ECN

Energy research Centre of the Netherlands

ALLOTHERMAL GASIFICATION for CO-FIRING

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- Gasification
- Allothermal gasification
- ECN-technology
- Comparing CFB with allothermal
  - Efficiency
  - Ash components
- Conclusions

GASIFICATION

the reactions

combustion:

fuel + air ($\lambda > 1$) → flue gas + heat

25%

pyrolysis:

fuel + heat → gas + char

75%

+

gasification:

fuel + air ($\lambda \sim 0.3$) → gas

solid fuel is converted to gaseous fuel… for further processing

GASIFICATION
for indirect co-firing

- Conversion to something acceptable for existing boiler: gaseous fuel
- Option to separate ashes: less fouling, less coal ash “pollution”
- Can handle hard-to-pulverize fuels

- Rule of thumb: every 1 Euro/GJ (15 Euro/ton, 3.6 Euro/MWh) lower fuel costs compensates for an extra 250 Euro/kW_e capex

capital costs 15%, O&M 5%, 0.1 Euro/kWh, 7500/6500 h/y direct/indirect, 40%/38% direct/indirect

GASIFICATION
for indirect co-firing

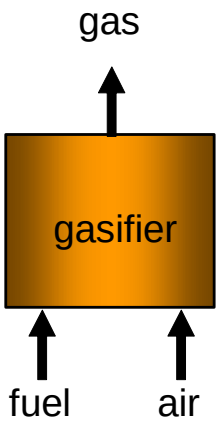
CFB FW, Lahti (Fin), co-firing PF boiler, 45 $MW_{th\_biomass}$

CFB Metso, wood, Varo (Swe), co-firing lime kiln 35 $MW_{th\_biomass}$

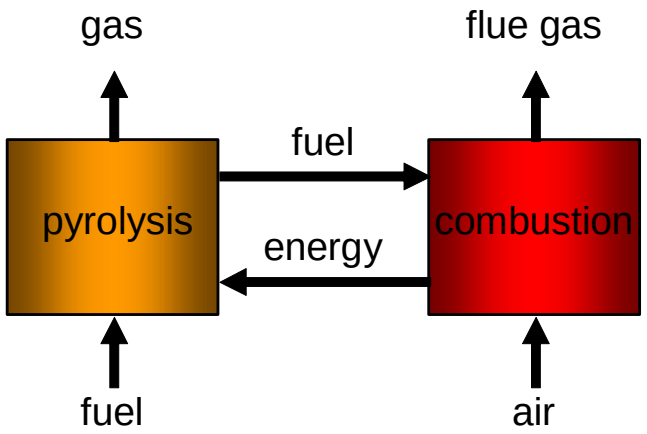
CFB (Lurgi), waste wood, Geertruidenberg (NL), co-firing PF boiler 85 $MW_{th\_biomass}$

ALLOTHERMAL GASIFICATION

- direct:
  - one vessel
  - all reactions



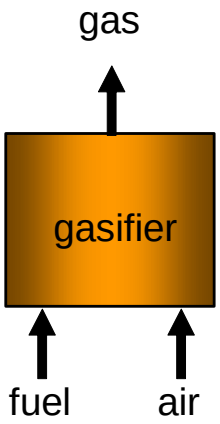
- allothermal:
  - two coupled reactors
  - combustor supplies heat



ALLOTHERMAL GASIFICATION

gasification:

fuel + air (λ~0.3) → gas

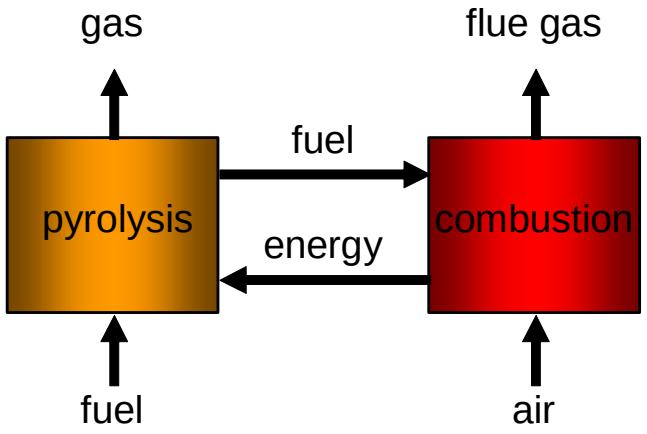


combustion:

fuel + air (λ > 1) → flue gas + heat

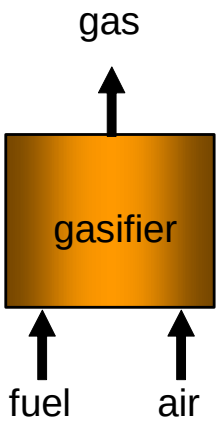
pyrolysis:

fuel + heat → gas + char

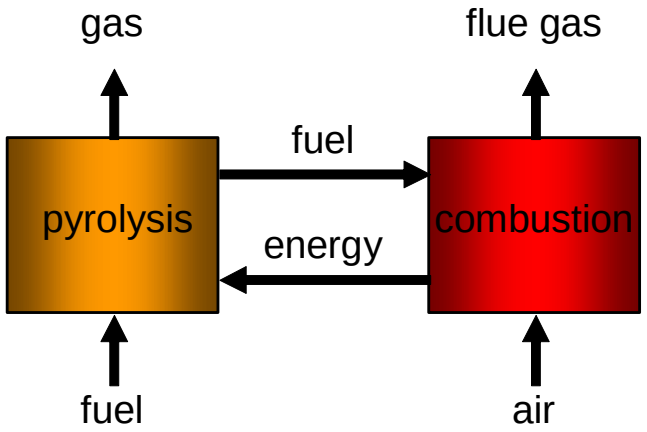


ALLOTHERMAL GASIFICATION

- direct:
  - gas contains ~50% N_2
  - char remains (5-10%)



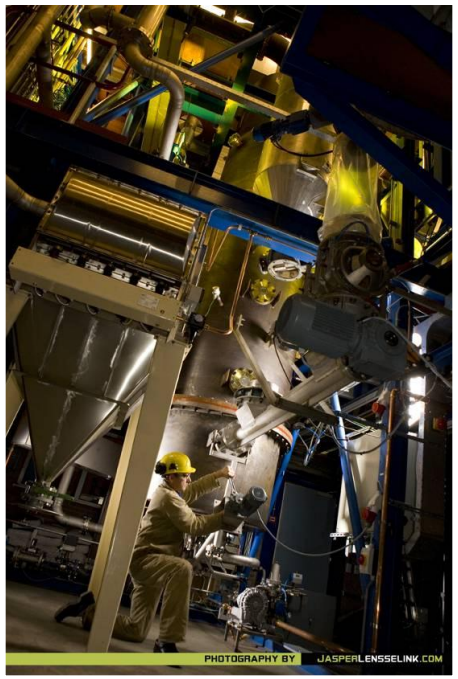
- indirect:
  - complete conversion
  - N_2-free / low-N_2



