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HEAT FROM BIOMASS VIA SYNTHETIC NATURAL GAS

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ABSTRACT: Biomass can be converted into synthetic natural gas (SNG), which can be transported easily and efficiently to local (small-scale) users. This paper shows that SNG is an excellent way to produce heat from biomass. It not only can probably count on a high social acceptance, it also is cheaper than the alternatives where biomass is used in a combined heat and power plant or local combustion plant with subsequent heat distribution. The relatively low costs are obtained from favourable scale and number of operating hours.
Keywords: gasification, chemicals from biomass, heat sector

1 INTRODUCTION

SNG (synthetic natural gas or substitute natural gas) is a combustible gas that can be made from biomass. It can be processed to resemble natural gas and can be transported and used as such. SNG can be produced from biomass through gasification and subsequent methanation. A biomass-to-SNG efficiency of 70% can be reached [1,2].

The biomass-to-SNG system is shown schematically in Figure 1. Biomass is gasified at relatively low temperature (<1000°C) in order to have a high initial yield of methane. The inevitably produced tar then is removed and preferably recycled to the gasifier. The gas subsequently is cleaned from sulphur, chlorine and other impurities in order to meet the specifications of the downstream catalytic reactor. Here, the H_2 and CO are converted into methane and also remaining olefins (e.g. ethylene) and aromatics (e.g. benzene) are converted into CH_4. The resulting raw SNG consists mainly of CH_4 and CO_2 and must be upgraded to meet the requirements of the natural gas grid.

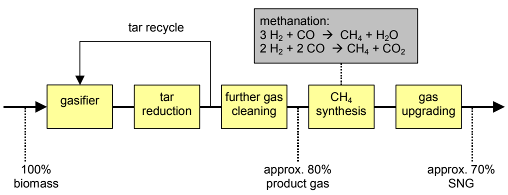

Figure 1. *Biomass-to-SNG concept*

SNG offers the advantages of large-scale production and small-scale utilisation. It therefore can profit from the economy of scale and at the same time has the advantages related to the ease of application at small scale. SNG can be stored, transported, and used wherever and whenever for the production of heat, but it can also be applied as chemical feedstock or transportation fuel.

Almost 50% of the energy consumption in the EU is used for heating purposes, making heating the largest consumer of energy [3]. Renewable heat however, has got only very little attention because it is relatively complex to stimulate and involves many (local) actors. SNG from biomass offers a way to overcome this problem. This paper focuses on the production of heat from biomass with SNG as intermediate energy carrier.

2 SNG BENEFITS

Converting biomass into SNG offers great benefits, summarised in Figure 2. For the case shown (the Netherlands), large-scale biomass energy must rely on imported biomass. SNG-plants will be located near a sea harbour to avoid relatively expensive local biomass transport. Because SNG can be stored e.g. underground, the large-scale plant can operate continuously throughout the year. In the Netherlands, gas storage is common practice in order to guarantee gas supply in cold periods, when exploitation of natural gas cannot keep up with the demand.

Once the SNG has been produced, it can be transported throughout the country with minimum losses. Whereas the average energy loss of heat in heating grids is 15%, the energy loss of gas during transport through the gas grid is negligible. Furthermore, a gas grid is relatively cheap compared to a heat grid and is not limited in scale and distance.

SNG at the final location can be treated like natural gas. It therefore can profit from existing equipment. Furthermore, the end consumer does not face any technical modification. Social acceptance therefore is expected to be very high. Because of the similarity with green electricity, existing administrative procedures can be copied.

In addition to the above-mentioned benefits, the production of SNG inevitably involves the production of CO_2. This can be stored to obtain a “beyond CO_2-neutral” concept if desired. The storage might be combined with the prevention of sinking grounds on top of depleted natural gas fields. But also the combination with enhanced oil recovery is an option that might increase the economics of an individual plant.

