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Challenges for Green Gas injection into the Natural Gas Grid

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ABSTRACT

Although green gas injection into the natural gas grid has been around for decades its quantity has been limited to a very low percentage. Now as the introduction of sustainable energy is prescribed by governmental bodies the ambitions are set to more significant percentages. This requires a complete new review of the production of sustainable gas and of the main aspects of gas supply such as the infrastructure, the gas quality, safety and regulation.

This paper gives insight into a number of the many challenges that arise from the new situation and give possibilities for directions of meeting them. The paper will highlight the following:

- Sourcing of (bio)energy
- Optimizing the green gas production
- Balancing process step configurations
- Green Gas Certification
- Specific technical problems

As these directions add to the solutions of the new gas arena it will help solve the environmental burden of the energy supply, build upon the role that natural gas as a transition fuel can play and make use of the abundance of knowledge and innovation potential that exists within the gas industry.

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1 INTRODUCTION

In the Netherlands and many other countries the climate change pushes the transfer to a highly sustainable energy supply, that is both needed urgently and a tremendous challenge for innovation, economy and societal acceptability. To meet the targets set by local governments, such as municipalities, where newly build residential areas are required to meet increasingly lower CO_2-emissions or even a climate neutral situation the view is changing to new energy concepts that exclude natural gas. As a result there is a more and more tendency to replace heating in residential areas by biobased heat or electric heat pumps.
In the gas industry there has been, ever since the discovery of coal gas and natural gas, a significant development of the infrastructural components, knowledge (including safety thinking) and the optimization of its economy but their accomplishment may be feared to become obsolete.
To safeguard the achievements that have been realized in the gas industry two combined ways forward are to be explored:

1. Replace natural gas by biobased green gas.
2. Build on the advantages there already are and the general believe that natural gas is the most significant transition fuel [1].

This paper deals predominantly with the first mentioned way but also takes the gas transition options into account.

To assure that the safe and secure supply of natural gas will continue and continue to improve, the addition of gas from renewable sources has to fit in at the high level that the natural gas industry already has achieved. To comply with this a great number of issues have to be dealt with.

2 GREEN GAS CHALLENGES

2.1 Sourcing of (bio)energy

Plants have only a limited efficiency in turning solar power into (bio)energy. Due to limiting conditions this ratio is about 0.5% which means that the surface necessary to produce green gas is quite large for arable land. The solution for this limitation will have to be found in use of waste, manure and energy crops which should not interfere with food and feed production.

At this moment the mostly used sources are landfills and digestion of manure from which biogas (landfill gas) is produced. Also large plants such as sugar refineries, waste water treatment plants etc can contribute to the availability of biogas. However as in Germany land use for biogas already is equal to half the surface of the Netherlands but only contributes a few percent of the total electricity production.

If the fuel for the Dutch electricity supply was to be replaced by biogas from manure with co digestion and from gasification of woody biomass 96% of the total surface should be made available for this.

To meet these requirements two ways are possible routes for solving this: cultivation of algae, which have a much higher solar power to bioenergy efficiency, or methanation of CO_2 with hydrogen produced from surplus of sustainable electricity.

2.2 Optimizing green gas production

Digestion is a well known process but its characteristics still has the potential of serious improvements and cost reductions which include technological, biological, agricultural and environmental aspects and a cascaded and multidisciplinary approach is expected to lead to significant improvements. Examples that are now being developed are manure and bio refineries that have a high yield and give an output that has no disposal drawbacks but can be usefully applied in the agricultural industry, giving more sustainability to this sector as well. Especially algae contain other useful feed stocks so that a cascading of processes with energy and gas production as one of the final steps will lead to increasing economic benefits.

Gasification of woody feed stocks is also one of the roadmaps that needs to be investigated. The limitation of the formation of tar and/or its removal, catalytic processes for methanation, sulfur removal and process and size optimization and intensification can be ways to improve the techno-economics of this conversion process.

