HANDBOOK ON BIOMASS GASIFICATION

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ABSTRACT: The Handbook on Biomass Gasification is meant to disseminate the results of the European Gasification Network (GasNet) to a wider audience, which started in 2001 with funding of DG TREN. The gasification network was clustered to the pyrolysis network, comprising the Thermonet project with 36 members of all EU countries including Switzerland. Each Network had its own work programme, but both ha also a common focus of addressing commercialisation issues and providing support for more rapid and more effective implementation of all the technologies in the market place. The Handbook describes specific topics discussed thoroughly within GasNet and additional chapters on more general aspects of biomass gasification including gasification of pyrolysis oil, market assessments, economics, legislative impacts, health and safety, tar standardisation and incentives for bio-energy through gasification. Authors and co-authors have been invited to contribute in various chapters.
Keywords: gasification, handbook, network

1 BACKGROUND

Thermal processing of biomass has the potential to offer a major contribution to meeting the increasing demands of the bio-energy and renewable energy sectors and to meet the targets set by the EC and member countries for CO_2 mitigation. Biomass gasification is considered one of the most promising routes for syngas or combined heat and power production because of the potential for higher efficiency cycles. Figure 1 shows a schematic presentation of processes involved in biomass gasification.

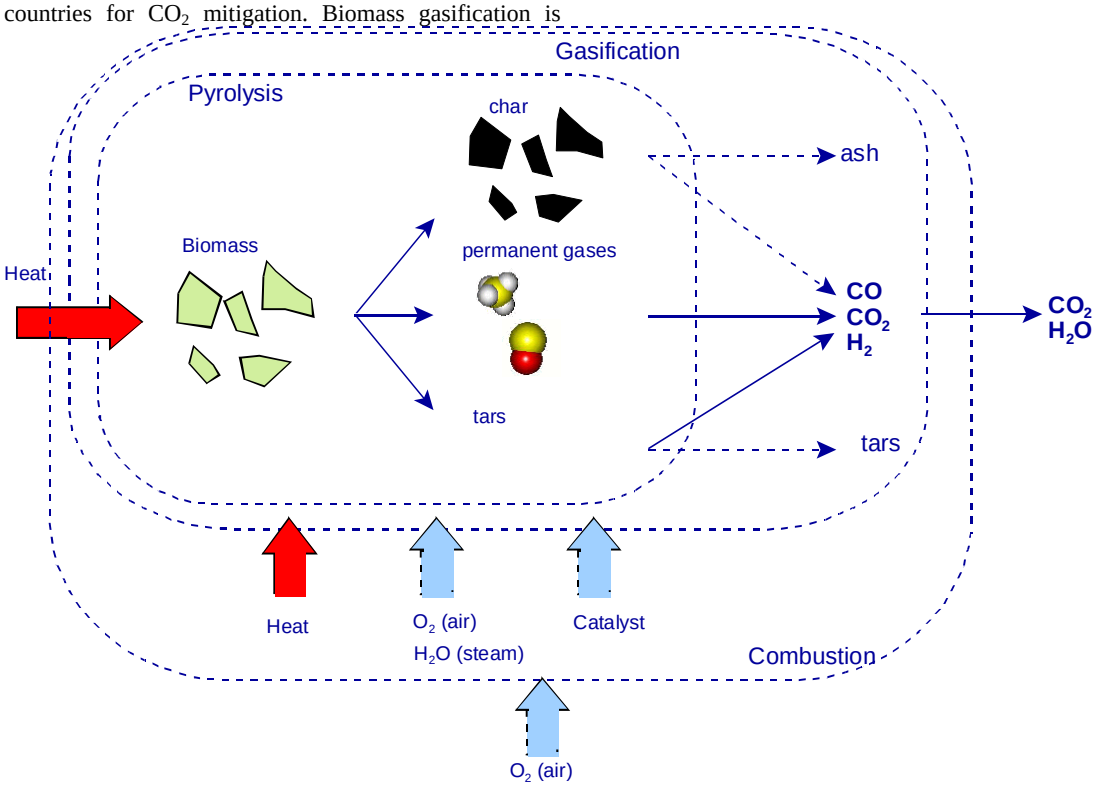

Figure 1: Schematic presentation of gasification as one of the thermal conversion processes [ref 1]

