Next generation biomethane technologies - experiences and further prospects

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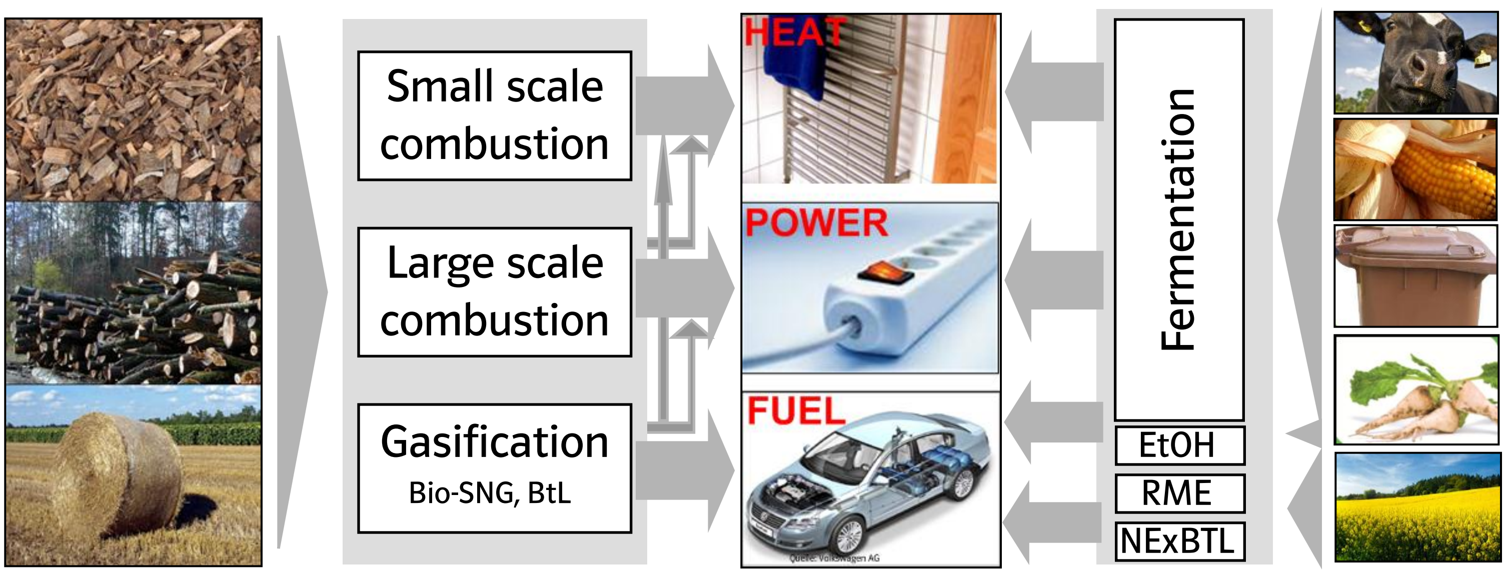
- Biomethane is one of the most **flexible** bioenergies:
  - It can be produced from energy crops, agricultural residues and waste
  - By using the natural gas network, heat, power and fuel applications are accessible
  - Biomethane can be stored and provides excellent security of supply

- Biomethane is one of the most **efficient** bioenergies



Status Quo – Biomethane (fermentation) in Germany

- Biomethane plants in Germany:
  - 46 Plants in operation ➔ 32.500 m_N^3/h overall
  - 65 under construction ➔ 43.500 m_N^3/h overall

