Biomethane – a sustainable natural gas substitute


[Fraunhofer IWES | Beil]

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

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Gas Upgrading, Injection and Grids

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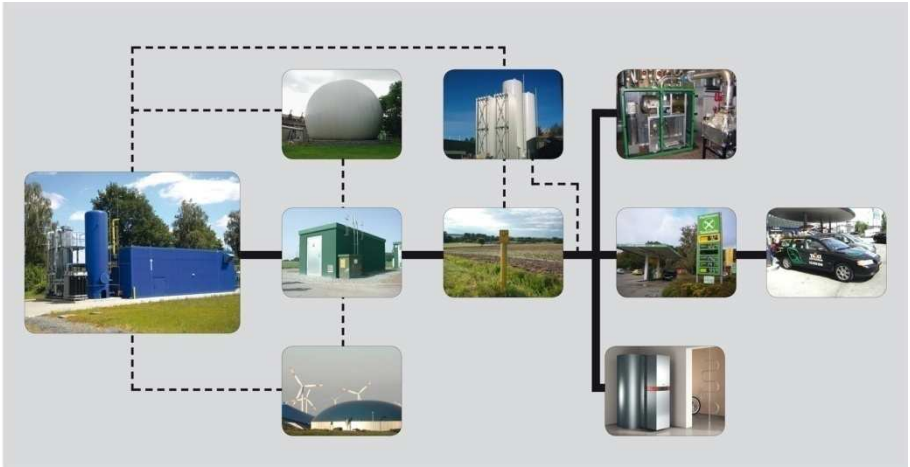

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Bioenergy System Technology

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Content

- 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 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)

- 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

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


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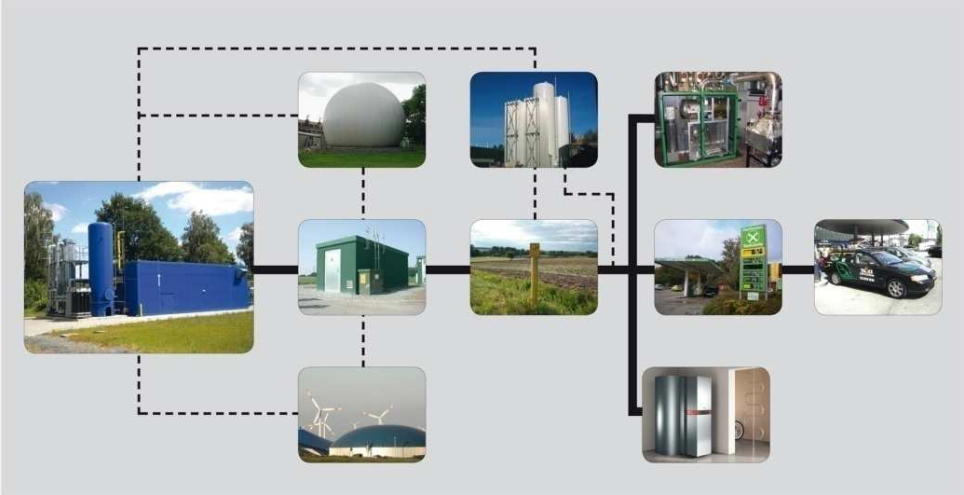
- R&D topics:
  - Technology and system analysis
  - Simulation and modeling of technologies and systems
  - Assessment of new technologies such as power-to-gas

Our services and products in the field of biomethane

Research and consulting along the whole value chain of biomethane…from well to wheel.



- 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

What's biomethane?

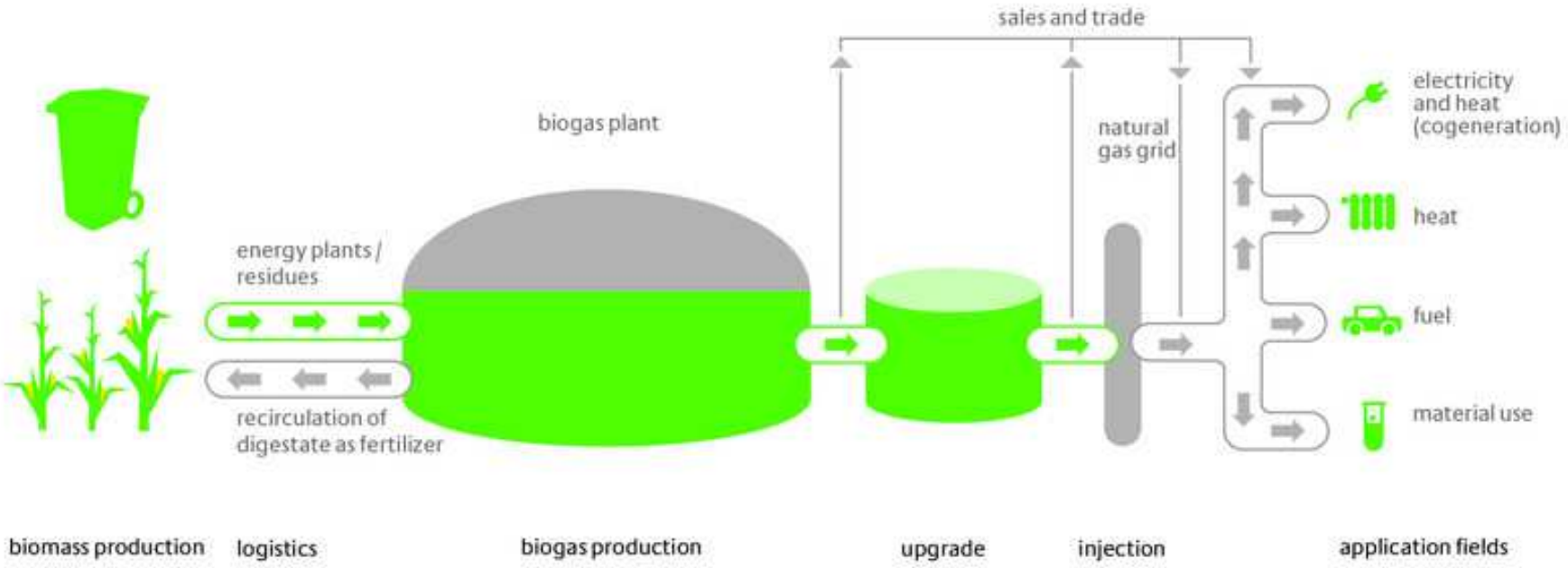
Biomethane is a cleaned (free of H_2S, water, etc.)

and upgraded (nearly free of CO_2) biogas…

…and therefore…

…a sustainable and renewable natural gas substitute

Biomethane value chains (in Germany)



[dena]

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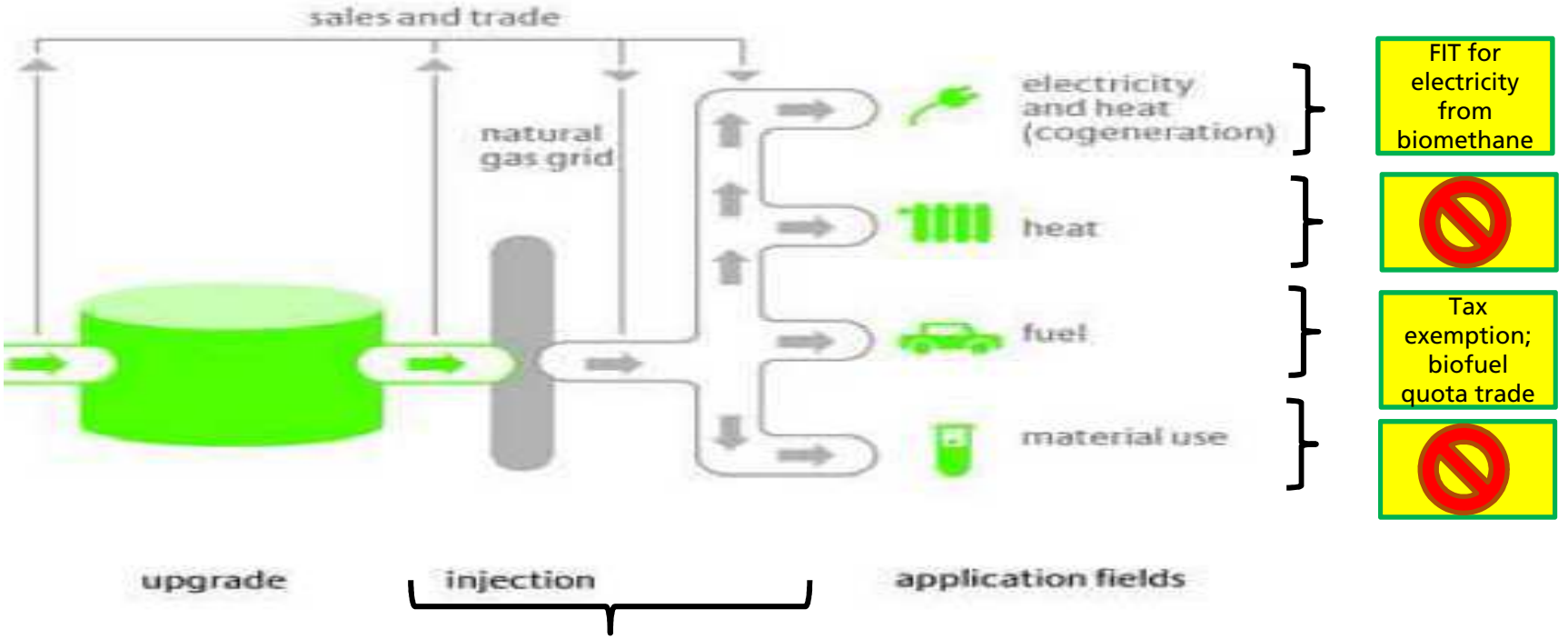
Biomethane incentive system in Germany



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]