ALLOTHERMAL GASIFICATION

Rentech, SilvaGas gasifier, Burlington (US), 40 $MW_{th\_biomass}$

Repotec FICFB gasifier, Güssing (Austria), 2 MW_e

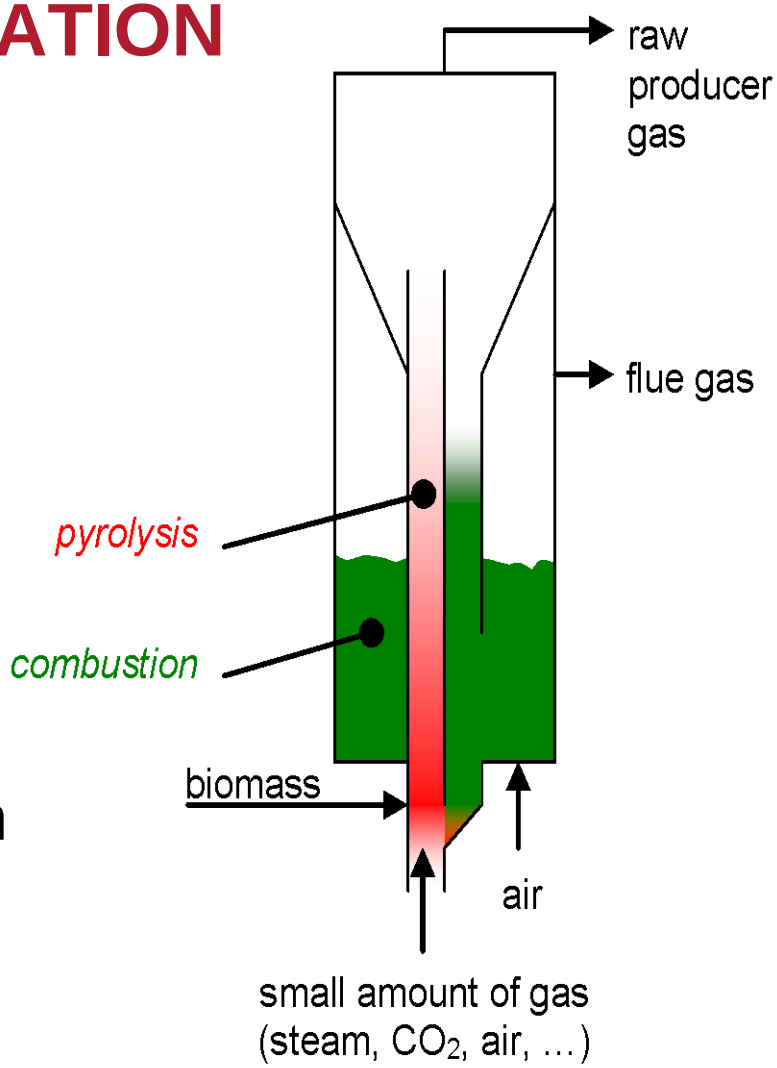


MILENA-technology, ECN pilot plant, 0.8 MW

ALLOTHERMAL GASIFICATION

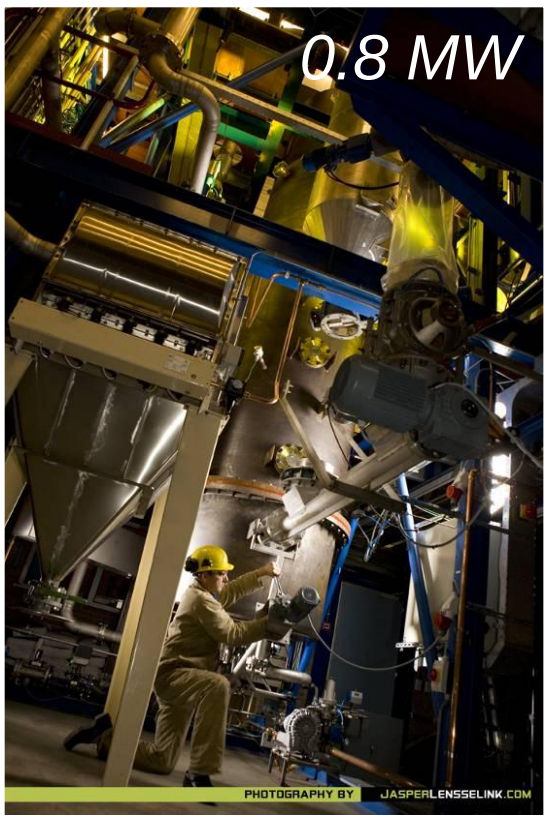
MILENA technology

- Complete conversion
- High efficiency
- Compact design
- 10-15 MJ/Nm^3 producer gas
- Test facilities at ECN
- Tested: wood, demolition wood, grass, lignite, digestion residue, straw, RDF



www.milenatechnology.com


25 kW
MILENA
PHOTOGRAPHY BY
JASPERLENSSELINK.COM


0.8 MW
PHOTOGRAPHY BY
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12 MW

ALLOTHERMAL GASIFICATION

MILENA gas composition (steam)

component	concentration	unit
CO	40	vol% dry basis
H_2	24	vol% dry basis
CH_4	15	vol% dry basis
C_2H_x	4	vol% dry basis
C_6H_x	1	vol% dry basis
tar	40	g/Nm^3 dry basis
N_2	4	vol% dry basis
CO_2	11	vol% dry basis
H_2S, COS, NH_3, …	…	

measured in 0.8 MW MILENA pilot plant at ECN: clean wood, olivine bed material, steam to riser, ~850°C

ALLOTHERMAL GASIFICATION

MILENA gas composition (air)

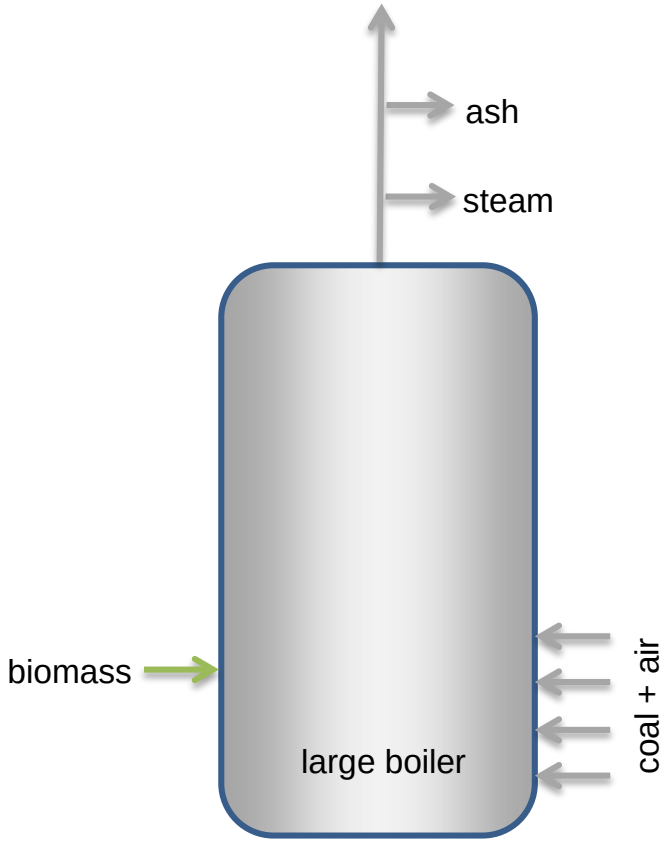
component	concentration	unit
CO	26	vol% dry basis
H_2	26	vol% dry basis
CH_4	12	vol% dry basis
C_2H_x	4	vol% dry basis
C_6H_x	1	vol% dry basis
tar	30	g/Nm^3 dry basis
N_2	12	vol% dry basis
CO_2	17	vol% dry basis
H_2S, COS, NH_3, …	…	

