
Biogas up-grading: a technical review

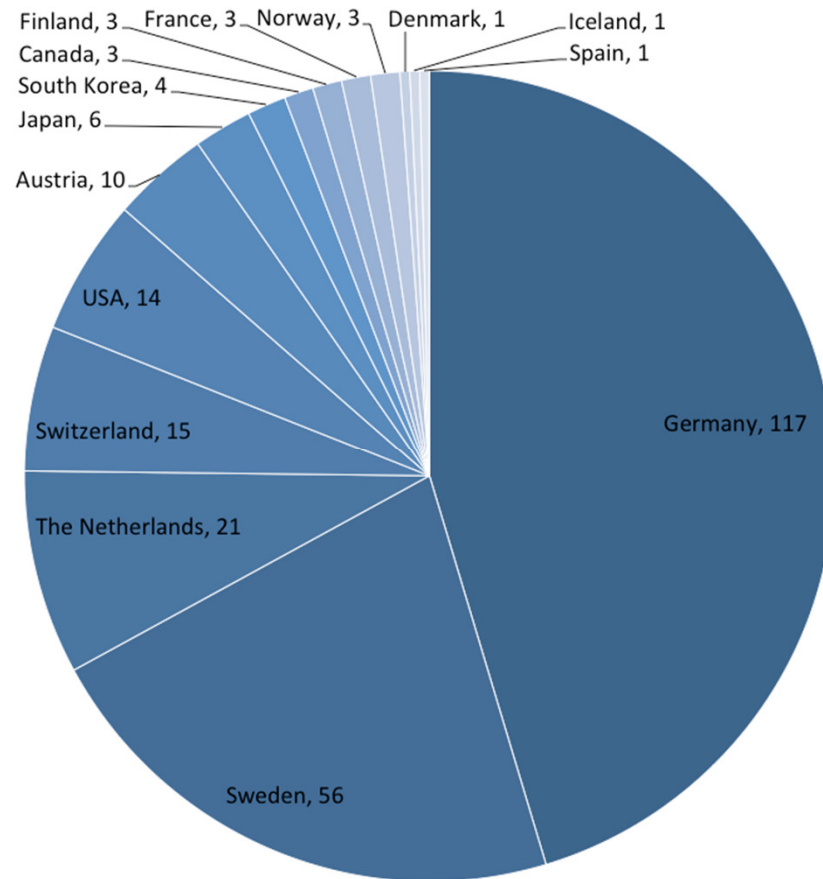
Tobias Persson
2013-11-14



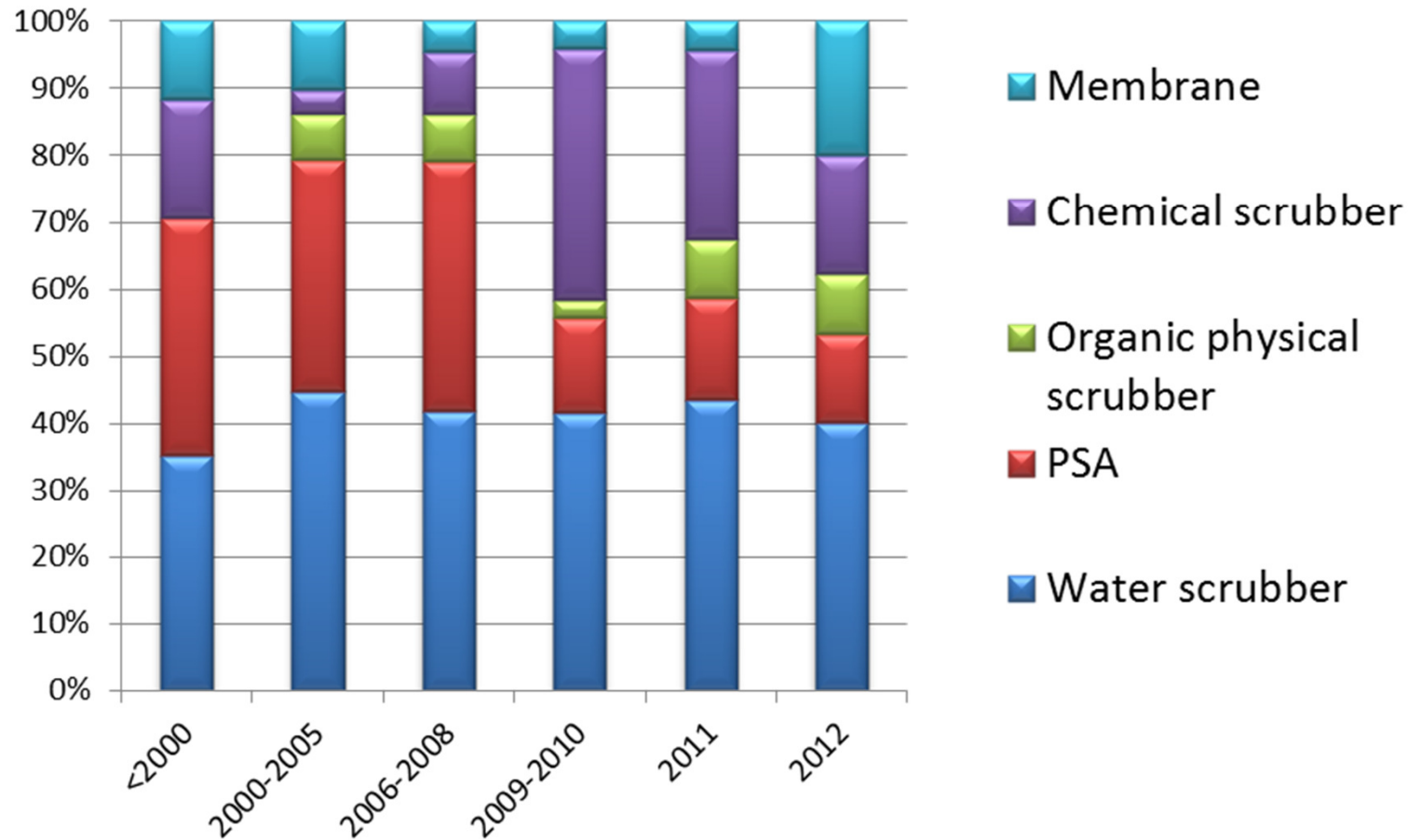
Outline

- 1. Existing biogas up-grading units**
2. Water scrubber
3. Genosorb scrubber
4. Membrane
5. Amine scrubber
6. PSA
7. Comparison between the different technologies

