Co gasification of biomass and lignite

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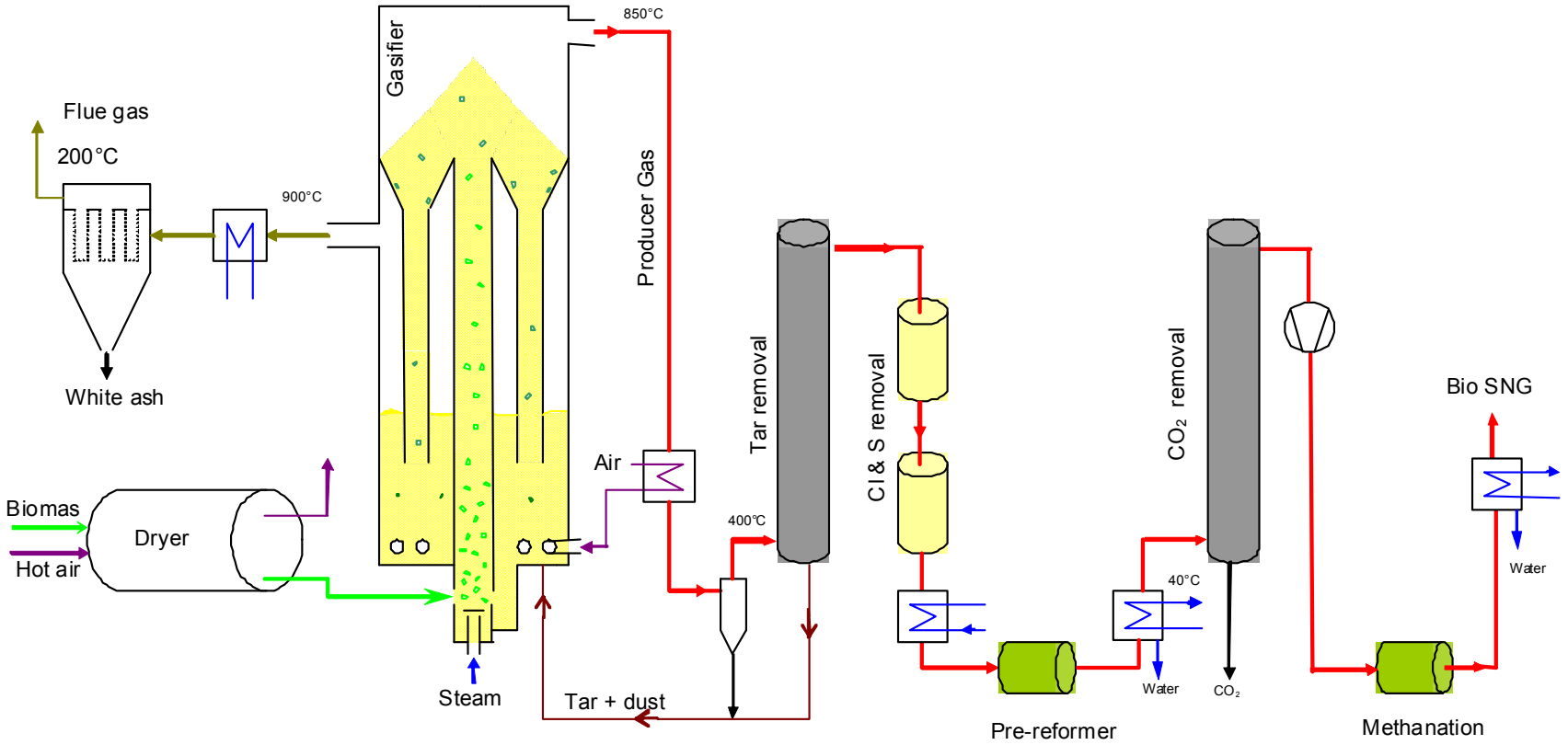
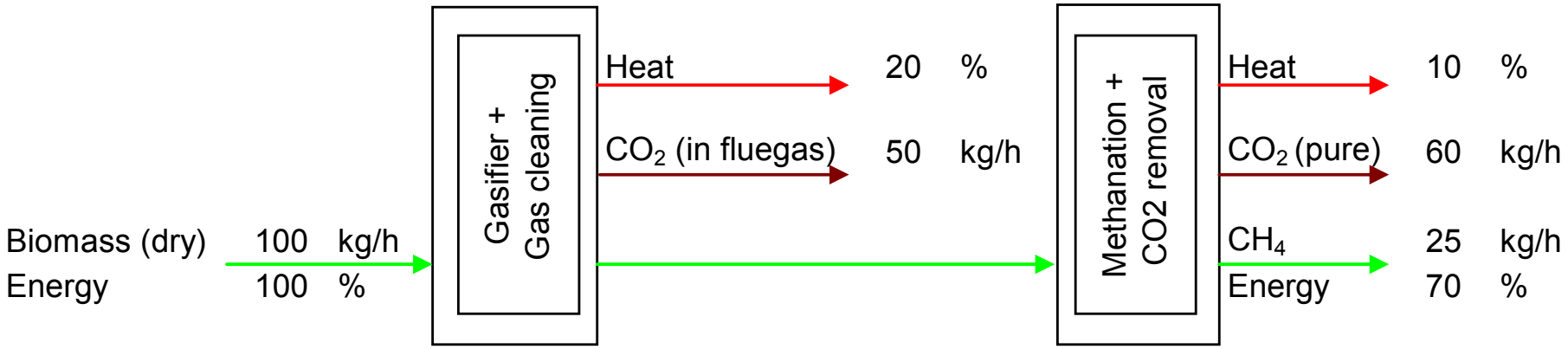
Biomass gasification and SNG production