Calculated for 100 MW MILENA: demolition wood, olivine bed material, air to riser (ER=0.03), ~800°C

COMPARING THE OPTIONS
direct co-firing

- All energy in boiler

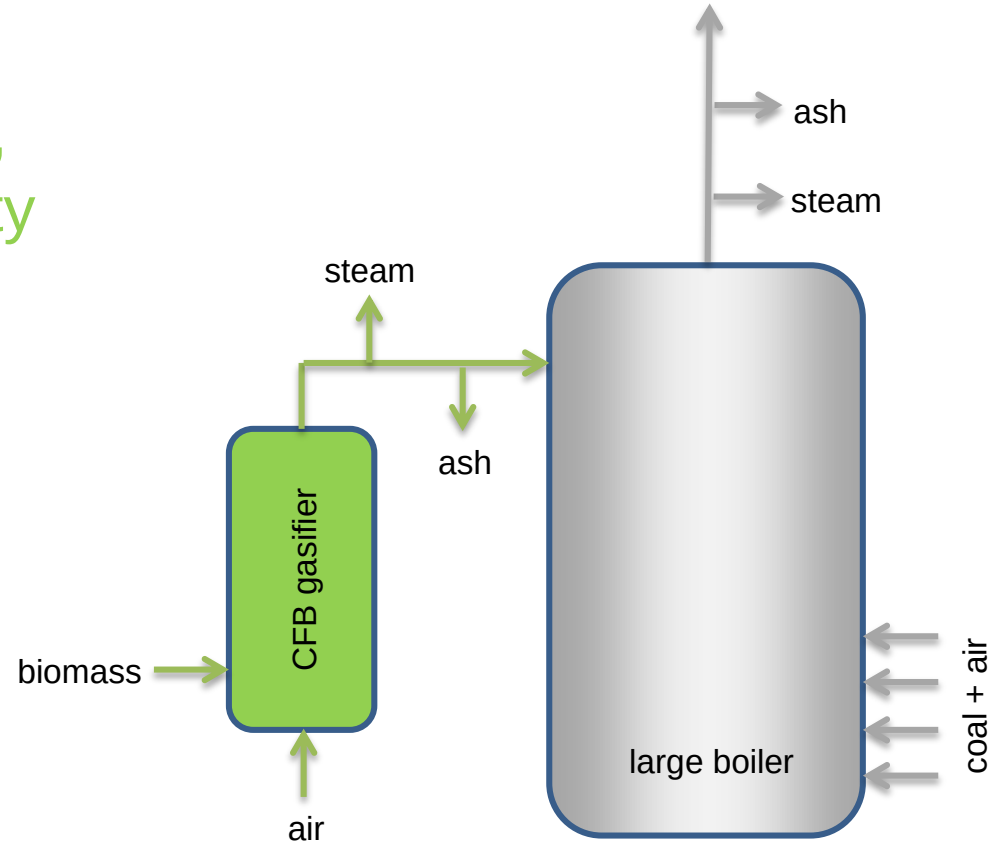
- All ash in boiler, so "limited" to clean biomass
- Biomass needs to be pulverized



COMPARING THE OPTIONS

indirect co-firing through CFB gasifier

- Only part of the ash will end up in boiler, so (more) low quality fuel acceptable
- Energy loss by ash/char
- Ash/char deposit problem
- Ash/char danger of self-ignition

