

BIOGAS AS VEHICLE FUEL

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BioMil AB

biogas, environment & recycling

BioMil AB

COMPANY PRESENTATION

Consultant company with engineering and environmental specialists

Unique expert knowledge in biogas systems

Office in **Lund**, Halmstad and Göteborg

Founded 1979 - over 30 years of experience

Over 200 references within the field of biogas

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biogas, environment & recycling



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SERVICES

- Studies and assessments
- Business & Project development
- Plant & Process design (detailed design)
- Procurement and Commissioning
- Operating support
- R&D with in-house laboratory
- Education
- LCA, Life Cycle Assessment
- EIA, Environmental Impact Assessment

EXAMPELS OF CLIENTS

- *Energy and waste management companies*
- *Municipalities*
- *Private companies*



Region Skåne

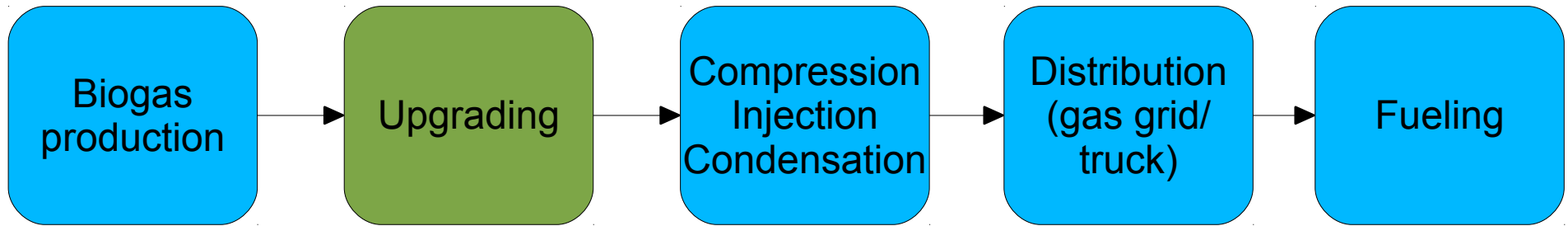


**FEDERATION OF
SWEDISH FARMERS**



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Biogas as vehicle fuel



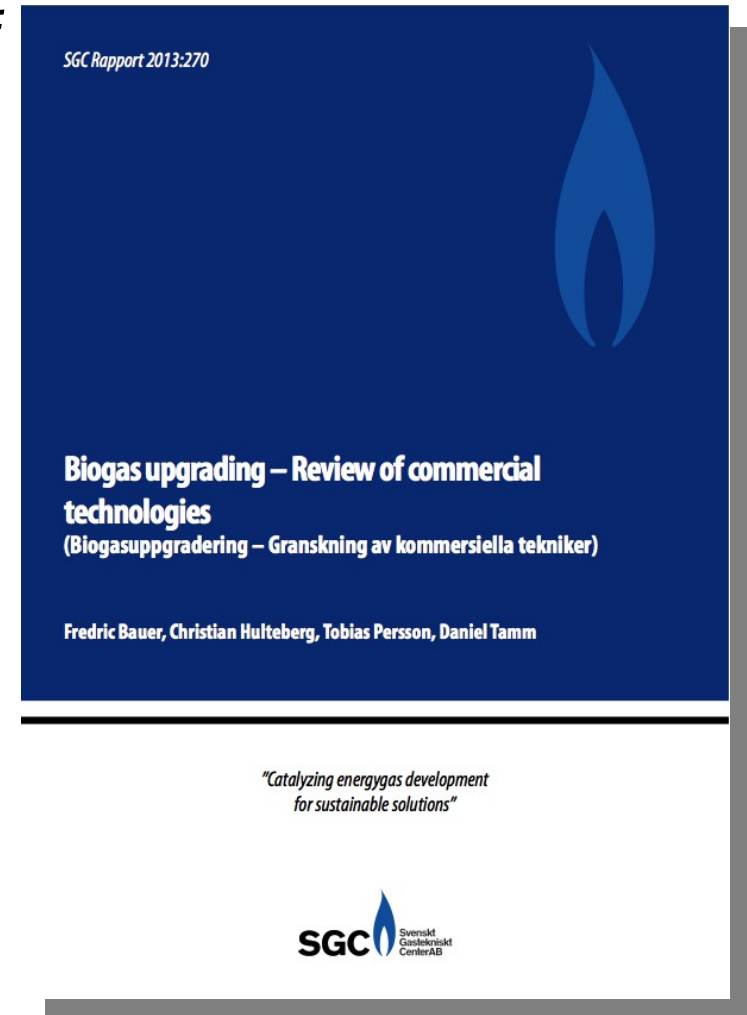
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NEW REPORT

- *Biogas upgrading – Review of commercial technologies*
- Published 2013 by Swedish Gas Technology Center



<http://www.sgc.se/ckfinder/userfiles/files/SGC270.pdf>



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Why biogas upgrading?

Biogas from anaerobic digestion:

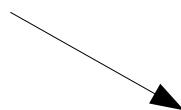
~63 % methane

~33 % carbon dioxide

~1 % nitrogen

~3 % water

hydrogen sulphide



-Vehicle fuel according to Swedish Standard SS 15 54 38:

95 - 99 % methane

< 5 % carbon dioxide, nitrogen, oxygen

< 1 % oxygen

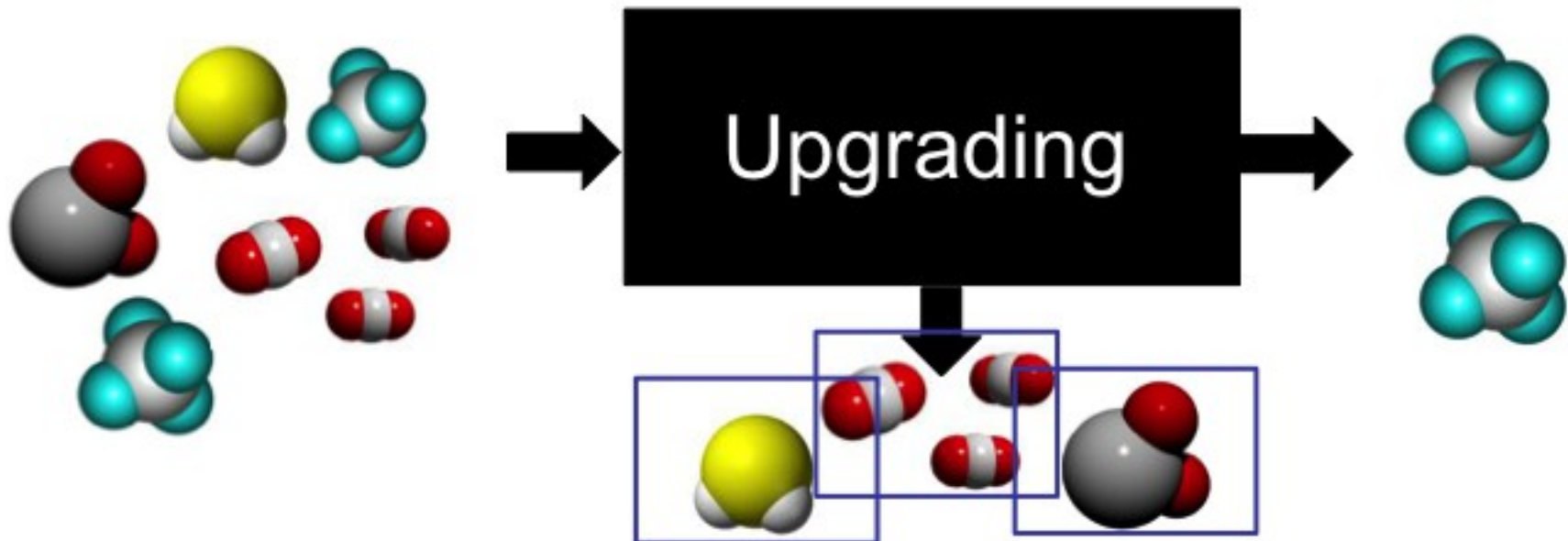
a low water content, dp -60°C

To achieve a heating value corresponding to the gas quality in the natural gas grid, propane addition may be necessary.

