



Allothermal Gasification for Co-firing

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ALLOTHERMAL GASIFICATION for CO-FIRING

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CONTENTS

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

GASIFICATION

the reactions

<p><i>combustion:</i></p> <p>fuel + air ($\lambda > 1$) \rightarrow flue gas + heat</p>	25%
<p><i>pyrolysis:</i></p> <p>fuel + heat \rightarrow gas + char</p>	75%
+	
<p><i>gasification:</i></p> <p>fuel + air ($\lambda \sim 0.3$) \rightarrow gas</p>	

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}

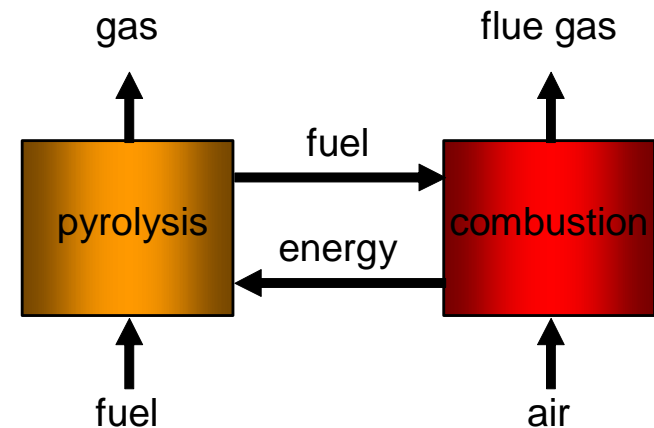
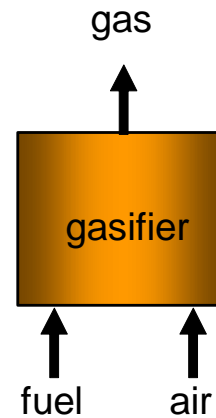


CFB (Lurgi), waste
wood, Geertruidenberg
(NL), co-firing PF boiler
85 MW_{th_biomass}

ALLOTHERMAL GASIFICATION

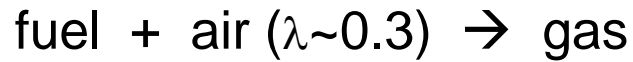
- direct:
 - one vessel
 - all reactions

- allothermal:
 - two coupled reactors
 - combustor supplies heat



ALLOTHERMAL GASIFICATION

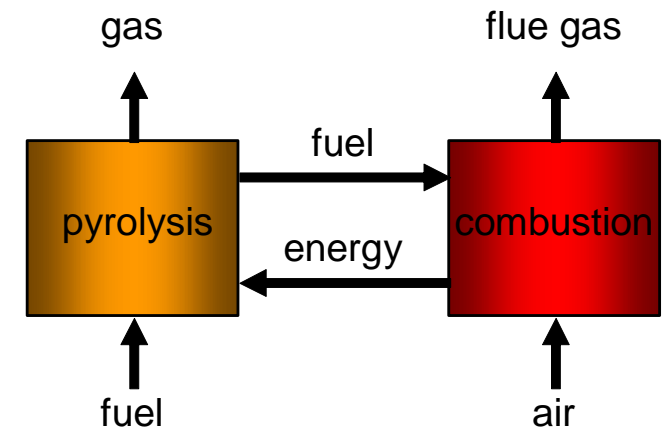
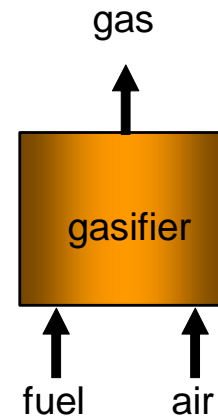
gasification:



combustion:

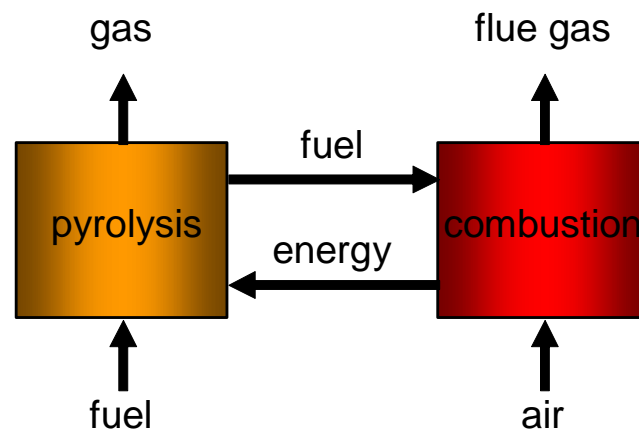
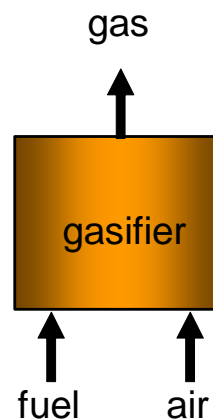


pyrolysis:



ALLOTHERMAL GASIFICATION

- direct:
 - gas contains ~50% N₂
 - char remains (5-10%)
- indirect:
 - complete conversion
 - N₂-free / low-N₂



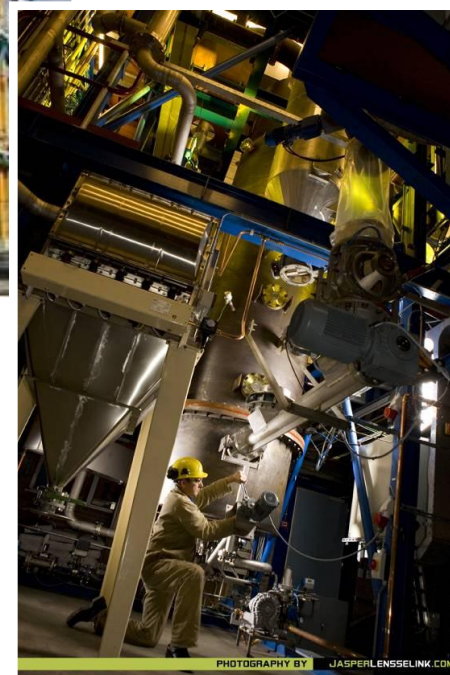
ALLOTHERMAL GASIFICATION



Rentech, SilvaGas
gasifier, Burlington (US),
40 MW_{th_biomass}



Repotec FICFB
gasifier, Güssing
(Austria), 2 MW_e

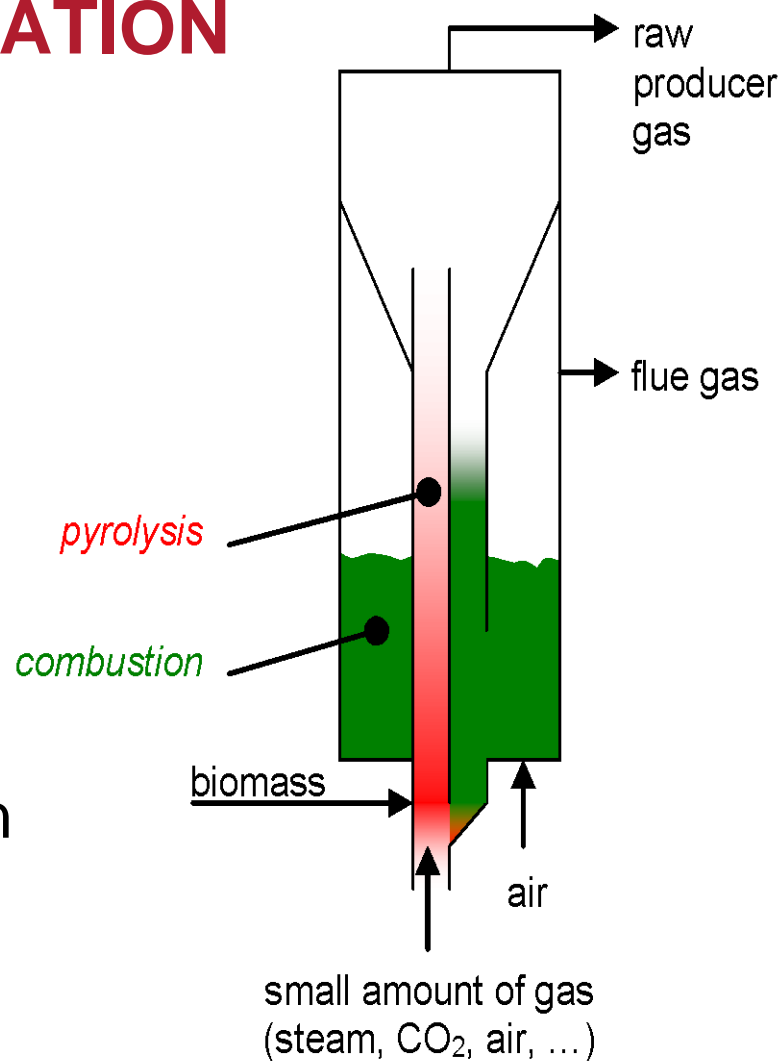


MILENA-technology,
ECN pilot plant,
0.8 MW

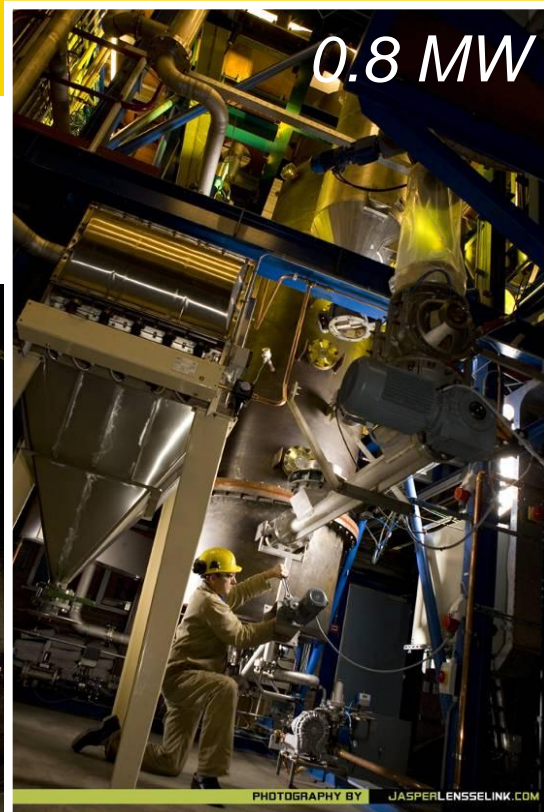
ALLOTHERMAL GASIFICATION

MILENA technology

- Complete conversion
- High efficiency
- Compact design
- 10-15 MJ/Nm³ producer gas
- Test facilities at ECN