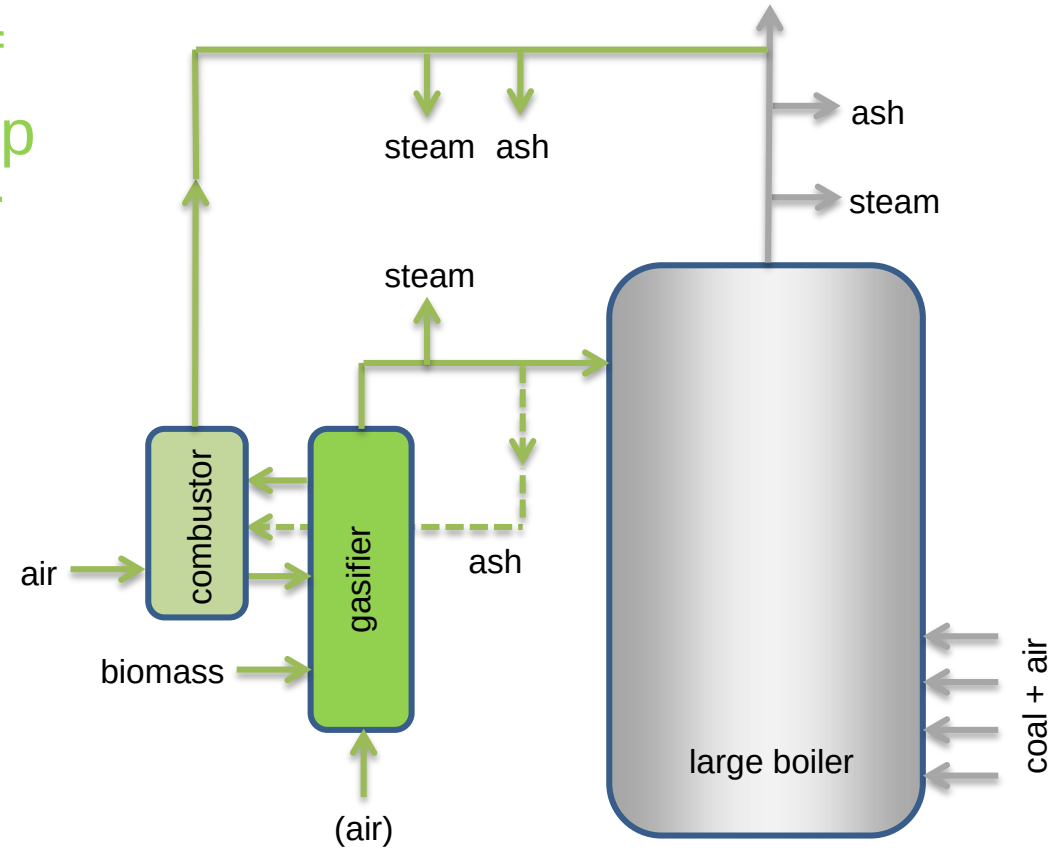


COMPARING THE OPTIONS

indirect co-firing through allothermal gasifier

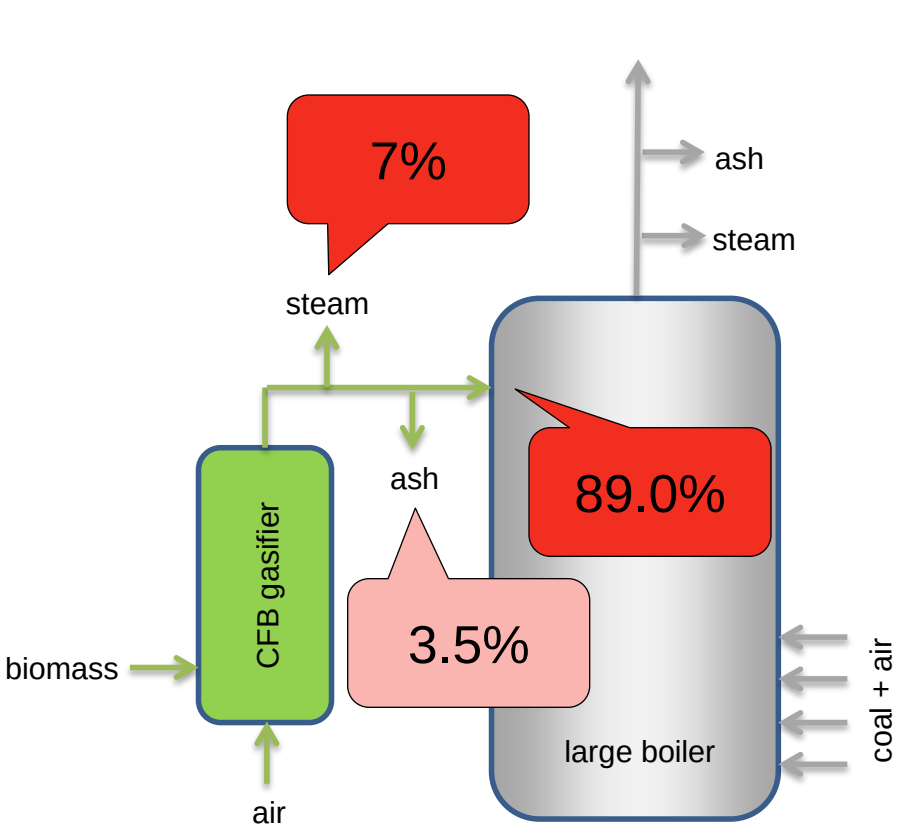
- Only small part of the ash will end up in boiler, so lower quality fuel acceptable
- No combustible waste