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Why biogas upgrading?

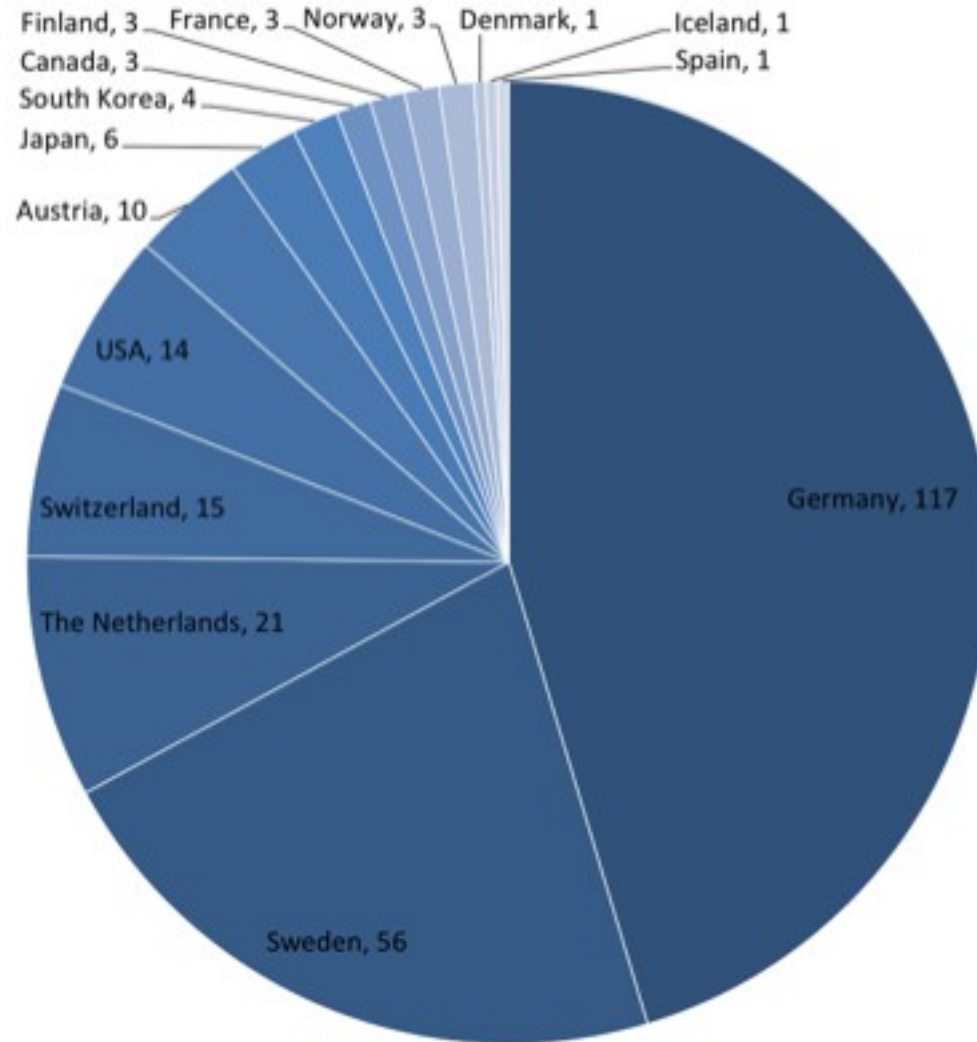
- To increase energy density
- To remove contaminants
- To avoid corrosion



Different technology

- **Water scrubber**
- **Chemical scrubber – Amine scrubber**
- **Organic physical scrubber**
- **Membrane**
- **Pressure Swing Absorption (PSA)**
- **Cryogenic technology**

