



**Institute for Biogas**  
Waste Management & Energy  
Prof. Dr.-Ing. Frank Scholwin



# Developments in Biogas Cleaning & Upgrading Technologies

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01.10.2014

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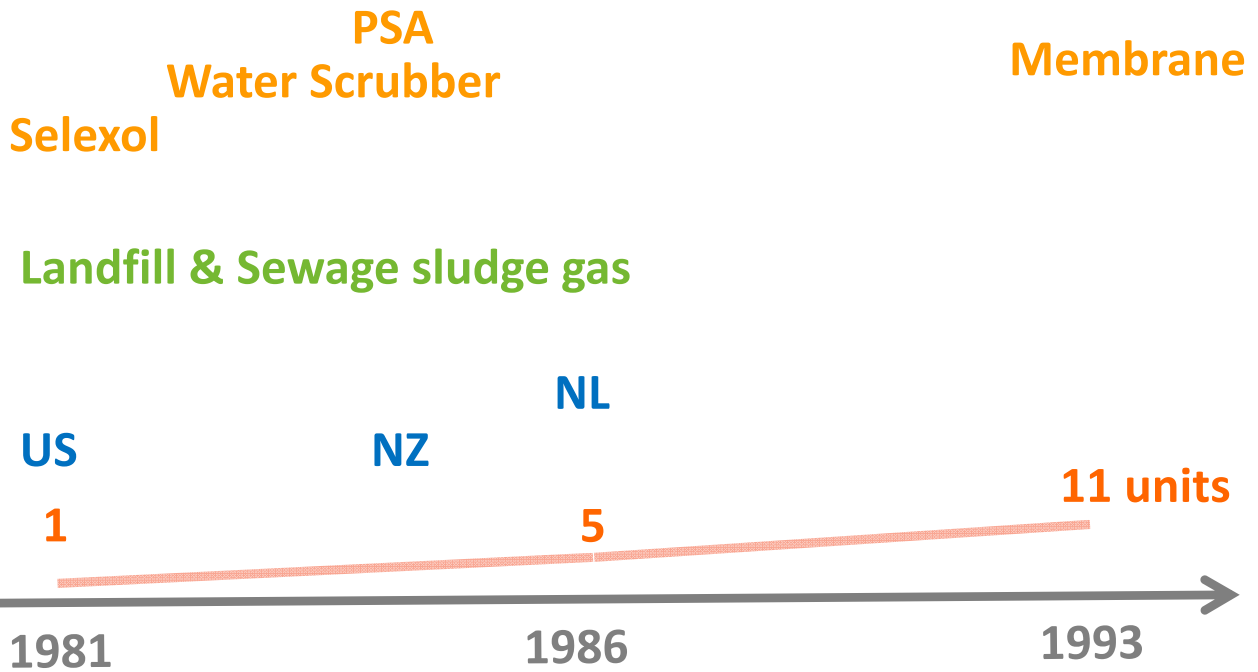