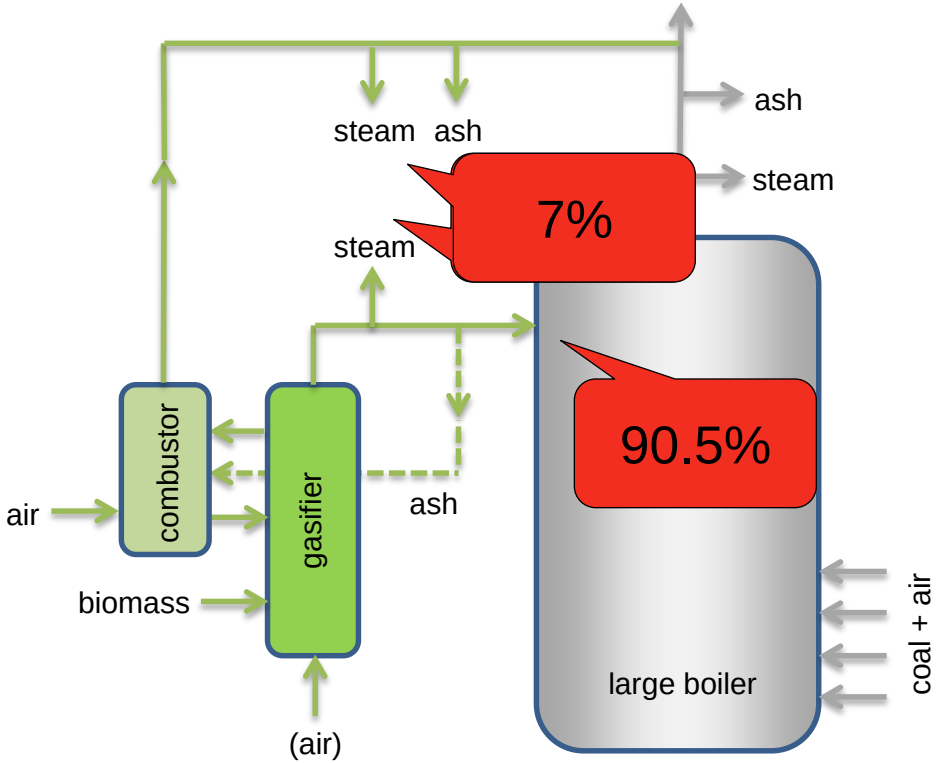
- Complex
- New technology



COMPARING THE OPTIONS

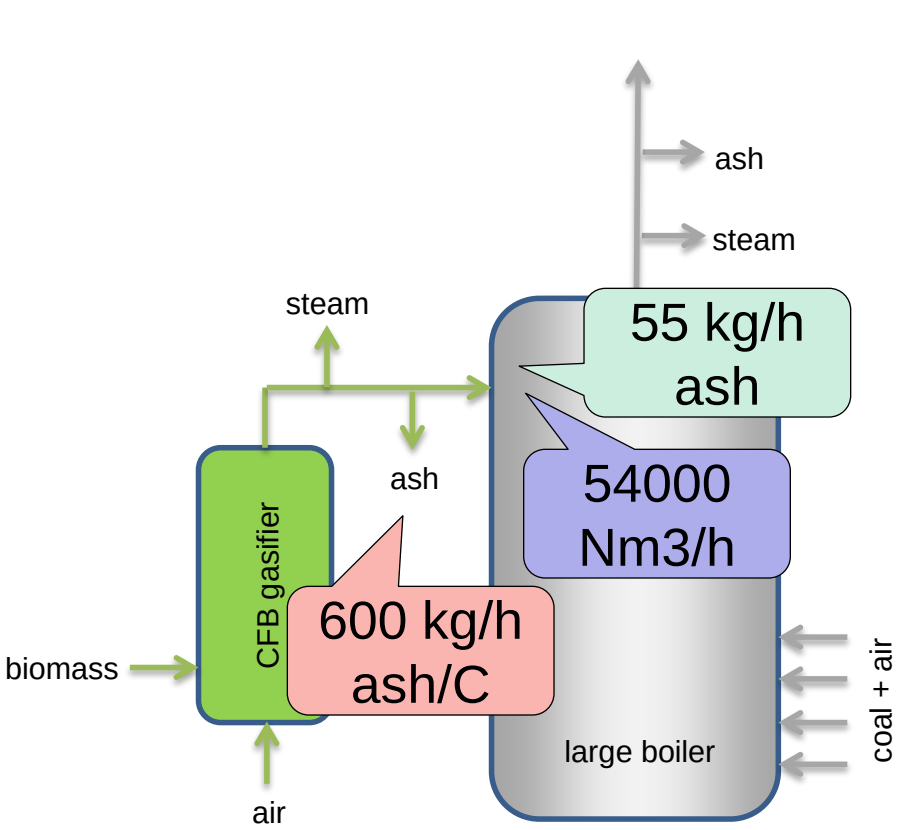
calculated efficiency (biomass LHV = 100%)