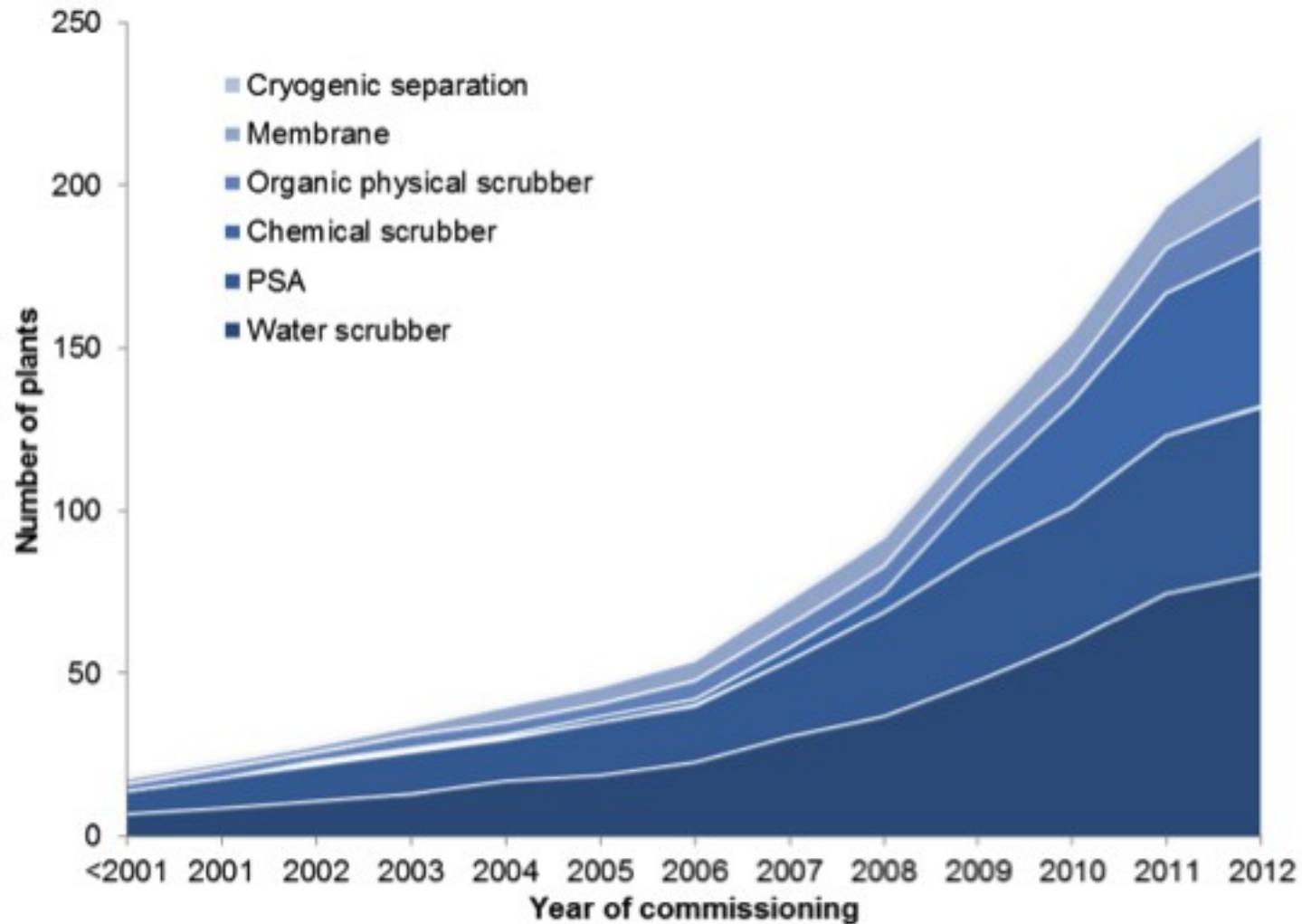
Biogas upgrading plants in operation



Source: IEA Bioenergy task 37

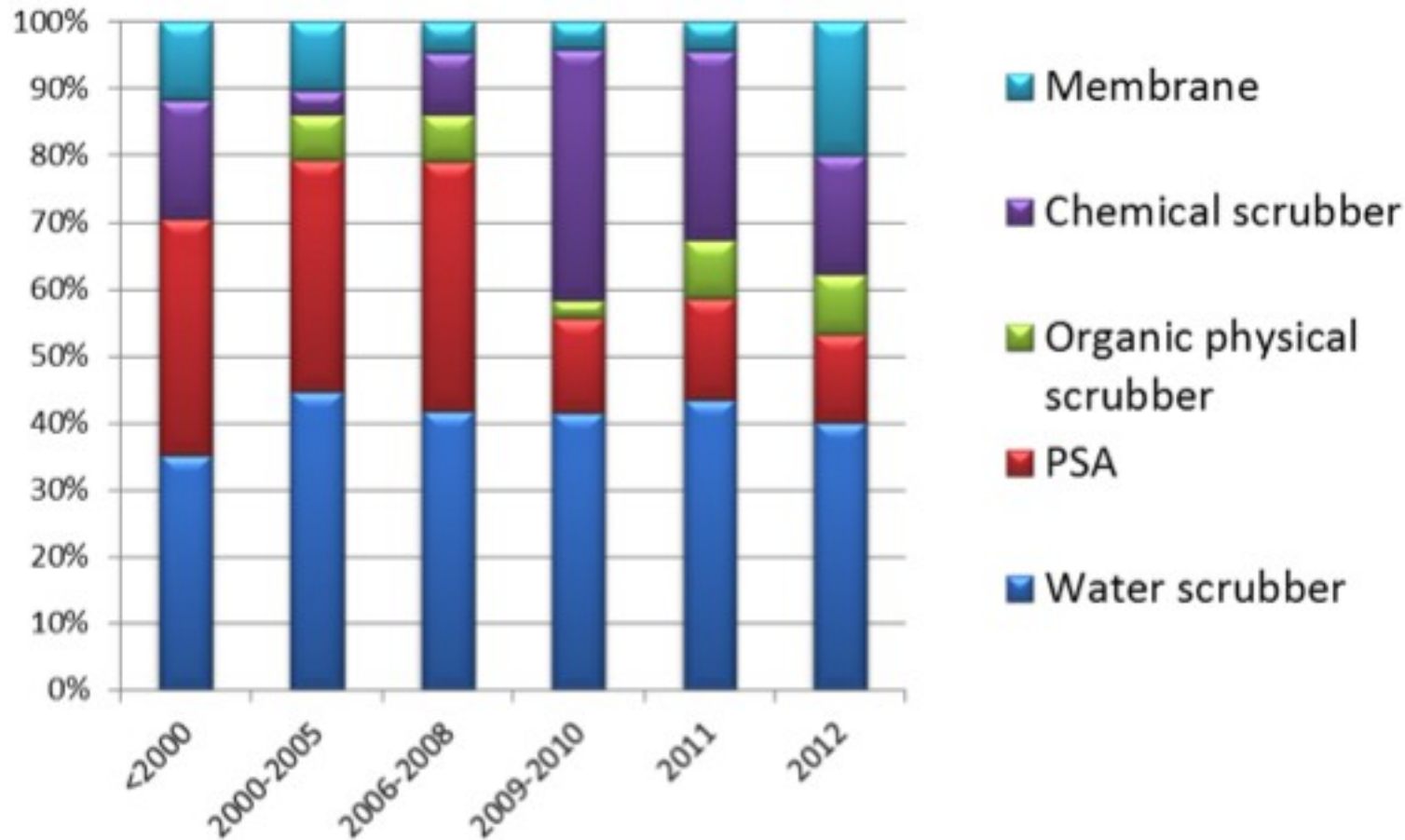
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Existing biogas upgrading units



