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INTELLIGENT INFRASTRUCTURE FOR USING BIOGAS

Biogas microgrids and stand-alone biogas filling stations

bmvit
Austrian Federal Ministry of Transport,
Innovation and Technology

NEW STRATEGIES FOR UTILIZING BIOGAS PROFITABLY

For biogas to be utilized efficiently and profitably, intelligent infrastructure is required, making it possible to integrate this source of energy into existing energy systems. Alongside feeding treated biogas into the grid (as with the pilot facility in Bruck an der Leitha described in FF 2/2009), both microgrids to supply settlements and industrial estates, and stand-alone biogas filling stations, have great promise for the future.

Within "Energy Systems of Tomorrow" HEI Eco Technology GmbH have (in collaboration with partners from science and industry) investigated various approaches to making biogas facilities more profitable. These approaches make it possible to develop new infrastructure and new business openings, and to integrate biogas into the overall energy system satisfactorily.

Given the availability of substrates, its excellent energy yield per acre, minimal pollution and wide choice of applications and storage forms make biogas a very promising alternative to natural gas. However, business data surveys for biogas in Austria reveal that the biogas sector is in a very critical state (cf. "Biogas Branchenmonitor – Erhebungen von Wirtschaftsdaten und Trends zu Biogas in Österreich", 2008). At the moment there are roughly 340 biogas facilities in Austria; 48% of the facility operators made a loss in 2007 and 2008, and 60% would not invest in a biogas facility again. 32% of the operators are actually considering closing their facilities down. This difficult situation is attributable partly to rising substrate prices (while the feed-in tariff for electricity from renewable sources stays unchanged) and partly to the fact that the waste heat from generating electricity is not utilized satisfactorily. There is thus an urgent need to develop new, economically attractive alternatives for using biogas.

Almost half the operators of biogas facilities admit to keen interest in new sales channels such as biogas filling stations, feeding biogas into the grid or biogas microgrids. But they have little or no information about the legal situation, possible business models and state-of-the-art facility engineering.

In a biogas microgrid purified, treated biogas is supplied to consumers at low pressure. This approach, which involves comparatively low costs, is an opportunity to earn significantly more cash than by generating electricity, where the State lays down fixed tariffs that in many cases do not cover the costs incurred.

One of HEI Eco Technology GmbH's projects was concerned with investigating the economic and technical feasibility of biogas microgrids. A second report (now completed) analyses the chances of providing low-cost biomethane filling stations nation-wide.

Photo: Universität für Bodenkultur, Institut für Landtechnik

Both reports indicate that the new approaches are in principle feasible and profitable, provided that:

- low-cost substrates or waste are used to generate biogas, or the biogas is obtained from electricity-generating facilities by feeding in more raw material
- biogas microgrids have a back-up supply arrangement – fuel switching or the natural-gas grid
- biogas filling stations are coupled to biogas microgrids or can feed into the grid (costs can be cut if facility components are shared)
- gas filling stations' spare compression capacity is used to supply biogas to locations not connected to the grid

Another point: for biogas filling stations and biogas microgrids to be profitable, close cooperation between biogas producers, grid operators and gas consumers is essential. This is the only way to achieve low production costs and use the equipment to the full, thus staying in the black. Cooperative arrangements would make both highly efficient utilization of biogas and new business models possible, and could ensure failproof supply to gas filling stations and public facilities in areas not connected to the grid.

The issue of reliable, efficient energy supply to provide services and products, both essential and convenient, is critical for a sustainable economy. The aim of the BMVIT (Austrian Federal Ministry of Transport, Innovation and Technology) subprogram "Energy Systems of Tomorrow" is to develop technologies and strategies for an efficient, flexible energy supply system based on exploiting renewable sources of energy and capable of meeting our energy needs indefinitely. Deploying a wide range of technology-related modules and concomitant activities is intended to provide impetus to this sector, and thus open up new opportunities for Austrian business.

Photo: Axiom Angewandte Prozesstechnik GmbH

PROJECT

MODELS OF LOCAL GAS SUPPLY VIA BIOGAS MICROGRIDS

In a biogas microgrid biogas generated locally is supplied to a number of consumers in a limited area through a network of low-pressure gas pipes. The biogas producers (agricultural, commercial or industrial) and consumers are linked together via the microgrid.

