Syngas from Biomass

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3rd International Conference on IGCC & Xtl Technologies

18 May 2009, Dresden,Germany

ECN-M--09-144 November 2009

ECN

Energy research Centre of the Netherlands

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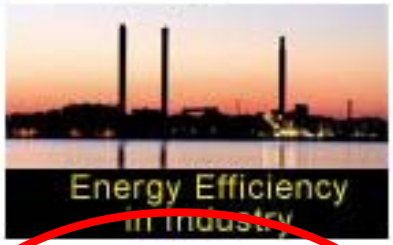
ECN mission: development of high-quality knowledge and technology for the transition to a sustainable energy supply, and bringing this to the market

~72 M€/y turnover
~600 employees (~550 fte)

ECN's business units



Energy Saving

Renewable Energy

Clean Fossil

Why syngas from biomass

- Syngas is a key intermediate product
- Syngas is needed: ~800GW_{th} installed (mainly fossil)
- Transition from fossil fuels to renewable biomass
- CO_2 reductions by “green” syngas
- Biomass: only source of renewable syngas/carbon
- Enabling net negative CO_2 emissions (with CCS)

Gasification is key (solid → gas)

What is Gasification?

combustion:

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

25%

pyrolysis:

fuel + heat → volatiles + char

75%

+

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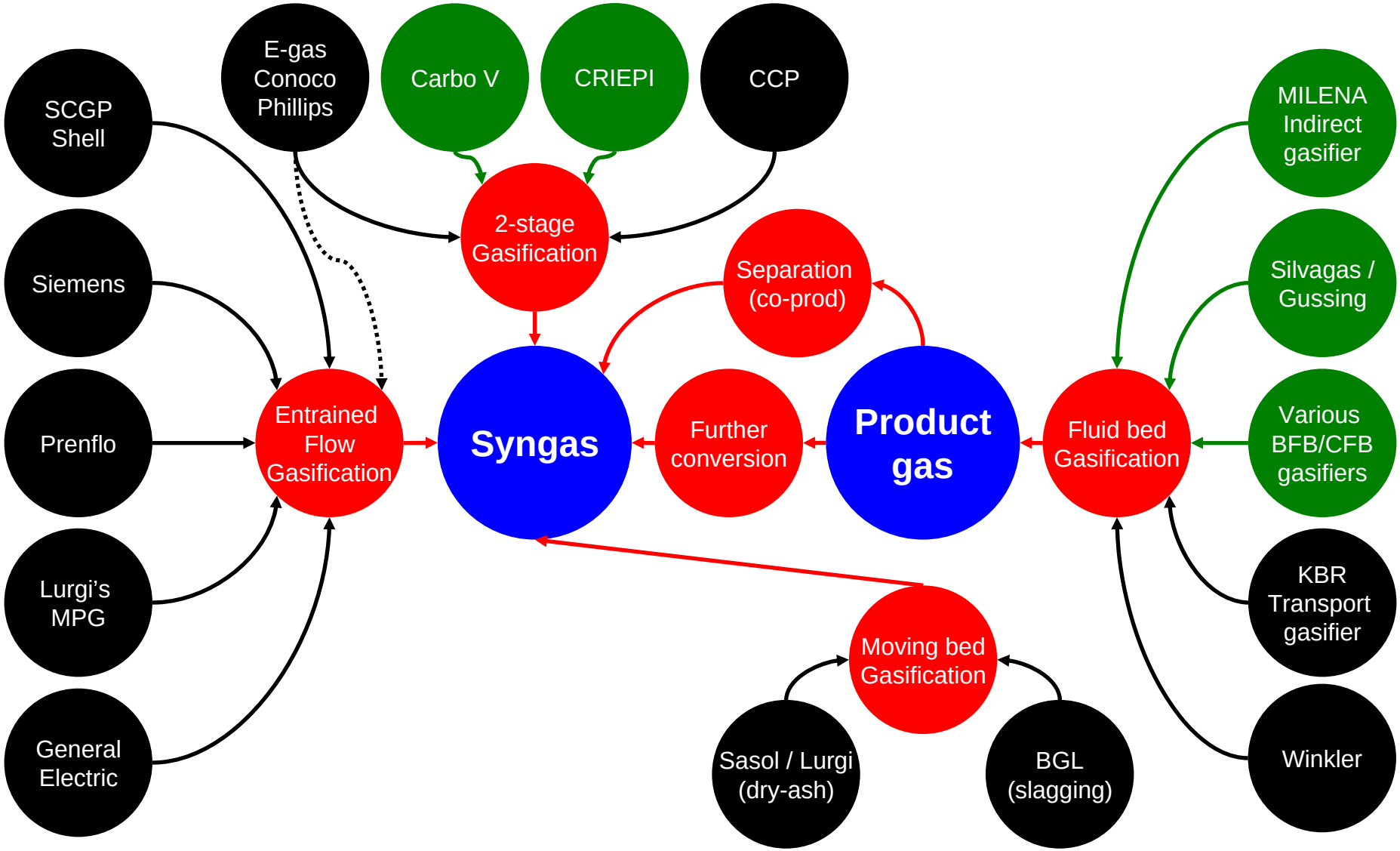
gasification:

fuel + air ($\lambda \sim 0.3$) → gas (volatiles)

~80% cold gas efficiency


SCGP Shell
E-gas Conoco Phillips
Carbo V
CRIEPI
CCP
MILENA Indirect gasifier
2-stage Gasification
Siemens
Separation (co-prod)
Silvagas / Gussing
Prenflo
Entrained Flow Gasification
Syngas
Further conversion
Product gas
Fluid bed Gasification
Various BFB/CFB gasifiers
Lurgi's MPG
KBR Transport gasifier
Moving bed Gasification
General Electric
Sasol / Lurgi (dry-ash)
BGL (slagging)
Winkler

Sustainable Biomass

Choice of gasifier for biomass

- Biomass is reactive: contains O_2 ($CH_{1.4}O_{0.6}$).
  - *No need for high T, large particles possible*
- Biomass contains 80% volatiles
  - *Volatiles released by heating to low temperature*
  - *No need for high T's, no O_2 or air needed*
- Remaining 20% is solid, combustible material
  - *Could be a source of heat*
- Biomass is difficult to grind
  - *No severe size reduction*

Indirect Gasification: principle

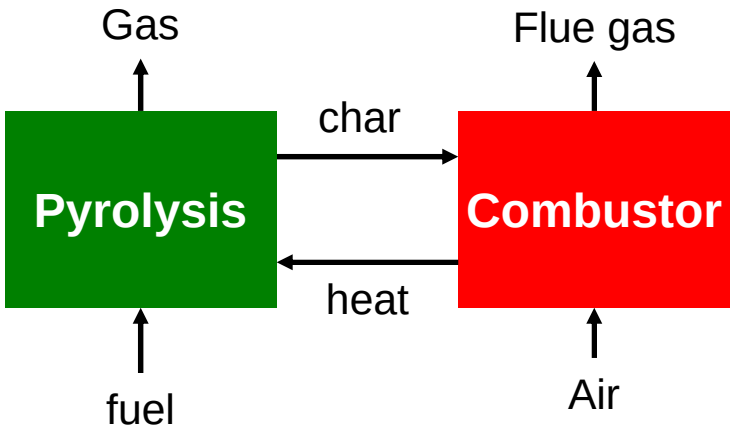
- Large reactive particles: fluid bed
- 80% volatiles by heating: only use heat in 1 reactor
- Low temperature: no O_2 plant, fluid bed

combustion:

