Introduction to Small Scale Biogas Upgrading & Bottling in EU

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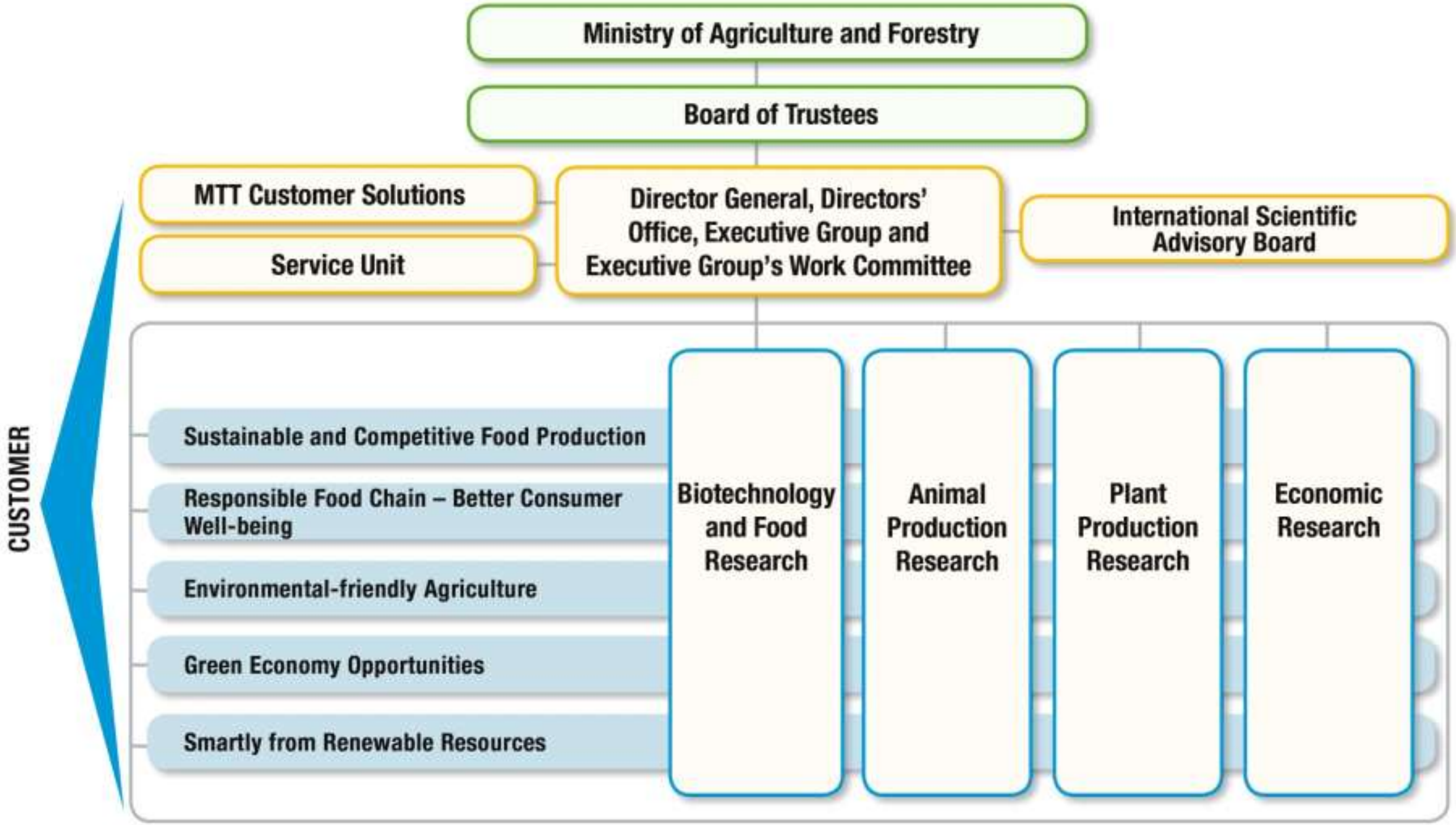
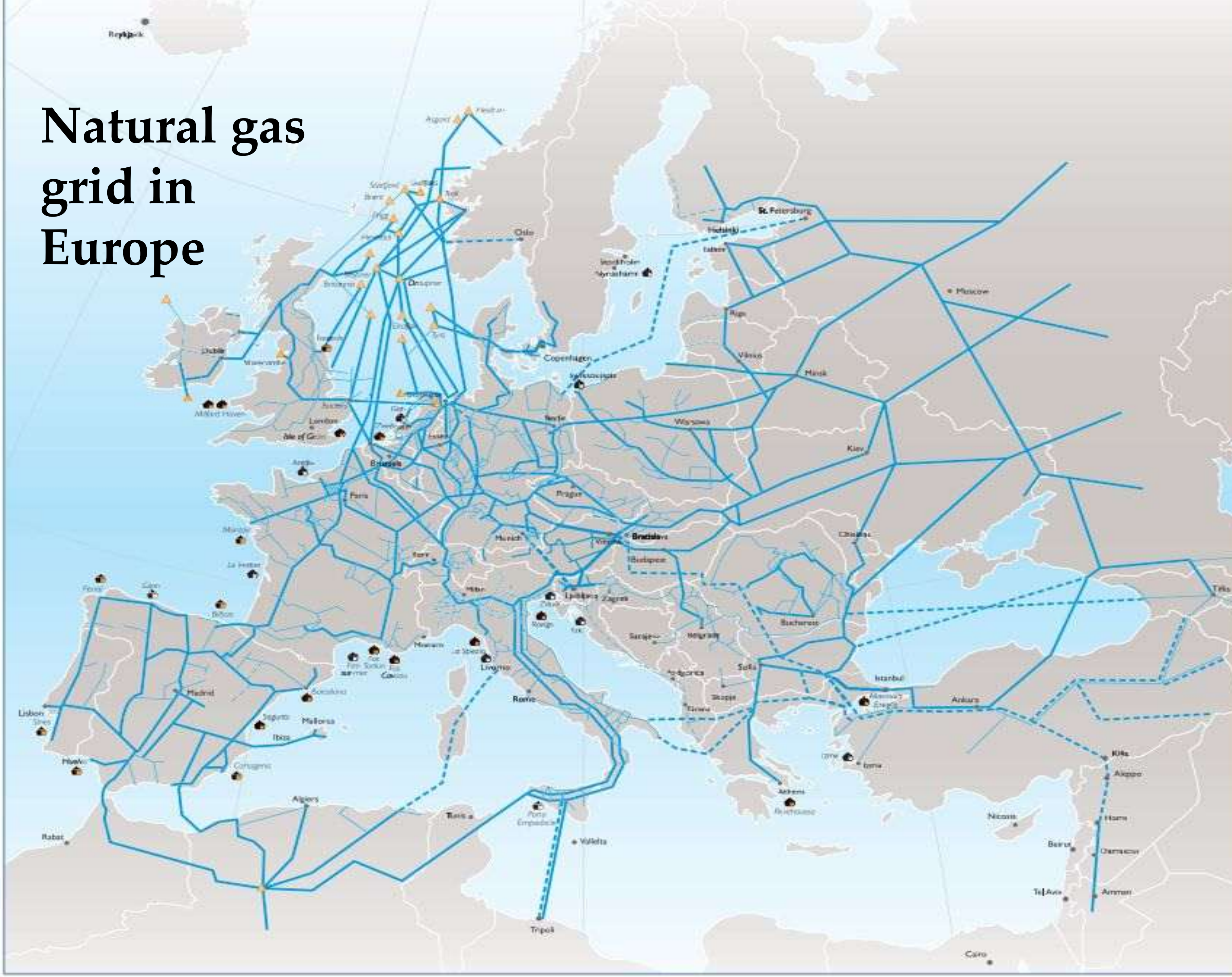


