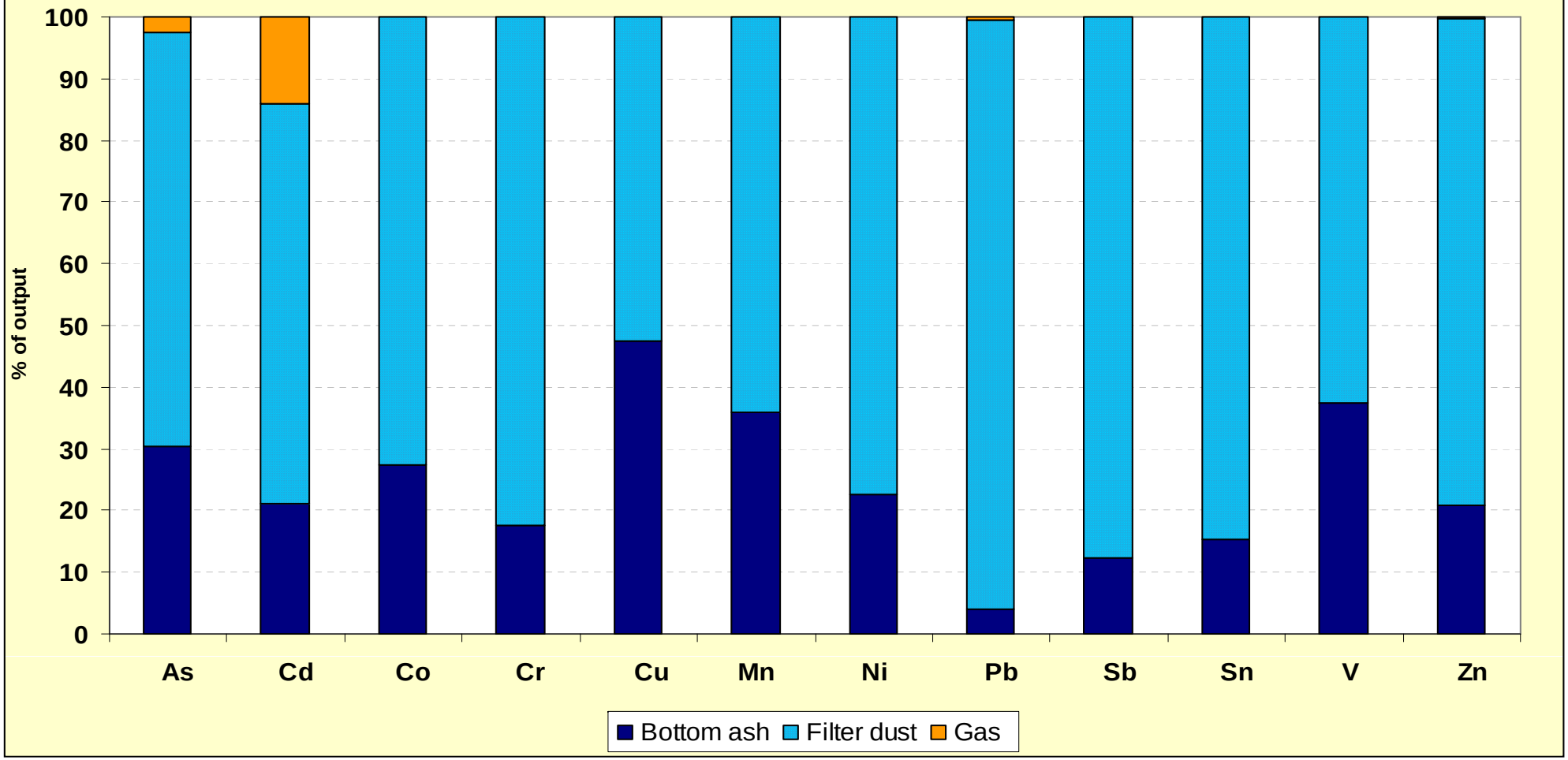
Ceramic fabric filter (FB-900)

Filtration at 410-420°C




Fuel: SRF ; Ceramic fabric filter (3M FB-900); Cyclone temperature 700-750ºC; filter temperature 395ºC)
% of output
100,0
90,0
80,0
70,0
60,0
50,0
40,0
30,0
20,0
10,0
0,0
Na K Cl Al Ca Hg Sn Sb As Cd Pb V Mn Co Ni Cu Zn Mo Cr Si Mg
Bottom ash
Cyclone dust
Filter dust
Gas

