Biogas Grids – An Intelligent Element in Efficient Utilisation of Renewable Energy

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Abstract— **Implementation of local or regional biogas grids (so-called micro gas grids) is an intelligent concept with high potential to increase overall efficiency of the biogas production and utilisation chain. One of the main advantages associated with the concept is that biogas energy can be supplied to areas which are not well suited for placement of an anaerobic digester but at the same time are excellent potential consumers of generated energy. The concept has high potential to establish links between urban areas with energy demand and peri-urban or rural areas suitable for running the AD plants. Therefore local or regional biogas grids are attractive elements in bringing bio-energy in the form of biogas into urban areas.**

Keywords- anaerobic digestion; micro gas grids; renewable energy efficiency; decentralized biogas production; bioenergy; urban areas

I. Introduction

The EU policies have set forward a fixed goal of supplying 20% of the European energy demands from renewable energy systems by the year 2020. At least 25% of all bioenergy in the future can originate from the energy carrier biogas, produced from wet organic materials such as animal manure, whole crop silages, wet food and feed wastes [1]. Biogas has the potential of covering almost 50% of the 2020 biofuel target of 10% of all automotive transport fuels, even without implying a change in land use [2].

Anaerobic digestion (AD) with biogas production is a well-established technology. However, the degree of adoption in different countries (including the EU countries) varies very much. Advances in sustainable biogas production will depend on several factors, including knowledge of different AD technologies, general perception of the topic and awareness of potentials, education and availability of training courses, favourable regulatory frameworks and their transnational harmonisation [3]. Implementation of intelligent technological solutions with potential to be transferred to other sites and other countries is among the key factors to further increase the renewable energy efficiency.

Compared to other renewable energies, the energy carrier biogas offers the advantage that it can be stored in order to be used according to fluctuating demands or to availability of alternative energies. Biogas can be very well combined with other energies and can be a particularly advantageous choice e.g. in hybrid power systems for electricity supply in remote areas or islands [4].

The energy carrier biogas causes less direct air pollution than other biomass fuels when burned. Therefore in some parts of the world a high number of small-scale AD plants at household level are in operation; they usually provide fuel to cover the demand of the household and the agricultural site. Besides direct use for cooking and lighting, biogas has various further possible applications:

- Heat generation
- Generation of electricity
- Fuel for cars/ vehicles
- Injection of biogas into the natural gas grid after upgrading

Feeding biogas into the natural gas grid has become one standard in industrialised countries when biogas is produced at large scale. Before it can be delivered to the natural gas grid, biogas needs to be treated in order to comply with the relevant quality standards. Different upgrading technologies exist; in order to achieve economic viability biogas treatment of larger gas volume is necessary.

Electricity production is the most common biogas utilisation method worldwide. Several engine types can be fuelled with biogas. Electricity generation is often accompanied by heat generation in combined heat and power plants (CHP), which increases overall efficiency of the installation.

Instead of direct use of the generated heat, the energy can alternatively (or additionally) be used to provide cooling/ chilling (e.g. for agricultural storage facilities, for pig stables, in nearby hospitals or other buildings). Simultaneous generation of electricity, heat and cooling can be one of the most attractive options at a site.

Among the main disadvantages of biogas is the fact that anaerobic digesters in most cases (in particular to keep odour nuisances at a tolerable level) need to be placed at remote sites where heat demand is low/ limited. Implementation of CHP units is in general favoured as standard application even if the generated heat can be used only partially, e.g. to cover the self-consumption of the site (in order to maintain the temperature level of the digester), to cover heat demand of the buildings on site, or to supply heat via a local heat system to consumers in acceptable proximity.

This study looks at potential scenarios for implementation of local/ regional biogas grids (micro gas grids), which are assumed to be a particular favourable option to further increase overall efficiency of biogas production.

II. The Concept “Micro Gas Grids”

A. Main Principle of Micro Gas Grids

Limited possibilities to make use of the generated heat are among the key factors of low overall efficiency at biogas sites, especially in remote areas (which is typically the case for agricultural AD plants).

It is however not necessary to make use of biogas directly at the production site. Local (or regional) biogas grids – so-called micro gas grids – can be a particularly intelligent solution to provide biogas to where it can be valorised at highest efficiency. Overall efficiency can therefore be increased by diverting biogas to where best use can be made of its energy content.