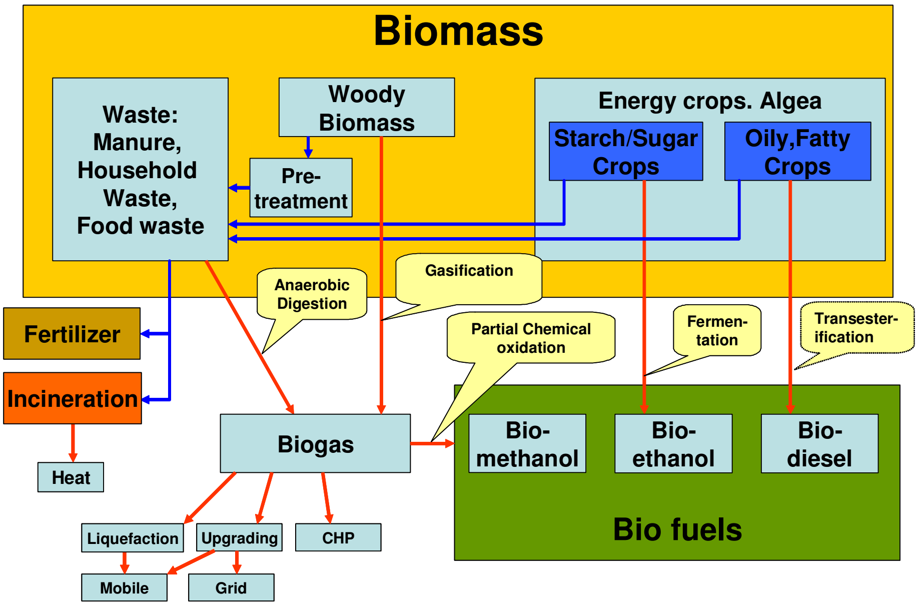

Figure 1. Overview of processing biomass into sustainable energy.

2.3 Balancing process step configurations

Balancing process step configurations also has a great potential. In a recent study, for instance, it was shown that the introduction of biogas hubs can lead to a prominent cost advantage. By distributed production of biogas the costly and frequent transport of bulk material such as manure, waste or crops are avoided. Transport of pre-conditioned (water and sulfur removal) biogas is relatively cheap and easy.

The most common biogas production consists of basically four steps:

- Transport of input material for the digester. This is mainly manure and/or energy crop biomass such as maize. This is costly and frequent. For a 36000 ton/year that is around once every hour. For a large scale plant that could be every 5 minutes.

- Production of biogas in a digester which needs a mixing, temperature control, storage of materials etc. As this is a bulk type process the economy of scale is limited. This is shown in figure 2.

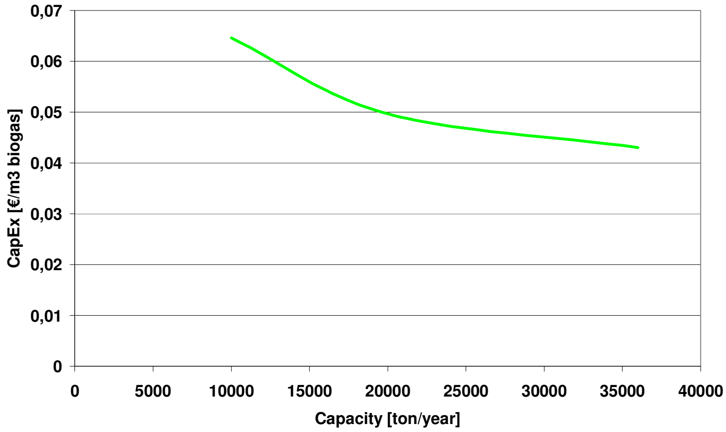

Figure 2. Economy of scale for digestion is limited.

- Transport of raw biogas to the upgrading plant. This can be done either over a short distance or in a biogas network which connects several production sites with one upgrading unit. This is relatively cheap. Especially when a number of farmers combine their manure digesters to produce for one upgrading facility.
- Upgrading plant. Unlike digestion the cost falls to low values quickly. This is indicated in figure 3.

