JER 2.2 - Prospects for production and use of substitute natural gas (SNG) from biomass

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Prospects for production and use of substitute natural gas (SNG) from biomass

Supporting organisations:

- NoE Bioenergy
- ERA-NET Bioenergy

Co-authors:

- Tuula Mäkinen and Carl Wilén (VTT)
- Philip Peck and Andrius Plepys (IIIEE)
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Outline

- Motivation for bioSNG
- Production of bioSNG

- Methanation issues
- High-efficiency bioSNG production concept

- RD&D needs and recommendations

Motivation for bioSNG

Large market

- Natural gas consumption is significant
- Targets for renewable and sustainable energy also valid for natural gas

Easy to implement

- Conventional fuel in an existing distribution grid

Efficient as well as sustainable fuel

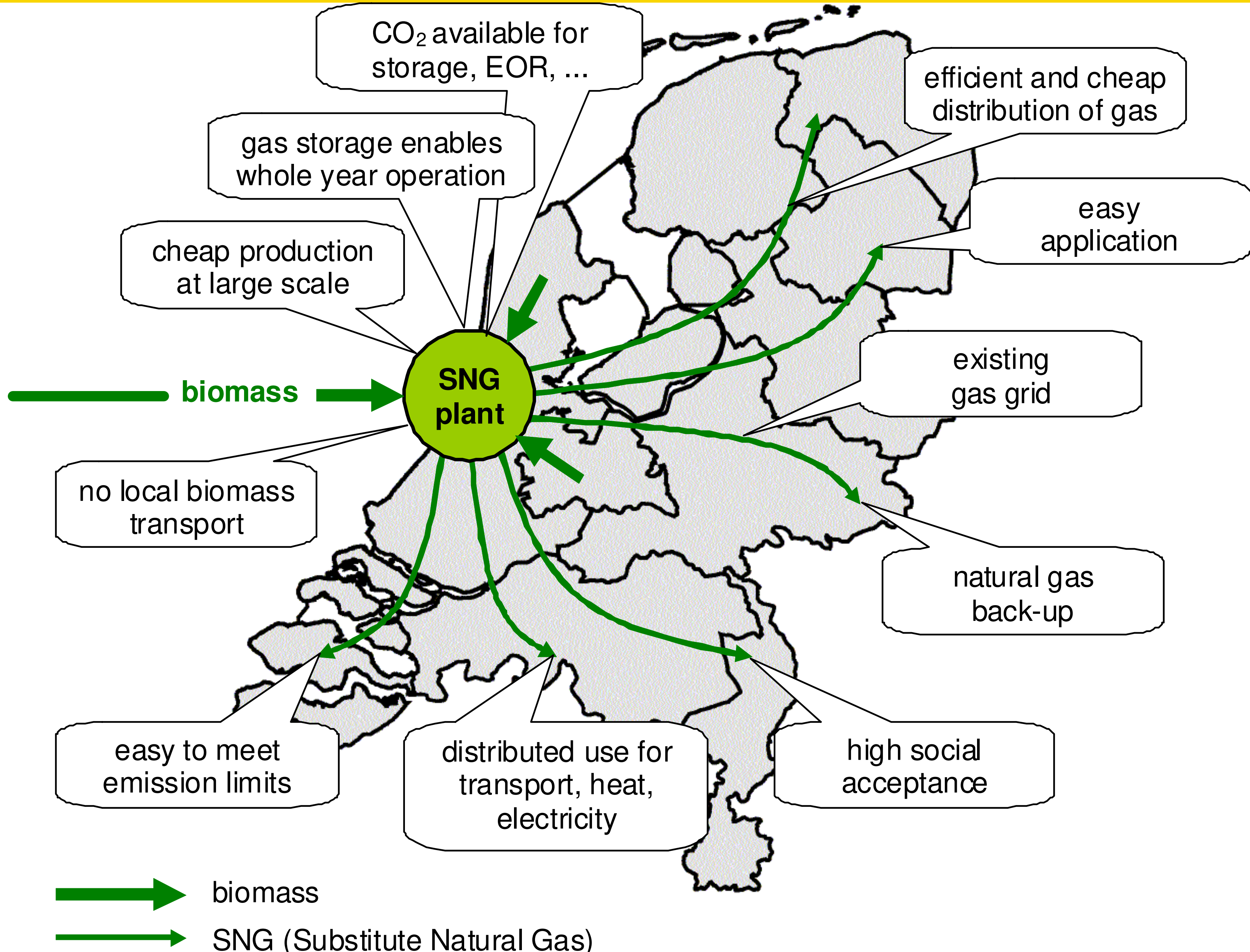
- High production efficiencies
- Excellent Green House Gas emission reduction

Increasing interest from the industry

2005 Primary Energy Consumption in EUROGAS Member Countries and EU25

Mt.o.e.	Oil	Solid fossil fuels	Natural gas	Nuclear el	Hydro el.	El. Imports	Renew-ables	Others	Total	Gas : Total [%]
Austria	14.6	3.9	**8.1**	0.0	3.3	0.0	4.2	0.0	34.2	24
Germany	122.0	82.1	**77.0**	42.5	4.1	-0.7	12.5	0.0	339.5	23
Denmark	8.2	3.7	**4.5**	0.0	0.0	0.1	3.1	0.0	19.6	23
France	92.0	13.6	**40.8**	117.7	5.0	-5.2	12.5	0.0	276.4	15
Finland	8.7	4.7	**3.6**	5.8	1.2	1.5	6.5	0.6	32.5	11
Netherlands	29.8	8.2	**35.5**	0.9	0.0	1.7	0.4	2.4	78.9	45
Poland	18.0	56.4	**12.2**	0.0	0.5	-0.6	4.7	0.0	91.3	13
Sweden	16.5	2.4	**0.9**	18.0	5.2	-0.6	9.5	1.1	53.0	2
UK	78.5	40.1	**93.6**	18.5	0.5	0.7	3.7	0.0	235.6	40
EU 15	595.4	220.6	**390.5**	230.8	26.5	2.8	67.9	4.2	1538.6	25
EU 25	639.3	316.9	**434.3**	251.2	28.4	3.1	75.6	4.7	1754.2	25

Source: Eurogas (2006) EU25 : Natural Gas Trends 2004-2005. Statistical Data & Taxes



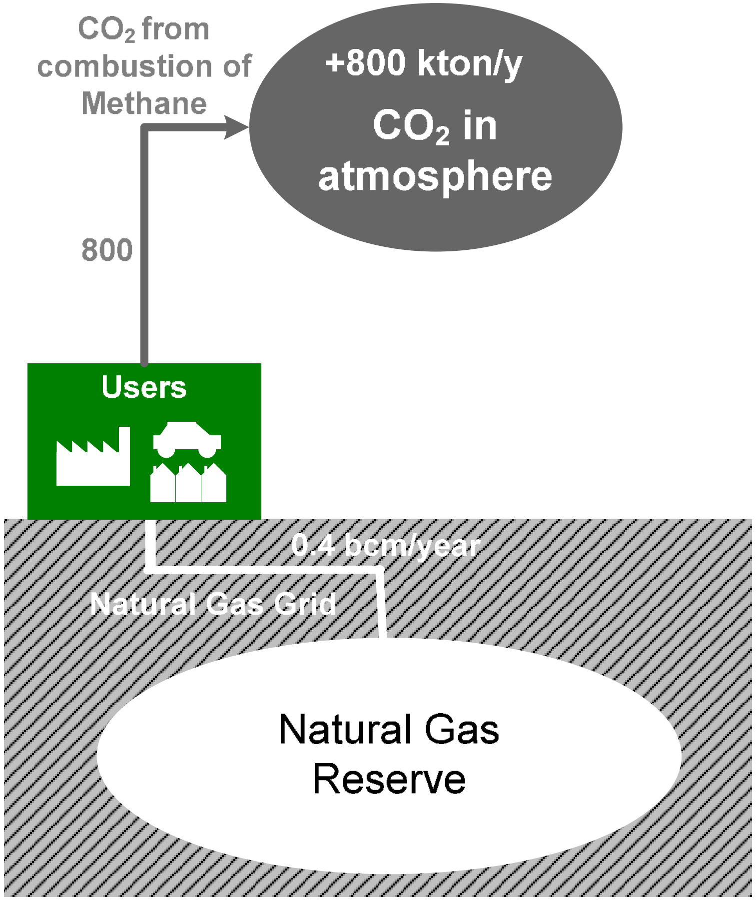
CO_2 available for storage, EOR, ...
gas storage enables whole year operation
cheap production at large scale
efficient and cheap distribution of gas
easy application
biomass
SNG plant
existing gas grid
no local biomass transport
natural gas back-up
easy to meet emission limits
distributed use for transport, heat, electricity
high social acceptance
biomass
SNG (Substitute Natural Gas)

gte
Gas Transmission Europe
Avenue des Arts 19 Tel +32 2 209 05 00 gte@gte.be
B - 1210 Brussels Fax +32 2 209 05 01 www.gte.be