Instead of utilising biomass in traditional low-efficient systems (steam cycles), high-efficient gas engines or combined gas- and steam turbine cycles can be applied. Good technical progress has been made in the field of biomass gasification, but at a commercial level good achievements still have to be attained. International Networks like the IEA Bioenergy and the Gasification Network, GasNet have been established to provide a world-wide forum for the discussion, exchange and dissemination of information on new scientific and technological developments regarding biomass gasification and related technologies. The ThermoNet project funded by the European Commission was established for three years. The ThermoNet project comprised two Networks on thermal processing of biomass for fuels and electricity. One Network addressed gasification (GasNet) and the other pyrolysis (PyNe).

This cluster of Networks – GasNet and PyNet – provided a forum for all involved and interested in gasification and pyrolysis of biomass and waste to discuss, review and address technical and non-technical issues that inhibit rapid and wide-spread implementation of these technologies. There were joint tasks that involved both Networks and provide common approaches including pyrolysis of waste for gas production, market assessments, economics, legislative impacts, health and safety issues, bio-fuel standards and incentives for bio-energy. Figure 2 shows the structure of ThermoNet.

The Networks operated through a regular programme of meetings and workshops addressing a range of technical and economic issues that affect those industries who are developing and potentially using these conversion processes.

Outputs included regular newsletters, two websites and technical reports addressing all the issues under consideration. A further result of the project is the publishing of a Handbook on Biomass Gasification.

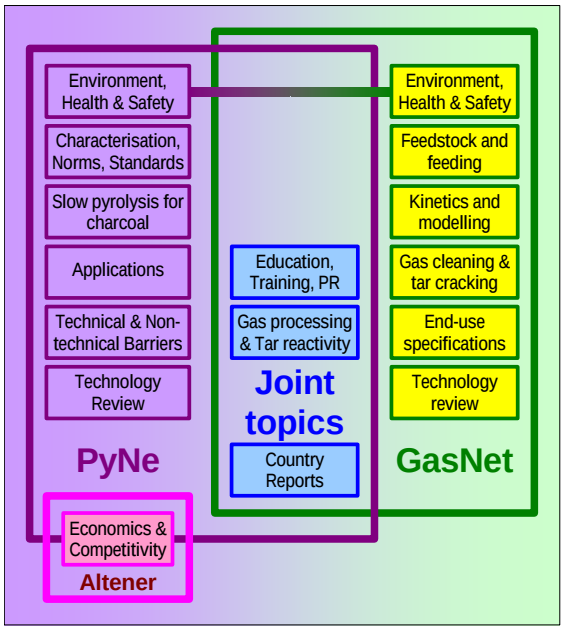

Figure 2: Structural organisation of ThermoNet.

2. PURPOSE OF THE HANDBOOK

The Handbook on Biomass Gasification is meant to disseminate the results of the European Gasification Network (GasNet) to a wider audience. The Handbook contains 19 chapters with approximately 400 pages describing specific topics discussed thoroughly within GasNet and additional chapters on more general aspects of biomass gasification including gasification of pyrolysis oil, market assessments, economics, legislative impacts, health and safety, tar standardisation and incentives for bio-energy through gasification. More than 20 authors and co-authors have been invited to contribute in various chapters. Figure 3 shows the frontpage of the Handbook.

Some of the data and information may be outdated sooner or later due to scientific progress and successful demonstration projects, but the general principles, gasification concepts and applications remain useful. Updated and additional background information can be found on the GasNet website www.gasnet.uk.net, which will continu for at least 3 years.