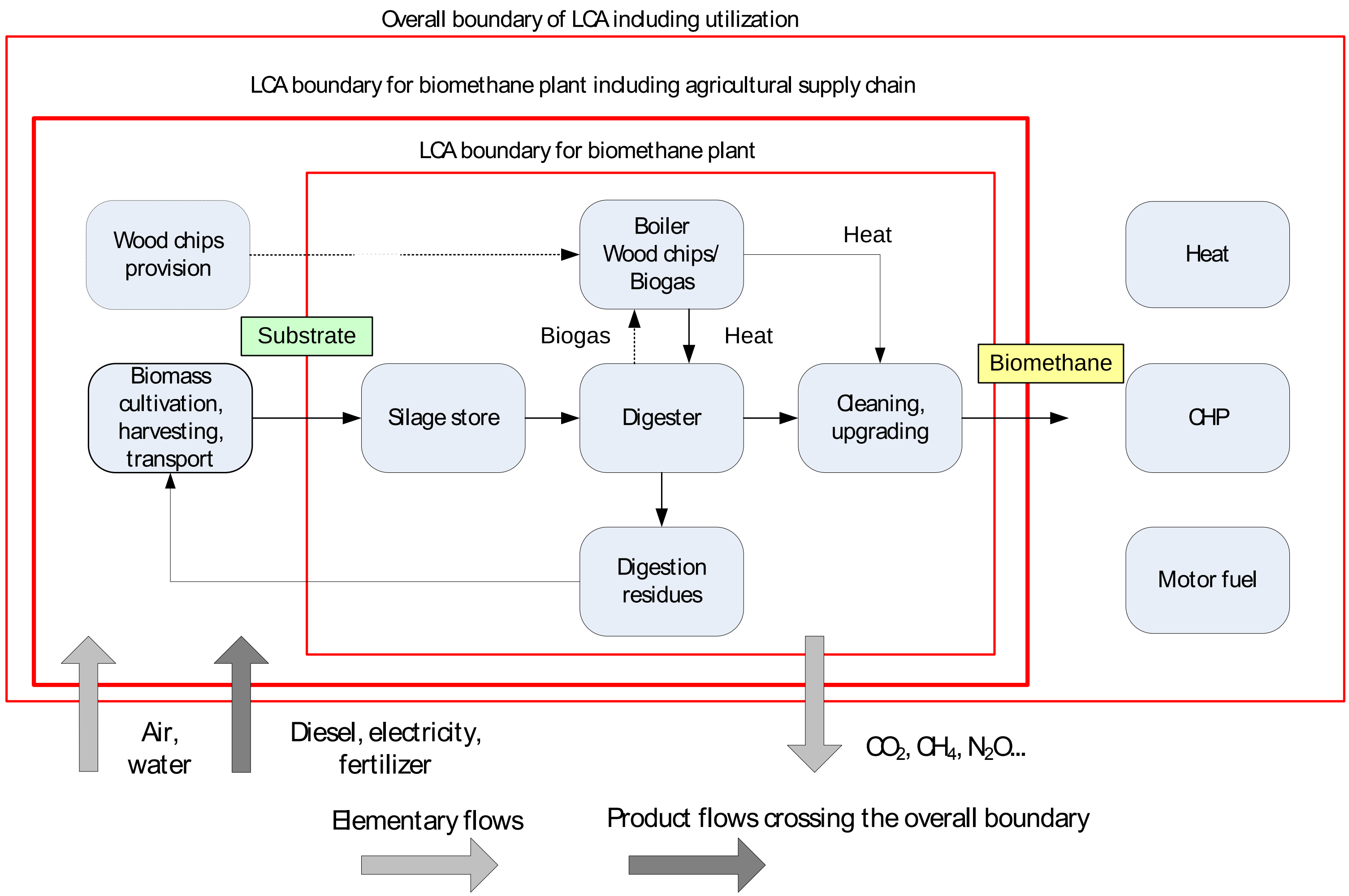
- Biomethane plants within the E.ON group:

Schwandorf II	E.ON Bioerdgas	1000 Nm³/h	02/2008
Einbeck	E.ON Bioerdgas	500 Nm³/h	09/2009
Aiterhofen	E.ON Bioerdgas	1000 Nm³/h	10/2009
Merzig	E.ON Bioerdgas	550 Nm³/h	05/2011
Hallertau	E.ON Bioerdgas	700 Nm³/h	2012
Ketzin	E.ON Edis-therm	200 Nm³/h	04/2008
Hardegsen	E.ON Mitte Wärme	550 Nm³/h	02/2009
Stausebach	E.ON Mitte Natur	350 Nm³/h	2011

