

New Gasification Technology for (High Ash) Low-Rank Coal





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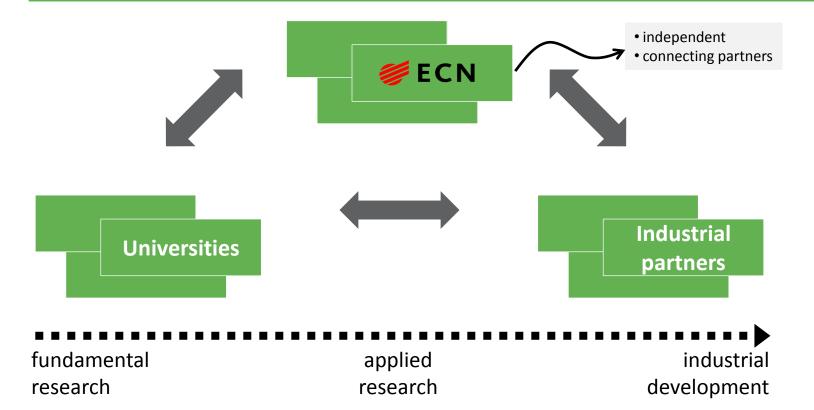
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- Fluidized Bed Gasification
- Allothermal Gasification
- ECN MILENA for biomass gasification
- ECN i-MILENA for (high ash) low-rank coal gasification
- Test results
- Promising configurations / applications
- Further development of the i-MILENA
- Conclusions and Outlook



ECN's mission and position

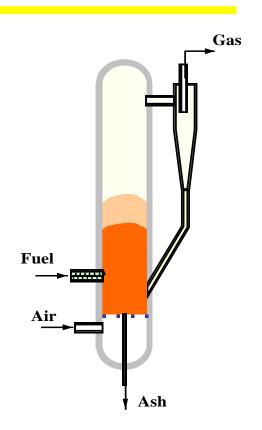
Making the renewable energy society come true



Fluidized bed gasification for low rank coal



- Proven technology
- Typical 850°C 1000°C, pressurization possible.
- Air blown or steam / oxygen mixtures.
- Scale > 5 MW_{th.}
- Hydrocarbons in the gas, some tar in gas.
- Fuel flexible (also used for waste and biomass)
- No fine milling required.
- Incomplete fuel conversion.
- Examples: ThyssenKrupp HTW, TRIG, U gas SES.
- Better suitable for high ash coals then EF
- In competition with fixed bed





Allothermal gasification

Combustion:

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

Pyrolysis / gasification:

allothermal gasification:

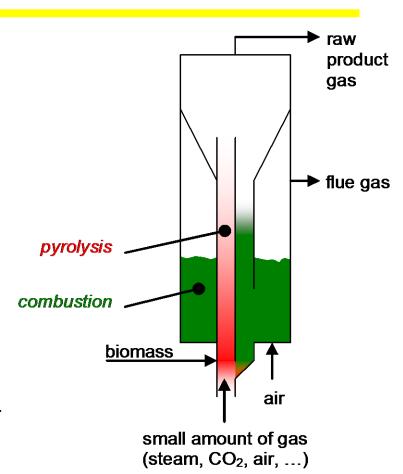
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fuel + air (\lambda \sim 0.3) \rightarrow gas + flue gas
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electricity, heat, fuels, SNG, chemicals, H₂, products

ECN MILENA biomass gasification process



- Fluidized bed gasification
- Temperature level: 700 900°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
- Fuel flexible: wood, RDF, lignite, sunflower husks, etc.



Present status MILENA for biomass gasification



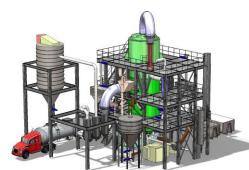
Lab-scale installation since 2004, pilot plant since 2008

Several demonstration projects based on MILENA + OLGA in preparation

- The Netherlands: Bio-Methane demonstration (4 MWth)
- England: RDF to Power gasification (7 MWe), 1st phase (pilot plant tests)
 finalized
- India: Soy stalks to power (1 MWe), with gas engine, under construction









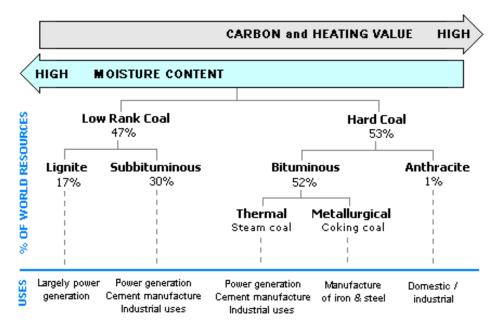


i-MILENA for high ash coal

Role of low-rank coal in energy society



- Coal will continue to play a key role in the world's energy scenario (power generation, fuels and chemicals.
- Coal resources have been estimated at over 861 billion tons.
- Coal meets around 30% of the global primary energy.
- Coal generates 42% of the world's electricity.
- Around 45% of the world's coal is either high-moisture or high-ash.



