ECN

Energy research Centre of the Netherlands

MILENA gasification bed materials

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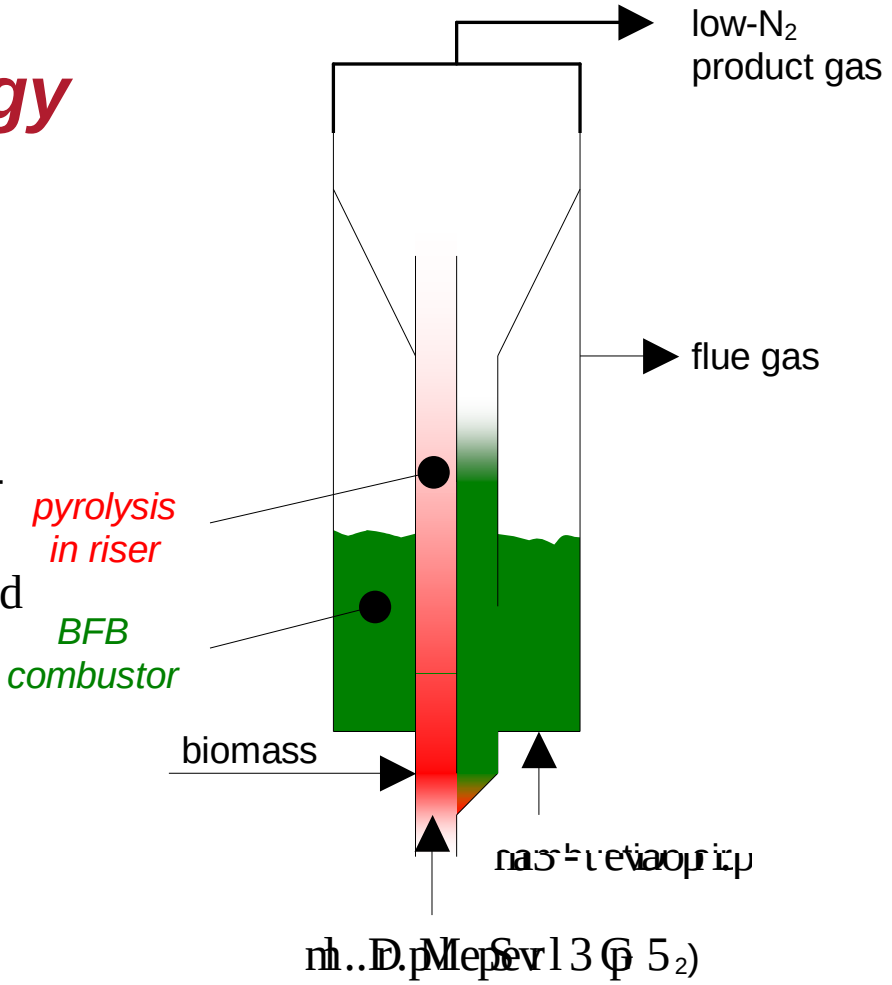
Overview

- MILENA gasification process
- Facilities
- Bed materials tested + results
- Conclusions.
- Bed material topics of interest

ECN MILENA
gasification technology

1. Developed for high efficiency
2. Medium calorific gas, low N2
3. Complete conversion, no carbon in ash
4. High CH4 content, suitable for Bio-SNG production
5. Suitable for scale-up and pressurized operation
6. High tar content



MILNEA 30 kWth Lab-scale installation

- More than 3000 hours of operation in gasification mode
- Tested fuels: Wood, sewage sludge, grass (not successful) and lignite.
- Bed materials: Olivine (Austria, Norway, Canada), dolomite (calcined and fresh) and Sand (+additives).