For a biogas microgrid it is vitally important that supply to the consumers is reliable and secure. It must therefore be ensured that peak demand for biogas can be met all year round. In addition the biogas facility must be capable of satisfying the criteria for feeding in throughout (purity, pressure, storage and treatment). Depending on size and the extent of expansion, it may be worth adopting a modular structure, so that an additional generator, more consumers etc. can be linked up.

Biogas microgrids vary in the following respects:

- Production: one or more than one producer
- Self-sufficiency / reliability of supply: independent grid or connected to main natural-gas grid
- Load management: supply-side and /or demand-side
- Consumer structure: predominantly commercial versus housholds
- Gas quality: constant or fluctuating methane content, partial or full gas treatment

Biogas contains significantly less methane than natural gas does. Where biogas needs to be supplied at natural-gas purity, elaborate treatment at no small cost is necessary, e.g. by means of pressure water scrubbing, pressure-swing adsorption, amine scrubbing, cryogenic treatment or membrane technology. In the case of biogas microgrids it may be possible to do without (part of) the purification train (methane content less than in natural gas as per ÖVGW G 31). Thus a biogas microgrid can supply biogas that has been partially, not fully treated straight to the consumers at low pressure. Depending on the exact details of treatment, the biogas supplied contains between 50% and 99.5% methane.

As part of HEI EcoTechnology GmbH's project, the logic, layout and operation of biogas grids has been described and the following investigations have been carried out:

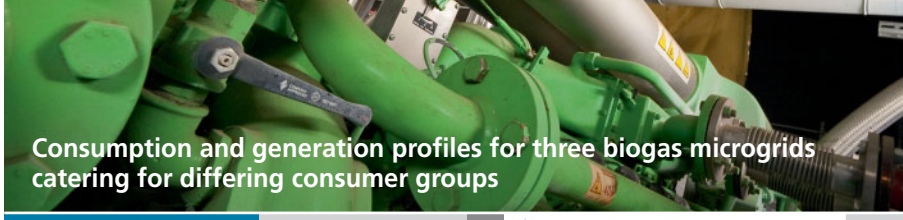
- Measuring differing grades of biogas and their effect on combustion
- Describing the requirements applying to grid and pipeline construction for biogas microgrids
- Assessing the economic feasibility of various different types of microgrid
- Defining the legal framework necessary for a biogas microgrid

Demand management and storage facilities play a key part in the successful operation of a biogas microgrid. On the demand side, new-style consumer equipment such as gas heat pumps and district heating grids can even out overall gas consumption over the year. Improvements are also possible if consumers can be switched on/off (load shedding) or if fuel switching is practised.

