MINUTES
IEA Bioenergy Agreement
Task 33: Thermal Gasification of Biomass
Spring 2006, Task Meeting, June 12-14, 2006
Dresden, Germany
Prepared by
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The fifth Task Meeting for the 2004 to 2006 triennium was held with assistance from Karlsruhe Research Center, Institute for Technical Chemistry Germany, from June 12 to June 14, 2006. The **Agenda** for the Task Meeting is shown in Attachment 1 and the list of 35 **Task Meeting attendees**, including invited speakers and observers, for the one day workshop on, June 13, 2006 on "Biomass Gasification: Gas Clean-up" is shown in Attachment 2. The **Task Member Unable to Attend**: Emanuelle Scoditti, Italy

On June 14 a **plant trip** was organized to Freiberg, to visit the Sustec/SVZ and the Carbo-V, CHOREN plant, both designed to gasify biomass and renewable waste materials in an entrained reactor to produce a tar-free synthesis gas which can be subsequently converted to methanol, liquid biofuels, and chemicals. Ash is discharged in molten state.

The **Agenda** (Attachment 1) was reviewed and approved as proposed. The **minutes from the Fall 2005 Task Meeting** in Innsbruck, Austria was also approved with a revision to incorporate one sub-heading change.

Country Report Updates: SenterNovem, which sponsored the early coordination and preparation of the Country Reports, has distributed the original draft from 2004 to all Task Members. Task members were requested to review and revise their respective Country Reports on biomass gasification and forward revised reports to the Task Leader.

Monday, June 12, 2006 – COUNTRY REPORTS
Germany: Eberhard Oettel speaking on behalf of ***FEE*** *(Fördergesellschaft Erneuerbare Energien e.V.,* Society for the Promotion of Renewable Energy, Innovations Park Wuhlheide, Köpenicker Str. 325, DE-12555 Berlin) reported that Future Energy GmbH, Freiberg has been sold to Siemens AG. Siemens acquired, 50 % of the (Swiss) Sustec part of the Sustec-Shanghai Ningxia Coal Group, along with the orders from three coal gasification plants in China. Siemens announced that it is going to scale-up the tested and proven GSP gasifier to build a 1,000 MW coal gasification plant at Schwarze Pumpe.

The German subsidiary Vattenfall Energy AG, Berlin and Cottbus, of Swedish Vattenfall Group, have already started construction of the first oxy-fuel plant with integrated coal gasification and CO2 separation capabilities at Schwarze Pumpe. Sustec Schwarze Pumpe GmbH, Spreetal, has made some changes to the British Gas Lurgi slagging gasifier and demonstrated successful operation of the system. Following the

announcement of the Shell - CHOREN partnership, the construction of the biomass to liquid fuels (BTL) plant at Freiberg has begun. TAF Technische Apparate Freiberg GmbH a sister company of brain tankUET Umwelt- und Energietechnik GmbH, Freiberg, (member of FEE), both subsidiareis of CHOREN have given a European license for the small scale CARBO-compact, two-stage BMG technology to FEE-member, Bio-strom Energiesysteme GmbH & Co. KG, Vechta.

Eckhard Dinjus, Karlsruhe Research Center, Institute for Technical Chemistry Germany, reported on the German projects involving synthesis of organic chemicals and synfuels, by-product energy employing BIGCC, and co-production concepts. Biomass as the primary renewable carbon resource is expected to play a major role in Germany's future organic chemicals and fuels industry. Conceptual biomass based thermochemical biorefineries could be > 1 GW(th) capacity to take advantage of the effect of scale of operation on reducing product cost. The high-throughput, pressurized, and entrained flow gasifiers are well suited for such large-scale applications. In the proposed concept, biomass is first converted to a pumpable liquid or slurry and then subjected to high pressure and high-temperature gasification to produces a tar-free, low CH4 content raw synthesis gas, with very high, >99 %, carbon conversion. This process is applicable to other carbonaceous fluids, fossil fuels, and waste materials. Future Energy has conducted extensive tests with the GSP reactor employing a 'cooling screen' and ash discharge in a molten state at Schwarze Pumpe. A summary of entrained flow BMG processes is given below.

