Introduction to Small Scale Biogas Upgrading & Bottling in EU

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Natural gas grid in Europe
• In Europe, the highest percentage of the total production of biogas comes from the many small scale digesters producing small quantities of biogas (50-200 Nm$^3$ hour$^{-1}$).
  • not feasible to upgrade the gas to natural gas quality and to inject this upgraded biomethane into the natural gas grid or use it as commercial fuel at a gas station
  • the cost: quantity, quality control and the high performance requirement for gas transport/injection
• In general, small scale upgrading plants is not used commercially but only locally within a small community or farm
Small scale biogas upgrading can be made economically viable by reducing the main cost elements in upgrading i.e. electricity and water costs

- electricity generation from the produced on-farm biogas
- use of ground water for water scrubbing
- regeneration of the wash water
- upgrading at low temperature
- use of low-cost high pressure storage containers
- compressing to high pressures (250-270 bars) so as to reduce the electricity costs at filling station
Small scale upgrading plants in EU

- In 2012 there less than 15 small-scale biogas upgrading plants (< 50 Nm$^3$ hour$^{-1}$ raw biogas) in Europe
  - In general the small scale plants are pilot plants (testing new technology) and are quite often extended → no remarkable growth in amount of small scale plants
  - Approximately 7 plants are active in upgrading biogas for vehicular quality (97 % methane) and the remaining plants are mainly involved in grid injection
  - The main upgrading technologies for vehicle fuel quality in Europe are PSA and water scrubbing, also membrane technology used
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Kalmari farm, Finland

- Kalmari farm is an old family farm
- Biogas plant was installed 1998
- Vehicle fuel production since 2002
- High pressure waste scrubbing system
- A product gas with 92-99% CH₄ depending on the raw gas quality
  - 1-5% CO₂, <2% inert gases and <1 ppmv H₂S
- The upgraded product gas is dehumidified before entering the high pressure gas storage system (250-270 bar)
- Gas is dried using silica gel or alumina

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Biosling, Sweden

- Biosling process contains rotating spirals or coins of hoses.
- Biogas and water are fed into the outermost turn of the coil at pressure of 2 bar.
- Coil is rotated to improve water and gas contact.
- As the coil rotates, water columns will be forced inward and compress the gas in between.
- Water and gas is led out from the coil centre $\rightarrow$ CH$_4$ content up to 94%.

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Biosling, Sweden

• Compared to traditional water scrubbing technology, a lot of mechanical maintenance is minimised as the rotating coils replace pumps, compressors and gas-water mixers

• If e.g. 97% methane gas is required, a traditional scrubber column is added as a final upgrading step

• Technology allows scaling up e.g. farms with ~75 milk cows or up to about 900 cows can upgrade gas
Plönninge, Sweden

- Demonstration and research site
- The biogas upgrading plant has a raw biogas capacity of 17 Nm$^3$ hour$^{-1}$
- Water scrubbing process
- Iron chloride dosing in digester for H$_2$S removal before upgrading
- The aim is that the finished product will enable medium to large-scale farmers to become self-sufficient in fuel production
  - requires that more private farmers invest in small-scale digesters on their farms
Plucking, Austria

- PSA process
- Austria’s first biogas upgrading plant
- The biogas is upgraded to natural gas quality and is injected into the existing natural gas grid
- The upgrading plant capacity is 10 Nm$^3$ hour$^{-1}$ of raw gas
- First biological sulphur removal
  - From about 2000 ppm H$_2$S to max 200 ppm
- CO$\text{}_2$ separation and drying stage (PSA)
- Adsorption material activated carbon, molecular sieves
- Methane content in product gas 97%
Bruck an der Leitha, Austria

- The upgrading plant capacity: a biomethane volume flow of 100 Nm$^3$ hour$^{-1}$
  - corresponding to approximately 180 Nm$^3$ hour$^{-1}$ of raw biogas
- The upgraded biogas is fed into the EVN grid and is transferred to the gas station operator OMV and Vienna Energy to be used as biofuel and two CHP-gas engines (830 kWel each) producing electric power and district heat
- A two stage membrane process
  - H$_2$S is removed before membrane process (biological and adsorptive)
Bruck an der Leitha, Austria

- The raw biogas is mixed with the permeate flow of the second membrane stage (recycle)
  - compressed and dried by cooling to gas temperatures < 7 °C
- The gas is reheated (waste heat from the compressor) to the optimum temperature
- The permeate flow of the first membrane stage leaves the upgrading plant as off-gas.
- A zero-emission-operation regarding methane is achieved by transporting off-gas to the gas engines (CHPs)
- During standard operation the methane content of the product gas is 98% and the CO₂ content is 1.8%
Bruck an der Leitha, Austria
Bottling

- Usually used only outside gas grid
- In Sweden bottles are transported to gas filling stations by trucks
Economics of small-scale biogas upgrading (<100 Nm³ hour⁻¹)

- For small-scale plants, the most economical approach is to use the produced gas locally or as vehicle fuel
- There is a minimum production rate to make the system economical viable
  - the profit per Nm³ of upgraded gas should be about 35-45 € cents to achieve a pay-back time of 5 years, without taking profits from the CHP unit in account
  - meaning the cost price for the biogas upgrading less than 0.2-0.3 € Nm⁻³
- At least 20 to 25 Nm³ hour⁻¹ of upgraded gas must be produced to obtain a production price of approximately 0.2-0.3 € Nm⁻³
- When the investment only comprises the upgrading, and there is already a CHP on the location, then the payback time for the same situation is just 3-4 years

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Thank you!

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