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# Cocombustion of calorific solid waste and sludge in a fluidised bed: Flanders as a model for New York

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# Waste in Flanders

- 2000, landfill ban for untreated MSW and some industrial wastes
- Thermal waste treatment capacity insufficient → exceptions

  2004, 96 kton MSW; 485 kton industrial waste; 69 kton residues of paper, textile and wood recovery were still landfilled
- To realise ban effectively, with (almost) no exceptions, more thermal treatment capacity required

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# Sludge in Flanders

- Shortage of incineration capacity for sludge ← amount of sludge was growing
- 2014, sewage plants (~300) produced 97 kton sewage sludge (DM)

not used fertiliser, compost ← Cu,

not landfilled ← ban

incinerated grate F, FB 61

power and cement plants 36 kton

- Industrial sludges: deinking, water treatment in paper, textile, food industry

treated in FB

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# Fluidised bed installation

FB installation (SLECO, 2005) provided

- additional incineration capacity for industrial and MSW → landfill ban effectively maintained
- incineration capacity for treatment of sludge (sewage and industrial)

Solid wastes considered usually high calorific → cocombustion with low calorific wet sludge ideal, otherwise cooling (water injection) to avoid ash melting, defluidisation, agglomeration

In FB waste combusted in turbulent sand bed, fluidised by air injection at bottom of bed

This causes scrubbing, mechanical treatment + thermal treatment

Depending on v and way of injection of air, 3 types:

Boiling, BFB

Internally rotating, RFB

Circulating, CFB

# Internally rotating fluidised bed combustor : RFBC

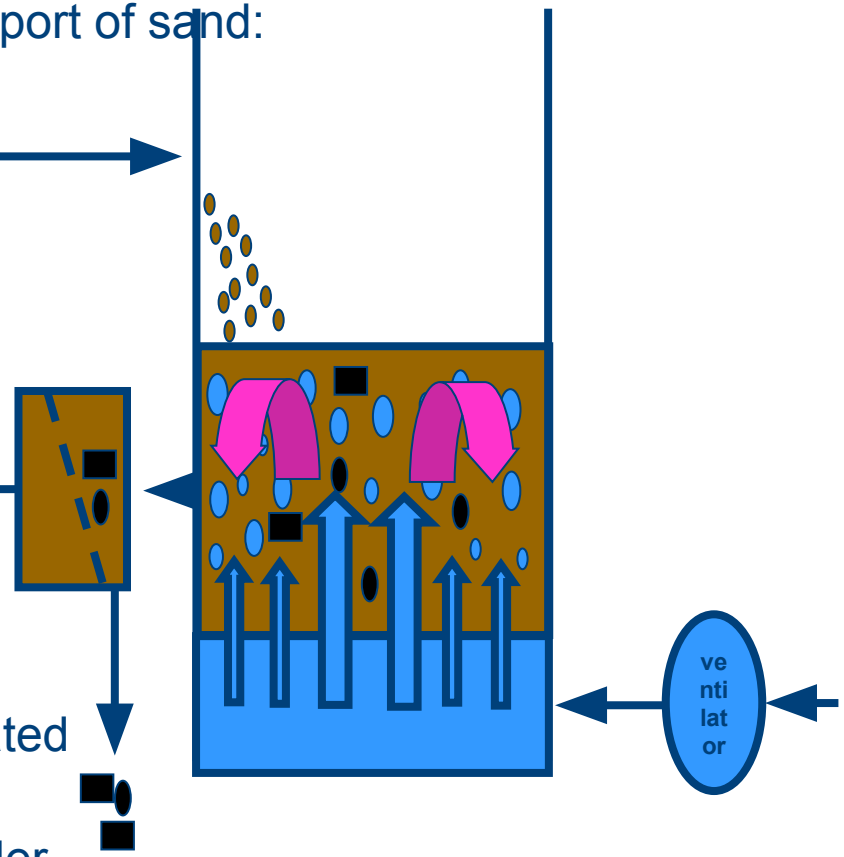
- In RFBC flow pattern of air → internal transport of sand:
  center, strong aeration → rises
  side, less aeration → descends
- At side, bed material continuously collected, sieved
  - Coarse (>1.5 mm) → bottom ash
  - Fine (<1.5 mm) → returned above bed

  No limitation of amount of coarse ash
- Small waste size not required in contrast to BFBC, CFBC