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

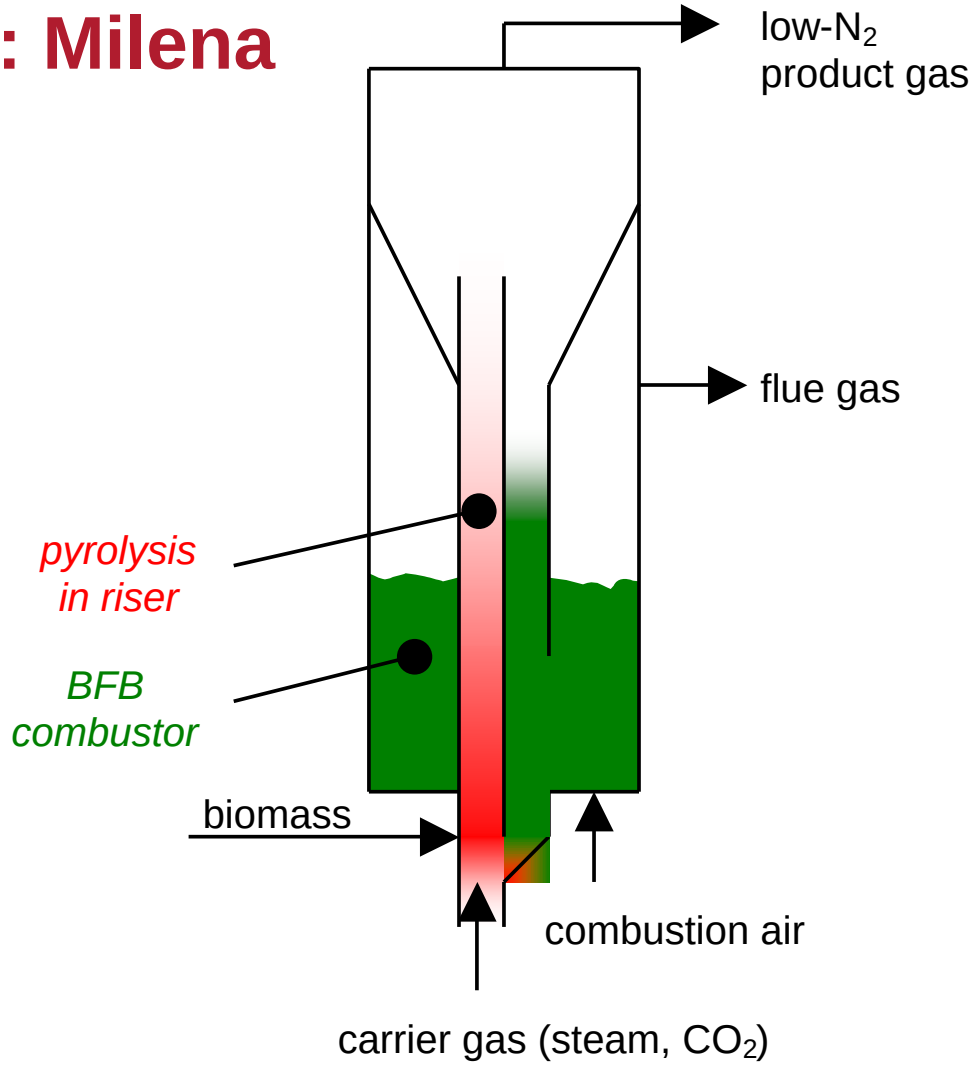
pyrolysis:

fuel + heat → volatiles + char



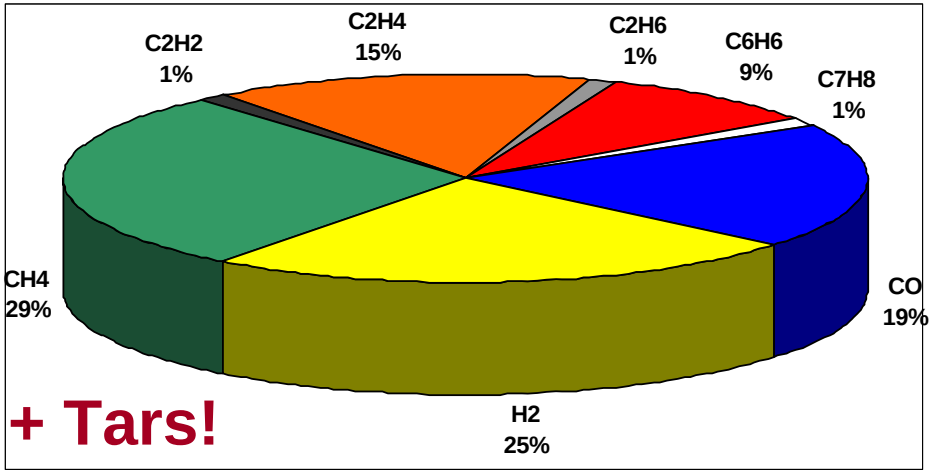
Indirect Gasification: Milena

- No O_2 plant, N_2 free gas
- 1 reactor
- Cold Gas Efficiency: 80% (LHV, incl. tar)
- Full carbon conversion
- Uses biomass chips
- Tars: 40 g/Nm^3 (mostly naphthalene, 50% unknowns)
- T riser: ~850°C, combustor: ~920°C,
- P: ~1.1 bara
- Control parameters: sand circulation: ~40kg/kg biomass

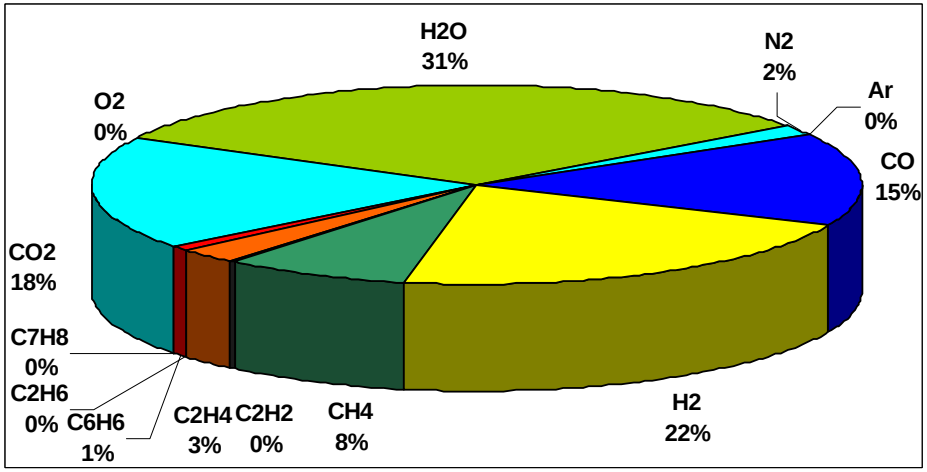


MILENA product gas characteristics (1)

LHV%

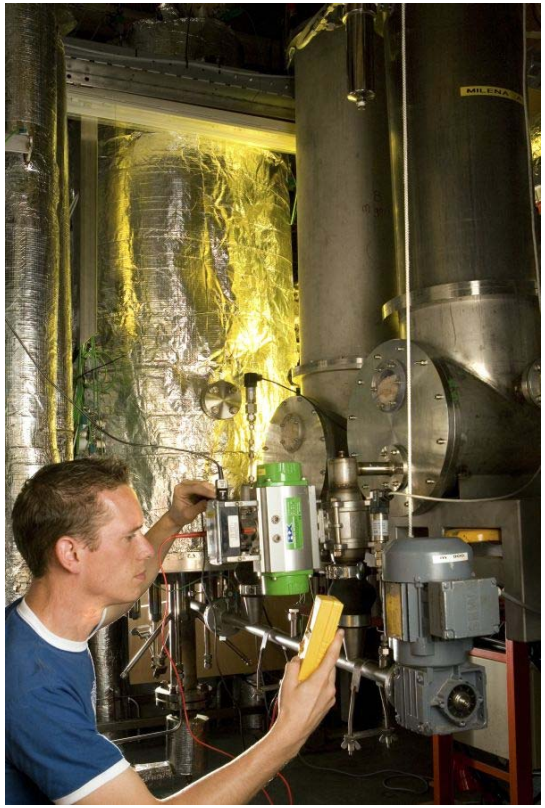


Vol% (wet)

