The MILENA gasification technology for the production of Bio-Methane

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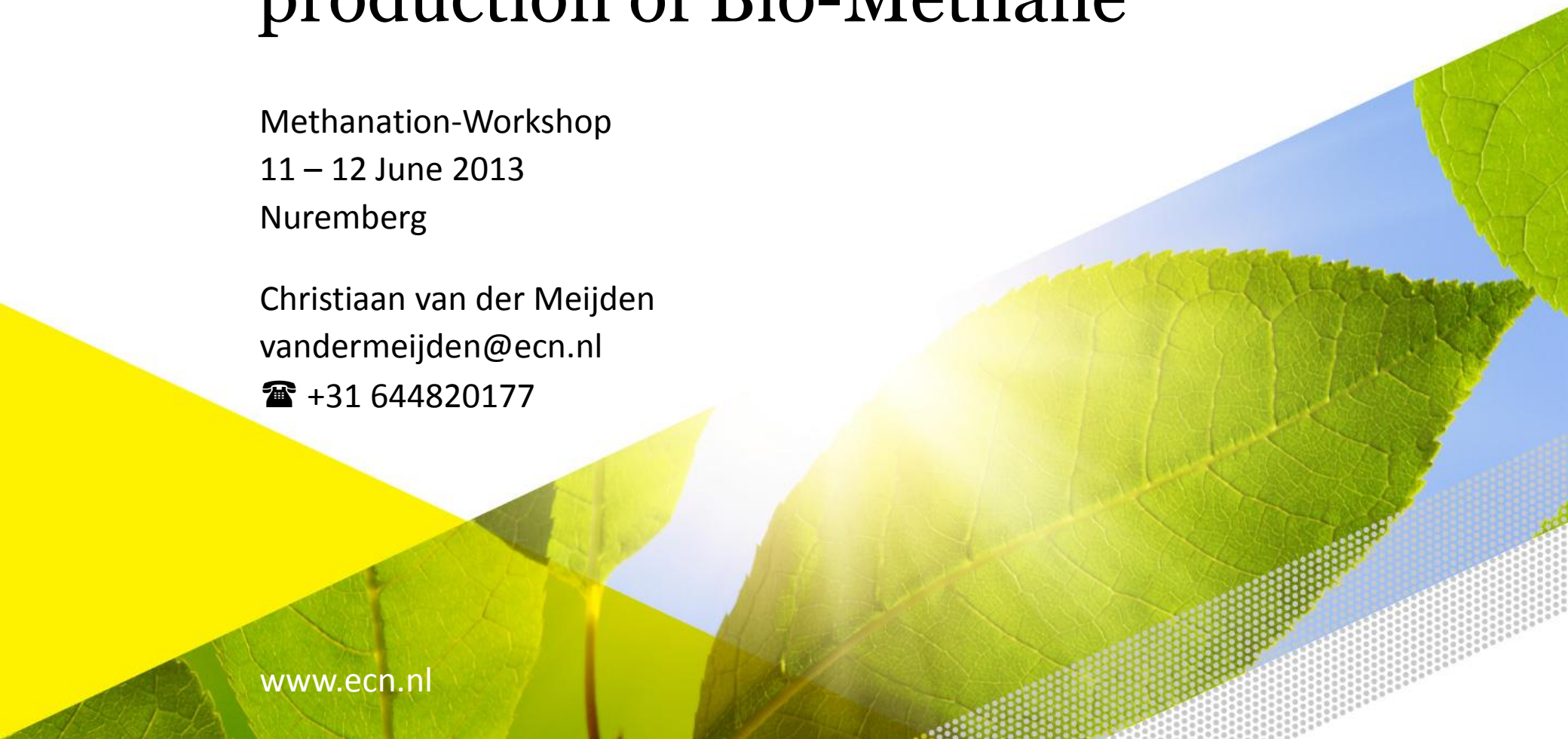


www.ecn.nl

The Energy research Centre of the Netherlands (ECN)

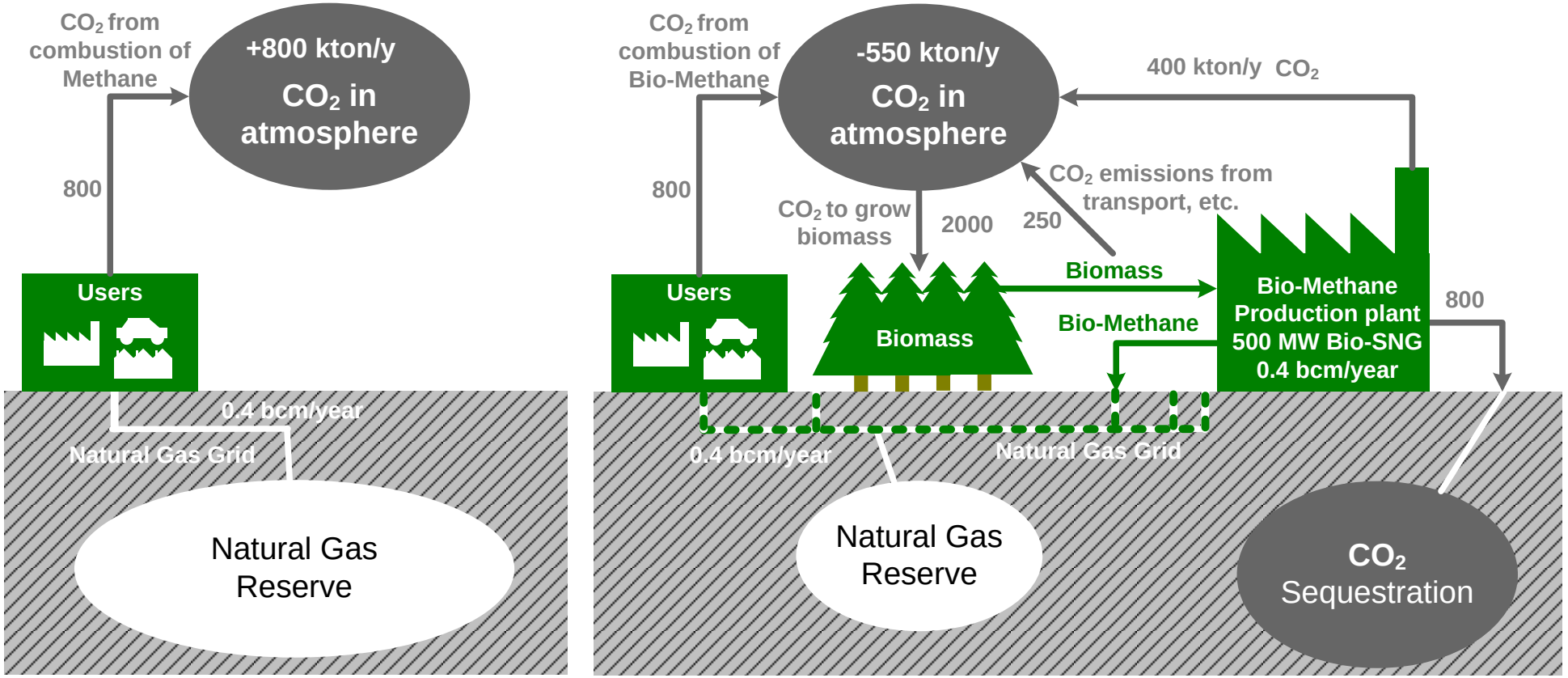
- Independent R&D centre for renewable energy.
- Partly financed by the Dutch government and EU government grants, and partly by contract R&D.
- Main products: technology licenses and contract R&D
- 600 staff