  Waste < handsize
  - Most domestic and comparable waste, RDF, ASR in principle not pretreated
  - Others shreddered (e.g. matresses)
  - For safety all solid waste through shredder
- Waste, sludge added above bed

  Under bed: primary air added in substoichiometric amount

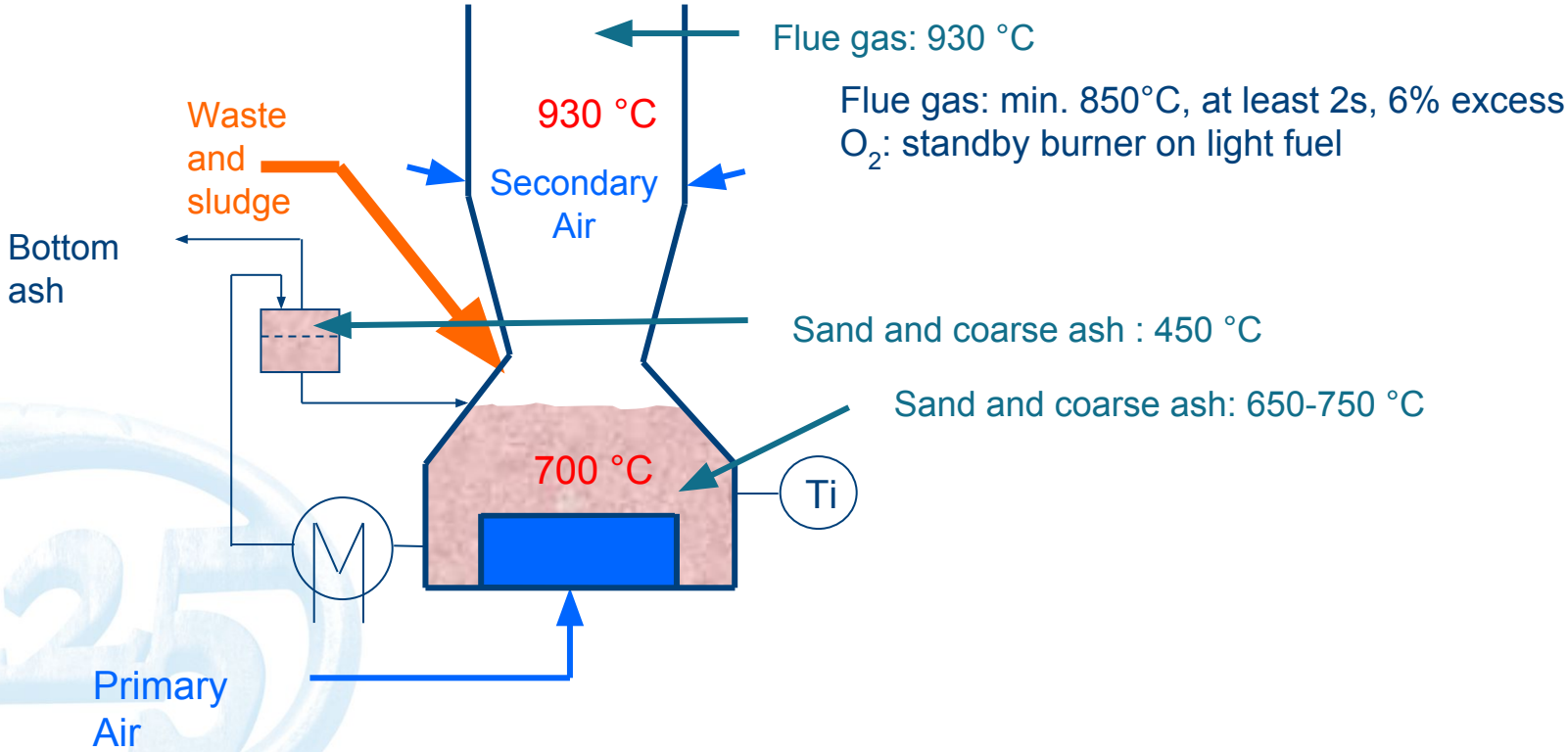
  Above bed: secondary air to arrive at an excess of oxygen