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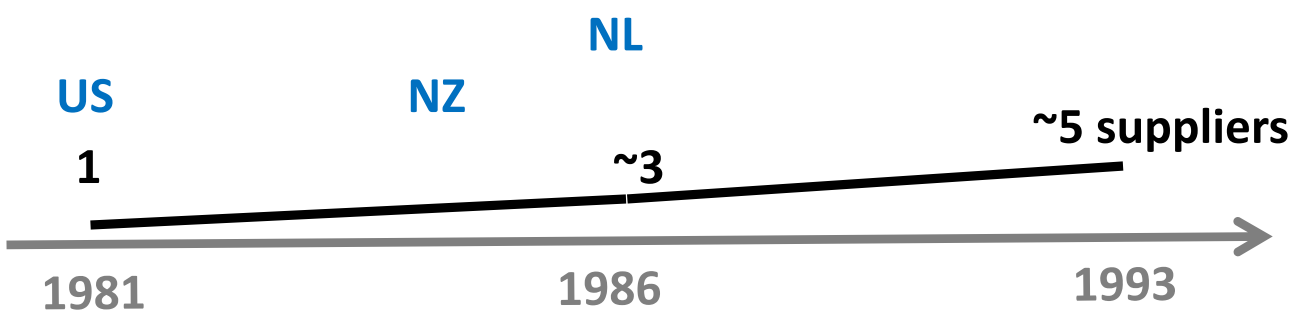
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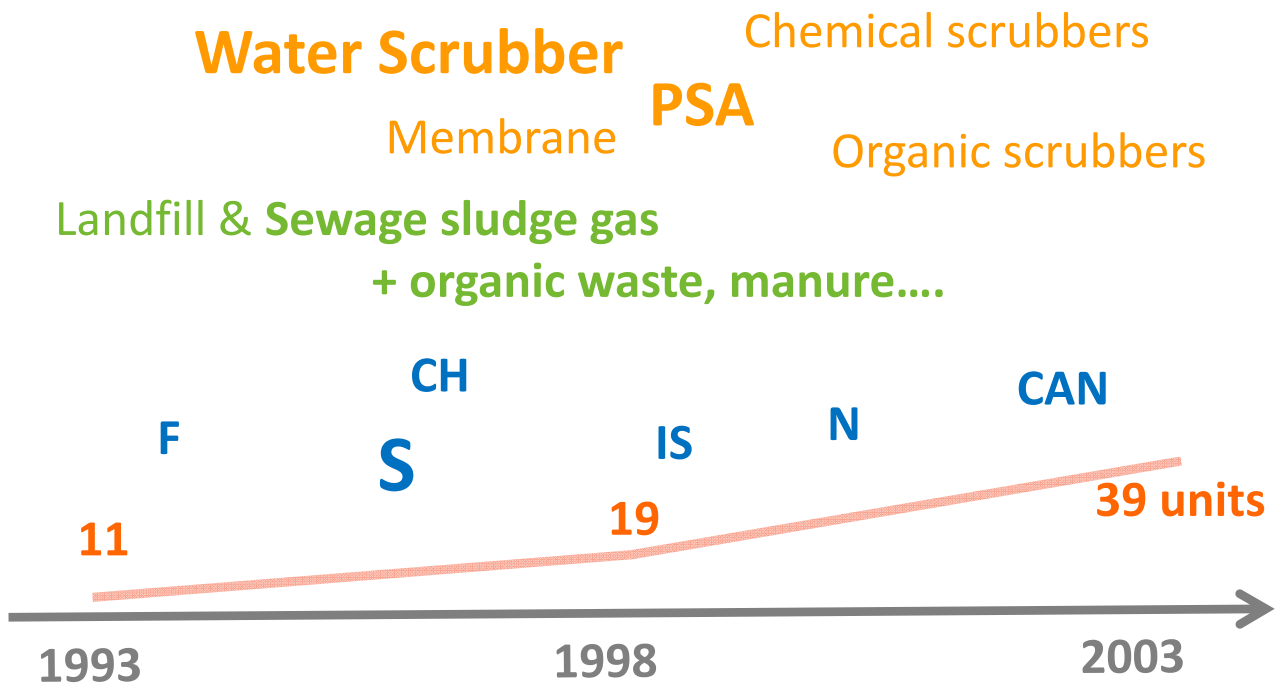
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**R&D activities**