- Tested: wood, demolition wood, grass, lignite, digestion residue, straw, RDF



www.milenatechnology.com



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 ₂ H _x	4	vol% dry basis
C ₆ H _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 ₂ S, 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)

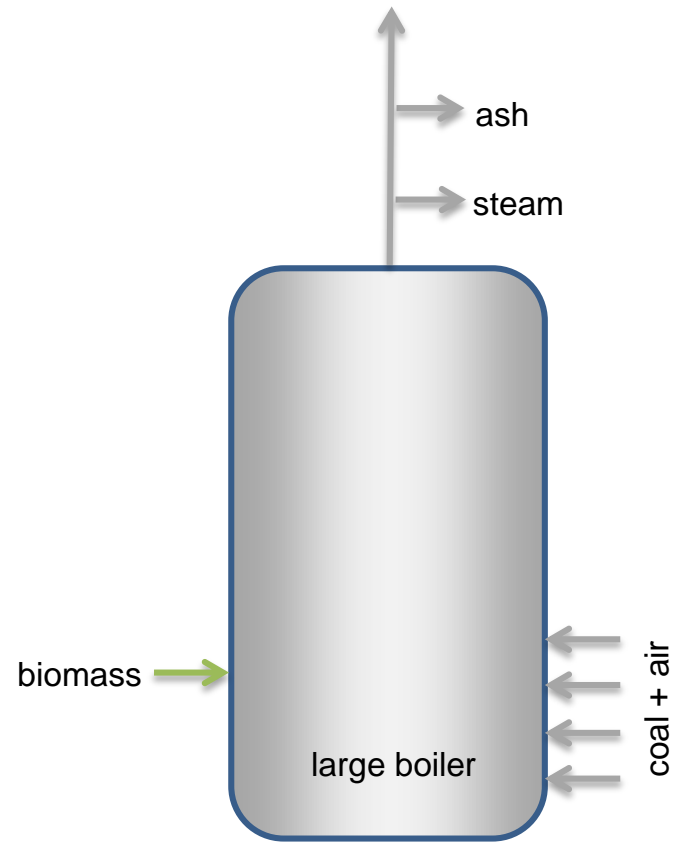
component	concentration	unit
CO	26	vol% dry basis
H ₂	26	vol% dry basis
CH ₄	12	vol% dry basis
C ₂ H _x	4	vol% dry basis
C ₆ H _x	1	vol% dry basis
tar	30	g/Nm ³ dry basis
N ₂	12	vol% dry basis
CO ₂	17	vol% dry basis
H ₂ S, COS, NH ₃ ,	