In contrast to transport of heat, transport of biogas is feasible (technically and with view to economic viability) over large distances. This allows implementation of more complex scenarios which integrate elements in considerable distances from each other.

B. Overview of Possible Concepts for Implementation of Biogas Grids

Figure 1 provides an overview on the main micro gas concepts.

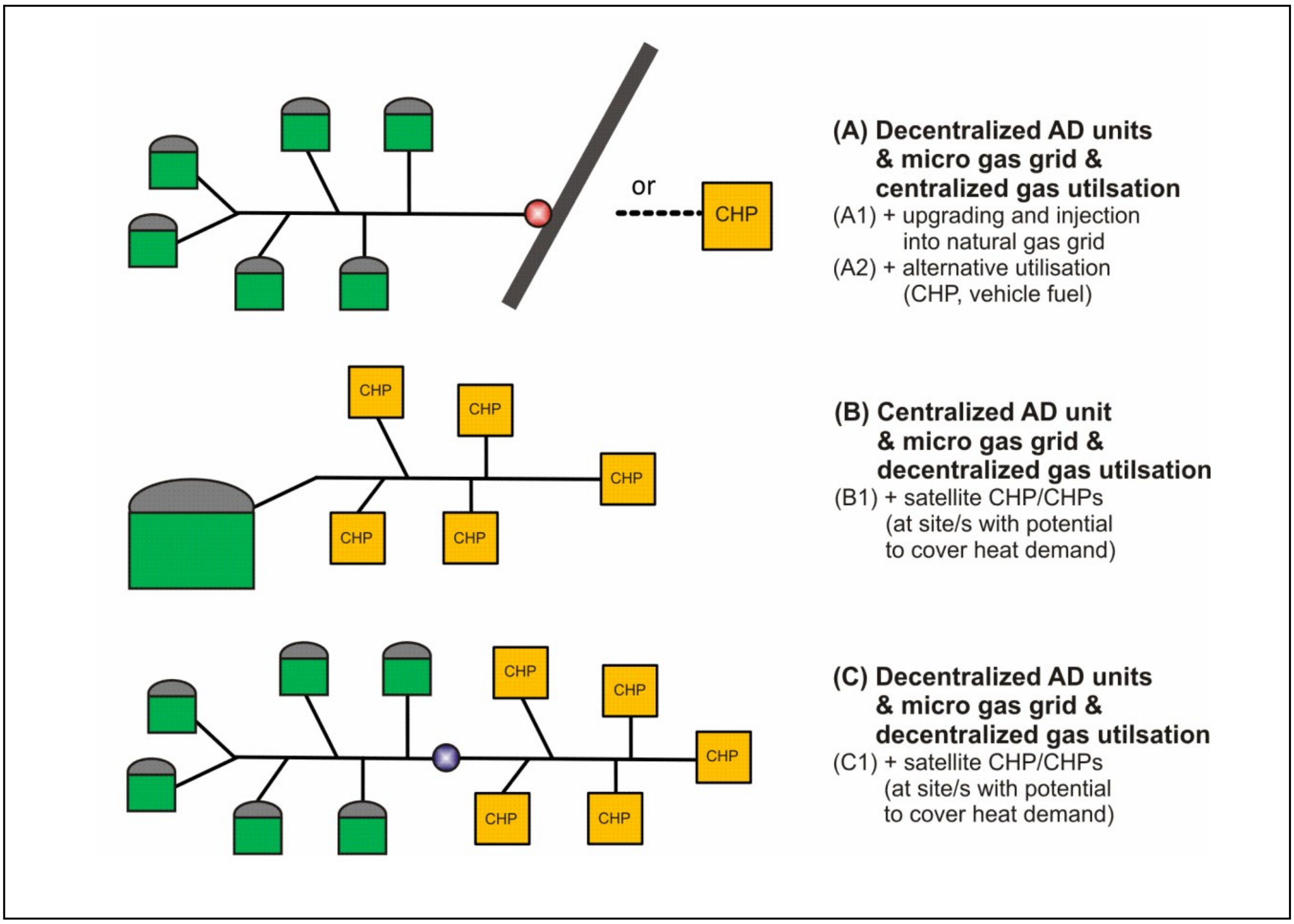

Figure 1. Main concepts for implementation of micro gas grids operated with biogas [3] (partially based on [5] and [6])

Biogas from different production sites (in general AD plants at smaller scale) can be collected in order to be supplied to a central utilisation area. Possible applications are upgrading of biogas to biomethane and injection into the natural gas grid, utilisation as vehicle fuel, or production of electricity with technical equipment allowing for higher energy conversion rates compared to individual small-scale CHPs and in best case assuring that at the same time much of the generated heat can be used as well.