ECN Bio-Methane vision

ECN – Bio-Methane vision

- Biomass will become expensive, so overall efficiency is important
- Fuels: Wood residues + possibly agro residues
- Medium level of complexity accepted, because of gains in efficiency and reliability.
- Scalable technology
- Markets:
  - Transport (Bio-LNG, Bio-CNG), competing with Bio-Diesel, Bio-Ethanol
  - Bio-SNG
- Competition with fossil natural gas without incentives or subsidies is not possible in the short and medium term.
- Long term
  - Co-production of chemicals (BTX, C_2H_4).
  - Co-production of FT
- CO_2 sequestration in the long term, in the short term CO_2 venting.

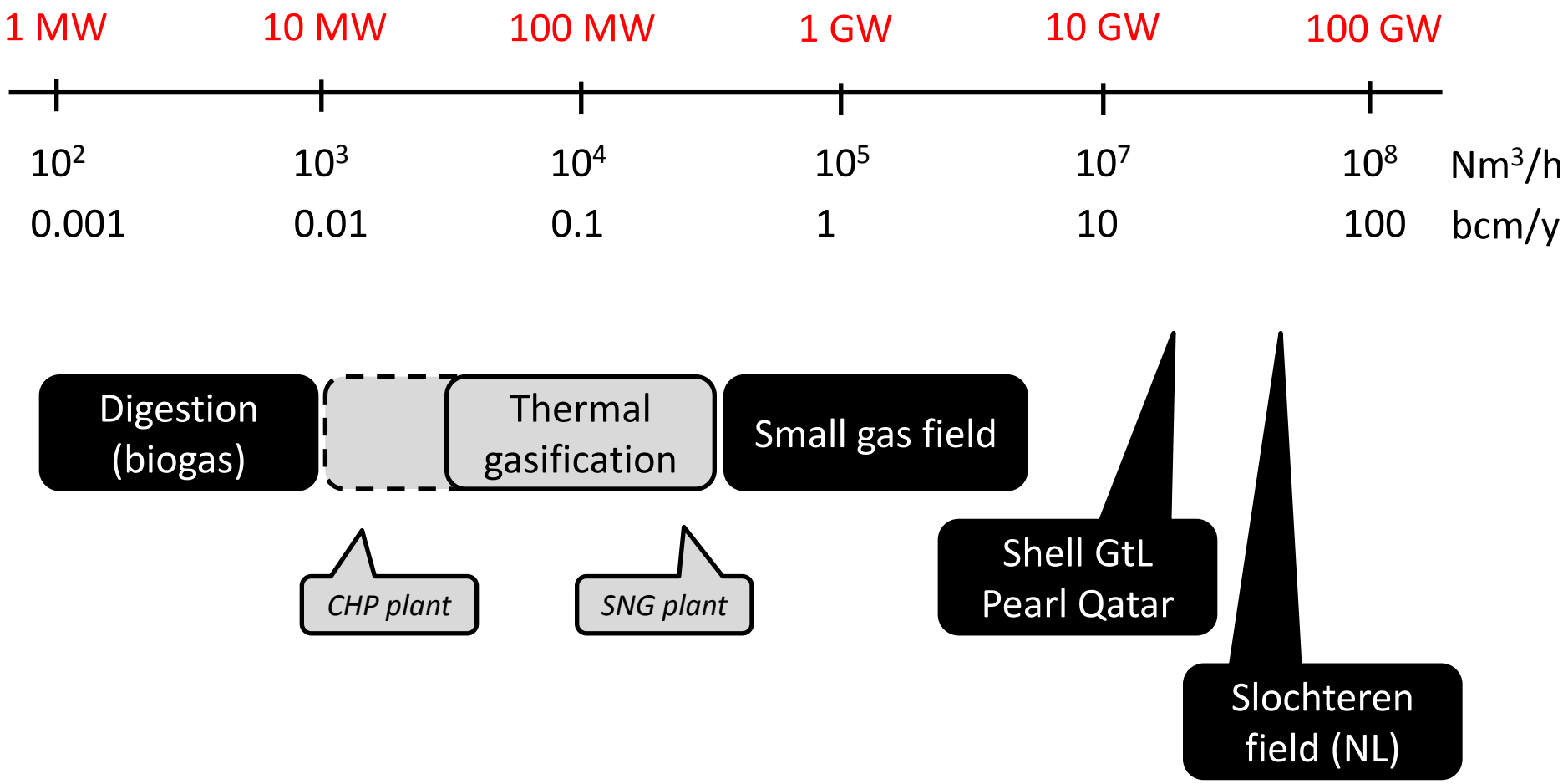
Becoming CO_2 negative, long term perspective