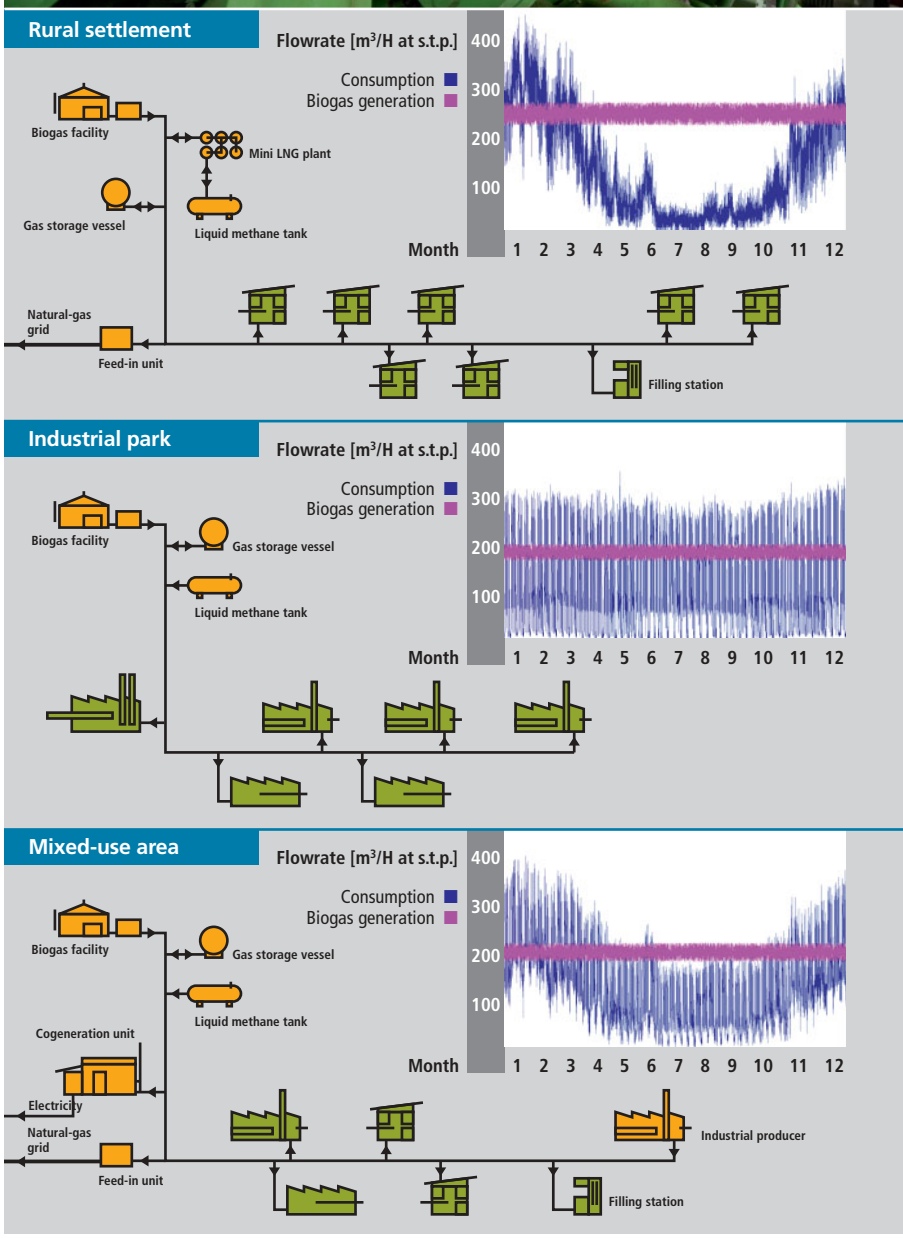
Storage systems play a key part in managing demand for stand-alone biogas microgrids. While low-pressure vessels are state-of-the-art for short-term storage, and medium-pressure vessels for longer-term storage in the annual cycle, very little experience has so far been gathered with biogas liquefaction facilities, and to date there are hardly any practical examples to refer to.

As part of the project, three prototypical consumer structures (rural settlement grid, industrial park, mixed-use area) were developed on the basis of actual demand profiles, in each case with and without access to the natural-gas grid., and three supply situations each (high, middling and low biogenic coverage rate) were simulated for the three microgrids.

To compute biogenic coverage rate, the amount of surplus biogas, the required quantities of make-up gas and the rate of withdrawal from storage, the simulation tool "HEI Micronet" was developed. The main defining data for the microgrid to be computed are demand and generating profiles throughout the year and the amount of storage capacity available. The simulation



Consumption and generation profiles for three biogas microgrids catering for differing consumer groups



Source: HEI Eco Technology GmbH / Salzburger AG

tool computes the discrepancy between the rates of generation and consumption hour by hour, the demand management actions required, and the amounts of surplus biogas and/or make-up gas involved.

In rural community grids gas consumption fluctuates with the time of year; it is much higher in winter than in summer. This means that a good deal of surplus biogas is available for "export" in summer. By contrast, consumption in microgrids with commercial customers is concentrated on opening hours each day; peak demand is a function of the firm in question's production level(s).

To achieve a balance between the biogas facility's production rate, which is fairly constant, and the consumers' fluctuating gas consumption, special arrangements are necessary. In the case of stand-alone microgrids surplus biogas is buffered to even out the discrepancy; if the microgrid is close to an existing natural-gas main, it can be connected to this, which greatly simplifies the task of balancing out: the biogas facility then covers the base load in the microgrid, and peaks in demand are accomodated by means of natural gas from the main.

In the course of the project extensive investigations revealed that none of the commercially available instrumentation and consumption appliances (e.g. gas burners) suitable for small-scale consumers of biogas can cope with low or fluctuating methane contents. No suppliers of small-scale systems to burn non-enriched biogas were identified, either. This situation makes it necessary to maintain a methane content of roughly 90% in the microgrid. While it is not essential to achieve natural-gas standard (> 97% CH_4) in microgrids, doing so has advantages: surplus biogas can be fed into the natural-gas grid, or used as a fuel.