The handbook is intended to be a useful guideline both to newscomers to the subject and those already involved in research, technology development, industry, policy makers, investors and end-users.

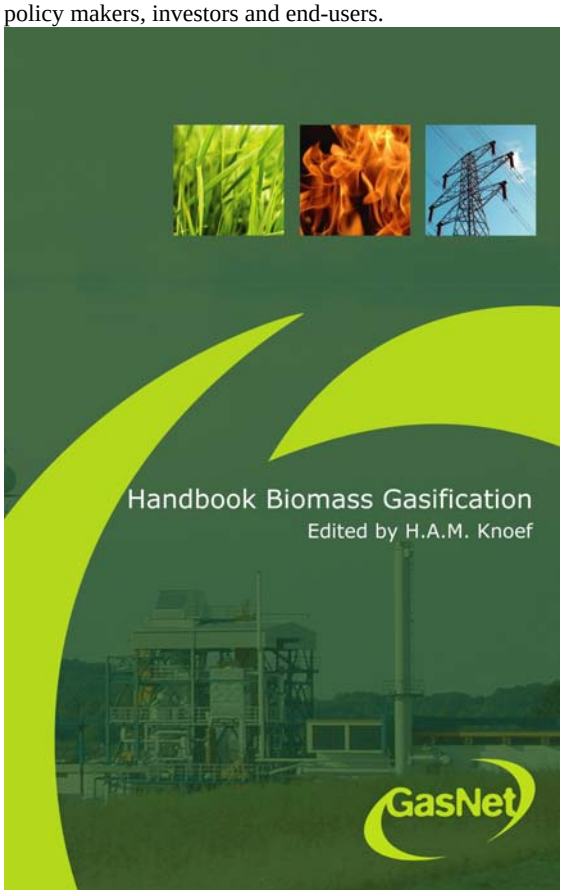

Figure 3: Frontpage of the Handbook, full-colour, hard-cover

3. TOPICS

Five topics were identified within GasNet and four joint topics with PyNe as illustrated in Figure 1. Experts were appointed to undertake the work in each of this topic. The topics areas included for GasNet:

- Feedstock and Feeding
- Gas cleaning and Tar removal
- Environment, Health and Safety
- End-use applications
- Technology review

Joint topics included:

- Kinetics and Modelling
- Education, Training and PR
- Technical & Non-technical Barriers
- Country reports

4. MEMBERSHIP

GasNet consists of scientist, consultants, policy makers, planners, investors, and equipment manufacturers who have hands-on experience with the

technology. This latter group was considered to be of great importance for discussion of the technical barriers and prospects. The following persons were involved in the GasNet membership:

1. Hermann Hofbauer, Vienna University of Technology, Dept of Chemical Engineering, Austria
2. Pépin Tchouate Heteu, Université Catholique de Louvain, TERM- Groupe, Belgium
3. Benny Gøbel, Dept of Energy Engineering, Technical University of Denmark, Denmark
4. Thomas Koch, TK Energi AS, Denmark
5. Esa Kurkela, VTT Processes, Finland
6. Laurant van de Steene, CIRAD-Forêt, France
7. Claus Greil, Lurgi Envirotherm GmbH, Germany
8. Eberhard Oettel, Fördergesellschaft Erneuerbare Energien e.V., Germany
9. Loukas Gavriil, Centre for Renewable Energy Sources, Greece
10. Emanuele Scoditti, ENEA, Italy
11. Giuseppi Neri, Bio-elettrica, Italy
12. Kevin Healion, Irish Bioenergy Association, Ireland.
13. Kees Kwant, SenterNovem, Netherlands
14. Ibrahim Gulyurtlu, INETI-ITE-DTC, Portugal
15. Truls Liliedahl, Kungl Tekniska Högskolan, Sweden
16. Krister Stahl, Ducente AB, Sweden
17. Michael Morris, TPS Termiska Processer AB, Sweden
18. José L. Sanchez, Universidad de Zaragozo, Spain
19. Ruedi Buehler, Ingenieurburo Umwelt + Energie, Switzerland
20. Andy Connor, Shawton Engineering Limited, United Kingdom
21. Richard McLellan, Wellman Process Eng Ltd, United Kingdom
22. Harold Boerrigter, ECN Biomass, The Netherlands
23. Nina Jensen, dk-Teknik Energy and Environment (later Force), Denmark and
24. Christian Wallner, TU-Graz, Austria