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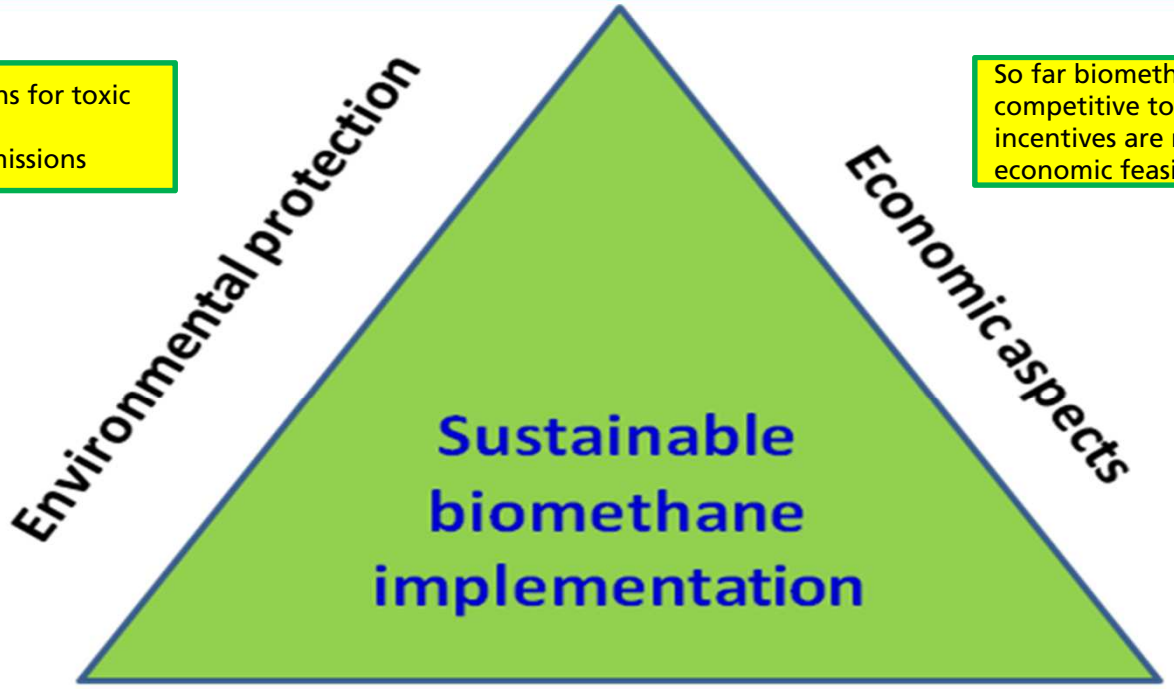
Triangle of sustainable biomethane implementation

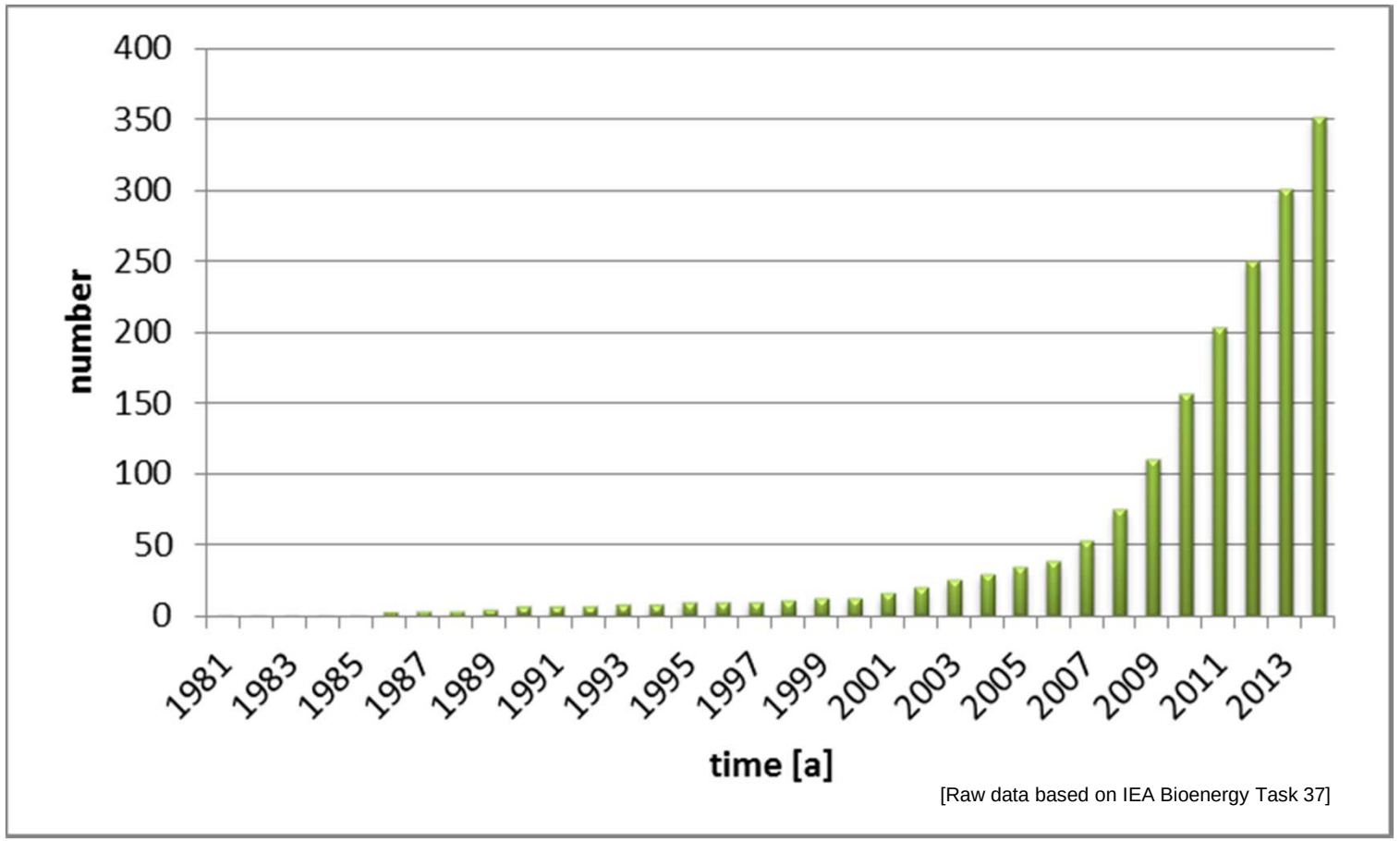
- Limitation of emissions for toxic gas compounds
- Limitation of GHG-emissions



So far biomethane is not competitive to natural gas, incentives are needed to ensure an economic feasibility

Additional costs of biomethane have to be accepted by society

Development of biogas upgrading plants worldwide



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

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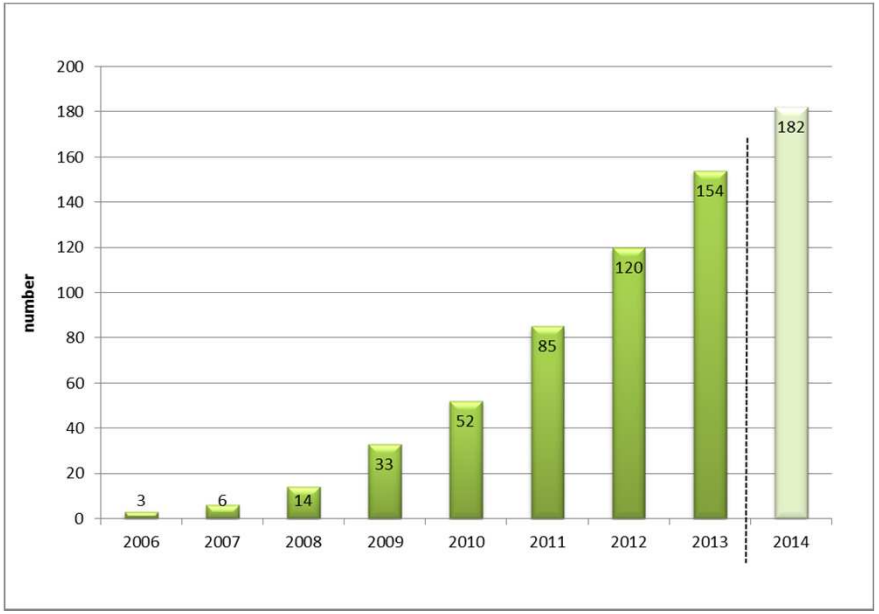
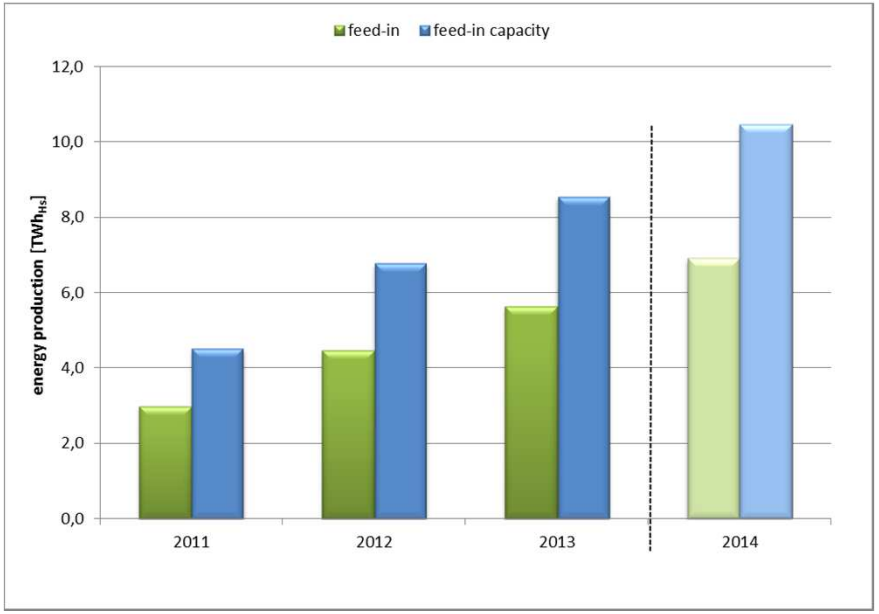
Development of biogas upgrading plants (left) and biomethane production (right) in Germany



[Fraunhofer IWES, 2014]



[Fraunhofer IWES, 2015]