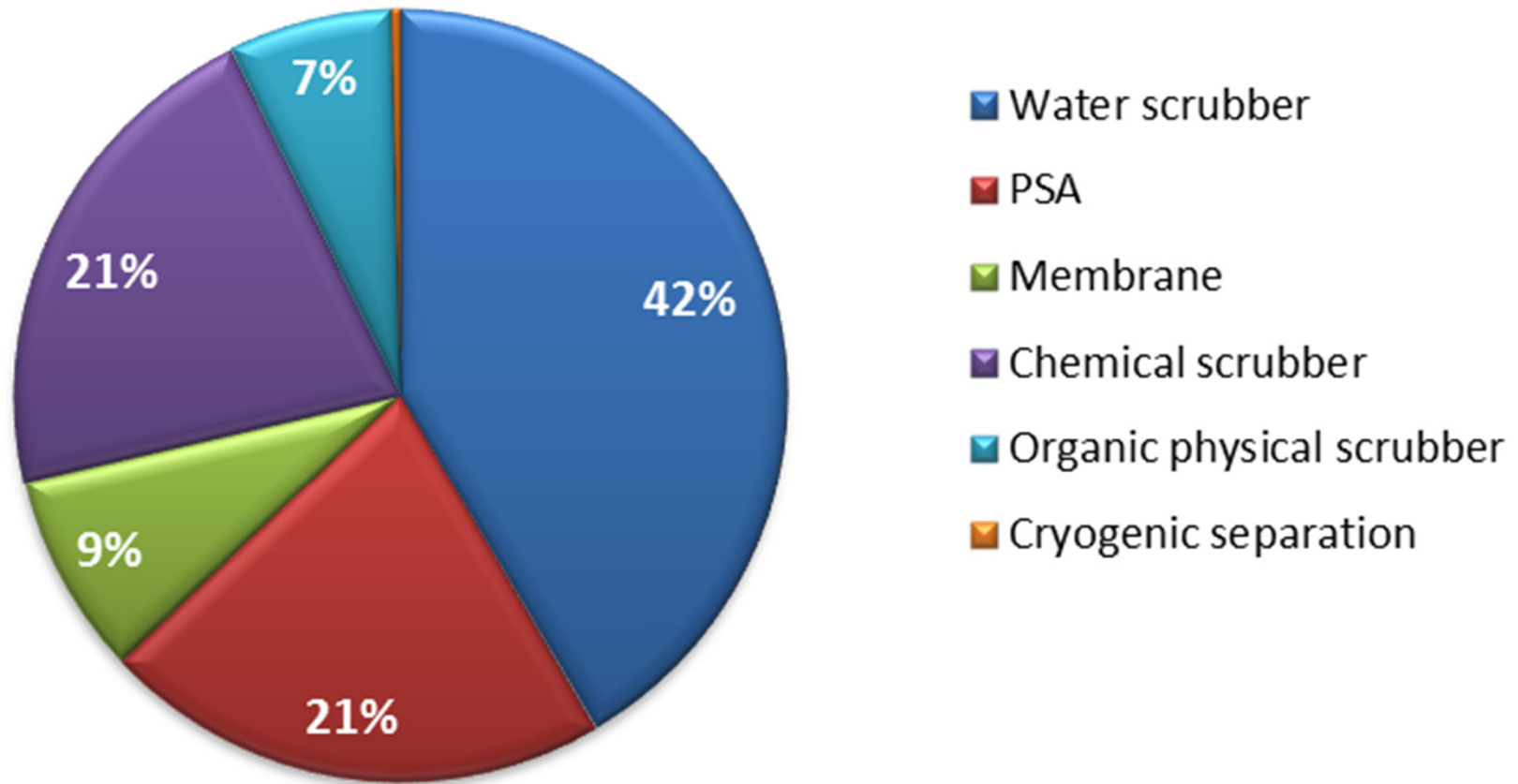
260 Biogas up-grading plants in operation 2012