THE EUROPEAN NATURAL GAS NETWORK

r	Location	from		to		max. flowrate in Mio Nm³/h
0	Tuy	Transgas	(P)	Enagas	(E)	0,04
1	Griespass	Transitgas	(CH)	SNAM Rete Gas	(I)	2,40
2	Panigaglia	LNG		SNAM Rete Gas	(I)	0,40
3	Mazara del Vallo	TPMC	(Tun)	SNAM Rete Gas	(I)	3,44
4A	Gorizia	SNAM Rete Gas	(I)	Geoplin	(Slov)	0,17
4B	Gorizia	Geoplin	(Slov)	SNAM Rete Gas	(I)	0,03
5	Tarvisio	OMV TAG	(A)	SNAM Rete Gas	(I)	3,12
6	Murfeld	OMV	(A)	Geoplin	(Slov)	0,42
7	Mosonmagyarovar	OMV	(A)	MOL	(H)	0,50
8A	Baumgarten	SPP	(SK)	OMV	(A)	4,56
8B	Baumgarten	OMV	(A)	SPP	(SK)	no transit
9	Lanzhot	SPP	(SK)	Transgas	(CZ)	6,50
0	Velke Kapusany	Ukrtransgas	(UKR)	SPP	(SK)	10,50
1	Revithoussa	LNG		DEPA	(GR)	0,22
2A	Bacton	Nat.Grid Transco	(UK)	Interconnector	(B)	2,30
2B	Bacton	Interconnector	(B)	Nat.Grid Transco	(UK)	1,00
3	Moffat	Nat.Grid Transco	(UK)	BGE (UK)	(IRL)	1,24
4	Twynholm	BGE (UK)	(UK)	Premier Transm.	(IRL)	
5	Kula	BulgarGaz	(Bul)	DEPA	(GR)	0,36
6	Imatra	Gazprom	(Rus)	Gasum	(FIN)	0,80
7	St. Fergus	Gassco	(N)	Nat.Grid Transco	(UK)	2,57
8	Beregdaroc	Ukrtransgas	(UKR)	MOL	(H)	1,75
9	Kiskundorozsma	MOL	(H)	NIS	(SER)	0,55
0	Bilbao	LNG		Bahia de Bizkaia	(E)	0,80
1	Sines	LNG		Transgas	(PT)	0,90

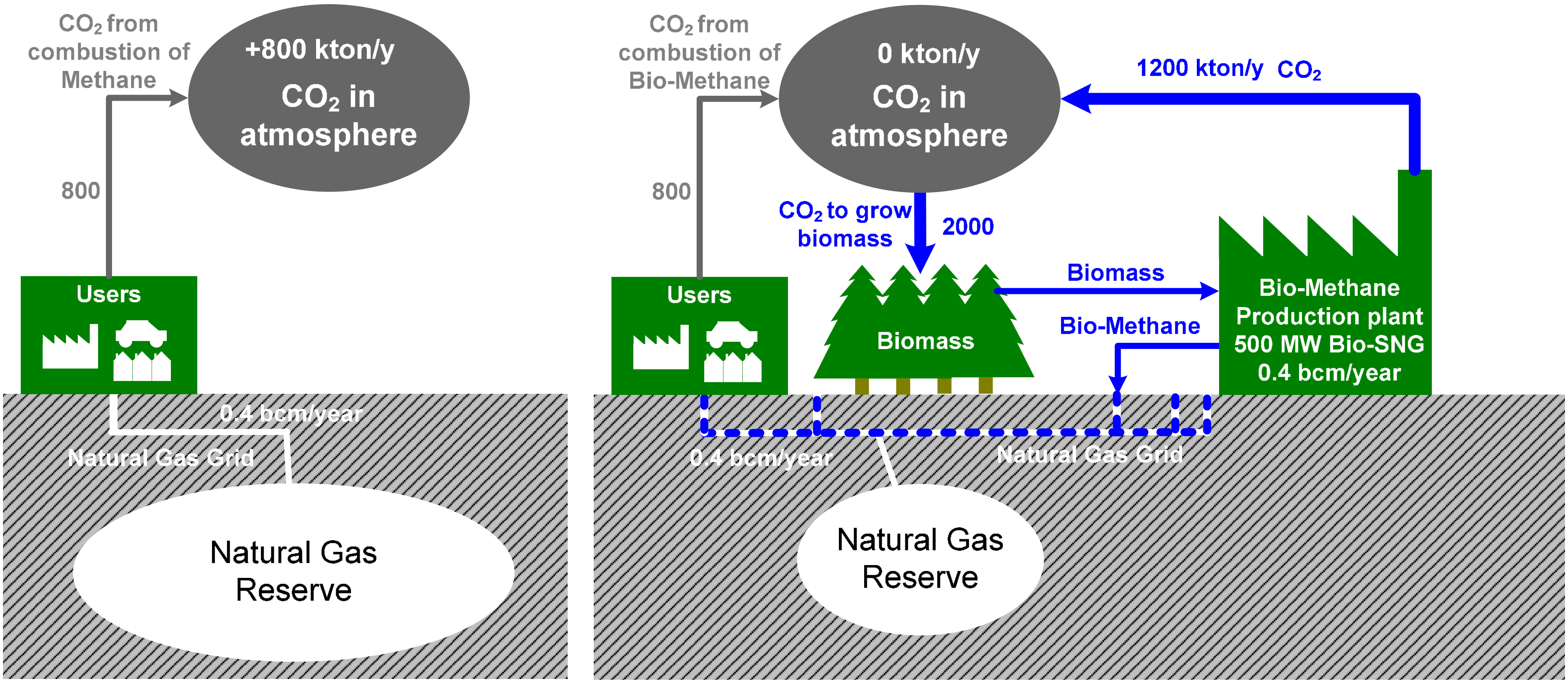
Motivation for bioSNG



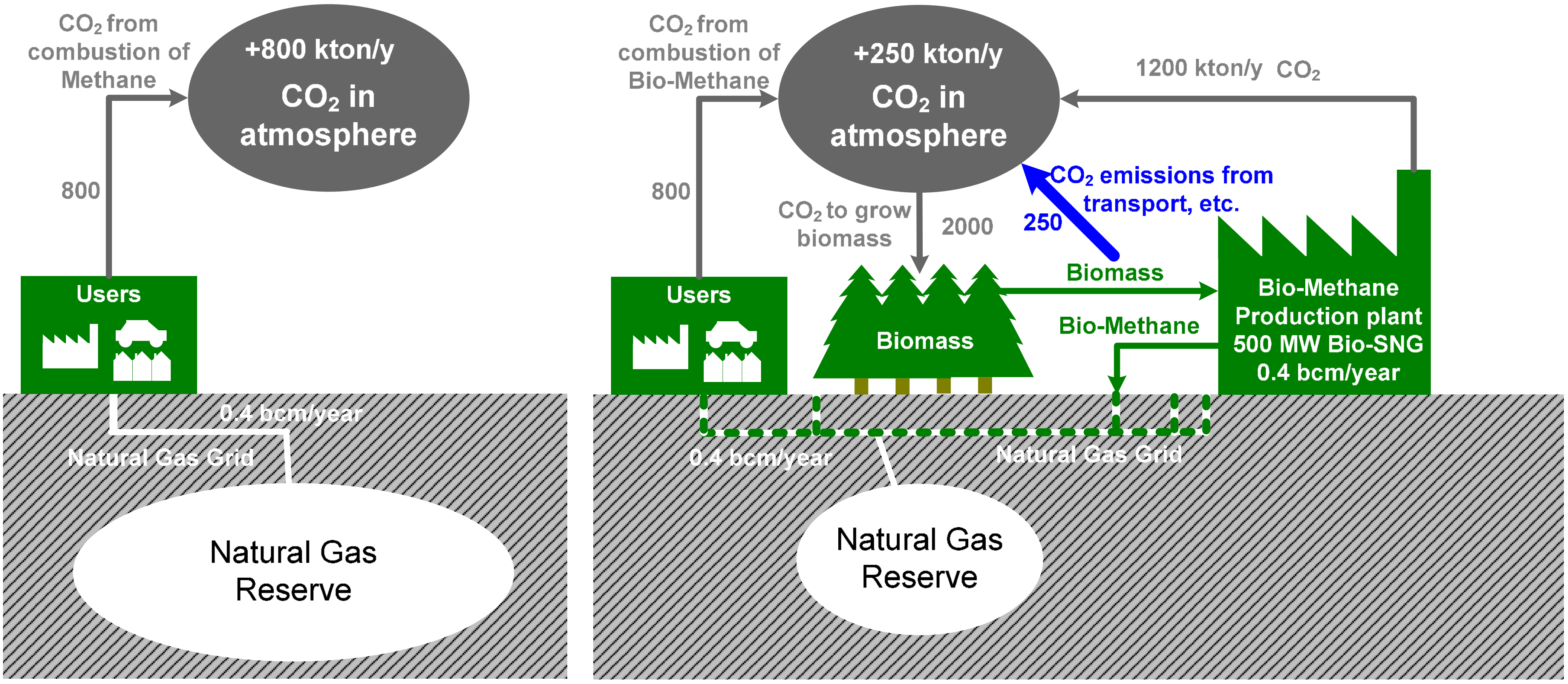
CO_2 emissions from fossil based natural gas

