

# Biomethane – a sustainable natural gas substitute



Thai-German Technology Conference Biogas in Thailand  
8<sup>th</sup> June 2015, Bangkok/Thailand

Dipl.-Ing. (FH) Michael Beil  
Fraunhofer Institute for Wind Energy and Energy Systems Technology  
Division Energy Process Engineering  
Department Bioenergy System Technology  
Gas Upgrading, Injection and Grids

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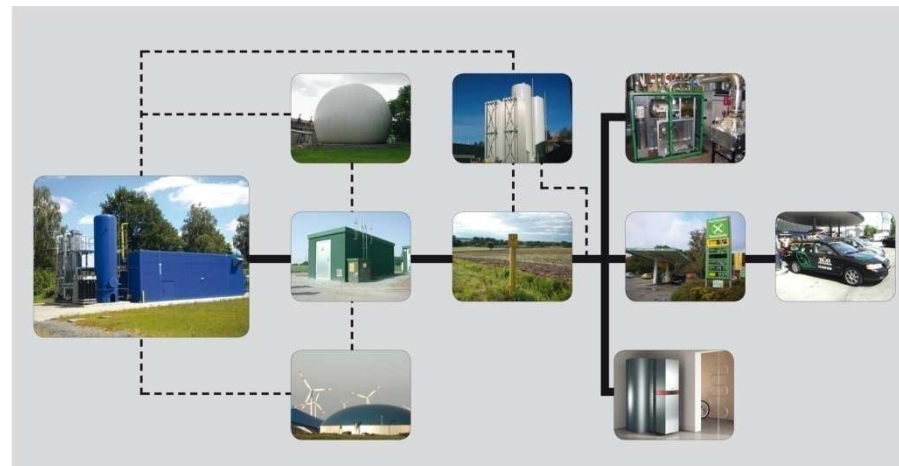
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# Content

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- Introduction
- Incentive systems for the market implementation of biomethane
- Technology overview biogas upgrading to biomethane
  - State of the art methods
  - Key parameters of biogas upgrading technologies
  - Off-gas treatment methods
  - Economic aspects of biomethane supply
  - Recommendations for technology selection



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# Fraunhofer-Gesellschaft

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- Fraunhofer is Europe's largest application-oriented research organization.
  - > 20,000 employees
  - > 60 institutes
  - Fraunhofer develops, implements and optimizes processes, products and equipment until they are ready for use and for the market.
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# Fraunhofer IWES (Institute for Wind Energy and Energy Systems Technology)

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- The research activities of Fraunhofer IWES cover all aspects of wind energy and the **integration of renewable energies into energy supply structures.**
- The main areas of research are:
  - Technology and operational management of wind turbines and wind farms
  - Dynamics of wind turbines and components
  - Component development for rotors, drive trains, and foundations
  - Test and evaluation methods for wind turbines and components
  - Environmental analysis of wind, sea, and seabed for utilization of wind energy and marine energy
  - Control and system integration of decentralized energy converters and storage systems
  - Energy management and grid operation
  - Energy supply structures and system analysis

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# Research Topic: Gas Upgrading, Injection and Grids

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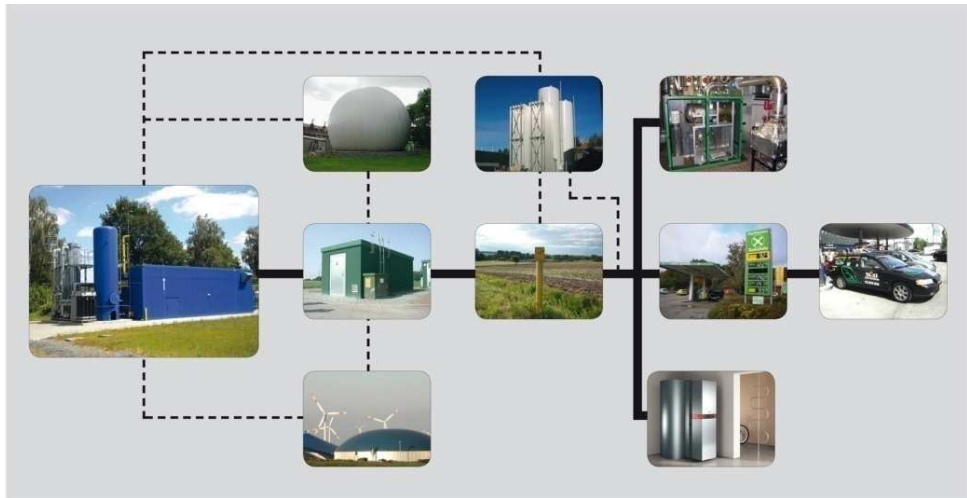
## ■ Intention of our work

- Integration of biomethane in future energy supply systems
- Improving efficiency of biogas upgrading
- Sustainable biomethane provision

## ■ R&D topics:

- Technology and system analysis
- Simulation and modeling of technologies and systems
- Assessment of new technologies such as power-to-gas





- Political consulting
- Feasibility studies for upcoming plant operators, utilities and investors
- Profitability analysis
- Due diligences for investors
- Surveys of new technologies for technology providers before market implementation
- Trainings in the fields of biomethane provision, distribution and utilization
- Technology and system evaluation
- Technology and system optimization
- Infrastructure for field tests of pilot plants

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# What's biomethane?

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Biomethane is a cleaned (free of  $\text{H}_2\text{S}$ , water, etc.)

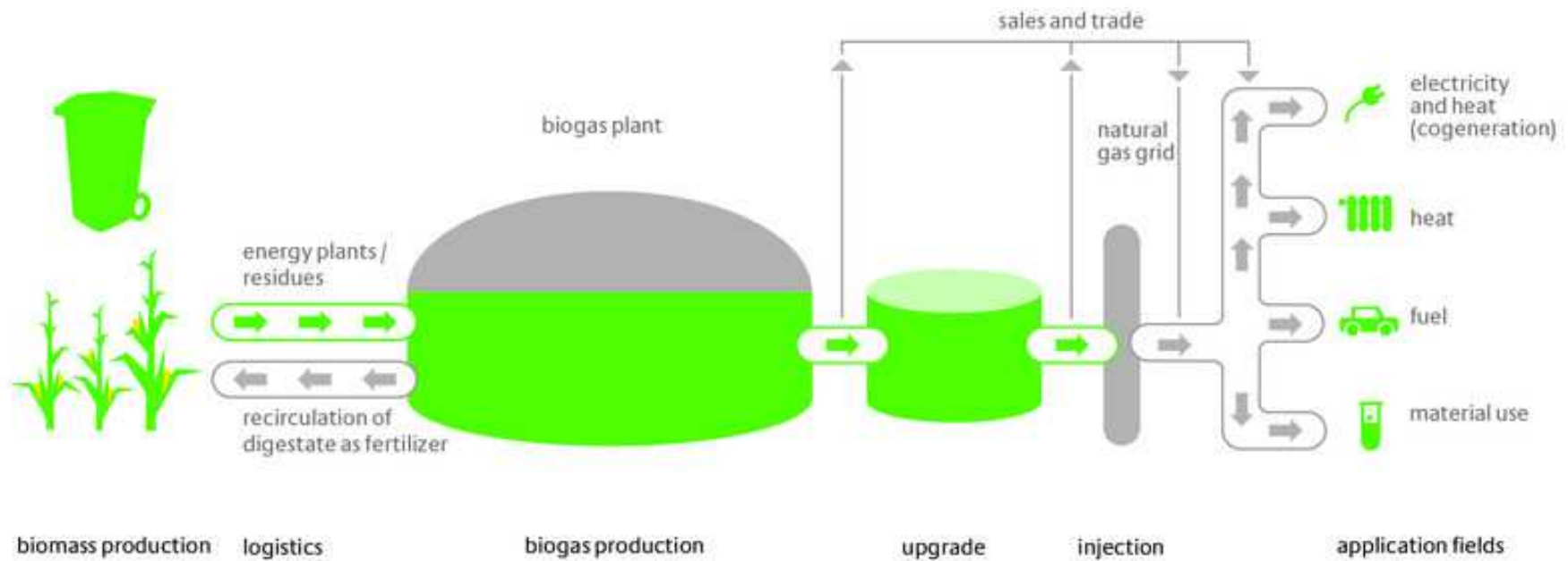
and upgraded (nearly free of  $\text{CO}_2$ ) biogas...

...and therefore...

...a sustainable and renewable natural gas  
substitute

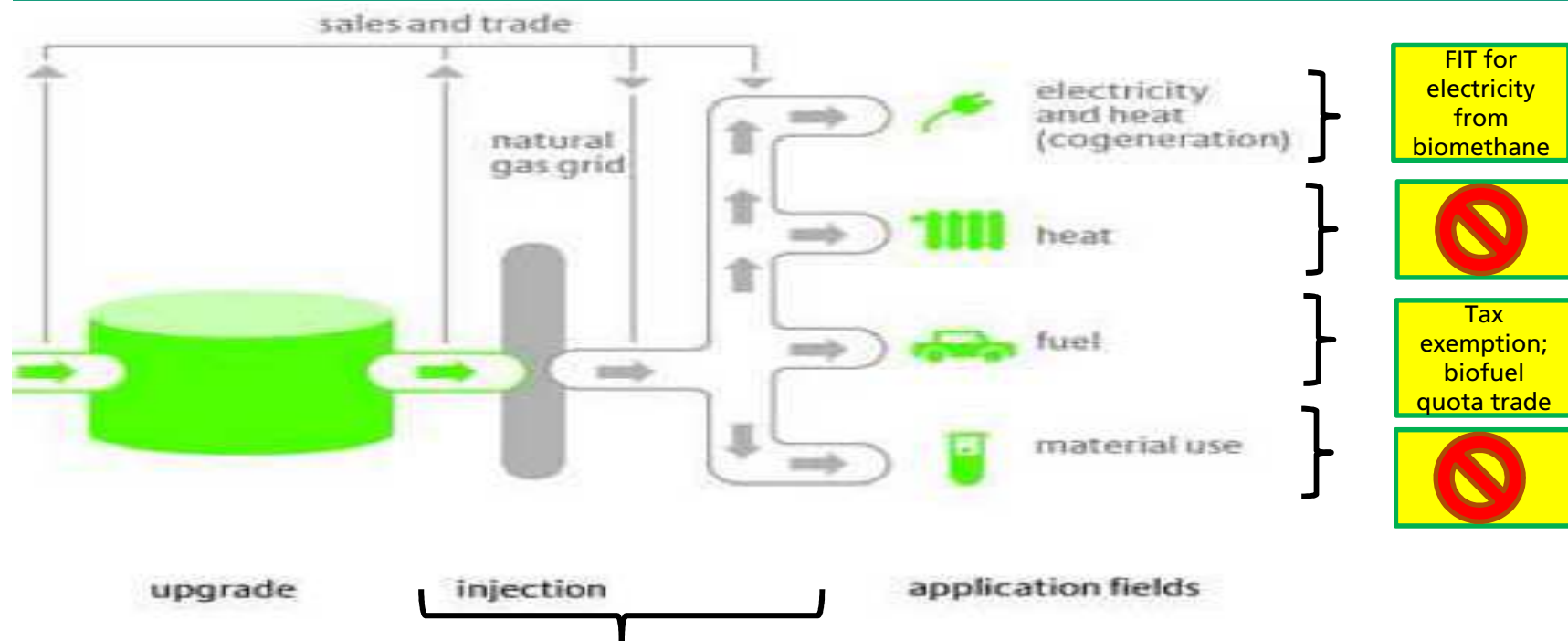


# Biomethane value chains (in Germany)



[dena]

