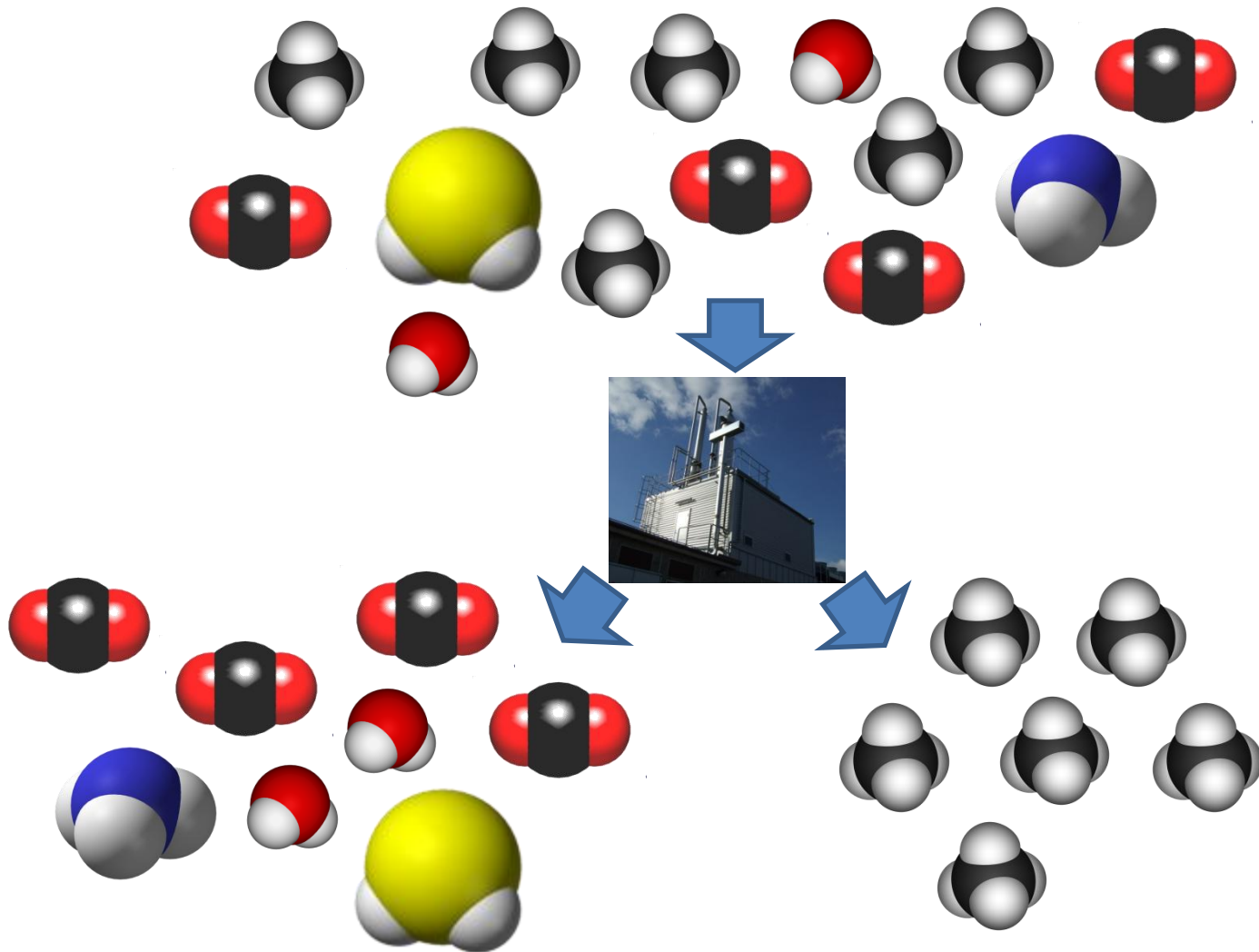


Modern technologies of biogas upgrading

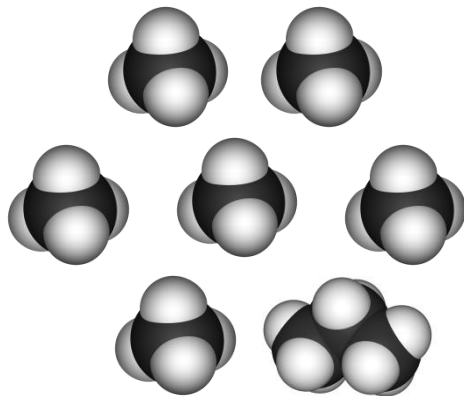
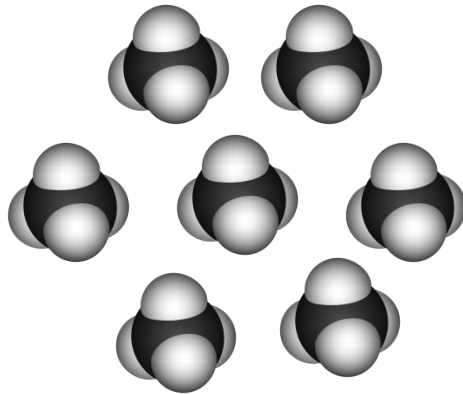


Anneli Petersson, Dr.
Swedish Gas Centre

Biogas upgrading



Utilization of upgraded biogas

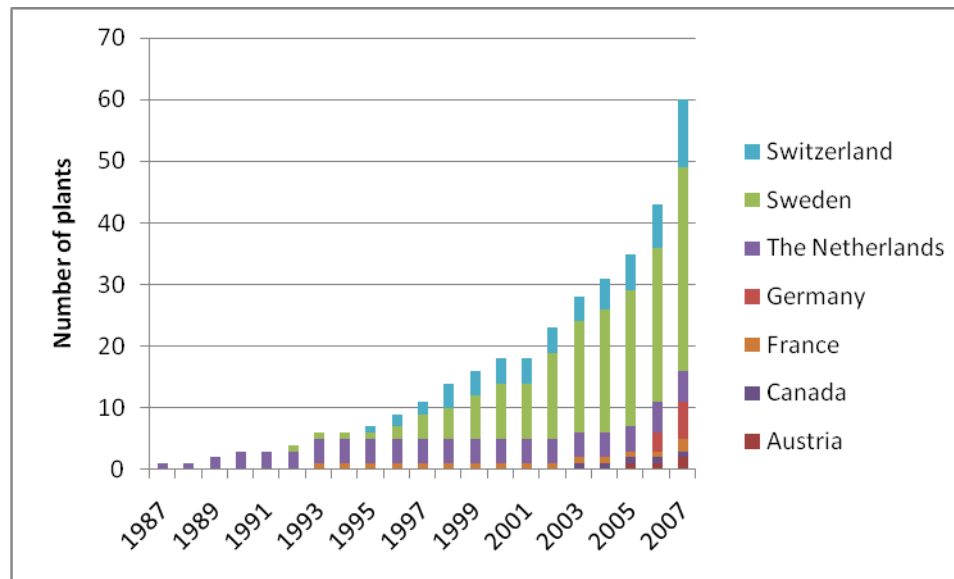


Environmental benefits – biogas as vehicle gas

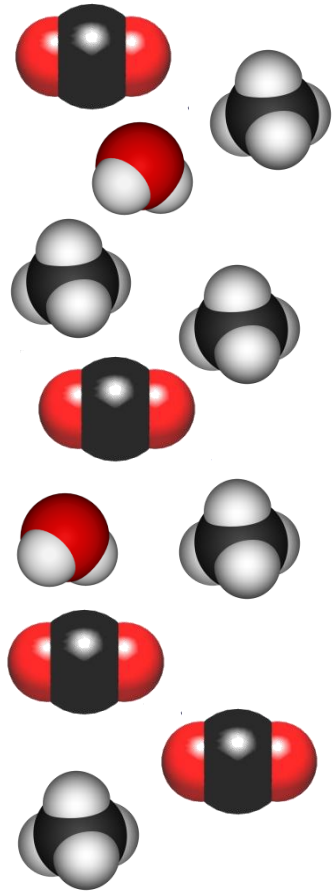
- Biogas is renewable – low CO₂-emissions
- 25 % less CO₂-emissions for natural gas compared to petrol
- Lower emissions of: NO_x, SO_x, particles
- Simultaneous production of biogas and fertilizer
- Decreased methane emissions compared to traditional manure storage