# INDAVER + SITA fluidised bed: **Sleco**

- Opened september 2005,
- Largest in Europe
- Lines: 3 identical
- Design: EBARA
- ROWITEC rotating FB incineration technology
- Capacity: approx. 580 000 t per year,
  1/3 (industrial) **sludge** (15-35% DM)
  2/3 **non-hazardous industrial waste**
- Thermal power: 134 MW
- Bed cross-sectional area of 1 FBC line: 22.4 m² (2.8 m x 8.0 m)
- Investment cost: 180 million € (2006)

# FBC: Temperatures



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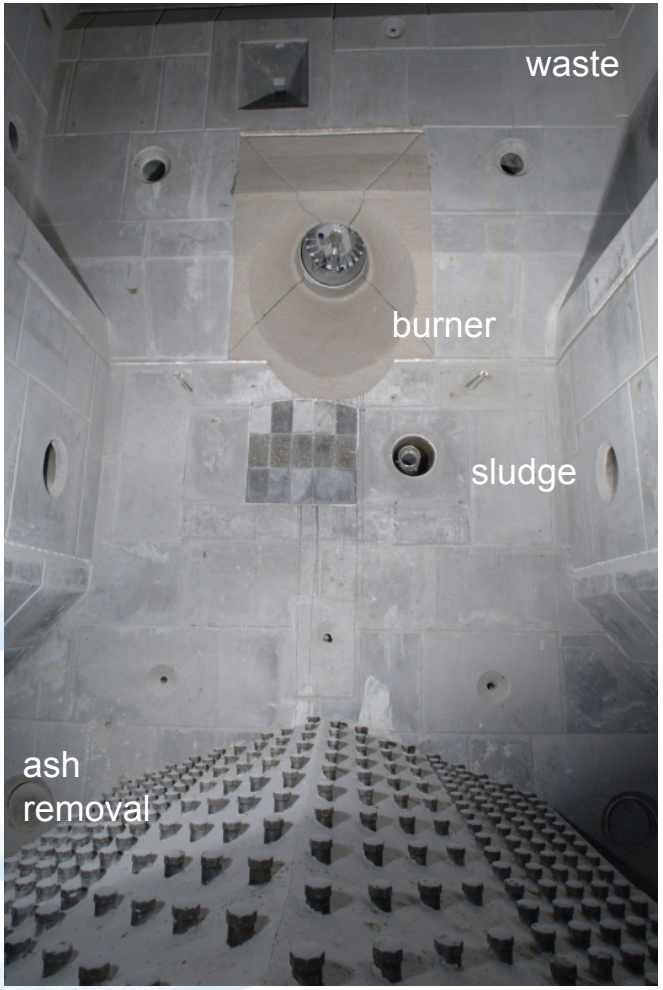