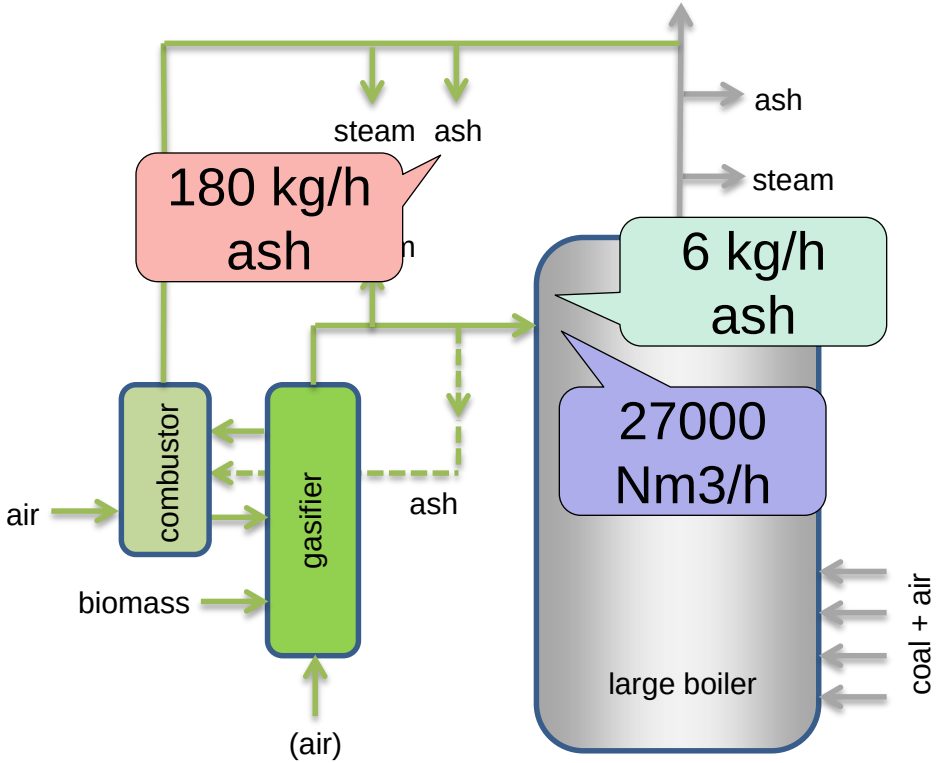




COMPARING THE OPTIONS

calculated, case 100 MW waste wood, 25% moist

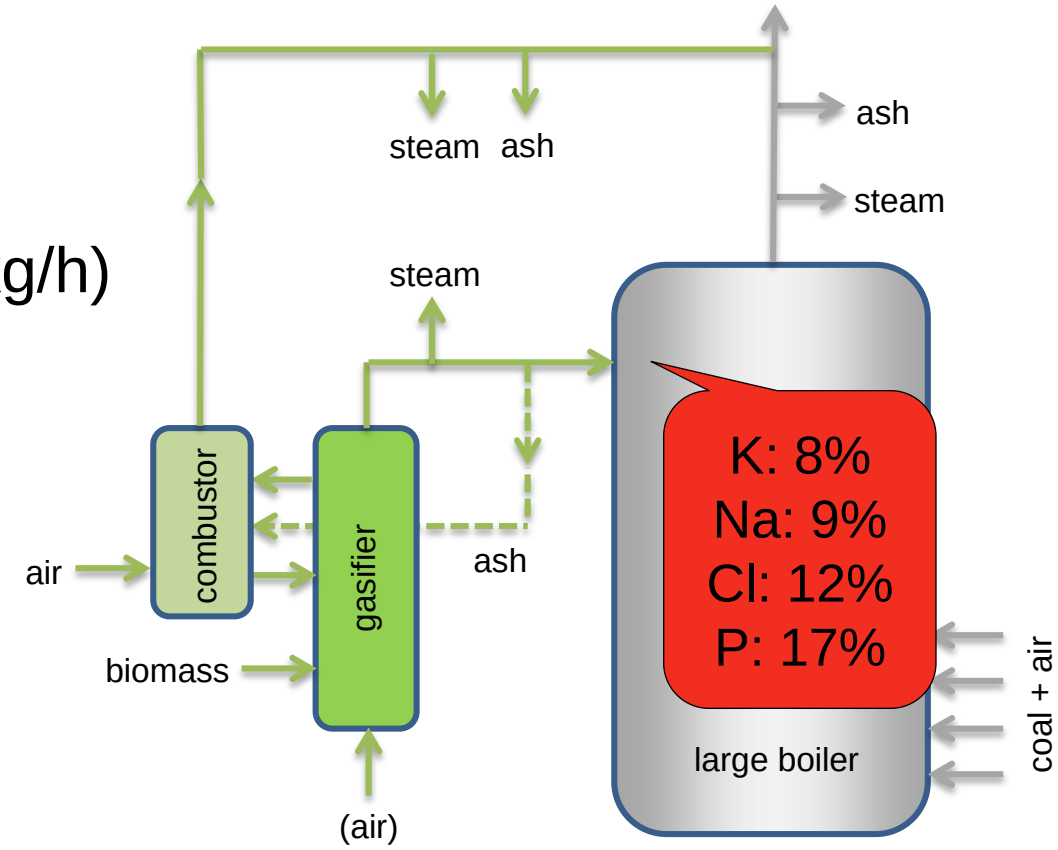




ASH COMPONENTS

MILENA test

- Straw as fuel
- Gasifier at 690°C
- Lab-MILENA (5 kg/h)



INDIRECT CO-FIRING

- Indirect co-firing through gasification creates option to treat dirty biomass/waste
- Because intermediate cleaning (partly) removes ash components
- Fuel specs can be relaxed

- CFB gasifier is *proven* technology
- Allothermal gasifier is *promising* technology…