➔ 4.850 m_N^3/h overall

Stand 08/2011

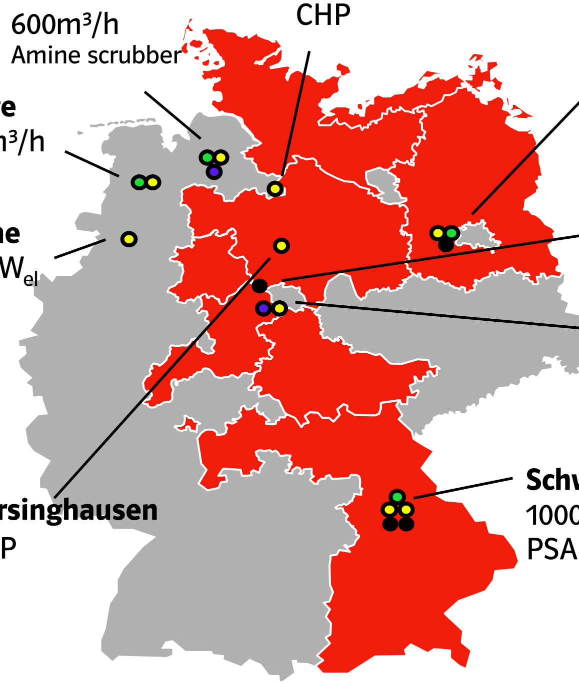
Basic Processes of the Biomethane Plant in Einbeck



Comprehensive analyses of German biomethane plants

Analysis of biogas for compliance with applicable rules and regulations, effects on gas infrastructure, harmful bacteria and CH_4 emissions

- Gas properties
- Microbiological analysis
  - Raw biogas
  - Conditioned biomethane
  - Condensate
- CH_4 emissions
  - GasCam tightness check
  - Gas concentration measurement with CH_4 detector



- Gas quality measurement
- Bacteria detection
- Flue gas analysis
- CH_4-emissions

Gas Properties – Plants Examined

Location	Substrate	Tratement PSA	Treatment Amine plant	Injetion into gas grid	CH_4-Measurements
Schwandorf I	M / G				X
Rheine	M / GÜ				
Soltau	M/CCM/G/HTK				
Barsighausen	Z				
Goldenstedt	M / G		X		
Schwandorf II	M / G	X		X	X
Ketzin	M / G / GE	X		X	X
Hardegsen	M / G		X	X	X
Werlte	GÜ / SA	X		X	
Einbeck	M / G		X	X	X
Aiterhofen	M / G	X		X	X

M → Maize silage
G → Grass silage
GÜ → Liquid manure
CCM → Maize grains

HTK → Dry chicken dung
Z → Sugar beets
GE → Grain
SA → Slaughterhouse waste

Microbiological Analysis

Samples: raw biogas; liquids obtained after treatment; pure biogas

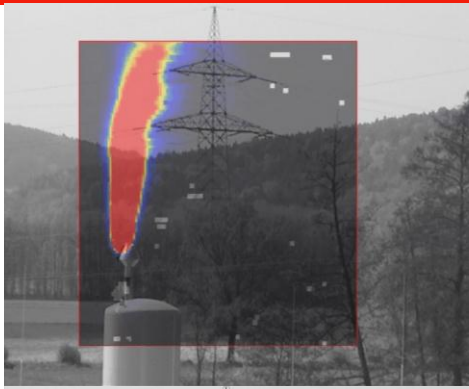
Method: bacteria DNA with specific polymerase chain reaction (PCR)

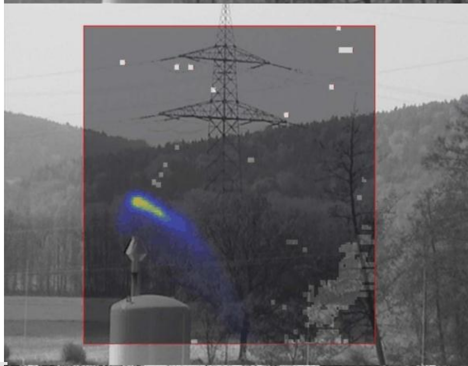
Bacteria group	**Negative effect on**	**Potentially negative effects**	**Test result (pure gas)**
Methane-decomposing bacteria (methane oxidizers)	Gas quality	$CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$	No methane-decomposing bacteria found
Corrosive bacteria (sulfate reducers)	Gas infrastructure	Corrosive H_2S	No corrosive bacteria found
Harmful germs (pathogenic bacteria)	Gas user	Harmful effects on health	Only opportunistic germs found