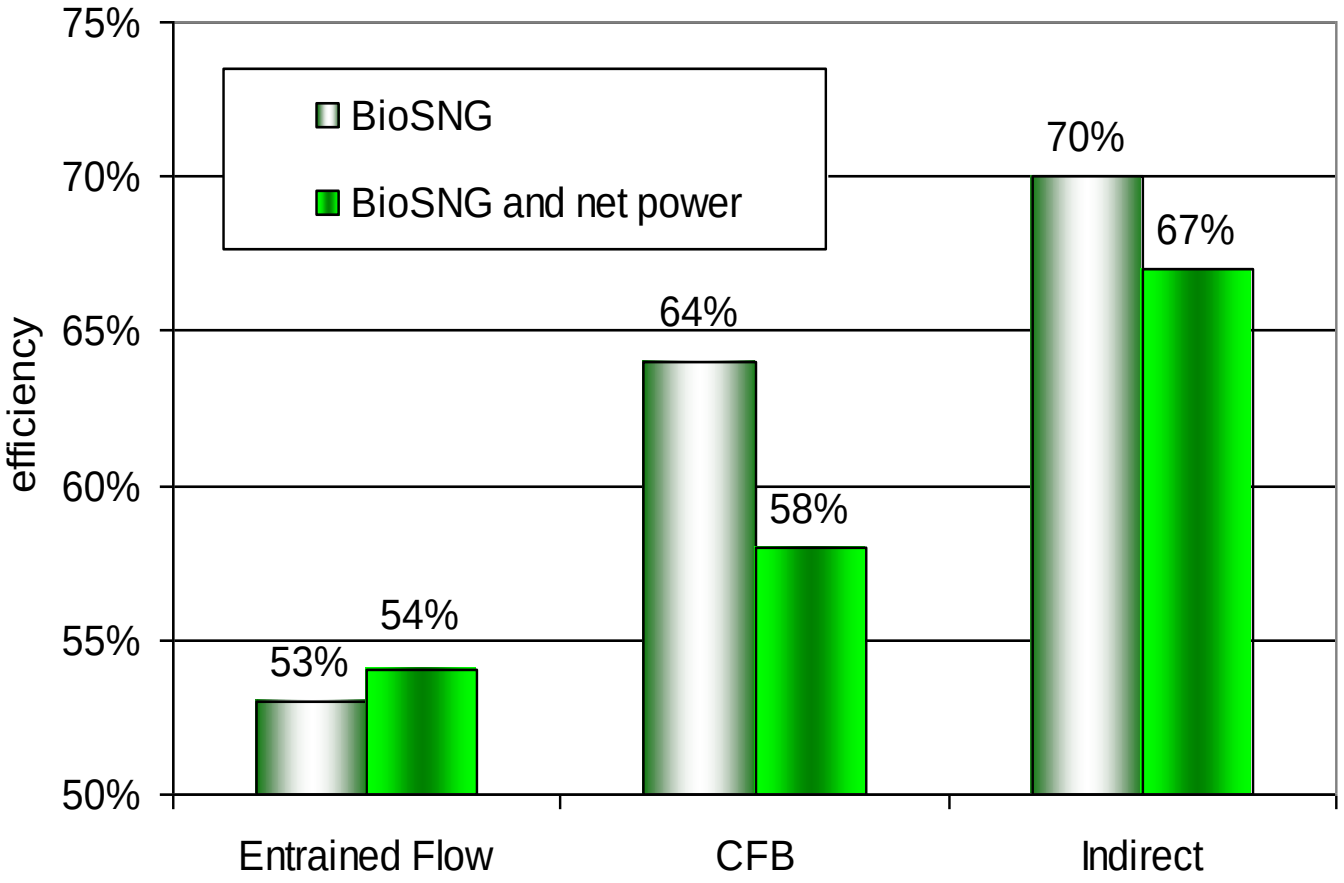
Short / medium term, no CO_2 sequestration. CO_2 is vented. Net CO_2 reduction 550 kton-year compared to natural gas

SCALE

natural gas (equivalent) capacity



Bio-Methane
System efficiencies



Meijden, C.M. van der; Veringa, H.J.; Rabou, L.P.L.M.;
The production of synthetic natural gas (SNG): A comparison of three wood gasification systems for energy balance and overall efficiency
Biomass & Bioenergy (Elsevier), 2009.