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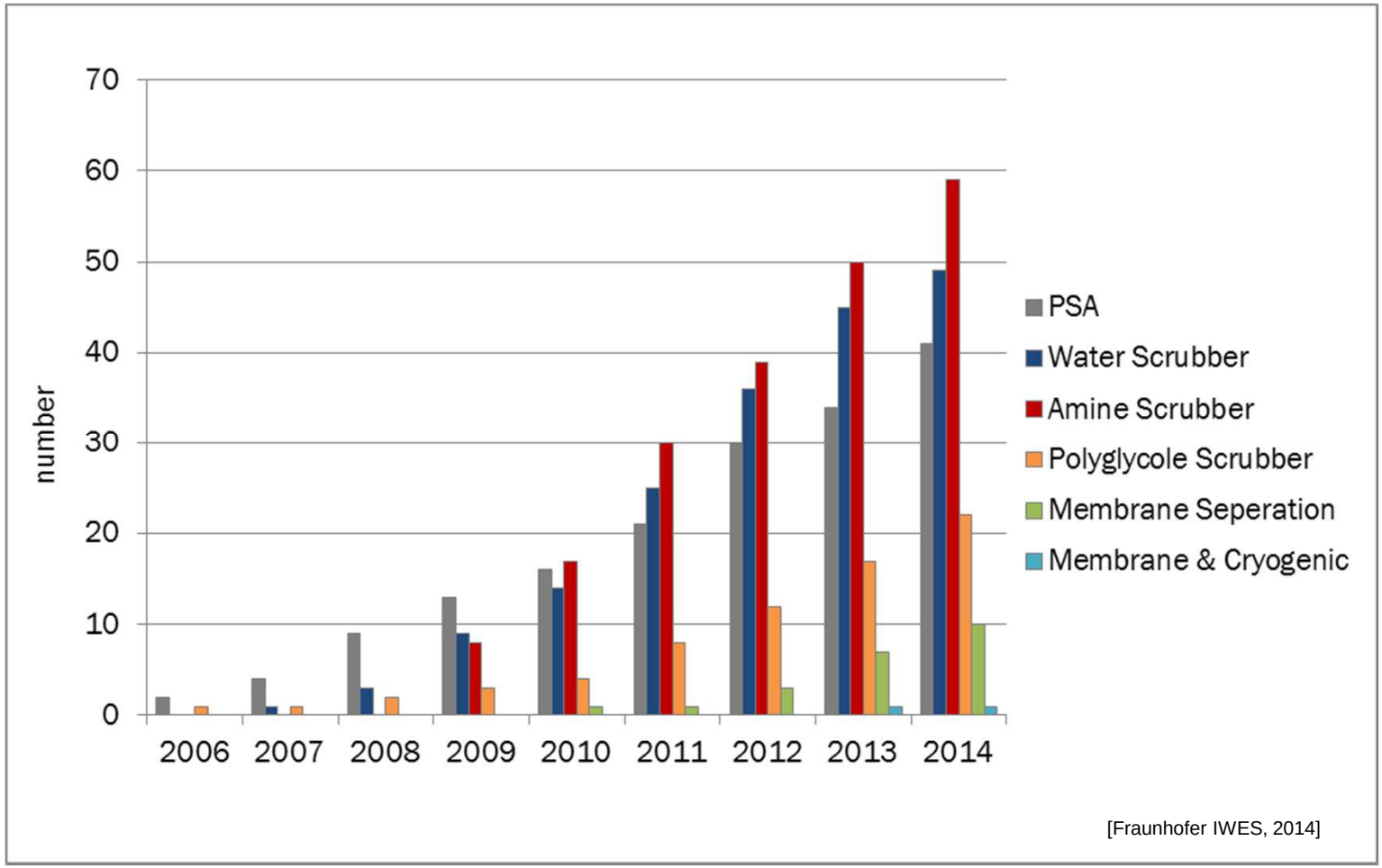
Development of biogas upgrading plants (referred to technologies) in Germany



[Fraunhofer IWES, 2014]

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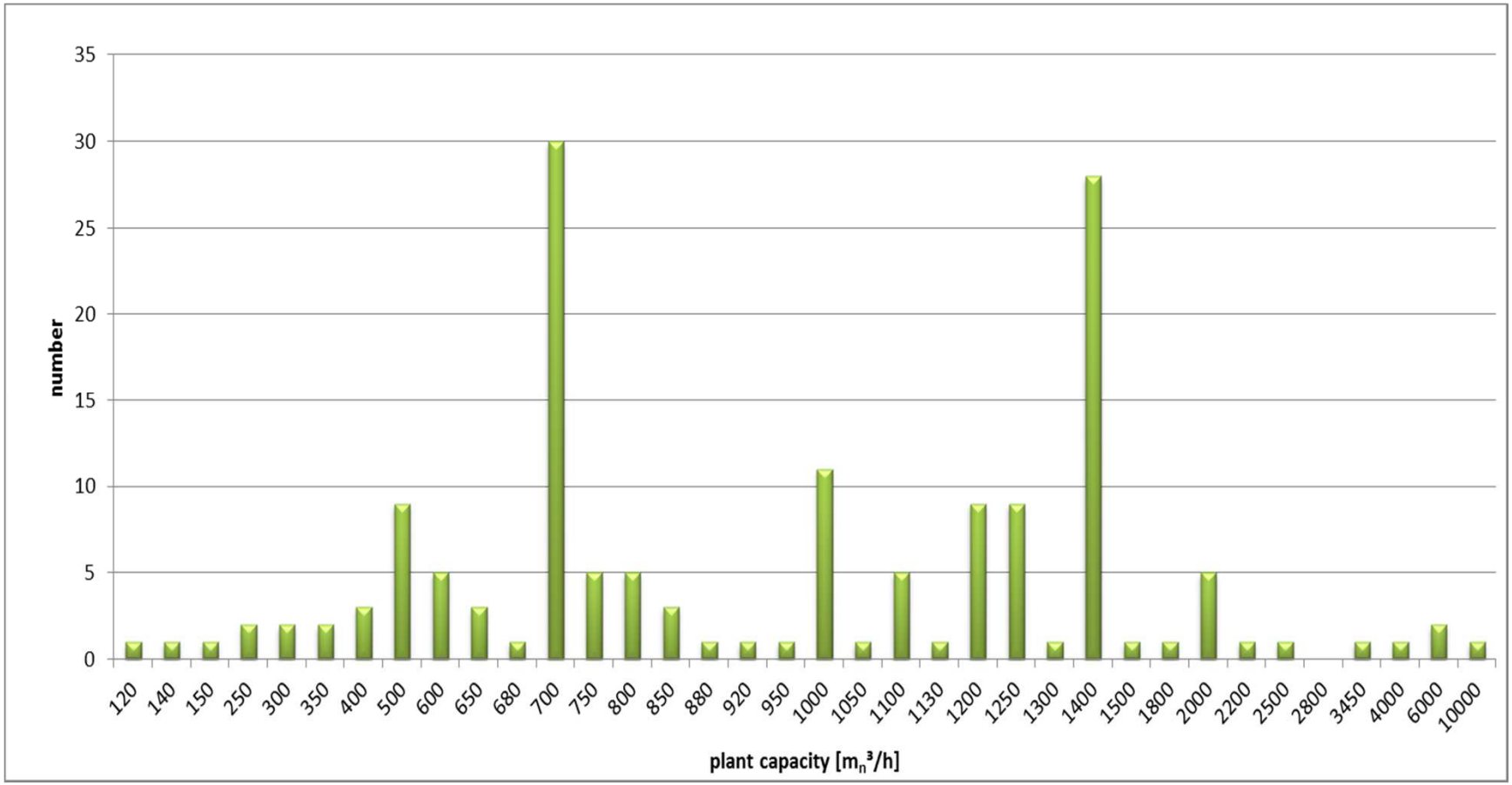
Biogas upgrading plants in Germany: Cumulative frequency of installed plant capacities



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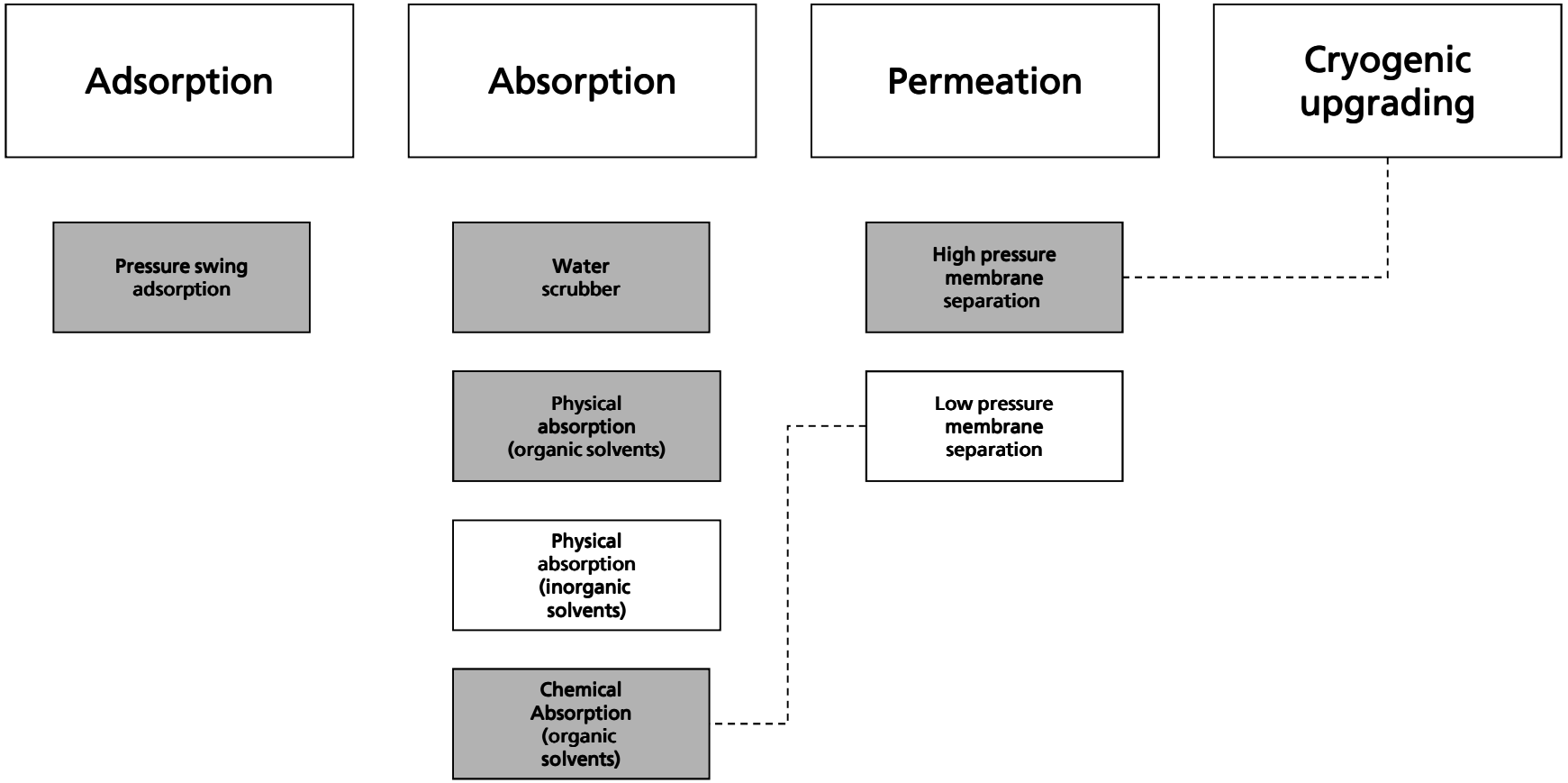
Biogas upgrading - Technology overview