Biogas upgrading

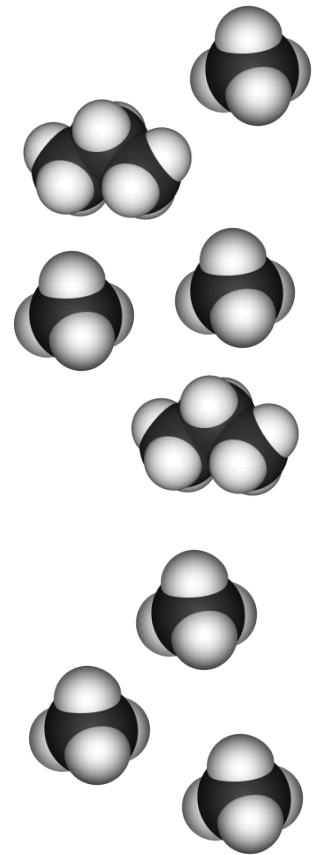
- Biogas upgrading plants in the Task 37 countries



Gas composition



| | | Biogas | Landfill gas | Natural gas (Danish) |
|-----------|--|--------|--------------|-------------------------|
| Compounds | Methane (vol-%) | 60-70 | 35-65 | 89 |
| | Other hydrocarbons (vol-%) | 0 | 0 | 9.4 |
| | Hydrogen (vol-%) | 0 | 0-3 | 0 |
| | Carbon dioxide (vol-%) | 30-40 | 15-50 | 0.67 |
| | Nitrogen (vol-%) | ~0.2 | 5-40 | 0.28 |
| | Oxygen (vol-%) | 0 | 0-5 | 0 |
| | Hydrogen sulphide (ppm) | 0-4000 | 0-100 | 2.9 |
| | Ammonia (ppm) | ~100 | ~5 | 0 |
| | Lower heating value (kWh/Nm ³) | 6.5 | 4.4 | 11.0 |



Swedish standard

- Particles < 1 μm
- Methane 97+/- 2 %
- Water < 32 mg/Nm³
- CO₂, O₂, N₂ < 5%
- Oxygen < 1 vol %
- Sulphur < 23 mg/Nm³
- N (except for N₂) expressed as NH₃ < 20 mg/Nm³
- Odorised
- Compressed to 200 bar

For grid injection: Addition of propane to reach the energy content of the Dansih natural gas (around 7-9 vol% is added)

Cleaning

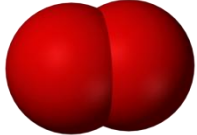


Water



Hydrogen sulphide

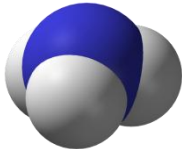
- Precipitation in digester
- Adsorption
- Absorption
- Biological treatment



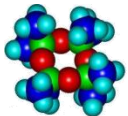
Oxygen



Nitrogen



Ammonia



Siloxanes



Particles

Upgrading

- PSA
- Water scrubbing
- Organic physical scrubbing
- Chemical scrubbing
- Cryogenic
- Membranes
- Technologies under development

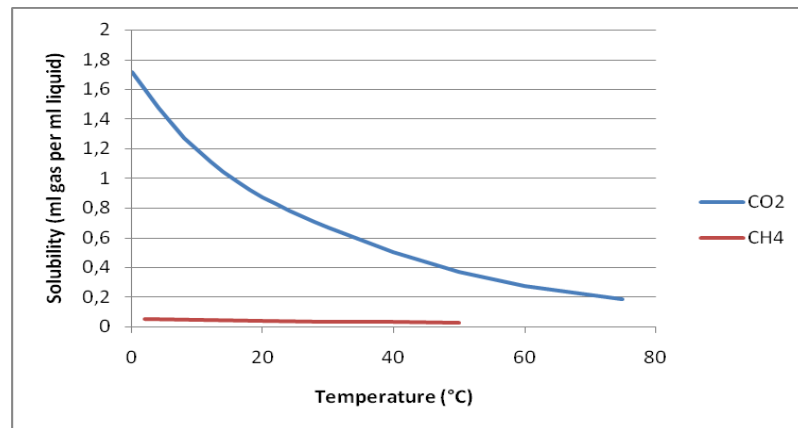
PSA

- Pressure Swing Adsorption
- Activated carbon or zeolites
- Regeneration by decrease in pressure
- Several vessels in parallel



