Task 33 Presentation to EXCo 59 in Golden, Colorado
April 25-27, 2007
Summary of Discussion at the Task 33 Workshop on Situation Analysis and Role of Biomass Gasification (BMG) Technologies in Future Energy Needs

General:

A. Member countries view BMG as a process that can convert heterogeneous feed stocks to a fairly uniform in composition fuel gas or synthesis gas
B. Recognize super critical pressure boilers/Rankine cycle offer efficiencies comparable to IGCC; BMG produces a product gas that can be used for a variety of applications
C. Mandatory GHG reduction targets in Europe require extraordinary measures; BMG can help. BMG based power production can make a significant impact on RPS
D. While there's significant interest in synthesis gas and BTL, NL and CH are also interested in producing SNG from biomass
E. BMG synthesis gas plants should be large, thousands of tons per day capacity, to take advantage of scale-of-operation to contain product costs; integration with existing refineries and chemical process industry could reduce capital costs and expedite market entry
F. BMG has made significant progress over the last 20 years
G. Resources for RTD&D and the market-pull for BMG should evolve with current global activities to secure supply of energy and to contain GHG emissions

Criteria for Commercial Success: Sale of 5 or more gasification systems of the same gasification island configuration.

Commercial BMG Processes:

1. Bioneer UD Gasifiers in Finland & Sweden (1982) – up to 5 MWth for district heating
2. Foster Wheeler's CFBG/BFBG Systems in Finland, Sweden, Portugal, & Belgium (1979) – upto 70 MWth for co-firing
3. Lurgi CFBG in Germany, Austria and Netherlands (1987) – upto 100 MWth for co-firing
4. Fluidyne in New Zealand (1976) – upto 500 kWe for small-scale power
5. Others ???

Note: *There are hundreds of small-scale thermal gasifiers and several power gasifiers in other parts of the world that have attractive pay-backs but they may not meet Western environmental standards*

Successful Commercial Demonstrations:

1. Babcock Borsig Vølund in Denmark (1988)– 1.3 MWe & 8 MWth for CHP, (Next plant: by Green Power Co. Ltd. will be located in Murayama City in Yamagata Prefecture, Japan -2 Mwe)
2. DTU Two-stage BMG in Denmark(1989) – 75 kWth for small-scale power
3. Pyroforce in Switzerland (1990) - upto 500kWe for small-scale power
4. Biomass Engg in UK (1995)– upto 250 kWe for small-scale power

5. Xylowatt sa in Belgium (20 years R&D at UCL, 2001) – upto 600 kWe for small-scale power
6. Biosyn in Canada, (1984) – 50 MWth for synthesis gas/MeOH
7. Nexterra in Canada, (1989) – up to 13 MWth for co-firing
8. TPS in Italy (Studsvyk 1980s, TPS 1992) – 15 MWth for power generation
9. Bioflow in Sweden(1991) – 6 MWe, 9 MWth for CHP
10. Fraunhofer Umsicht in Germany, (1990) – 0.5 MWth, for many applications
11. TUV FICFB in Austria (2000) – 2 MWe, 4.5 MWth for CHP
12. Shell/Buggenum in Netherlands (co-gasification in 2002) - ~30% of 250 MWe
13. Future Energy in Germany (since 1960s) – 75 MWe and MeOH
14. Others???

Commercial Demonstrations in Progress:

1. NOVEL in Finland (1998, 2005) – 1.8 MWe+3.3 MWth for CHP
2. CHOREN in Germany (1990, 2006) – 45 MWth for synthetic fuels
3. CARBONA in Denmark (1990, 2005) – 5.45 MWe, 11.5 MWth for CHP
4. TKE in Denmark and Japan (1990, 2006) – 2.3 MWth for CHP
5. Shell/Magnum in Netherlands (2006-2011) – ~50% of (4x300) MWe
6. Taylor gasification in USA (2007-2011) – Integrated TCC+Biological Conversion,11.5million Gals of EtOH/year
7. Others???