Lab scale MILENA + OLGA + SNG installation

More than 2500 hours of operation in gasification mode since 2004.
Tested fuels: Wood, sewage sludge, grass (not successful) and lignite

MILENA

gasification

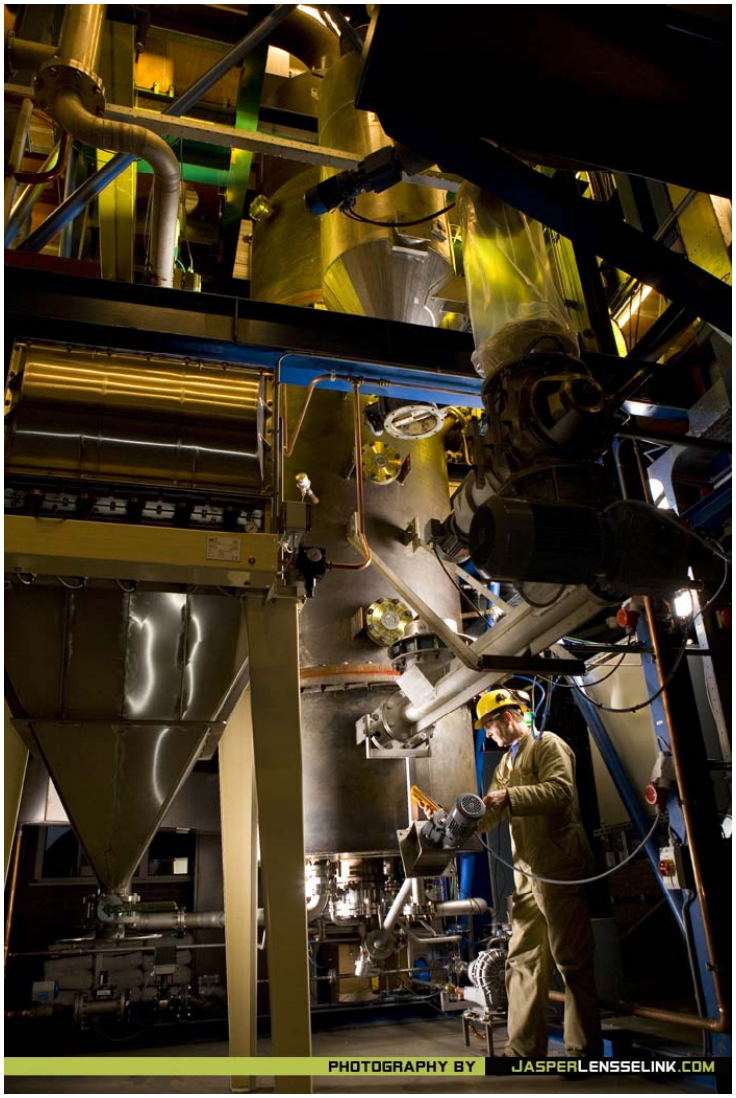
OLGA

Gas cleaning

Methanation

MILENA pilot plant

- Thermal input 160 kg/h (800 kW HHV)
- In operation since 2008
- Connected to OLGA tar removal in 2009.
- Design fuel wood
- Gasifier / Riser diameter: 0.2 m
- Combustor diameter: 0.8 m
- Total height: 8 m
- Duration tests done with demolition wood and clean wood to generate engineering data for 12 MW_{th} demo plant.
- Approx. 1000 h of operation.



MILENA pilot fuel example

MILENA gas composition example

Fuel			demolition wood		clean wood
Fluidization gas			steam	air	steam
Bed material			olivine	olivine	olivine
CO	[vol%]		33,6	28,6	39,9
H_2	[vol%]		28,1	21,1	23,8
CO_2	[vol%]		14,0	13,7	11,1
CH_4	[vol%]		13,1	9,8	15,3
N_2	[vol%]		4,2	23,5	3,9
C_2H_2	[vol%]		0,3	0,2	0,2
C_2H_4	[vol%]		3,5	2,1	4,3
C_2H_6	[vol%]		0,2	0,1	0,3
C_6H_6	[vol%]		1,0	0,7	1,1
C_7H_8	[vol%]		0,1	0,1	0,1
H_2S	[Vppm]		403	355	-
COS	[Vppm]		14	20	-
NH_3	[Vppm]		19450	-	-
HCN	[Vppm]		-	4000	-
HCl	[Vppm]		150	-	-
Tar total	[g/nm^3]		30	-	40

Bed material research in MILENA:

- Main goal: Preventing fouling in cooler between gasifier and gas cleaning (OLGA). OLGA performs well, no need for additional tar / dust removal.
- Tar dew point reduction preferably below 300°C.
- No interest in reduction of light tars like naphthalene.
- No CH_4 reforming.
- Costs / bed material loss should be low.
- No negative effects on bed agglomeration.