**Alternative use of local available (renewable) fuel**

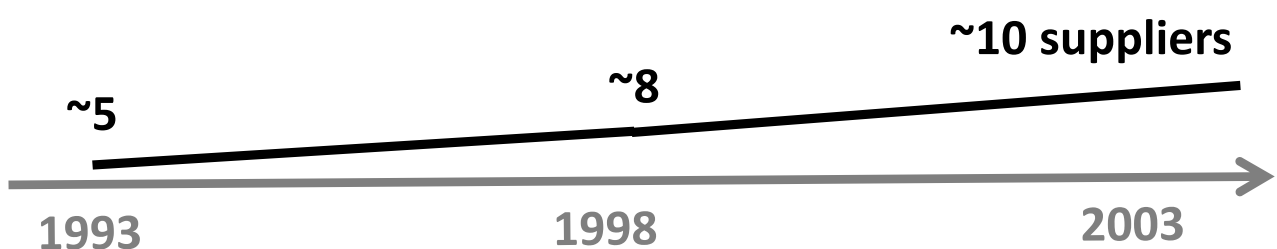


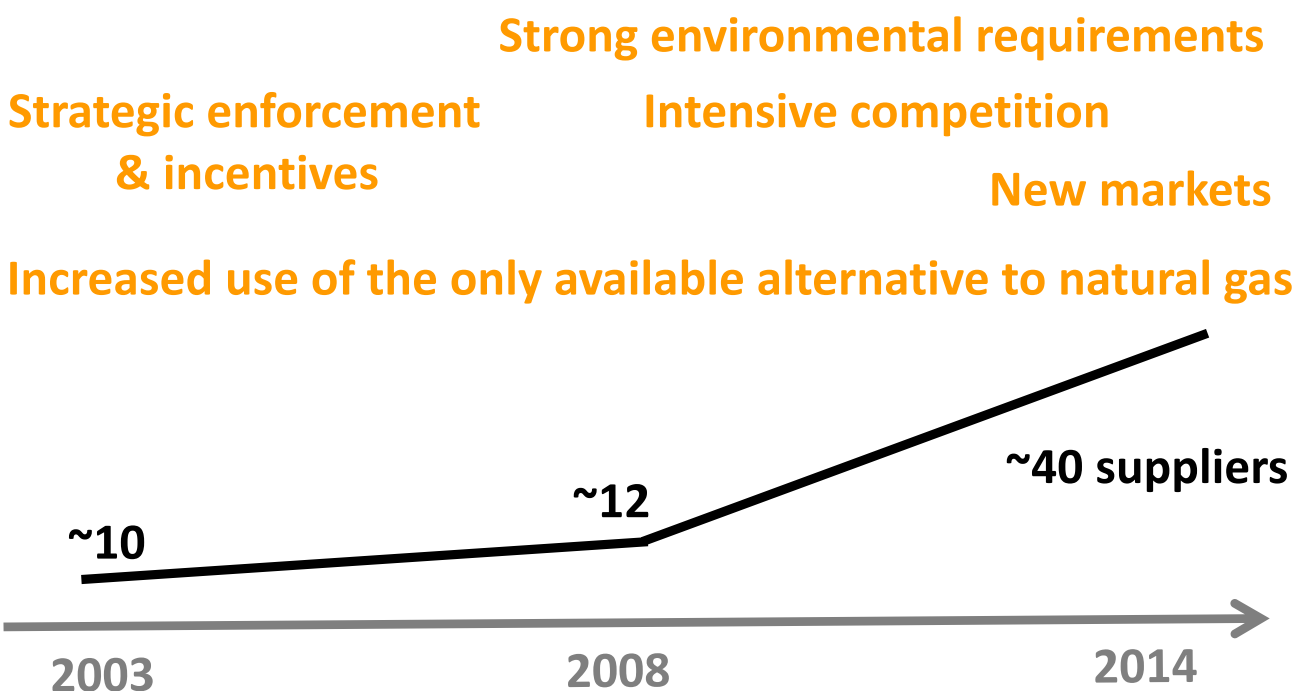
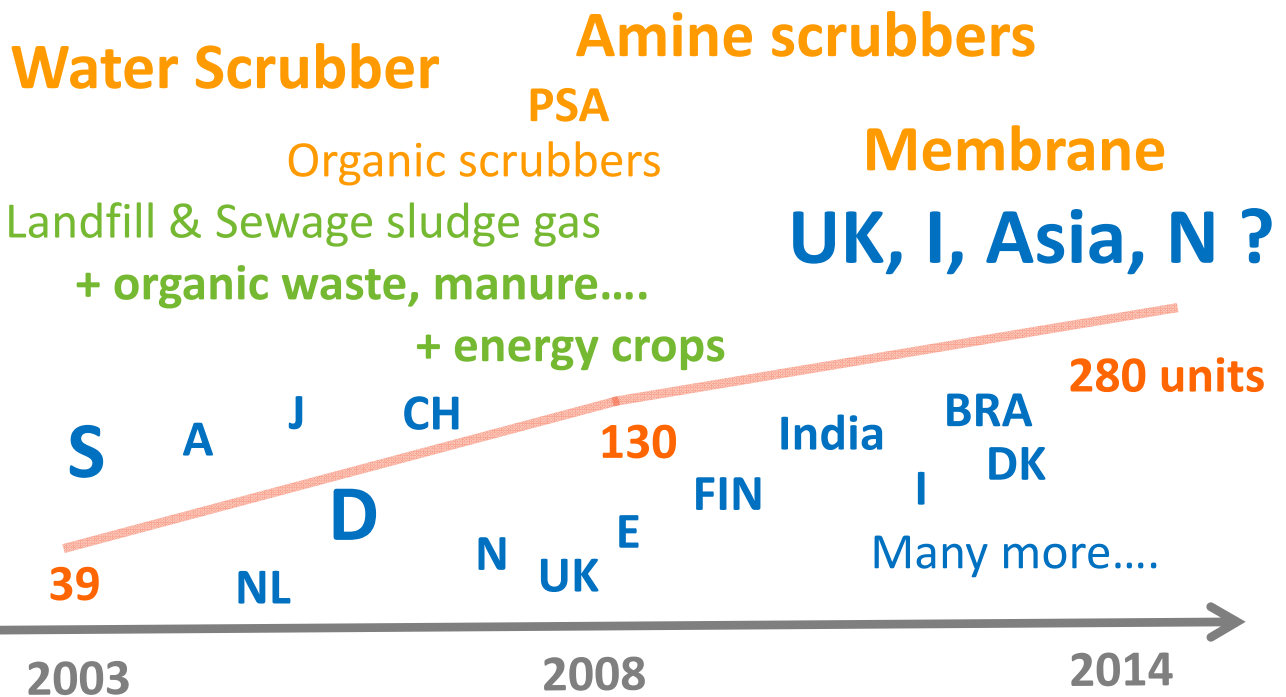