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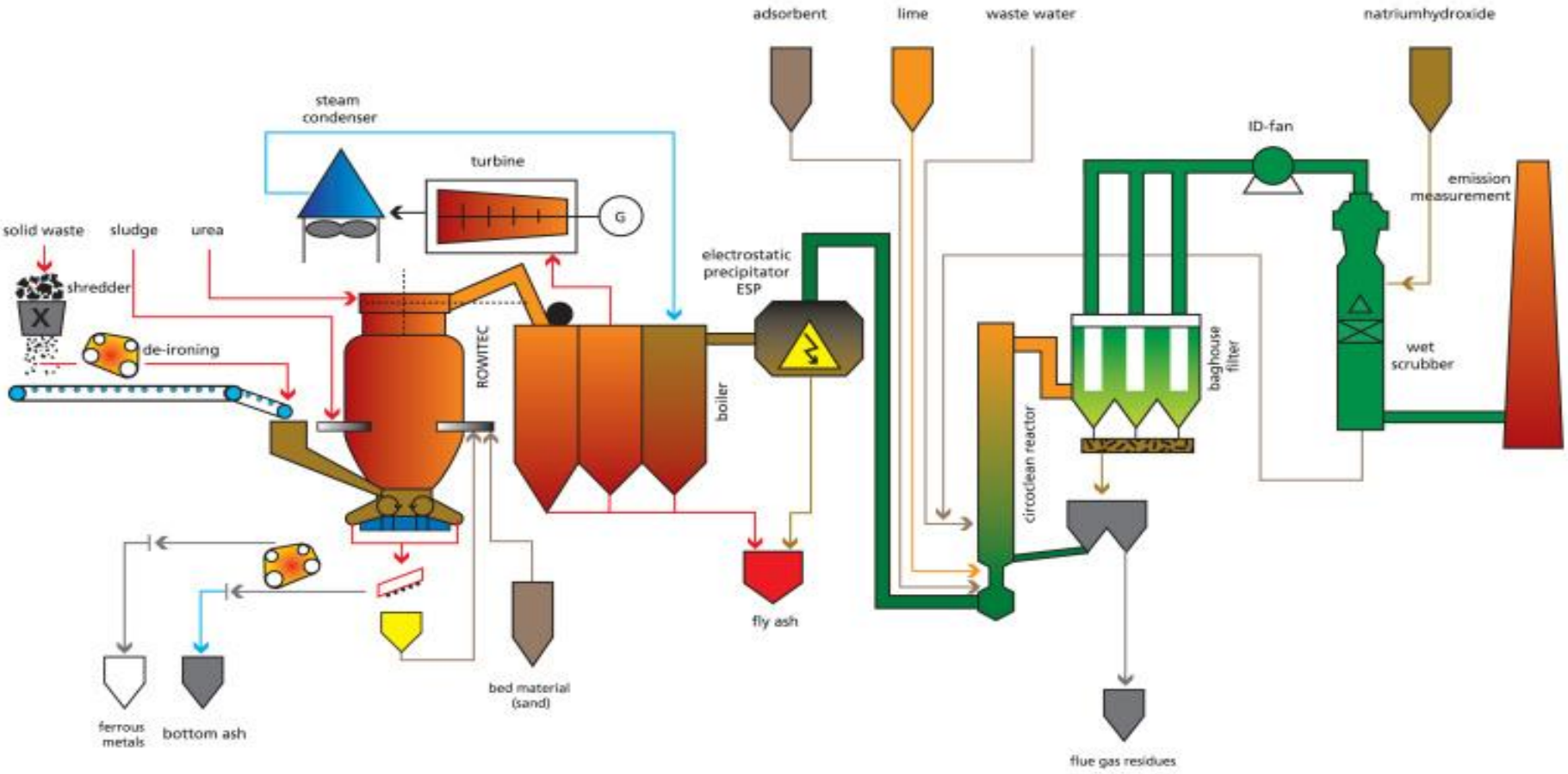
# Fluidizing bed incinerator

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# Fluidised bed incinerators Doel – Mass balance 2017

## IN

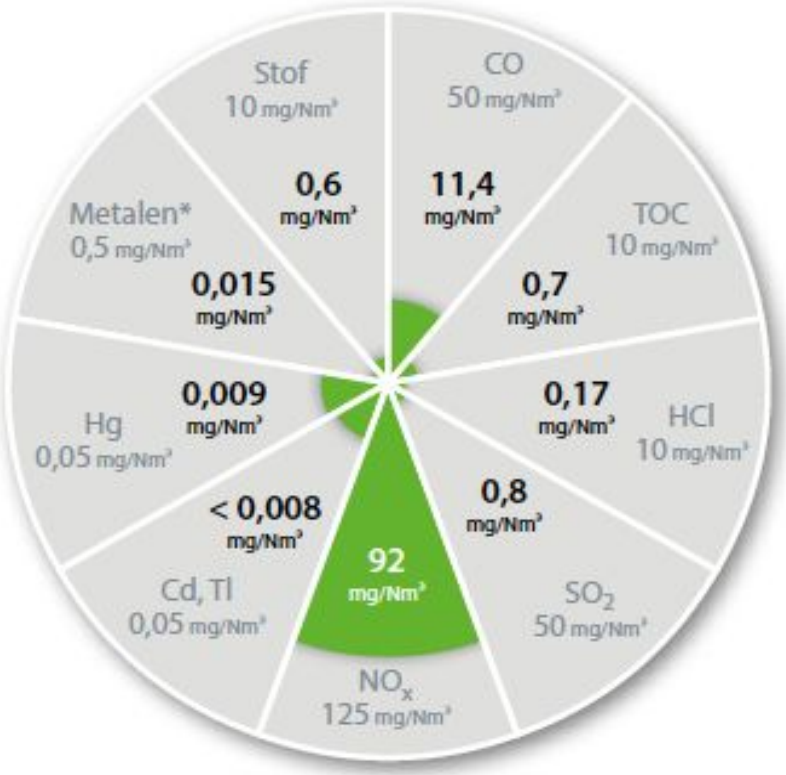
| | |
|---|---|
| Waste | 618,962 tonnes |
| **Energy** | |
| Heating oil | 1,114 tonnes |
| Steam | 114,461 GJ |
| Electricity | 70,144 MWh |
| **Flue gas cleaning additives** | |
| Quicklime | 9,819 tonnes |
| NaOH | 237 tonnes |
| Absorbent for dioxins and heavy metals | 632 tonnes |
| DeNOx reagent | 840 tonnes |
| **Incinerator additives** | |
| Sand | 4,736 tonnes |
| **Water** | |
| Mains water | 319,556 $m^3$ |
| Re-used water | 20,278 $m^3$ |