Lessons Learned & Reasons for Lack of Market-pull:

a. In order to stay competitive RTD&D proposals promise more than what they can deliver. Sustained support for several years beyond the initially proposed schedules/milestones has resulted in success.
b. Review of ‘Commercial’ technologies show that it may take up to 10 years to develop and demonstrate clean BMG processes.
c. In order to stay competitive, RTD&D proposals promise more than what they can deliver. Sustained support for several years beyond the initial proposed years has resulted in success.
d. Adequately financing first-of-a-kind BMG process scale-up and demonstration is a challenge
e. First-of-a-kind commercial demonstrations may result in product prices 3 to 4 times conventional alternatives; adequate incentives and policies should be implemented to assist with market entry
f. Commercial success may require funding support through the commissioning of 5th plant (‘financing the learning curve’)
g. Performance guarantees should be backed-up with financial support for process optimization
h. Industry wants Western-class gasifiers at Eastern-country prices

Feed Stock and Feed Handling Issues and Front-end RTD&D Needs

i. Biomass prices are high; availability uncertain due to lack of reliable supply infrastructure
j. Seasonal availability of biomass feedstock requires large feed storage capability

k. R&D Needs: Feeding dry biomass, feeding or drying wet bio-refinery streams

Biomass Gasification Research Needs:

l. Cleanup and conditioning: hot-gas clean-up, syngas clean-up and conditioning, alternatives to Rectisol gas scrubbing, validation of syngas quality, and sensors and controls.
m. Gasification to minimize or eliminate CH4 Formation, gasification of biorefinery residue streams, hydrothermal gasification of biorefinery residues
n. Synthesis gas conversion: low-pressure synthesis gas conversion processes and synthesis gas conversion to SNG, EtOH, Higher Alcohols, other fuels and chemicals
o. Long duration BMG process demonstrations to validate operational reliability
p. High-efficiency power : IGCC, integration with HTFC and thermo- photovoltaics
q. Cross-cut environmental impact (emissions and effluents) and preservation
r. Process modeling and techno-economic and life cycle analysis
s. Gasification of pyrolysis oils, co-gasification with other carbonaceous fuels
t. Develop standard analytical protocols for gas (contaminant) composition measurements

Process Scale-up, Fabrication and Transportation of System Components

u. Scale-up by a factor of 10 is too large (scale-up factor of 4 may be less risky) to incorporate guarantees and warrantees for unproven unit operations, in particular for down stream unit operations dependent on unproven upstream operations
v. Important to work with credible engineering and manufacturing companies
w. Process scale-up to facilitate transportation of system components and to optimize cost reduction
x. Modular shop-fabricated plants are cheaper than field-fabricated plants

Commercialization, Marketing Plans, Market Entry, and Other Challenges

y. Performance guarantees should be backed-up with financial support for process optimization
z. Review industrial heating applications to identify opportunities for introducing thermal gasifiers to displace fossil fuels. Thermal gasifiers provide the opportunity to refine the basic technology
aa. Expand biomass based CHP to CH,C&P
bb. Explore opportunities for integrated thermochemical and biological conversion processes
cc. Federal government should be the first adaptors of new and advanced technologies
dd. For power generation address and resolve issues related to grid-connection
ee. Availability of process water
ff. Availability of skilled man-power for gasifier system fabrication, assembly, operations, and maintenance
gg. Task 33 should highlight merits of BMG for government agencies and industries with technical publications.

Note 1: *Projections for market entry, timelines/milestones, role of industry require surveys and interviews with primary stake holders.*

DRAFT

IEA Energy Technology Essentials

Situation Analysis of Biomass Gasification and Hurdles to Technology Commercialization***

