Small Scale Biogas Upgrading Experience in Kalmari Farm, Finland

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SEVENTH FRAMEWORK PROGRAMME

VALORGAS

Backround

- 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 diversed feedstock capabilities in 2008
- Founding of Metener Ltd

Current status

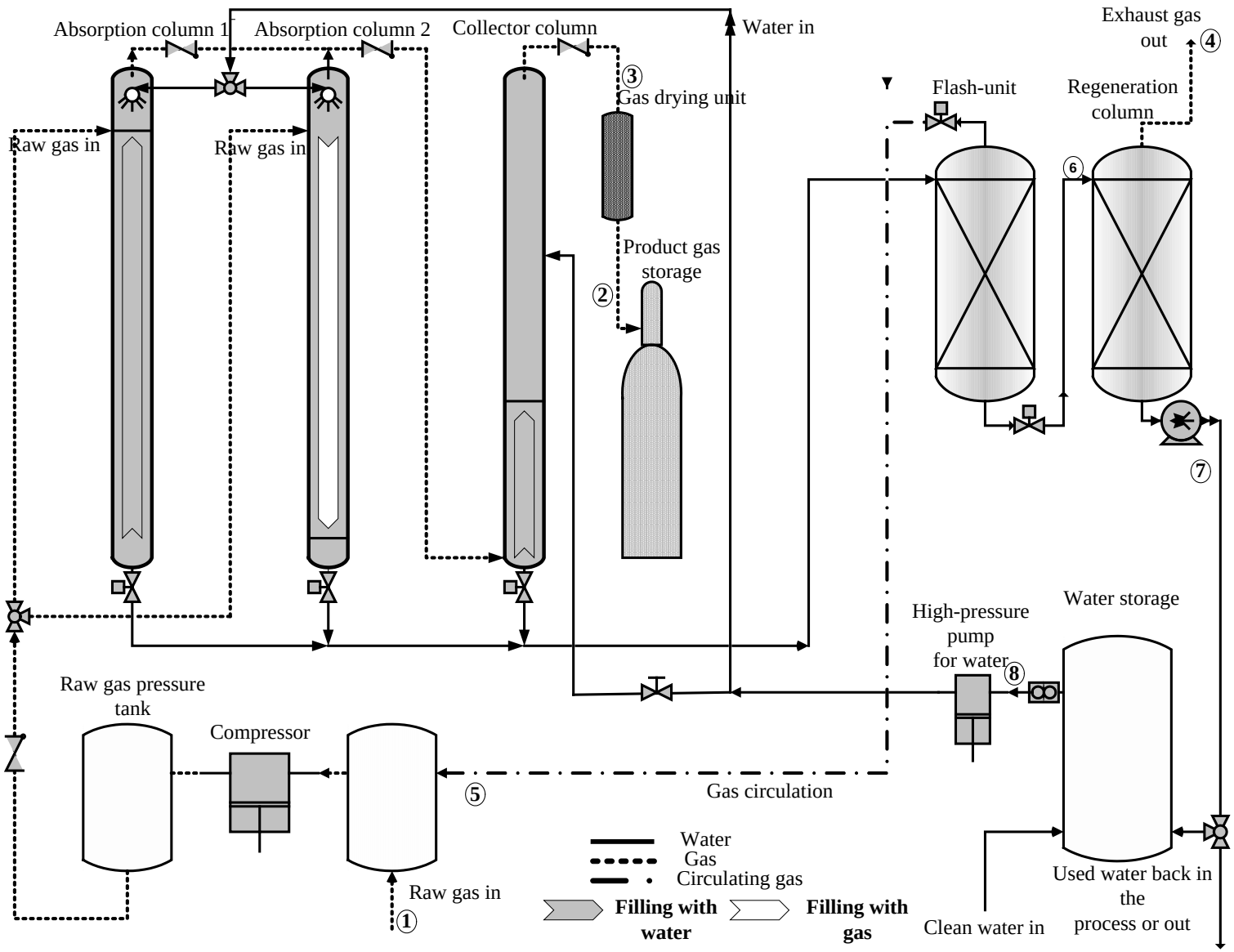
- Cow manure 2000 t / a
- Animal by-products 500 t / a
- Plant based food industry waste 200 t /a

- 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:



- 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_2S.
- 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 Nm^3, 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^{-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^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 m^3/h

Other applications

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

Rasi, S., Läntelä, J. & Rintala, J. 2014. Potential of high pressure water absorption process for landfill gas upgrading. Fuel 115: 539-543

Rasi, S., Läntelä, J., Veijanen, A. & Rintala, J. 2008. Landfill gas upgrading with countercurrent water wash. Waste Management. 28:1528-1534.

Thank you!

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Photo: www.valtra.fi