## OUT

| | |
|---|---|
| **Emissions to atmosphere** | |
| Flue gases | 2,518,780,000 $Nm^3$ |
| **Energy** | |
| Energy | 4,149,621 GJ |
| **Water discharged** | |
| Waste water | 0 $m^3$ |
| **Residual products** | |
| Bottom ash | 41,548 tonnes |
| Electrostatic filter and boiler ash | 93,281 tonnes |
| Flue gas cleaning residue | 17,452 tonnes |
| Scrap | 2,004 tonnes |

# Incineration of ASR

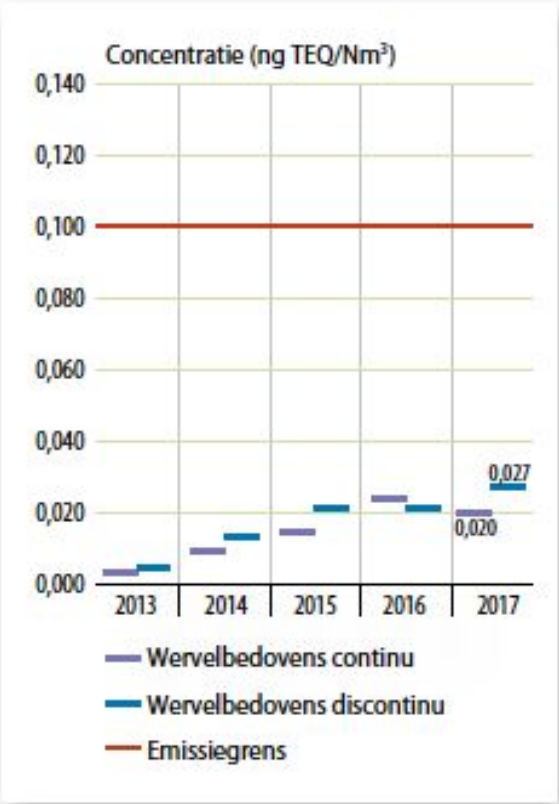
- Environmental concern:
  - Change **emissions to the air:** impact on human health?
- Normal waste input: 30% WWT sludge + 70 % RDF
  - Calorific value 8.7 MJ/kg
- 8 day full scale trial:
  - Input: 50% WWT sludge + 25% RDF + 25% heavy ASR
- All input and output streams were analysed for pollutants in both situations




Daggemiddelde norm tenzij anders vermeld in milieuvergunning

Prestaties 2017

(*) Som van Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn




Vuilvracht dioxines = 57,1 mg TEQ
(in normale omstandigheden)

www.indaver.com



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# Human toxicity, POPs

| INPUT | Sludge/RDF (30/70) | Sludge/RDF/ASR (50/25/25) |
|---|---|---|
| PCDD/Fs [µgTEQ/ton] | 2.8 | 60 |
| Dioxin-like PCBs [µgTEQ/ton] | 9.4 | 197 |
| PCBs [mg/ton] | 445 | 3,586 |
| PAH [mg/ton] | 6,127 | 38,129 |

- POP concentration in input higher with ASR
- Most important conclusions:
  - Not much change in POP output compared to normal input
  - POPs in the input are efficiently destroyed during incineration
  - Formation of new POPs in post combustion process is to a large extent independent of POP input

# Human toxicity, heavy metals

| INPUT | | Sludge/RDF (30/70) | Sludge/RDF/ASR (50/25/25) |
|---|---|---|---|
| **Hg** | **[g/ton input]** | 4.4 | 6.6 |
| **Cd + Tl** | **[g/ton input]** | 36 | 30 |
| **Other** (sum Sb,As,Pb,Cr,Co,Cu,Mn,Ni,V,Sn) | **[g/ton input]** | 1,235 | 2,064 |