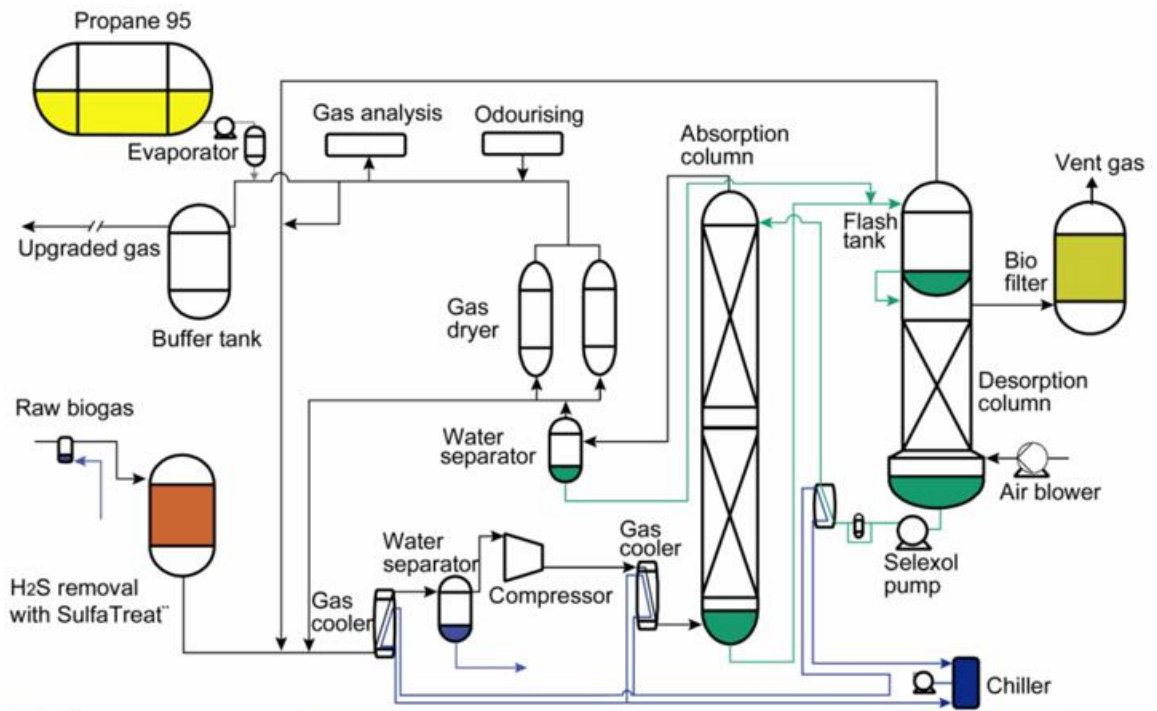
Water scrubbing

- Carbon dioxide dissolves in water
- Methane dissolves to a much lower extent
- Dissolved methane recovered in flash tank
- Water regenerated in desorption column



Organic physical scrubbing

- Similar to water scrubbing, but carbon dioxide is absorbed in an organic solvent such as polyethylene glycol instead of water.



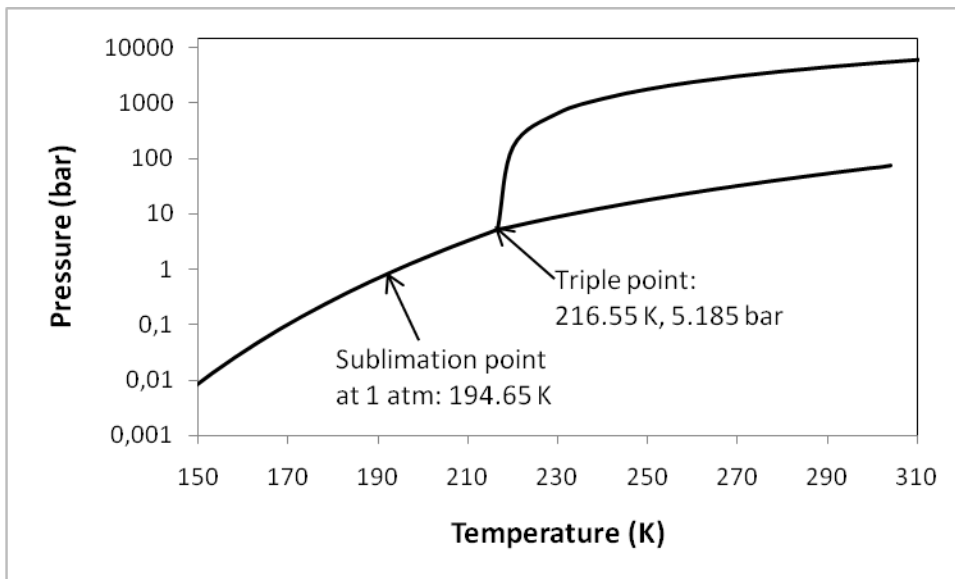
Chemical scrubbing

- Carbon dioxide binds chemically
- Selective reaction
- Low methane losses
- MEA or ETA in the liquid
- Regeneration by heating



