Improving commercial viability of biomass gasification by standardisation of fuel

Development of a fixed bed gasifier system operating on a standard gasifier fuel

Objectives

In the past, several gasifier systems for utilisation of different biomass feedstock have been developed and tested. The main market was expected to be generation of motive power or electricity in developing countries, and local biomass resources have invariably been used, either directly or after previous conversion to charcoal.

Despite the fact that after ten years some installations are still operational, the overall performance is poor due to both technical and economic reasons. It is therefore necessary to seek means to improve the technical reliability of the systems and to reduce the resulting energy cost. In order to these issues a project having the following objectives was defined:

- Identify and test technologies (drying, sizing, sieving, briquetting, carbonization) for the production of a standard gasifier fuel (SGF) suitable for fixed bed gasifiers.
- Identify and test suitable fixed bed gasifier systems for standard gasifier fuels.
- Develop a fixed bed gasifier system operating a combustion engine on a standard gasifier fuel.
- Identify a suitable gas cleaning system to be used with the gasifier system developed.
- Develop a control system for automatic gasifier operation.

The Project

Prior to the project fixed bed gasifiers were not competitive to other renewable energy sources for power generation and they required a uniform type of feedstock, which was in most cases too costly. The main problems to be attempted solved in the project were consequently how to reduce the investment and operation costs of fixed bed gasifiers, and the preparation of a standard gasification fuel based on a mixture of different cheap biomass raw materials.

The project studied the production of the standard gasifier fuel from several possible feedstock and two possible routes for utilisation of the SGF. One route consisted in use of the SGF directly in a gasifier system, the other involved production of charcoal from the SGF and subsequent use of the charcoal in a gasifier system.

The partnership consisted of ten companies with different background and interest. It contained research organisations, industry, university, consultants and end-users. The partnership turned out to co-operate very well with many spin-off opportunities for most of the involved partners.

One of the industrial partners withdrew from the consortium, but its activities were taken over by two of the other participants.

The Results: Technical

The project advanced the knowledge of fixed bed gasifier systems on a number of important areas, and the new knowledge could be successfully integrated in the design of an improved gasifier system. The following list summarises the most important results:

1. A SGF pre-treatment plant was designed and built. It was able to process 500 to 1000 kg/h of different wet biomass materials, ranging from woody to fibrous materials. The rotary dryer operated without major problems. The overall drying result is not affected seriously by the inlet moisture content of the fuel: moisture contents between 15% and 50% by weight wet basis yielded an outlet moisture content between 5 and 10% by weight.

2. With the briquetting screw press, SGF briquettes based on different biomass mixtures could be successfully produced. When assessing the quality of different briquettes, red wood sawdust was taken as a reference material. Strength tests proved that especially thinning wood and miscanthus-based briquettes with a weight fraction up to 90% have a very good quality. A similar quality could be achieved with 50% red wood / 50% straw briquettes. Stable briquettes with plastic scrap material could not be produced.

   Most materials had a higher ash content than redwood, and a higher wear rate of the screw press was therefore observed. The press needed to be replaced every 10-15 hours. With ordinary red wood briquettes, 40-100 hours of continuous operation can be achieved.

3. The four selected SGF-briquette types could be successfully carbonised in a small-scale batch reactor. The average yield was 32% of carbonised product. Although no separate strength tests were carried out, it can be concluded that the briquettes maintained their original shape.

4. The uncarbonised SGF briquettes were tested in separate tests in a downdraft gasification system. All four types proved to be suitable as fuel for the gasifier. There is not much difference in operating the system on red wood-, thinning wood-, miscanthus- or straw-based briquettes.
5. The carbonised SGF briquettes were tested in a charcoal gasifier. No technical constraints were encountered: the tar level was below the detectable level and the engine ran smoothly.