- Inputs of heavy metals **increase,** except Cd +Tl
- Emissions remain well below regulatory limit
  - Hg: 0.009 0.032 < 0.05 mg/Nm$^3$
  - Cd + Tl: <0.008 <0.008 < 0.05 mg/Nm$^3$
  - Other HM 0.015 0.021 < 0.5 mg/Nm$^3$



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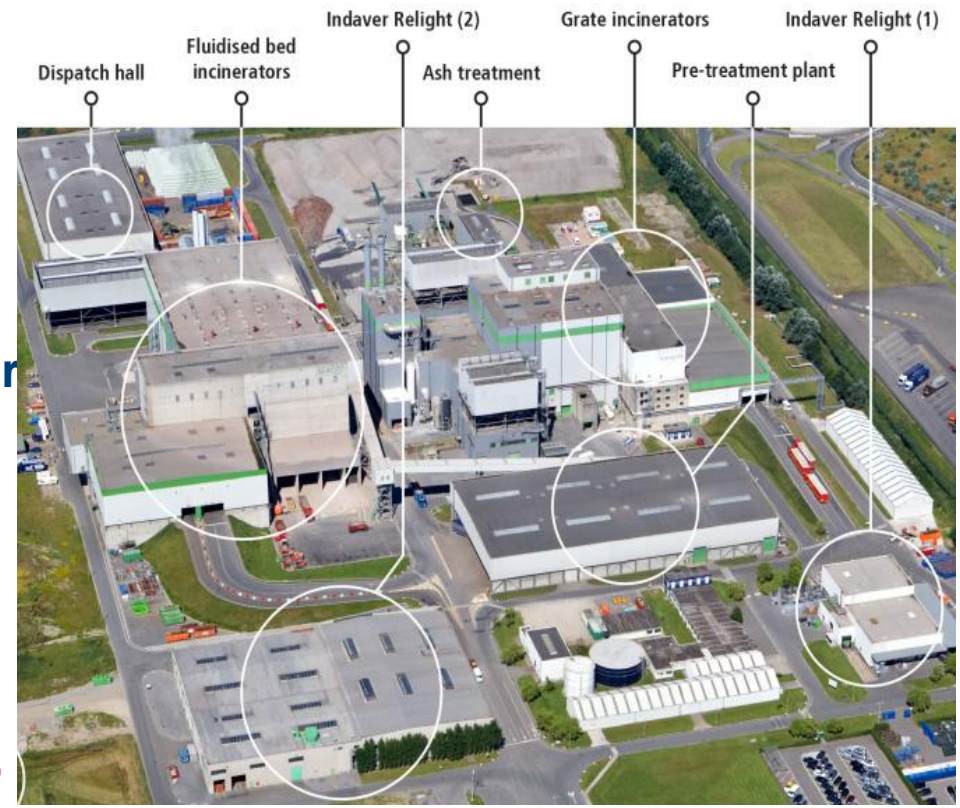
# Ecluse




**3 SLECO FB incinerator lines** (sludge & solid waste) situated in INDAVER **waste treatment complex** in Antwerp (left bank) along with a.o.3 **grate furnace incinerator lines** (household & commercial waste)

Overall 1,000,000 ton/y; heat (steam) production: 250 $MW_{th}$

MSW, sludge contain material from biological origin. Energy ~50% renewable, ~50% of $CO_2$ climate neutral

Port of Antwerp home to largest chemical cluster in Europe
Chemical industry energy intensive, needs lots of steam for use in distillations, evaporation/drying, driving endothermal chemical reactions

# Ecluse

- In WtE, the steam generated in boiler is applied in a Rankine superheated steam cycle to generate electricity using turbine, as in fossil fuel power plant
- In WtE less advanced steam conditions (400°C, 40 bar) ← flue gas (more Cl, Na, K) corrosive and smaller installations