# Biomethane incentive system in Germany

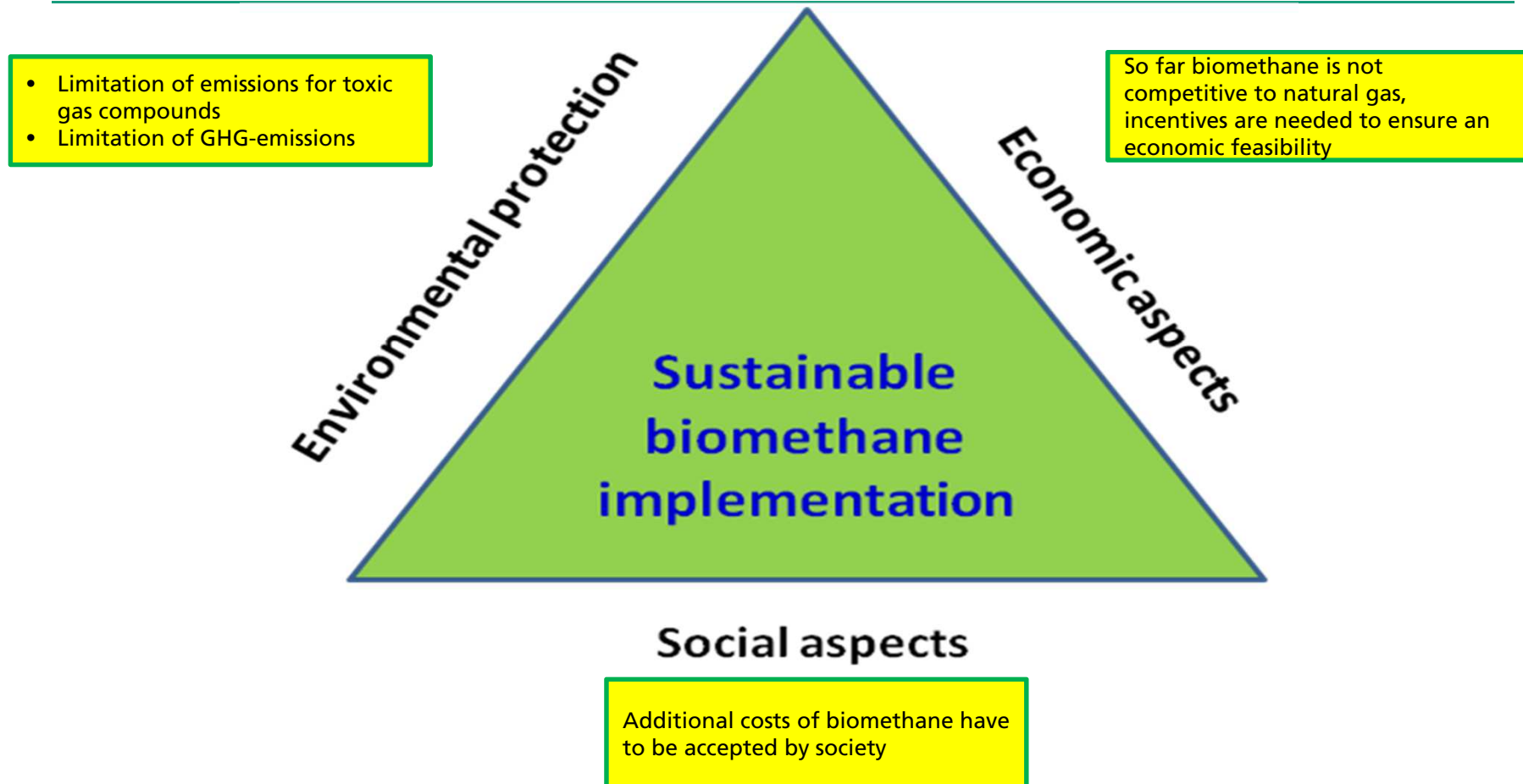


## Incentives scheme (amongst others):

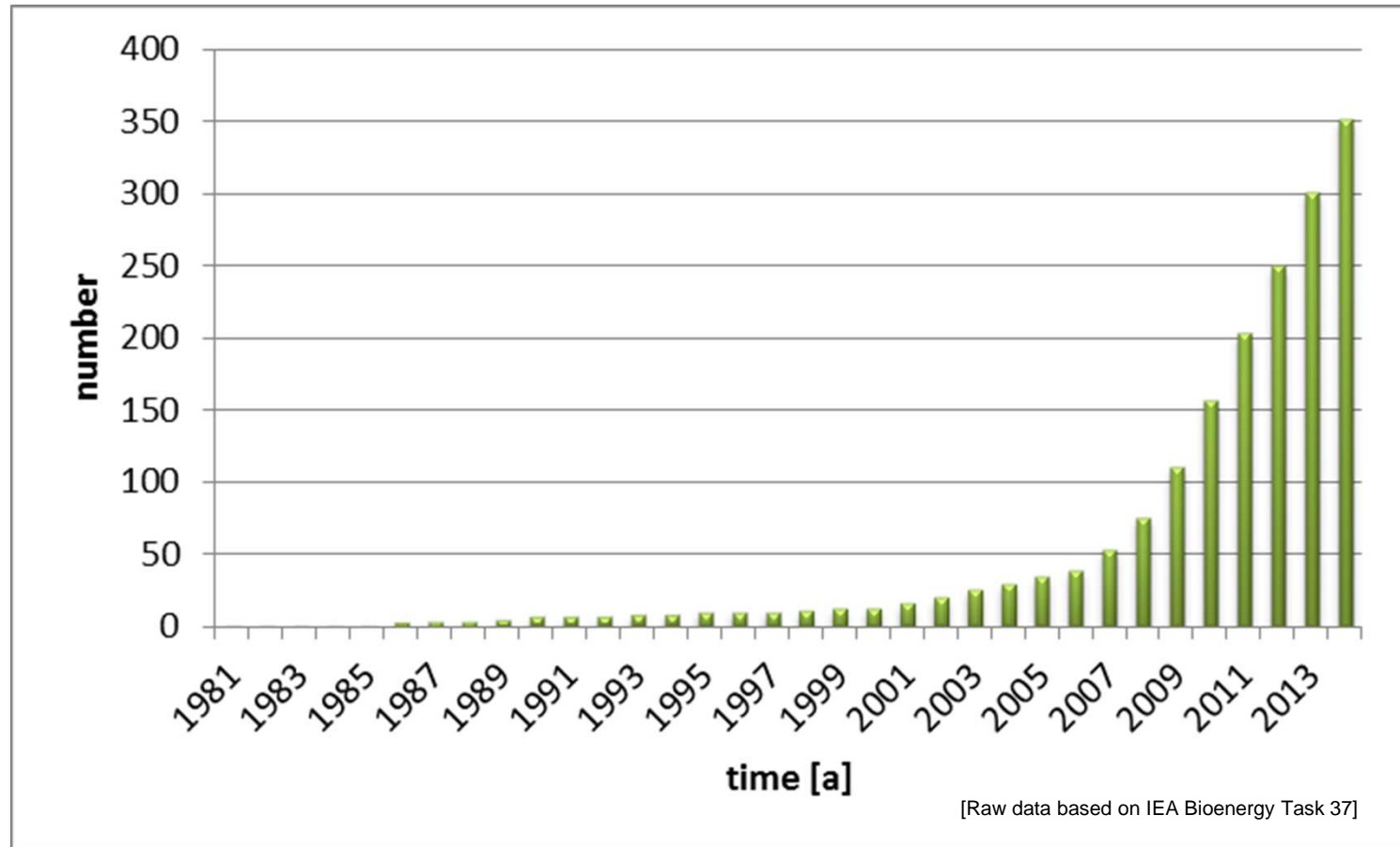
- Investment cost share between connectee and grid operator
- Covering of operational costs by grid operator
- Fee for "avoided grid costs" paid by grid operator to connectee

[IWES after dena]