Market development

Market development

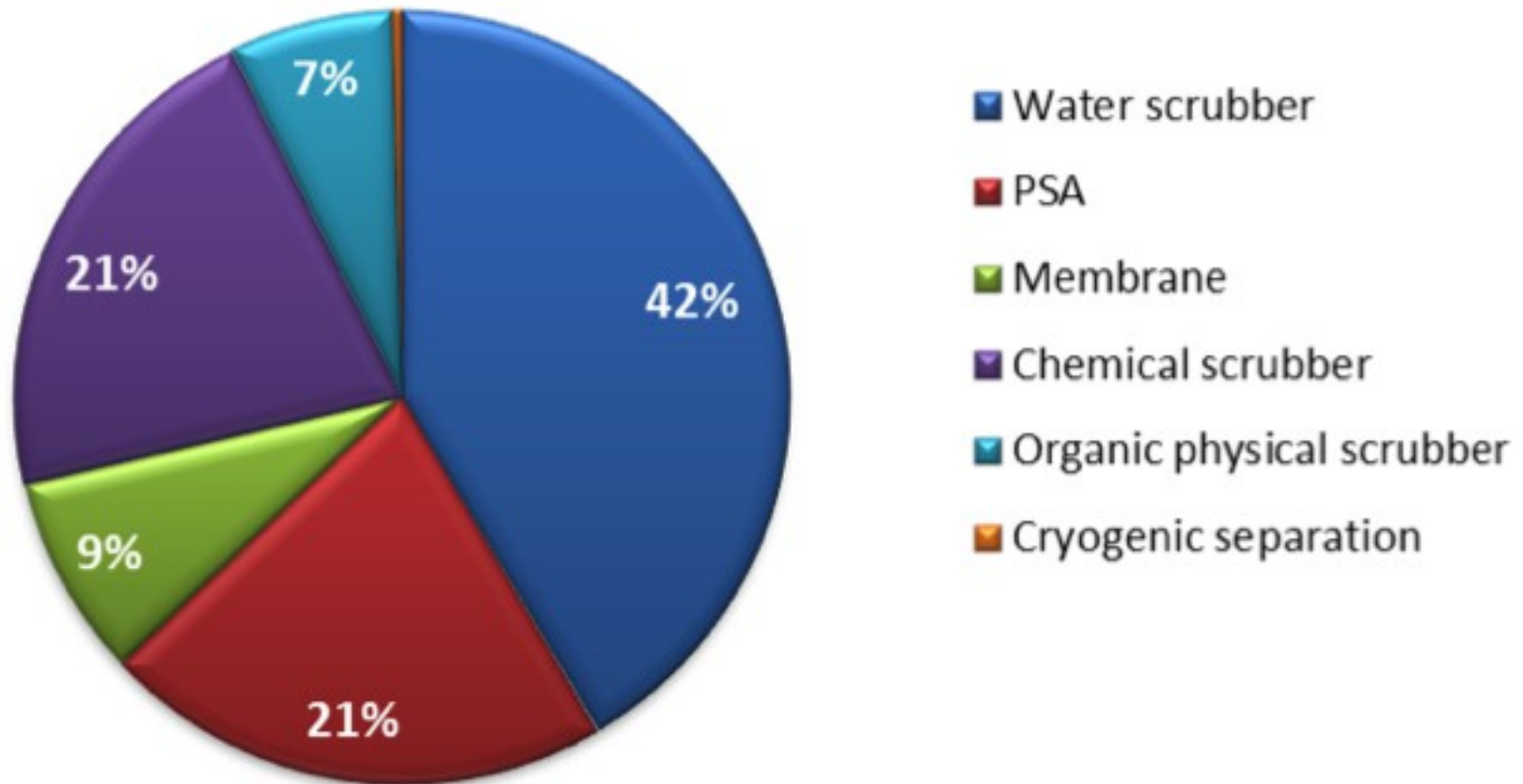


Source: IEA Bioenergy task 37

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Market share today

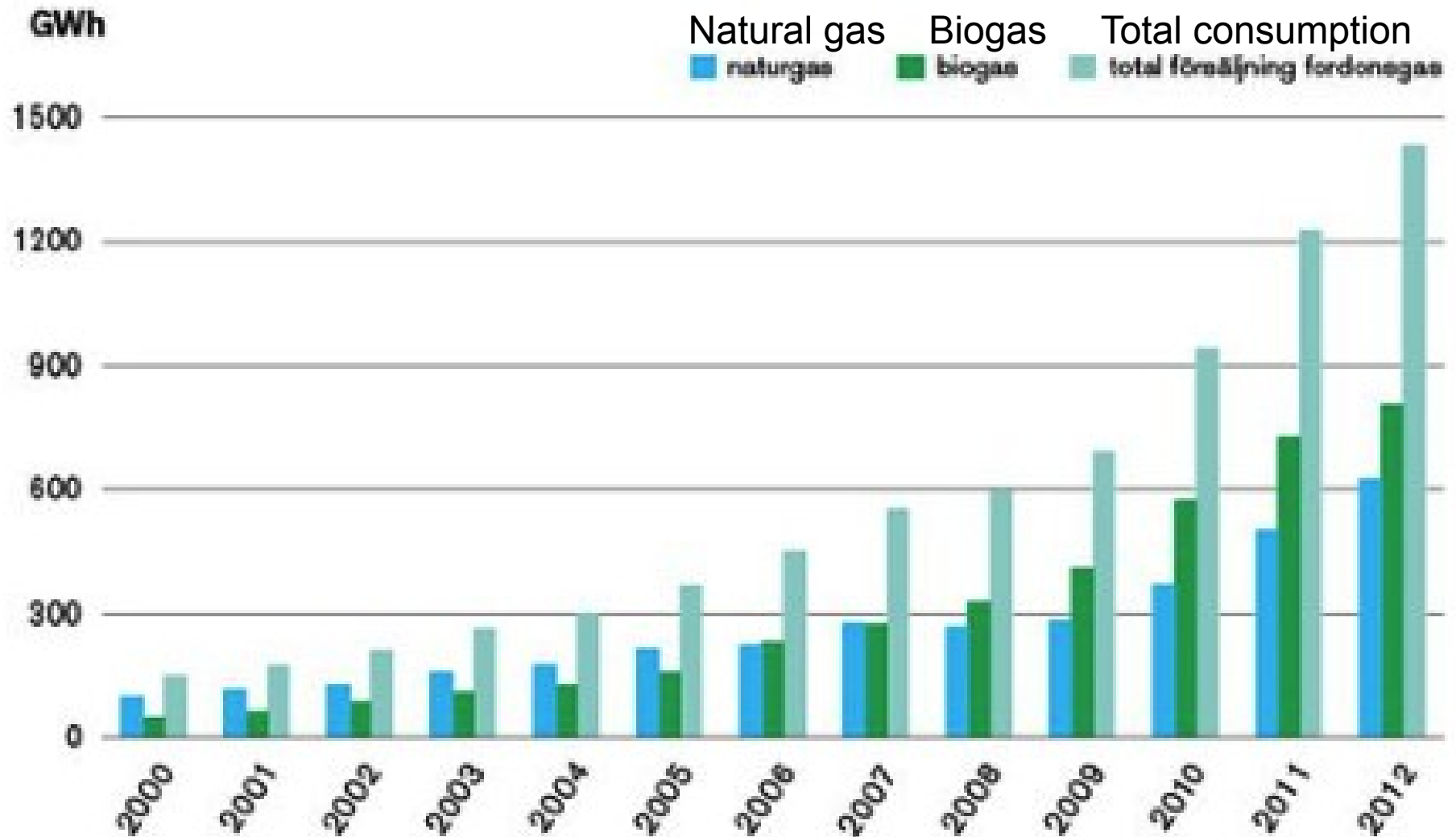
Market share today



Source: IEA Bioenergy task 37

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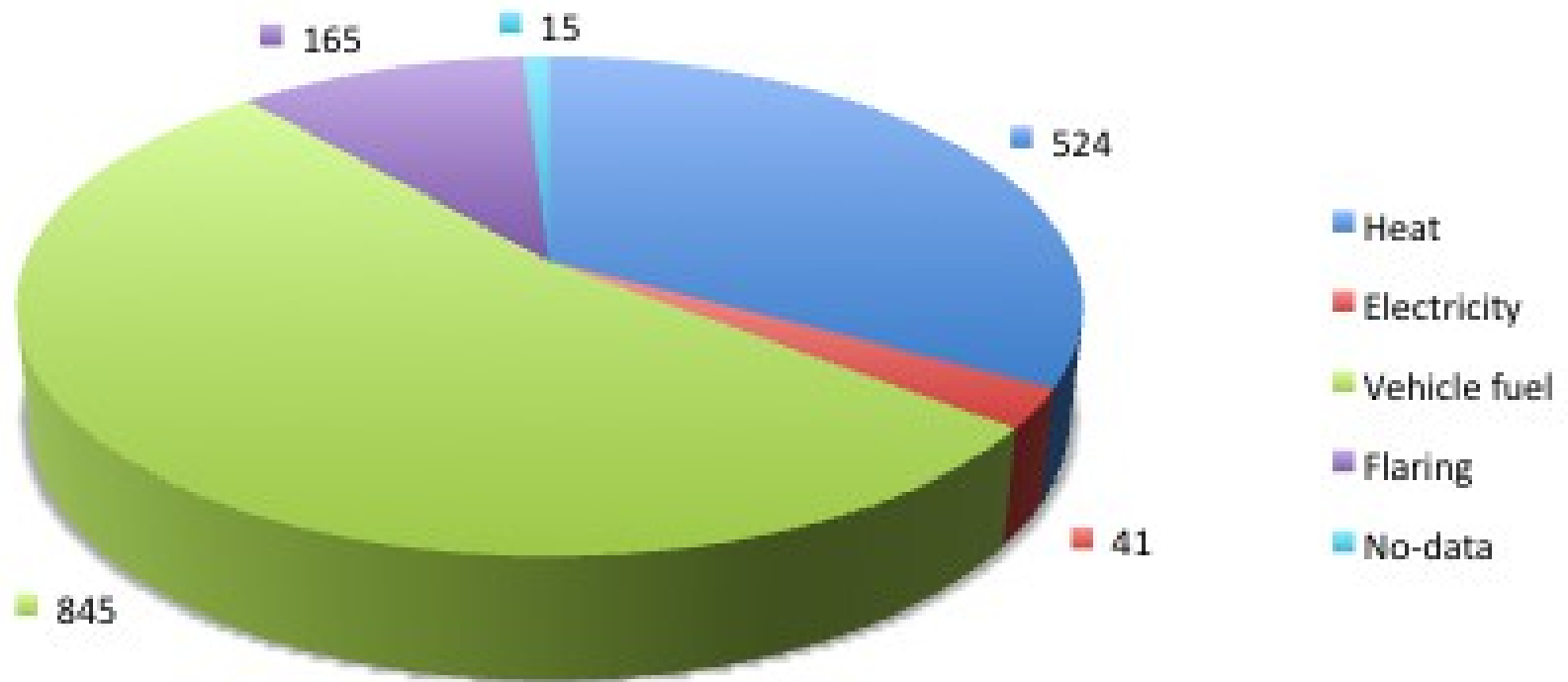
Biogas as vehicle fuel in Sweden