From the report it is clear that the state of the art certainly makes implementing a microgrid feasible; however, care must be taken with some aspects, for instance in connexion with gas treatment. How demand is managed, and which storage technology is used, both have a considerable effect on how profitable the microgrid is.

As regards consumers, the main R&D need has to do with gas instruments and biogas combustion systems; these must be developed specially and tested. How the individual components interact is not yet state of the art, either more development work in a pilot project is needed here. And in the field of storage technology there is an urgent need for R&D aimed at low-cost storage systems for daily and seasonal storage at both ends (producers and consumers). Liquefying biomethane is an interesting option for seasonal gas storage; various manufacturers are currently developing small-scale liquefaction units. Further research is also needed into ways of storing liquid methane at the consumer end (liquid methane tanks for detached houses).

P R O J E C T

COSTING BIOGAS MICROGRIDS

In comparison with generating electricity from biogas, utilizing biogas in a microgrid has the advantage that overall energy efficiency is higher: less energy is lost in the form of waste heat, say. Then again, no charges are incurred for using the natural-gas grid, and biogas is currently exempt from energy and fuel tax (a further monetary advantage). Analysis of various types of microgrid reveals that biogas microgrids can compete with other sources of energy successfully.

The substrate, the biogas facility and the storage system to cover peaks in demand account for the bulk of production costs for biomethane in microgrids. Gas treatment and the gas grid each account for 10% of total production costs.

In the case of a rural settlement grid with considerable fluctuations in demand over the year, the lowest-cost way of supplying biomethane in regions with a natural-gas grid is to connect the microgrid to the natural-gas grid, so that peaks in demand can be covered and surplus biogas can be fed into the grid; here production costs total 0.74 €/m³ gas. In areas without grid access, if consumption in the microgrid exceeds 1 million m³/year and the biogas facility has spare generating capacity over and above this consumption level, surplus gas can be stored for extended periods in a medium-pressure vessel or be liquefied in a mini LNG plant; in this case biomethane can be provided for roughly 0.85 €/m³. If the biogas facility's annual production capacity is less than the settlement's annual consumption, gas can be supplied at an attractive price only in regions with a natural-gas grid or by means of balancing techniques (e.g. fuel switching or load shedding).

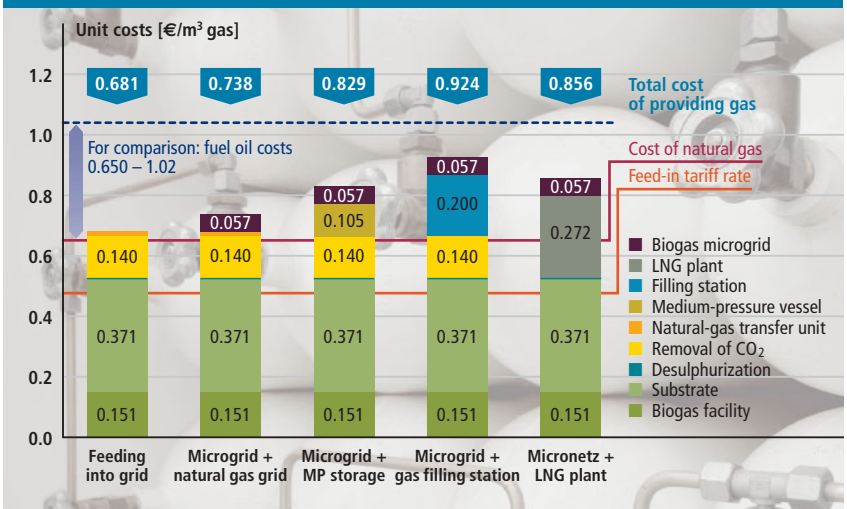
If only commercial consumers are involved, one can expect only modest fluctuations in gas consumption over the year, but considerable fluctuation during the day. In such cases there is no need to store biogas for lengthy periods. To cover fluctuation during the day, one low-cost solution is to install a low-pressure storage vessel. In a microgrid of this type gas costs between 0.61 and 0.82 €/m³, depending on what share of consumption is covered by biogas.

The costing calculations show that biogas supply in conjunction with the natural-gas grid comes very close to 100% natural-gas supply cost-wise. Even in microgrids with seasonal fluctuations in demand, biogas supply can be profitable if arrangements are made to cope with peaks in demand. Synergies with biomass power plants are desirable here. Surplus gas can be either fed into the grid or supplied to a gas filling station.