ALLOTHERMAL vs. CFB GASIFIER
for indirect co-firing

- No carbon in ash (less waste, no self-ignition danger)
- And better efficiency
- Less ash to boiler (less fouling, less corrosion, less coal ash quality issues)
- Lower gas volume to boiler
- Freedom to operate at lower temperature (no conversion penalty): more fuel flexible, better ash removal, higher efficiency

FOR EASY GAS COOLING

TARA technology

Objective: reduction of heavy tars and dust removal:

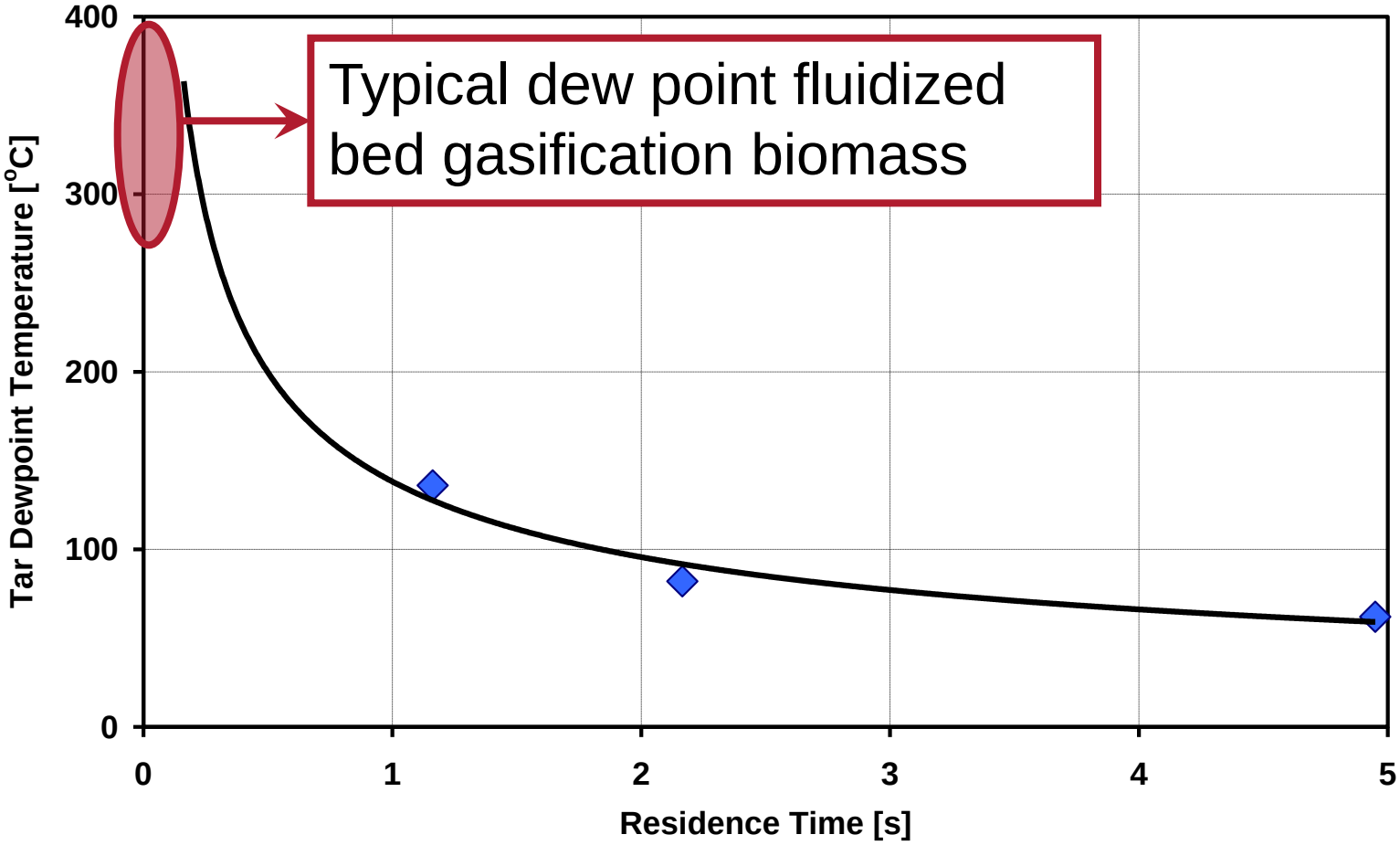
- Straightforward slow moving bed design
- Inexpensive catalyst
- Positioned directly downstream of gasifier
- Catalyst regeneration provides heat

Preliminary results:

- Tar dew point reduced from >300°C to below 100°C
- Dust removal >95%
- Producer gas cooling becomes “a walk in the park”

TARA

effect of residence time



MORE INFORMATION

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publications: www.ecn.nl/publications
fuel composition database: www.phyllis.nl
tar dew point calculator: www.thersites.nl
IEA bioenergy/gasification: www.ieatask33.org
Milena indirect gasifier: www.milenatechnology.com
OLGA: www.olgatechnology.com / www.renewableenergy.nl
SNG: www.bioSNG.com and www.bioCNG.com