# Triangle of sustainable biomethane implementation

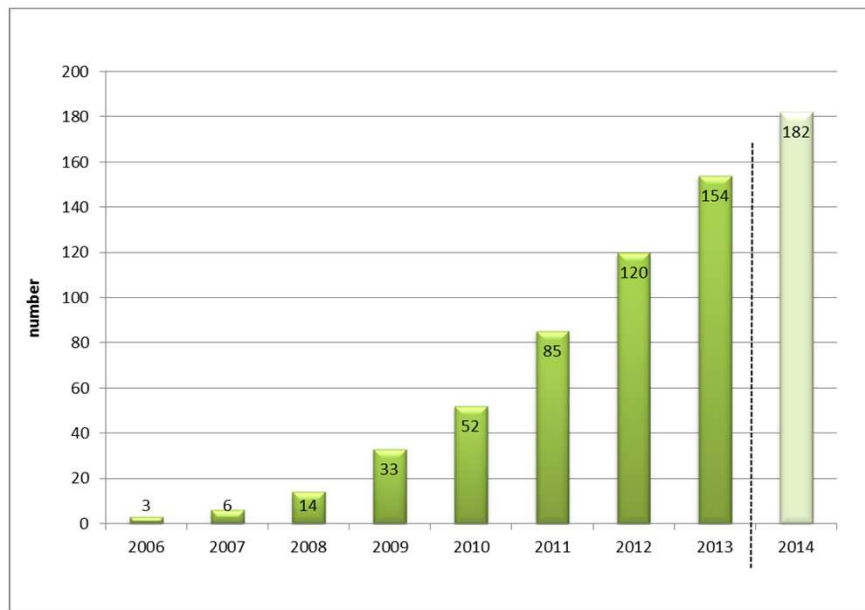


# Development of biogas upgrading plants worldwide

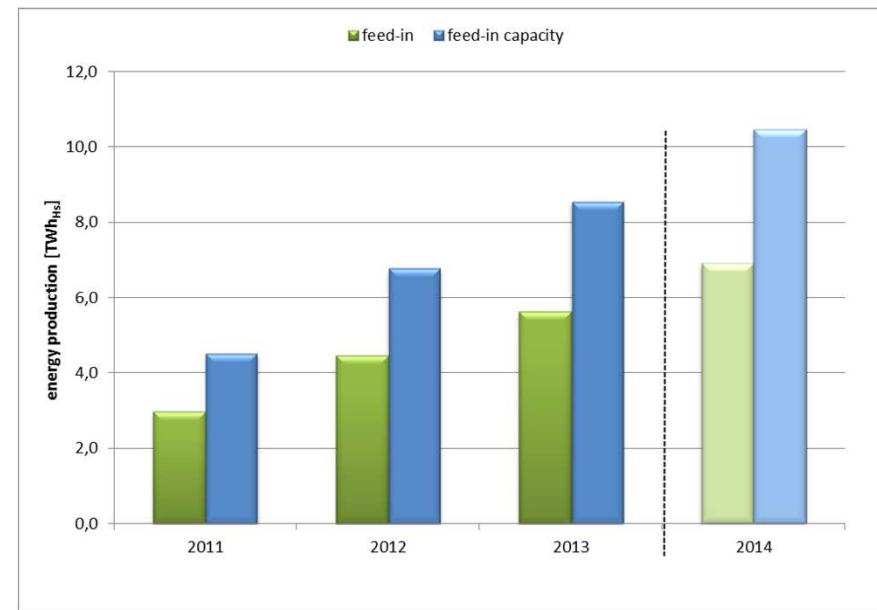


- Figure shows 351 plants
- Estimation: Total number by end of 2014 is > 400

# Development of biogas upgrading plants (left) and biomethane production (right) in Germany

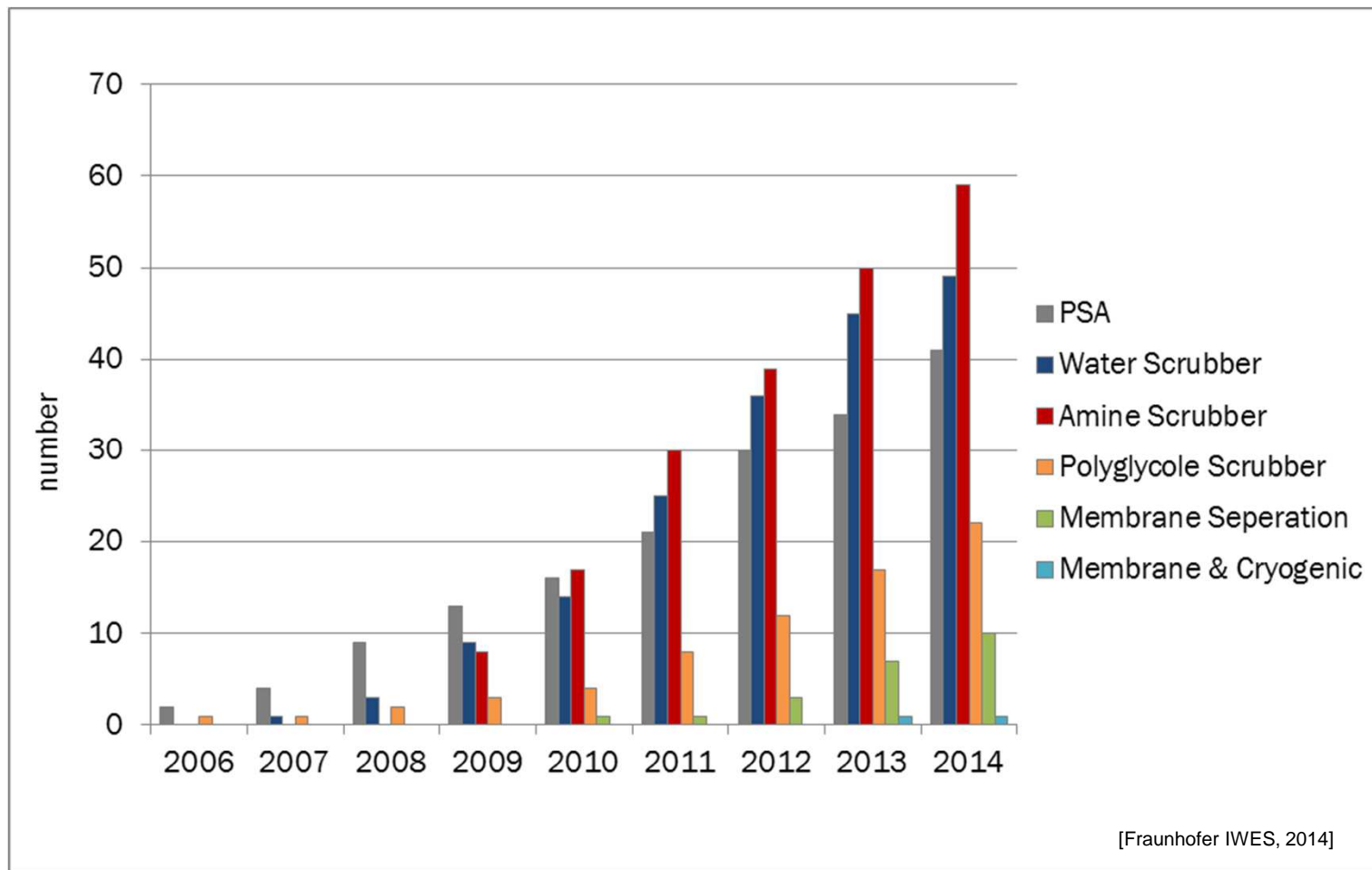


[Fraunhofer IWES, 2014]

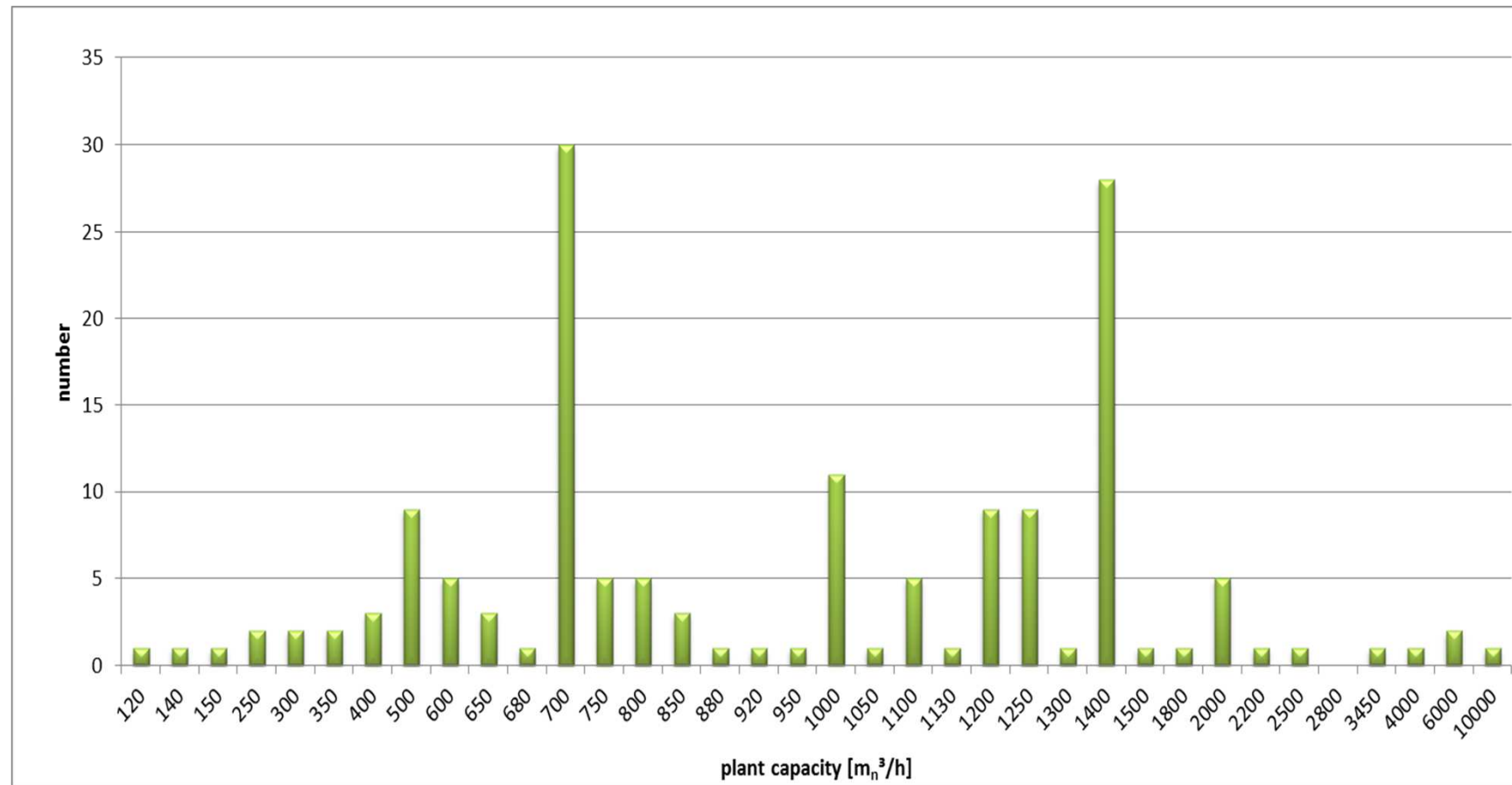


[Fraunhofer IWES, 2015]