0.4 bcm/year natural gas results in 800 kton/year CO_2 emissions

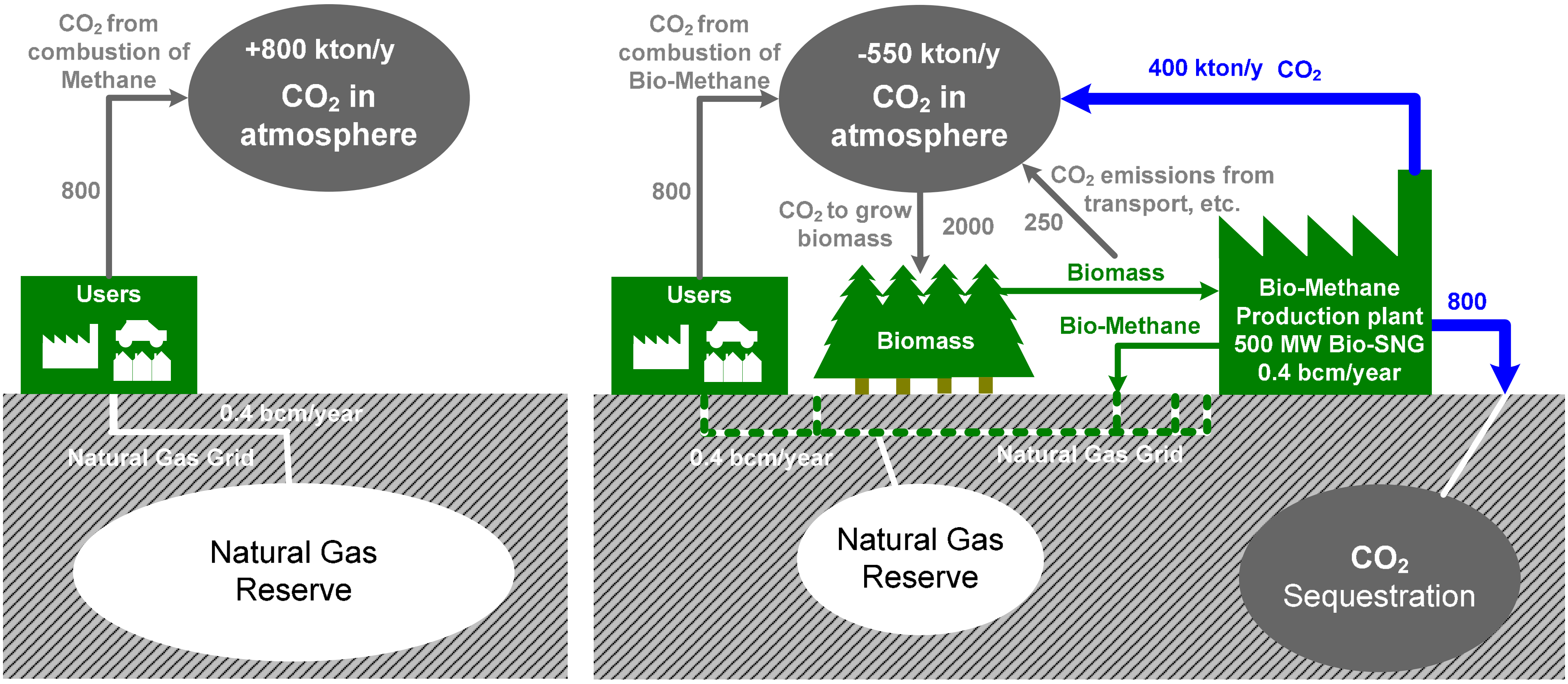
Motivation for bioSNG



Motivation for bioSNG

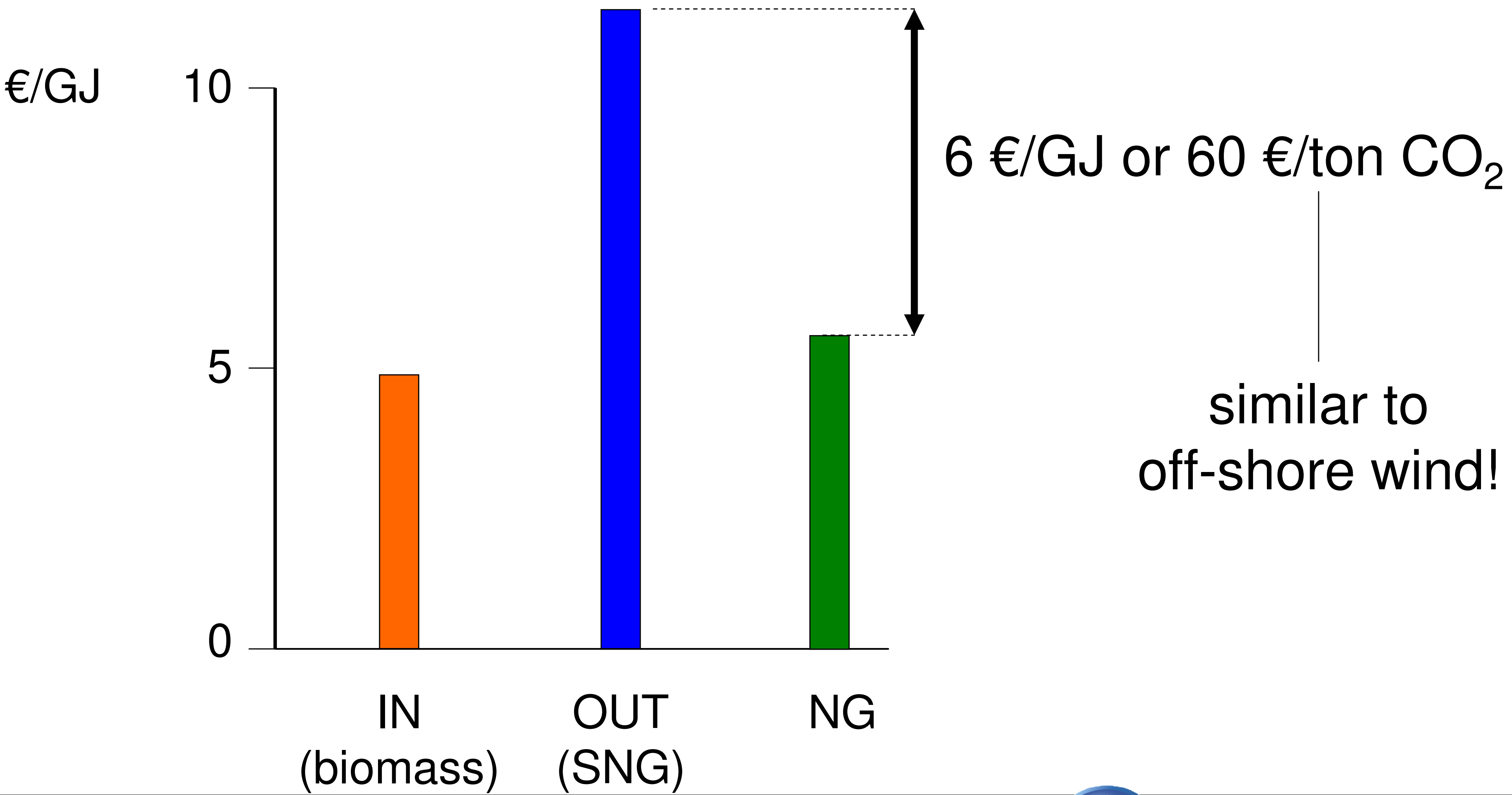


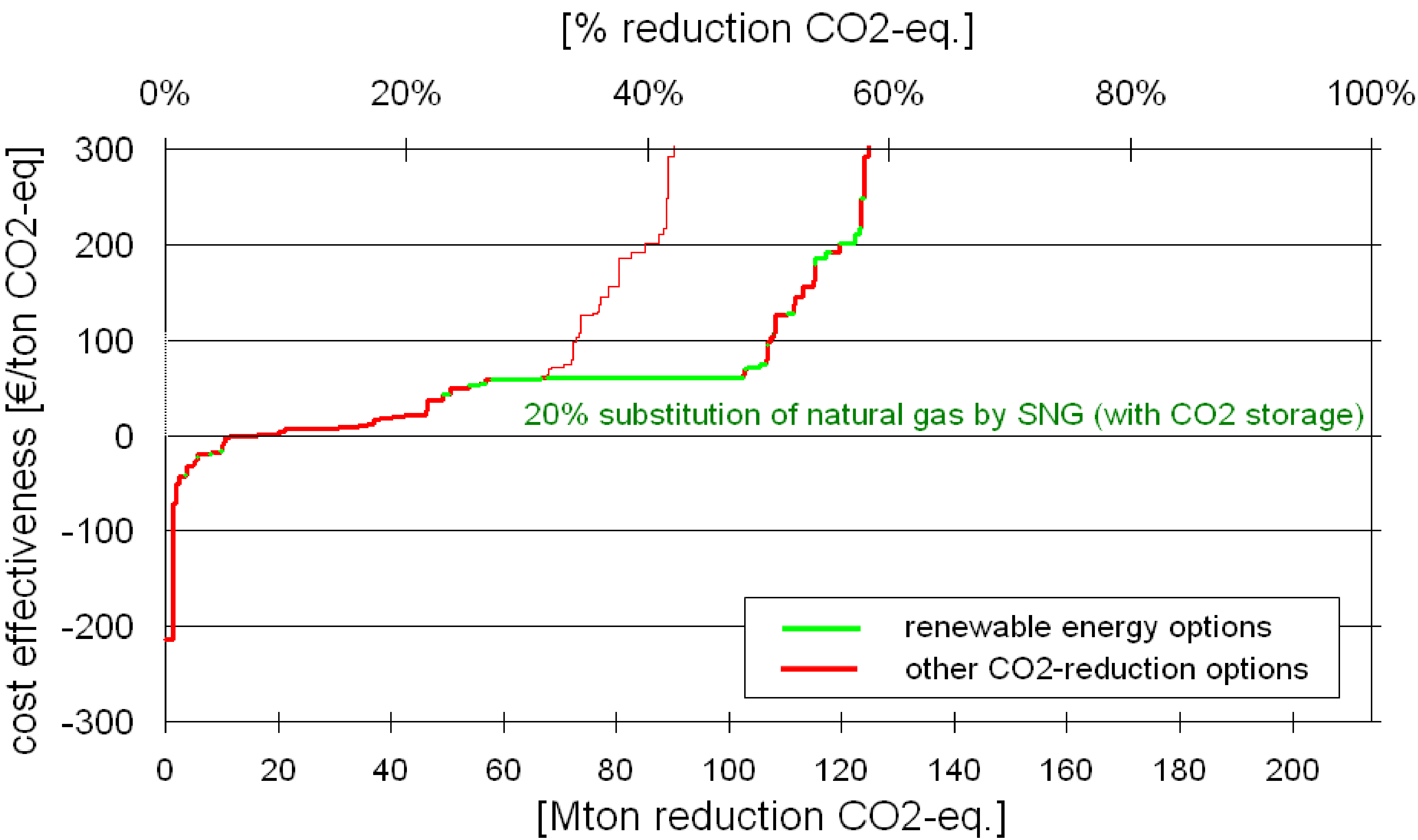
Motivation for bioSNG



Motivation for bioSNG

Assumption: mature technology




[% reduction CO2-eq.]
0%
20%
40%
60%
80%
100%
300
200
100
0
-100
-200
-300
cost effectiveness [€/ton CO2-eq]
20% substitution of natural gas by SNG (with CO2 storage)
renewable energy options
other CO2-reduction options
0
20
40
60
80
100
120
140
160
180
200
[Mton reduction CO2-eq.]

Motivation for bioSNG

Technology developers and suppliers

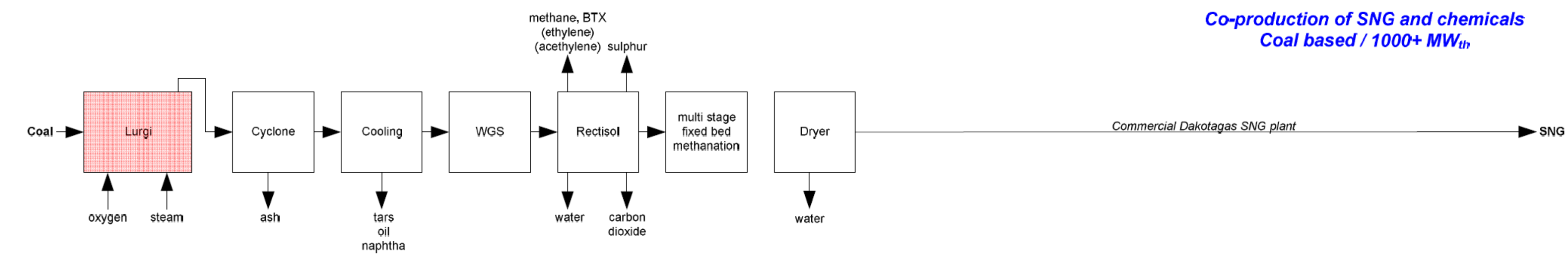