5 methods state of the art



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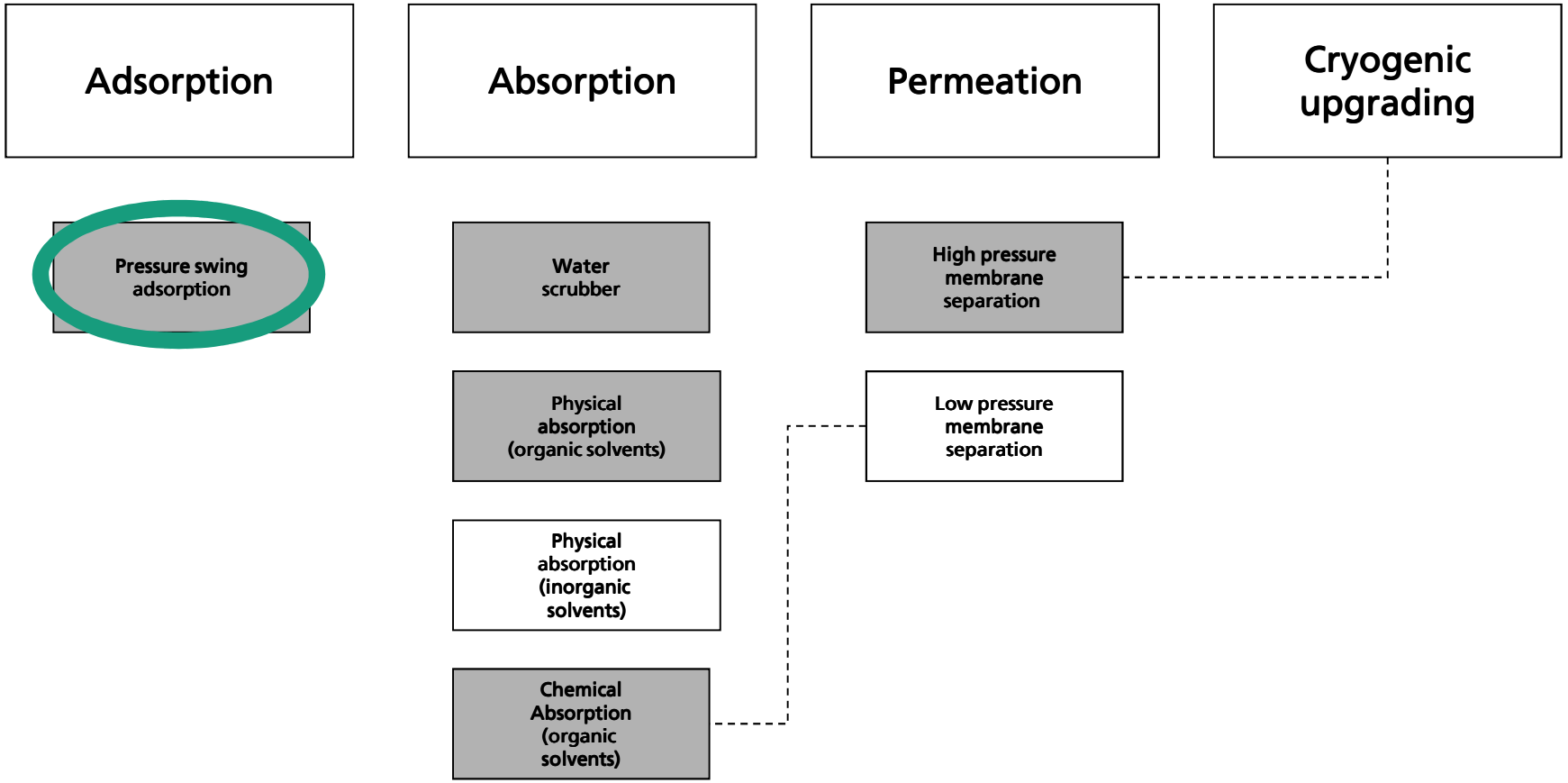
Biogas upgrading - Technology overview



Pressure Swing Adsorption (PSA)

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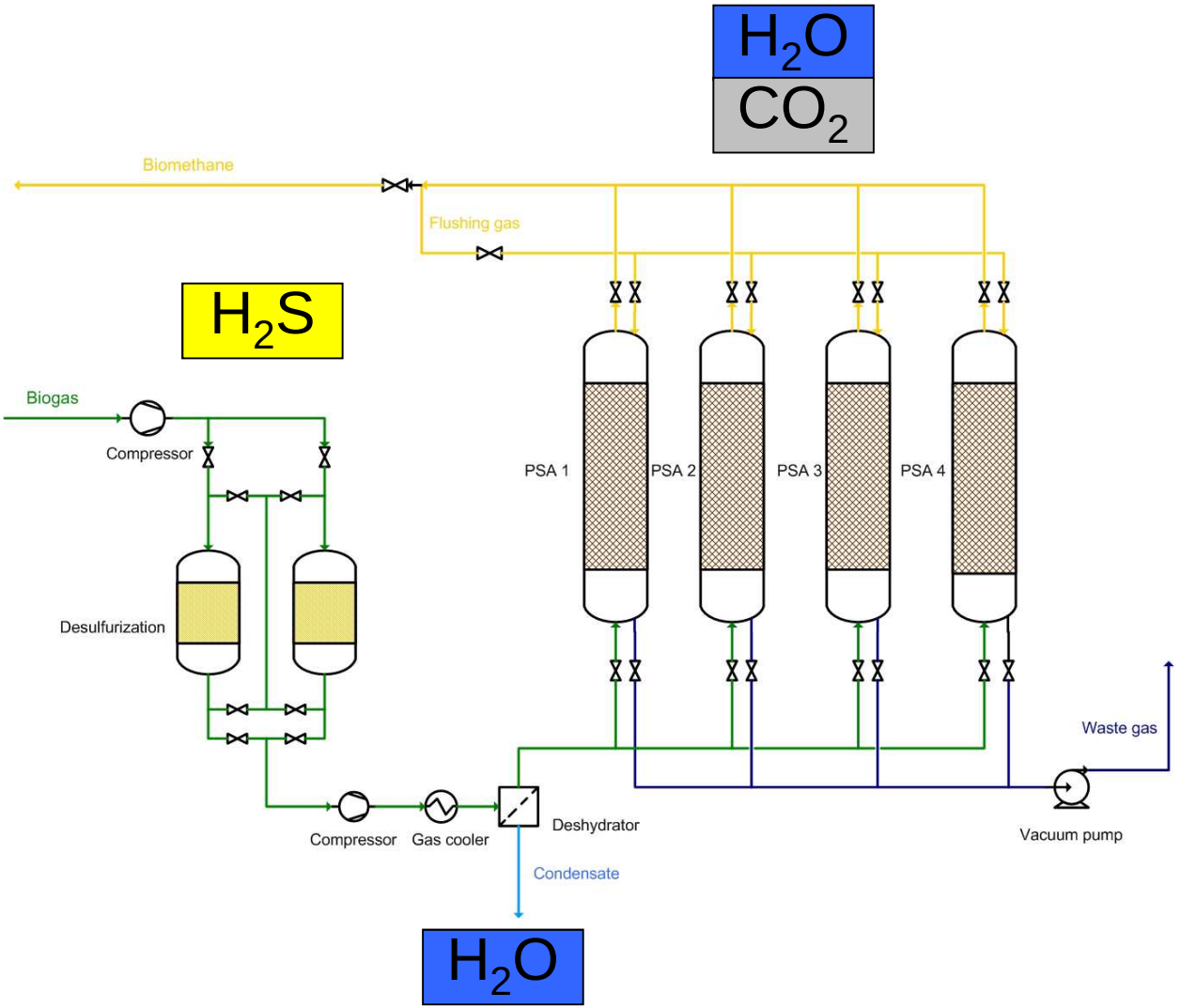
Pressure Swing Adsorption (PSA)



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Pressure Swing Adsorption (PSA)

	Electricity demand	Heat demand	Water demand	Demand on chemical substances	Operation pressure	Methane loss	Methane recovery rate	Off-gas treatment recom-mended	Precision desulphuri-zation required
	[kWh/$m_n^3{}_{BG}$]				[bar]	[%]	[%]		
ranges	0.16-0.35	0	No	No	1-10	1.5-10	90-98.5	Yes	Yes
typical values	0.2-0.25	0	No	No	4-7	1.5-2.5	97.5-98.5	Yes	Yes

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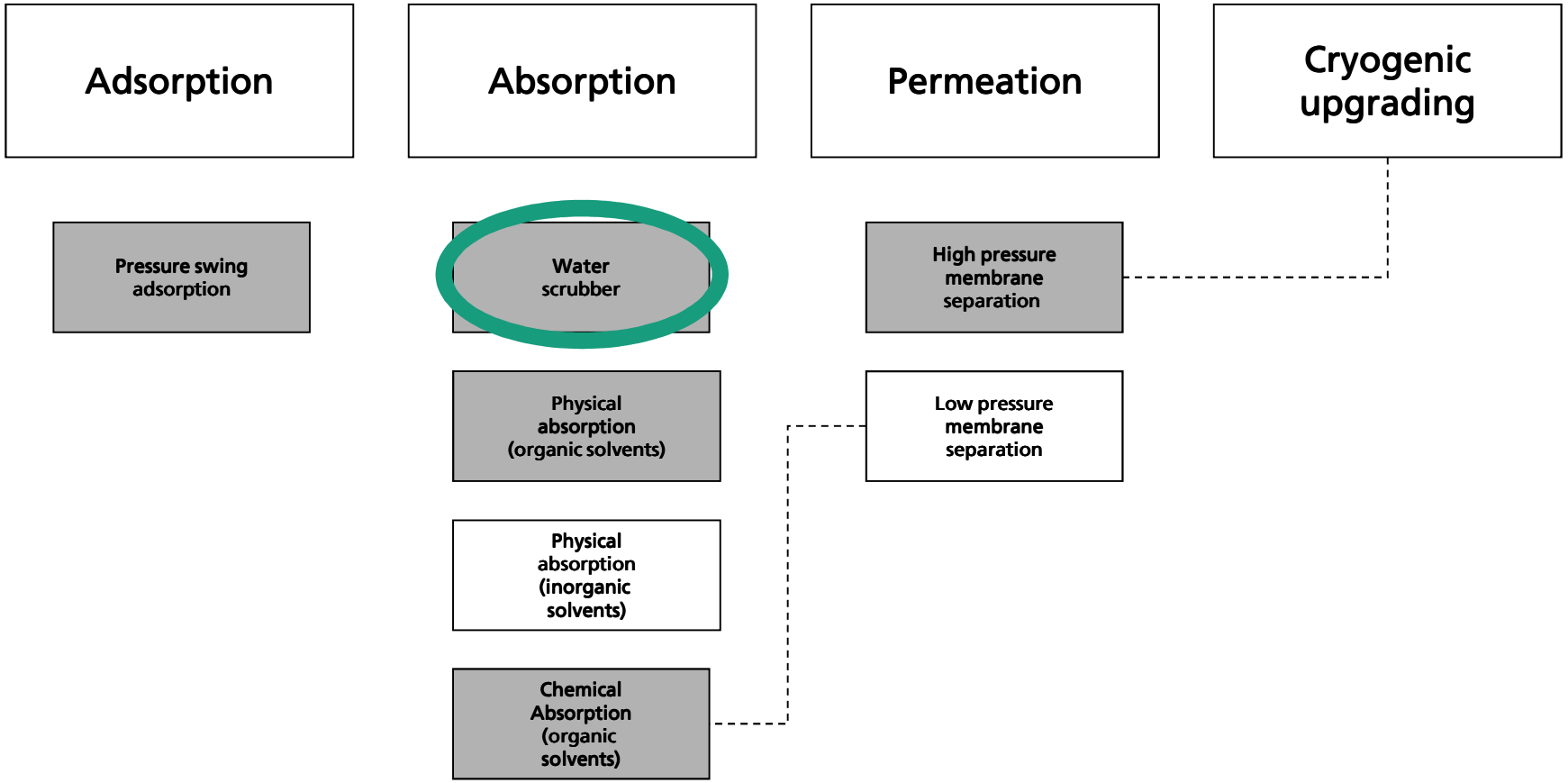
Water scrubber