Market development



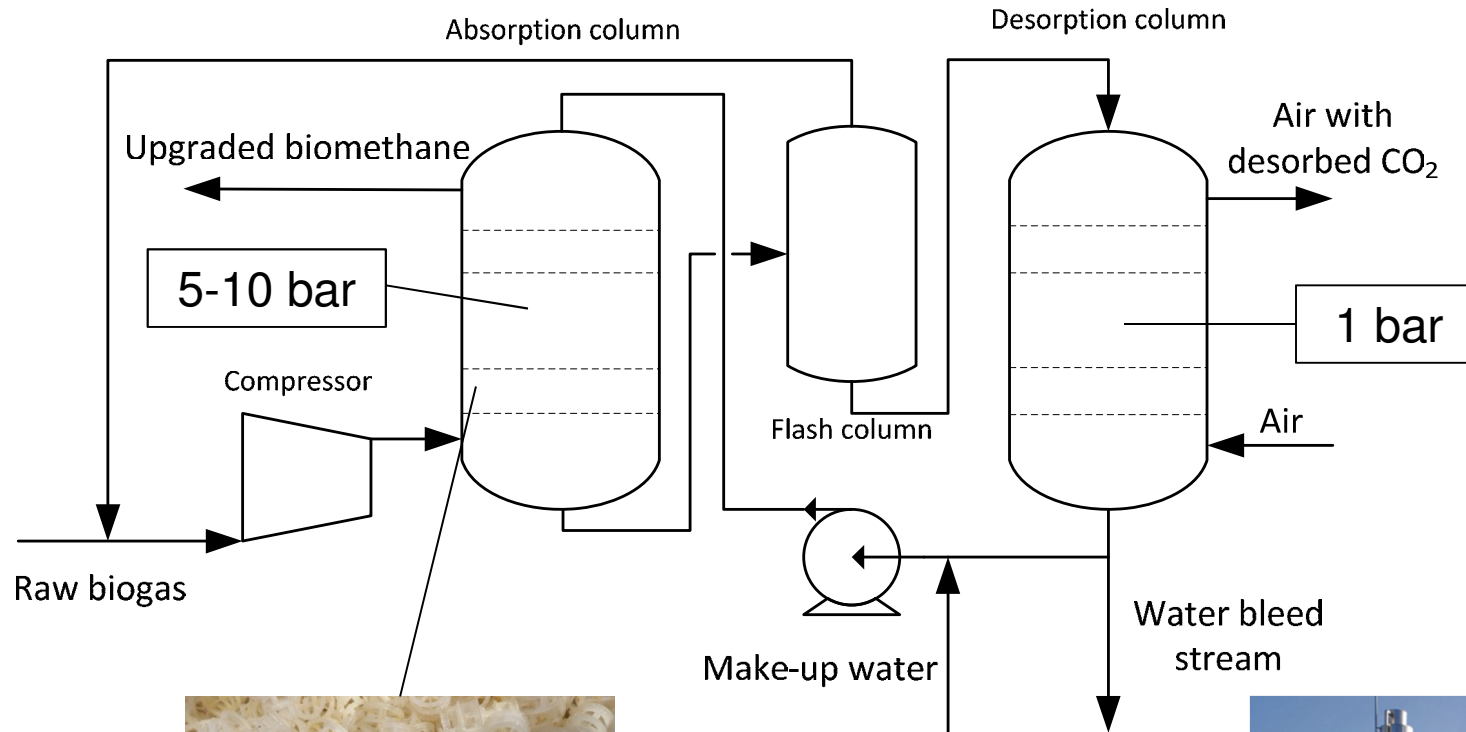
Market share today



Agenda

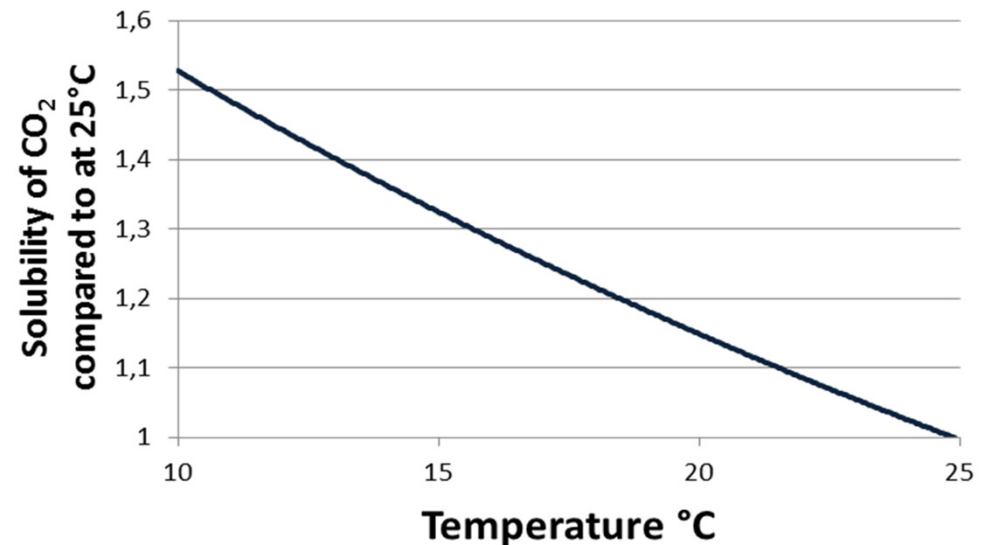
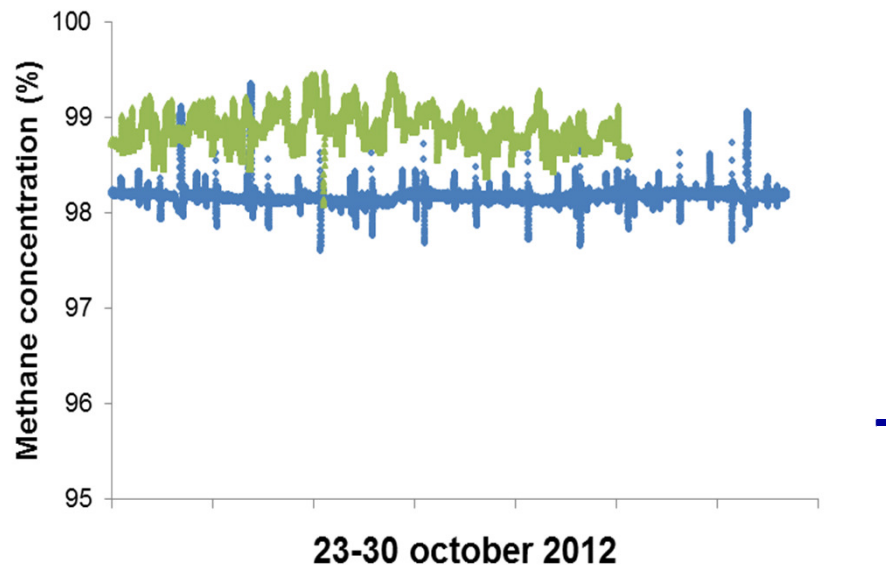
1. Existing biogas up-grading units
- 2. Water scrubber**
3. Selexol/Genosorb scrubber
4. Membrane
5. Amine scrubber
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Water scrubber



Development

- Single pass in the early applications, not today
- Pressure has been decreased from 7-10 bar to 5-6 bar to save energy
- Decreased temperature of the process water
- Improved regulation