6. Endurance tests of 150 hours continuous operation were conducted with four different gasifier installations. Based on these tests, modifications were identified and implemented. These include:
   - Changes to the gasifier system (throat design, steam injection, grate design, control system),
   - Changes to the gas cleaning system (revamping of the cyclone and baffle filter, automatic ash discharge, automatic cleaning device for the fabric filters,

safeguard filter to protect the engine),

- Changes to the engine system (ignition timing, vacuum safety device, automatic secondary air control based on lambda measurement, heat recovery system, electronic flare ignition system to monitor gas quality, determination of exhaust gas composition under various conditions), and
- Changes to the control and monitoring system.

Among the project spin-offs, the standard procedure for endurance tests of gasifier systems and a standardised procedure for tar measurements deserve mentioning. Both have seen use outside of the project, and further development of the tar measurement procedure is now the subject of a separate project.

The project did not identify one gasifier system that was superior to any other system. All four tested gasifiers (downdraft, updraft, open top, cross draft) had their respective merits and drawbacks.

The Results: Economic, Social and Environmental

Although the technical development did not result in an economic performance that made the technology immediately commercially viable, several improvements as compared to the previous state of the art were achieved. The following points highlights the economic results:

1. The cost of centralised production of uncarbonised SGF-briquettes lies at about 42 EUR/tonne, assuming a raw material price of 0 EUR/tonne, e.g. the feedstock must be a waste product that can be had for free.

2. Gasification of uncarbonised SGF is not economically viable under base case conditions: the tariff for feed-in to the grid required to break even with other options is 16.3 EUR ct/kWh. A more reasonable electricity sales tariff could be expected to lie in the range of 7 to 10 EUR ct/kWh. In order to achieve this level an SGF fuel cost in the range of -25 to +5 EUR/tonne is required. This corresponds to a raw material price between -45 and –25 EUR/tonne. This means that SGF-briquettes can only be viable for waste streams (contaminated wood or other residual material) for which it is possible to charge a gate fee, i.e. the material has a negative market value. Using waste streams as feedstock, however, will imply that stricter and more comprehensive criteria for emissions to air may apply, possibly requiring more costly emission control. If all the power can go to self-consumption, the economy will be slightly better, but it will not reverse the picture.

3. The production and gasification of carbonised SGF is even less attractive. The relatively simple and cheap charcoal gasification system does not counterbalance the high base case production costs of 195 EUR/tonne. An electricity feed-in tariff of 20.6 EUR ct/kWh is required to attain break-even.

Co-generation based on biomass feedstock will reduce the emission of greenhouse gases. The developed gasifier system produces no harmful waste streams like contaminated scrubbing water. The prototype has been scaled up in a follow-up project and is being exploited commercially. After proven success it can be expected that more units are going to be implemented. Cost-effective power and heat production based on local resources will lead to benefits for the local economy.

Improving the Programme and Project Management

In hindsight it may be said that if the project had to be undertaken again, the general approach would remain the same but the work programme would be somewhat modified. The route for preparing SGF was to a large extent decided upon already in the proposal. Cheaper options may exist, and a better approach would have been to identify possible routes for SGF production, calculate preliminary figures for production cost and select a route based on this evaluation.

Furthermore, the development of the fixed bed gasifier was based on endurance tests of four existing different types of gasifiers, a costly exercise. Most probably, a selection could have been made by comparison of rough data only. However, it was of the interest both to different partners and to the scientific community to compare the performance of all systems based on a standardised measurement protocol.

The project as such functioned smoothly, relying on project meetings twice a year and task meetings as necessary to achieve the necessary co-ordination of efforts. During the project the scientific officer changed, which created some delays in project execution. Although it will not be possible to avoid such situations completely, it would be worthwhile to try to maintain scientific officers in their position for sufficient long periods to cover a framework programme.

Information

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Partners:	BTG biomass technology group BV, NL EDON BV, NL Rijkuniversiteit Groningen, NL TNO Road-Vehicles Research Institute, NL Ingenieurgemeinschaft Holzenergie, CH FEE Fördergesellschaft Erneuerbare Energien, DE Comprimo Beratungs- und Anlagenbaugesellschaft GmbH, DE dk-Teknik Energy & Environment, DK de Schelde, NK Hyperion, IR

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