# Development of biogas upgrading plants (referred to technologies) in Germany



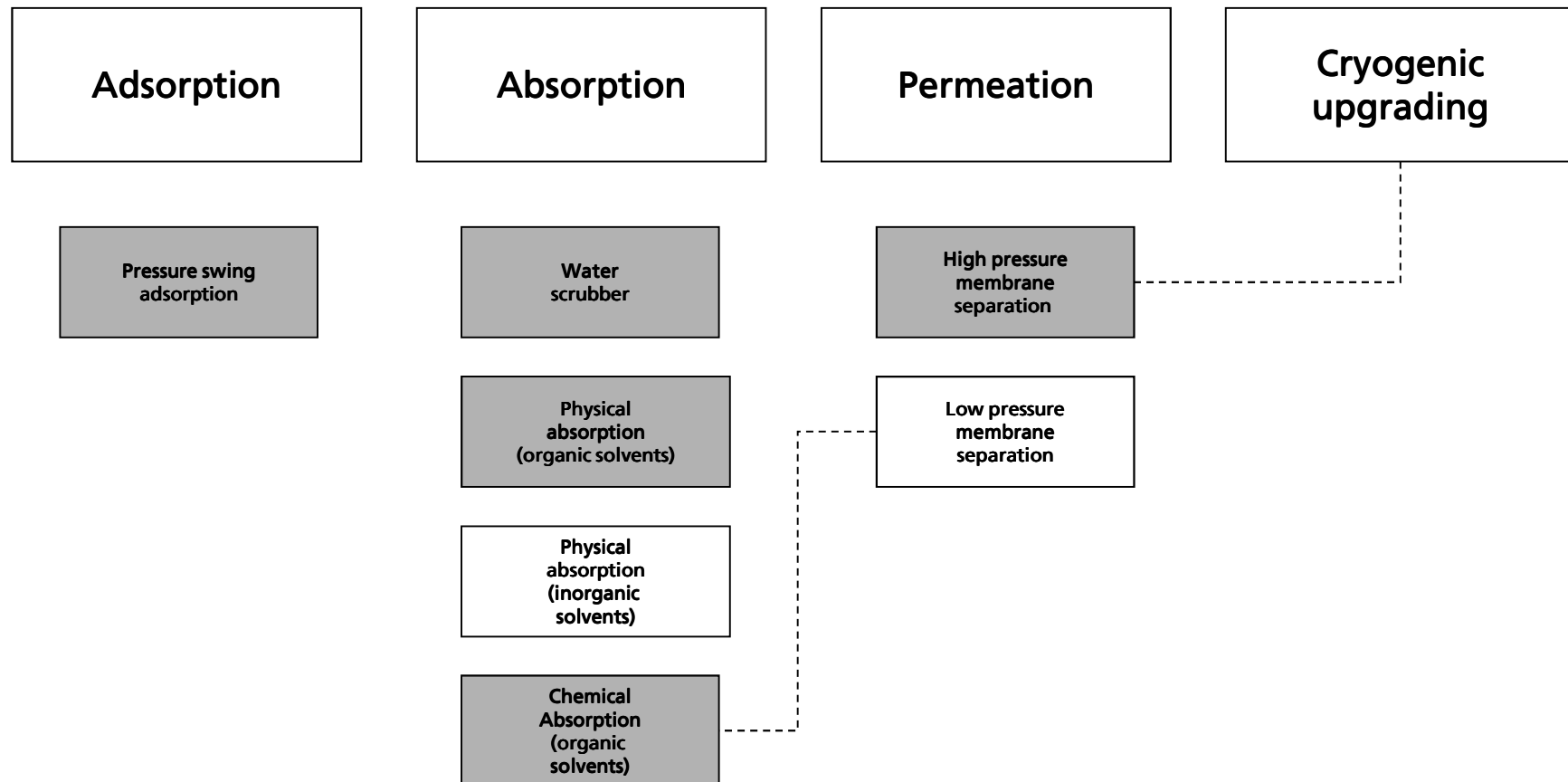
# Biogas upgrading plants in Germany: Cumulative frequency of installed plant capacities



[Fraunhofer IWES, 2015]

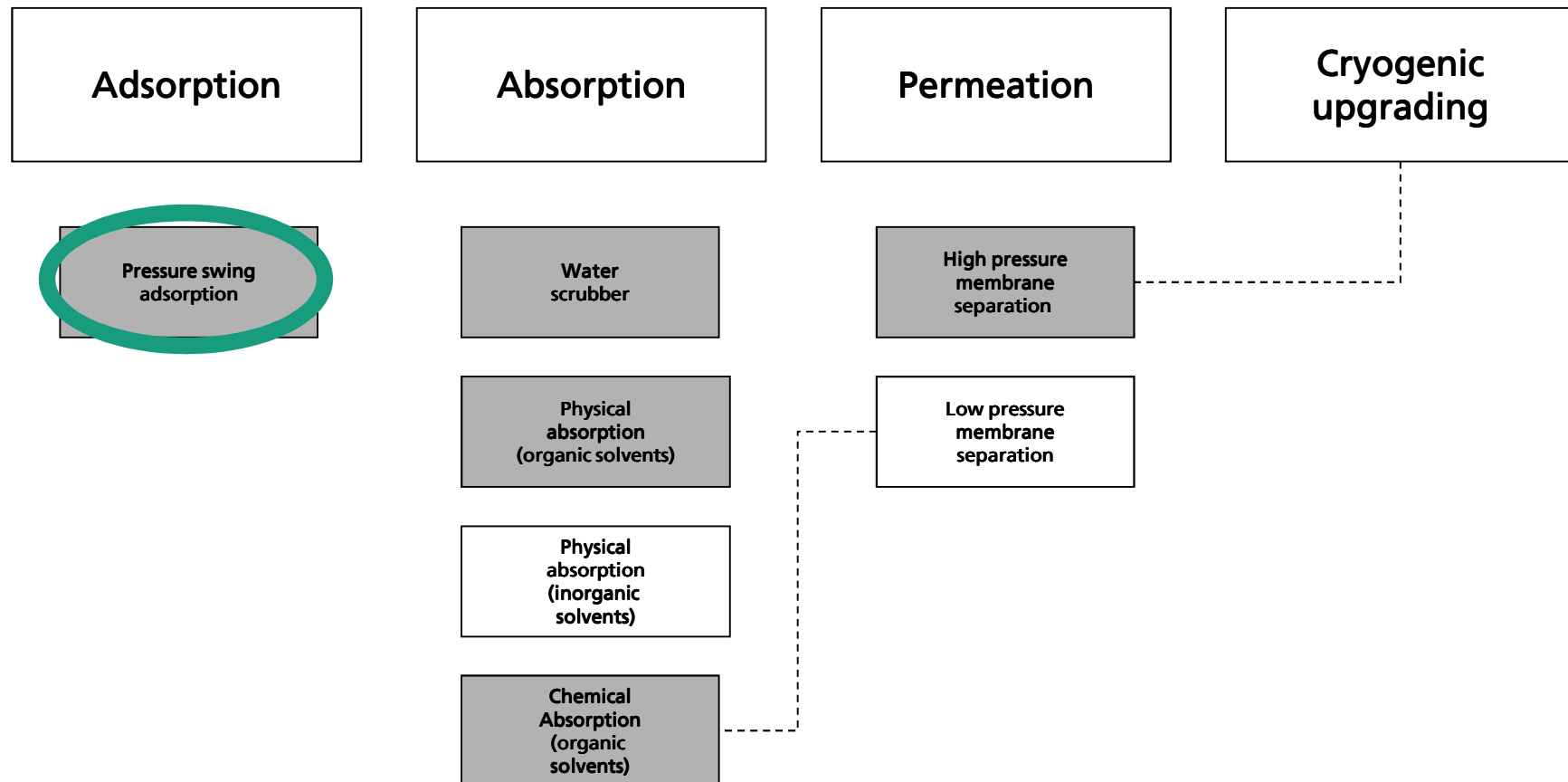
# Biogas upgrading - Technology overview

## 5 methods state of the art





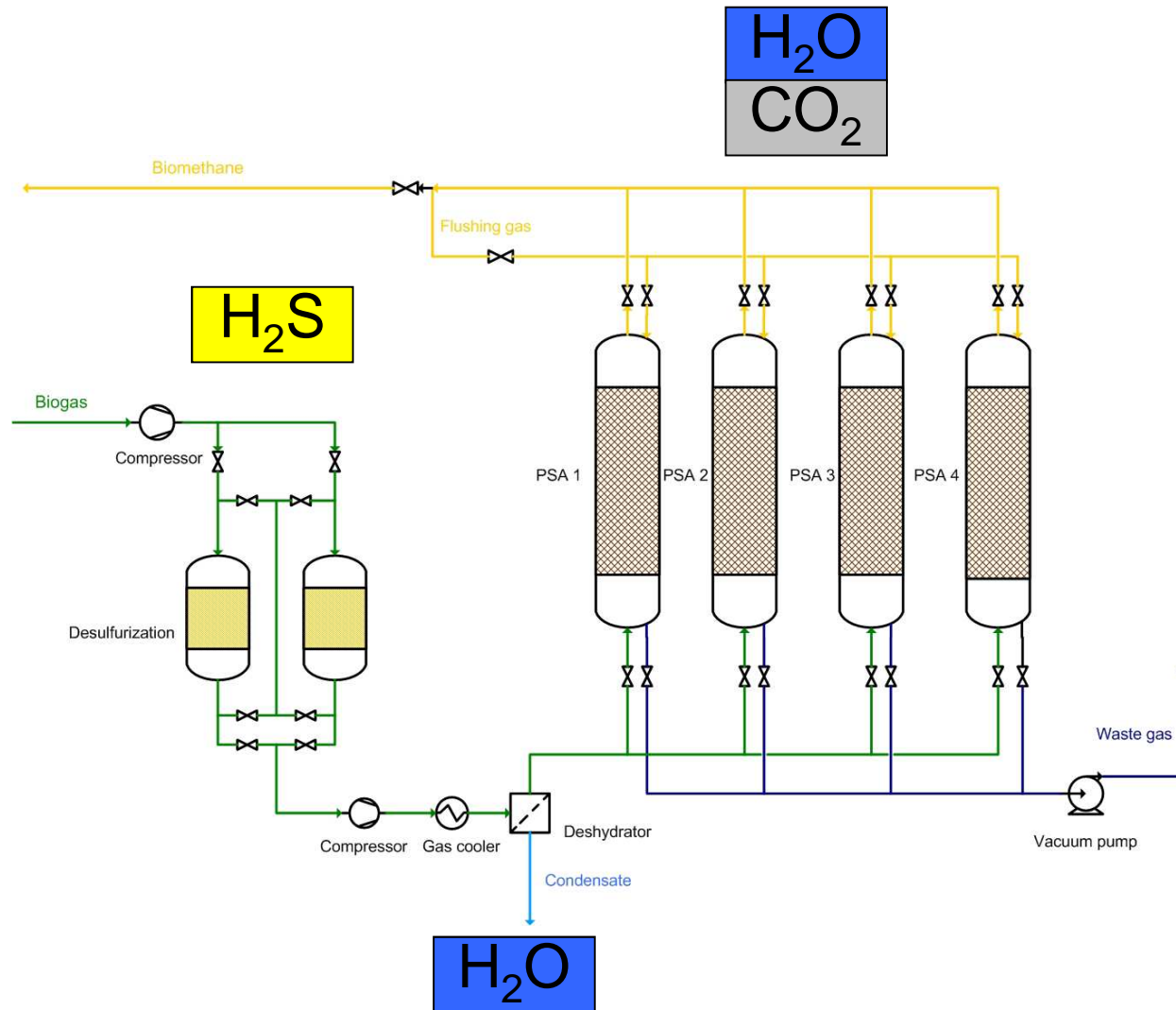
# Biogas upgrading - Technology overview