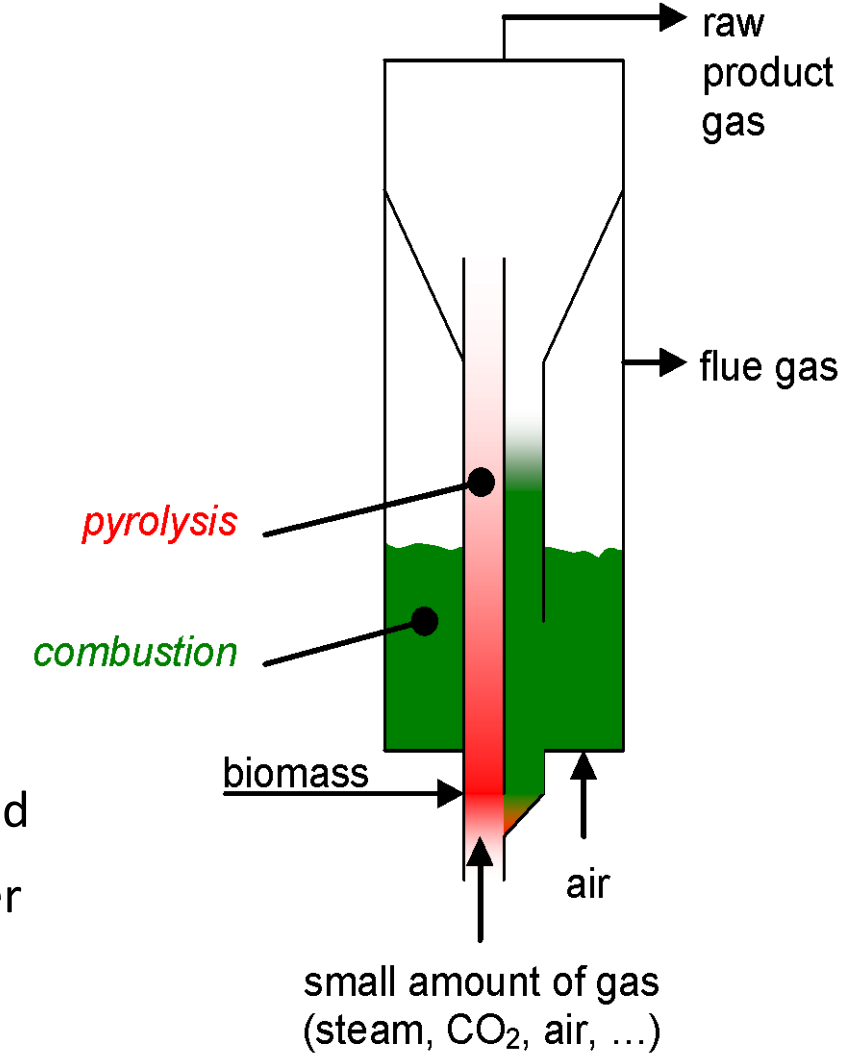
ECN – Bio-Methane vision

- Technology basics
  - Indirect / Allothermal gasification, because of complete fuel conversion and high CH_4 yield. No ASU required.
  - Minimizing CH_4 emissions by using amine scrubbing at low pressure for CO_2 removal.
  - Atmospheric / low pressure biomass feed
  - Fixed bed adiabatic catalytic reactors.
- Development:
  - Lab-scale: gasifier, gas cleaning, methanation
  - Pilot scale: gasifier, gas cleaning
  - Demo scale: gasifier, gas cleaning, methanation, gas grid injection.
  - Work done at smaller scale should be relevant for large scale, system will not change significantly after demonstration.
  - Gasifier & gas cleaning also suitable for other applications (gas engines, etc.).

MILENA gasification technology

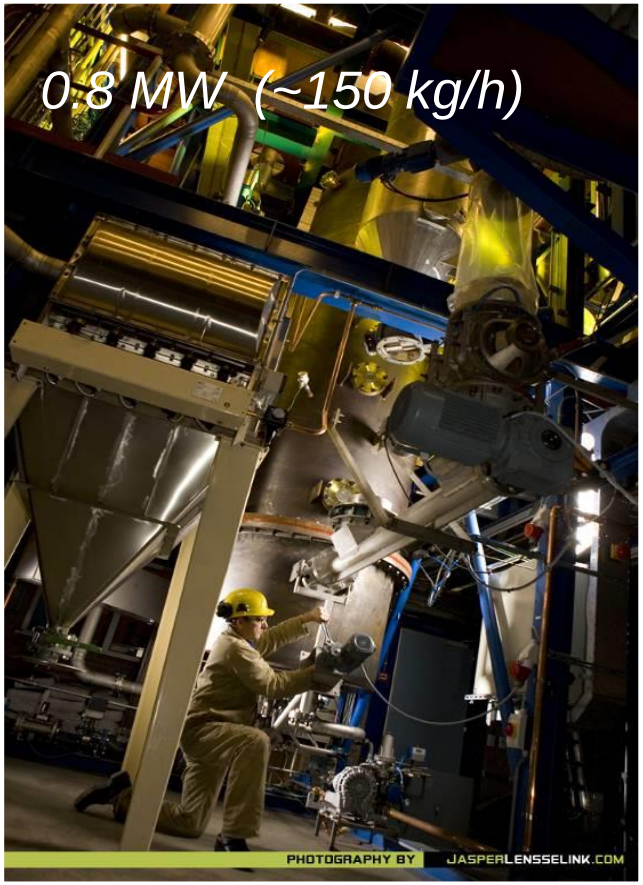
MILENA Indirect Gasification

- Fluidized bed gasification
- Temperature level: 850°C
- Product gas contains methane, ethylene, benzene and tars
- Complete conversion of the fuel
- No carbon in the ash
- High efficiency
- Very little nitrogen in producer gas
- Heat transfer through bed material
- One single vessel: compact design. Limited
- Fuel flexible: wood, RDF, lignite, sunflower husks, etc.