Utility companies

Timeline

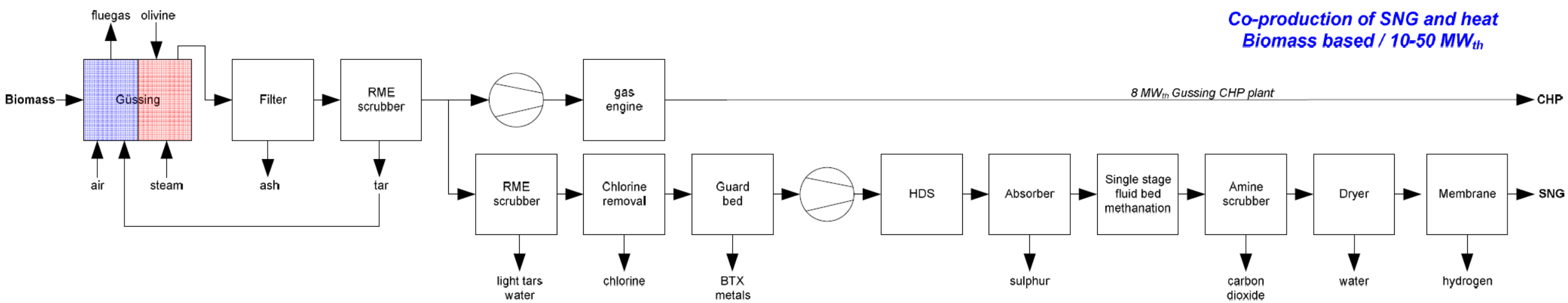
- 2009:
  - Final decision on GoBiGas project
  - Decision on HVC project
- 2010:
  - Construction phase 1 GoBiGas project
  - Design 200 MW_{th} E.On project
- 2012:
  - Operation phase 1 GoBiGas project
- 2013:
  - Construction phase 2 GoBiGas project
  - Design 300 MW_{th} E.On project
- 2014:
  - Construction 50 MW_{th} HVC project
- 2015:
  - Operation 50 MW_{th} HVC project
  - Operation 200 MW_{th} E.On project
- 2016:
  - Operation phase 2 GoBiGas project

Production of bioSNG

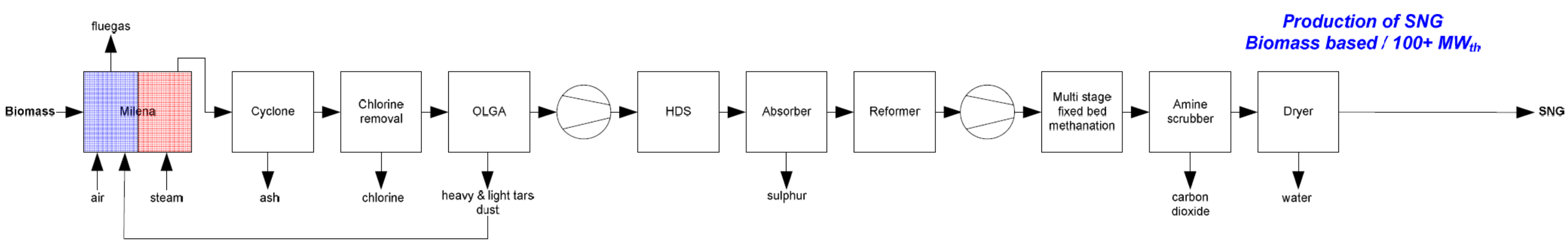
Dakotagas: Lurgi coal gasification for the production of SNG [23]