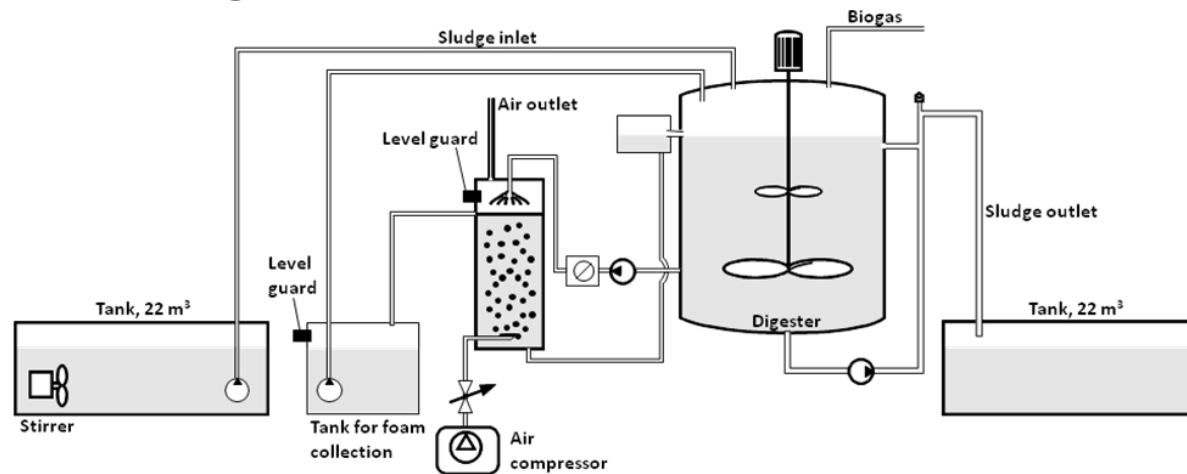
Cryogenic

- Separation by cooling
- Carbon dioxide removed as solid or liquid
- If cooled further liquid methane gas is formed



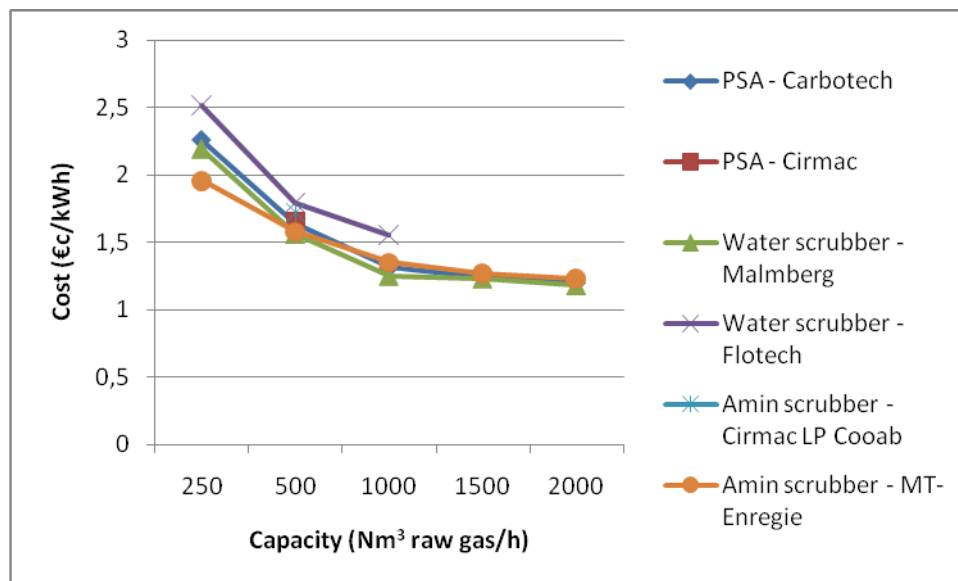
Other upgrading technologies

- Membranes
- Technologies under development
 - *In situ* methane enrichment
 - Ecological lung