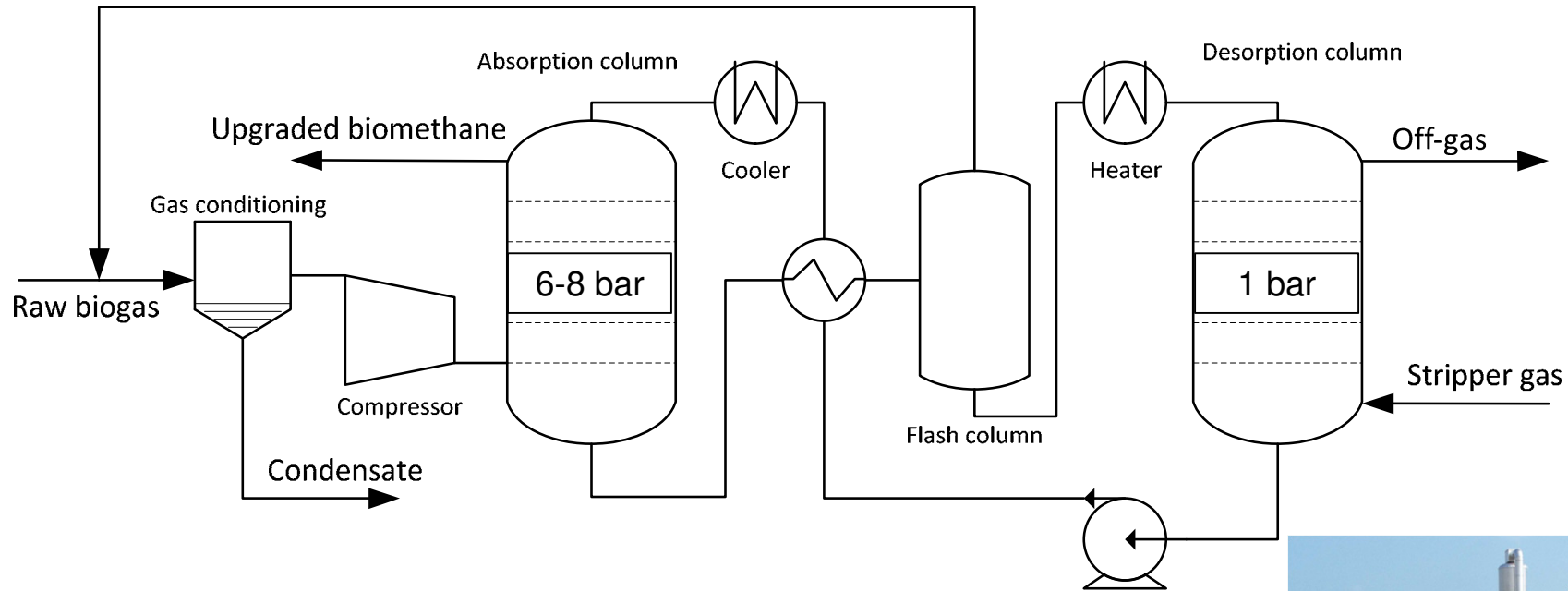
Properties

- Maintenance: 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: 95-98%
- Mature technology
- Methane slip: 1%

Agenda

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Design of a Seleoxol/Genosorb scrubber



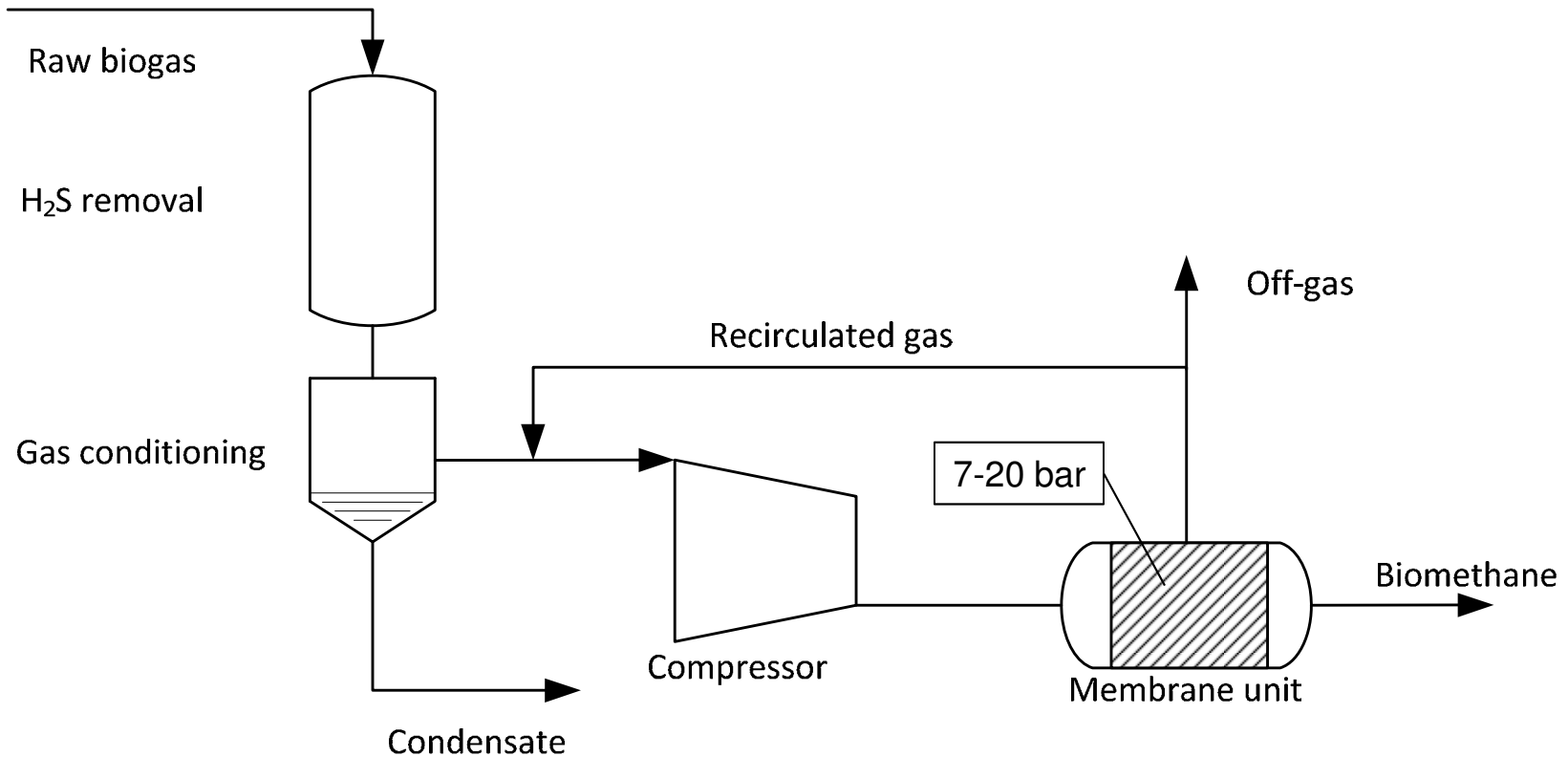
Genosorb vs. Water

- Genosorb® 5 times larger solubility of CO₂
- Different temp adsorption-desorption (20/40 °C)
- Heat from RTO and compressor used internally
- Larger methane loss (1,5% vs. 1,0%)
- No bacterial growth in Genosorb
- H₂S is removed separately

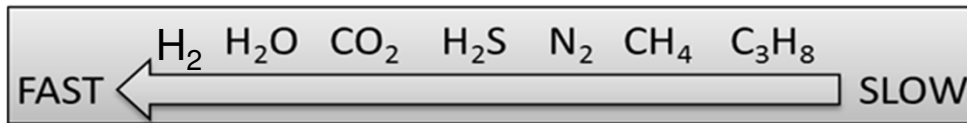
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Biogas upgrading with membrane



