FROM BIOGAS TO GREEN GAS

Upgrading techniques and suppliers

Biogas is produced by fermenting plants such as crop residues, liquid residues and maize, often in combination with animal manure. It is usually used to generate electricity. However, there is a more sustainable and profitable option: to upgrade the biogas and inject it into the national gas grid. Biogas that has been upgraded to natural-gas quality is known as 'green gas'.

The Dutch government (Cabinet Balkenende IV) and other EU Member States have set ambitious targets for making energy supplies more sustainable. The Dutch goal is to achieve 20% sustainable energy by 2020. Making the gas supply more sustainable can make an important contribution to this target.

Around 10% green gas in 2020

The pre-conditions are present: green gas can be certified (just like green electricity) and there is financial support available via the SDE scheme (an incentive scheme for sustainable energy production). In its vision document 'Let's give full gas!' the Green Gas working group states a target of 8–12% natural-gas replacement by the year 2020. This target is included in the Energy Innovation Agenda, as one of the subjects that the Dutch Cabinet plans to focus on over the next few years.

Green gas based on fermentation

Green gas can be produced in two ways: by upgrading biogas (from fermentation of wet biomass) to natural-gas quality, or by gasification of biomass. This brochure explains green gas production based on fermentation, details example projects and lists suppliers of these installations.

UPGRADING BIOGAS

Increasing methane levels...

When upgrading biogas to green gas the energy content is increased until the Wobbe-index is equal to that of natural gas. A higher methane content is achieved by extracting the CO_2 from the biogas.

...and cleaning

Siloxanes (organic materials, such as chlorine, sulphur etc.) also need to be removed in a pre-treatment or post-treatment process. Cleaning is important in order to prevent air pollution, contamination of surface water, as well as pollution of engines, for example.

Creative Energy
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UPGRADING TECHNIQUES

Determining which is the best, most efficient upgrading technique for a particular situation depends on so many factors that this can only be decided on an individual basis. However, a few initial guidelines can be given.

If the plant capacity is over 2000 Nm^3 per hour, then membrane filtration is less economically viable. If residual heat is available at the location, this is an extra plus point for amine gas cleaning (Cirmac LP Cooab), because this results in extremely low electricity consumption. Only the cryogenic technique produces industrial-quality liquid CO_2. (See table for further details.)

Costs

In order to make a correct comparison of investment and operation costs, the necessary costs for pre/post treatment also need to be taken into consideration, as well as the savings in useful utilisation of residues. Price comparisons of the 'basic installation' usually give a false picture, because one supplier integrates all process stages into a single installation, and another takes a different approach. In a report published at the end of 2008 the German Fraunhofer UMSICHT compared gas scrubbing and PSA techniques of various manufacturers, including Cirmac. The investment costs of a 500 Nm^3 capacity plant were around one million euro. The scale advantages are considerable, particularly when scaling up from 250 to 500 Nm^3. For further details this report can be obtained from the secretary of the Committee for Green Gas.

PROJECT

WSTP Mijdrecht

Upgrading technique:

Gas cleaning (LP Cooab technique)

Equipment supplier:

BioGast, using Cirmac technique

The Waternet wastewater sewage treatment plant has produced green gas since the end of 2008. Around 280,000 Nm^3 of biogas are upgraded annually, into 205,000 Nm^3 of green gas. This amounts to 30 Nm^3 of green gas per hour. The green gas is then injected into the natural gas grid (Stedin) and used as a transport fuel.

	FROM BIOGAS TO GREEN GAS: UPGRADING TECHNIQUES			
	GAS CLEANING	**CRYOGENIC TECHNIQUES**	**VPSA**	**MEMBRANE FILTRATION**
	Liquid absorbs CO_2	Separating liquid CO_2	Active carbon adsorbs CO_2	Separating CO_2 via a membrane
Dutch suppliers	• **Cirmac** (LP Cooab-technique) • **DMT** (TS-PWS process) • **See also De Marke project***	• **GTS** (GPP-technique)	• **Cirmac** (VPSA = vacuum swing adsorption)	• **Cirmac** • **Van der Wiel Stortgas**
Methane loss (without using residue gas)	< 0.1% (Cirmac) < 1% (DMT)	< 0,5%	1–3%***	15–20%****
Methane content product gas	max. 99,5% (Cirmac) max. 98% (DMT)	max. 99,5%	max. 98%	max. 90%
Working pressure	atmospheric (Cirmac) 8–10 bar (DMT)	10–18 bar	6–8 bar	6–8 bar
Electricity consumption	0,05–0,12** kWe/Nm^3 raw gas (Cirmac) 0,20–0,25 kWe/Nm^3 raw gas (DMT)	0,20–0,28 kWe/Nm^3 raw gas	0,25 kWe/Nm^3 raw gas	0,20 kWe/Nm^3 raw gas
Comments	CO_2-exhaust gas can be utilised usefully	Pure CO_2 (liquid) as useful by-product		Equipment is compact, simple and lightweight

The aforementioned figures are indications only, based on information provided by the suppliers.