# Pressure Swing Adsorption (PSA)



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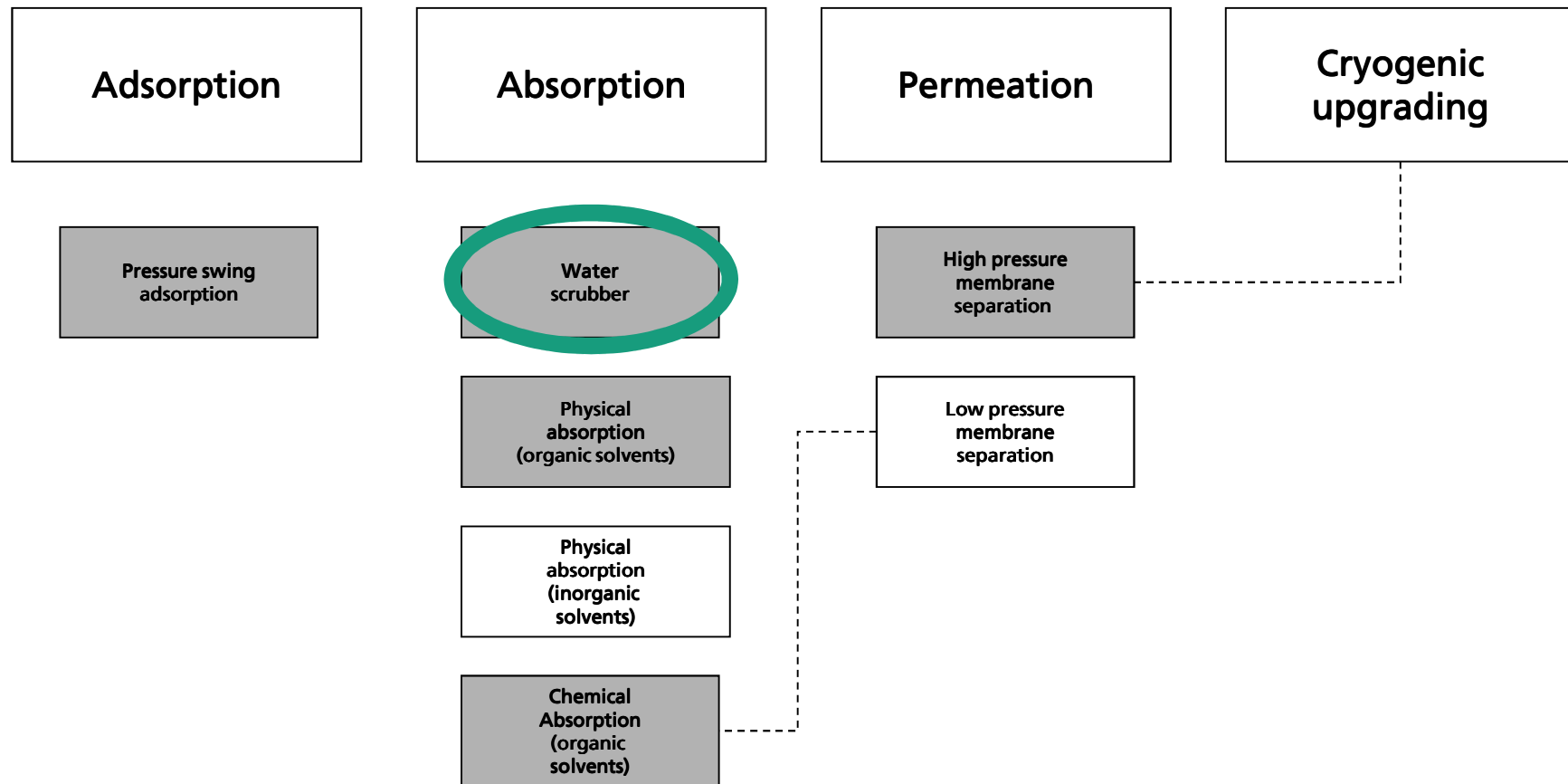


	Electricity demand	Heat demand	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recommended	Precision desulphurization required
	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]				[bar]	[%]	[%]		
<b>ranges</b>	0.16-0.35	0	No	No	1-10	1.5-10	90-98.5	Yes	Yes
<b>typical values</b>	0.2-0.25	0	No	No	4-7	1.5-2.5	97.5-98.5	Yes	Yes



[Fraunhofer IWES | Beil]

# Water scrubber



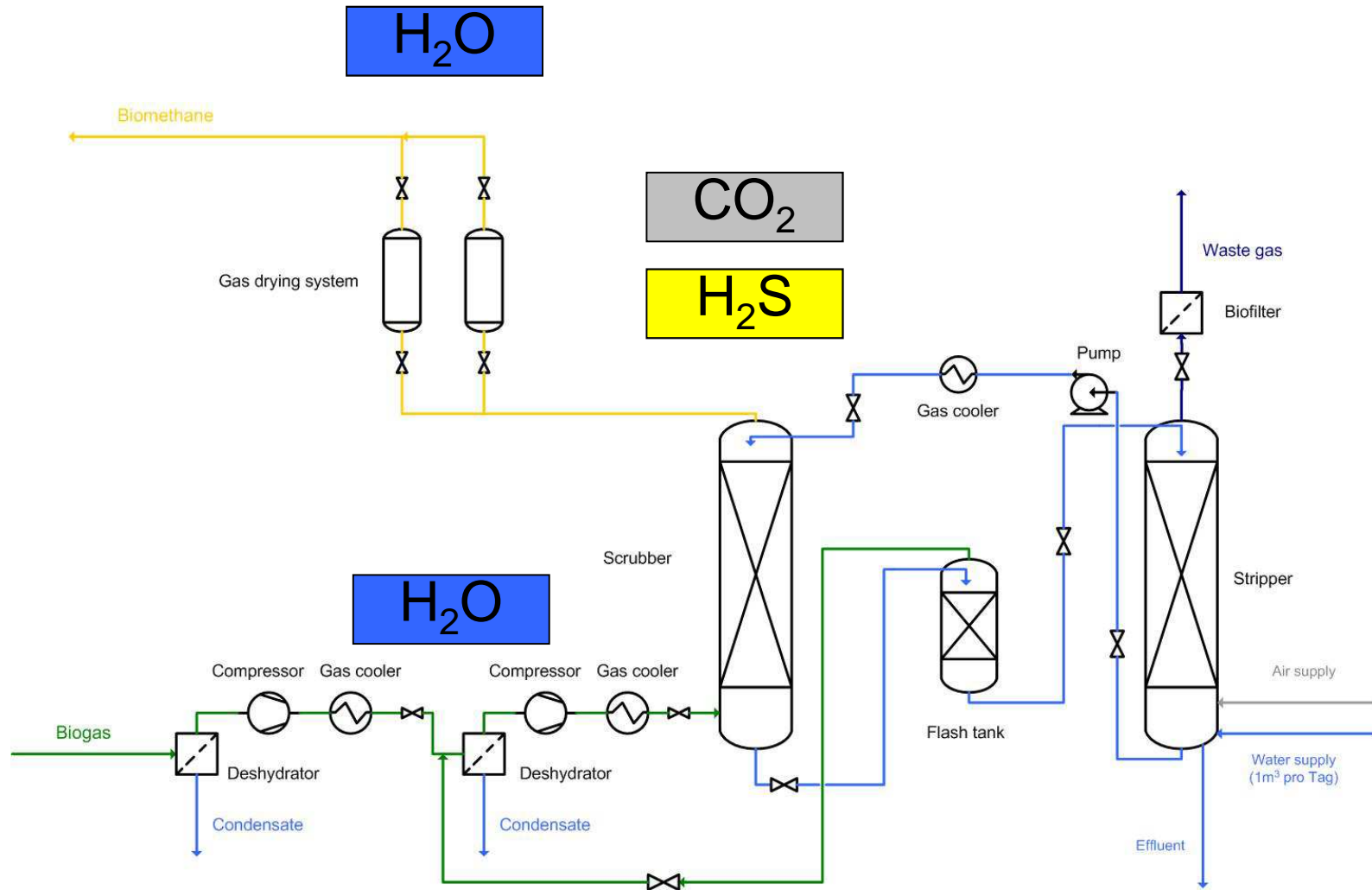


# Water scrubber



[Fraunhofer IWES | Beil]

# Water scrubber



# Water scrubber

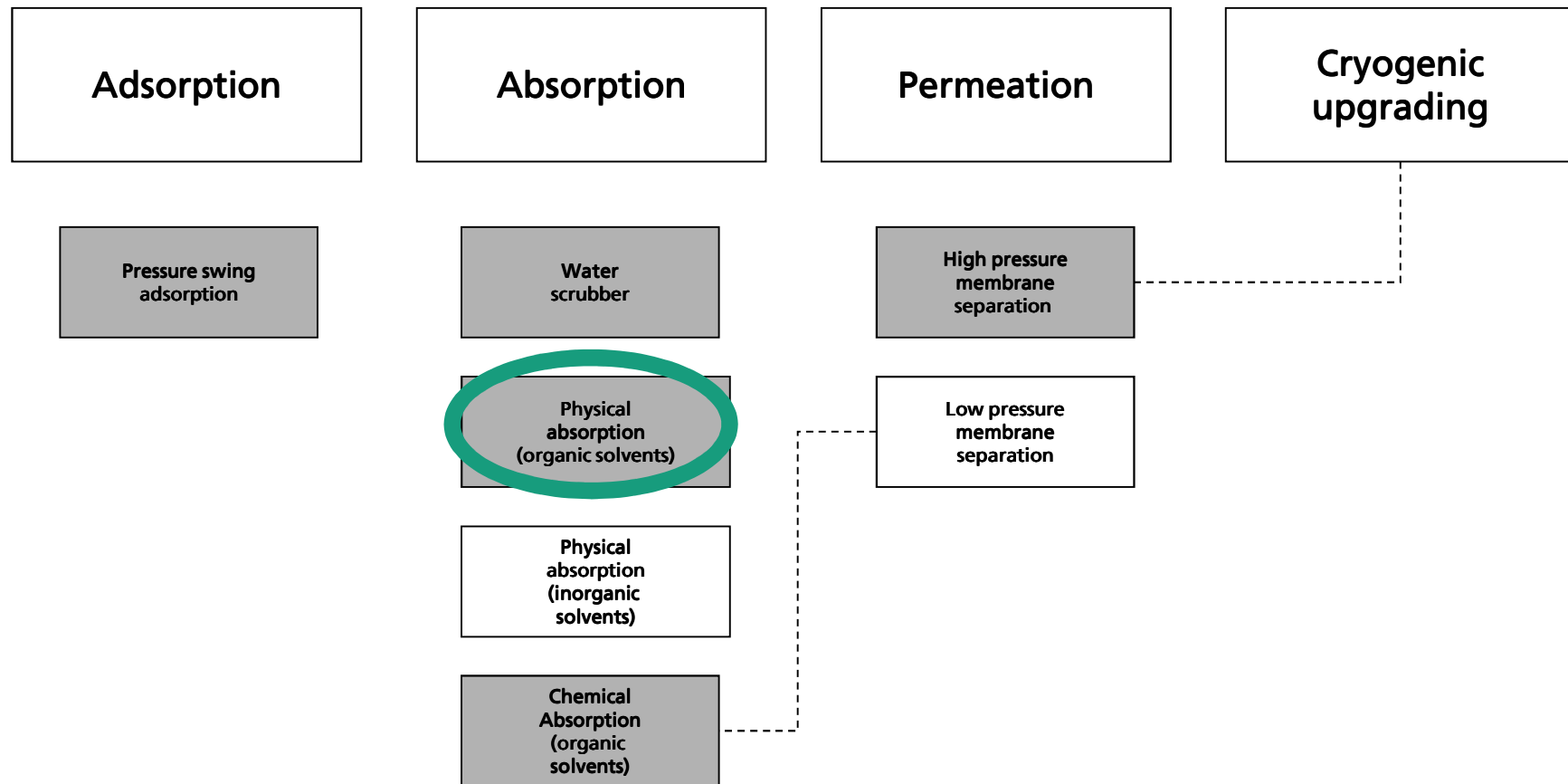


	Electricity demand	Heat demand	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recommended	Precision desulphurization required
	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]				[bar]	[%]	[%]		
<b>ranges</b>	0.20 - 0.30	0	Yes	No	4-10	0.5 - 2	98-99.5	Yes	No
<b>typical values</b>	>0.2 - <0.3	0	Yes	only e.g. anti-scaling/fouling agents on demand	4-10	0.5 - 2	98-99.5	Yes	No