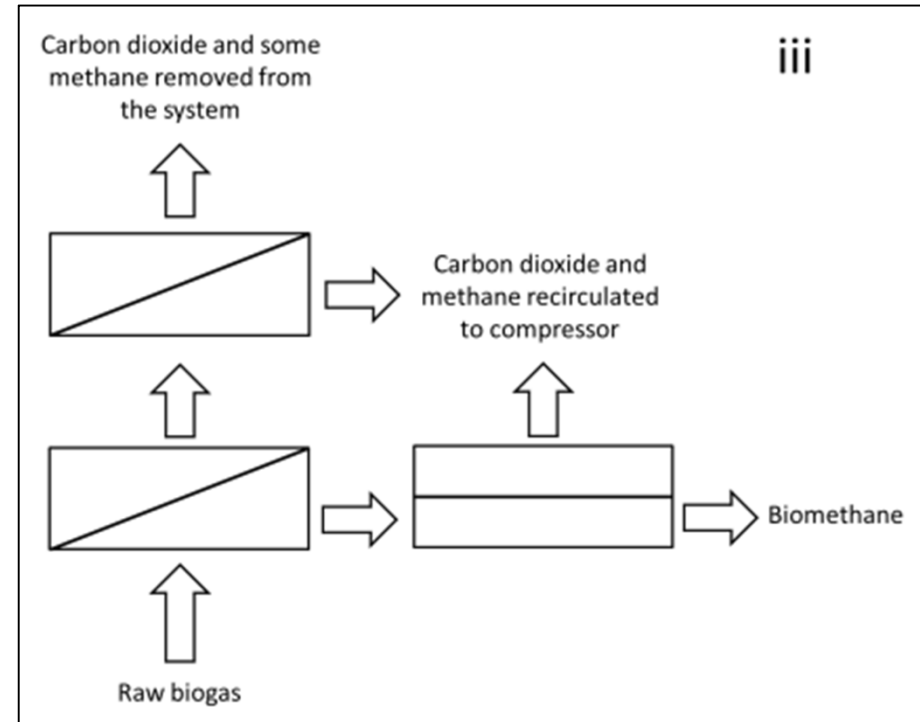
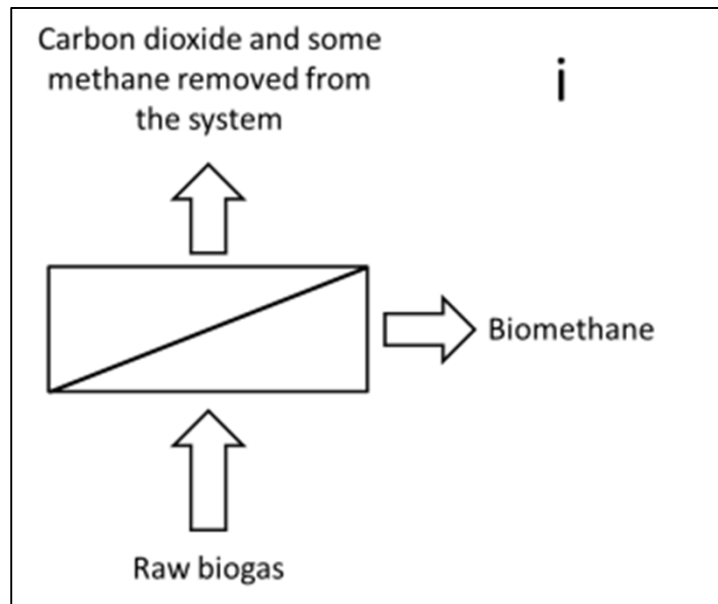
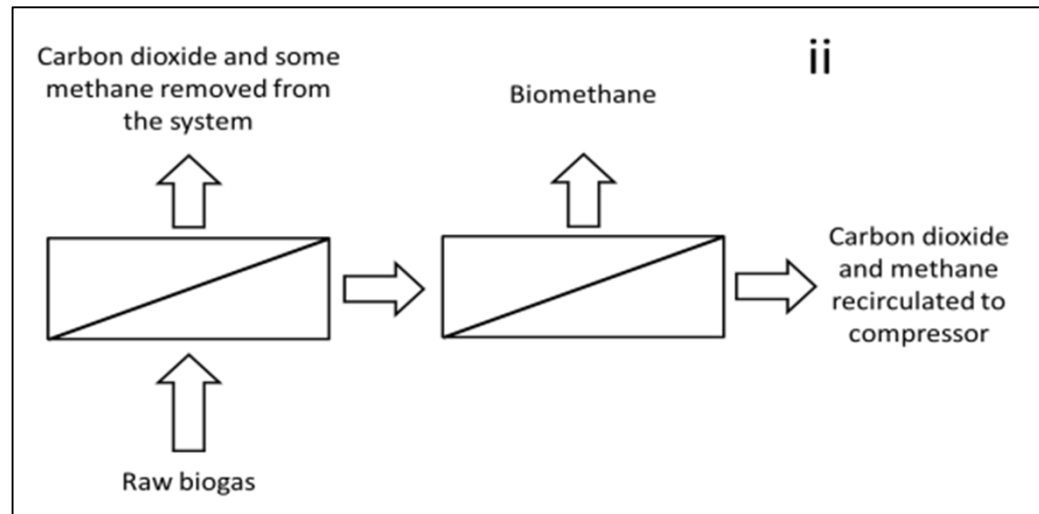
Relative permeation rate