* This demonstration project (see back page) used a third gas scrubbing technique, developed by TNO, Techno Invent and LTO Noord.

** 0.05 kWe/Nm^3 applies if compression is not necessary (such as when injecting into the 100 mbar low-pressure grid). The energy consumption increases if compression is used to inject at higher pressures. Heat is also necessary to regenerate the absorption substance. The advantage of much lower energy consumption therefore only remains if there is residual heat available.

*** Up to 3% of the (strong greenhouse gas) methane ends up in the residual gas. This methane emission may not be acceptable to competent authorities that issue permits, so additional measures may be required.

**** With membrane technology (and from an efficiency point of view), the permeate gas should be used to generate energy.

SUPPLIERS

Cirmac International Cirmac has specialised in biogas upgrading systems for over 20 years. The company's LP Cooab-technology (CO_2 absorption by an amine) has less than 0.1% methane loss, very low electricity consumption, and high energy efficiency. A useful byproduct: pure CO_2 gas. Exhaust-gas treatment is not necessary. The process works on atmospheric pressure and is easily controlled: the supply pressure can be changed easily. Increased pressure does require more electricity. Cirmac systems are being operated both inside and outside the Netherlands, with capacities ranging between 160 and 1600 Nm^3 per hour. Systems with capacities of 60–3450 Nm^3 per hour are now being built, which show that Cirmac systems are economically viable at various scale sizes.

DMT Environmental Technology DMT is a member of the Coalition for Driving on Biogas, and has specialised in desulphurisation and upgrading processes for biogas for over 20 years. The TS-PWS process used by DMT is a further development of the PWS (pressure water scrubber) technology. This process has been developed in order to remove CO_2, hydrogen sulphide, ammonia, higher hydrocarbons and siloxanes, and to minimise waste residues. Gas is dried and brought up to a pressure of 8–10 bar. The only residue: air with a high concentration of CO_2. This can be used in commercial horticultural greenhouses. Capacities of 100–5000 Nm^3 per hour are possible. The equipment is compact and is constructed (on a modular basis) in shipping containers.

Gas Treatment Services (GTS) This company manufactures an innovative cryogenic technique that upgrades biogas to natural-gas quality and also produces industrial-quality liquid CO_2. This can be used in commercial greenhouses, beer breweries etc. The system consists of four stages:

(1) gas compression,
(2) gas drying, removing pollution, followed by cooling to -25°C,
(3) further gas cleaning with a catalytic filter,
(4) CO_2 removal and upgrading to the required quality.

Since gas cleaning and CO_2 extraction are combined, it is not necessary to remove the sulphur beforehand. Methane losses are low: max. 0.5%. GTS supplies standard systems that can cope with 50–2500 Nm^3 biogas per hour.

Van der Wiel Stortgas This company offers a wide range of solutions and services regarding environmental techniques. In order to upgrade biogas to natural-gas quality, Van der Wiel supplies equipment that can cope with an input of 200–3000 Nm^3 per hour.

CO_2 is removed at low pressure using membrane filters – this is a dry process that uses no chemicals. Contamination by sulphur, fluorides and chlorine is removed from the gas using active carbon. The complete installation is mounted on a galvanised steel skid. The control system is built into an insulated and ventilated room. Van der Wiel supplies three standard units with a maximum input of 400, 800 or 1200 Nm^3 per hour, for biogas with less than 8% nitrogen and less than 100ppm sulphur.

PROJECT

WSTP Beverwijk

Upgrading technique:
membrane filtration
Equipment supplier:
BioGast
using Cirmac technology

The wastewater sewage treatment plant operated by the Hoogheemraadschap Hollands Noorderkwartier (HHNK) upgrades 1.4 million Nm^3 of biogas into 650,000 Nm^3 of green gas on an annual basis. This is 80–100 Nm^3 of green gas per hour. The methane content in the biogas is 62%, and 89% in the product gas. The permeate gas is used to heat the fermenter. The green gas is injected into the natural gas grid (Stedin) and used for transport.

PROJECT

Bergerden horticultural area

Upgrading technique:
cryogenic
Equipment supplier:
GTS

Arable farmers in the horticultural area between Arnhem and Nijmegen have set up an association known as the Bio Energie Bergerden (BEB). This company plans to produce biogas by fermenting around 36,000 tons of biomass per year, half of which is manure. The residues from the fermentation process can be used as organic fertiliser.