Water scrubber

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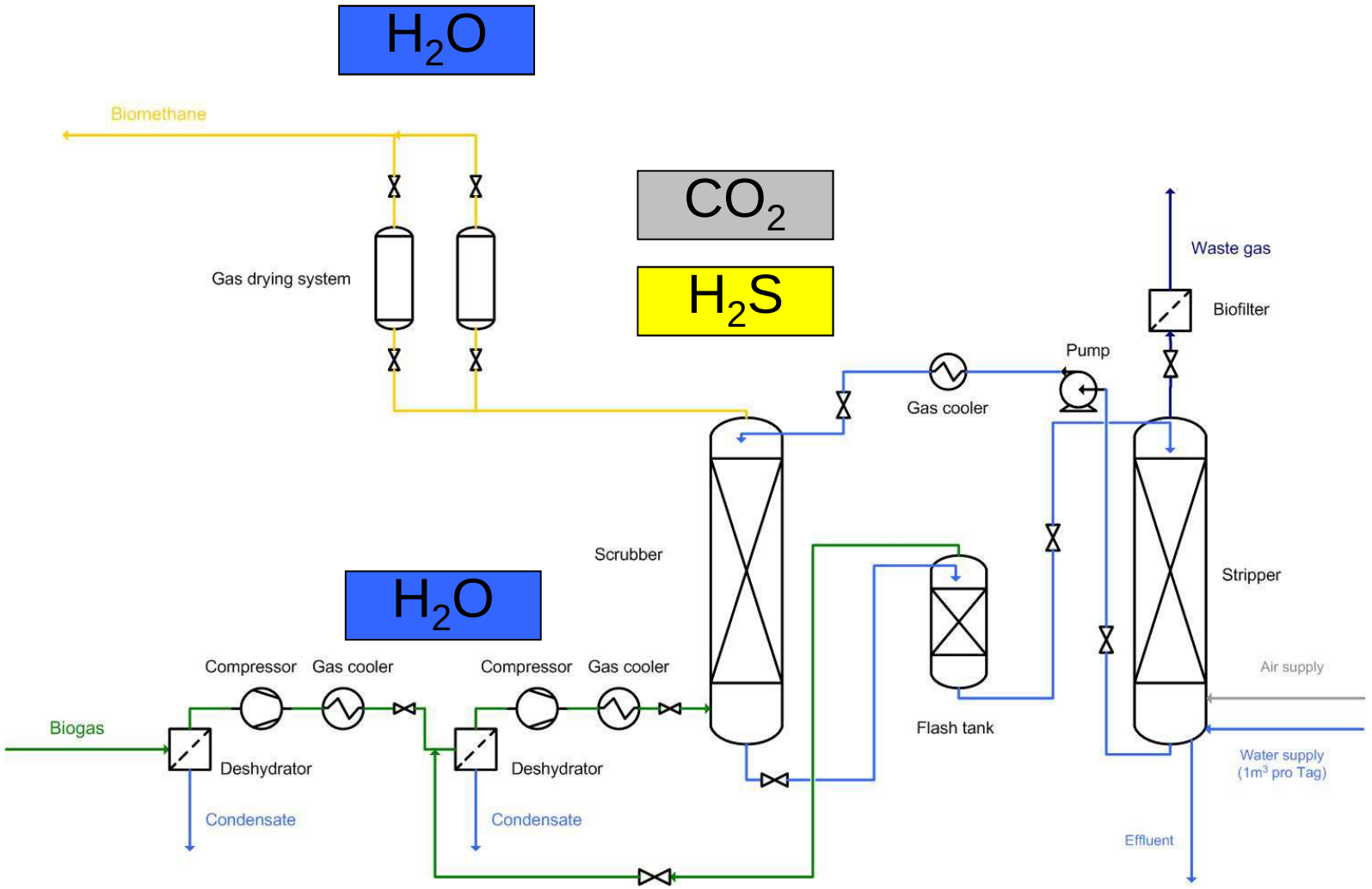
Water scrubber



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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/$m_n^3{}_{BG}$]				[bar]	[%]	[%]		
ranges	0.20 - 0.30	0	Yes	No	4-10	0.5 - 2	98-99.5	Yes	No
typical values	>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

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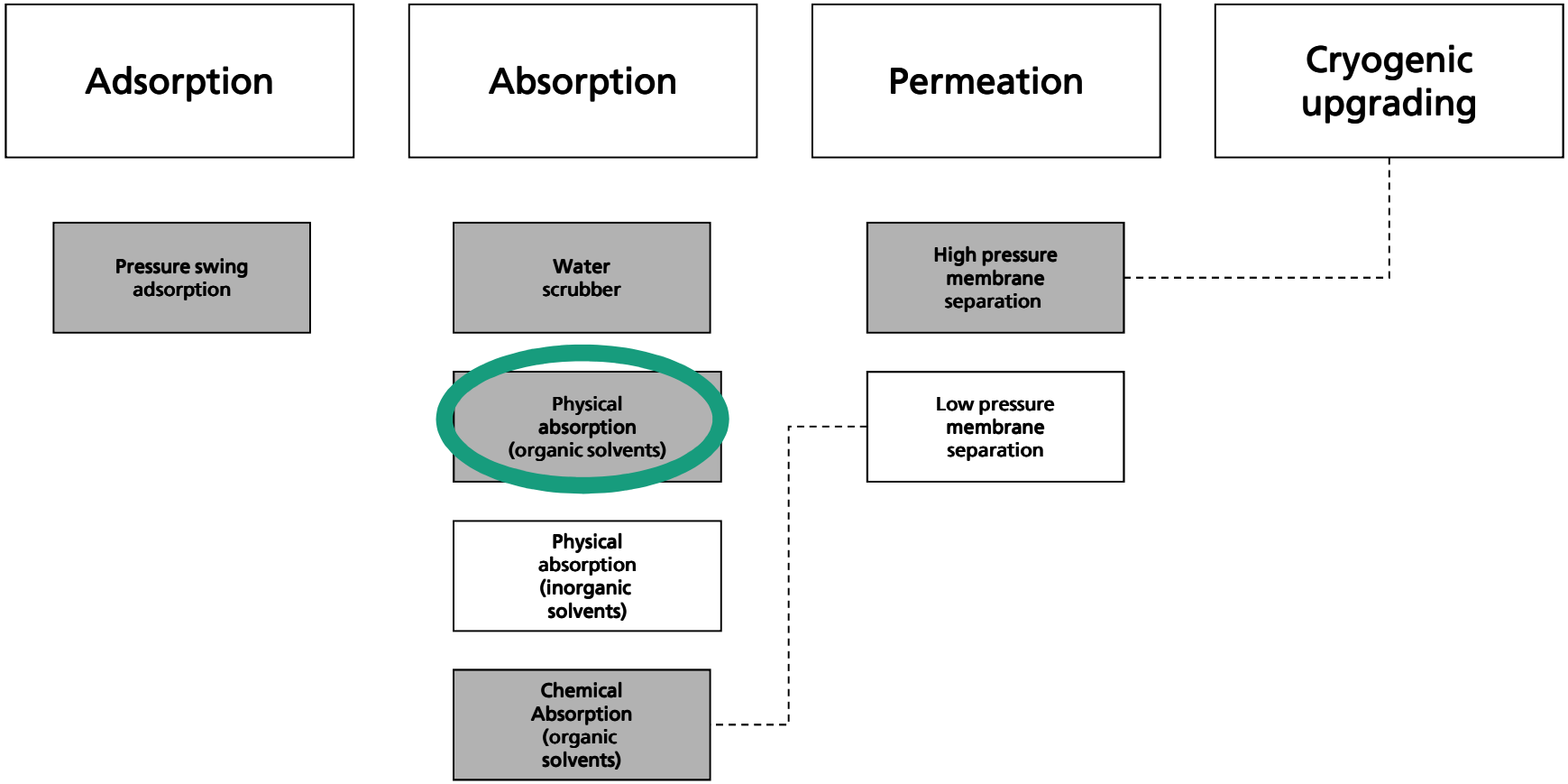
Biogas upgrading - Technology overview



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Physical Absorption (using organic solvents)