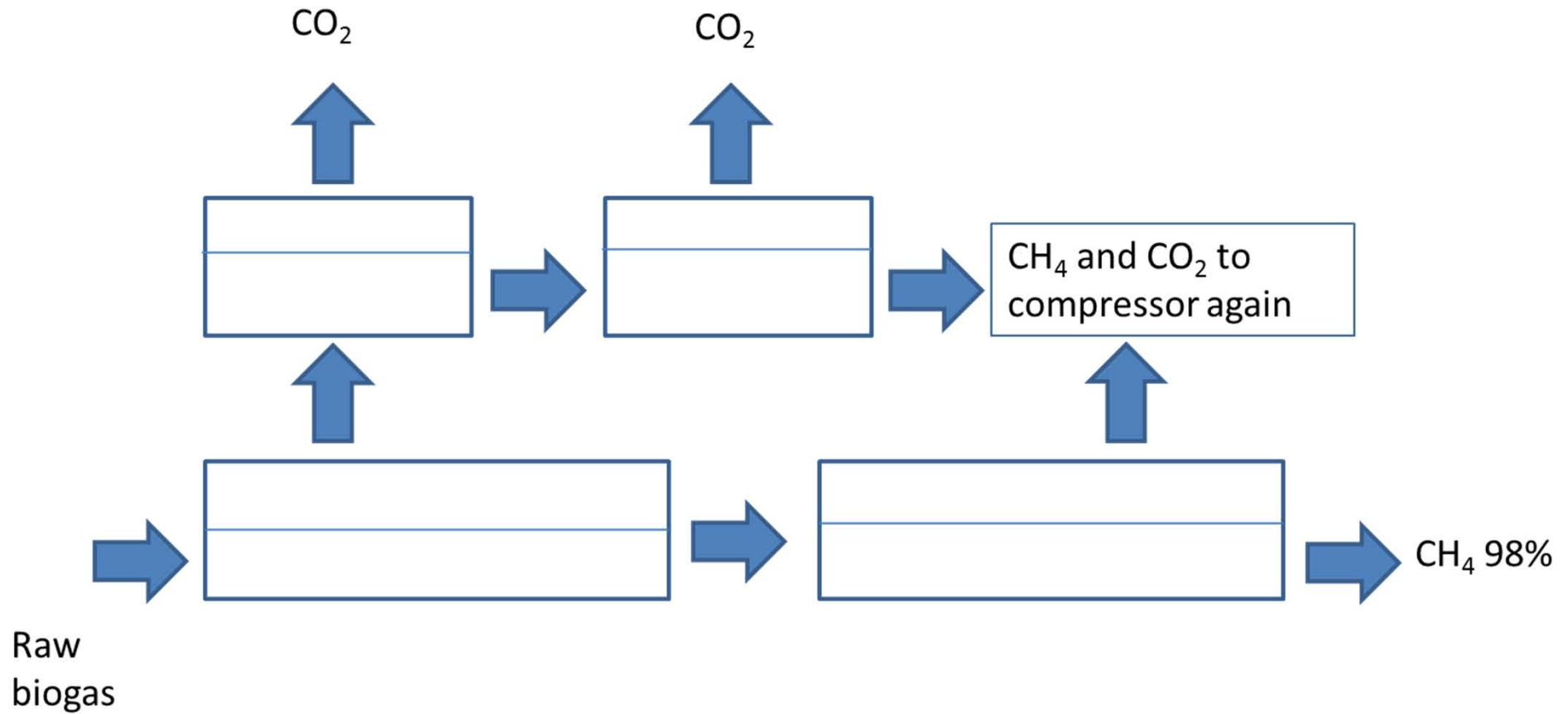
The selectivity (CO₂/CH₄) is increasing



Design alternatives



New design this year



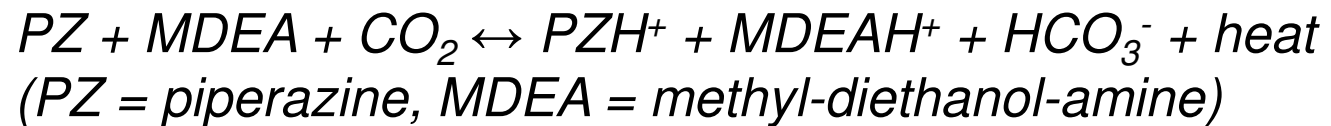
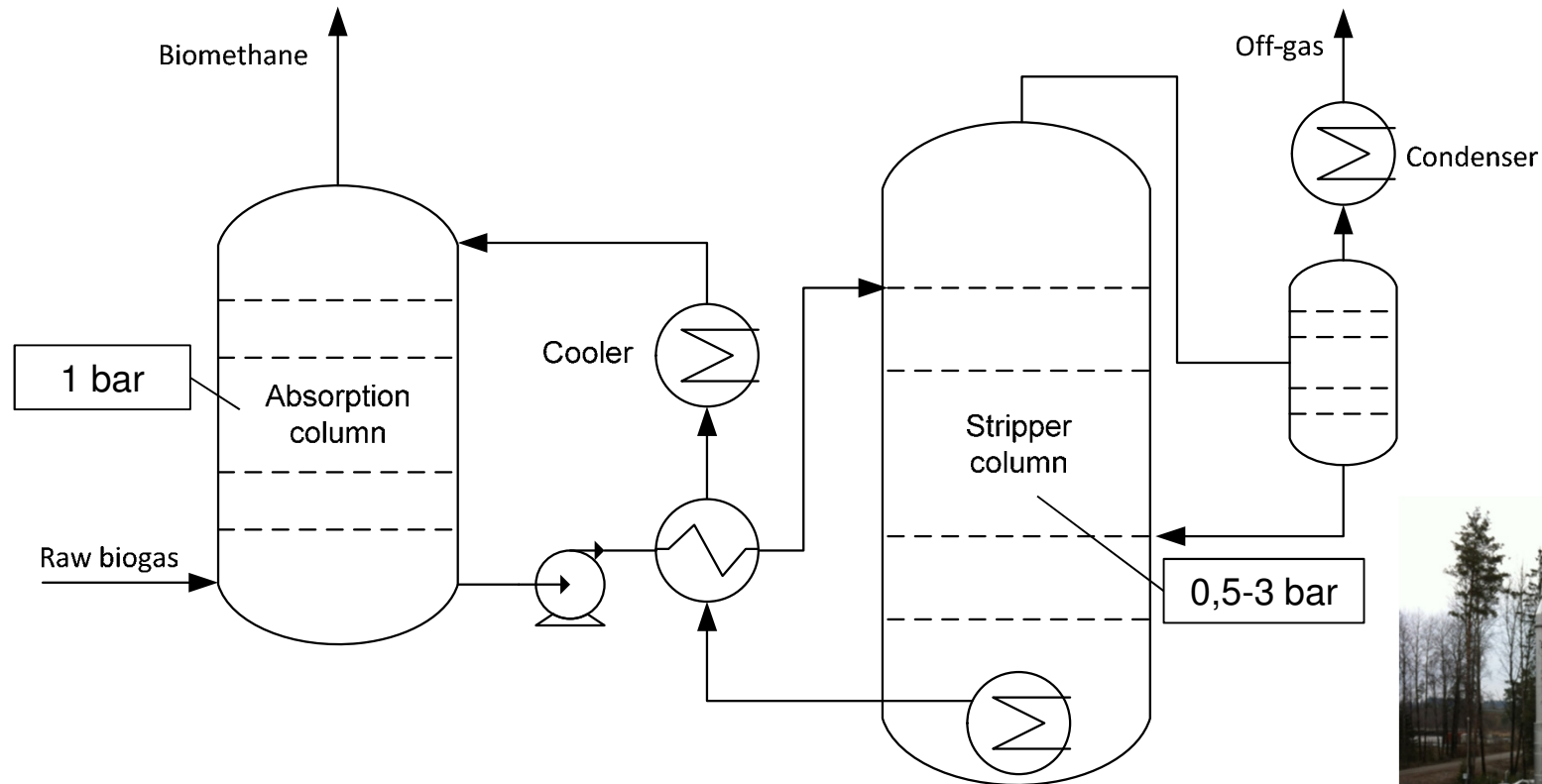
Important properties

- 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 technology)
- Maintenance: 3-4% of the investment, including membrane replacement
- Partly able to separate oxygen