MILENA tests:

- Tested bed materials / bed additives:
  - Sand
  - Austrian olivine (limited)
  - Norwegian olivine (no thermal pretreatment), MILENA standard bed material.
  - Canadian olivine (Olimag, thermally pretreated).
  - Dolomite as additive
  - CaO as additive

Note: Bed material testing was never a major topic, because tar removal is done by OLGA.

Dolomite experiments: lab scale (30 kWth)

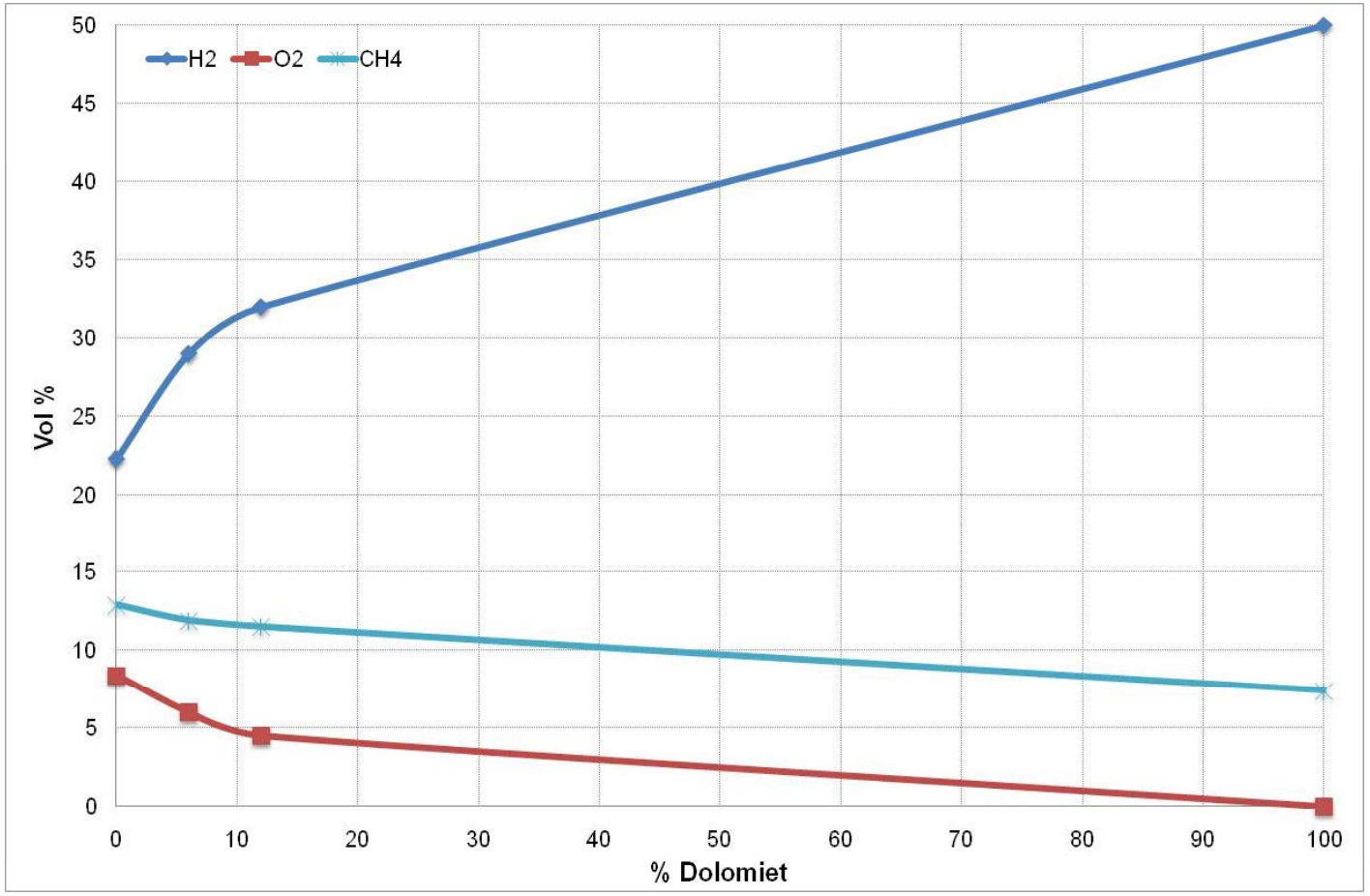
- Dolomite was tested because it is cheaper than olivine & is catalytically active
- Tests conducted:
  - 100% dolomite ($CaCO_3$/$MgCO_3$) as bed material
  - Mixed with sand
  - Calcined dolomite (CaO/MgO) mixed with sand