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

COMPARING THE OPTIONS

direct co-firing

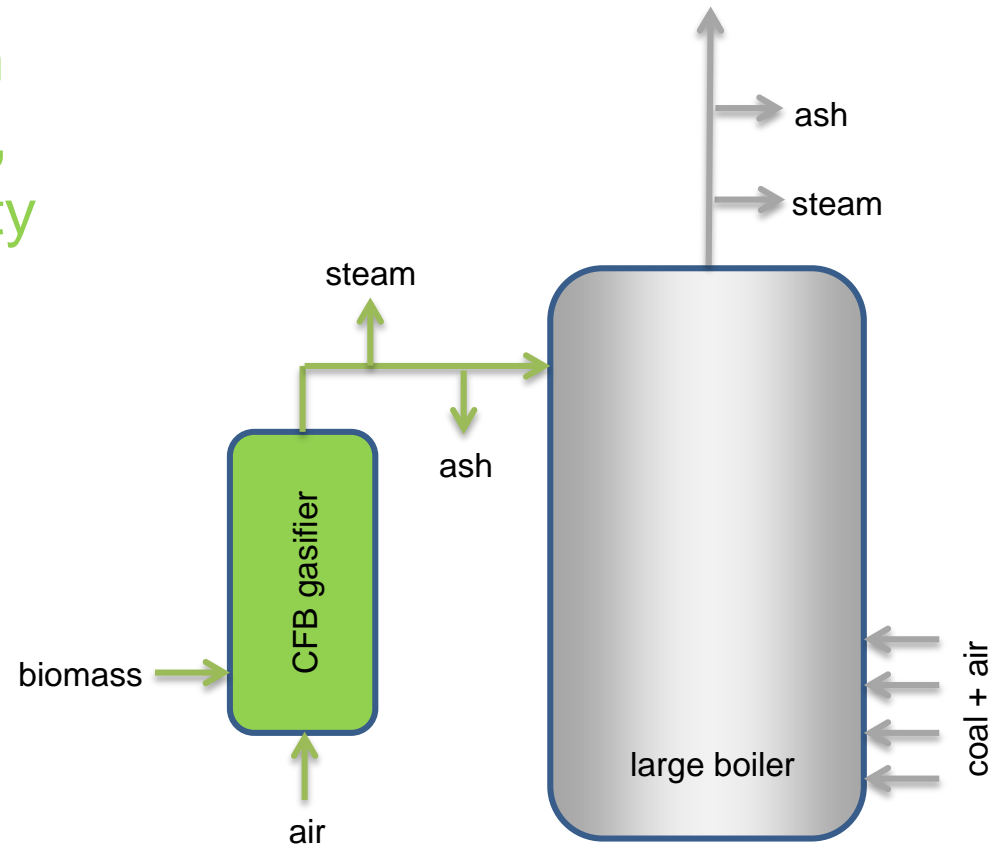
- All energy in boiler
- All ash in boiler, so “limited” to clean biomass
- Biomass needs to be pulverized