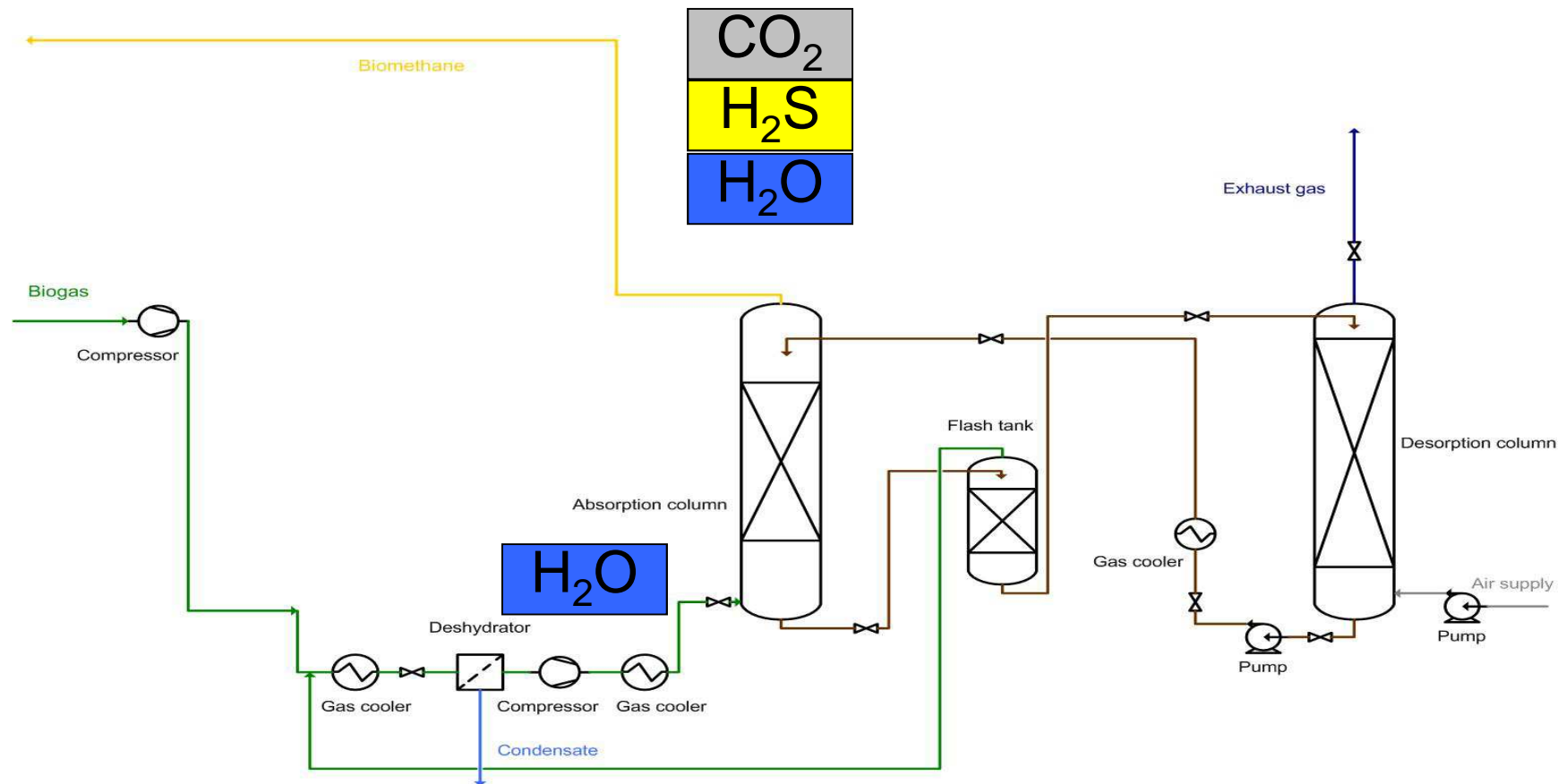
# Biogas upgrading - Technology overview



# Physical Absorption (using organic solvents)



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# Physical Absorption (using organic solvents)

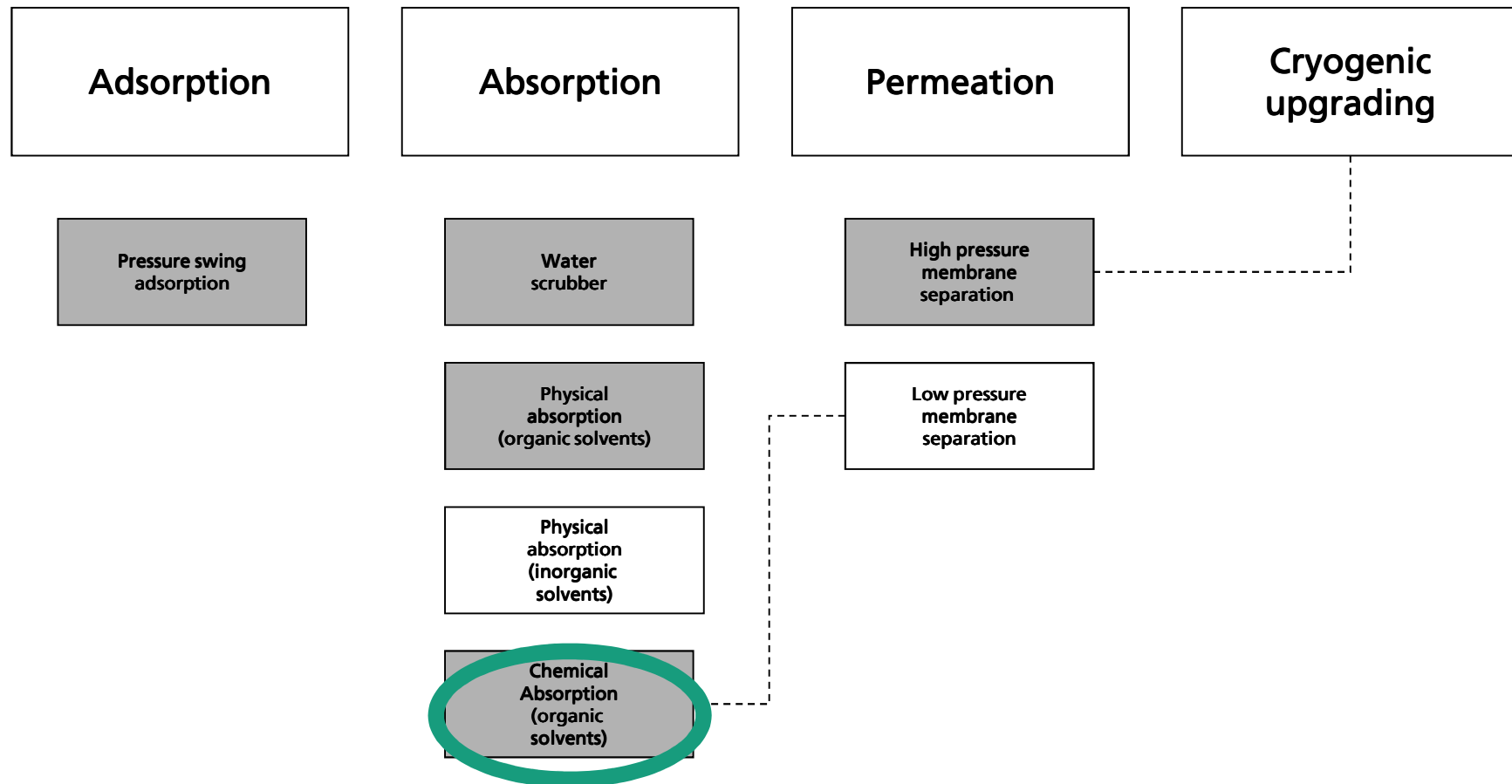


	Electricity demand	Heat demand	Temperature level process heat (in the column)	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recommended	Precision desulphurization required
	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]		[°C]			[bar]	[%]	[%]		
<b>ranges</b>	0.23-0.33	0.10-0.15	40-80	No	Yes	4-8	1-4	96-99	Yes	No
<b>typical values</b>	0.23-0.27	0.10-0.15	40-50	No	Yes	6-7	~1.5	~98.5	Yes	No



[Fraunhofer IWES | Beil]