- Natural gas is the main source of energy in the Netherlands and fossil natural gas reserves are in decline -> renewable alternative required.
- SNG has many applications: Heat and electricity production, feedstock for chemical industry and recently as a transport fuel.
- Biomass will become expensive, so a high overall efficiency from biomass (wood) to fuel is required. Efficiency Substitute Natural Gas up to 70%.

Simplified Bio-SNG system



Expected yields ECN Bio-SNG concept commercial scale



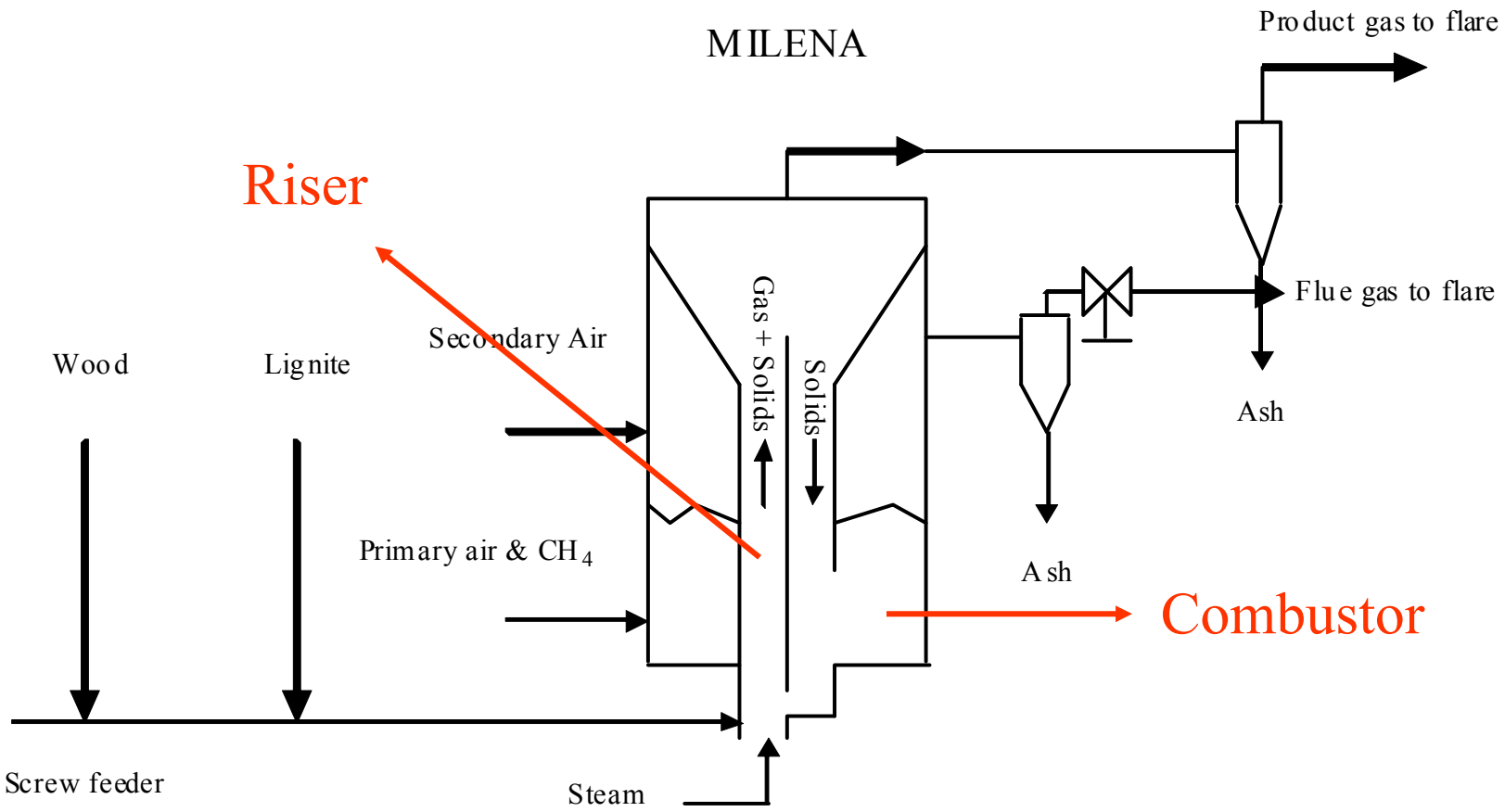
MILENA gasifier

OLGA gas cleaning

Why co gasification with coal?

- Coal is cheaper than biomass and therefore a combination of the two will increase the economic margin of an SNG production facility.
- Coal is still abundantly available and can help the start up of SNG production facilities.
- Coal might simplify the SNG production facility.
- ECN develops a fuel flexible gasifier, therefore testing different fuels is necessary.