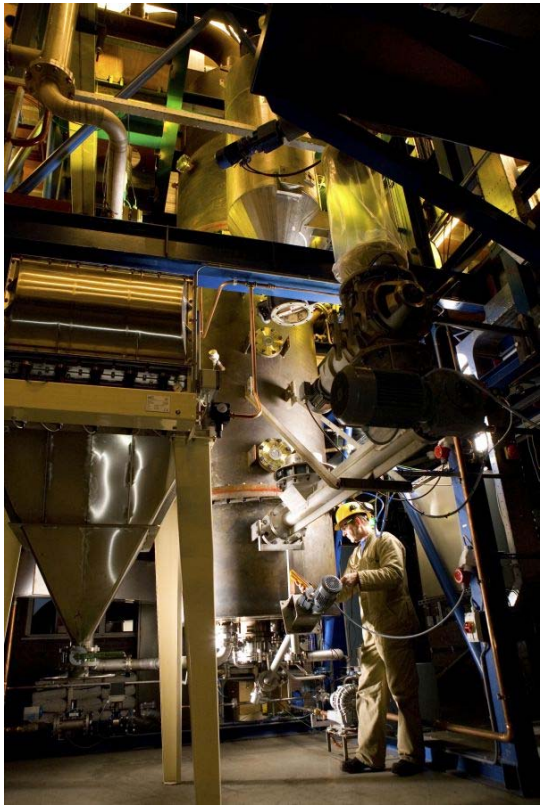


- LHV (wet) = 9688 kJ/Nm^3
- LHV (dry) = 14278 kJ/Nm^3
- Optimization to less hydrocarbons is possible!
- Less CH_4, less tars

Development Milena at ECN



- 25kW lab scale gasifier
- 5 kg/hr of biomass
- ~1500 hours of operation



- 800kW pilot scale gasifier
- ~150 kg/hr of biomass
- Recently started up

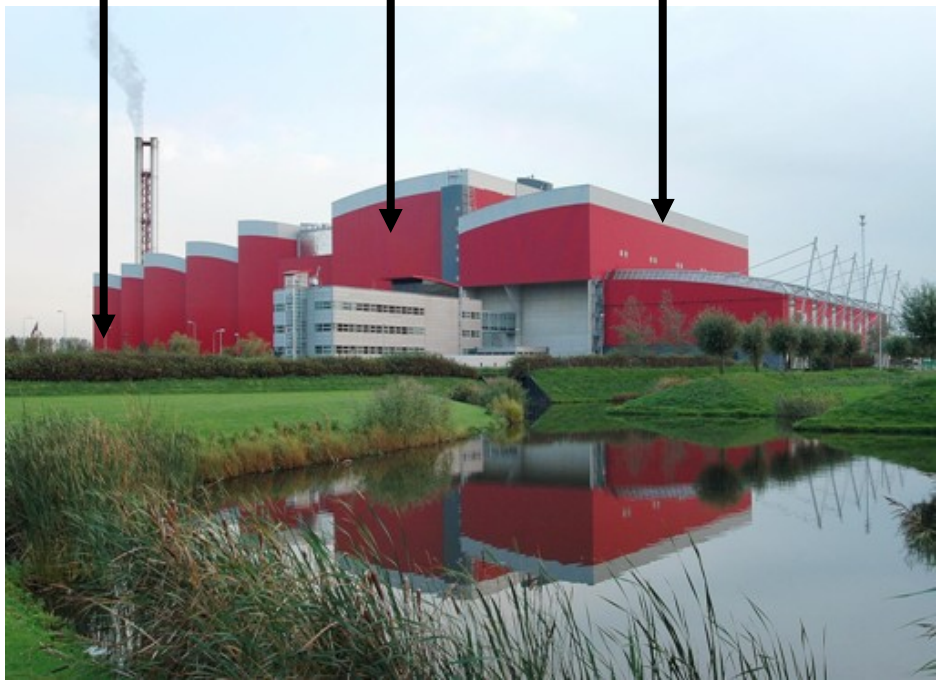
Photos by Jasper Lensselink

Plans at Dutch waste incinerator plant (HVC)

