

Commercialization of the ECN MILENA gasification technology

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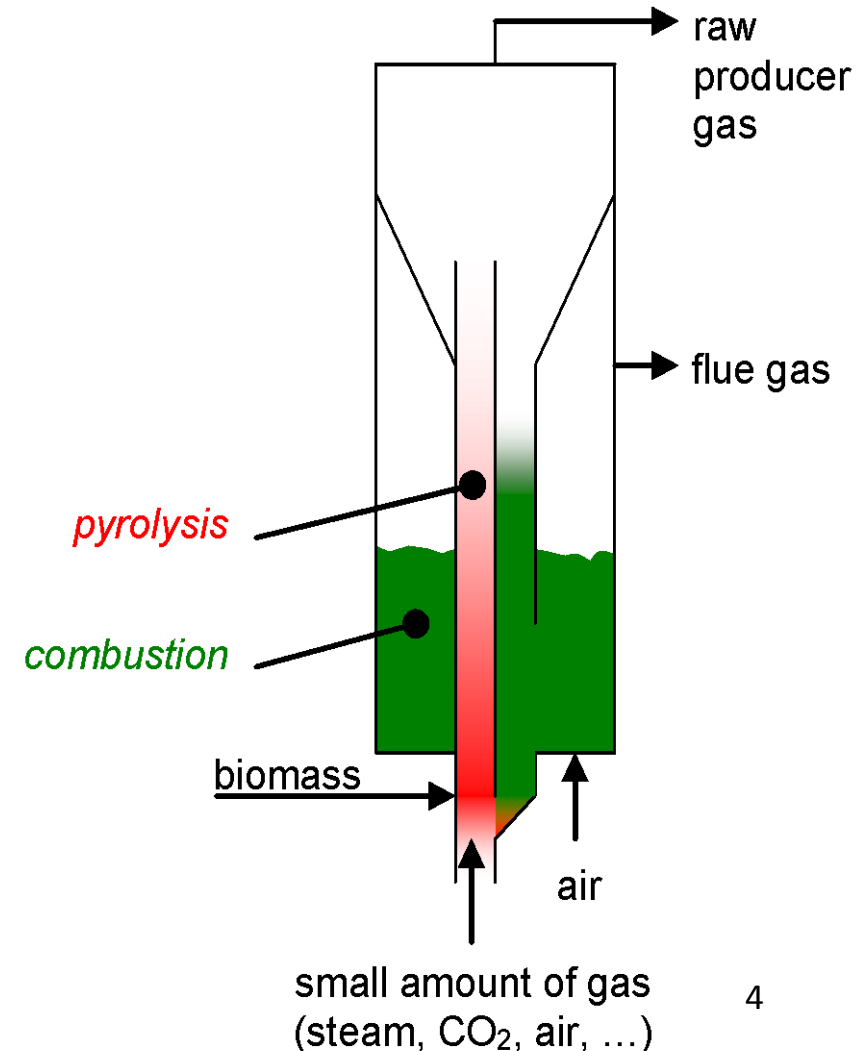
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What is MILENA?

MILENA Indirect Gasification

- Fluidized bed gasification
- Temperature level 650 -950°C
- Producer 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



Comparison

	MILENA	CFB/BFB	Downdraft
Conversion	100% / white ash	~90% / black ash	~90% / black ash
Cold Gas Efficiency	~80%	~70%	~70%
Temperature control	Good control, no char accumulation	Lower controlability due to char hold-up	Very heterogeneous
Temperature versus Efficiency	lower temperature = higher efficiency	lower temperature = lower conversion	lower temperature = lower conversion
Fuel flexibility	waste, agricultural residues any size	less freedom any size	woody only large chunks
Producer gas	12-15 MJ/Nm ³ essentially N ₂ -free	5-6 MJ/Nm ³ ~50% N ₂	5-6 MJ/Nm ³ ~50% N ₂
Scale	Scalable (>100 MW)	Scalable (>100 MW)	Max. 1 MW