Milena Technology test facilities at ECN

In operation since 2004, operation hours >> 5000



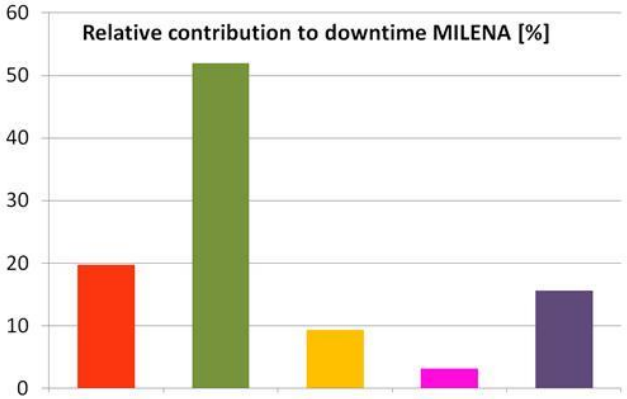
In operation since 2009

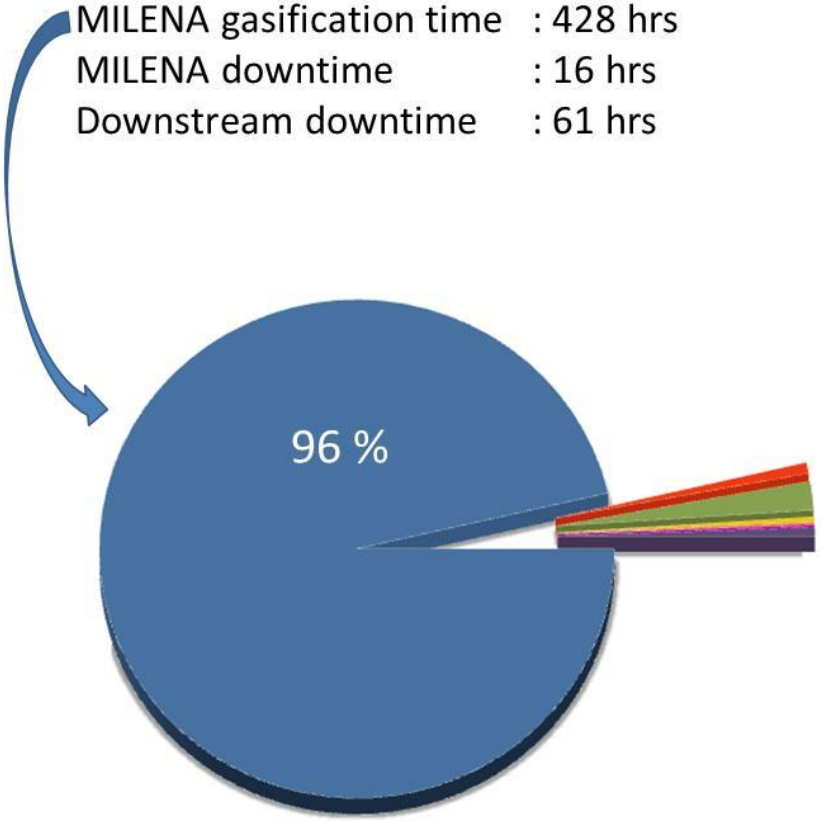
Tested feedstocks

- Clean Wood
- Demolition Wood
- Straw
- Soya stalk
- High-ash coal
- Lignite
- RDF
- Sunflower husks

Results 500 hour test of 1 MW Milena + OLGA tar removal system

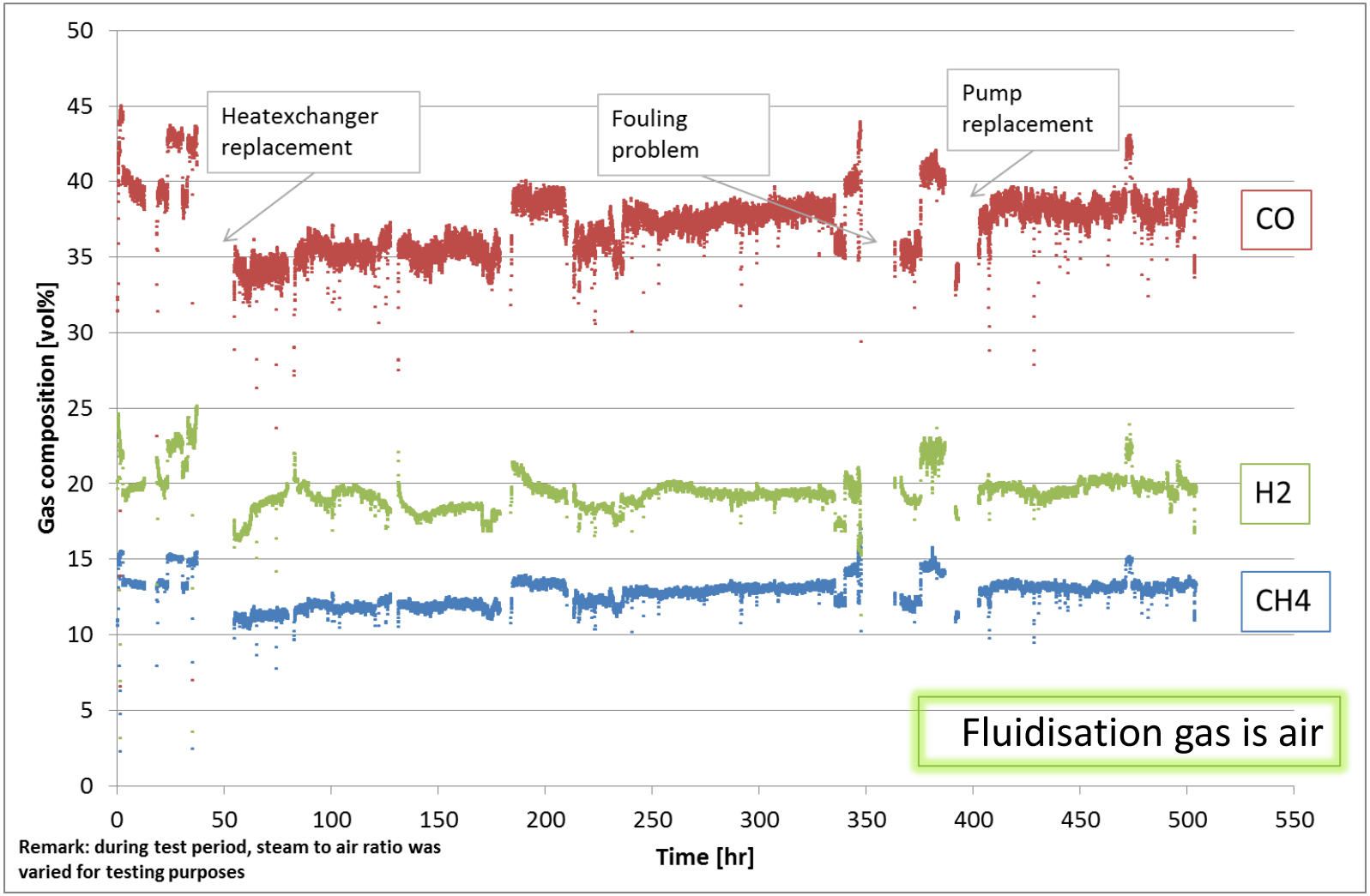
Duration experiment : 505 hrs
MILENA gasification time : 428 hrs
MILENA downtime : 16 hrs
Downstream downtime : 61 hrs