50MW$_{th}$ Milena SNG Plant in 2015

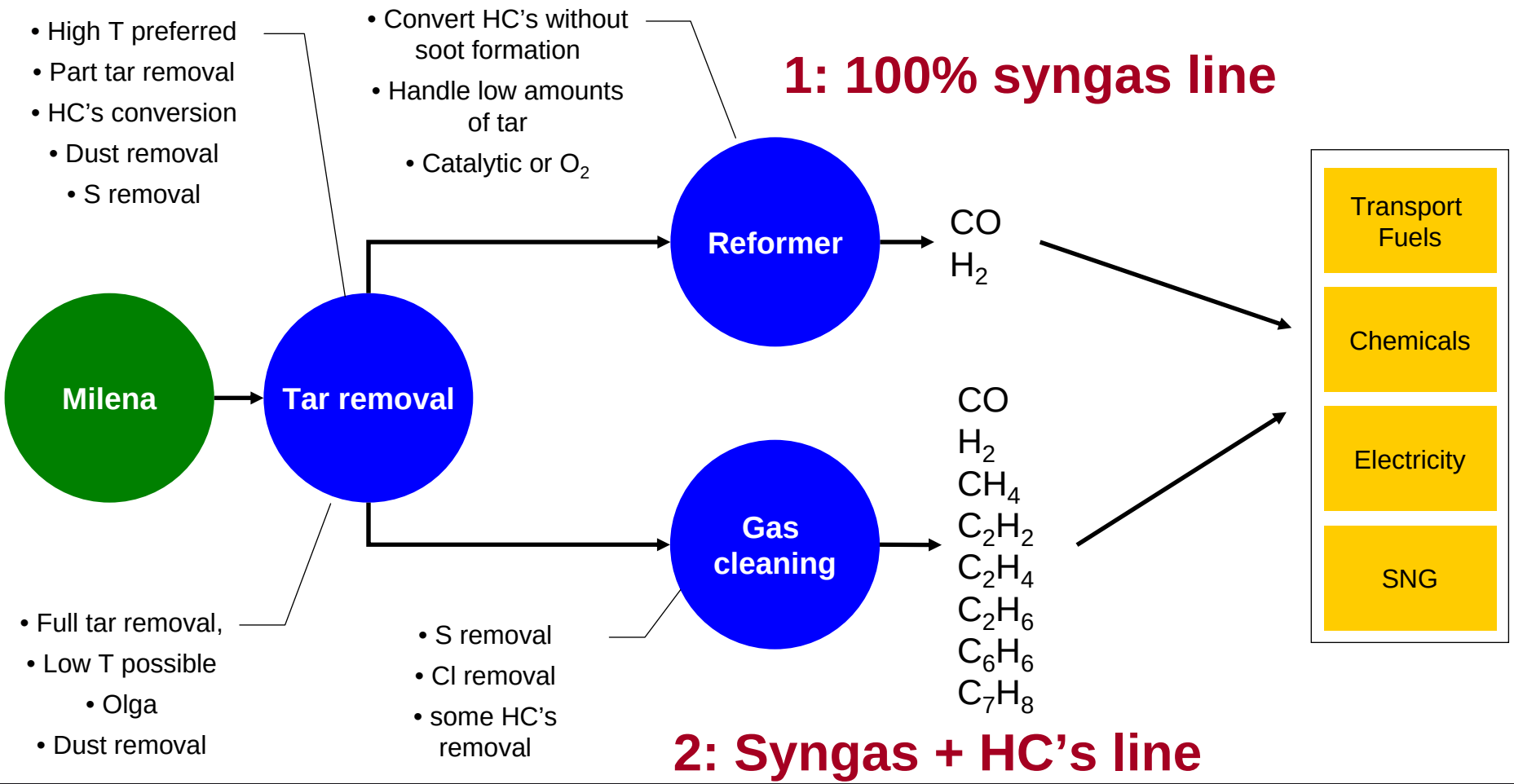
10MW$_{th}$ Milena CHP Plant in 2012

Potential for slip stream testing!