Introduction: Almost all types of biomass, with less than 50% moisture can be gasified with air, enriched air, or oxygen to produce a fairly uniform in quality fuel and synthesis gas that could readily substitute for fossil fuels and fossil fuel derived products. Although biomass gasification (BMG) has a long history, the present commercial uses in Europe are limited to CHP and co-firing applications, employing both large (about 15 MWth) and small-scale (about 250 KWe or about 1 MWth) plants. A large number of intermittently operated BMG plants are deployed in India, China, and other Asian and Southeast Asian Countries for a wide variety of thermal applications, albeit at small-scale (below about 250 kWth), and a limited number for power generation in. BMG can play an important role in mitigating greenhouse gas emissions while producing high efficiency power in combined cycles (40+%) and even higher efficiencies when integrated with gas turbines and high-temperature fuel cells (50+%). BMG can produce a tailored synthesis gas for manufacturing fertilizers, chemicals, and fuels. In countries such as Netherlands and Switzerland, the current interest in exploiting BMG for energy security and climate control also includes producing synthetic or substitute natural gas. At present, BMG and the subsequent commercial utility of the product gas for high-efficiency power or value-added fuels and chemicals are expensive to build and operate, and require significant policy driven incentives for market entry.

While measures to legislate appropriate policies and incentives are being deliberated, it is generally agreed that BMG can play an important role in implementing the recent decisions to enforce mandatory GHG reduction targets in Europe and some parts of North America. Furthermore, the essential involvement of rural communities in all aspects of a BMG industry, from feedstock supply to ash recycling, would stimulate local economies while setting-up the essential foundations for a sustainable future. Against this backdrop, in March 2007, about 15 members of IEA Bioenergy Agreement, Task 33: Thermal Gasification of Biomass and 30 members of European Thermalnet/GasNet have conducted back to back technical workshops on Situation Analysis and Success and Visions for BMG[1,2]. A combined summary of the proceedings from the two Work Shops is given below.

Discussion on Criteria for Commercial Success: While discussing the situation analysis of BMG, the participants at the two workshops discussed at length the criteria for commercial success for BMG processes. Every one agreed that the development, optimization, and commercialization of first-of-a-kind BMG process are challenging and require substantial financial resources. As it is the case with most technologies, it is necessary to solve the inevitable technical issues that arise from process scale-up and process integration during the first commercial demonstration. These challenges are

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difficult to anticipate during the project formulation stage. Historical trend in funding projects, even with continued support from sponsors who can finance resolution of such hurdles, successful development in terms of performance and compliance with standards for emission and effluents and projected economics, may take about a decade. Once technology is proven and commercialized, replication should be expeditious.

For those who have witnessed success with recent renewable technologies such as wind energy, a survey of the BMG-landscape may appear to be scattered with a few commercial plants and a large number of 'struggling for sustained funding' process demonstrations that are yet to be considered 'commercial' technologies. A review of discussions in the Handbook on Gasification[3] and the observations and comments by the two Workshop participants, the following criteria were offered for consideration to determine the commercial readiness of BMG processes:

1. Continuous integrated plant operation under commercial conditions for a minimum of 2,000 hours
2. Plant availability of 80% or higher
3. Profitable plant operation without government support; an example is the sustainable financial support from CHP operations with feed-in rate for electricity and heat
4. Plant operation without major modifications during the first year of commissioning
5. Process owners willing to specify investment and operational costs and offer or arrange performance, service, and maintenance guarantees
6. Process owners ready to offer 'turn-key' plants

It was further argued that real commercial success is achieved only after building and operating the first five plants and demonstrating profitability in the absence of any local, regional, and national incentives. While these are valid arguments, the ultimate and final determination of success rests with stake holders who undertake the financial risks.

Discussion on Lessons Learned in Commercializing BMG: The two Workshops have also discussed and identified the following issues that should be either avoided or addressed and resolved upfront by the principal stake holders to commercialize BMG:

1. Inadequate attention paid to feedstock specifications and supply contracts
2. Commercialization of immature technologies without rigorous engineering design
3. Specification of materials of construction with limited performance demonstration
4. Cutting corners in process design to reduce capital cost, may raise questions on who should pay for the 'missing links/components' leading to project delays
5. Individual system components that may be considered commercially ready, may not necessarily guarantee success when they are operated in an integrated BMG process
6. Underestimation of the cost of detailed engineering, project management, permitting and project documentation, health, safety, and environmental (HSE) assessment, approval for CDM considerations, quality control and quality assurance, and insurance costs. These costs will invariably increase with increasing process complexity (particularly for the first-of-a-kind process)
7. Unexpected increase in steel prices and direct & indirect labour costs during project implementation
8. Cutting (cost) corners on efficient air/product gas/exhaust controls for gas engines