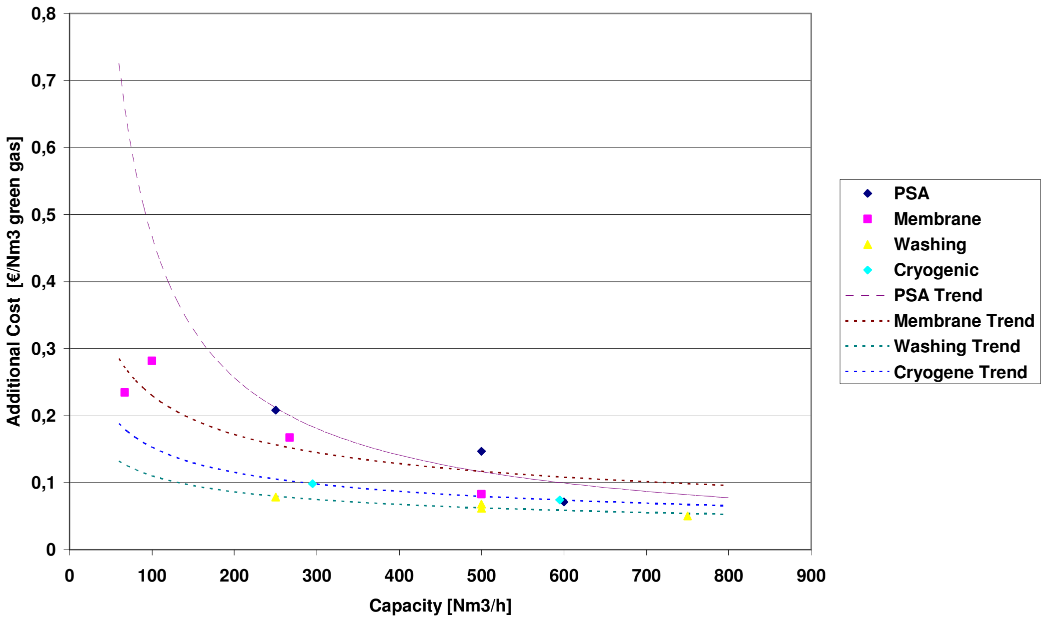

Figure 3. Economy of scale for upgrading technologies

Combining the insights of the four steps a comparison is made between three alternative routes:

1. Both the digestion and upgrading are decentralized. This results in low transport costs as the upgraded gas can be injected into the natural gas grid without complications. The investment cost for the upgrading plant, however, are high.

2. The digestion is distributed (e.g. with the farmers) but the upgrading is centralized near a connection point of the gas grid. These two facilities are connected with a biogas hub.
3. Both digestion and upgrading are centralized. This results in economies of scale for the processes but the transport of bulk materials is costly.

The main results are presented in figure 4.

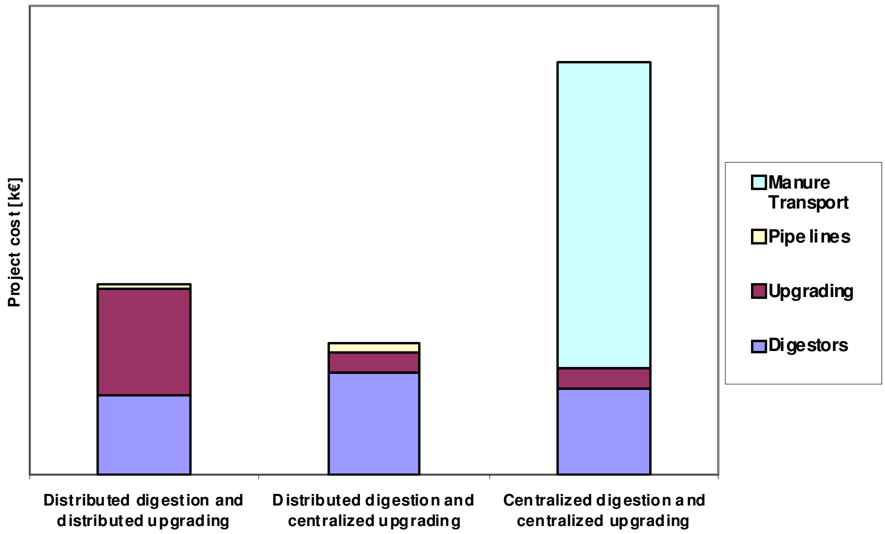

Figure 4. Economic comparison of three possible configurations.

2.4 Matching supply and demand

Matching supply and demand is also a challenge for green gas introduction. Whereas the production is best served with a constant flow of biogas the demand varies during the day and even more on a yearly scale.

In the load duration curve below this contradiction is shown.