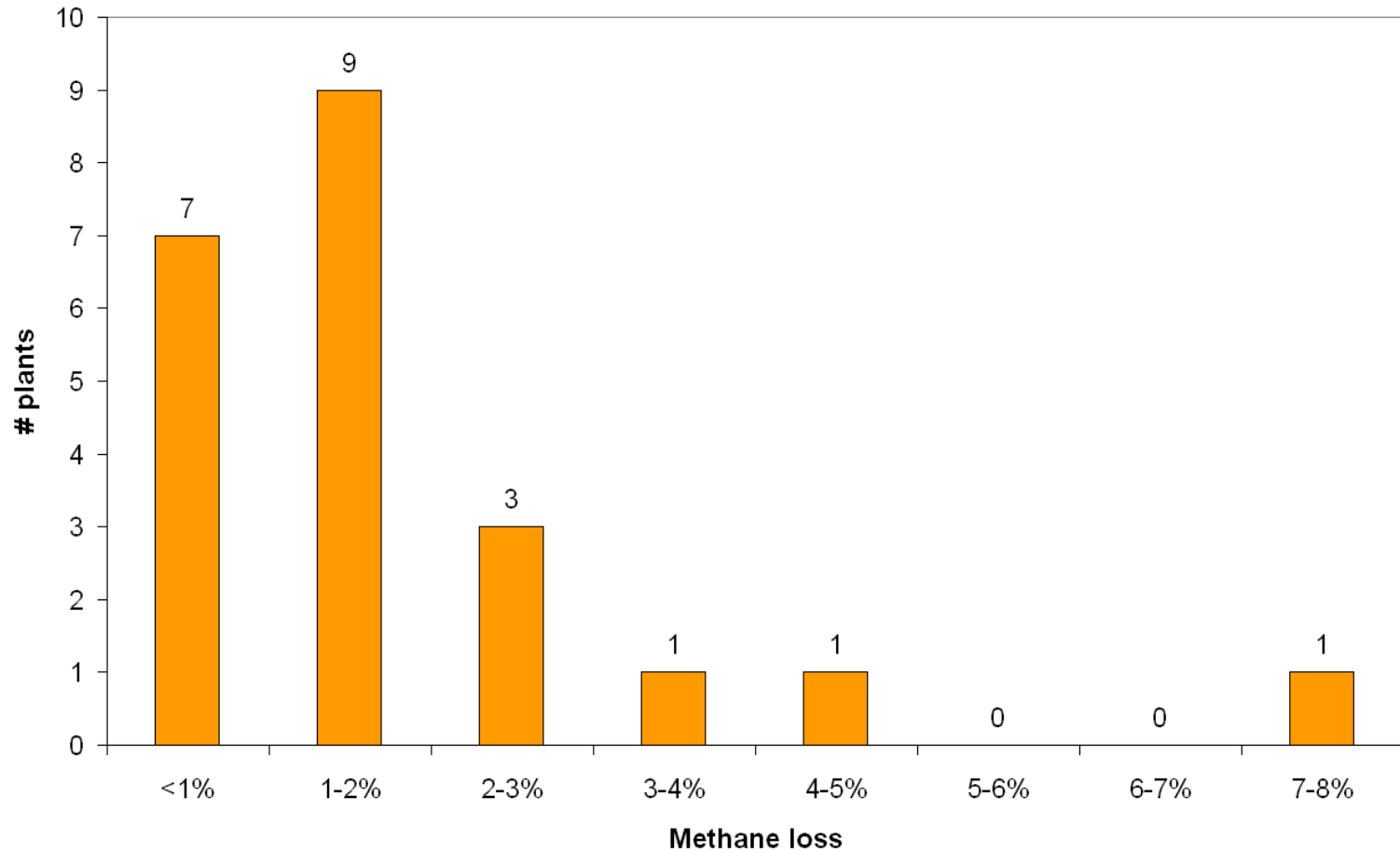
Schematic view of *in-situ* methane enrichment research plant. (Courtesy of Åke Nordberg, SLU, Sweden).