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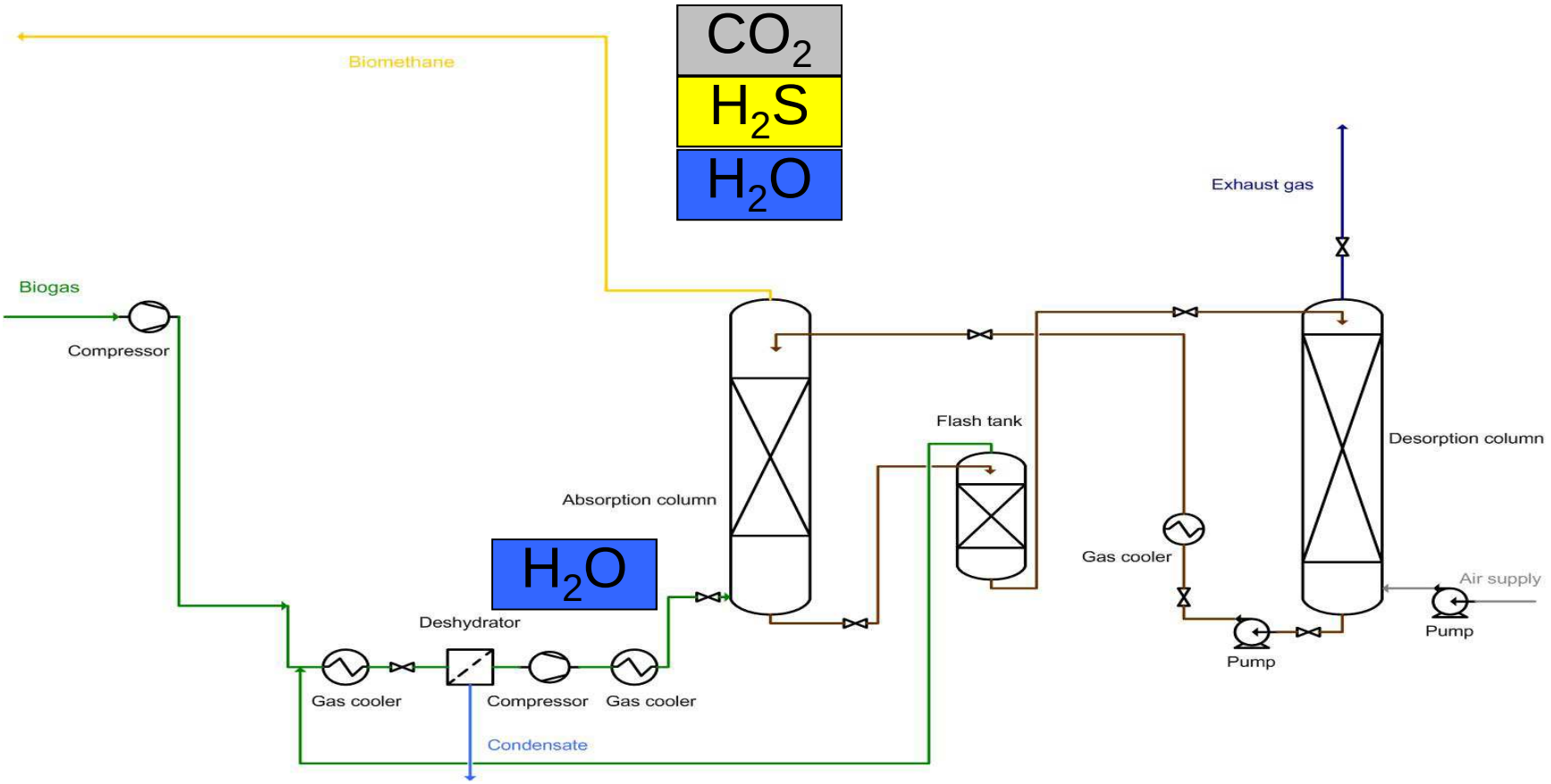

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Physical Absorption (using organic solvents)

	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/$m_n^3{}_{BG}$]		[°C]			[bar]	[%]	[%]		
ranges	0.23-0.33	0.10-0.15	40-80	No	Yes	4-8	1-4	96-99	Yes	No
typical values	0.23-0.27	0.10-0.15	40-50	No	Yes	6-7	~1.5	~98.5	Yes	No

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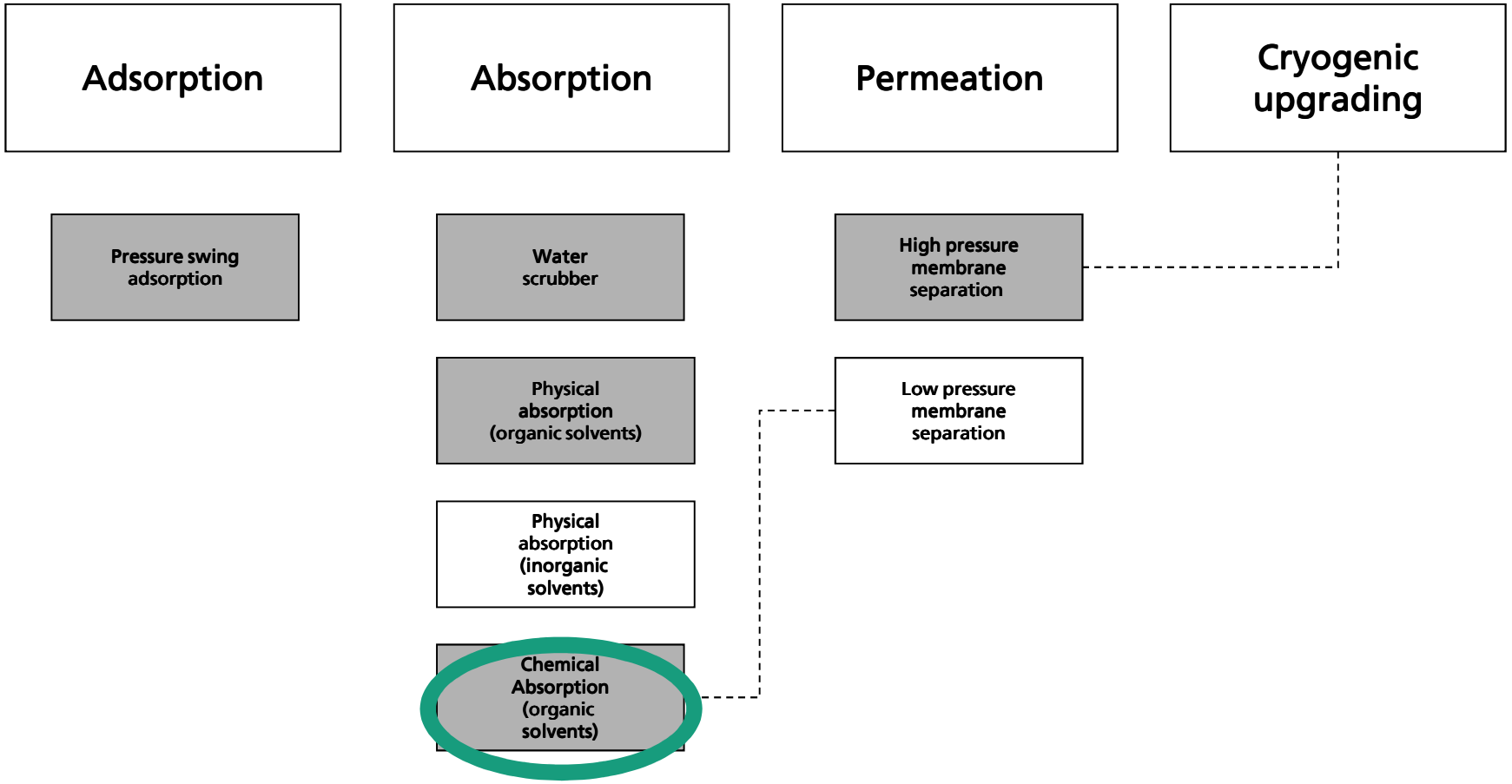
Chemical Absorption (using organic solvents)



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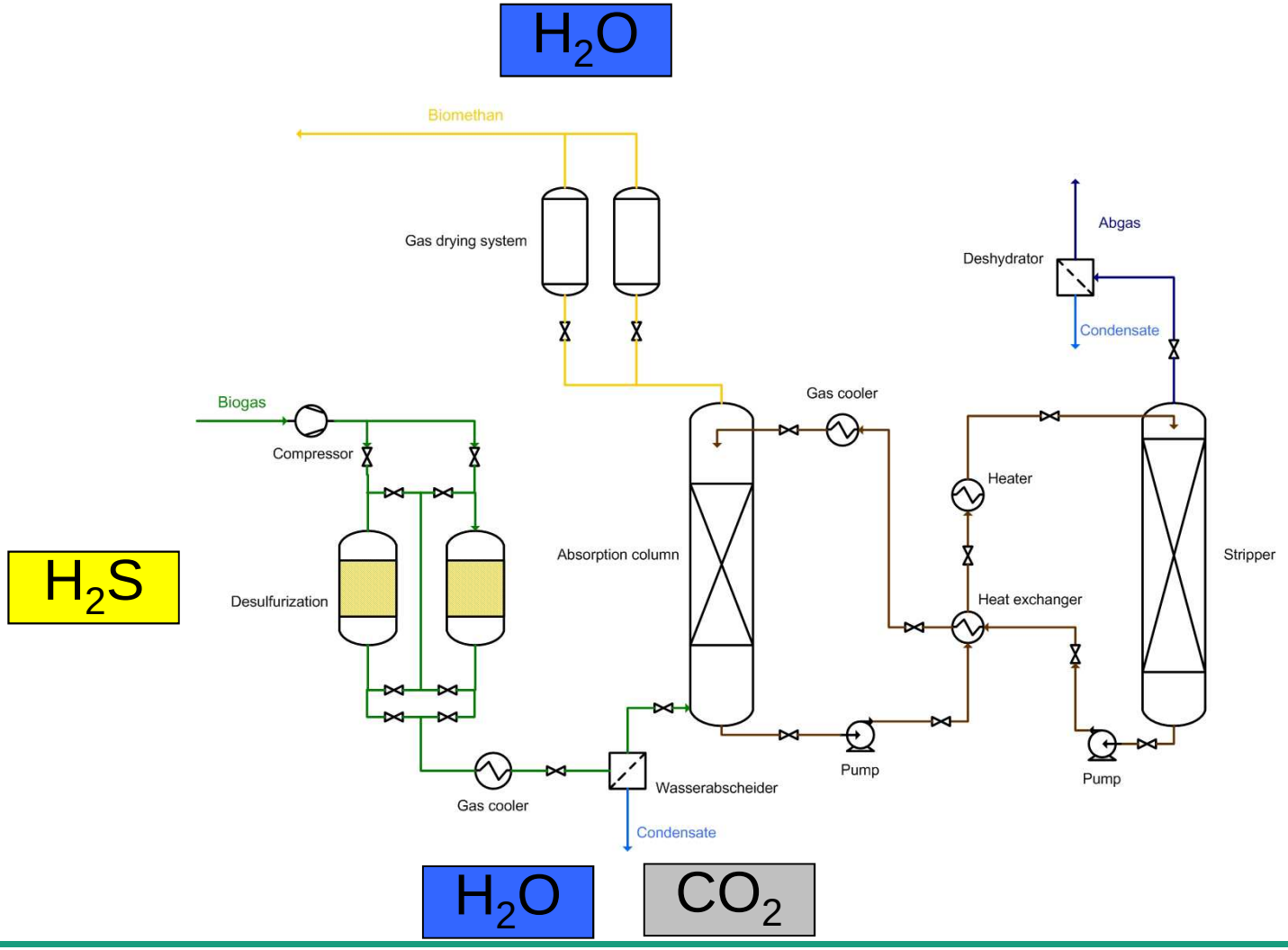