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Biogas as vehicle fuel in Sweden

Utilization of biogas in Sweden 2013 (GWh)



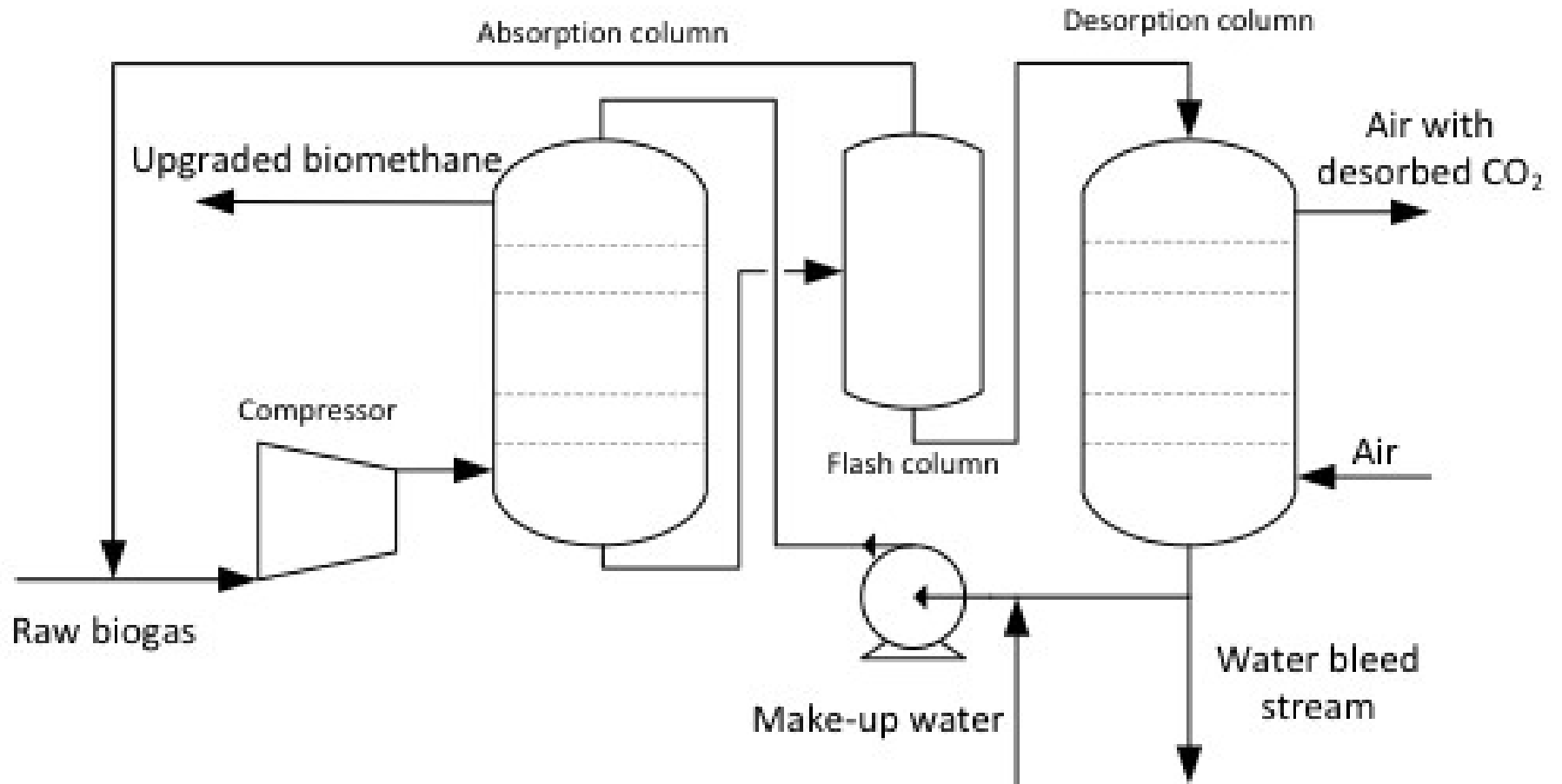
Biogas as vehicle fuel in Sweden

- ~50 000 vehicles runs on biogas
- ~200 fueling stations
- 53 upgrading plants
 - 37 Water scrubbers
 - 9 Amine scrubbers
 - 7 PSA
- 11 sites where biogas is injected to the gas grid

Different technology

- **Water scrubber**
- **Chemical scrubber – Amine scrubber**
- **Organic physical scrubber**
- **Membrane**
- **Pressure Swing Absorption (PSA)**
- **Cryogenic technology**

Water scrubber



Water scrubber

Henry's law

$$C_A (M) = K_H (M/atm) * p_A (atm)$$

K_H 26 times larger for CO_2 (compared to CH_4)

Water flow

Water flow = amount of CO_2 / solubility of CO_2

$$\frac{\% CO_2 * \text{biogas flow (Nm}^3\text{/h)}}{\% CO_2 * \text{absolute pressure} * K_H}$$