COMPARING THE OPTIONS

indirect co-firing through CFB gasifier

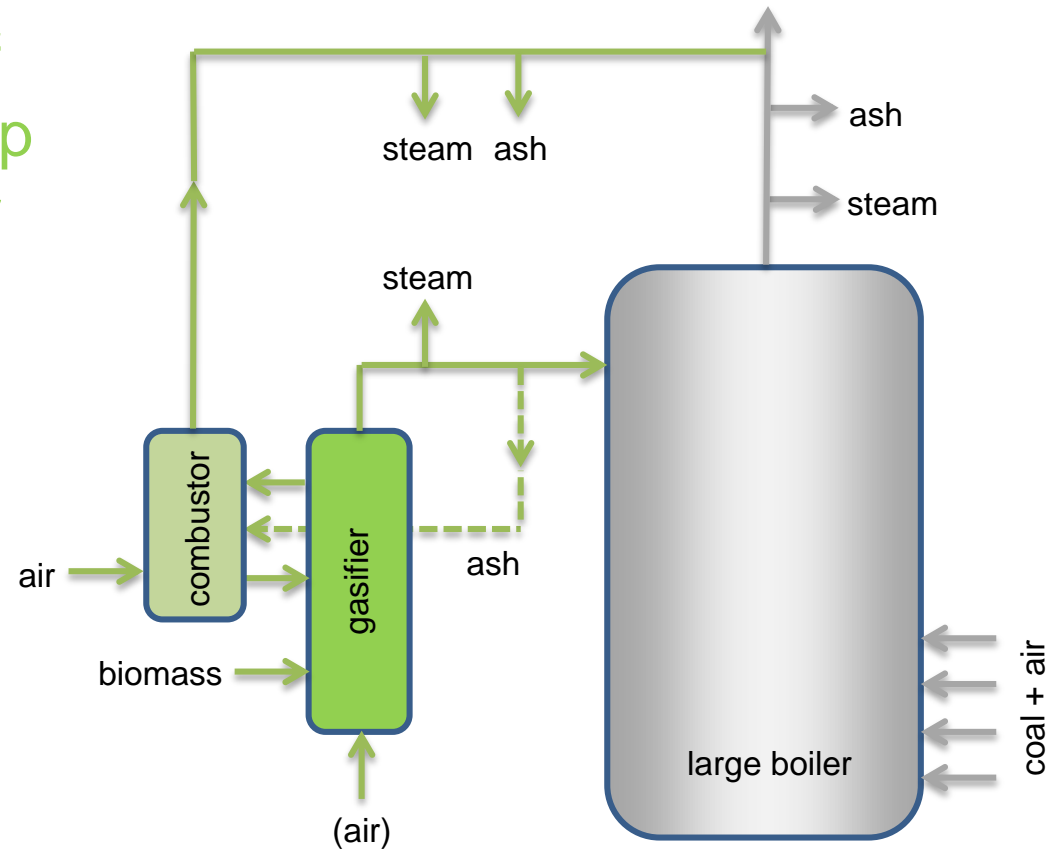
- Only part of the ash will end up in boiler, so (more) low quality fuel acceptable
- Energy loss by ash/char