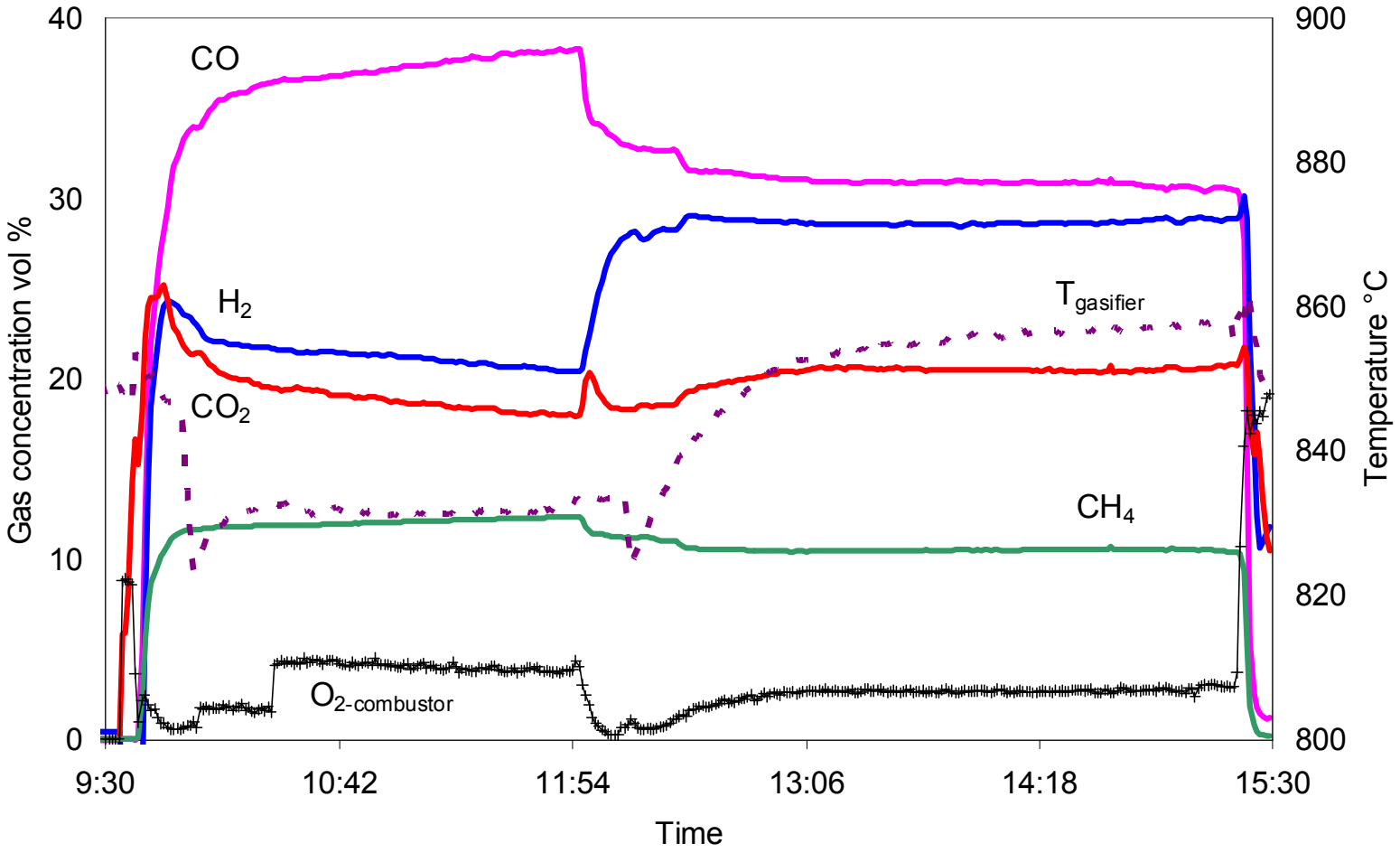
Experimental work



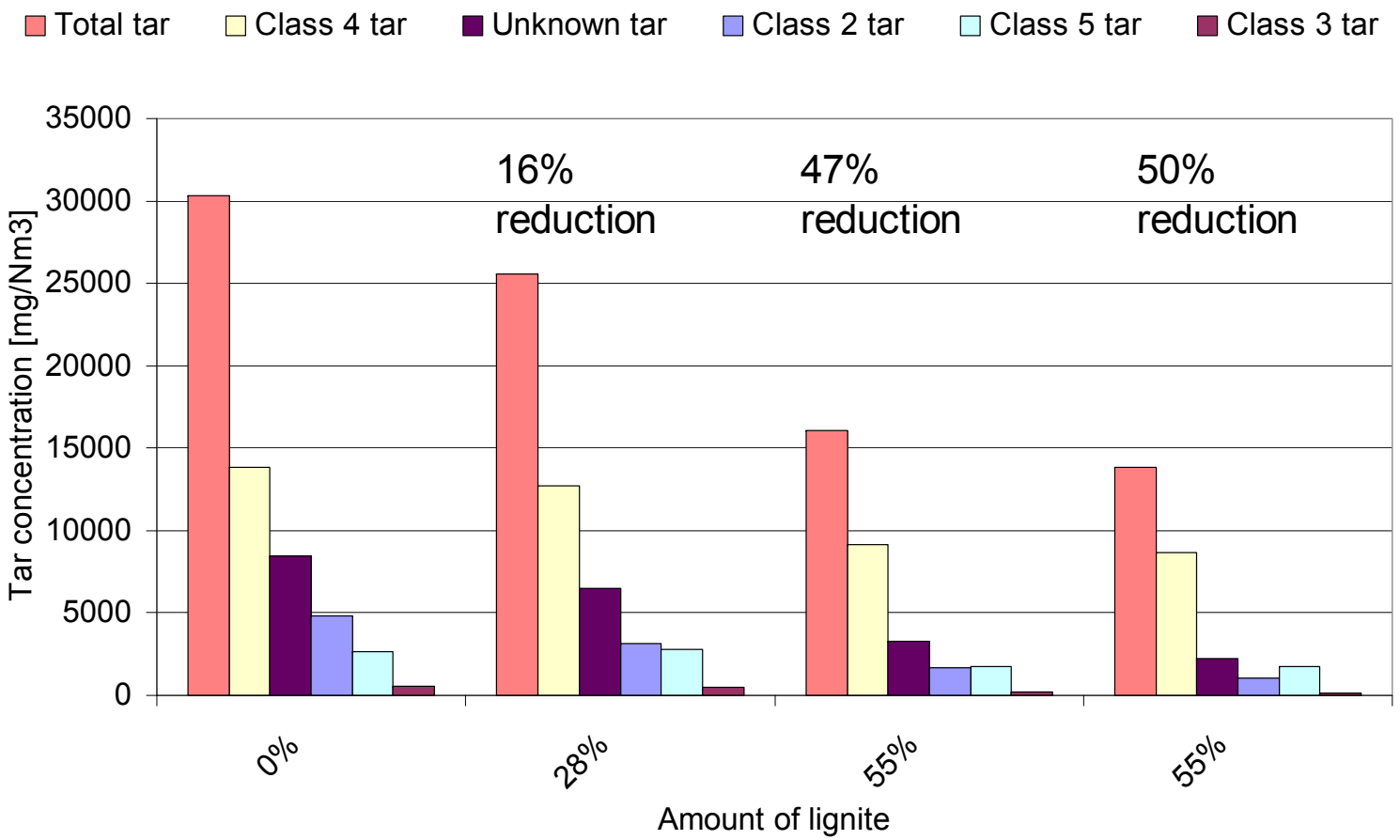
Experimental settings

Primary air combustor	[nl/min]	99	119	119	119
Secondary air combustor	[nl/min]	25	25	25	20
Methane combustor	[nl/min]	1	0	0	0
Beech wood chips	[gram/h]	5900	4200	2000	2000
Lignite	[gram/h]		1655	2440	2440
Percentage of brown coal	[%]	0	28	55	55
Steam on the riser	[kg/h]	2.0	2.0	2.0	2.0
N_2 on the riser	[nl/min]	1.0	1.0	1.0	1.0
CO_2 on the feeding screw	[nl/min]	1.0	1.0	1.0	1.0