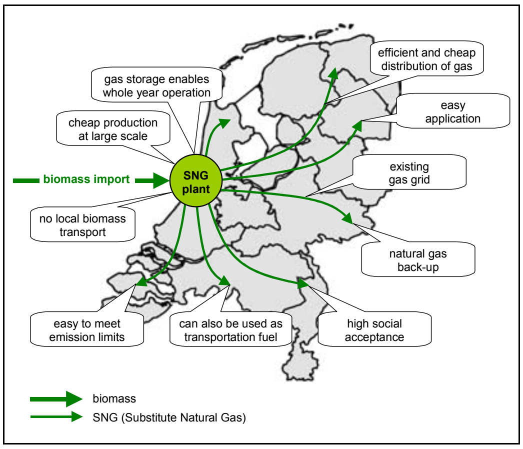

Figure 2. *Typical benefits of using SNG from biomass for local heating in e.g. the Netherlands*

3 ECONOMICS AND EFFICIENCY

In order to quantify the above-mentioned advantages of SNG as a versatile renewable energy carrier, calculations have been performed. The focus is on heat as end product. The following case has been defined: a fixed amount of heat from biomass is required throughout a large region. Three options are considered: SNG, small-scale local combustion, and combined heat and power plants with medium-scale heat distribution. Because the latter option also produces green electricity, a direct comparison is difficult to make. The three cases therefore are extended to the production of heat and electricity with a fixed ratio. The following cases have been selected, all operated on biomass:

1. large-scale SNG-plants with gas grid and local heat production by SNG combustion and large-scale BIGCC power plants (biomass gasification combined cycle),
2. small-scale local combustion with heat grid and large-scale BIGCC,
3. medium-scale combined heat and power (CHP) with heat grid and small-scale local combustion units.

In the calculations, the ratio of heat and electricity as delivered at the site of the consumer is fixed. The biomass costs are assumed to be 4 €/GJ independent of the scale and location of the conversion plant. Furthermore, grid losses are assumed to be 1%, 4% and 15% for gas grid, electricity grid and heat grid respectively. The efficiency from SNG to heat is taken as 95%. Annual costs of investment, operation, and maintenance are assumed to be 20% of the total investment. Table 1 contains the main assumptions for the different plants. Costs related to transport of biomass, heat and electricity have not been included in the calculations.

Table 1. *Main assumption for the different plants*

	SNG	BIGCC	CHP	local
hours/year	8000	8000	4000	4000
typical size [$MW_{th\_biomass}$]	500	500	20	5
investment [€/$kW_{th\_biomass}$]	300	300	500	500
heat				
plant efficiency	70%	-	40%	90%
overall efficiency	66%	-	34%	77%
electricity				
plant efficiency	3%	45%	30%	-
overall efficiency	3%	43%	29%	-

The above given assumptions have been used to calculate the break-even price of heat. The electricity is assumed to be 0.07 €/kWh. Table 2 shows the results. Option 1 appears to be the cheapest option. This is due to the fact that this concerns relatively cheap large-scale plants. Furthermore, these plants operate the whole year, whereas the local combustion and CHP-plants only operate during the cold season.

Table 2. *Calculated break-even heat price in €/GJ heat*

ratio of heat vs. electricity	option 1: SNG BIGCC	option 2: local comb. BIGCC	option 3: local comb. CHP
2	7	12	13
10	9	14	14

4 CONCLUSIONS

Biomass can be converted into heat in different ways. This paper focuses on the route where SNG (substitute natural gas) is produced as intermediate. This is a very attractive option, because it matches very well with the existing fossil fuel based society. A simple economic assessment shows that heat from biomass can be produced cheaper via SNG than by the alternatives of combined heat and power or local combustion units. The positive outcome for SNG is due to the relatively large scale of the SNG plant and the possibility to operate the whole year (not only during the cold season) because of the SNG storage possibility.

5 REFERENCES

1. A. van der Drift, C. M. van der Meijden and H. Boerrigter: *MILENA gasification technology for high efficient SNG production from biomass*. In: 14th European Biomass Conference & Exhibition, 17-21 October 2005, Paris, France (2005).
2. E. Deurwaarder, H. Boerrigter, H. Mozaffarian, L. P. L. M. Rabou and A. van der Drift: *Methanation of MILENA product gas for the production of bio-SNG*, 14th European Biomass Conference & Exhibition, 17-21 October 2005, Paris, France (2005).
3. EREC (European Renewable Energy Council): 25% of the EU heating and cooling supply by renewables in 2020, joint declaration for a European Directive to promote renewable heating and cooling, EREC, Brussels, www.erec-renewables.org, 12 p. (2005).