9. Inadequate supply of process water
10. Building plants expecting (but not guaranteed) cost offsets for reduced CO_2 emissions or for 'green energy products'
11. Unexpected and deliberate delays in executing project implementation schedules
12. High grid-connection costs relative to plant capacity for small BMG power plants
13. Hiring inexperienced staff to install, operate, and maintain the plant
14. Non-adherence to operations and maintenance manuals
15. Limited interest and lack of adequate 'project' knowledge at the financial institutions
16. Difficulty in finding proper insurance to protect the stake holders
17. Implementation of ATEX (explosion prevention) standards may increase some instrumentation and ancillary equipment costs by a factor of 2 to 3.
18. In order to stay competitive, project proposals promise more than what they can deliver. First-of-a-kind project financiers should provide for sustained support for several years beyond the initially proposed schedules/milestones to ensure success.
19. First-of-a-kind commercial demonstrations may result in product prices that are 3 or 4 times higher than the conventional alternatives
20. 'Commercial success' may require funding support through commissioning of the 5^{th} plant (i.e., financing the learning curve)
21. Performance guarantees should be backed-up with financial support for process optimization
22. Industry's expectation to acquire Western-class gasifiers at Eastern-country prices
23. While implementing projects abroad, the capabilities of local support staff to build, commission, and operate units should be evaluated carefully. Local engineering costs, cost of local support labour, import duties, and insurance costs may be expensive and wipe out the modest set-aside margin for profits.
24. Insufficient attention paid to handling and disposal of process effluents may become 'show stoppers' for continued plant operations

Discussion on Feed Stock and Feed Handling Issues: A challenging task for all BMG projects is to ensure sustained supply of biomass feedstock with in certain limits of QC/QA and cost, for the life of a plant, at least for about 15 years. The following are some of the key challenges related to feedstock supply and handling:

hh. Infrastructure to ensure supply as per quality, quantity, and cost specifications
ii. Seasonal availability of certain biomass feed stocks may require building large and expensive feed storage facility
jj. Need for efficient biomass drying and reliable biomass feeders, particularly for high-pressure gasifiers

Discussion on Process Scale-up, Fabrication and Transportation of System Components: The following observations were made during the two Workshops while addressing issues related to process scale-up and certain aspects of plant construction:

a. Scale-up by a factor of ten may be risky, while a scale-up factor of 4 may be common practice to incorporate guarantees and warrantees for unproven unit operations, particularly for down stream unit operations which may depend on unproven upstream operations

b. Scale-up of process components should take into consideration the necessity to comply with transportation of system components to plant site
c. Modular shop-fabricated plants are more cost-effective and significantly reduce plant construction schedules compared to field-fabricated plants

Discussion on Commercialization, Marketing Plans, Market Entry, and Other Opportunities and Challenges: Proceeding to the next step in process commercialization, the workshop discussions have identified the following issues:

a. Technology developers should share information of common interest, i.e. planning approvals, such as IPPC or WID applications so that companies can adopt consistent standards
b. Companies should also standardize their design and stick to a modular approach and ensure that each gasifier is not a "special gasifier" for each client or application
c. Explore industrial heating applications to identify opportunities for introducing thermal gasifiers to displace fossil fuels. Large scale implementation of thermal gasifiers should result in know-how to refine the basic gasification technology
d. Expand biomass based CHP to heating and cooling, while producing power
e. Explore opportunities for integrated thermochemical and biological conversion processes to improve efficacy of feedstock utilization and process performance
f. Federal government should be the first adaptors of new and advanced technologies
g. Power generation projects should address and resolve issues related to grid-connection early in the project

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