System A: Low tar FICFB gasification and RME scrubbing for the production of BioSNG (Güssing) [24,25,26,27,27]



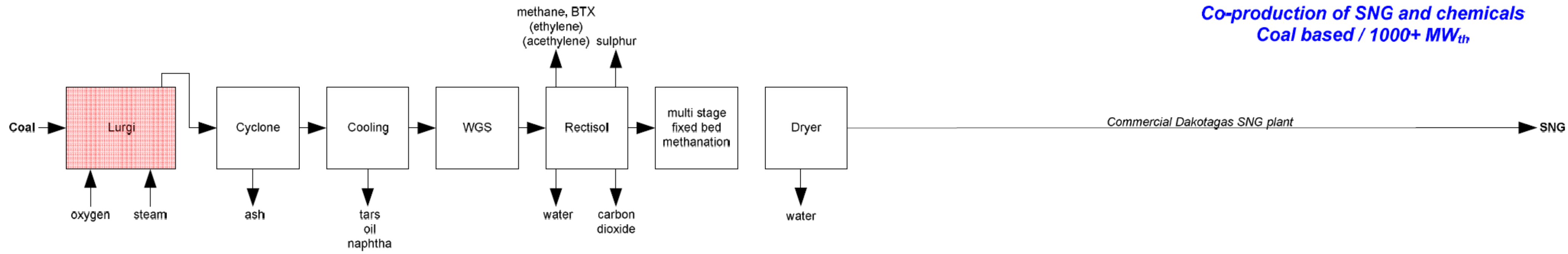
System B: High efficiency MILENA gasification and OLGA tar removal for the production of BioSNG (ECN)



Production of SNG

Dakotagas (USA): Lurgi coal gasification

Dakotagas: Lurgi coal gasification for the production of SNG [23]



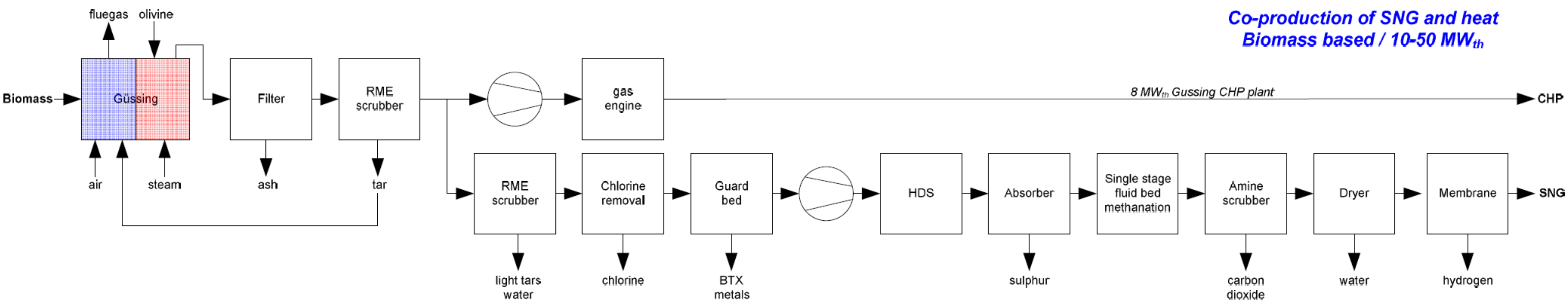
<u>Large scale coal based SNG production</u>:

- The gasifier is not suitable for conversion of biomass and/or tars
- The gas cleaning and conditioning applied is operating at pressure levels and sulphur loads being (for the moment) not realistic for biomass based systems
- The Rectisol unit removes to many high valuable gas components

Production of bioSNG

Güssing (Au): FICFB gasification & RME scrubbing

System A: Low tar FICFB gasification and RME scrubbing for the production of BioSNG (Güssing) [24,25,26,27,27]



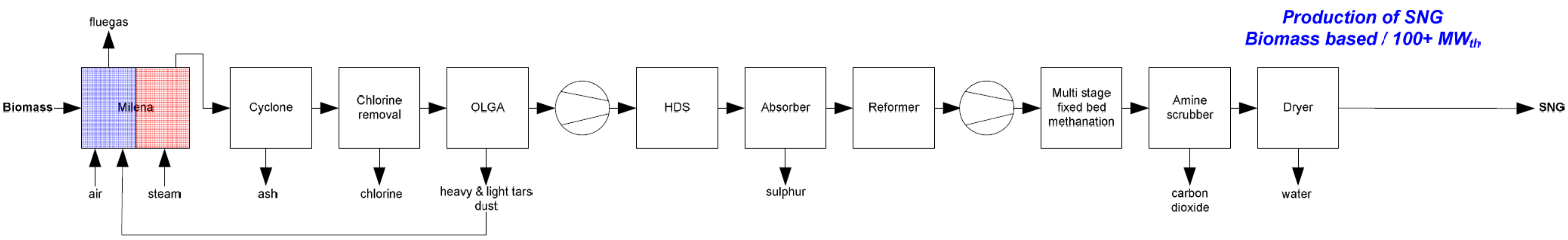
Small scale biomass based heat and SNG production:

- The gasifier is not optimised for SNG production
- The gas cleaning and conditioning applied starts with the conventional RME scrubber of Güssing and does not allow high tar contents in the initial product gas
- Water is condensed out before the methanation

Production of bioSNG

Petten (Nl): MILENA gasification & OLGA tar removal

System B: High efficiency MILENA gasification and OLGA tar removal for the production of BioSNG (ECN)



<u>Large scale biomass based SNG production</u>:

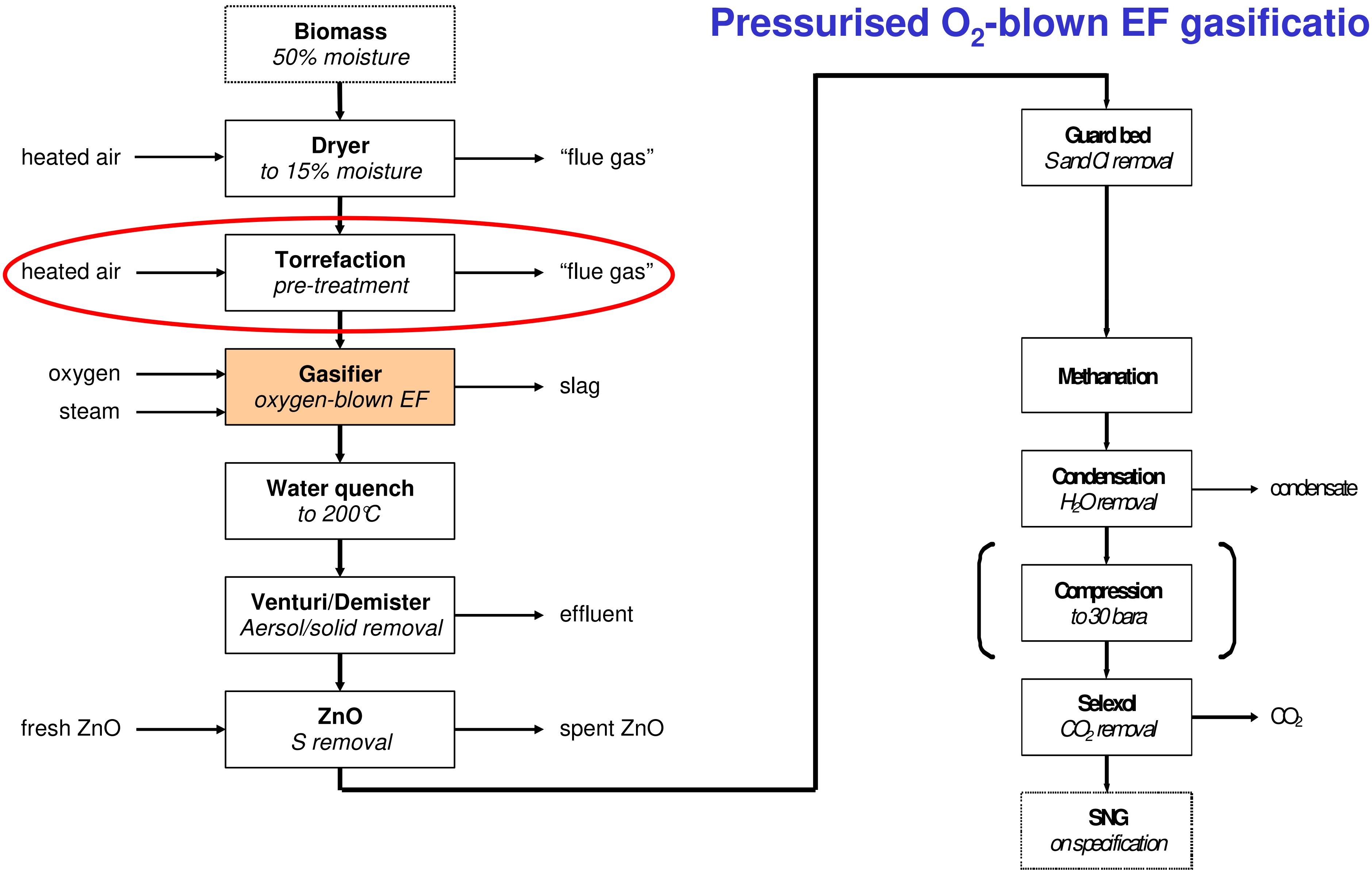
- The gasifier is optimised for SNG production
- The gas cleaning and conditioning applied starts with the flexible OLGA tar removal technology and hence does allow high tar contents in the initial product gas
- Water is not condensed out before the methanation