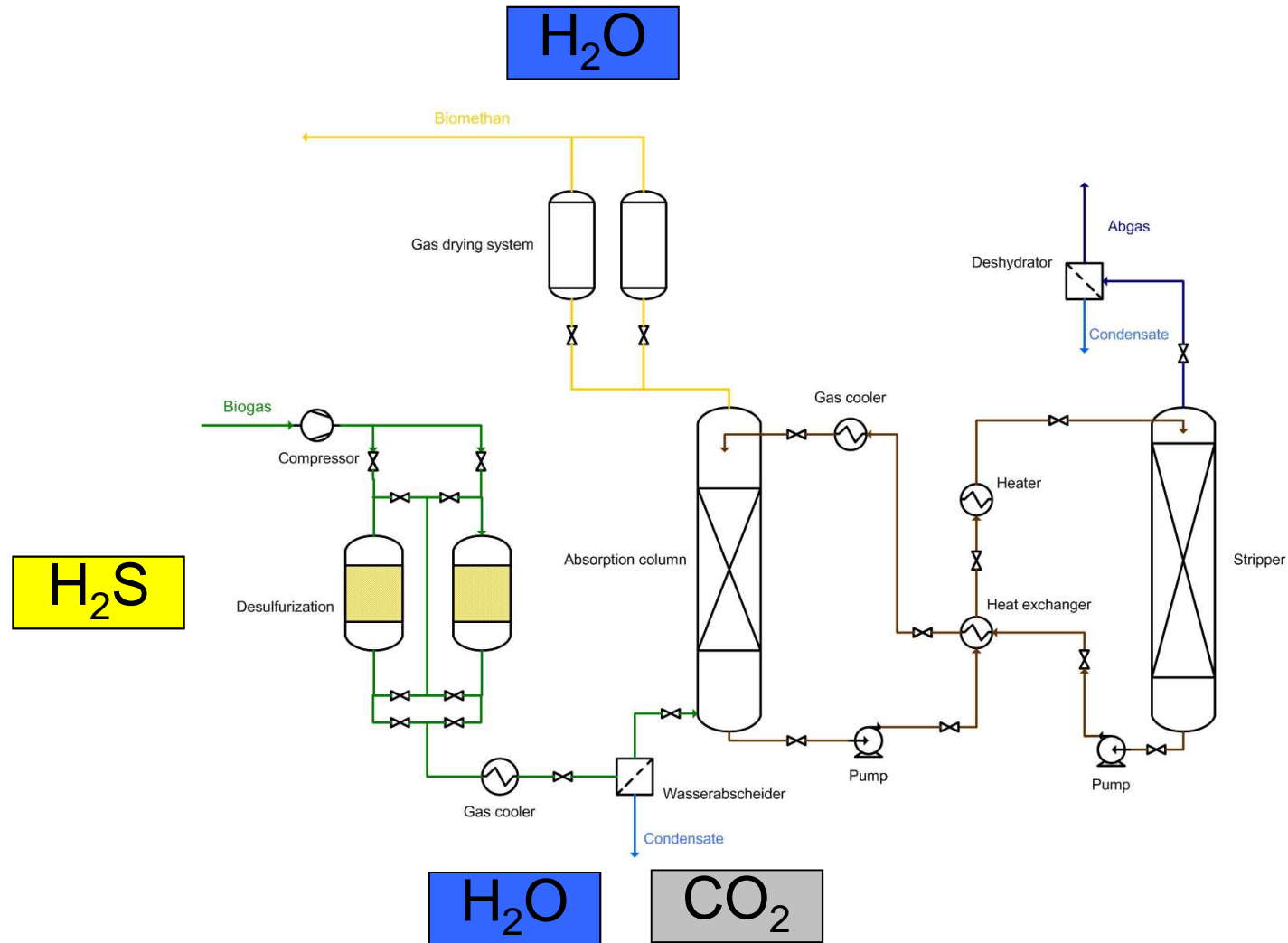
# Chemical Absorption (using organic solvents)



# Chemical Absorption (using organic solvents)



# Chemical Absorption (using organic solvents)





# Chemical Absorption (using organic solvents)

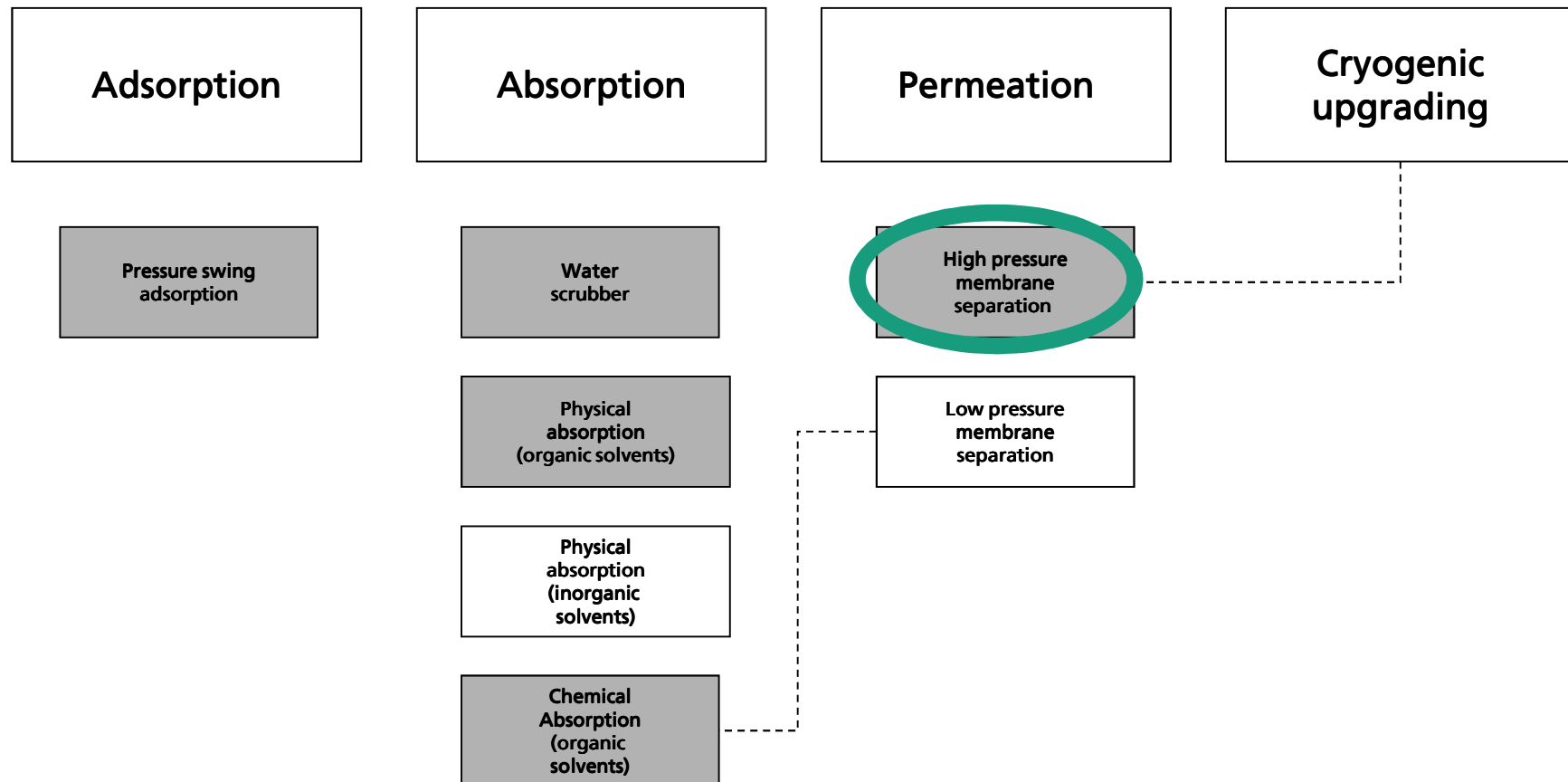


	Electricity demand	Heat demand	Temperature level process heat (in the column)	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recommended	Precision desulphurization required
	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]		[°C]			[bar]	[%]	[%]		
<b>ranges</b>	0.06-0.17	0.4-0.8	106 - 160	Yes	Yes	0.05 - 4	~0.1	~99.9	No	Yes (Depending on manufacturer)
<b>typical values</b>	0.09-0.11	~0.5-0,7	106 - 160	Yes	Yes	0.05 - 4	~0.1	~99.9	No	Yes (Depending on manufacturer)





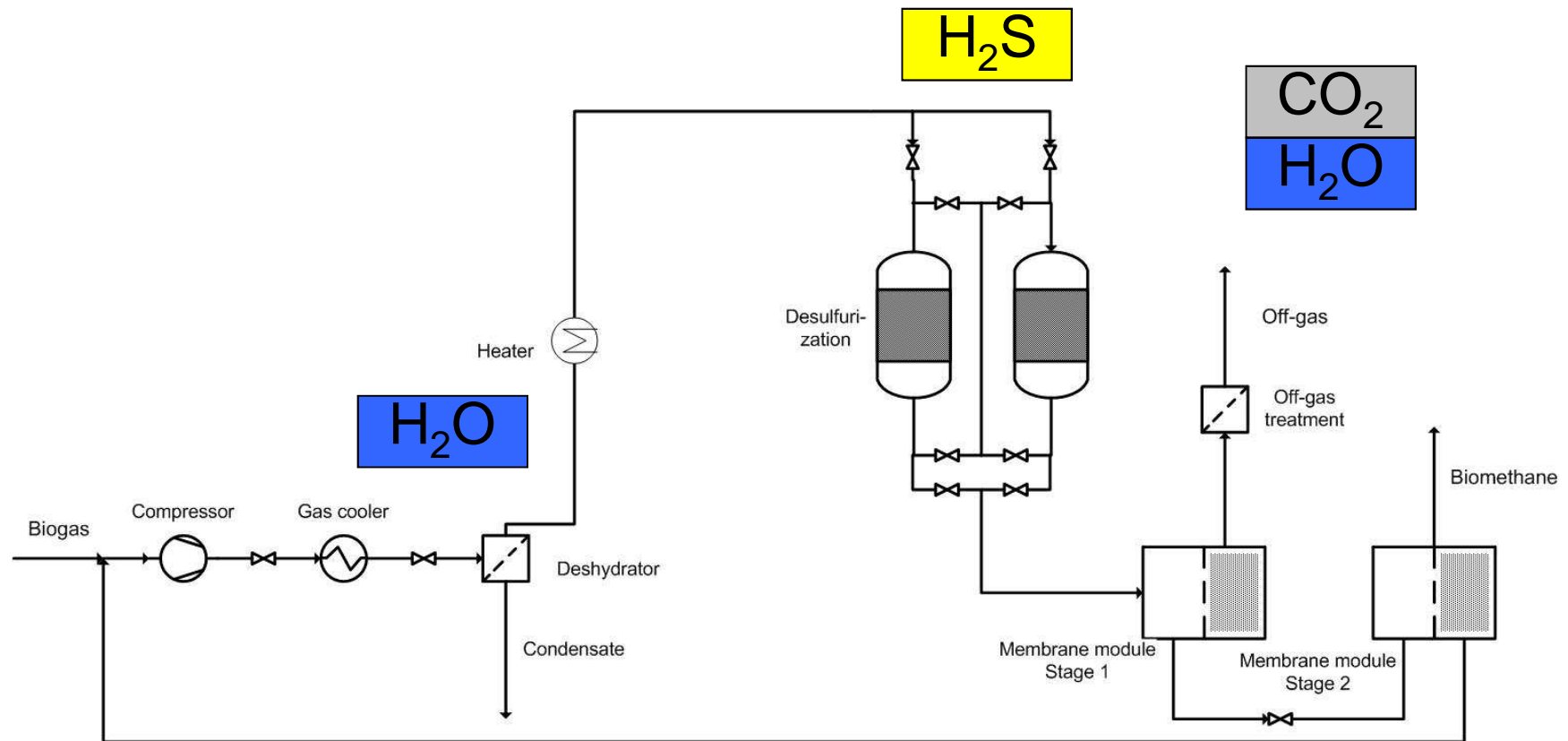
# Membrane separation



# High Pressure Membrane Separation



# High Pressure Membrane Separation



# High Pressure Membrane Separation





# High Pressure Membrane Separation

	Electricity demand	Heat demand	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recommended (methane loss >1%)	Precision desulphurization required
	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]	[kWh/m <sub>n</sub> <sup>3</sup> <sub>BG</sub> ]			[bar]	[%]	[%]		
<b>ranges</b>	0.18-0.35	0	No	No	7-20	1-15	85-99.5	Yes	Recommended
<b>typical values</b>	~ 0.22	0	No	No	7-20	0.5 - 2	98.0 - 99.5	(Yes)	Recommended