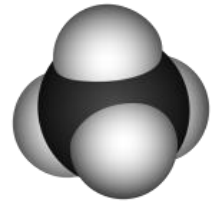
Upgrading - cost



Urban W, Girod K, Lohmann H. Technologien und Kosten der Biogasaufbereitung und Einspeisung in das Erdgasnetz. Ergebnisse der Markterhebung 2007-2008. Fraunhofer UMSICHT. 2008

Methane losses

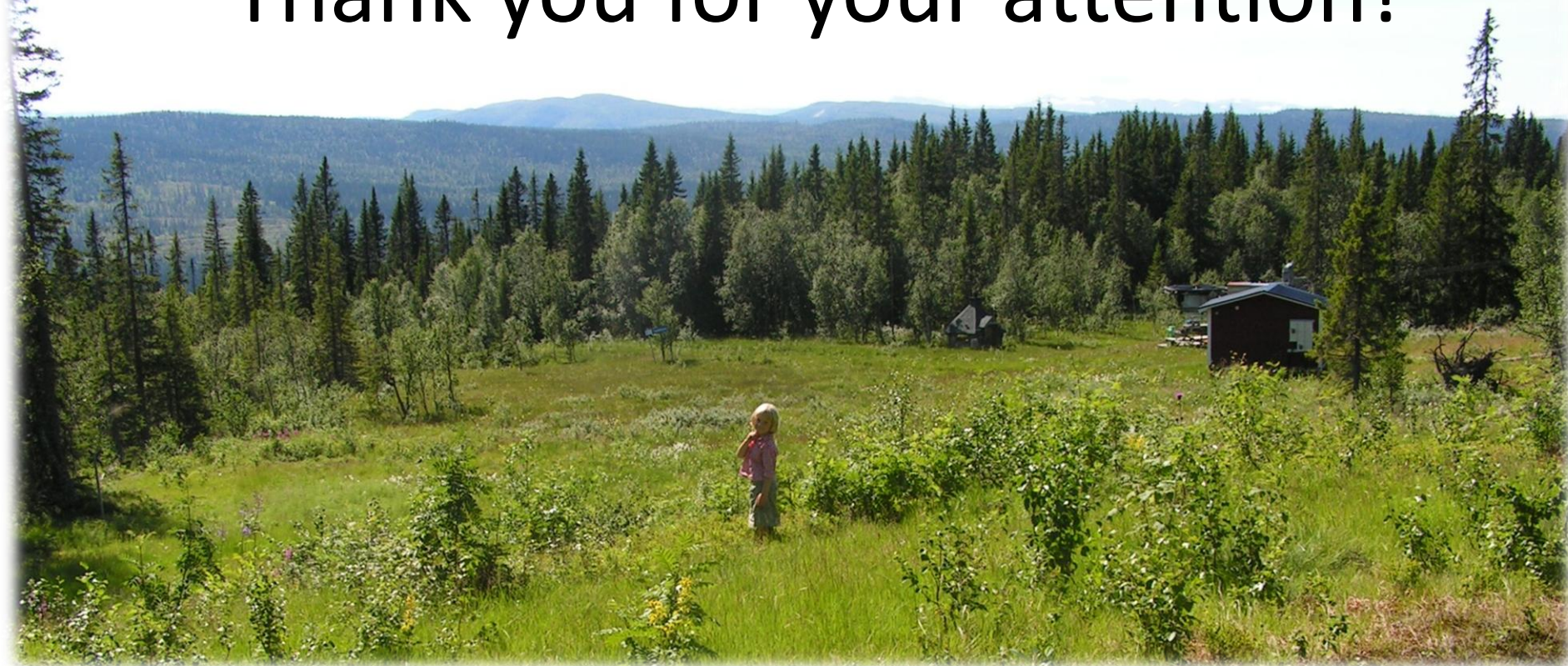




Conclusions

- Biogas is upgraded for utilization as a substitute to natural gas or as a vehicle fuel
- The treatment of the biogas can be divided into cleaning and upgrading
- Upgrading technologies
 - PSA
 - Water scrubber
 - Organic physical scrubbing
 - Chemical scrubbing
 - Cryogenic
 - Membranes
- Other technologies in research phase
- Many aspects, such as economical and environmental, have to be considered when plants are evaluated, or new plants are under planning

Thank you for your attention!



www.sgc.se

anneli.petersson@sgc.se

+46 40 6800764