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Amine scrubber



Development

- Improving amine mixture for low energy demand and high absorption capacity
- Evaluating different additives to improve the process
- Developed desorption with vacuum to use district heating as a heating source

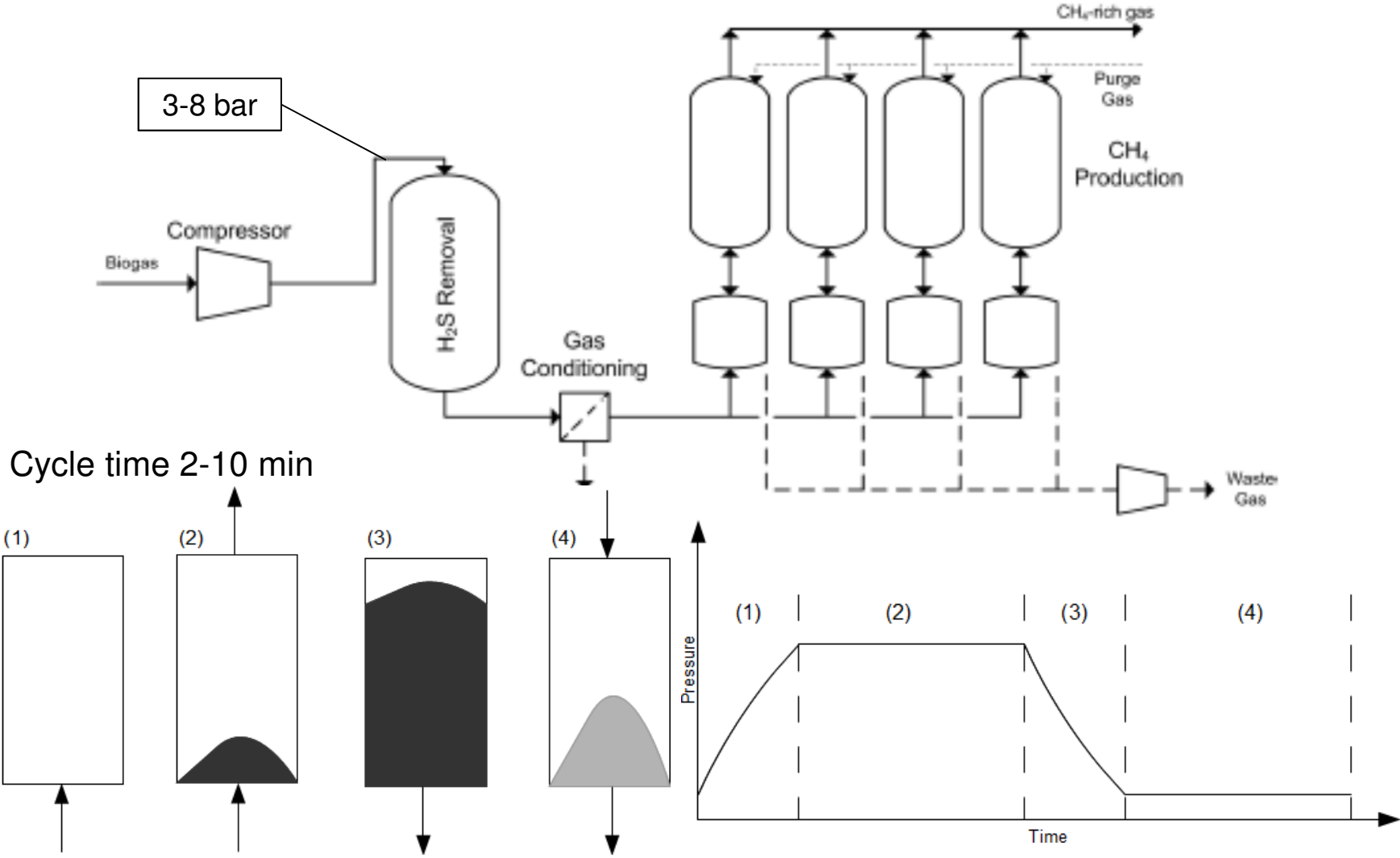
Important properties

- Maintenance costs: 2-3% of investment
- Energy demand: 0,10-0,15 kWh_{el}/Nm³ (@ 5 bar)
+ 0,45 – 0,6 kWh_{heat}/Nm³
- H₂S: commonly separated prior to scrubbing,
if included 10% extra heat consumption
- Methane slip: ~0,1%
- Oxygen in raw biogas reacts irreversibly with amine

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Biogas up-grading with PSA



Development

- Plant design, regulation and the adsorbent are developed to minimise the methane loss.
- Low pressure unit has been developed to save energy. In operation 2013.