R&D activities

**Strategic enforcement  
& incentives**

**Alternative use of local available renewable fuel**





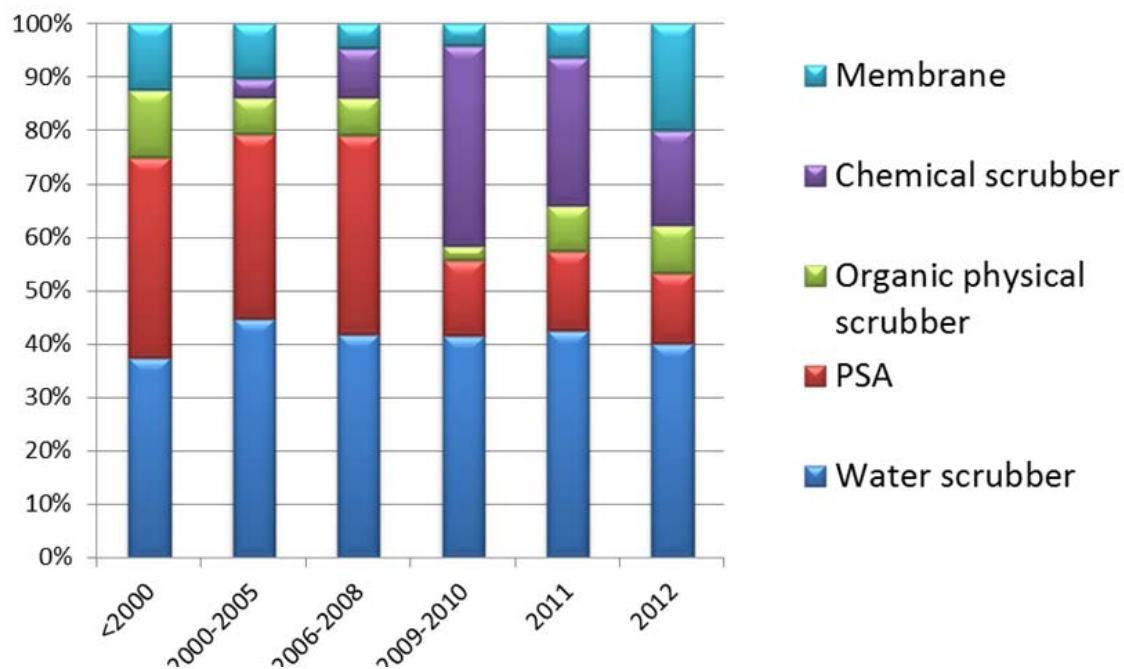
- Independent on application, cleaning is most important to reduce maintenance & upgrading costs
- Biogas drying: technical drying promises less corrosion & longer maintenance intervals, zeolites are an option
- Desulphurisation: no clear trend
  - Internal biological: cost efficient for 1<sup>st</sup> stage; but N<sub>2</sub>-source
  - Internal chemical: costly
  - External: most efficient
    - Biological processes
    - Adsorption
- O<sub>2</sub> removal with ABC<sub>4</sub>O<sub>7</sub> materials
  - A = rare earth element; B = Barium
  - C = Cobalt