Production of bioSNG

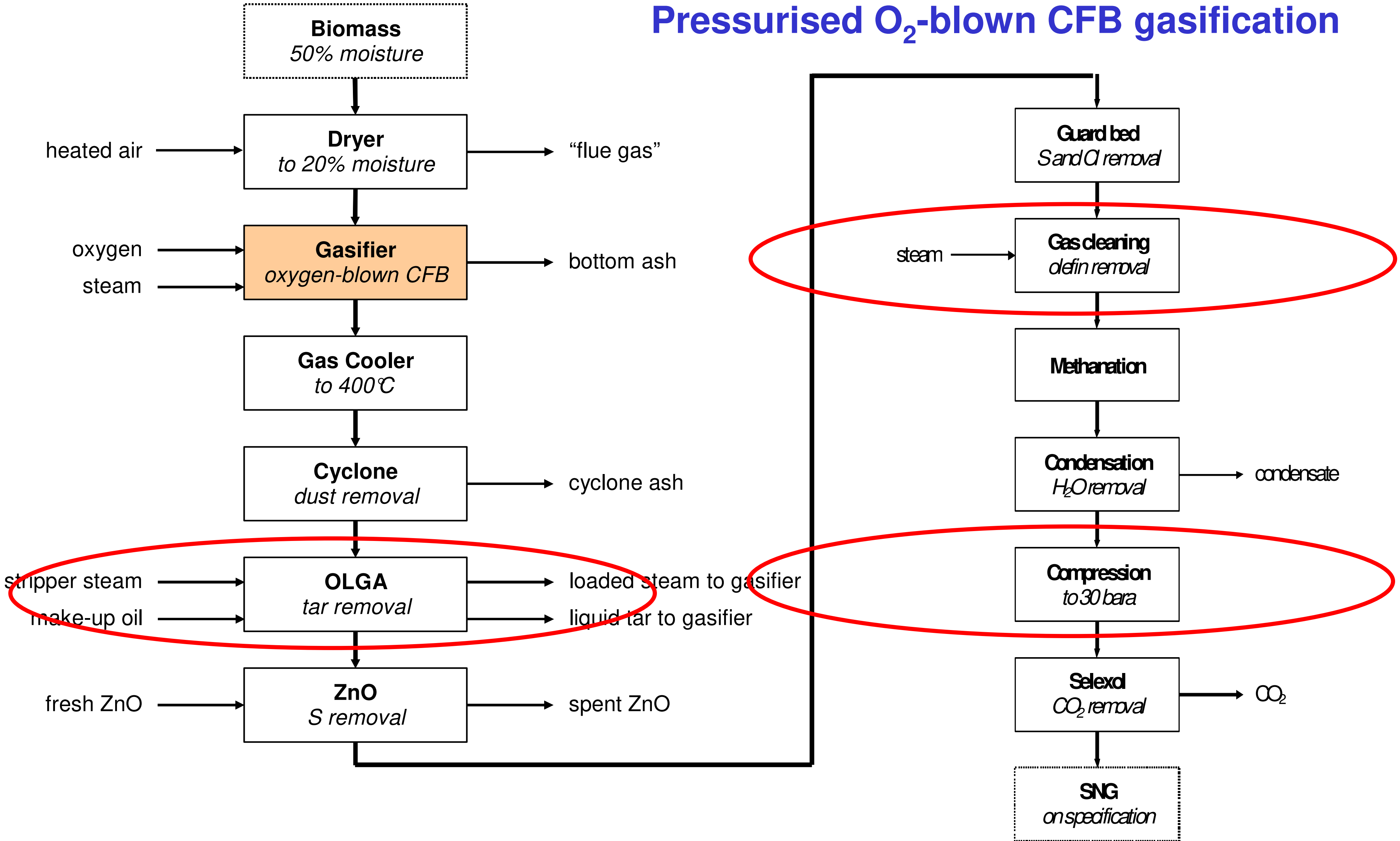
Comparison with entrained flow and pressurised O_2 blown

- Entrained flow:
  - operated at elevated pressure ↑
  - no tars in product gas ↑
  - no methane in product gas ↓
  - complicated feeding ↓
- Oxygen blown CFB:
  - operated at slightly elevated pressure ↑
  - methane in product gas ↑
  - tars and organic sulphur in gas ↓
  - "limited" char conversion ↓
- Indirect/allothermal:
  - methane in product gas ↑
  - no oxygen plant requied ↑
  - tars and organic sulphur in gas ↓
  - atmospheric, compression required ↓