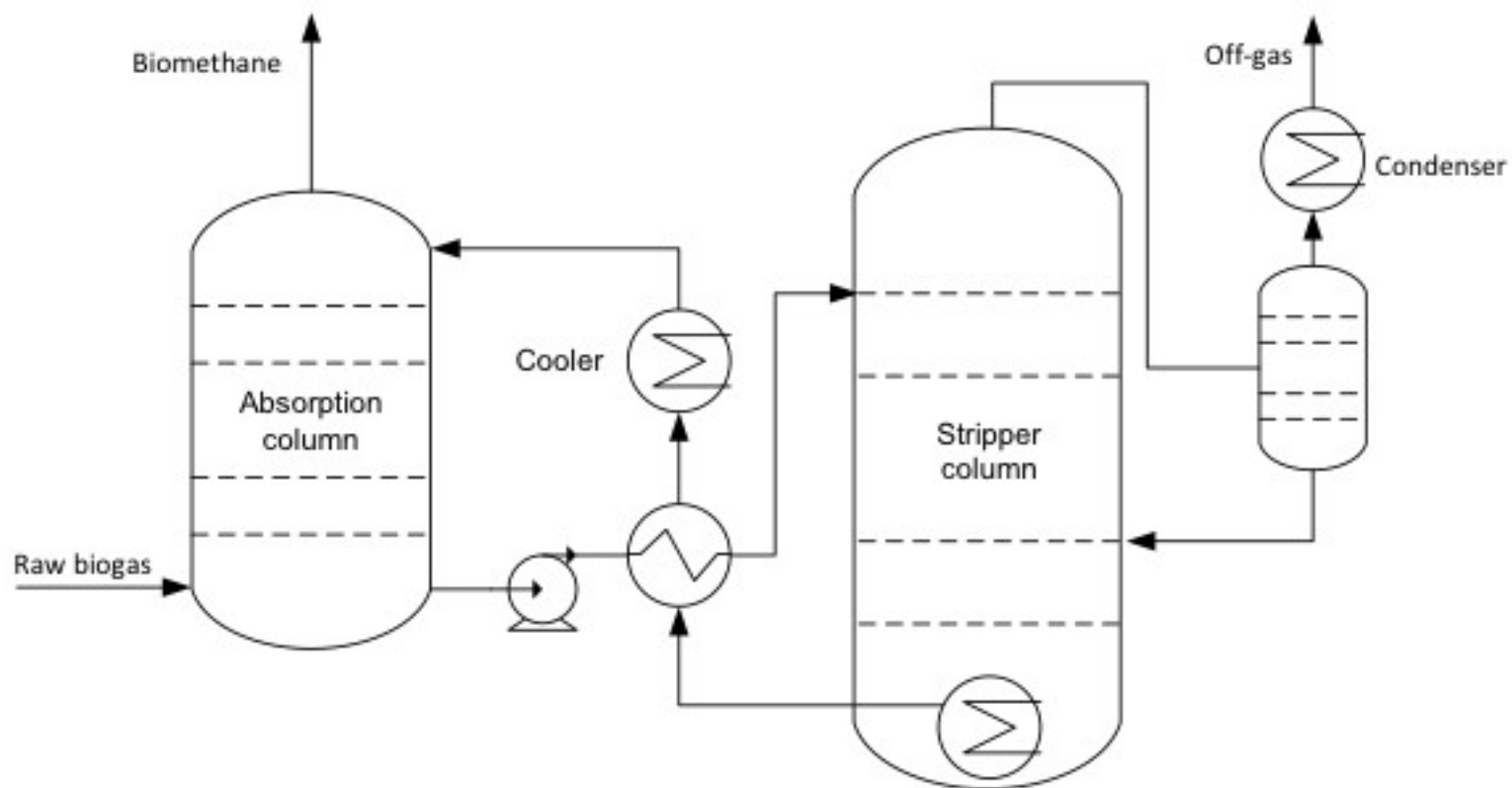
*Water flow independent of
% CO_2 in the raw biogas*

Solubility in water is higher for carbon dioxide than for methane

Water scrubber

- Service – 2-3% of the investment
- Energy consumption 0,20-0,30 kWh/Nm³ raw gas (pressure, size, climate)
- H₂S – separated in the scrubber (<300-2500 ppm)
- Availability - 95-97%
- Mature technology (depending on the manufacturer)
- Methane slip 1%, RTO is needed sometimes (1,5 – 2,5 MSEK)

Amin scrubber



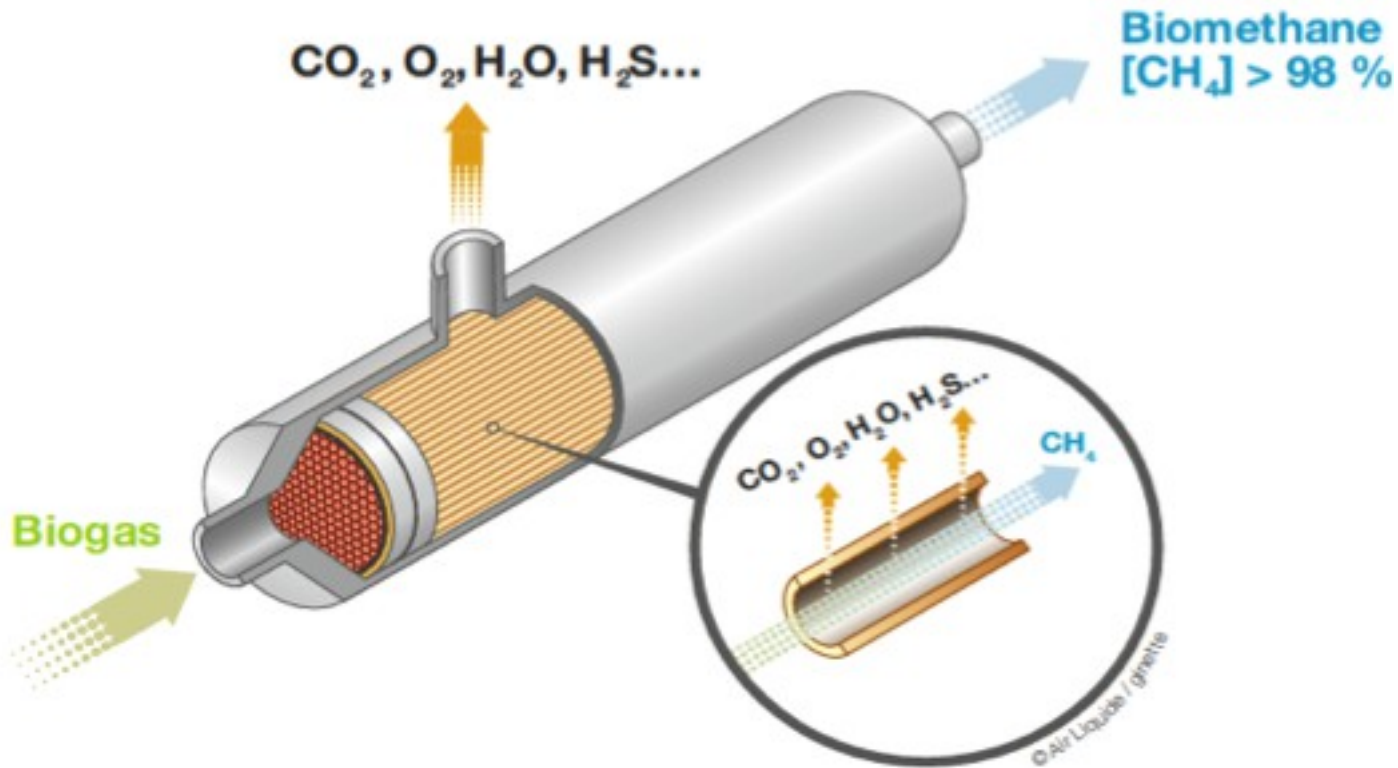
Amin scrubber

- Heat added to produce steam and to reverse the absorption reaction
- Steam lowers the partial pressure of CO₂ which drives the reaction
- Normally operated at 120-140°C (1,5-3 bar(a))
- Option to use low pressure desorption (90°C +0,05 kWh_{el}/Nm³) with DH as heat source