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Chemical Absorption (using organic solvents)

	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/$m_n^3{}_{BG}$]		[°C]			[bar]	[%]	[%]		
ranges	0.06-0.17	0.4-0.8	106 - 160	Yes	Yes	0.05 - 4	~0.1	~99.9	No	Yes (Depending on manufacturer)
typical values	0.09-0.11	~0.5-0,7	106 - 160	Yes	Yes	0.05 - 4	~0.1	~99.9	No	Yes (Depending on manufacturer)

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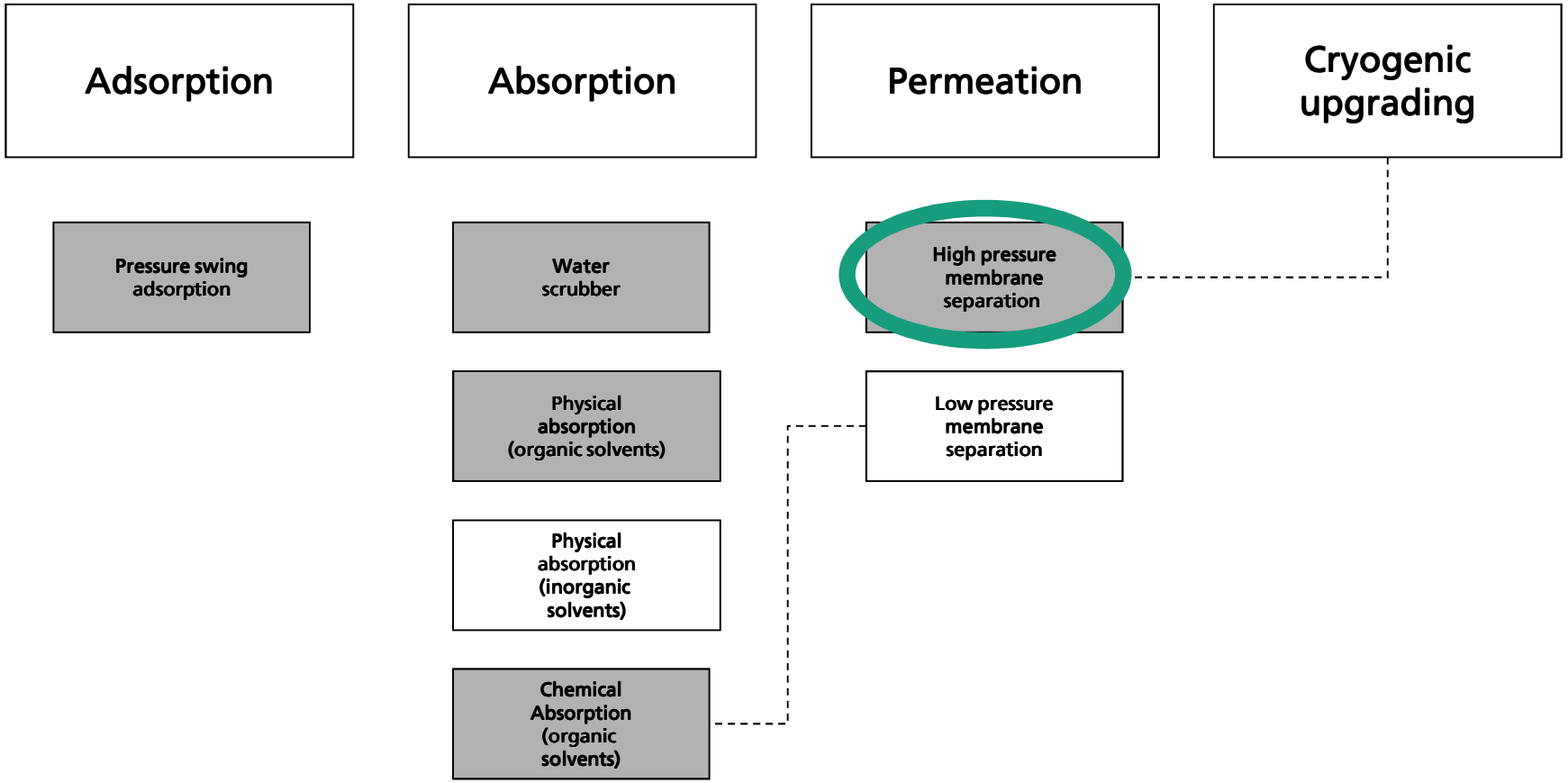
Membrane separation



High Pressure Membrane Separation

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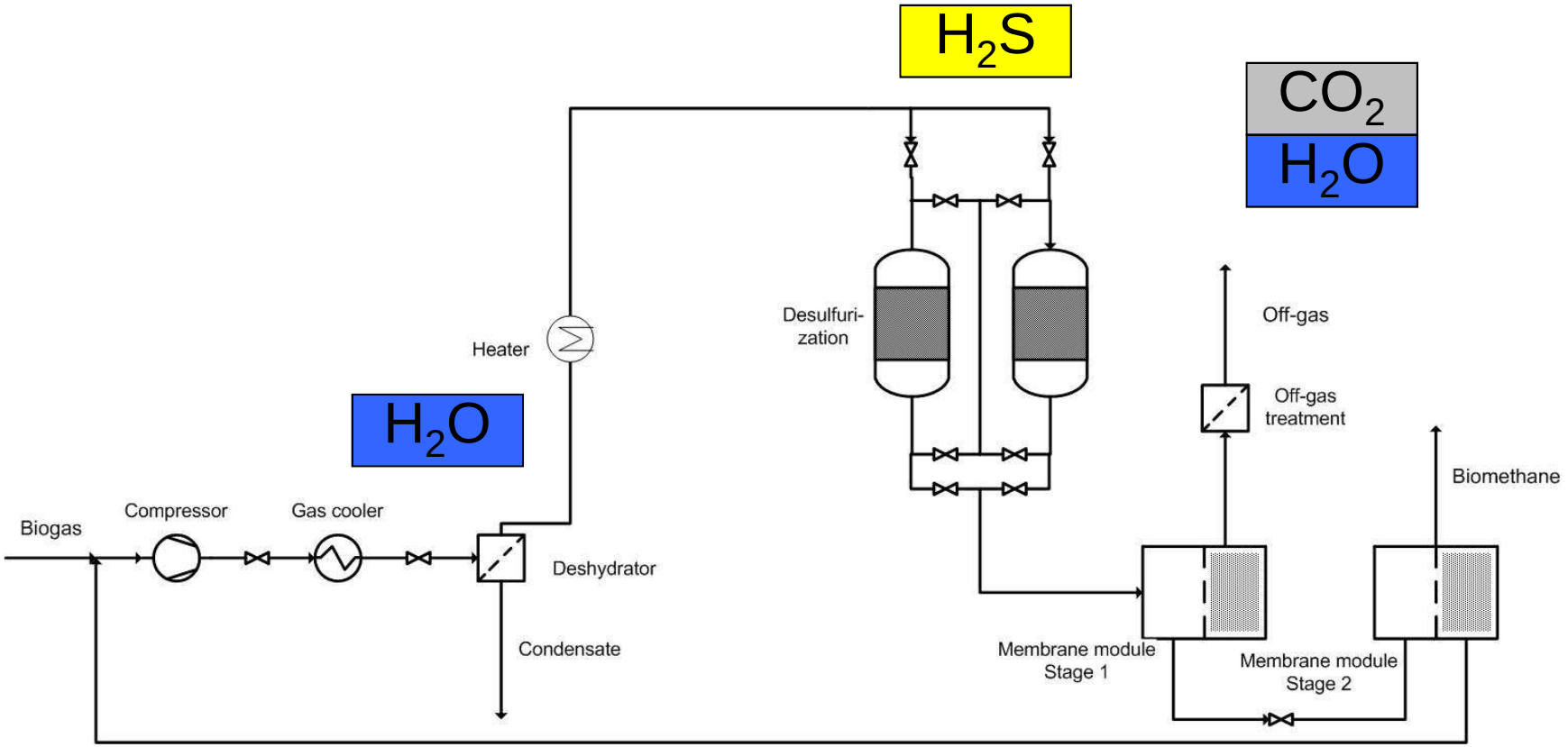
High Pressure Membrane Separation



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High Pressure Membrane Separation


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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 desulphuri-zation required
	[kWh/$m_n^3{}_{BG}$]	[kWh/$m_n^3{}_{BG}$]			[bar]	[%]	[%]		
ranges	0.18-0.35	0	No	No	7-20	1-15	85-99.5	Yes	Recommended
typical values	~ 0.22	0	No	No	7-20	0.5 - 2	98.0 - 99.5	(Yes)	Recommended

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Off-gas treatment

Degradation of CH_4 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)