Gasification of (high ash) low rank coal

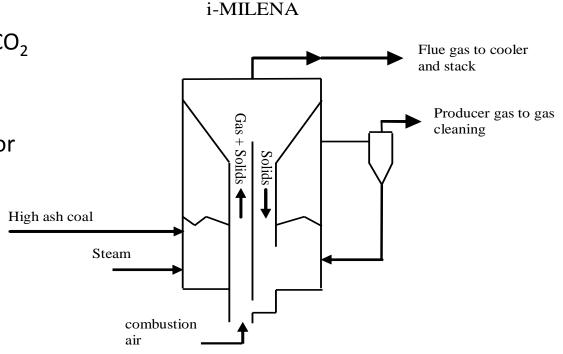


- Subcritical combustion of high ash coal, often results in inefficient operation of the power plants.
- Emissions of fly-ash in power plants as well as the ash disposal pose an ecological and environmental challenge.
- Gasification of coal has minimal environmental impact by conversion of the coal into Synthetic Natural Gas (SNG), i.e. high-quality methane.
- During the production of SNG CO₂ is separated from the gas. Upon sequestration, the carbon footprint can be reduced to the same level as natural gas.

i-MILENA gasifier for (high ash) low rank coal



- Carbon conversion in gasifier
 - 60 70% -> CO, CH₄, C₆H₆ & CO₂
 - production of H2 via CO shift
- Carbon conversion in combustor
 - 30 40% -> CO2
- Overall conversion is 100%
 - ashes are white / grey





Tests with low-rank coals

- Extensive testing done in 2012, 2013 & 2014 as part of the EU Optimash project; cooperation with Thermax from India
- Several low rank coals from India and Turkey tested
- Ash content over 50%
- Ash of coal used as bed material
- Gasifier connected to gas cleaning section (OLGA)





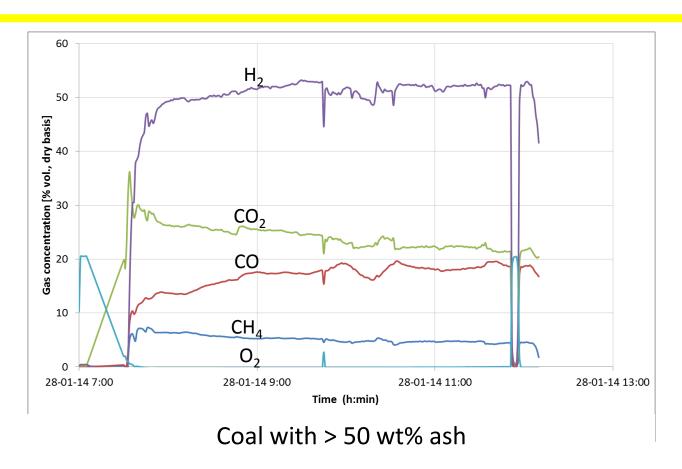


i-MILENA GAS CLEANING

METHANATION



Producer gas composition low rank coal



Producer gas composition from coal with > 50 wt% ash



		Test 1	Test 2
Producer gas con	nposition		
CO	[% vol. dry]	17.1	17.4
H_2	[% vol. dry]	51.7	52.2
CO_2	[% vol. dry]	23.7	25.1
CH_4	[% vol. dry]	5.2	5.3
$O_2/(Ar)$	[% vol. dry]	0.07	0.04
C_2H_2	[% vol. dry]	0.071	0.070
C_2H_4	[% vol. dry]	0.482	0.377
C_2H_6	[% vol. dry]	0.011	0.006
C_6H_6	[ppmv dry]	2309	2574
Toluene	[ppmv dry]	< 10	< 10
N_2	[% vol. dry]	3.8	1.2
H_2S	[ppmv dry]	3586	3229
COS	[ppmv dry]	56	106



Bottom ash

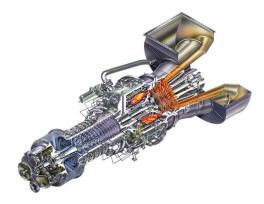




Foreseen applications

- (Co-)firing in boilers, scale > 1 MW_{th.}
- Gas engines for combined heat and power production, limited tar removal required, scale 2 – 20 MW_a.
- Combined Cycles using gas turbines for power production, tar removal required (OLGA), scale > 6 MW_e.
- SNG production, preferably in combination with CCS, tar removal required (OLGA), scale > 100 MW $_{th}$.









SNG from low-rank coal using i-MILENA

- i-MILENA produces a gas with a high initial yield of CH₄
- Overall efficiency for low-rank coal to SNG is about 60%
- No Air Separation Unit (ASU), low investment
- Low overall water consumption
- Low rank coal is the ideal fuel for the i-MILENA SNG configuration
- Construction of MILENA biomass gasifier to produce SNG is scheduled;
 final investment decisions end 2014



Conclusions & Outlook

- Demonstrated that i-MILENA is able to produce a medium calorific value producer gas without the need for an air separation unit (ASU).
- The overall carbon conversion is close to 100% yielding a grey/white ash
- Operated at low temperature, no ash melting.
- Simple gasifier, also suitable for small scale applications (<100 MW), low investment cost.
- High cold gas efficiency of about 65%, due to full carbon conversion and relatively low temperature
- Process is ideal for SNG production, low investment, high efficiency and low water consumption, coal to methane efficiency is about 60%
- Next step in development: pilot scale testing and preparations for demo plant with commercial partner



THANKS FOR YOUR ATTENTION

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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 /www.bioCNG.com