Dolomite experiments: lab scale (30 kWth)

	Sand	Dolomite	12% Dolomite/sand	6% Dolomite/sand	9% Cal. dolo./sand
Tavg [°C]	860	854	857	845	~835
S/B [-]	0.5	0.37	0.34	0.33	0.34
H_2 [vol%]	20	38-50	33	23	25
CO [vol%]	39	20-21	28	25	35
CH_4 [vol%]	13	8-11	11	10	12
Tar class 5 [g/nm3 dr]	**5**	**0.5**	**2.2**	**3**	**2.5**
Total tar [g/nm3 dr]	32	2.1	21.8	27.3	26
Fines [gr/hr]	50	550	275	n.m.	45

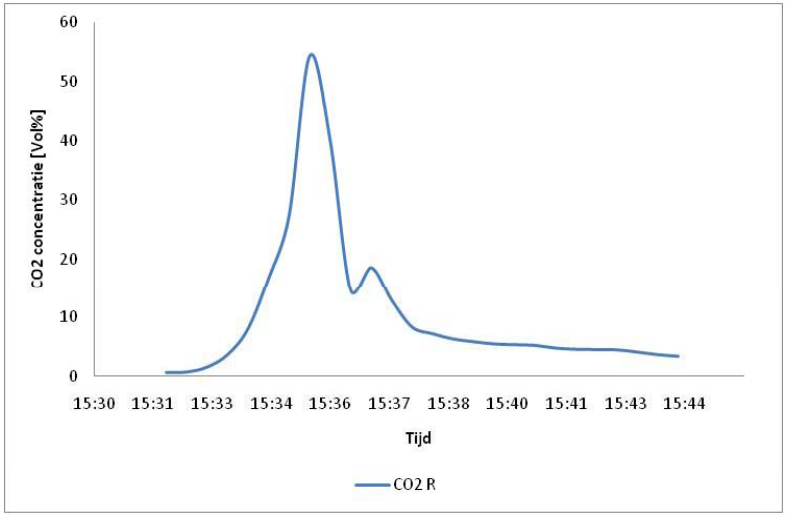
Remark: fines from combustor only. No producer gas cyclone in lab MILENA

Dolomite experiments: lab scale (30 kWth)