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



Examples of gasification and gas cleaning test trials at VTT

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

Gas cleaning by filter:

-particles

-chlorine

-heavy metals

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

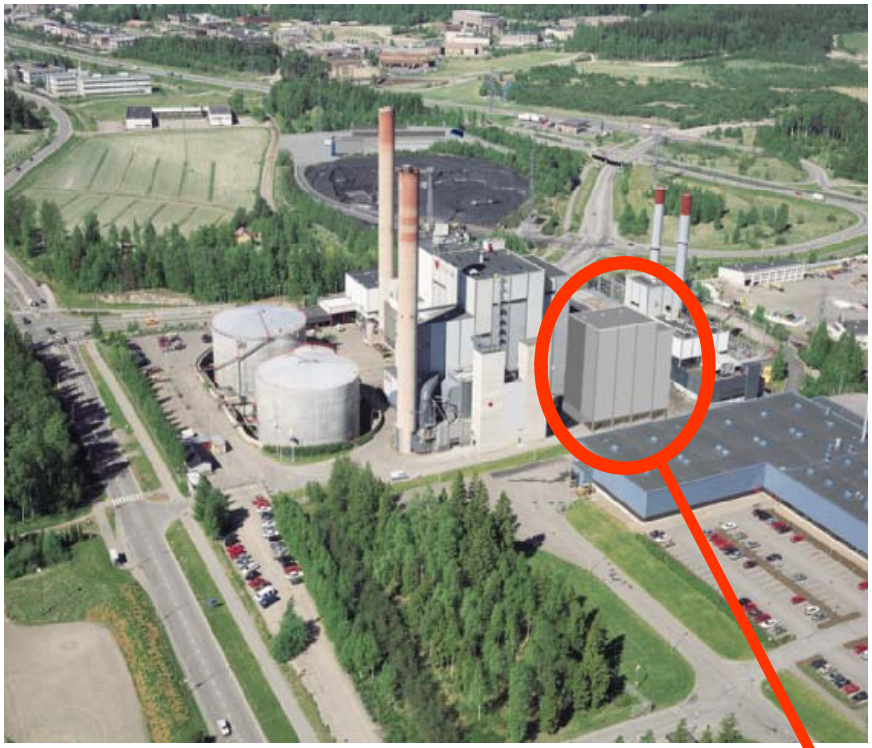
Air blown CFB gasification & dry gas cleaning at 395°C

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 %



Condensing power plant:

SRF to power 35…40 %

(planned projects, not implemented)