Day 1 – 28% lignite co gasification



Effect of lignite on tar



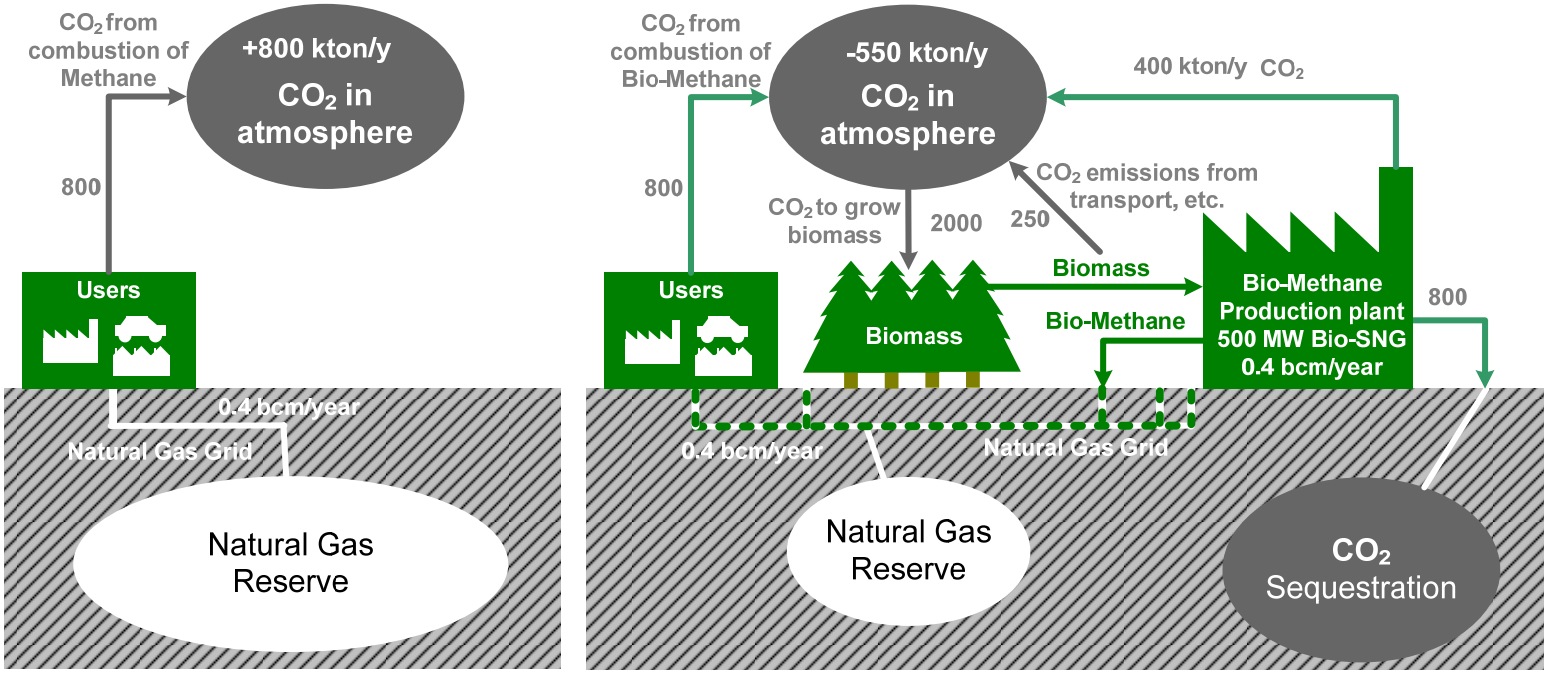
Gasifier mass balance

Percentage of brown coal	[%]	0	28	55	55
C in CO / C in fuel	[wt. %]	35.8%	30.2%	24.1%	25.0%
C in CO2 / C in fuel	[wt. %]	18.3%	20.2%	23.6%	27.0%
C in CH4 / C in fuel	[wt. %]	11.7%	10.3%	8.5%	8.6%
C in C2H2 / C in fuel	[wt. %]	0.8%	0.7%	0.4%	0.4%
C in C2H4 / C in fuel	[wt. %]	8.9%	7.5%	6.1%	5.0%
C in C2H6 / C in fuel	[wt. %]	0.7%	0.5%	0.4%	0.2%
C in C6H6 / C in fuel	[wt. %]	4.9%	4.8%	4.3%	4.6%
C in C7H8 / C in fuel	[wt. %]	0.9%	0.8%	0.7%	0.4%
C in tar	[wt. %]	5.1%	4.4%	2.9%	2.6%
C in char	[wt. %]	14.5%	22.4%	30.9%	28.1%
H in H2 / H in fuel	[wt. %]	15.2%	26.8%	40.1%	44.5%
Carbon conversion	[%]	85.5%	77.6%	69.1%	71.9%
Gasifier temperature	[°C]	757	776	776	801
CO shift equilibrium temp.	[°C]	2252	1342	1005	895
ER gasifier	[-]	0.096	0.093	0.095	0.110
CO	[vol.% wet]	21.5%	19.1%	14.5%	14.8%
H2	[vol.% wet]	12.3%	17.7%	22.6%	24.7%
CO2	[vol.% wet]	10.9%	12.7%	14.1%	15.9%
O2	[vol.% wet]	0.0%	0.0%	0.0%	0.0%
H2O	[vol.% wet]	42.1%	37.8%	38.4%	34.9%
CH4	[vol.% wet]	7.0%	6.5%	5.1%	5.1%
Ar	[vol.% wet]	0.0%	0.0%	0.0%	0.0%
C2H2	[vol.% wet]	0.2%	0.2%	0.1%	0.1%
C2H4	[vol.% wet]	2.6%	2.4%	1.8%	1.5%
C2H6	[vol.% wet]	0.2%	0.1%	0.1%	0.1%
C6H6	[vol.% wet]	0.5%	0.5%	0.4%	0.4%
C7H8	[vol.% wet]	0.1%	0.1%	0.1%	0.0%