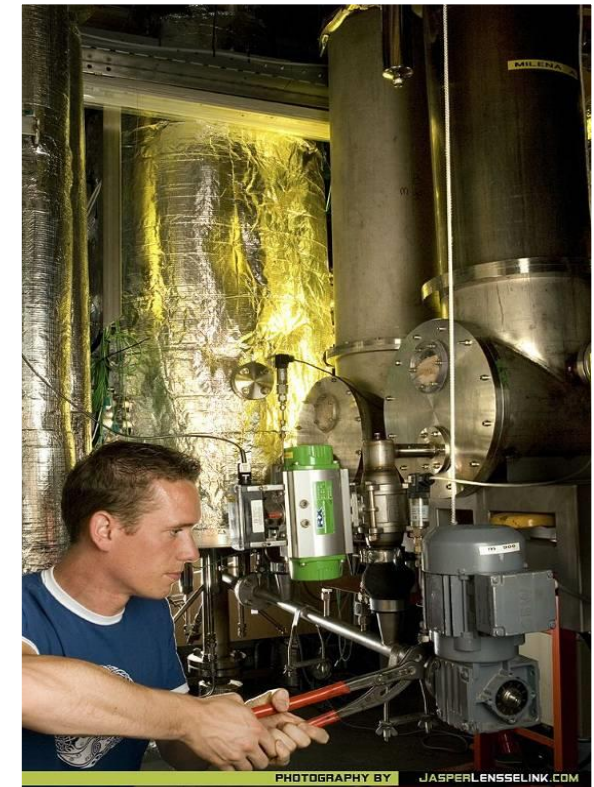
Markets for MILENA based gasification

- Co-firing in coal boilers or gas turbines
 - Clean gas feeding to boiler or turbine
 - With Milena lower grade biomass or waste can be used, rather than the clean wood pellets needed for direct co-firing in boilers
- Combined heat and power
 - On-site conversion of waste to energy
 - In combination with gas engine or small gas turbine
 - Milena produces high calorific gas, not diluted with nitrogen
- Substitute Natural Gas production
 - High methane content of producer gas makes Milena very suitable for SNG production
- Production of fuels or chemicals