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- All required gas specifications of European gas grids can be fulfilled
- High pressure transmission & underground gas storages: oxygen concentration requirements still a challenge
- All impurities can be reduced to the detection limits
  - Landfill gas upgrading is an increasing topic (out of central Europe)
- Development of methods and measurement standards (e.g. European Metrology Research Programme)





Source: Persson 2014, IEA task 37

## Developments – methane slip

- Increased environmental requirements & cost efficiency are drivers
- Slip is reduced from ~10 % in the first plants to less than 2 % at all technologies today
- < 1% at water scrubbers, membranes with more stages, organic scrubbers
- < 0.1% amine scrubbers
- Increased selectivity of membranes
- Typically less than 0.5% can be guaranteed
- Regularly used for process heat supply
- Oxydation technologies available at all technology suppliers

- Increased environmental requirements & cost efficiency are drivers for R&D activities
- Decreased operational pressures (water scrubber, amine scrubber, organic scrubbers, PSA)
- Decreased/optimised temperature (water scrubber, amine scrubber – e.g. desorption with vacuum at temperatures below 100 °C)
- Use of internally available heat sources (e.g. compressors)
- Combination of both (amine scrubber) for site adaptation
- Improved amine mixtures & enzyme additives
- Electricity demand < 0,2 kWh/m<sup>3</sup> offered

- LNG market develops – LBG is an additional option for biogas
  - Higher energy density
  - Increased efforts & energy demand for production
- Pure Liquid Carbon Dioxide as valuable by product
- Synergies with PtG technologies and gasification
- Biomethane as carbon resource in Biorefineries



- Technology combinations offer improved operational performance or better product quality
- Waste heat utilisation (e.g. from compressors & RTO)
- Small scale upgrading seems to have a market (membranes, water scrubber, PSA)
- Upgrading technologies go towards low cost solutions outside Europe (Brazil, India)
- Landfill gas will play an increasing role (out of central Europe)
- South America and Southeast Asia seem to be the most growing markets.