Biogas can also be supplied to individual sites (so-called satellite CHP units placed individually in direct proximity to the user) with high and continuous heat demand. This will assure that not only generated electricity is supplied to the grid, but also that energy present in the form of heat can be used. Considering the fact that at most AD plants heat requirement is low and that consequently it is one major drawback of biogas technology that overall efficiency is much lower than possible, this is one smart concept towards more sustainability and higher overall efficiency of AD.

While the concepts A and B in Figure 1 (either centralized biogas production site or centralized biogas valorisation site) are more common choices, the concept C is more challenging due to a higher degree of complexity.

III. Implementation in Practice

Several projects have already been implemented in Germany since the year 2005, and individual implementations exist in other European countries as well. An overview of the current status of micro gas grids and on existing challenges is provided in [7].

Compared to transport of heat, transport of biogas via gas pipelines is far less complex and economically viable for significantly longer distances. The following factors are relevant when comparing implementation of heat or biogas pipelines:

- No insulation necessary for transport of gas
- Only one supply pipeline from the biogas generation site to the gas consumer (heat supply requires a two-way solution for circulated water)
- Biogas transport solutions are easier to be adapted to varying demands of costumers in particular by implementation of alternative gas utilisation for surplus biogas (e.g. electricity generation directly at production site)

To cope with fluctuations in biogas generation or biogas utilisation, a solution for biogas storage is necessary. When suitably implemented, the biogas grid itself can provide storage capacity.

When diverting biogas to another site, it will in general be of advantage to still use some of the biogas on site in order to cover the heat demand (and where suitable also the electricity demand) of the anaerobic digester and its direct infrastructure. Placement of a small-scale CHP in direct proximity to the AD facility is a common and suitable solution.

Supplying biogas to be used by a potential heat consumer (including industrial sites, public buildings) can significantly improve economic viability of AD facilities of all sizes, and should therefore be considered as one possible element when planning a biogas facility [8].

IV. Conclusions and Outlook

Local or regional biogas grids are suitable elements to increase overall efficiency of the biogas utilisation chain. The two key elements relevant for an improved overall efficiency are as follows:

- Increased degree of heat valorisation in CHP applications by supplying biogas directly to sites with heat demand
- Possibility to move from decentralized biogas utilisation to centralized technologies with higher energy conversion efficiency (upgrading of biogas for natural gas grid, biogas as vehicle fuel, electricity generation)

From the technical point of view, biogas grids are relatively simple elements with a low degree of complexity. Information is available from a range of pioneering installations in practice. Aside of a need to reduce the general lack of knowledge about this intelligent technology, favourable frameworks are the most essential driver to a more widespread and sustainable implementation. This includes that grants are made available for the gas grid although it is part of the infrastructure and not the actual AD facility. Furthermore it is essential that remuneration schemes for renewable energy (e.g. feed-in tariffs for electricity from biogas) include valorisation of biogas at remote sites after supply via gas grids among the scenarios with attractive conditions.

With view to upgrading of biogas to biomethane it is a distinctive advantage of biogas grids that they can collect sufficient volumes of biogas to allow for economically viable biogas treatment while the actual biogas production can be kept a decentralized level. This reduces transport of substrates and digestates and due to its size the biogas plant and its operation are easier to be integrated at farm level.

By establishing links between urban areas with energy demand and peri-urban or rural areas suitable for placement of AD plants, the intelligent concept of micro gas grids is particularly well suited to bring bio-energy in the form of biogas into urban areas. This in particular ensures that biogas finds its way to where heat demand is high (and also demand for cooling).

Currently no study is available which quantifies the ecological benefit of micro biogas grids in different scenarios and economic feasibility of biogas grids under different national regulations. In order to identify the ecologically most favourable options, LCA (Life Cycle Assessment) is a suitable approach to study model sites (including looking at digestion of different substrate types such as waste materials and energy crops, different biogas valorisation options, various sizes of installations both at biogas production sites and gas valorisation sites).

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