CH_4 Emissions – Qualitative Measurement

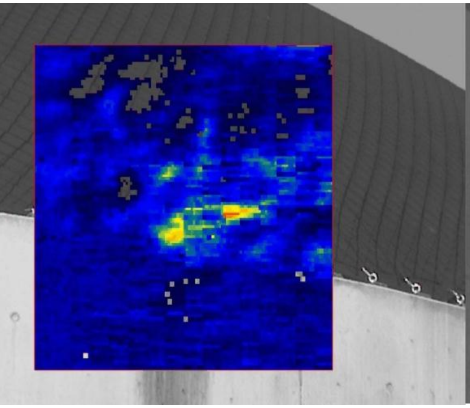
- GasCam tightness test
- CH_4 detector to measure gas concentration
  - Ketzin
  - Schwandorf I
  - Schwandorf II
  - Einbeck

(0.5 vol% according to Gas Network Access Code)

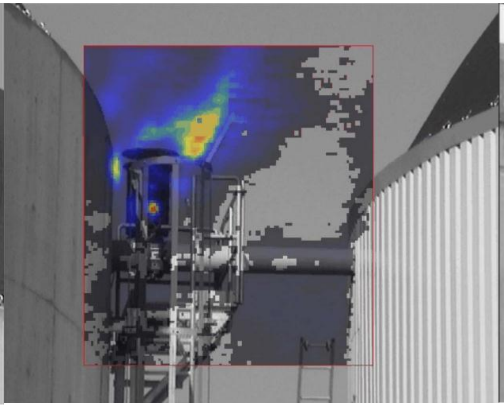




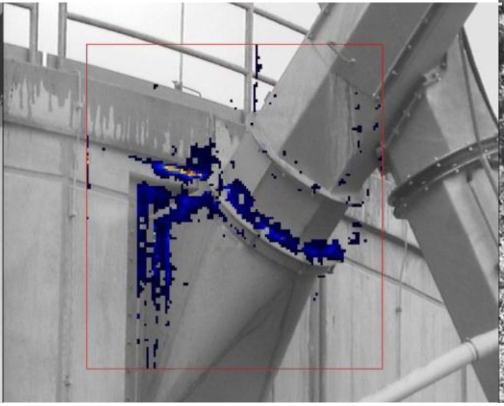
Waste gas, PSA SADII



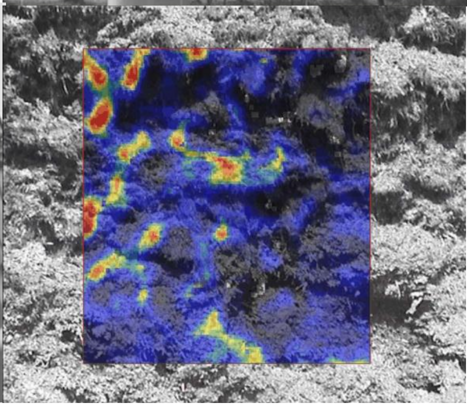
Sheet sealing, SULER SAD I



Pressure relief device, SULER SAD I