Natural gas grid in Europe



Backround

- 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 (testin new technlogy) 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

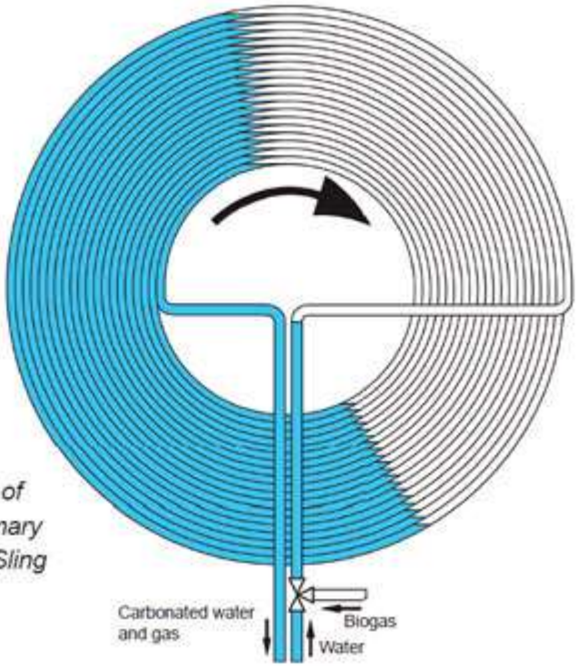
Place	Substrate	Utilisation	CH_4 requirements (%)	Technology	Plant capacity (Nm^3/h raw gas)
Finland	Energy crops, manure	Vehicle fuel	96	Water wash	30
Austria	Manure	Gas grid	97	PSA	10
Sweden	Sewage sludge	Vehicle fuel	97	PSA	20
Sweden				PSA	25
Switzerland	Biowaste	Vehicle fuel	96	PSA	30
Switzerland	Biowaste	Gas gris, vehicle fuel	96	PSA	50
Switzerland	Biowaste	Gas grid	96	PSA	50
Switzerland	Biowaste	Vehicle fuel	96	PSA	50
Norway		Gas grid, vehicle fuel	97	Water wash	
Hungary	Sewage sludge	Gas grid, vehicle fuel	97	Water wash	50
Netherlands	Landfill gas	Gas grid	88	Membrane	50