- Ash/char deposit problem
- Ash/char danger of self-ignition



COMPARING THE OPTIONS

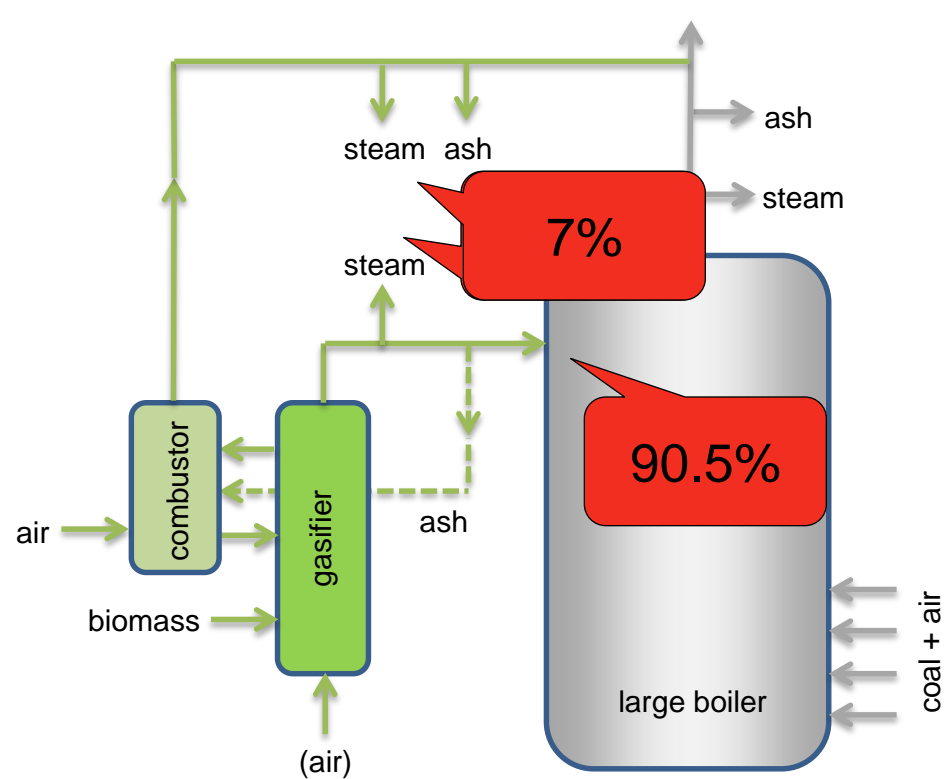
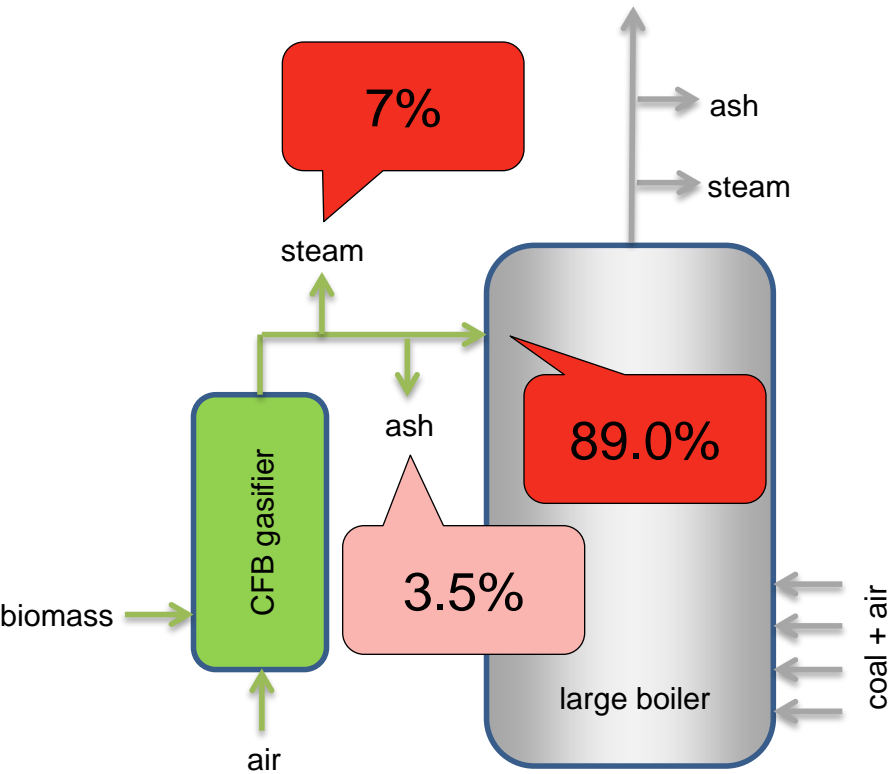
indirect co-firing through allothermal gasifier