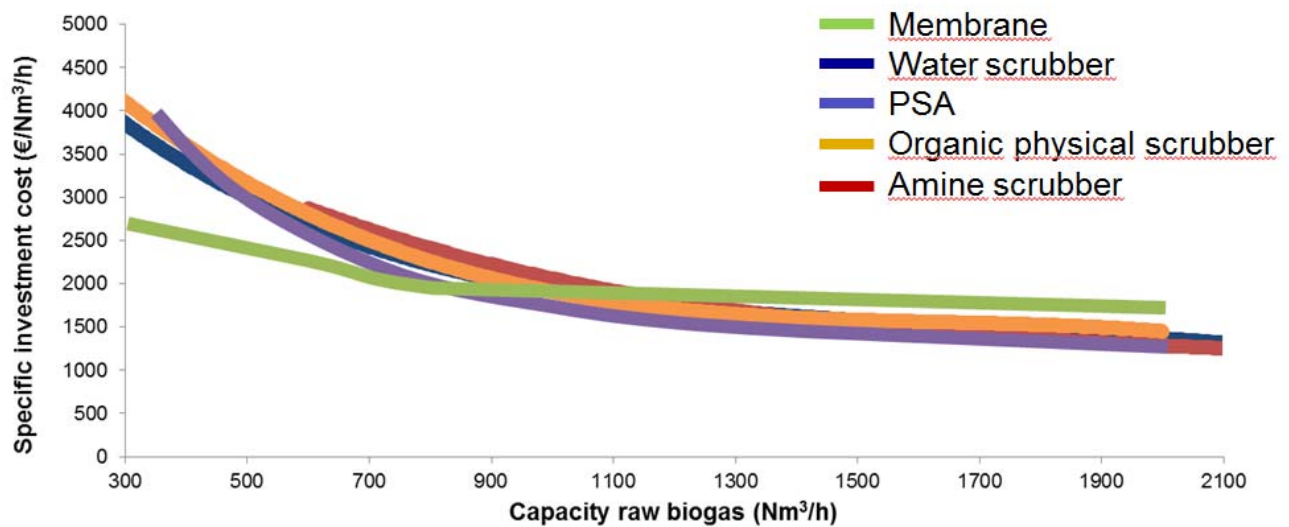


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- Cryogenic gas separation: 1 pilot plant
- High pressure water scrubber: small scale applications are working
- Some technologies in research scale
  - PCC precipitated calcium carbonate;
  - internal enrichment, pressurised fermentation
  - Ash filter (CO<sub>2</sub> is fixed by calcium oxide under the formation of calcite)
  - Temperature swing adsorption
  - Solid state amine adsorption
- Upgraded biogas will play a role in Power to Gas technologies
  - Renewable CO<sub>2</sub> source
  - Combined with electrolyzers increased methane yields (microbial methane enrichment)



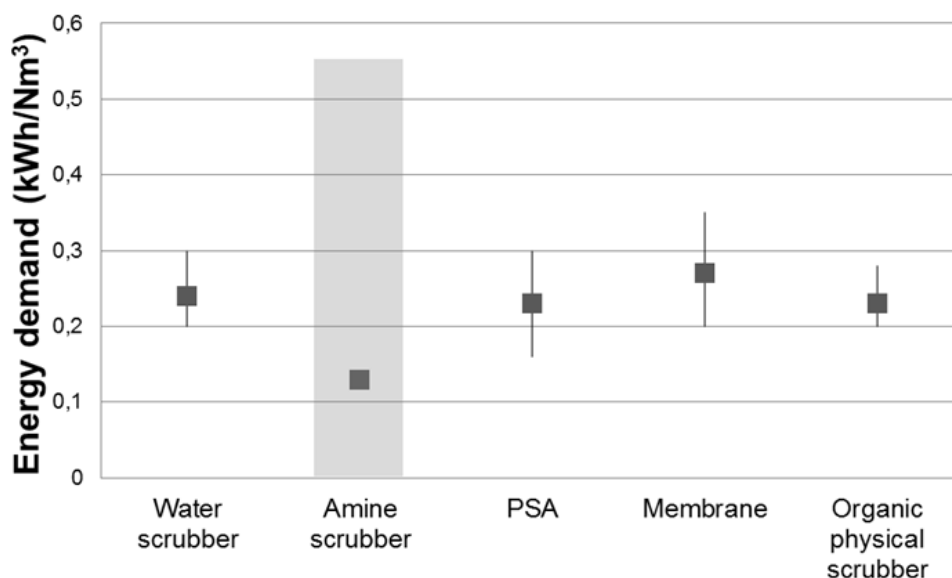
## Specific investment costs



Differences in requirements for gas pretreatment, waste gas treatment, pressure, gas quality, energy consumption and heat recovery will affect the total budget.

Source: Persson 2014, IEA task 37

## Specific energy demand



To be observed: product gas is supplied at different pressures!

Source: Persson 2014, IEA task 37

- Rapid market growth in Europe and international
- Process efficiency raised strongly in the past
  - Energy demand and waste energy utilisation
  - Reduced methane slip
  - Increased methane recovery
- No general advantages of a single technology visible
- High dependency on the given economical framework
- Local situation defines technology choice



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