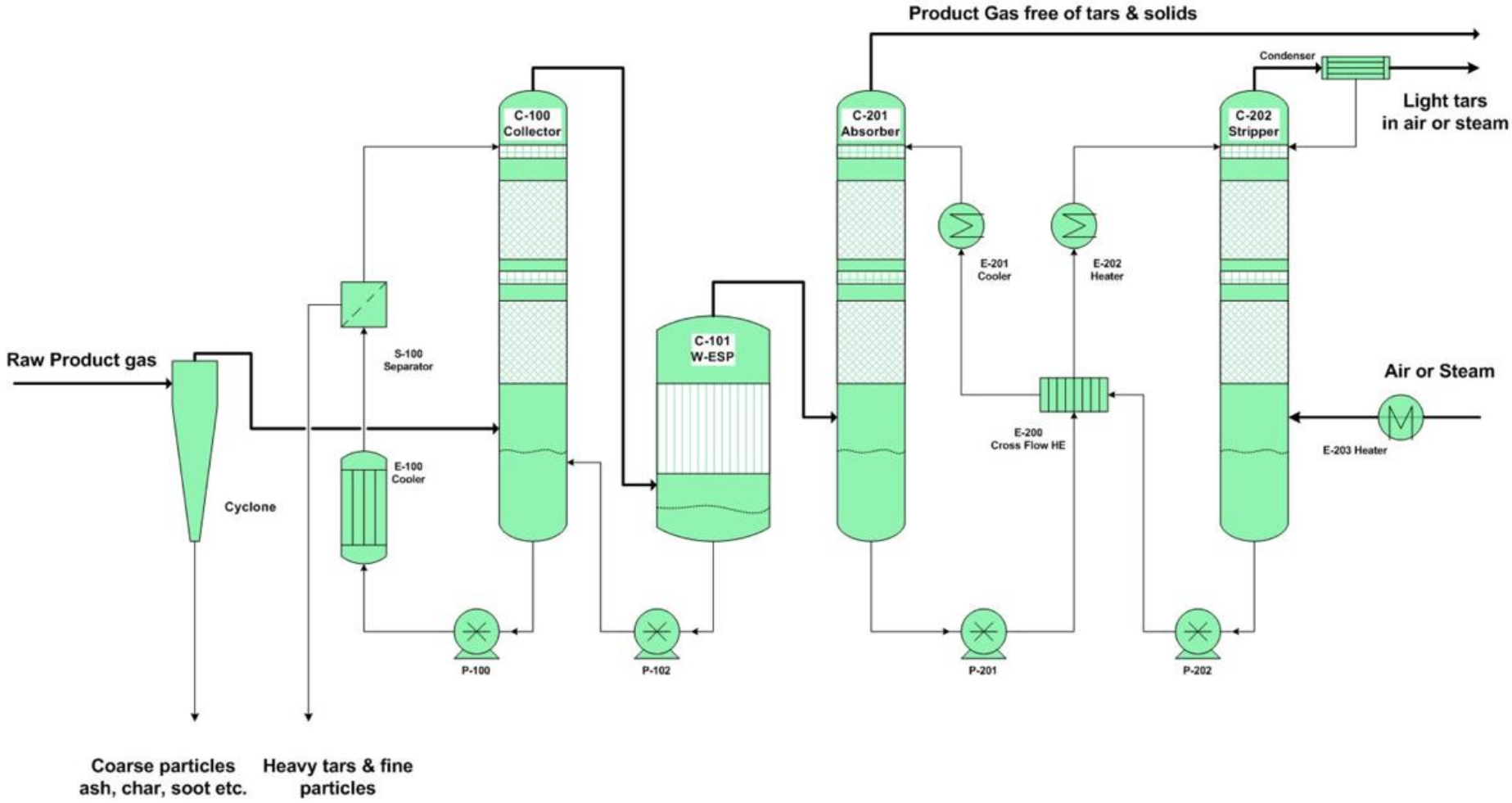
- Availability Milena 96%

Gas composition 2012 duration test



OLGA Tar Removal System

ECN OLGA gas cleaning

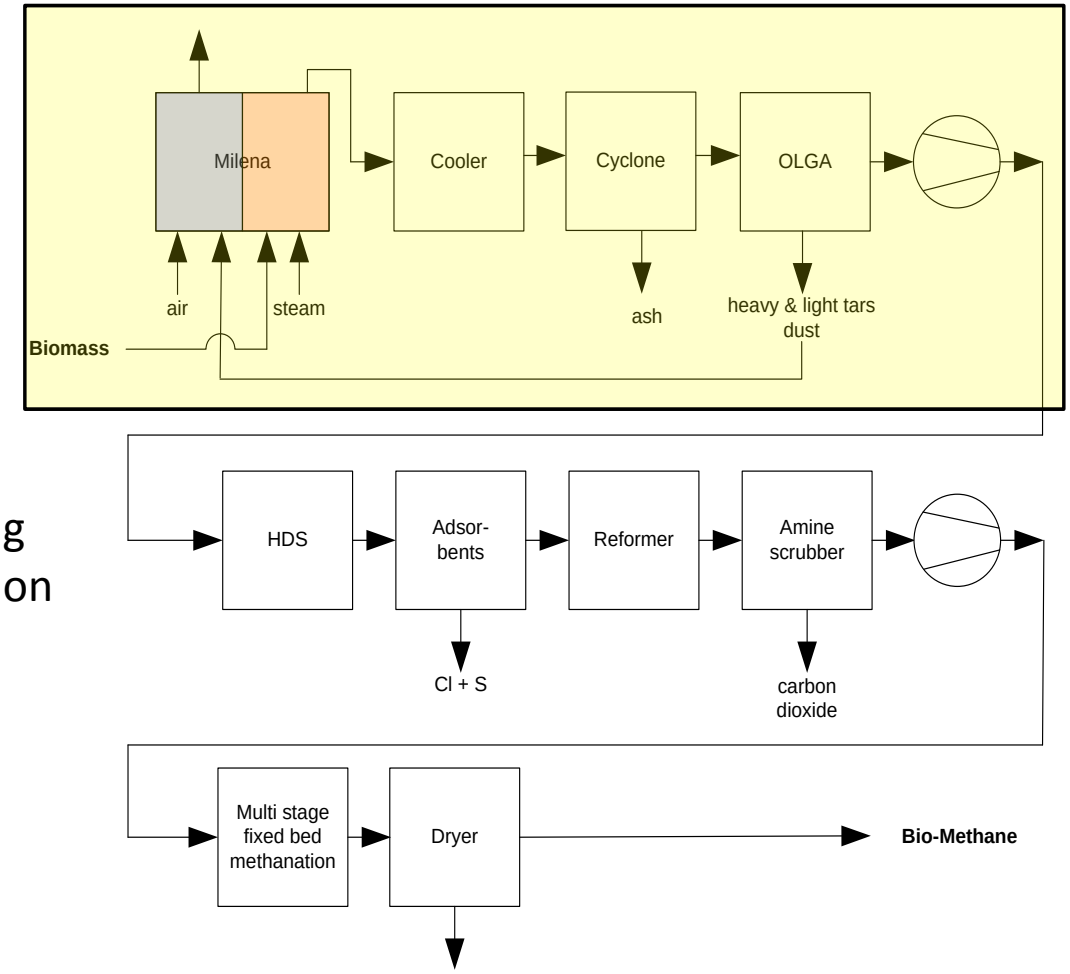



Tar dew point < 10°C
No water pollution with tars!
DAHLMAN

Bio-Methane system

Bio-Methane process in more detail

Reformer:
550 – 600°C
Endothermic reforming
Exothermic methanation

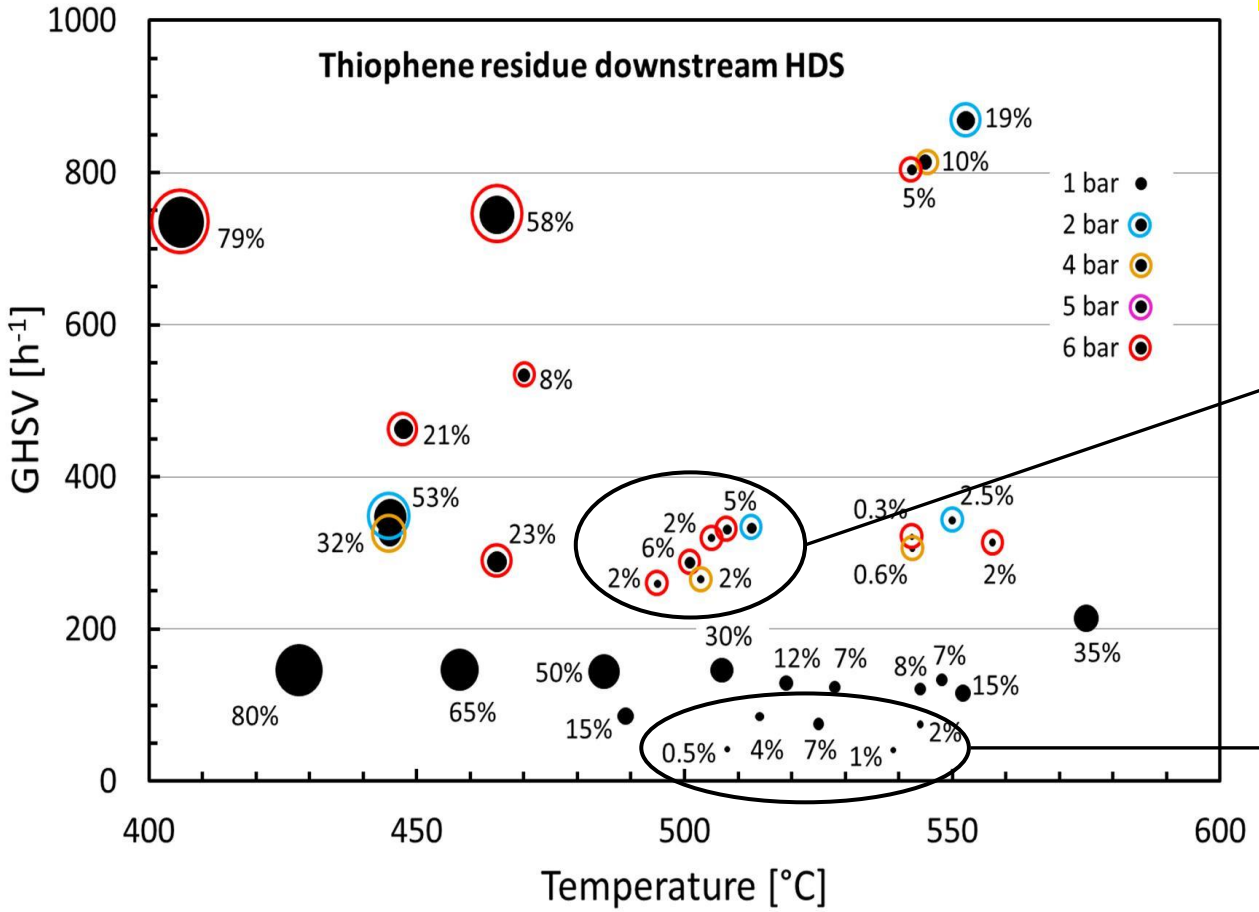


Pressurised HDS & SNG test rig

HDS

SNG: Lefthand and righthand view

HDS results: thiophene conversion



Lower temperature & higher gas velocity allowed for >95% conversion at 6 bar

High temperature & low gas velocity required for >95% conversion at 1 bar

Pre-reforming & Methanation results

- Full conversion of BTX in syngas and CH_4.
- Methane content according chemical equilibrium
- Several duration tests done, good results, acceptable decline in catalysts performance.
- Soot production can be suppressed.