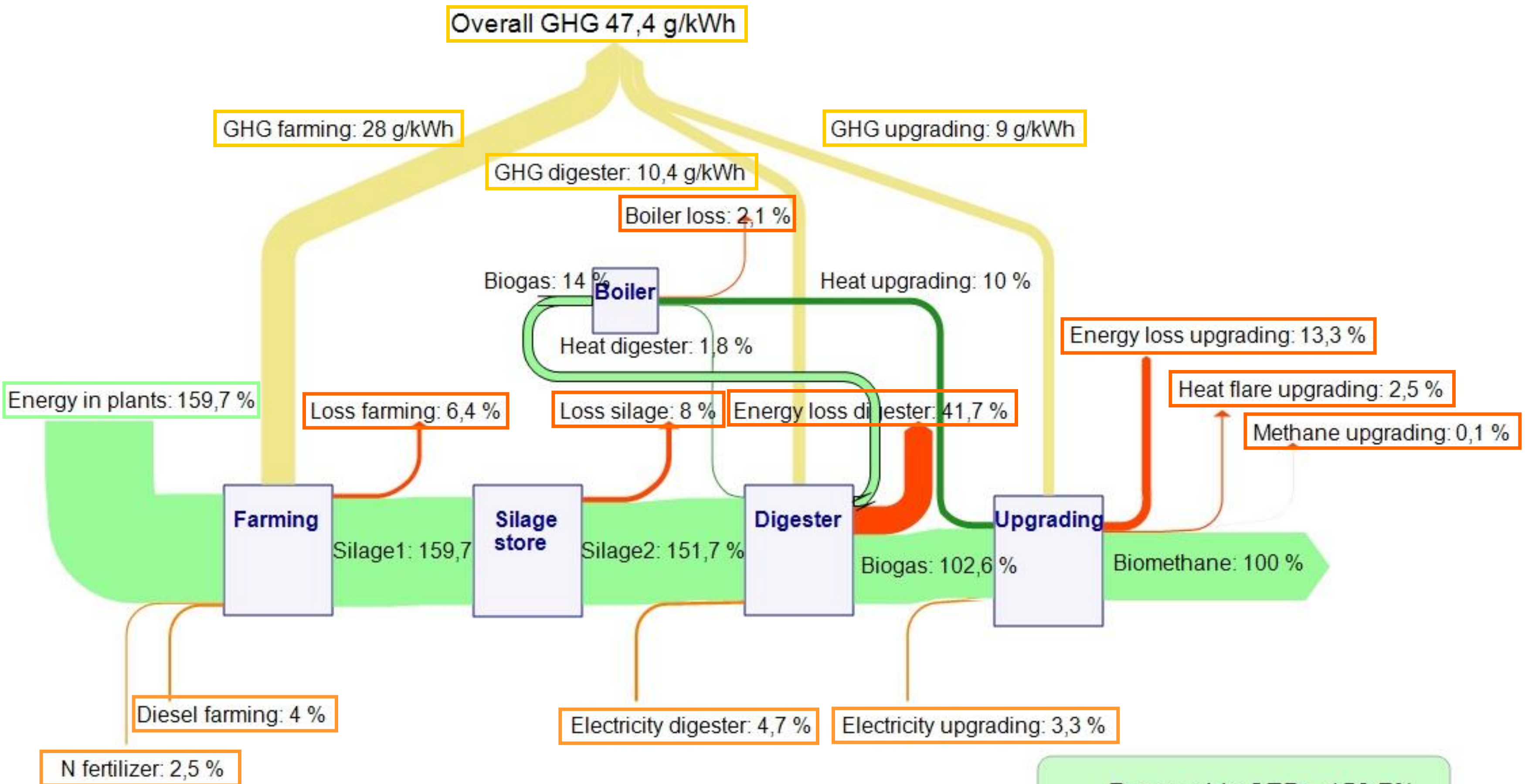


Conveyor, Ketzin



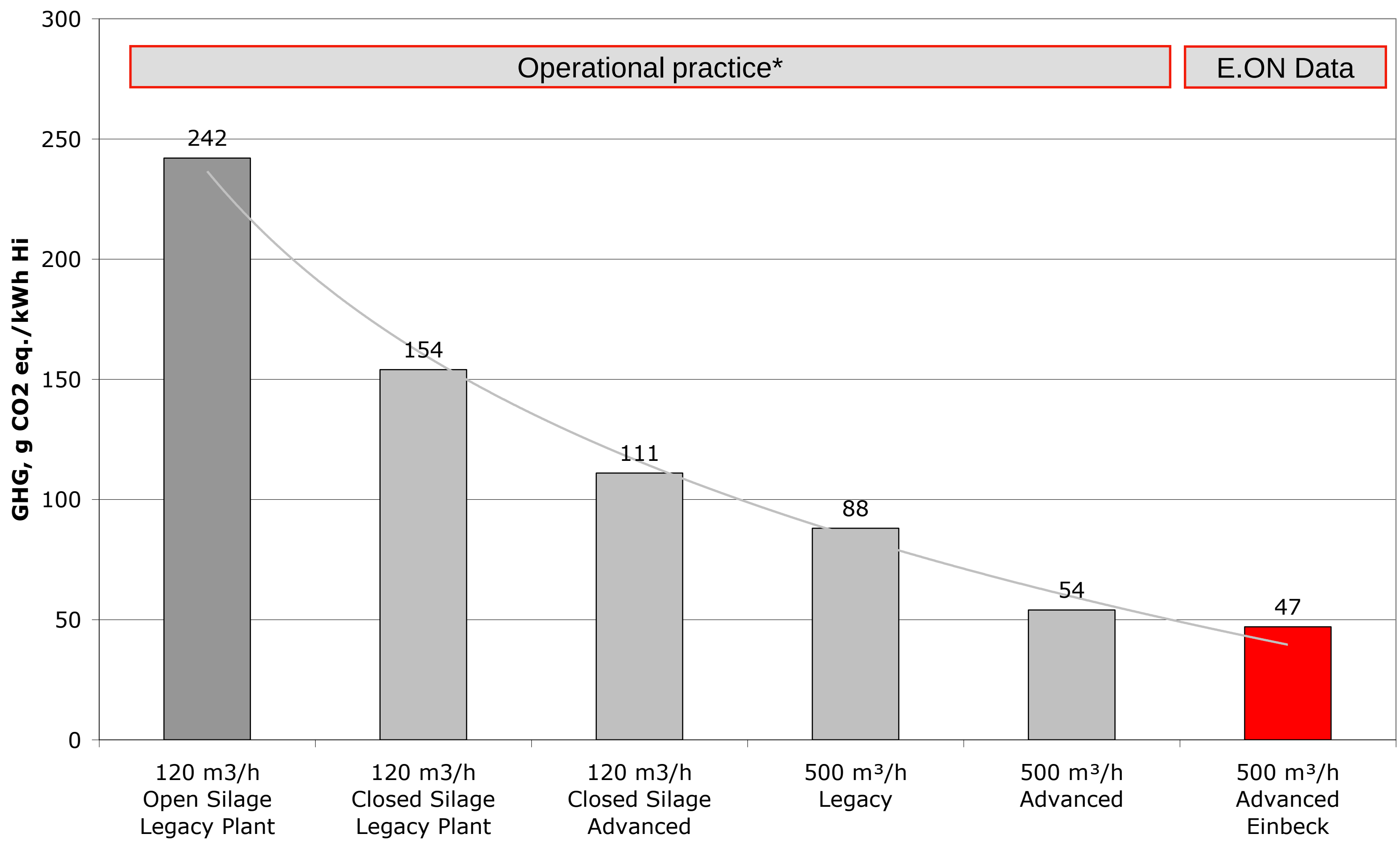
Bunker silo joint, SAD II

Results – Energy/GHG Flow Diagram for Biogas Heating



Renewable CED = 159.7%
Non-renewable CED = 14.4%
Overall CED = 174.1%

Reduction of GHG by Technical Progress



*Source: "Basis Data for GHG Inventories of Biomethane Processes", Institute for Energy and Environment Research, Heidelberg, Internal Study, April 2008

Membrane Technology for Biogas Upgrading

Conventional upgrading technologies (water, amine treatment, PSA):

- Intermediate storage medium liquid (water, amine solution) or solid (active carbon) for CO_2 are necessary
- Regeneration of the storage medium requires energy (heat or electricity)
- Storage media handling raise additional investment, maintanance and operation costs

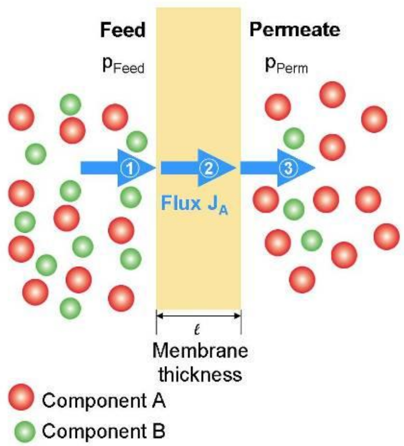
Membrane upgrading technology – key benefits:

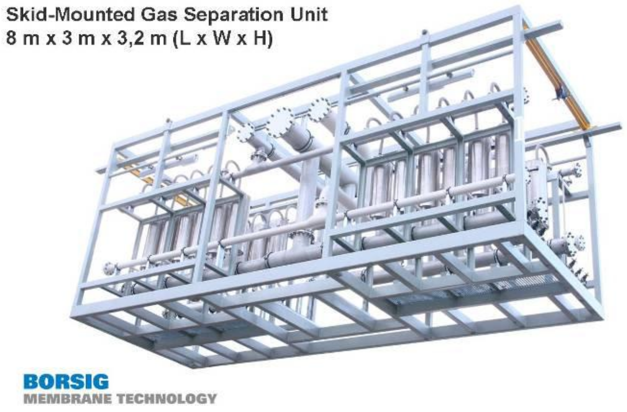
- No intermediate CO_2 storage
- Simple upgrading plant design
- Continuous process

➔ Performance and durability tests of membranes under operational conditions
➔ Cooperation with an equipment manufacturer

Membrane Technology for Biogas Upgrading

Our approach:
from basic principle → over system test → to commercial plant





- Innovative 'dry' biomethane upgrading technology, no auxiliary media
- Energy efficient and flexible
- Low maintenance costs, simple process control

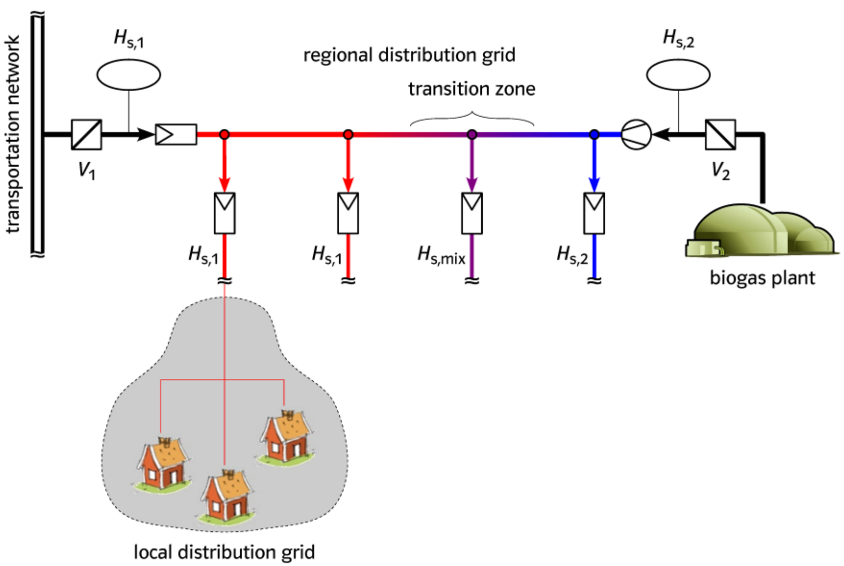
Membrane Test Rig in Kirchlengern – General View

Membrane Test Rig – Envelope/Spiral Wound Modules

Membrane Test Rig – Hollow Fiber Module

Tasks for increasing the volume of biogas in the natural gas grid

- Odorant removal:
  - Regional distribution network: biogas with odorant injected
  - Transportation network: biogas without odorant injected
  - In case of low gas consumption the increased volumen of (bio)gas has to be fed from the distribution grid back to the transportation network ➔ odorant has to be removed
  - Special adsorbents are developed for odorant removal