5 CONTENT OF THE HANDBOOK

The Handbook on Biomass Gasification consist of the following chapters:

1. Introduction
2. History of biomass gasification
3. Practical aspects of biomass gasification
4. Status of small scale biomass gasification
5. Status of large scale biomass gasification
6. Success stories
7. Status of gasification in Asia
8. Feedstock and fuel feeding
9. Update on gas cleaning technologies
10. Syngas production and utilisation
11. Supercritical gasification
12. Entrained flow gasification
13. Public perception and social marketing of biomass conversion technologies
14. Standardisation of tar measurements in producer gas
15. CO and PAH emissions from engines operating on producer gas
16. Health, Safety and Environmnetal Aspects of Biomass Gasification
17. Economics of Biomass Gasification
18. European Union Policies for the Promotion of Bioenergy Technologies
19. USA Renewable Energy Policies and Incentives

6 PROSPECTS AND SUCCESS STORIES

In the Handbook barriers (technical and non-technical), prospects and success stories can be found. Main technical barriers are 1) feeding due to the varing characteristics, 2) gasifier reactor which is fuel flexible, scaling-up aspects and multi-reactor designs and 3) gas cleaning which is lso application dependent.

There are quite a significant number of different non-technical obstacles which hampers the research, development, demonstration and commercialisation of biomass gasification. Major non-technical barriers are 1) financial aspects like high intial investment, fuel price, competing technologies, long-term contracting, etc. 2) permitting procedure, 3) Environmental, Health, Safety aspects including emission legislation, and 4) public perception, which is negative in general.

Nevertheless, the general prospects are good when obstacles can be overcome and recommendations are serious taken. New European Directives, tax measures, fiscal instruments, convenants, action plan biomass, green credits, etc. give new impetus to biomass gasification. To achieve a commercial product, several accompanying measures are needed and promotional measures. Networks – like the gasification network – are a very effective way of supporting development, identifying and prioritising issues, and directing future directions, particularly if they can be provided with financial, resources to address the most critical problem areas. Also education and training is recognised as an important tool for promotion of biomass gasification.

The more recent trend of liberalisation of the energy markets has resulted in decreased direct support from national governments for technology development and of investments of the energy sector in longer-term options. For bioenergy, this has proven to be a barrier for further developments because many options are not profitable yet. For this trend to be reversed there is a need for increased financial support and increased certainty over prolonged periods.

More and more pyrolysis and gasification are not considered to be competing but there are good prospects to benefit from both technologies, i.e. gasify the bio-oil in entrained flow gasifiers. Since the bio-oil is mineral-free this route has the potential to produce a high-quality syngas. Supercritical water gasification is another promising route for the production of hydrogen. Emission regulations should become in force specifically for gasification; the CO production in combustion plants from solid biomass is totally different from combusting a productgas containing large amounts of CO.

Several success stories of gasification projects and plants are outlined in the Handbook. This includes the following gasification plants

- Enamora, Spain, using almond shell,
- Greve-in-Chianti, Italy, using RDF pellets
- Güssing, Austria, using wood chips
- Harboore, Denmark, using wood chips as well
- Lahti, Finland, using various raw material
- Rüdersdorf, Germany, using various raw material
- SVZ, Germany, using various raw material
- Värnamo, Sweden, pressurised CFB gasifier
- Vermont, USA, using two CFB vessels
- Carbo-V, Germany, using 2-stage gasification

- Viking, Denmark, also 2-stage gasification

Obvious this is a snapshot of installations operating at the early years of 2000. Several promising projects are in the planning stage and demonstration is necessary for more rapid implementation.