MILENA development

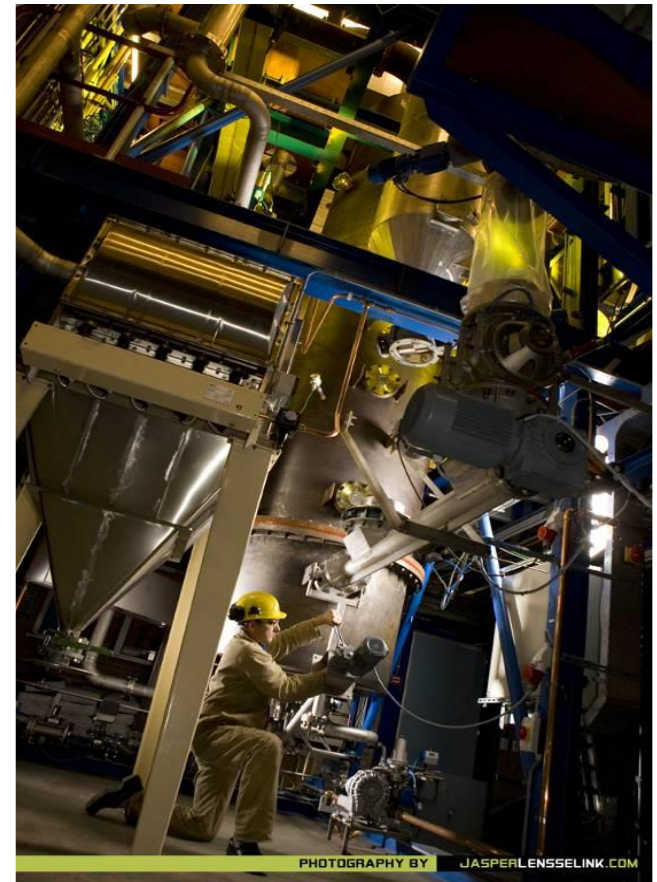
MILENA development history

- 1998 First MILENA concept, based on CFB gasification experience
- 2000 Cold Flow testing / pre design commercial scale unit
- 2000 First patent application
- 2003 Engineering 30 kWth lab-scale unit
- 2004 Start test program at lab-scale
- 2007 Engineering / financing pilot
- 2008 Commissioning of 800 kWth pilot plant
- 2009 Coupling to OLGA gas cleaning
- 2010 First duration tests on demolition wood
- 2010 Basic Engineering with Dahlman of demo plant
- 2012 Second duration tests pilot plant



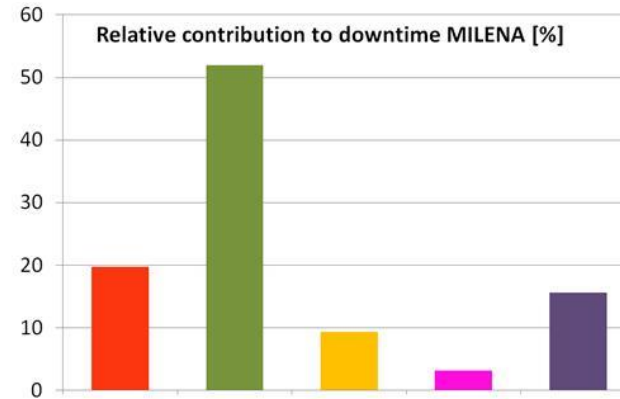
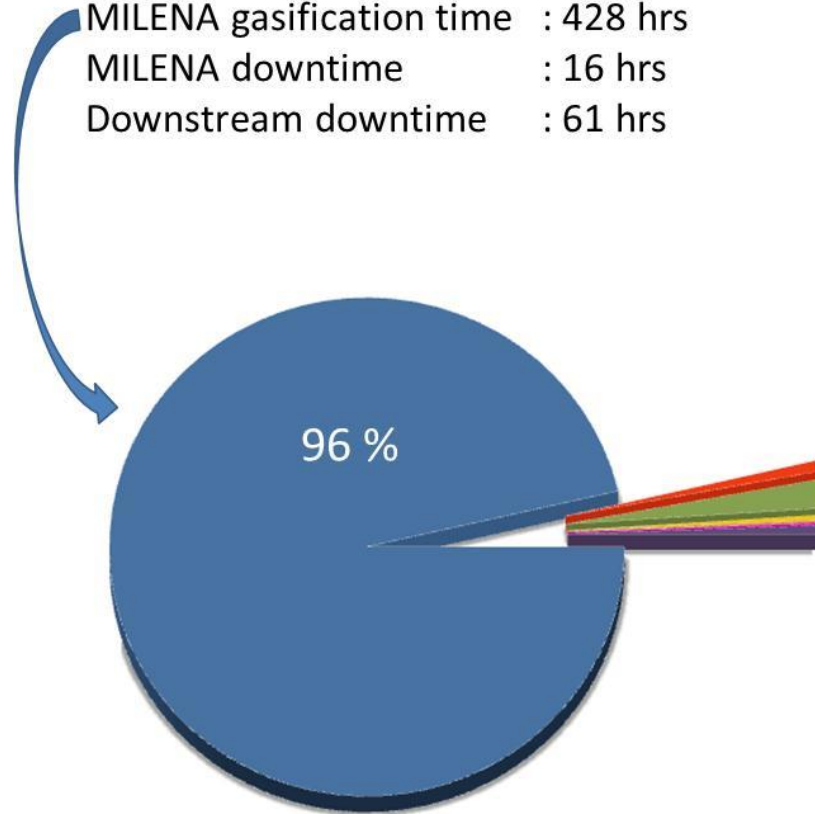
0.8 MW MILENA pilot plant

- In operation since 2008
- Fuels tested
 - Clean Wood
 - Demolition Wood
 - Waste RDF/SRF
- Runs in campaigns
- Construction similar to commercial scale (refractory lining). Same materials.
- Connected to OLGA tar removal system
- Several duration tests done on wood and demolition wood.