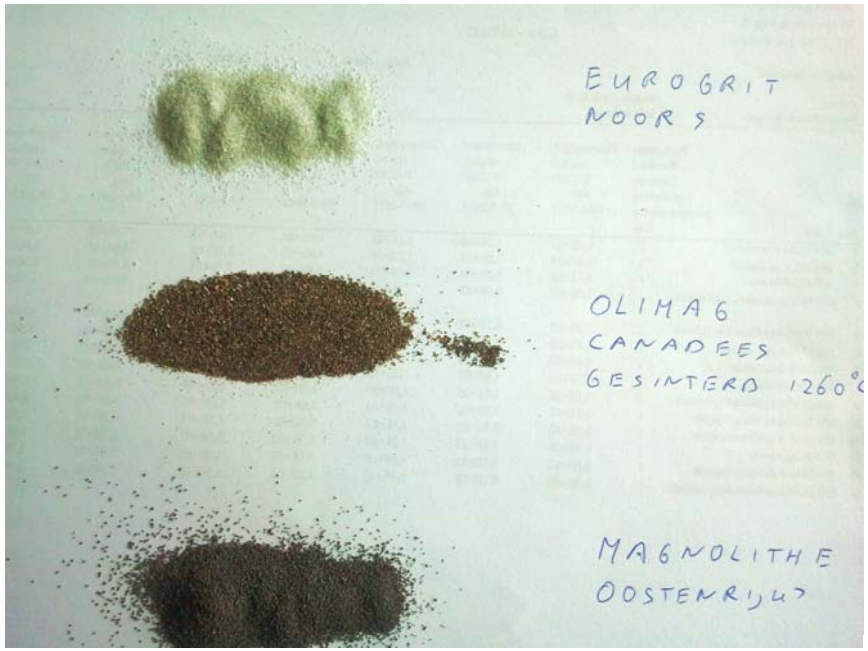
Dolomite experiments: lab scale (30 kWth)

- Dolomite is flash calcined when added to the hot bed, can result in pressure peaks & alarms
- 100% dolomite results is too much tar/carbon transport to the combustor and increasing temperatures
- 12% dolomite in sand results controlable temperatures and reduces tar
- Calcined dolomite: no CO_2 peaks



Olivine experiments: lab scale (30 kWth)

- 3 types of olivine tested:
  - Pretreated olivine from Austria and Canada
  - Untreated olivine from Norway