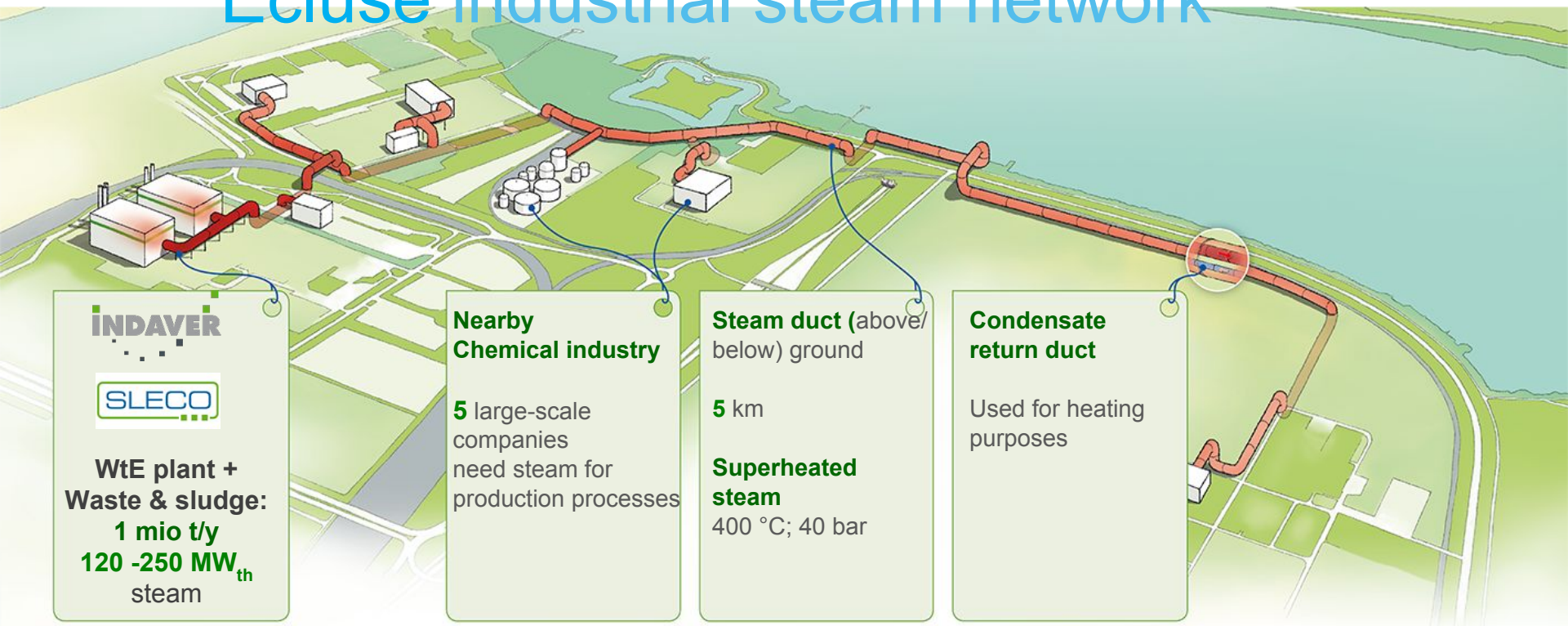
→ lower $\eta_e$ (typically 20-25%)

In WtE (as in other power plants) 3 possibilities for energy utilisation:

- generate **electricity, residual energy (**LP steam from turbine**) lost in condenser**→ limited $\eta_e$
- generate **electricity**, **and also use residual thermal energy (steam, hot water)** e.g. in district heating network. CHP → high overall η. Ex. Scandinavian countries, Vienna, Paris
- use high T, high p steam (in part) directly→ high overall η (up to 80-90%).

- In many countries (e.g. B) WtE not in or near city, but in industrial area. Steam can then be used in an industrial steam network eg the ECLUSE network from Indaver

# Ecluse industrial steam network




Location: Antwerp port– Waasland port

ECLUSE provides high temperature, high pressure, **process steam** to chemical companies and replaces approximately 10 steam boilers

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# ECLUSE in figures


**5 km**
*network*

**100 000 tonnes**
*$CO_2$ reduction/year*

**2018**
*start operations*

**30 mio EUR**
*investment*

**10 mio EUR**
*subsidy by Flemish government*

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# Conclusion

- In Flanders SLECO + ECLUSE provide:
- Combustion capacity
  - High calorific MSW and non-hazardous industrial waste
  - Wet sludge (sewage and industrial)
- High p and T process steam for (chemical) industry

- As in New York similar needs exist, a similar installation may prove highly useful