7 AUTHORS CONTRIBUTED TO THE HANDBOOK

Over 20 experts in different areas contributed to the Handbook. In alphabetic order these are:

1) Jesper Ahrenfeldt, Technical University of Denmark (DTU), Denmark
2) Richard L. Bain, National Renewable Energy Laboratory, USA
3) Bert van de Beld, BTG biomass technology group, The Netherlands
4) S.C. Bhattacharya, Lake Gardens, India
5) Harold Boerrigter, ECN Biomass, The Netherlands
6) Markus Bolhàr-Nordenkampf, Austrian Energy & Environment AG, Austria
7) Tony (AV) Bridgwater, Bioenergy Research Group, Aston University, UK
8) Ruedi Bühler, Umwelt + Energie, Switzerland
9) Maarten J. van der Burgt, The Netherlands
10) André Faaij, Copernicus Institute for Sustainable Development, The Netherlands
11) Benny Gøbel, Technical University of Denmark (DTU), Denmark
12) Hermann Hofbauer, Vienna University of Technology, Dept of Chemical Engineering, Austria
13) Sascha Kersten, University of Twente, Netherlands
14) Henrik Laudahl Iversen, Technical University of Denmark (DTU), Denmark
15) Friedrich Lettner, Technische Universität Graz, Austria
16) Kyriakos Maniatis, DG Energy and Transport, EC, Belgium
17) Michael Morris, Termiska Processer AB, Sweden
18) Jo Penninger, Sparqle International, The Netherlands
19) Wolter Prins, University of Twente, Netherlands
20) Reinhard Rauch, University of Technology Vienna, Austria
21) Harald Rohracher, Interuniversitaeres Forschungs-zentrum für Technik, Arbeit und Kultur, Austria
22) Krister Ståhl, KS Ducente AB, Sweden
23) Helmut Timmerer, Technische Universität Graz, Austria
24) Lars Waldheim, Termiska Processer AB, Sweden
25) Christian Wallner, Technische Universität Graz, Austria

The Handbook on Biomass Gasification can be ordered at
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Handbook on biomass gasification. H.A.M. Knoef BTG biomass technology group B.V. Colosseum 11, 7521 PV, Enschede, The Netherlands Tel: +31 53 486 1186, Fax +31 53 486 1180, Email: Office@btgworld.com. ABSTRACT: The Handbook on Biomass Gasification is meant to disseminate the results of the European Gasification Network (GasNet) to a wider audience, which started in 2001 with funding of DG TREN. Biomass gasification has trailed coal gasification due to technical differences deriving from the characteristics of the feedstocks, as well as the typical scale of operation. Technological advances particular to biomass gasification have been successfully demonstrated and commercial-scale projects are proceeding. Around the world, more than 100 biomass gasifier projects are operating or ordered. This handbook explains how biomass can be converted to a gas in a downdraft gasifier and gives details for designing, testing, operating, and manufacturing gasifiers and gasifier systems, primarily for shaft power generation up to 200 kW.Â In one sense, biomass gasification is already a well proven technology. Using biomass gasification to make producer gas is one of the promising sustainable energy options available for small scale and rural applications for off-grid technology. Tar content in producer gas is the main problem if it is used directly as a fuel for an engine. A low-tar biomass (LTB) gasifier of approximately 30 kW capacity has been developed to solve this. Academic Press. 2010. 356p Modernized biomass gasification for power generation has attracted increasing interests as an attempt to reduce our reliance on fossil fuel. In fact, over the past couple of years, a lot of RD&D has gone into overcoming the...Â Handbook Biomass Gasiï¬cation. BTG Publisher , Enschede, The. Netherlands, pp. 32, 239â€“241.