# Off-gas treatment

Degradation of CH<sub>4</sub> in the off-gas through:

- Regenerativ thermal oxidation (RTO)

- Water scrubber, Phys. Absorption, PSA (new generation), Membrane (new generation)

- Catalytic oxidation

- PSA, Membrane

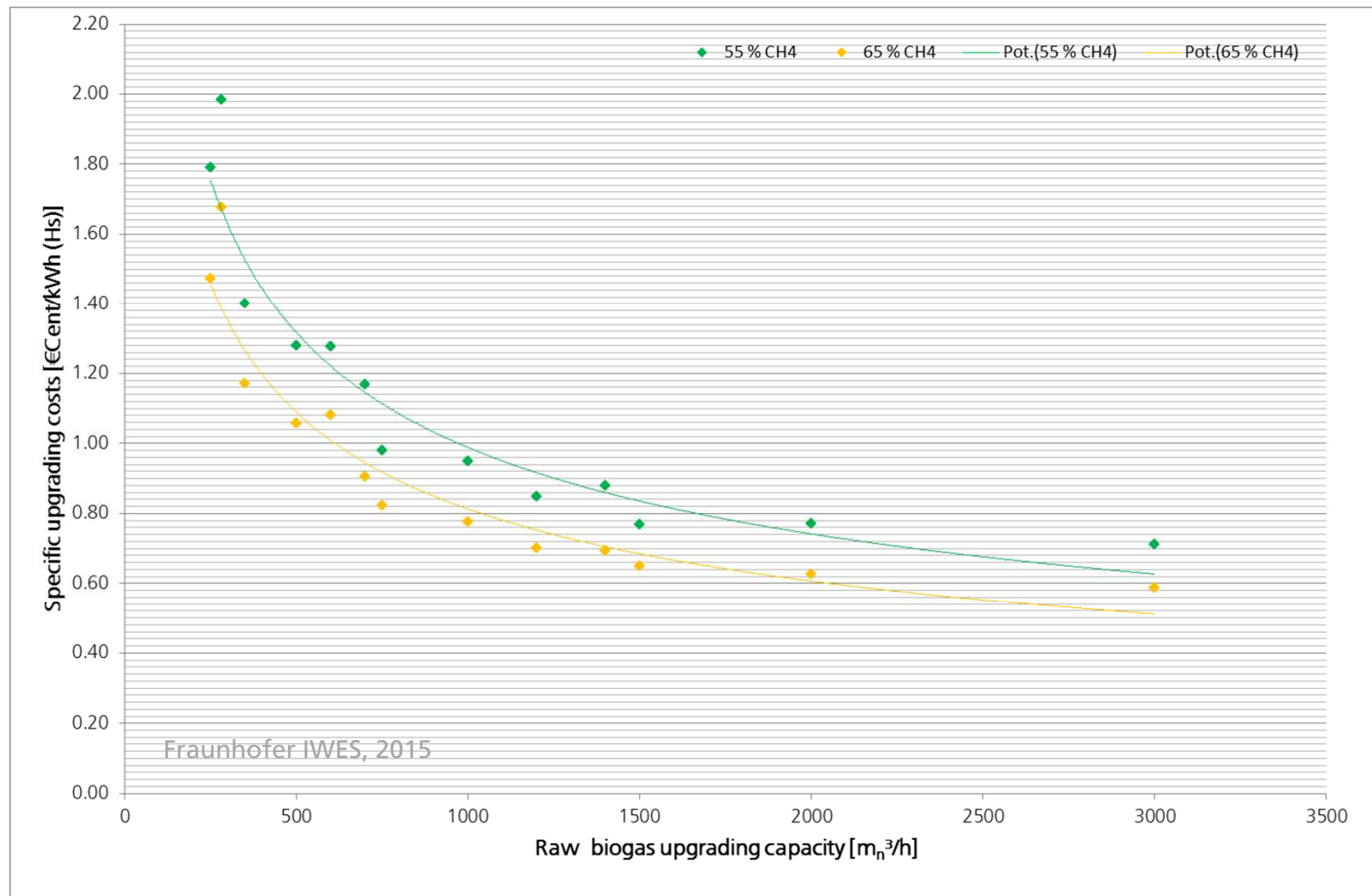
- Flameless oxidation

- PSA, Membrane

- Co-firing in combustion engines (e.g. micro turbines)



# Specific biogas upgrading costs for Thailand (related to 2015)

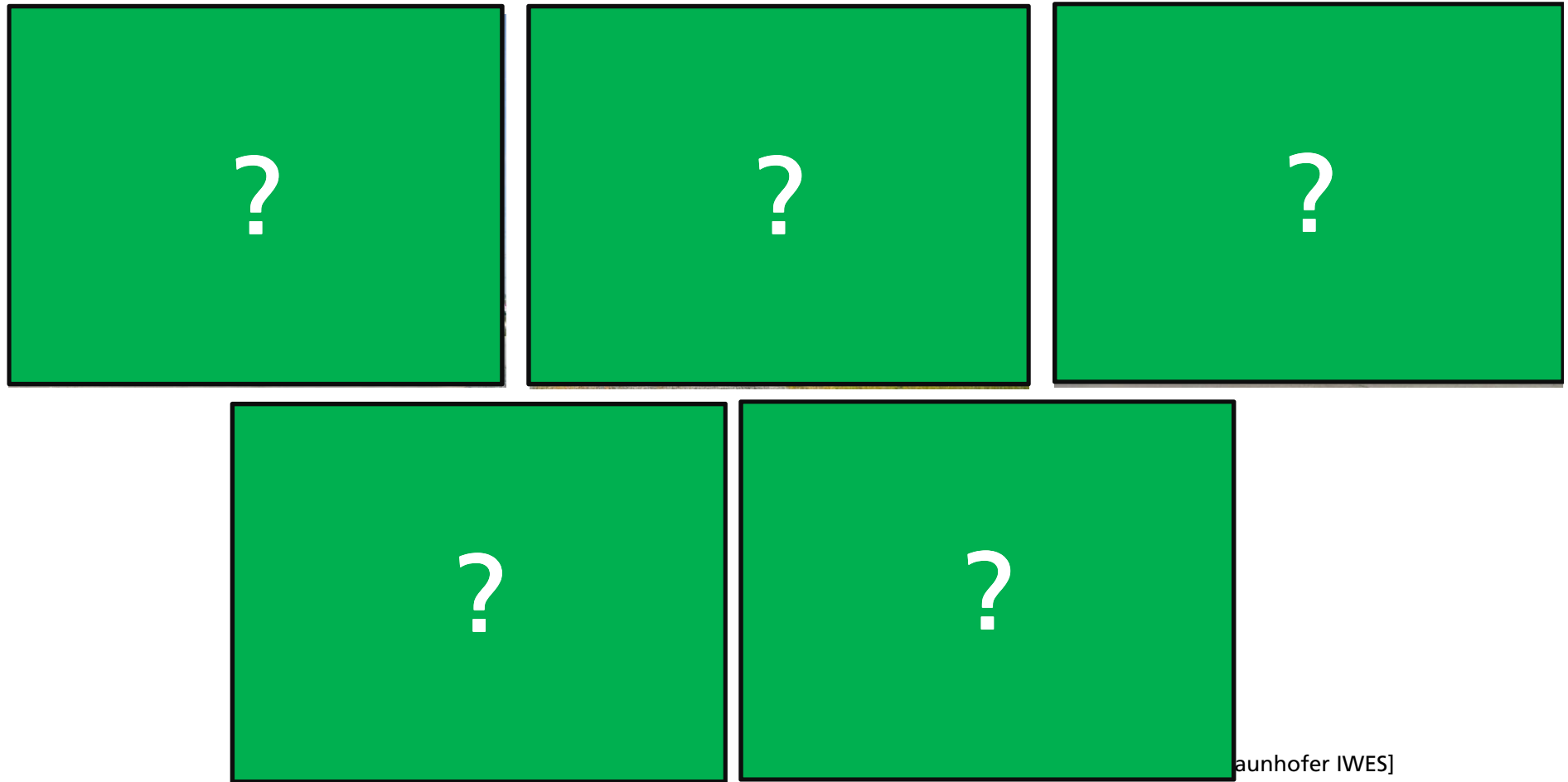


# Specific upgrading costs – assumptions and framework conditions for calculation

- Place of delivery: Bangkok/Thailand
- Costs are related to 2015 (no average costs over lifetime)
- Considered technologies: PSA, Water Scrubber, Amine Scrubber, Membrane
- Product gas pressures vary: 150 mbar (amine scrubber) – 15 bar (membrane)
- Investment and maintenance (as full maintenance contract) costs based on price indications of current plant generations of 4 technology providers
- Costs for planning, permission and further construction costs: 10 % related to investment costs
- Interest rate: 5 %
- Operating time: 15 years
- Costs for insurance: 0.5 % related to investment costs
- Plant availability: 96 % (8410 h/a)
- Specific energy consumptions (related to 55 % and 65 % methane concentrations in the raw gas flow) and methane recovery rates are based on warranty values
- Costs for process energy: 4 THB/kWh<sub>el</sub>
- Personal costs for: included
- Precision desulfurization (if required): H<sub>2</sub>S reduction by 100 ppm, 5 € per m<sub>n</sub><sup>3</sup> raw gas upgrading capacity and year (includes costs for activated carbon, costs for disposal of loaded coal as hazardous waste and carrying costs)



# Biogas upgrading – Which technology should be selected?



# Biogas upgrading – Which technology should be selected?

## ■ „Technology open“!

➔ there is no “best upgrading technology”

## ■ First define your project!:

- Raw gas quantity (“today” and “tomorrow”)
- Raw gas composition main compounds ( $\text{CH}_4$ ,  $\text{CO}_2$ ,  $\text{N}_2$ ,  $\text{O}_2$ )
- Raw gas composition trace compounds ( $\text{NH}_3$ , organic silicon compounds, etc.)
- Product gas requirements (standards, grid operator, ...)
- Process energy availability and costs
- Experience of own staff

## ■ Site visits

- Talk to operators
- Get objective practical information about experiences made



# Biogas upgrading – Which technology should be selected?

## ■ Define your evaluation criteria

- Investment costs are only one part of...
- Specific biomethane provision costs
- Costs of full service contracts
- Methane loss resp. methane yield
- Plant availability
- Required space, height, ...
- References (experience of manufacturer)
- Service (availability, quality, ...)
- ...

## ■ Call for tenders

## ■ Evaluation

## ➔ Decision





[Copyright: Schmack Biogas AG]

# Contacts

Michael Beil  
Fraunhofer IWES  
Department Bioenergy System Technology  
Gas Upgrading, Injection and Grids

Königstor 59  
34119 Kassel/Germany  
+49 (0) 561 7294-421  
[michael.beil@iwes.fraunhofer.de](mailto:michael.beil@iwes.fraunhofer.de)