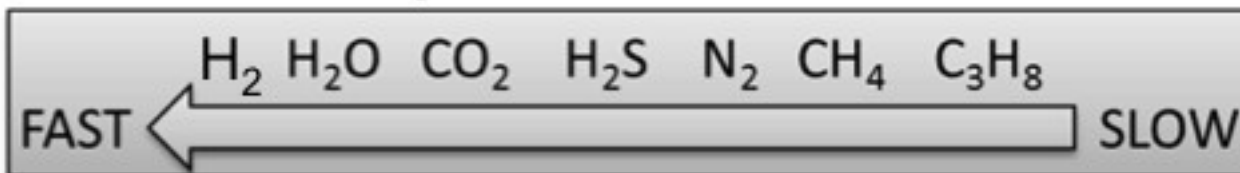
Amin scrubber

- Maintenance costs – 2-3% of investment
- Energy demand – $0,12-0,14 \text{ kWh}_{el}/\text{Nm}^3 + 0,55 \text{ kWh}_{heat}/\text{Nm}^3$ (low dependency on methane content)
- H_2S commonly separated prior to scrubbing, could be included with extra heat addition (10 %)
- Availability - about 96%
- Methane slip ca 0,1%
- Can deliver 98% methane
- Oxygen in raw biogas reacts irreversibly with amine

Membrane



Relative permeation rate



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Membrane on the market today

Evonik Industries



Air Liquide

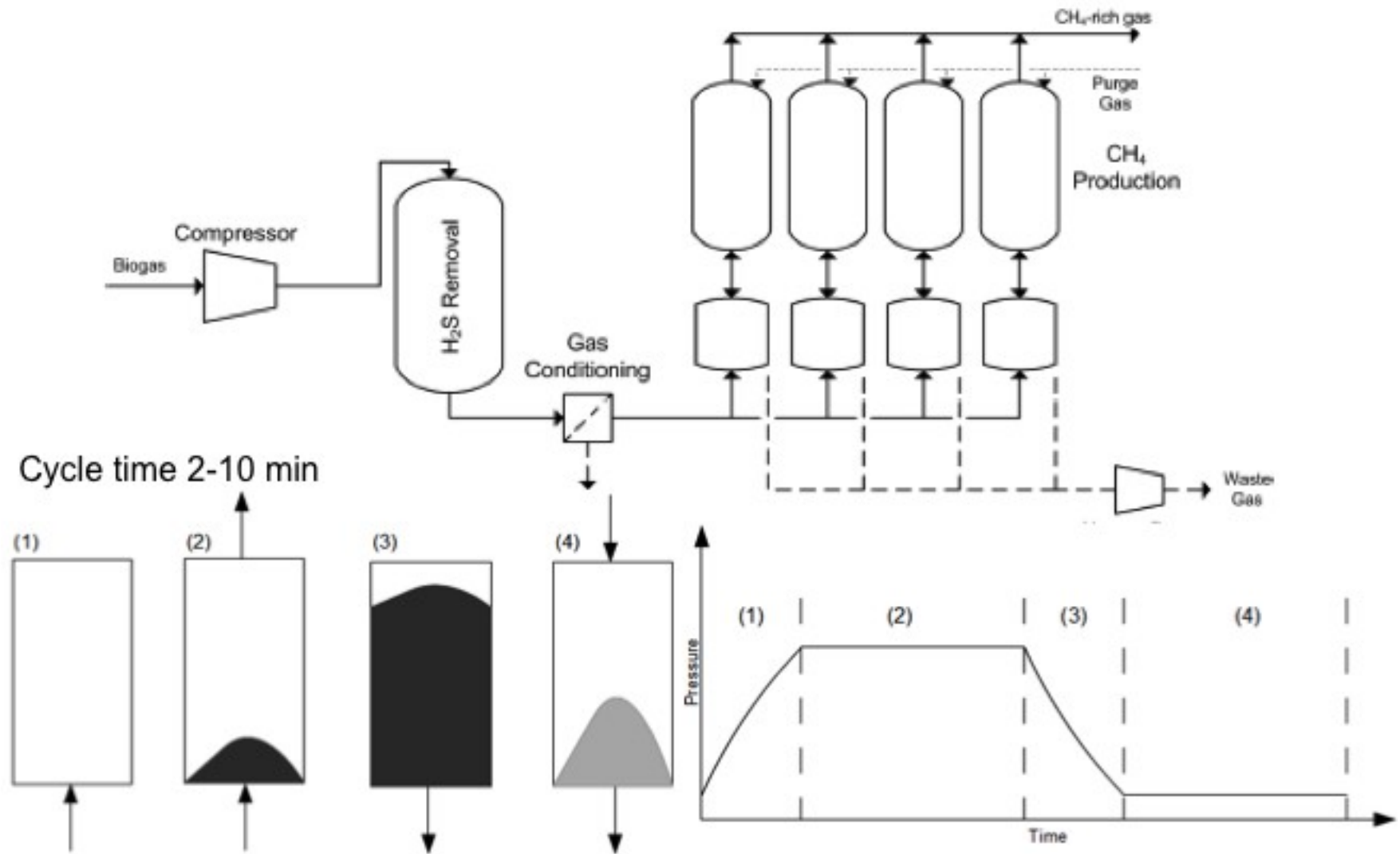


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Membrane

- Electricity - 0,20-0,30 kWh/Nm³
(depending on the pressure and the design)
- H₂S – separated externally
- Developing technology
- Methane loss 0,5-2% (0% with Haffmans solution)
- Service 3-4% of the investment including membrane replacement
- Partly separation of oxygen