N2	[vol.% wet]	2.5%	2.9%	2.7%	2.4%

Summary of the tests

- Lower carbon conversion, due to less volatiles in lignite
- Less tar production, due to less complex fuel will improve the gas cleaning line up
- Increase in sulphur – incomplete S balance – impact on the gas cleaning is unknown
- Co gasification of biomass and lignite is possible in the indirect gasifier MILENA

Bio-SNG CO_2 performance



1GW$_{th\ input}$ bio SNG plant

- 35 w-% Lignite →Saves ~ 30 M€ on feed costs
- 35 w-% Lignite →Reduces tar concentrations with ~30%
- 35 w-% Lignite →Will change gas compositions and impurities. Need for a different gas cleaning?
- 35 w-% Lignite →Overall CO_2 balance is 0% extra emissions to the environment.

Transport fuel - Policy

- UK 5% in 2013-2014
- US 36 billion gallons in 2022
- NL 4% in 2010
- EU P10% in 2020 and 25% in 2030

Transport fuel - Prices

- NL as Substitute Natural Gas → 6 €/GJ
- NL as Compressed Natural Gas → 20 €/GJ

Conclusions

- Co gasification of lignite and biomass is possible for more than 50 w-% of lignite
- 35 w-% lignite is identified as the optimum regarding CO_2 emissions
- Co gasification reduces the amount of tar
- Producing SNG as a transport fuel in combination with co gasification of lignite and biomass seems to be the best economical option

MORE INFORMATION

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