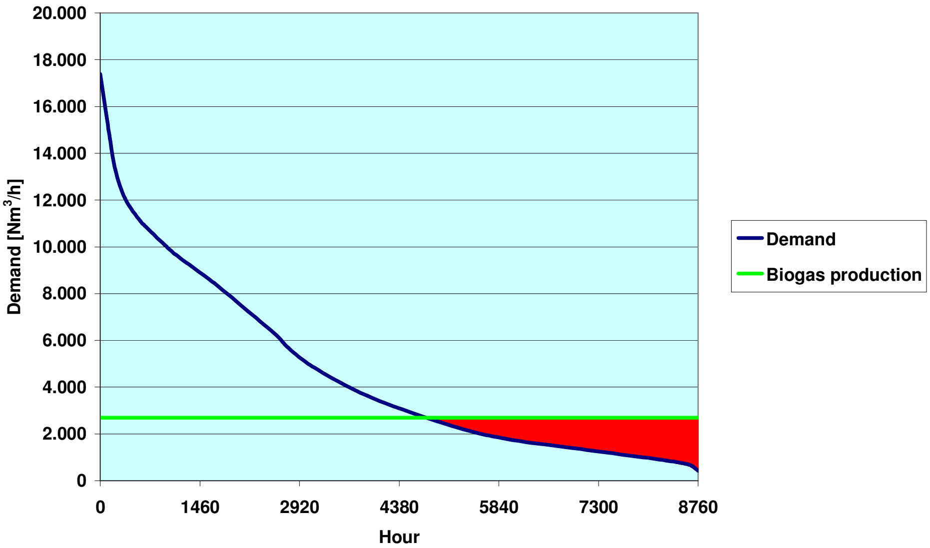

Figure 5. Load duration curve for a typical residential area fed with green gas.

In figure 5 the red area indicates where the gas demand is lower then the (constant) production of green gas. This amount can be either flared, which is a waste of sustainable energy, but this can also be solved by using the characteristics of the transmission network that is able to transport the gas to other local distribution networks or even seasonal storages. Although this requires more energy input to increase the biogas pressure, studies show this would be the most beneficial application per unit of energy.

A schematic overview of the compressor and the biogas hub is given in figure 6.

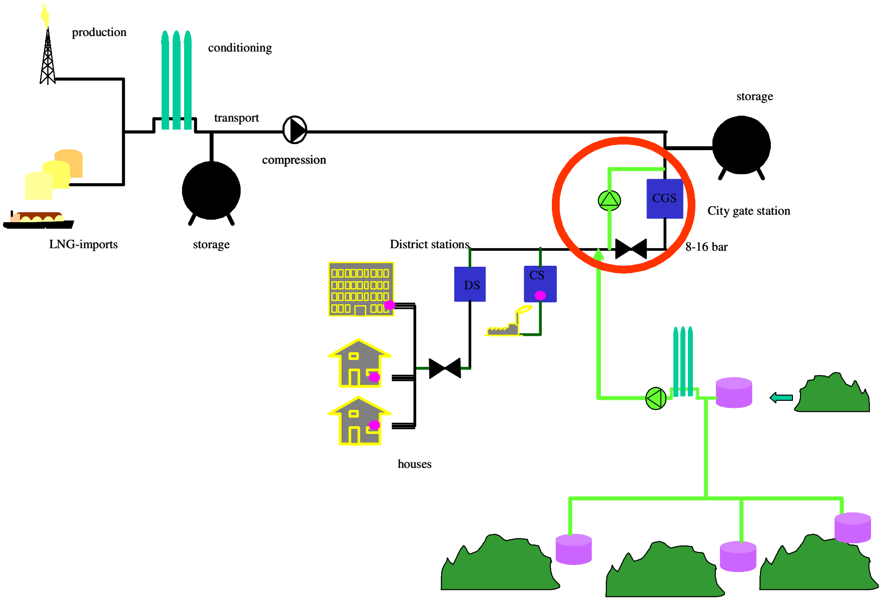

Figure 6. Scheme of decentralized biogas production, centralized upgrading and surplus compression into the transmission network (red circle).

2.5 Green Gas Certification

If green gas is not transported to specific customers directly the higher value of its sustainability can still be guaranteed by the introduction of independent certificates that are used to sell this value to more considerate consumers.

2.6 Specific technical aspects

Specific technical problems such as the odorization of small gas streams and the exclusion of the risk of microbiological contamination of the gas and the grid are to be solved by dedicated technologies such as specially designed injection equipment for odorants and filters for viruses and bacteria.

Also adequate demonstration facilities and projects to show the practicability, economics and gain experience are part of the deliverables to the introduction of green gas into the grid.

3 CONCLUSIONS

The specific circumstances in the Netherlands, with its extended gas network, well defined gas quality, safety awareness and sustainability ambition make it a favorable situation to develop new technologies for the production, transport and upgrading of green gas. Although there are many challenges that are to be met, green gas production is a sensible way forward to the extension of a future ready gas industry.

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