PSA

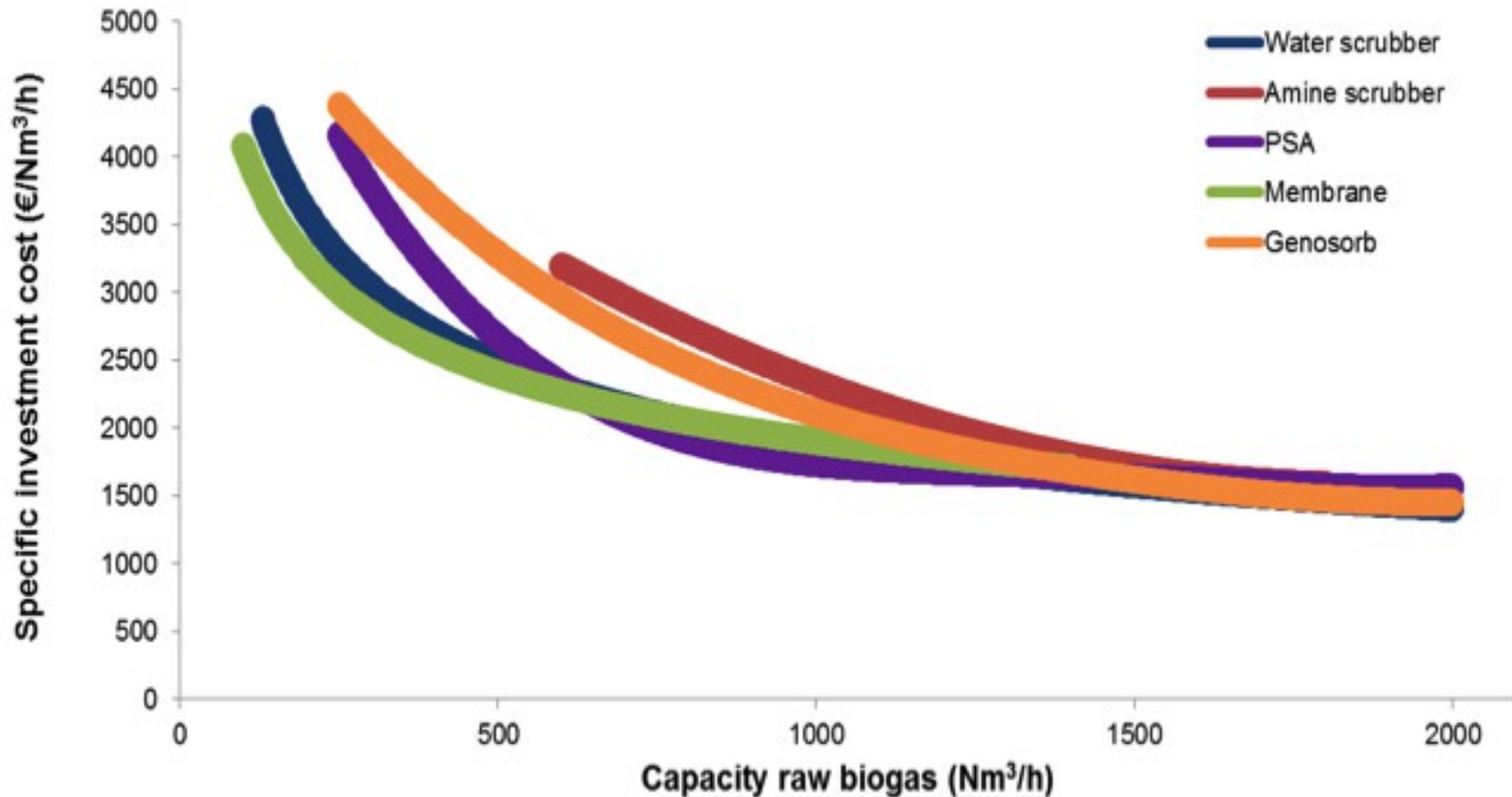


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PSA

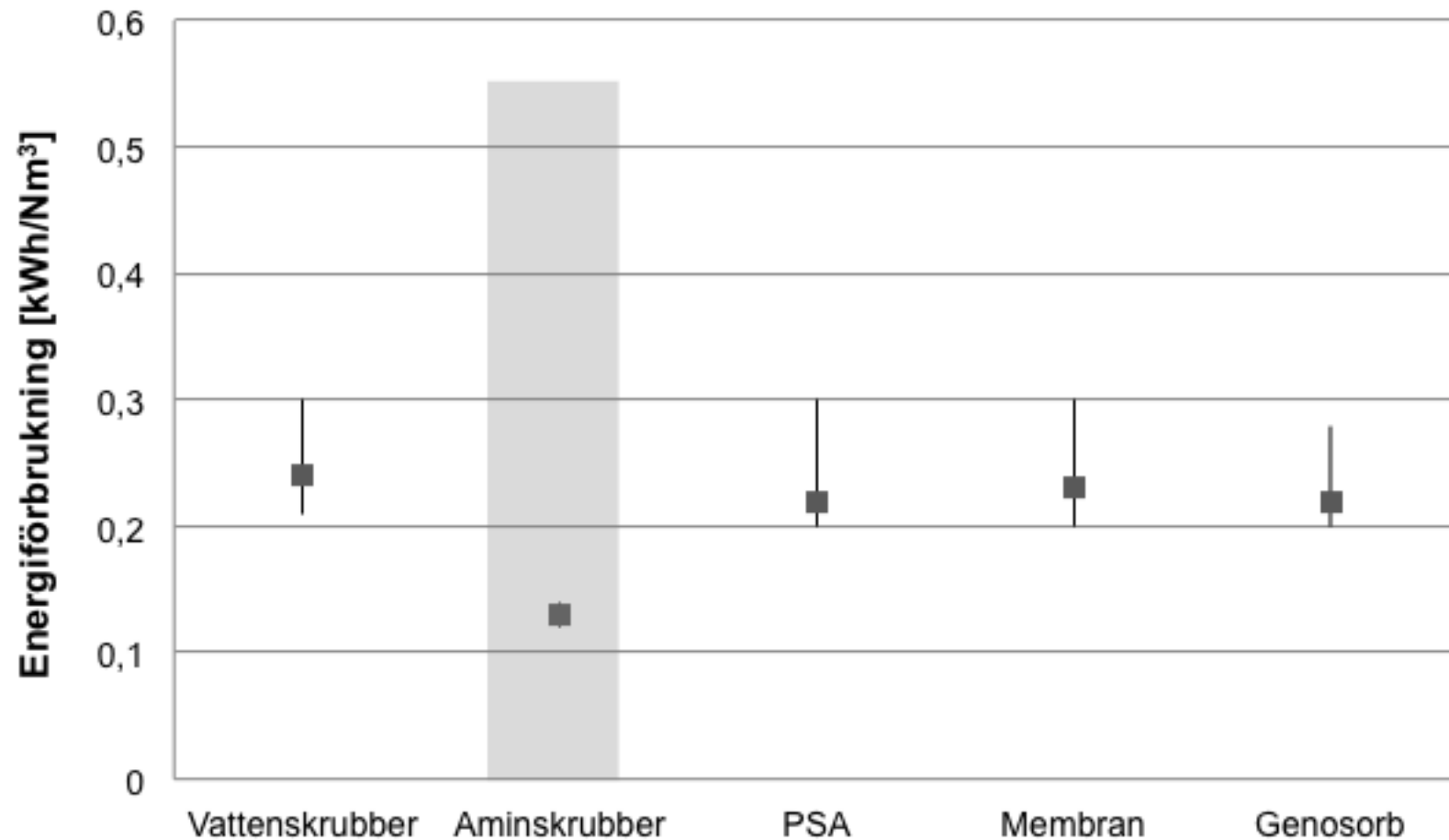
- Maintenance costs – 2-3 % of investment
- Availability 96-98 %
- Energy demand – 0,2-0,3 kWh/Nm³ (0,18 kWh/Nm³ LPSA 2-3 bar(g)) (dependent on pressure and CH₄ content)
- H₂S – must be separated prior to PSA
- Mature technology
- Methane slip ca 1,5 %
- Can deliver 98 % methane according to some manufacturers

Specific investment cost



Clear economies of scale for all technologies up to about 1500 Nm³/h capacity

Specific energy demand



Methane slip

Technology	Methane slip
Water scrubber	1,0%
Organic scrubber	1,5%
Amine scrubber	0,1%
Membrane	0,5-2,0%
PSA	1,5-2,0%

Publications

Bauer F, Hulteberg C, Persson T & Tamm D. *SGC Rapport 270. Biogas upgrading – Review of commercial technologies*. SGC, Malmö, 2013.

Bauer F, Persson T, Hulteberg C & Tamm D. Biogas upgrading – technology overview, comparison and perspectives for the future. *Biofuels, Bioproducts and Biorefining*, 2013. DOI: 10.1002/bbb.1423

Thank you for your attention

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