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



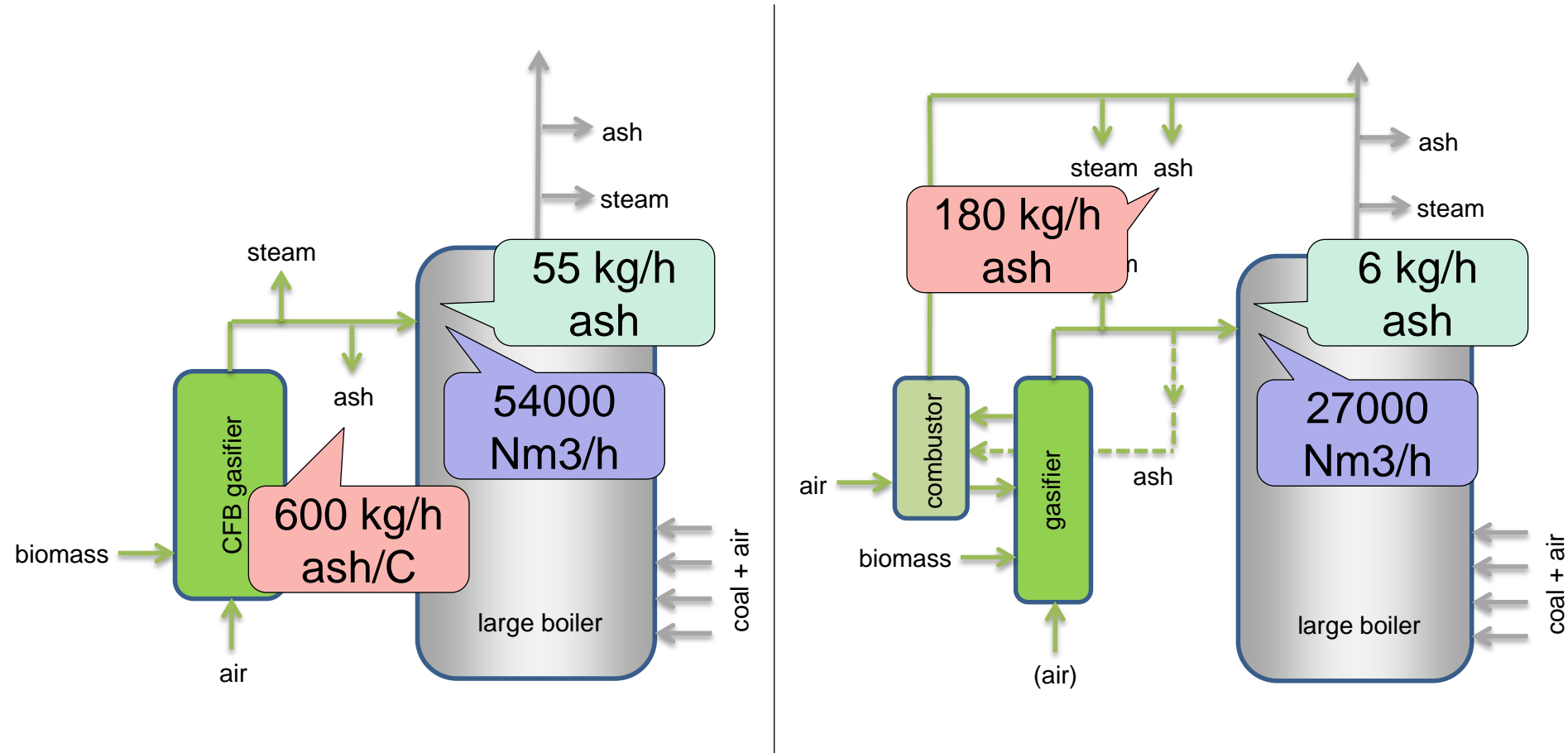
COMPARING THE OPTIONS

calculated efficiency (biomass LHV = 100%)



COMPARING THE OPTIONS

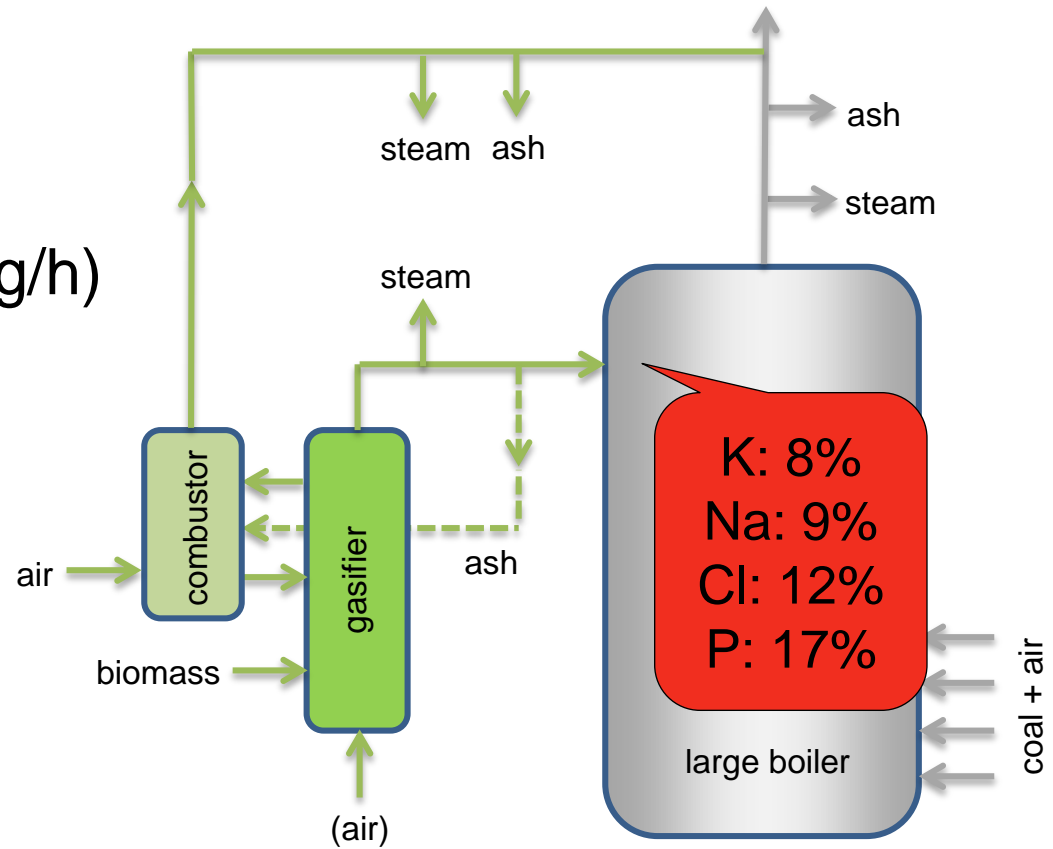
calculated, case 100 MW waste wood, 25% moist