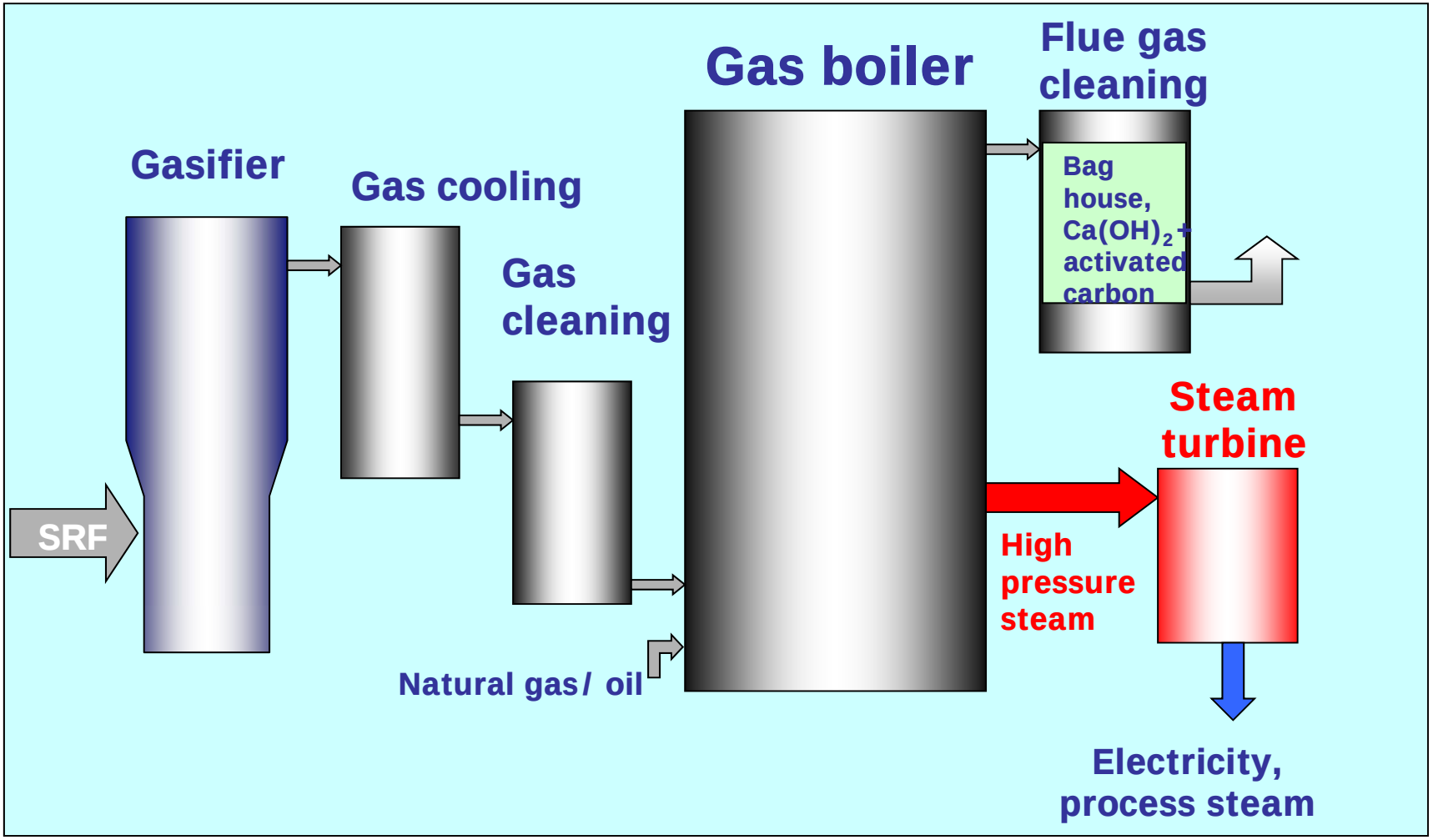
Gasification based WtE technology

- **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)**
- **Fulfils gas cleaning requirements set by WID**