Photos courtesy of the HVC

Milena for syngas production systems



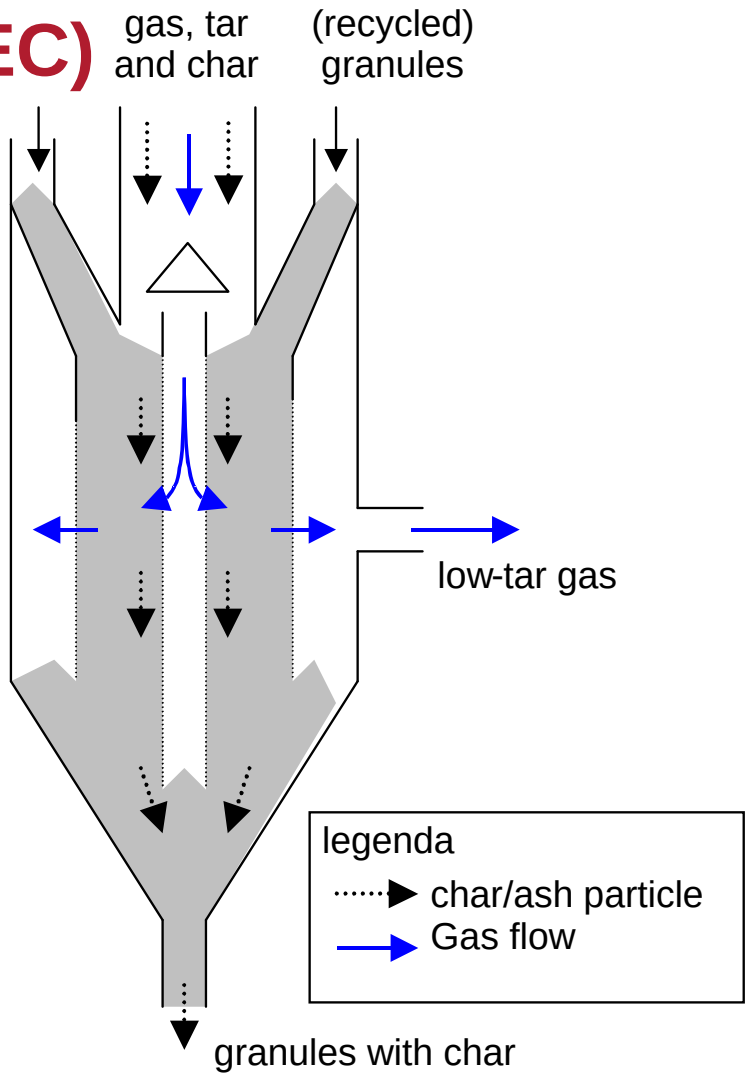
System 1: tar removal (TREC)

Specifications:

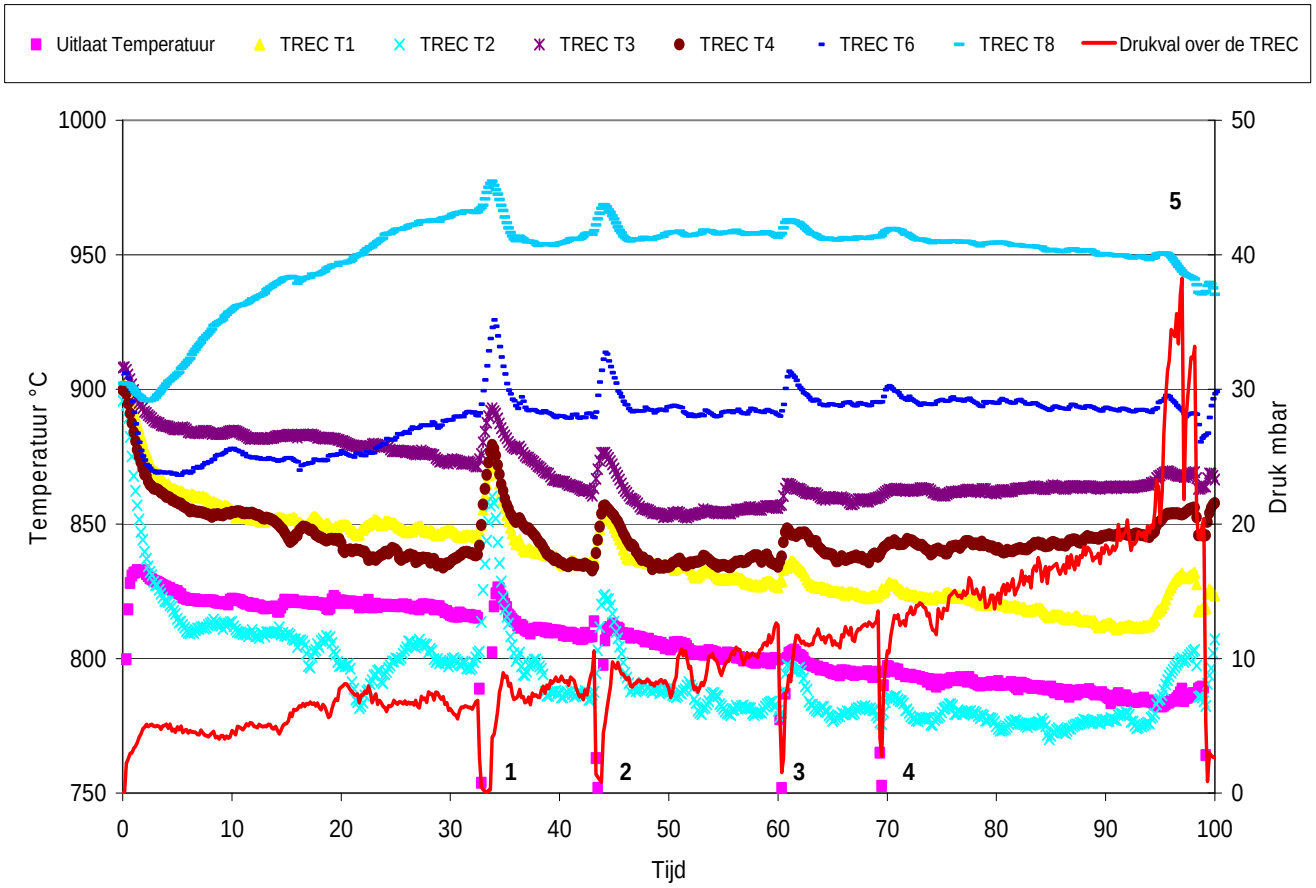
- Good contact tar/char
- Sufficiently long: > 1 s
- T~900°C
- Robust
- Low P-drop

Reactor:

- Moving granular bed filter
- Char deposition mainly on top



Experimental results Milena + TREC



Experimental results Milena + TREC

- Tars from 4 to 1-2 g/Nm^3
- Tar dew point down to 80°C
- Almost complete reduction of C_2H_2
- C_2H_4 reduced
- ~80% reduction of thiophenes
- CH_4 and C_6H_6 remain almost unchanged
- Filter efficiency ~99%
- Particle concentration reduced to <100 mg/Nm^3
- Dust formation due to olivine “milling” in transport

Development of both syngas systems

- Develop technology for biomass-to-syngas line based on Milena
- Investigate co-production SNG and FT / E
- Seek strategic partners for processes in both lines
- Combine syngas applications with Milena demo’s
- Bring syngas technologies to the market.

Conclusions

- Biomass properties suit Milena indirect gasification
- Syngas from biomass is important for CO_2 reduction
- Milena technology is being scaled up in 2 demo's
- Milena gasification could be suited for 100% syngas production and co-production
- High temperature tar removal has been tested on a lab-scale
- ECN is actively looking for partners for its Milena-to syngas line

MORE INFORMATION

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publications: www.ecn.nl/publications
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
SNG: www.bioSNG.com and www.bioCNG.com