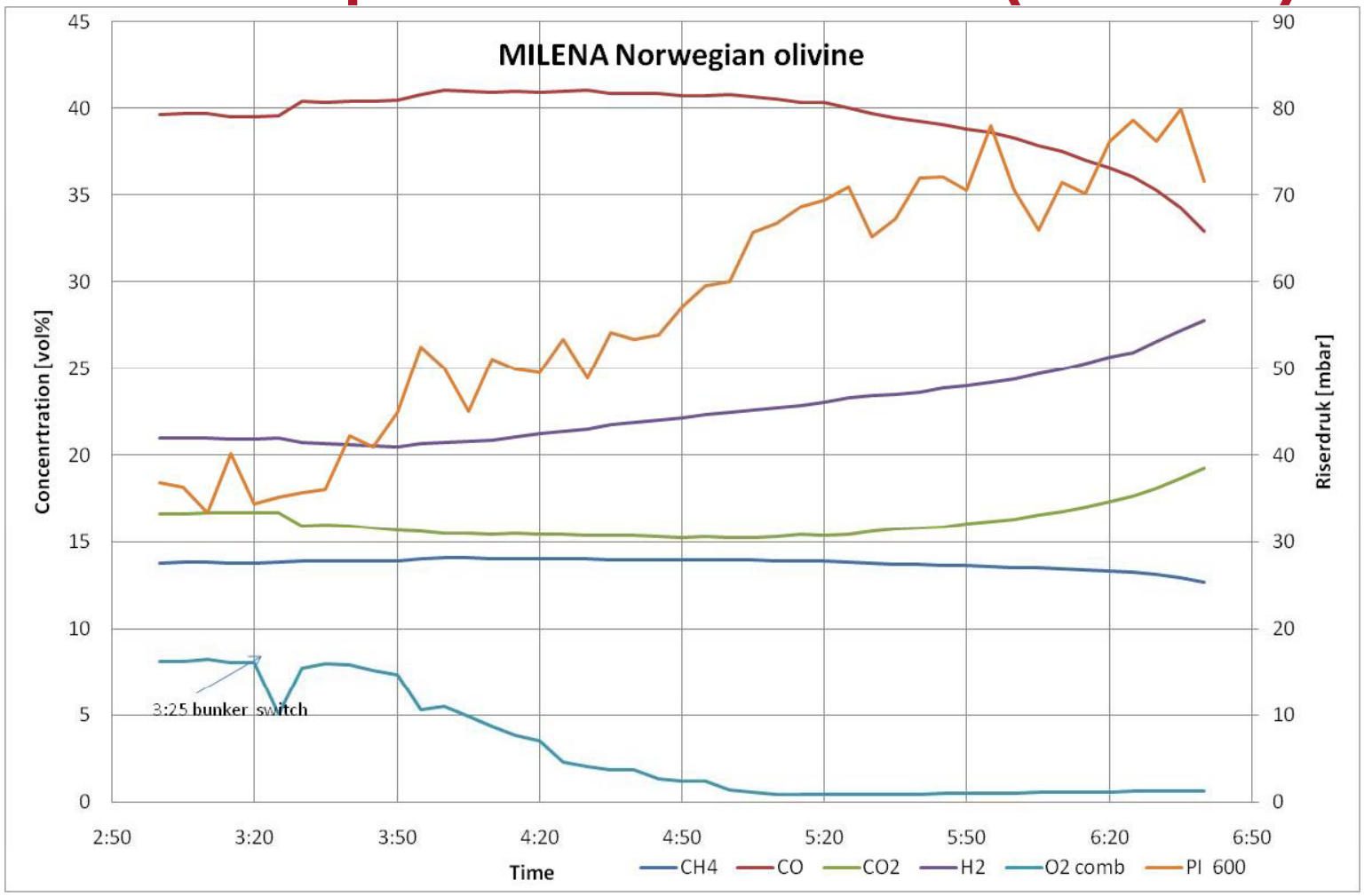


Olivine experiments: lab scale (30 kWth)

	Sand	Olivine (No)	Olivine (Au)	Olivine (Can)
Tavg [°]	860	865	860	856
S/B [-]	0.5	0.5	0.7	~0.35
H_2 [vol%]	20	26	21	22
CO [vol%]	39	33	31	30
CH_4 [vol%]	13	12	10	12
Sum O_2 + CO_2 [vol%]	18	17	14	15
Tar class 5 [g/nm3 dr]	5	3	3	3
Total tar [g/nm3 dr]	32	28	25	25

Note: duration tests were done with Norwegian olvine

Olivine experiments: lab scale (30 kWth)



Finding MILENA olivine experiments (1/2)

- Tar reduction is limited.
- Norwegian olivine is the worst option, but availability in right fraction is best.
- Pretreated olivine (sintered, migration of Fe to surface) reduces tar concentration and transports O_2 (typical between 0 – 0.3 wt%).
- Untreated olivine, gets more active, over time during the reduction/oxidation cycles in MILENA.

Finding MILENA olivine experiments (2/2)

- Catalytic CO shift activity is influenced by air to fuel ratio in combustor.
- Despite bad performance Norwegian olivine is our standard in the lab and the pilot installation.

Conclusions

- MILENA using sand or Norwegian olivine produces a lot of tar (40 gram/nm3), OLGA can handle this. The sensitive part is the cooler.
- Despite the high tar concentration both the lab-scale and the pilot scale installation run without fouling problems.
- Activity of Norwegian olivine is limited, better alternatives are available. Norwegian olivine has become our standard because of practical reasons.
- Bed materials remain a fuzzy subject.
- Measuring heavy tars is problematic.
- Addition of small amount of calcined dolomite looks promising, but pilot scale test failed because of flue gas cooler clogging.

Bed material topics of interest

- Fundamental understanding olivine (Fe, Ca, etc.).
- Alternative bed material testing in indirect gasifiers (e.g. MgO).
- Additives testing in indirect gasifiers.
- Practical issues related to dolomite (gas coolers, calcination, etc.).
- Measurements of heavy tar concentration.

MORE INFORMATION

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