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



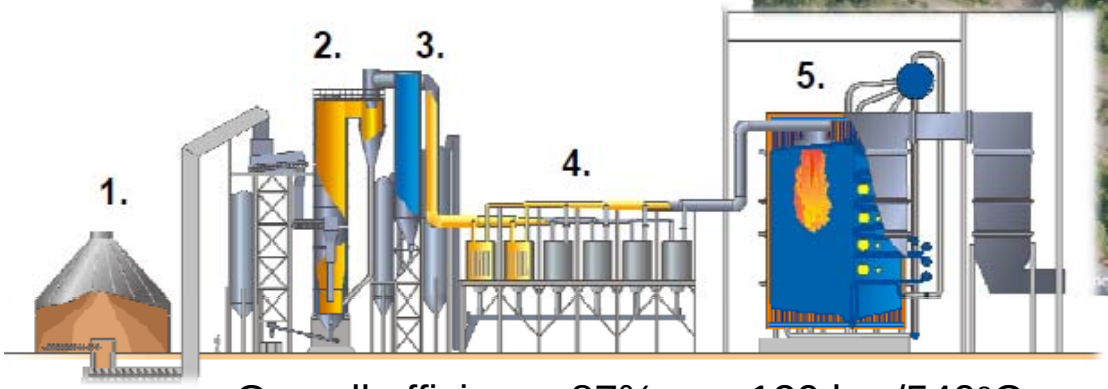
Metso's Gasification Projects

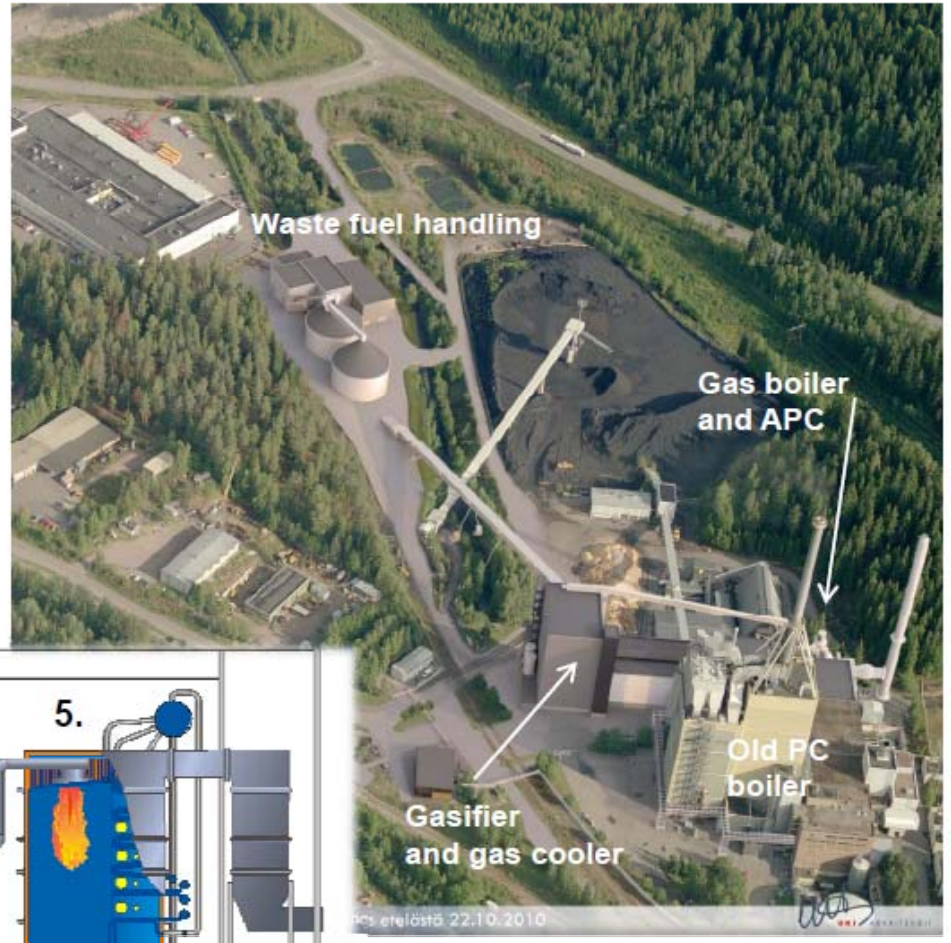
Lahti Energia – Gasification Power Plant

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€





Architecture study of the plant

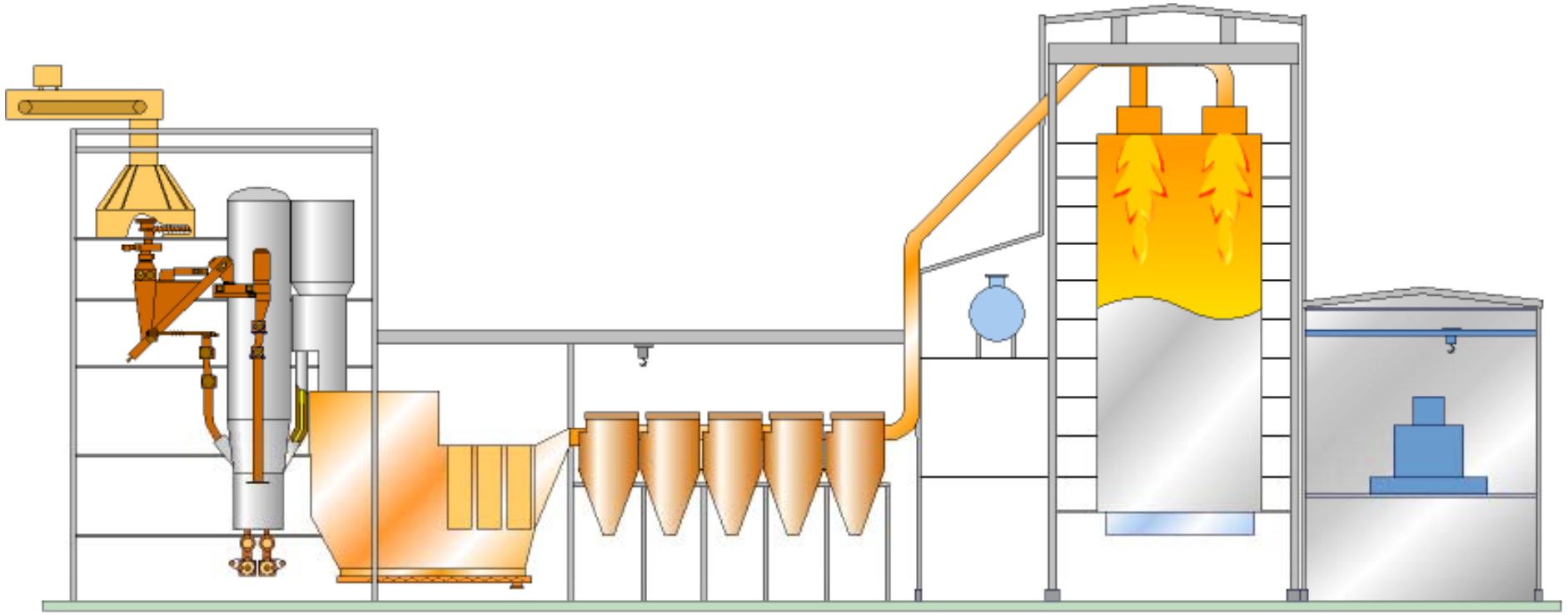
Overall efficiency 87% 120 bar/540°C

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)