All in all, the investigations reveal that biogas microgrids are an attractive component for a sustainable regional energy supply strategy. It is safe to assume that fossil oil and gas prices will go on rising steadily in future, too. The only way to achieve a reliable, sustainable supply of energy is to increase the share of renewables; and here new, economically attractive methods of utilizing biogas could play a significant part. It would be perfectly possible to even out the current discrepancy in production cost by raising prices for fossil sources of energy incrementally and/or by means of green taxes. If the various sources of energy cost more or less the same, there would be a considerable incentive for grid operators and energy suppliers to increase the share of renewables in their energy mix.

The cost of gas in various types of biogas microgrids

Reference facility with a capacity of 500 kW_{el} (equivalent to 130 m³/h biogas to natural-gas standard)



Source: HEI Eco Technology GmbH

The diagram provides examples of unit costs per m³ gas for individual cost factors with various methods of utilizing surplus gas. For purposes of comparison, the grid feed-in tariff for biogas and the cost of two other sources of energy are included.

P R O J E C T

OPENINGS FOR STAND-ALONE BIOGAS FILLING STATIONS

■ Another project focussed on tracking down and assessing examples from other countries, so as to identify possibilities of supplying stand-alone filling stations with biogas profitably. The cost structure of filling stations supplying natural gas from the grid was surveyed, and suitable adjustments made for the requirements of stand-alone gas filling stations. Potential synergies (cost and energy-wise) between gas treatment, gas compression and facility capacity were also identified. The analysis shows that stand-alone gas filling stations can operate profitably only in favourable circumstances (filling-station capacity used to the full, low substrate costs) and in conjunction with other ways of utilizing biogas, e.g. by means of a biogas microgrid.

Extensive experience with supplying stand-alone gas filling stations is already on hand from many different countries. Gas is usually supplied compressed to 200 – 250 bar in cylinders. As part of this project, various different technologies for transporting gas were investigated. To identify the best approach, costs were modelled for various different scenarios combining gas provision, sales channels and delivery. Analysis of these models shows that combining gas filling stations with biogas microgrids and/or cylinder filling units improves the degree to which the capacity of compression and treatment equipment is utilized and lowers the cost of providing gas. Systems of this kind can achieve gas production costs of 0.75 €/m^3 or 1.01 €/kg biomethane (excluding VAT and duty). Where lower-cost substrates (organic and residual waste) are used, production costs can be lowered by up to 0.1 €/kg. However, with the production costs of biogas filling stations up to 0.3 €/m^3 higher than those of natural-gas filling stations, the former are competitive only if their investment costs and/or tariffs are subsidized.

The business model of a biogas microgrid with gas treatment and compression located centrally makes full use of the gas treatment and compression equipment possible, while a wide range of business openings are available to an organization operating a biogas facility plus microgrid and filling station: for instance, electricity and heat can be generated demand-responsively right on the consumer's doorstep. To develop these strategies further, pilot projects will be needed, and arrangements must be made for cooperation between the various stakeholders.

PROJECT PARTNERS

■ **Gasversorgung mittels lokaler Biogas-Mikronetze**
(Local gas supply via biogas microgrids)
Project management:
HEI Eco Technology GmbH
Dieter Hornbachner, Vitaliy Kryvoruchko et al.
Vienna 2008
www.hei.at

■ **Wirtschaftliche Chancen der Biogas-Versorgung netzferner Gas-Tankstellen gegenüber konventioneller Erdgas-Versorgung**
(Openings for supplying stand-alone gas filling stations wth biogas, as opposed to conventional supply with natural gas)
Project management:
HEI Eco Technology GmbH
Dieter Hornbachner, Vitaliy Kryvoruchko et al.
Vienna 2010
www.hei.at

■ **Biogas Branchenmonitor**
(State of the biogas production sector)
Project management:
Tatwort – Gesellschaft für Kommunikation und Projektmanagement
Franz Tragner et al.
HEI Eco Technology GmbH
Dieter Hornbachner, Vitaliy Kryvoruchko et al.
Vienna 2008
www.tatwort.at, www.hei.at

F I G U R E S / D A T A / F A C T S

INFORMATION PUBLICATIONS

Final reports on the projects have been published by bmvit (in German) in the series "Berichte aus Energie- und Umweltforschung".

These reports can be downloaded from
www.NachhaltigWirtschaften.at

Photo: MethaPUR

FORSCHUNGSFORUM on the Internet:
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