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% CH_4 depending on the raw gas quality
  - 1-5% CO_2, <2% inert gases and <1 ppmv H_2S
- 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

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



Schematic picture of coil pump, the primary component of BioSling

- 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 → CH_4 content up to 94%

Biosling, Sweden

- Compared to traditional water crubbing 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 scubber 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_2S 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_2S to max 200 ppm
- CO_2 separation and drying stage (PSA)
- Adsorption material activated carbon, molecular sieves
- Methane content in product gas 97%

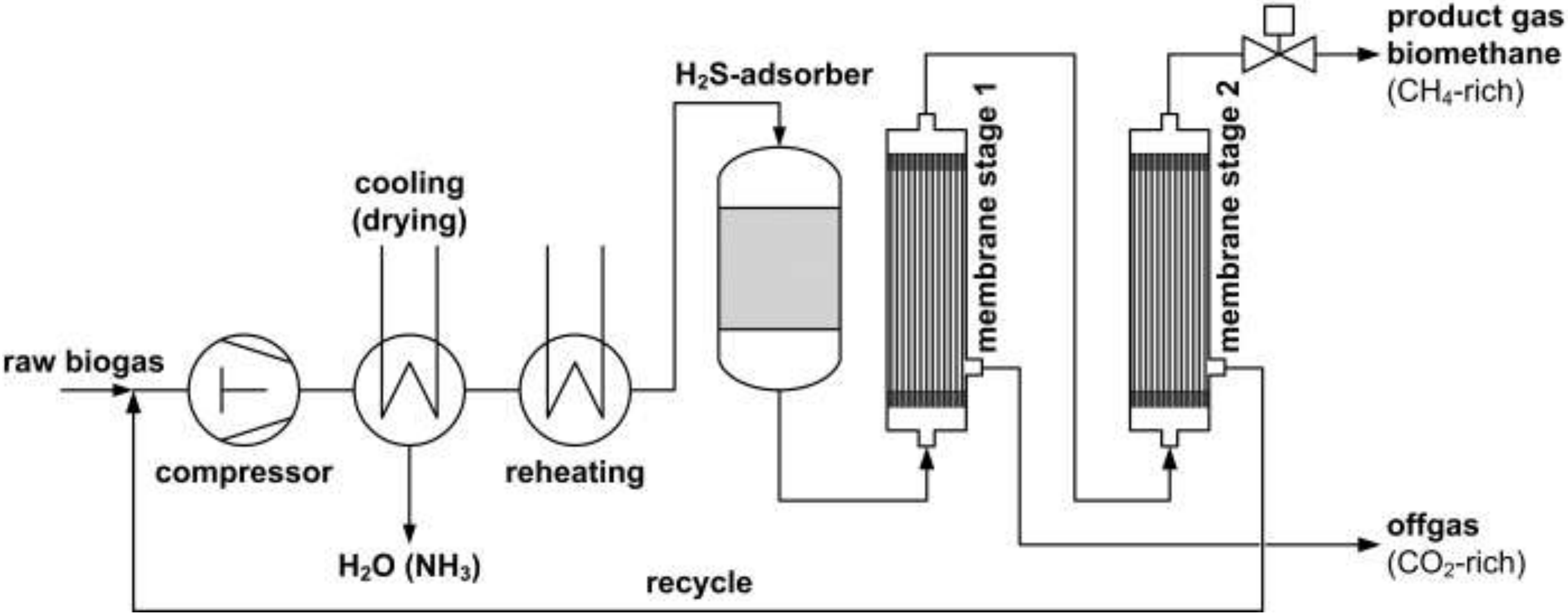
Bruck an der Leitha, Austria

- 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_2S 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 CO_2 content is 1.8%

Bruck an der Leitha, Austria



Bottling

- Usually used only outside gas grid
- In Sweden bottles are trasported to gas filling stations by trucks

Economics of small-scale biogas upgrading (<100 Nm^3 $hour^{-1}$)

- 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 Nm^3 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 Nm^3 $hour^{-1}$ 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

Thank you!

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