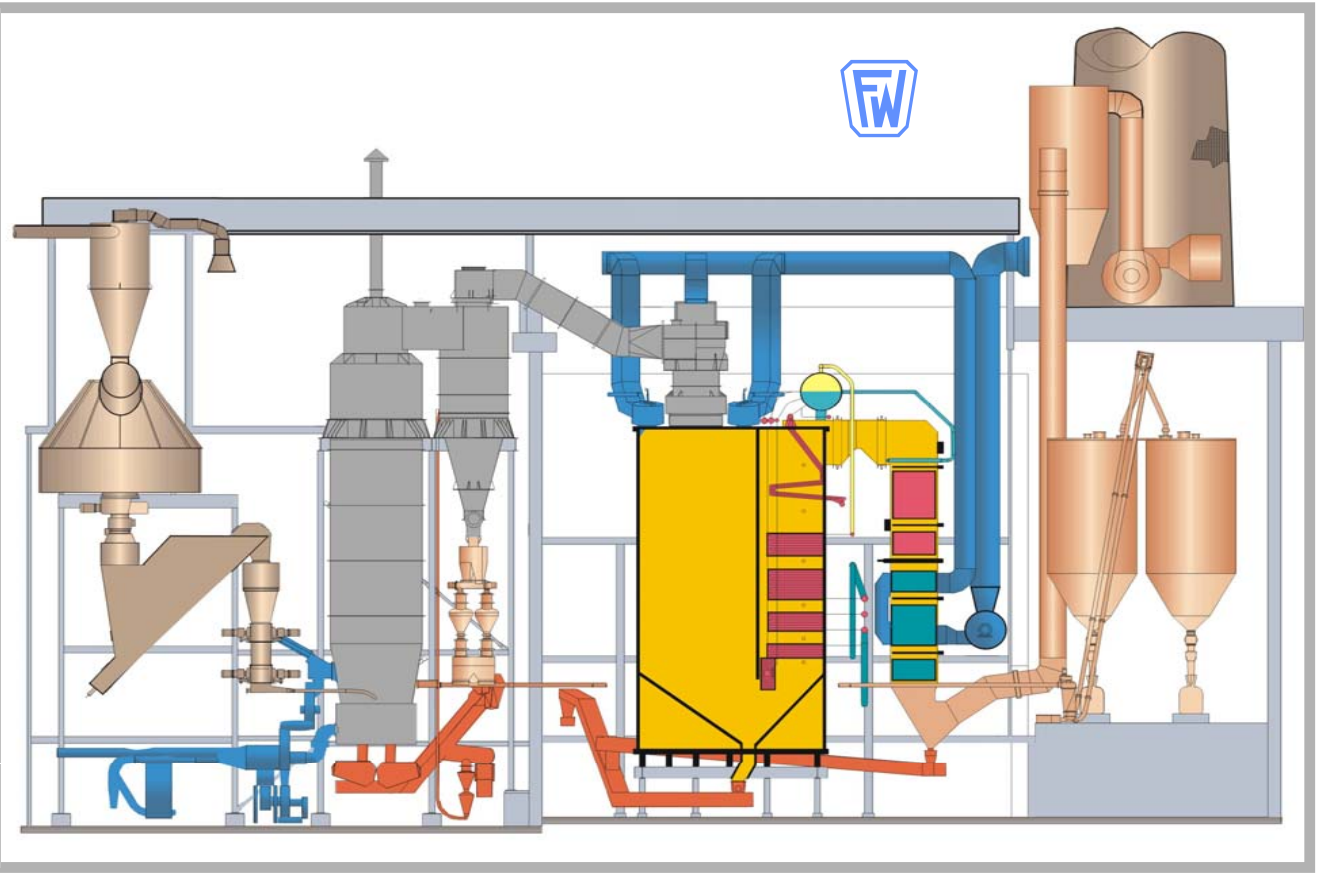
Foster Wheeler design for gasification based WtE plant



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