Small Scale Biogas Upgrading Experience in Kalmari Farm, Finland

Saija Rasi, Ph.D.
23.08.2013, IIT DELHI
Background

- Kalmari farm is an old family farm
- Biogas plant was installed 1998
- Driver was need to get animal manure more hygienic and produce heat for farm estate
- CHP production to remove day time electricity purchase from grid
- Vehicle fuel production since 2002
- 10 fold larger bioreactor with more diversified feedstock capabilities in 2008
- Founding of Metener Ltd
Current status

- Cow manure 2000 t / a
- Animal by-products 500 t / a
- Plant based food industry waste 200 t / a
- Sufficient heat production to cover farm, workshop and crop drying need (200 MWh/a)
- 2/3 of needed electricity (100 MWh/a)
- Biomethane sales 1100 MWh/a
High pressure water scrubbing technology

- The main difference with respect to traditional water scrubbing technology is the utilisation of high pressure water in batch absorption columns.
- First raw biogas is compressed to buffer storage where it flows to fill the upgrading column.
- Once the column is completely filled, the gas flow is cut off and the column is filled with water by a high pressure water pump.
- Carbon dioxide and sulphurous compounds are absorbed into the water and simultaneously the gas is pressurised to ~150 bar.
Process:

Absorption column 1 → Absorption column 2 → Collector column

Water in → Flash-unit → Regeneration column

Exhaust gas out

Water storage

Raw gas in → Compressor

Gas circulation

Clean water in

Used water back in the process or out

© MTT Agrifood Research Finland
• After the scrubbing cycle, wash water is recycled to the process after a regeneration step
• During regeneration, the absorption column is filled with raw biogas and cycle begins again
• Two parallel columns operate in different phases, one filling (compression) and other emptying (regeneration) phase
• The product gas is stored in intermediate pressure bottle banks or boosted by hydraulic compressor to the high pressure bottle banks of the refuelling station
Product gas

- The upgraded product gas is H-level biomethane with energy content 36-50 MJ kg\(^{-1}\) and 30-40 MJ Nm\(^{-3}\).
- The Wobbe index is 45.6-54.7 MJ Nm\(^{-3}\).
- During normal operation, the upgrading unit produces a product gas with 92-99% CH\(_4\).
- Product gas contains 1-5% CO\(_2\), <2% inert gases and <1 ppmv H\(_2\)S.
- Gas is dried using silica gel or alumina.
Process advantages

- Simplicity, gained by combining the scrubbing and pressurisation phases
- The compact size of the plant
- The technology is most suitable in the range of 30-100 Nm$^3$ hour$^{-1}$ raw biogas
- Units are easily fitted and delivered in a container
New filling station

- In 2011, a new card vehicle filling station with high pressure gas tanks (300 Nm³, 270 bar) was installed
- Currently, around 100 vehicles including two delivery lorries and one taxi use the upgraded biomethane as vehicle fuel
Economics

- The total cost of upgrading is estimated to be around 0.32 €kg\textsuperscript{-1} biomethane.
- Electricity and water consumption are the main components and account for 87% of the total upgrading cost.
- High pressure absorption system and filling station total energy use is 0.85 kWh/Kg product gas upgraded and pressurised.
- Water use 0.02-0.03 m\textsuperscript{3} / Kg of product gas.
- Maintenance cost estimate 0.04-0.08 Euro / Kg of upgraded and pressurized gas.
Low pressure water absorpiton unit

- "Traditional" water scrubber was developed under Valorgas project
- Aim was to meet same simplicity and robustness as with high pressure system
- Goal was met and better gas quality was achieved, but with slightly higher energy consumption compared to high pressure system
- Standard Unit 10 m³/h
Other applications

- High and low pressure water absorption systems were used for landfill gas upgrading


Thank you!

Saija Rasi, Ph.D.
saija.rasi@mtt.fi
Phone: +35829 5317655