- Commercially available catalyst selected
- Duration tests ongoing to optimize process.

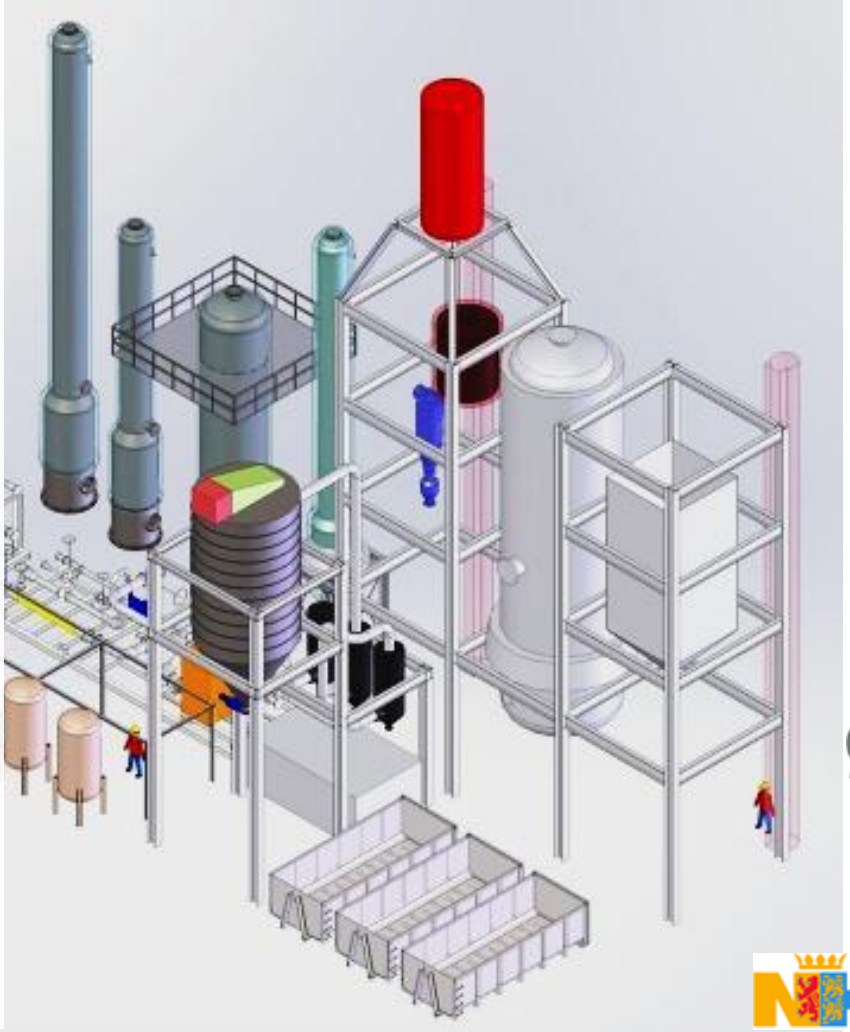
MILENA and OLGA commercialisation with Royal Dahlman

Royal Dahlman

- Royal Dahlman is a Dutch company with approx. 100 staff
- Longstanding experience in filter technology, e.g. gas turbine inlet filters for GE.
- OLGA license from ECN in 2007
- First 4 MW_{th} OLGA system build in France in 2008
- Second 4 MW_{th} OLGA system build in 2010 in Portugal
- MILENA license for certain regions from ECN in 2013

Project in Development in Alkmaar, The Netherlands

- Preparations on-going since 2010
- Several changes in project / available subsidies over past years.
- 4 MW_{th} MILENA and OLGA producing Bio-Methane
- Royal Dahlman will build the plant
- 23 M€ subsidy on Bio-Methane granted April 2014.
- Final investment decision in mid 2014



Bio-SNG plant Alkmaar (NL)

Conclusions

- MILENA + OLGA Technology proven on pilot scale using realistic fuels (demolition wood and wood chips).
- Availability of technology was increased significantly over past years, commercial partners are convinced that the technology can be operated under commercial conditions.
- Technology is now available from Dahlman. Three potential Bio-Methane projects in Europe.
- 1 MWe MILENA + OLGA under construction using Soya residue.
- Bio-Methane concept proven on lab-scale.
  - Several configurations and process conditions tested
  - Several commercial catalysts tested
  - Several duration tests done, results are sufficient.
  - Duration tests will continue to optimize process.
  - No scaling issues, fixed bed & adiabatic process.

MORE INFORMATION

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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 /www.bioCNG.com

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