Green gas

The aim is to inject 5 million Nm^3 of green gas per year into the local natural-gas grid. During the winter, production of 600 Nm^3 per hour covers one-fifth of the need and can even be fully sold during the summer months, when less heating is required.

Industrial-quality liquid CO_2

The biogas, with 50–60% methane, is upgraded into green gas. The cryogenic technique releases clean liquid CO_2 that can be used in the food industry and as crop-enhancing gas in the horticultural areas. The process heat and electricity (cogeneration) required will be derived from the area itself.

Plans

BEB hopes to start producing green gas in 2009. The installation has been sized such that production can be expanded considerably, as required. Other green gas products, such as LBG (liquid biogas) are also being considered.

PROJECT

Natuurgas Overijssel

Upgrading technique:

gas cleaning

Natuurgas Overijssel, a cluster of waste organisations ROVA and HVC Groep, process 30,000 tons of household compostable waste into 12,000 tons of compost and over 3 million Nm^3 of biogas, with a methane content of 50–70%. The gas upgrade equipment processes the biogas into natural-gas quality at a rate of 400 Nm3 per hour.

Project 'Rijden op GFT ' (driving on compostable waste)

As part of this project, a number of vehicles demonstrate driving on green gas. Vehicles were selected that had been fitted with natural-gas engines by the manufacturer. Cars, delivery vans and buses, as well as the most modern dustcarts and street-cleaning machines can also run on gas. In Zwolle, a public filling station has been fitted with a refuelling point for green gas. The project is financed by Natuurgas Overijssel, Salland Oil and the province of Overijssel.

Groen gas in natural-gas grid

At the beginning of 2009, Natuurgas Overijssel, Gasunie and Enexis signed a collaboration agreement to implement a demonstration project. A new pipeline (8 bar) will transport green gas to a compressor, from where it will be injected into the high-pressure (40 bar) grid run by Gasunie. The supply of green gas to clients will be based on a certification system, such as also exists for green electricity. The province of Overijssel and Gasterra also contribute to this project.

RESEARCH INTO EFFICIENCY

The installation includes a range of facilities to minimise micro-organisms and other substances. The gas is eventually passed through a HEPA filter (this type of filter is also used in hospitals). Part of the project objectives are to study whether or not these extra measures are really necessary, and how risk minimisation can be achieved more efficiently and economically in the future.

PROJECT

Experimental farm: De Marke

Upgrade technique:

gas cleaning

Equipment supplier:

TNO/Techno Invent/LTO Noord

Using a technology developed by TNO (among others), the plant at De Marke processes biogas into gas that contains over 95% methane, which is ideal for use as a transport fuel. Natural-gas quality is achieved by adding nitrogen. The equipment is compact (2.5 x 2.5 x 4.5 m) with a capacity of 500 Nm3 per hour, and is entirely automatic. It is profitable at capacities of 50 - 500 Nm^3 per hour. Methane losses are less than 0.5%.

TNO desulphurisation technology

In a single simple cleaning step, all pollutants (CO_2, hydrogen sulphide, ammonia and silanes) are removed from the biogas. The TNO-developed desulphurisation technology forms the basis for the system. The resulting sulphur slurry is reinjected into the digestate, and used as fertiliser.

For natural-gas grid and tractors

The green gas contains less than 1 ppm of hydrogen sulphide, which is well below the maximum of 3 ppm that the Gasunie has set for injection into the gas grid. The green gas is injected into the regional gas grid at De Marke (Liander) and is used for tractors.

BIOGAS UPGRADING IN BRIEF

Who benefits from upgrading biogas?

- Farmers and market gardeners
- The food and luxury food industry
- Waste processors
- Transport sector
- Project developers and investors
- Authorities, especially provincial authorities

Where is biogas produced?

- At co-fermentation plants in the agricultural sector
- At fermentation plants based on waste streams from the food and luxury food industry
- At water purification plants with sludge fermentation
- At the existing landfill refuse sites where landfill gas is upgraded

What are the advantages of upgrading to green gas?

- No energy is lost in the form of heat, which is almost always the case when electricity is produced from biogas
- Green gas can be transported via the natural-gas grid and used in vehicles with natural-gas engines

Which companies in the Netherlands provide the necessary technology?

- BioGast: www.biogast.nl
- Certified Energy: www.certified-energy.nl
- Cirmac International: www.cirmac.com
- DMT Environmental Technology: www.dmt-et.nl
- Gastreatment Services: www.gastreatmentservices.com
- Van der Wiel Stortgas: www.vanderwiel.nl

This list is not exhaustive.

Further information

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