Results recent 500 hour test of 800 kW 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%
- “Downstream downtime”: in OLGA tar removal system

■ In operation ■ Screw conveyor blockage ■ Repair dosing system
■ Forced stop ■ Rotary airlock valve blockage ■ HSE

OLGA Tar Removal

Tar removal

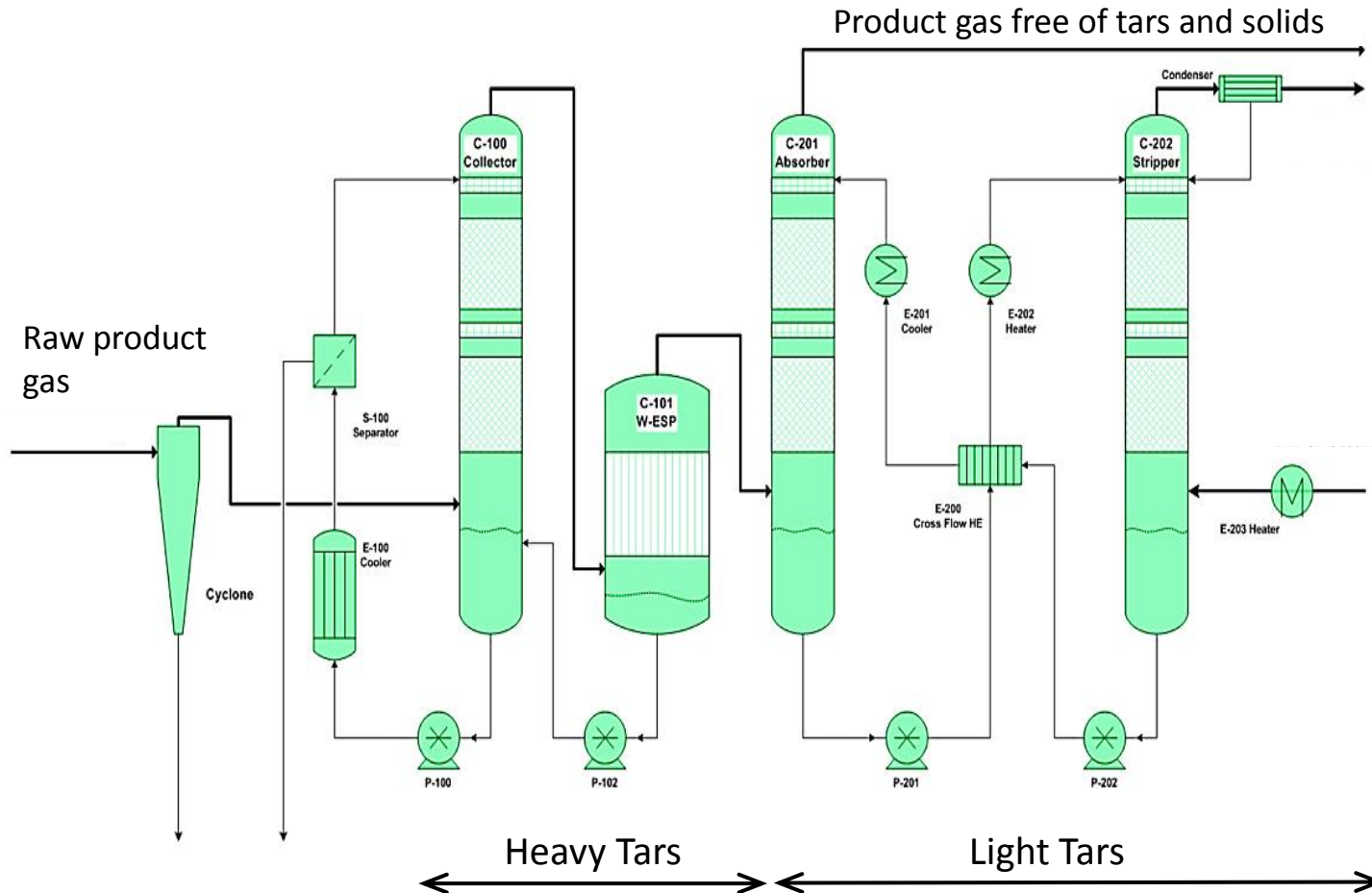
- All fluidized bed gasification processes produce tar.
- MILENA gasifier has been developed for high efficiency. The disadvantage of this approach is a high tar content of the gas.
- Tars condense during cooling ($< 450^{\circ}\text{C}$) and cause problems.
- ECN has been working on tar removal for a long time, which resulted in the OLGA tar removal technology.
- Tars are removed by the OLGA system and recycled to the MILENA combustor. No tar waste!