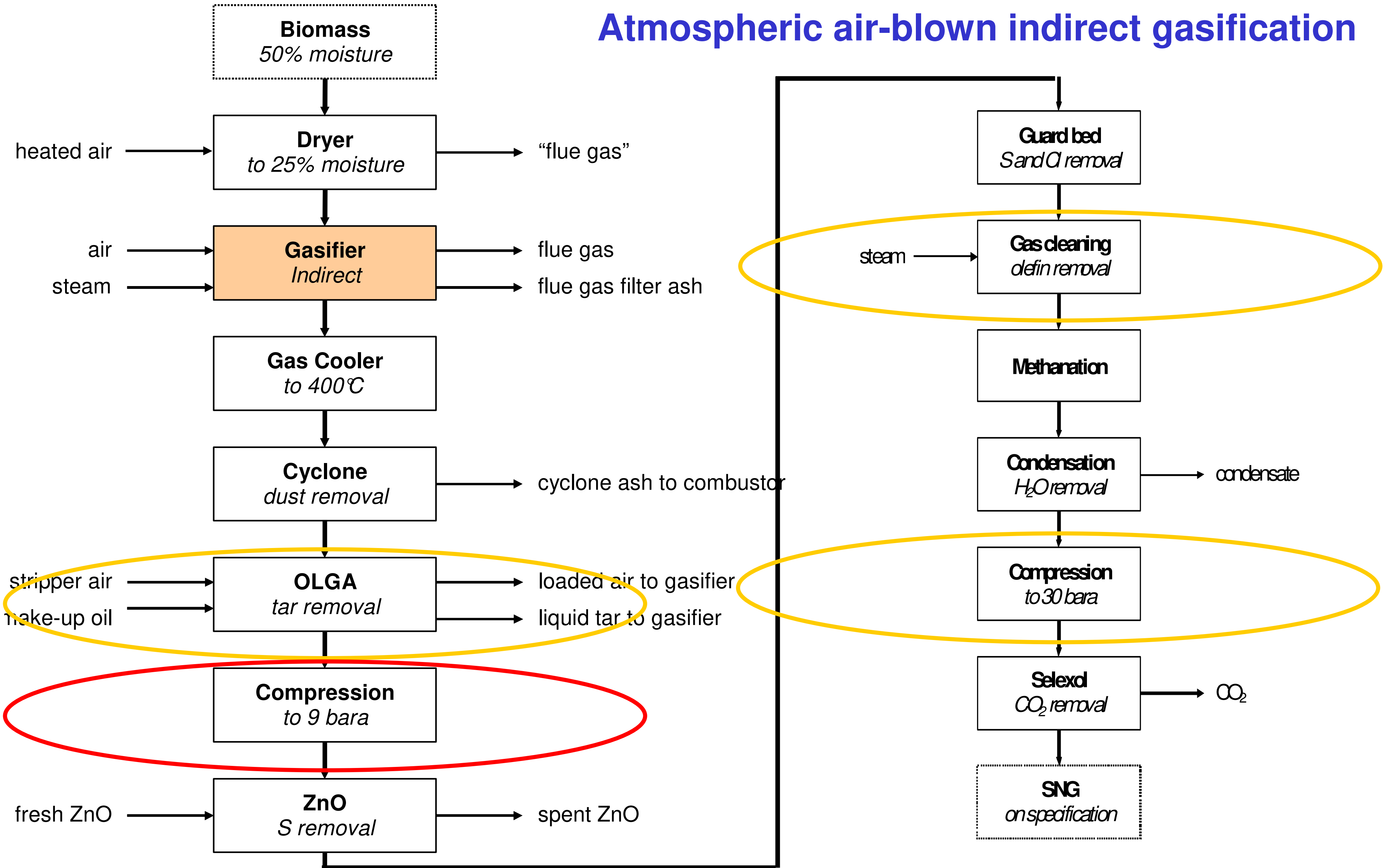
Pressurised O_2-blown EF gasification



Pressurised O_2-blown CFB gasification

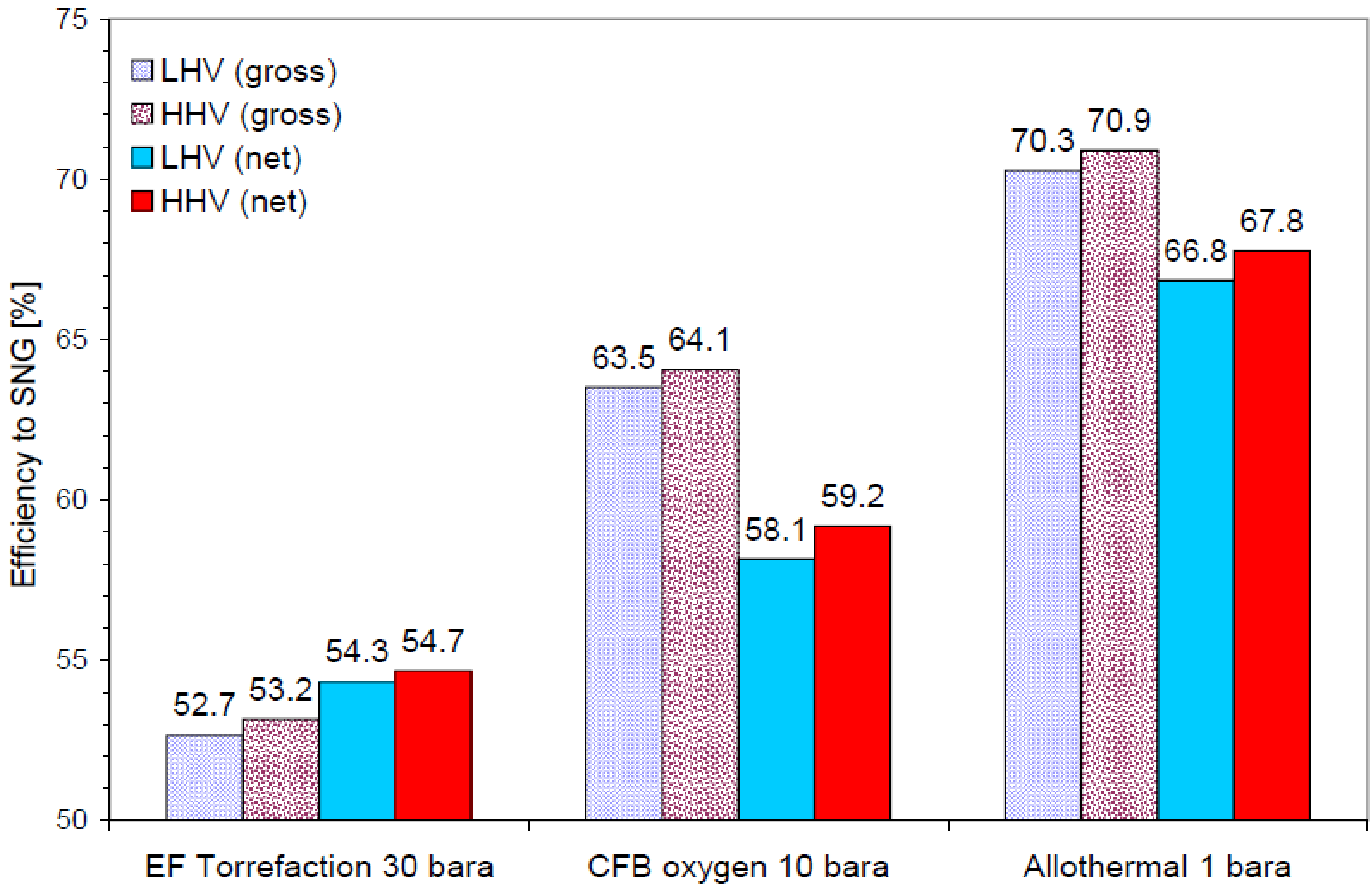


Atmospheric air-blown indirect gasification



Production of bioSNG

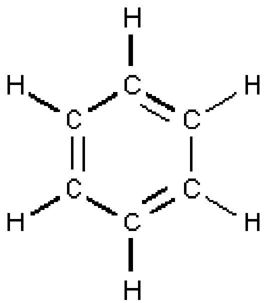
Others: entrained flow, pressurised O_2 blown, …



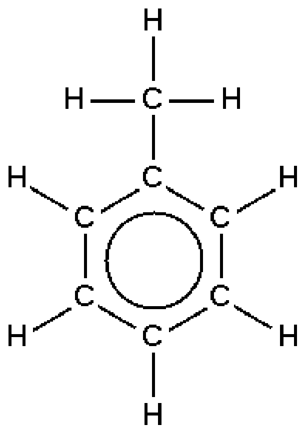
Methanation issues

Problematic components for methanation

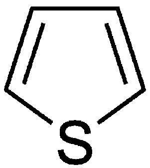
Benzene:



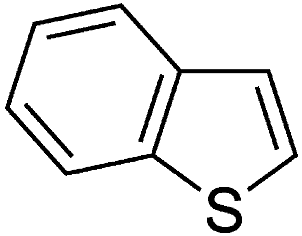
Toluene:



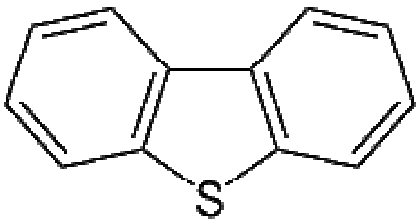
Thiophene:



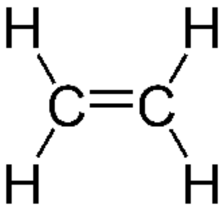
Benzothiophene:



Dibenzothiophene:



Ethylene:



Acetylene:

$H-C\equiv C-H$

Methanation issues

Non-problematic components for methanation

Saturated hydrocarbons:

Saturated hydrocarbons are converted into methane

Phenol:

Phenol is converted

Ammonia and hydrogen cyanide:

Hydrogen cyanide is converted into ammonia

Chlorine:

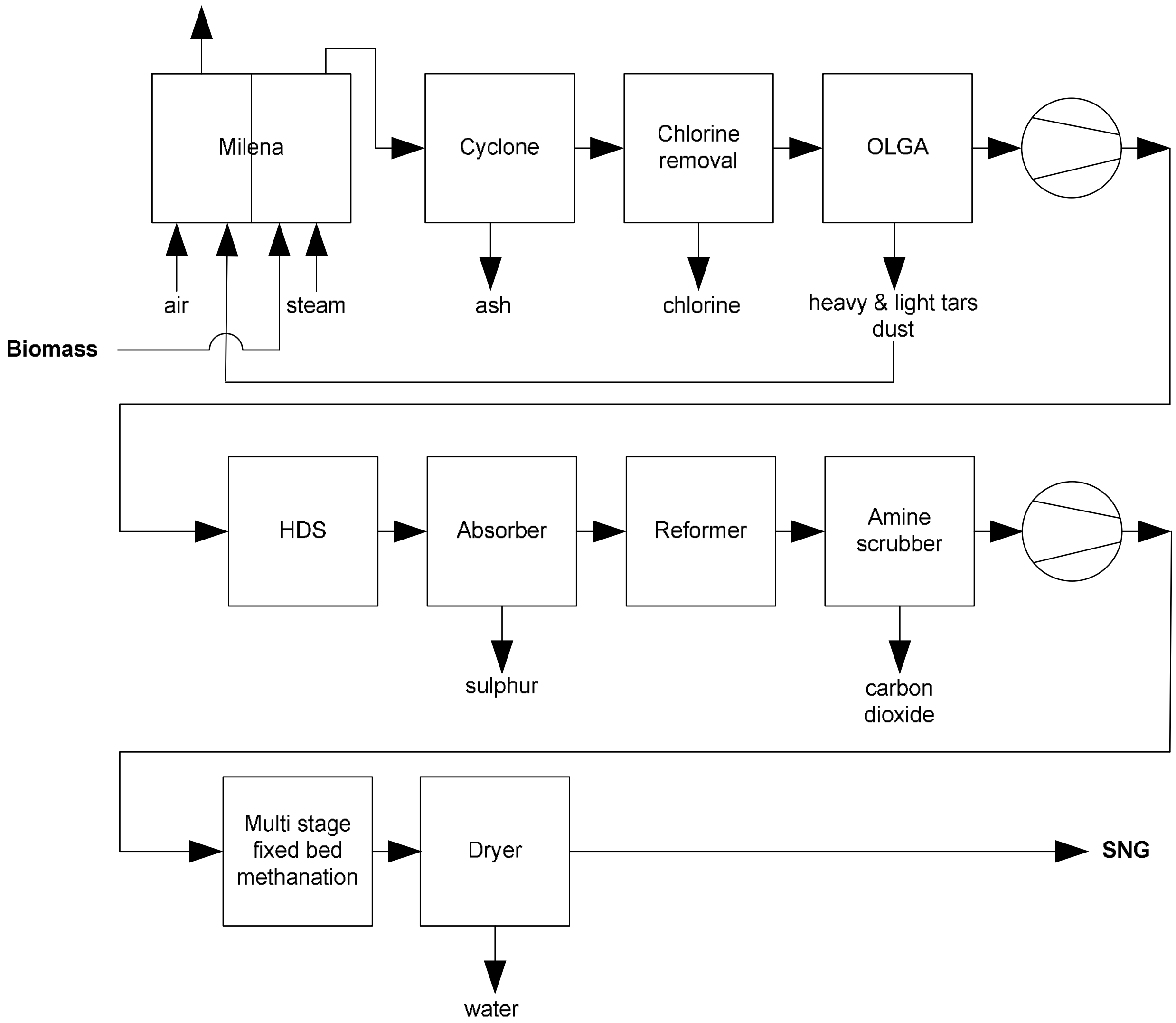
Although not problematic for the catalyst it can result in corrosion of materials!

High-efficiency bioSNG production concept

Based on MILENA gasification and OLGA tar removal

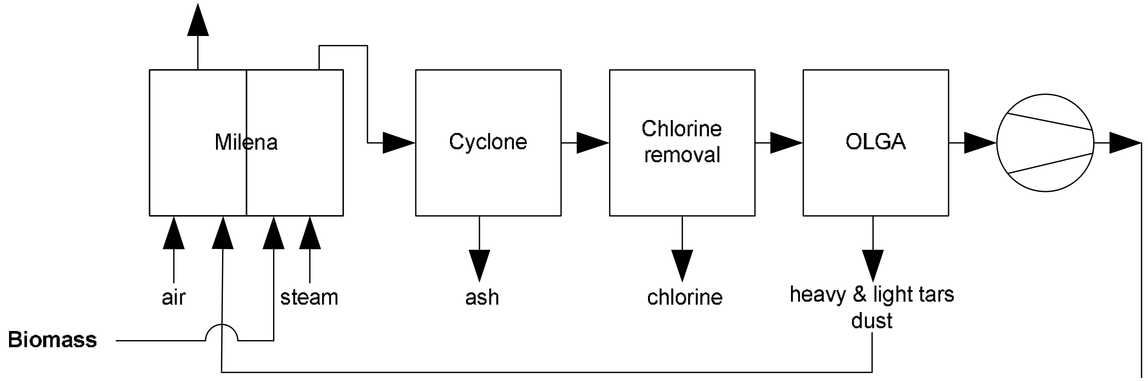
Component		Downstream MILENA	Downstream OLGA
CO	vol%	30.1	30.6
H2	vol%	32.0	32.5
CO2	vol%	19.2	19.4
O2	vol%	0.0	0.0
CH4	vol%	12.2	12.4
N2+Ar	vol%	0.1	0.1
C2H2	vol%	0.2	0.2
C2H4	vol%	3.9	3.9
C2H6	vol%	0.2	0.2
C6H6	vol%	1.0	0.5
C7H8	vol%	0.1	0.0
Tar	g/mn3	52.1	0.2

High-efficiency bioSNG production concept



RD&D needs and recommendations

Upscaling gasification and tar removal



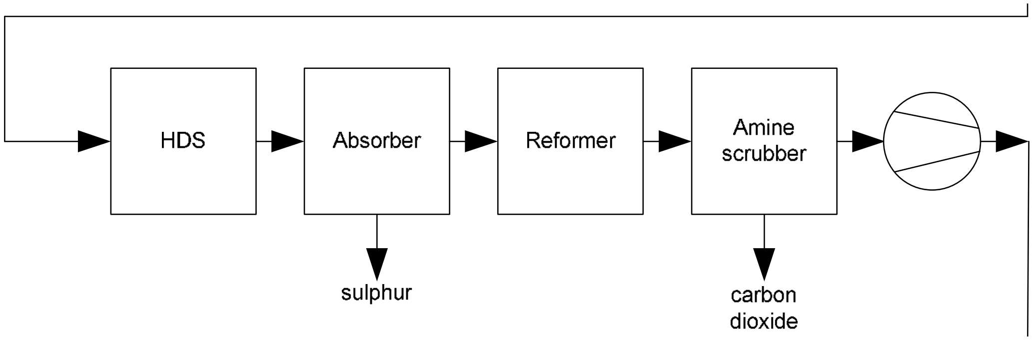
Biomass gasification has still not yet matured:

- Commercial Güssing gasifier has a capacity of 8 MW_{th}
- Pilot MILENA gasifier has a capacity of 1 MW_{th}

- Goteborg Energi wants 20-100 MW_{th}
- HVC starts with 50 MW_{th}
- E.ON wants 200+ MW_{th}

RD&D needs and recommendations

Demonstrating the critical gas cleaning steps

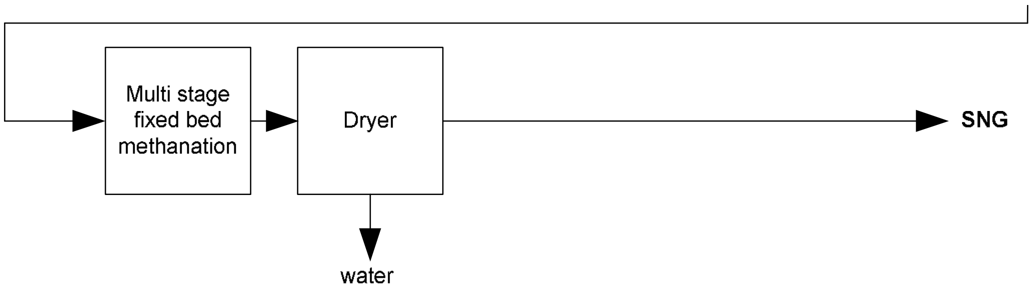


Cleaning was developed for fossil fuel based systems:

- The critical gas cleaning systems did not have to handle unsaturated hydrocarbons, tars, organic sulphur, nor were optimised for being able to handle these components
- Demonstration of the critical gas cleaning steps up till now has been limited to lab and pilot scale testing for limited amount of time

RD&D needs and recommendations

Adjusting the methanation catalyst



<u>There is only 1 commercial methanation unit in operation</u>:

- The methanation catalyst was optimised for this specific coal based application and has over the last 25 years hardly been improved
- Optimisation of the catalyst, either in order to be able to handle specific biomass related contaminants in the product gas or in order to produce CH_4 more efficiently will require realistic long-term testing

RD&D needs and recommendations

Recommendations:

Demonstration of the critical gas cleaning steps

- application of commercial catalysts in real gases
- optimisation of catalysts to improve performance
- demonstration of the overall system

Adjustment of the methanation catalyst

- catalysts tolerant to sulphur
- catalysts tolerant to unsaturated hydrocarbons
- Catalysts inert to saturated hydrocarbons

Keep in mind the differences between SNG and other fuels

Contact information

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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 tar removal: www.olgatechnology.com
SNG: www.bioSNG.com and www.bioCNG.com