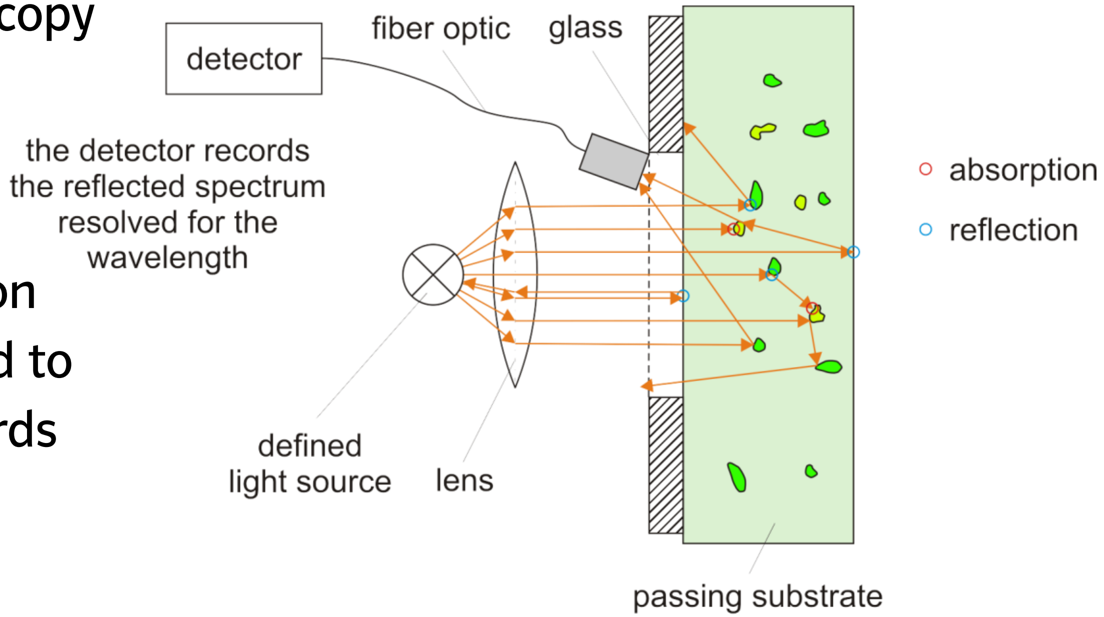


- Gas quality tracking:
  - Calculation of gas quality (natural gas / biogas)
  - LPG injection not needed
  - Software tools developed by E.ON

What's next - Optimized biomethane production

- Efficient production of biogas needed to yield the most biogas from either energy crops or organic waste
- High space-time yield possible via elaborate measurement technologies
- Novel measuring technologies are testet by E.ON:
  - continuous analysis of biomass input
  - analysis of the digestion media
- Ultrasonic biogas meters
- Near infrared spectroscopy (NIRS)

- First results show a high degree of precision
- The results will be used to develop a model towards process automation



Future challenges - New energy crops and residual biomass

- New **energy crops**:
  - Adaption to different soil qualities possible
  - Permanent cultures lead to lower fertiliser demand and reduced farming costs
  - Low fertiliser demand leads to improved carbon footprint

- **Residual** biomass:
  - No seeding / cropping needed
  - very high GHG emission reduction possible
  - Adapted biogas technologies needed
- **Woody** biomass:
  - Conversion via thermo-chemical gasification allows for feedstock diversification

Bio-SNG – 2nd Generation Biomethane from Wood

$C_xH_yO_z$ →

CH_4 →

Heat

CHP

Mobility

solid biomass

Bio-SNG production plant

all utilisation options

- Innovative process for production of methane from woody biomass as
  - "second main pillar" of E.ON´s renewable gas production ?
  - high efficient and flexible alternative on power production and CHP ?
- Existing feedstock access of E.ON as biomass power plants (e.g. full conversion and new built sites) could be used

Comparison of fermentation and gasification

		 Biomethane	 Bio-SNG
Feedstock	Feedstock source	Biogas substrates e.g. energy crops, residues	Lignocelluloses wood (resid., crops), straw
Feedstock	Methane Potential (D) 2020 [m³/a]	> 6 bn from crops	> 3 bn from forest
Technologies	Process	Bio-chemical	Thermo-chemical
Technologies	Development Status	Mature Technology	Demonstration
Technologies	Scale (Status/ commercial) [MW]	$10^0 – 10^1$	10^0 / $10^1 – 10^3$
Technologies	Technology provider	Small scale companies	Chemical plant vendors
Cost & Climate	Specific Investment Costs [€/MW_{CH4}]	~ 2000	1600 – 2200 (?)
Cost & Climate	Gas Production Costs [€ct/kWh]	7 – 8	6.5 – 8.5 (?)
Cost & Climate	GHG-Emissions [$g_{CO2eq.}$/kWh_{CH4}]	47-120	20-100 (?)

Bio-SNG is not yet "the mature silver bullet", but it could act as future "second main pillar" for the diversification of E.ON´s renewable gas production.

Thank you.

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