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:

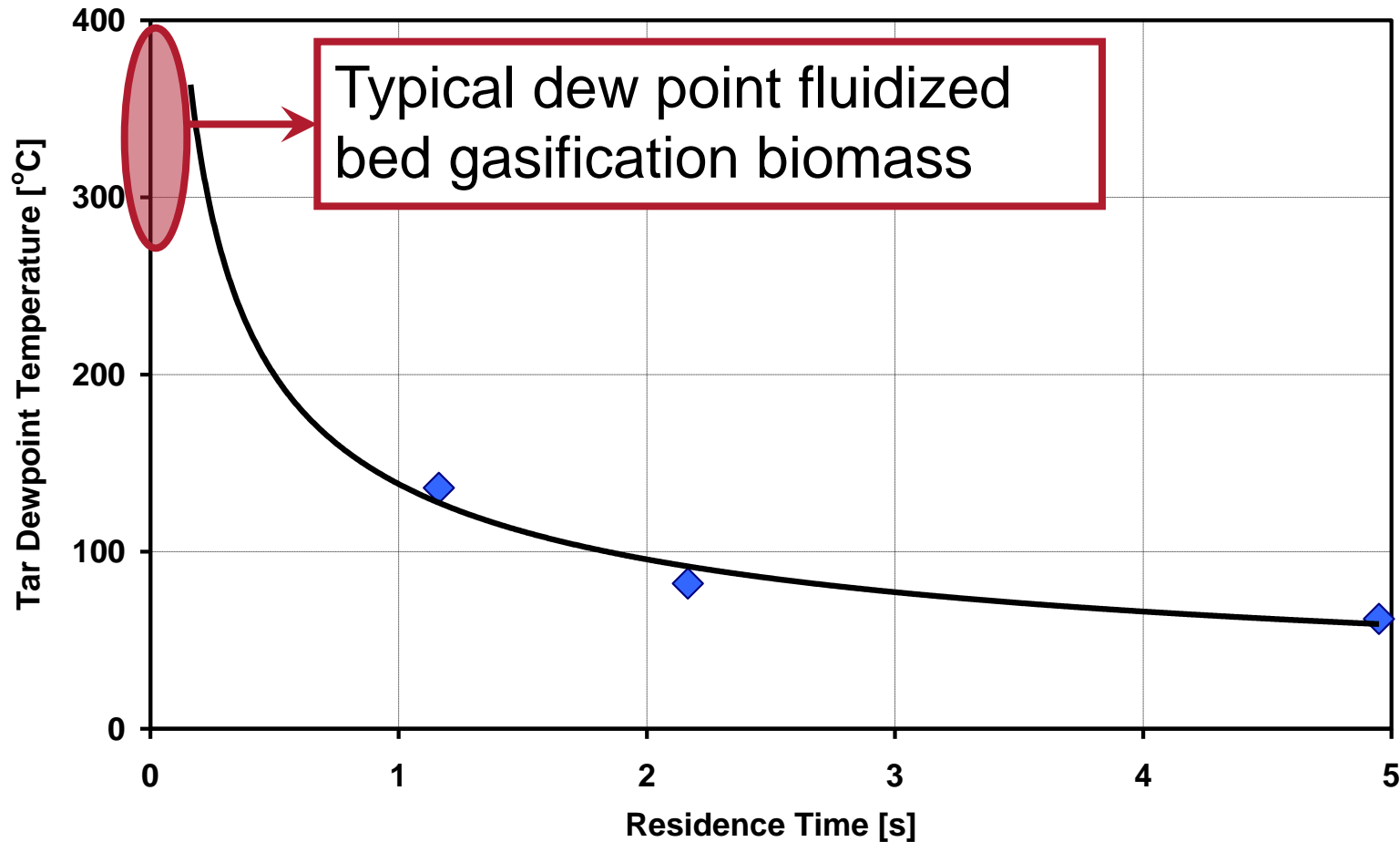
- Straightforward slow moving bed design
- Inexpensive catalyst
- Positioned directly downstream of gasifier
- Catalyst regeneration provides heat

Preliminary results:

- Tar dew point reduced from $>300^{\circ}\text{C}$ 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