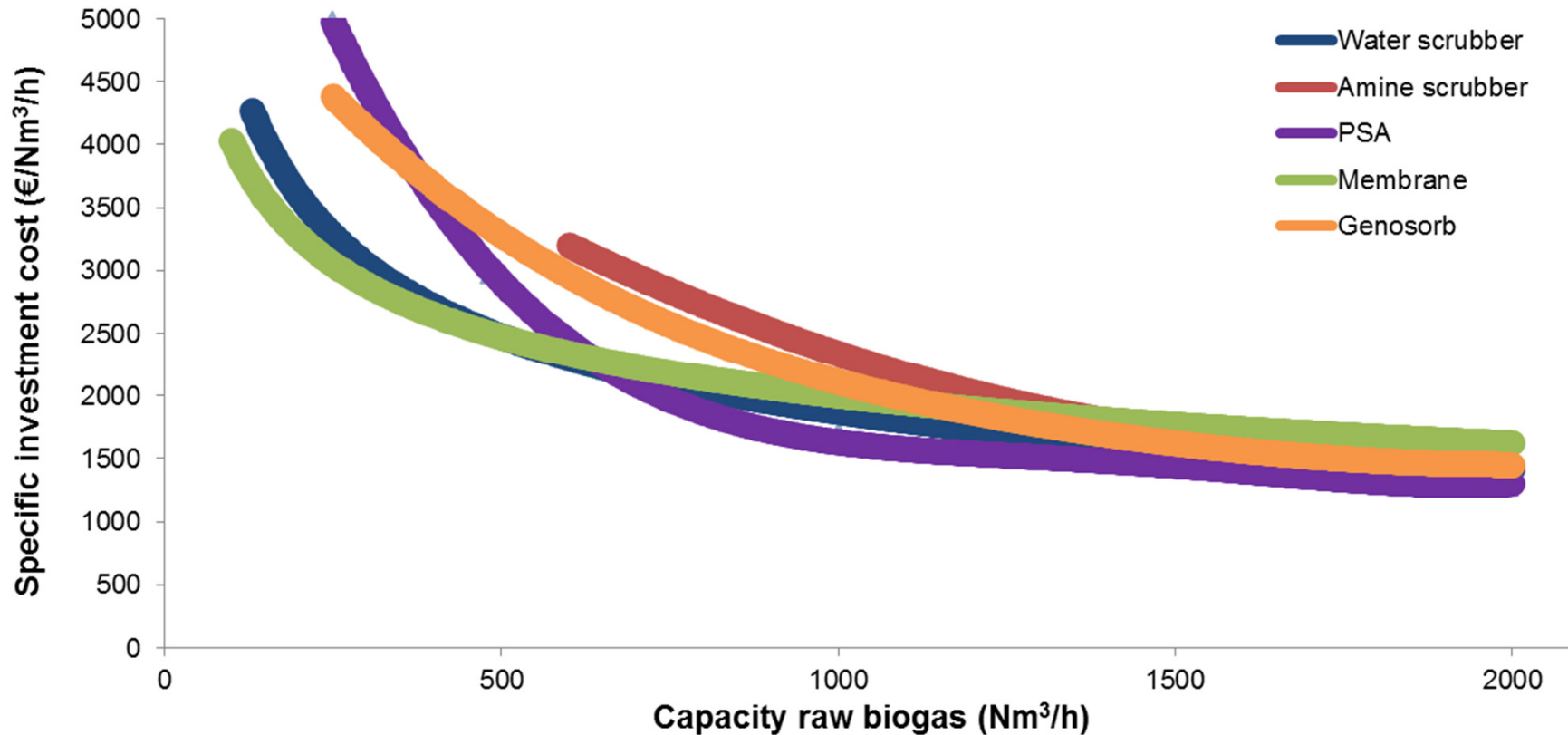
Important properties

- Maintenance costs: 2-3 % of investment
- Energy demand: 0,2-0,3 kWh/Nm³
- H₂S: must be separated prior
- Mature technology
- Methane slip: ca 1,5 %
- N₂ and O₂ is partly separated

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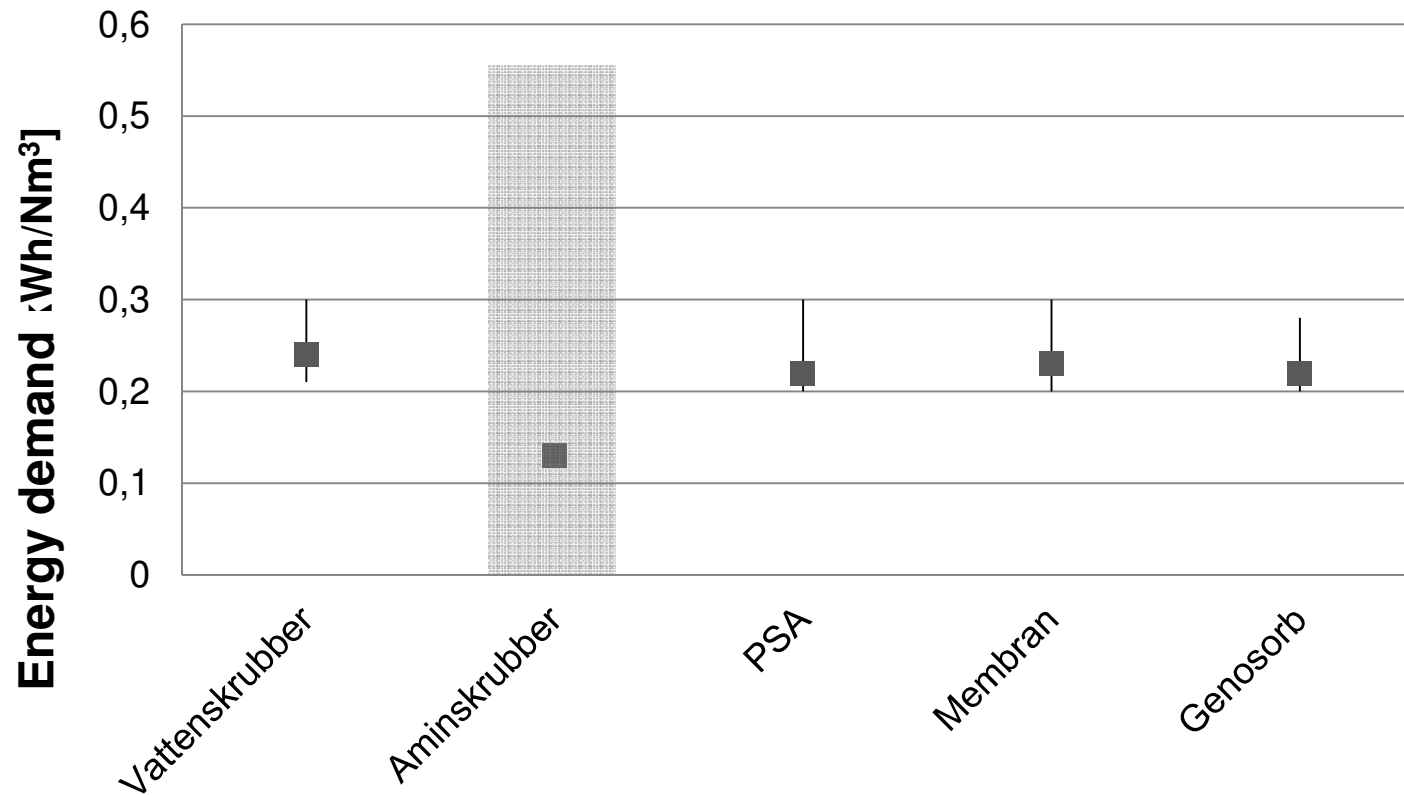
Specific investment cost



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

Specific energy demand

(Pressurisation valuable for many applications, an energy value not to be forgotten in comparisons)



Availability: 95-98% for all technologies

Emissions

Technology	Methane slip	Pure CO ₂ ?
Water scrubber	1,0%	No, with air
Organic scrubber	1,5%	No, with air
Amine scrubber	0,1%	Yes
Membrane	0,5-2,0%	Yes
PSA	1,5-2,0%	Yes

If required, regenerative thermal oxidation (RTO) is costly (0,15 – 0,25 €)

Contributors



Svenskt Vatten



VIESSMANN Group



MALMBERG



LUNDS
UNIVERSITET
Lunds Tekniska Högskola



biogas, miljö och kretslopp

Thank you!



Svenskt Gastekniskt Center

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