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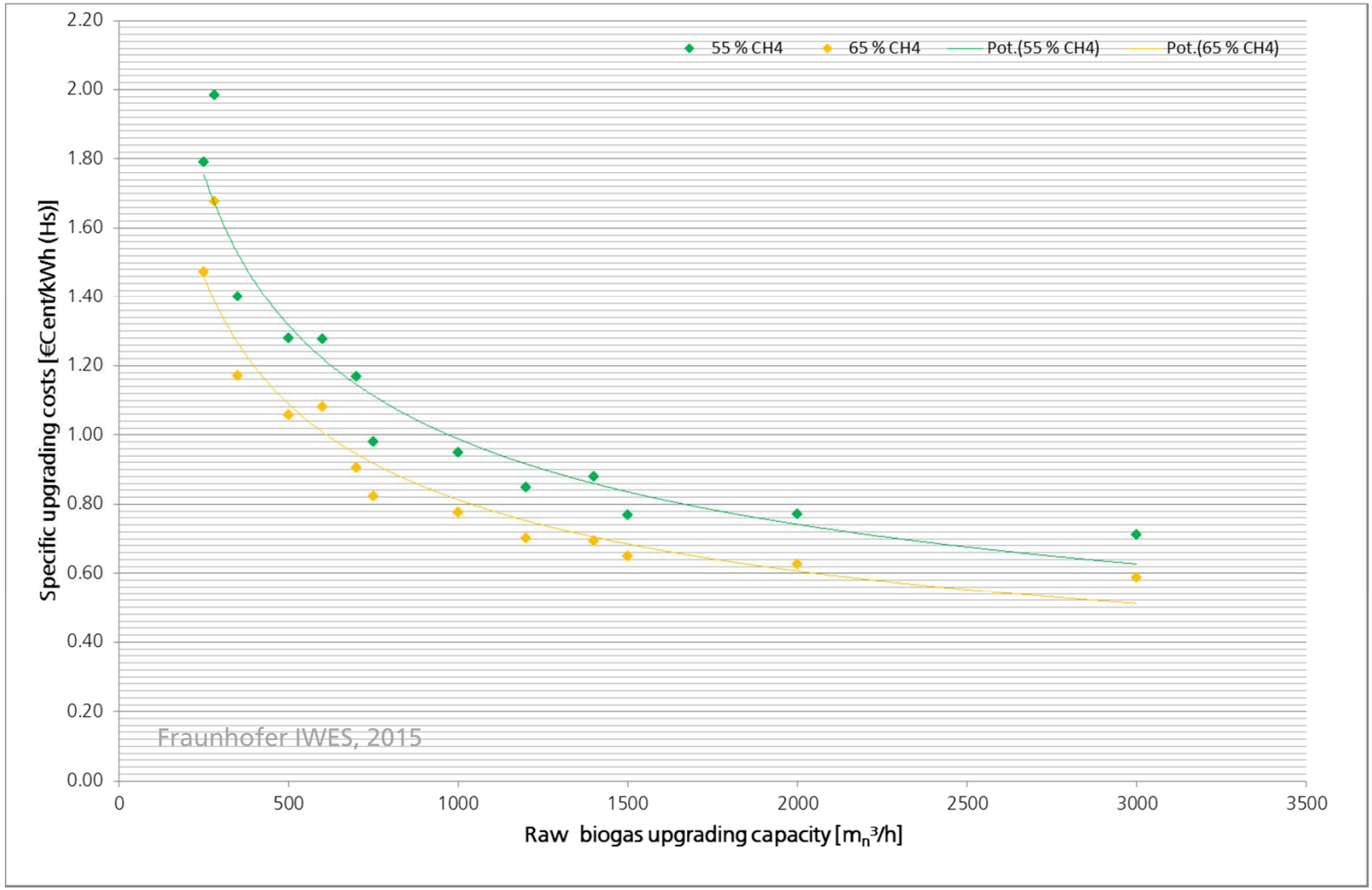
Specific biogas upgrading costs for Thailand
(related to 2015)



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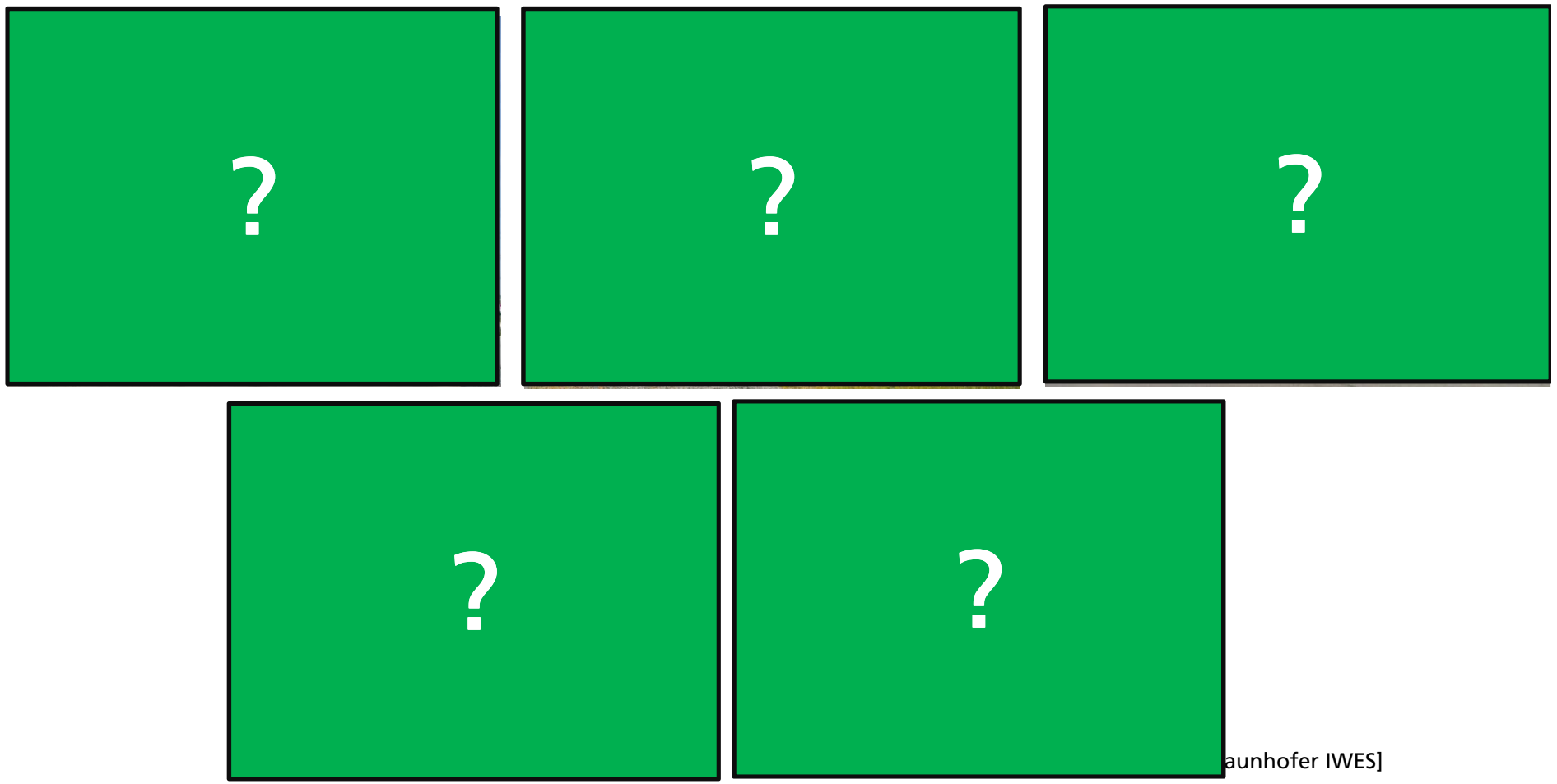
Specific upgrading costs – assumptions and framework conditions for calculation

- 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_{el}
- Personal costs for: included
- Precision desulfurization (if required): H_2S reduction by 100 ppm, 5 € per m_n^3 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?



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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 (CH_4, CO_2, N_2, O_2)
  - Raw gas composition trace compounds (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


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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**


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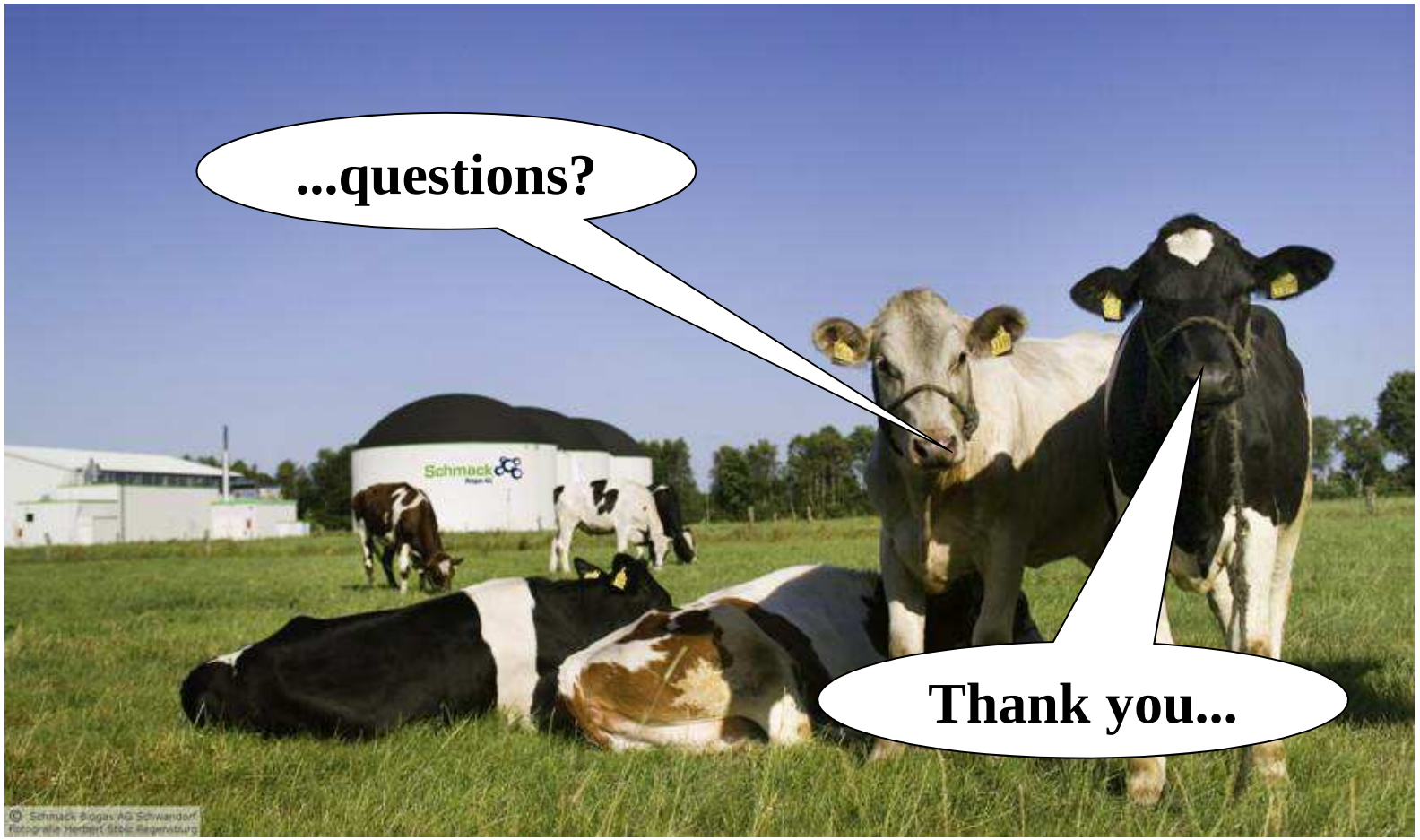

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