OLGA development history

- 2001 Patent filed in 2001
- 2003 Pilot plant constructed and operated in cooperation with Dahlman.
- 2006 Duration test of OLGA gas cleaning connected to CFB gasifier
- 2006 Commercial scale OLGA in France
- 2009 OLGA pilot coupled to MILENA pilot gasifier
- 2010 OLGA for CFB chicken manure gasifier in Portugal
- 2014 Construction of OLGA coupled to MILENA in India



OLGA Gas Cleaning



- Tar dew point <math>< 10^{\circ}\text{C}</math>
- Tar cleaning above water dew point
- ➔ No mixing of water and oil

All tars recycled back to gasifier, i.e. no energy loss, no waste streams



MILENA and OLGA

Collaboration with Royal Dahlman

ECN – Dahlman cooperation

- Royal Dahlman is a Netherlands company with approx. 100 staff.
- Longstanding experience in filter technology.
- Cooperation started in 2001.
- License agreement OLGA in 2006 and MILENA in 2013.
- Several joint R&D projects, focused on testing fuels, scale up, and cost reduction.
- ECN supports engineering and commissioning of commercial plants.



OLGA 2006



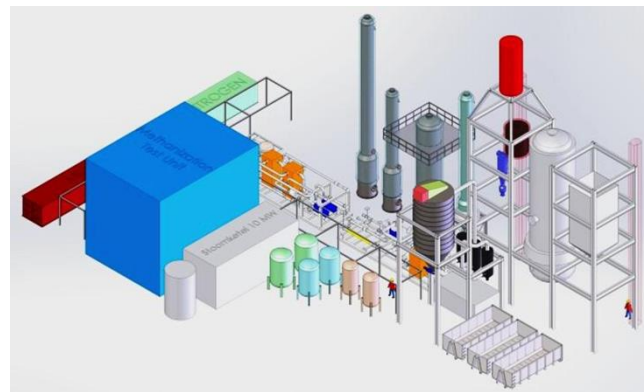
MILENA 2013

Present MILENA + OLGA projects

- 1 MW_e MILENA – OLGA - GAS engine demonstration project under construction. Thermax + Dahlman
- 4 MW_{th} MILENA – Bio-Methane project in Alkmaar. 22 M€ SDE⁺ subsidy granted recently. Final investment decision expected within months.
- 7 MW_e IGCC demonstration using RDF in the UK; FID in 2-4 months.
- Many other projects under discussion with potential clients.



India, soy residue



NL Bio-Methane demo



UK Waste to Power demo

Conclusions / Outlook

- Time from idea to market implementation can be long. In case of MILENA development over 10 years.
- Duration tests at pilot scale were very important in convincing potential clients that technology is ready for next step.
- A lot of interest in technology, many potential clients for commercial systems, but demo installation is essential.
- ECN & Dahlman continue to improve the technology (reduce cost)
- Focus on development of methanation technology for MILENA gas
- BTX co-production under development
- Modified MILENA for low rank coal to SNG tested at lab-scale, further development at pilot scale.

Thank you for your attention

Visit us at booth B11

For more information: www.milenatechnology.com

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