Table 1: Summary of selected slagging entrained flow biomass gasifiers

Advantages: complete conversion, tar-free low CH_4 syngas, high capacity at high pressure & T
Disadvantage: the need to pyrolyze biomass close to feedstock resources and transporting the pyrolysis liquids to a central gasificatrion plant

Company	Gasifier Feed	Gasification Conditions	Feedstock Pretreatment
Choren, DE	hot pyrolysis vapour, chemical quench with char powder	30 bar, 1300+°C quench to ~ 900°C (β- plant)	integrated into on-site autothermal pyrolysis at gasifier pressure
Chemrec, SW	concentrated black liquor	~ 30 bar, 950°C	On-site integration with the pulp mill
FZK, DE Future Energy	any bioslurry (from pyrolysis biooil and char)	ca. 80 bar, 1200°C (pilot 26 bar)	fast pyrolysis on- or off- site
ECN, NL	pulverised char	ca. 80 bar, 1200°C	torrefaction (low temp. pyrolysis on- or off-site)

syngascleaning, synthesis and product upgrading are similar to GTL or CTL plants

Photographs of the Sustec Schwarze Pumpe facility and the Future Energy GSP gasifier are given in Figure 1.

Figure 1: Illustration of the 130 MW(th) GSP – GASIFIER in operation at `Schwarze Pumpe´, Saxony since 1987

main feature: cooling screen with pressurised cooling water ~ 250 °C

Financial support for Future Energy's technology development effort is provided by the Baden-Württemberg Ministry of Agriculture, EU-IP RENEW Program, and dem Bundesministerium BMVEL mit der Fachagentur für nachwachsende Rohstoffe, FNR.

Switzerland: Ruedi Bühler presented the Policy, Programs, BMG projects and BMG Industry in Switzerland. The government policy is to double the current consumption of biomass and wood, from the present 5 and 2.5% respectively, of the total primary energy consumption in Switzerland. At present, the primary utilization of biomass will be for heat applications, and heat and power, and in the future for SNG, Biodiesel, and to replace fossil fuels.

The primary research support is provided by the Federal Government, Electricity Companies, and regional governing bodies. New incentives that are currently being developed in the parliament to promote the use of renewables in electricity production are similar to the German "Stromeinspeisegesetz."

The government programs include :

- Energie Schweiz
  - Action program of the Federal Government to cut energy consumption
  - Support of voluntary actions of industries, communities etc.
- Klimarappen

- Program of the oil trade association to avoid CO2 tax
- Voluntary contribution of 0.01 €/liter of diesel and of gasoline sales from 2008-2012 to support projects which reduce CO2 emissions
- 70 Million €/year financial support for
    - Energy conservation (buildings)
    - Renewables (e.g. wood)

The Swiss industrial small-scale BMG project, Xylowatt has stopped all development efforts because of the inability to demonstrate a satisfactory gas cleaning method for turbocharged gas engine, primarily due to carry-over of dust particles. Pyroforce, which developed the Kloeckner-Humbolt-Deutz type gasifier, at Spiez, has successfully employed high-temperature gas cleaning, by sorbent injection, and bag filters to clean the gas, and in operating an Jenbacher engine for over 10,000 hours with engine at part load.

At present, Pyroforce is constructing a BMG power generation system at Güssing, AT. The commercial installation will include two gasifiers with gas cooling and dust removal to produce 300 kWe in a single Jenbacher engine. In order to improve safety, at the end of every gasifier operation, the system will be flushed with nitrogen, therefore avoiding explosion risks and health risks to the operators when they open the system for inspection. Plant commissioning is scheduled for January 2007. Pyroforce is also building a 900 kWe plant at Ferlach, AT, employing two parallel lines of three BMG plants, with dedicated gas cleaning systems, gas coolers, bag house filters with ***sorbalit*** (active char coal blended with certain active ingredients) injection, and two Jenbacher engines of 450 kWe capacity each. The commissioning of this plant is also scheduled for January 2007.

Pyroforce is involved in the development of six more BMG power generation plants in Germany and Switzerland. The present cost of plant designs and the anticipated revenues project total plant amortisation within six years.

The Swiss company, DASAG Renewable Energy AG (Dasagren), is involved in the development of the Indian Institute of Science, open top, down draft re-burn gasifier, produced by Netpro, Bangalore, India. Several such plants are in operation in India. Two plants are under construction, a 350 kWe plant at Wila and a 600kWe plant for installation in Zollhaus. The main features of the Wila CHP plant are:

- Capacity: 350 kWe + waste heat utilisation.
- Feed rate: 450 kg/h of 15% moisture content biomass
- Producer gas cleaning system with cyclone separation, quenching, scrubbing and filtering.
- 1 Jenbacher engine
- Plant under construction and commissioning planned for November 2006

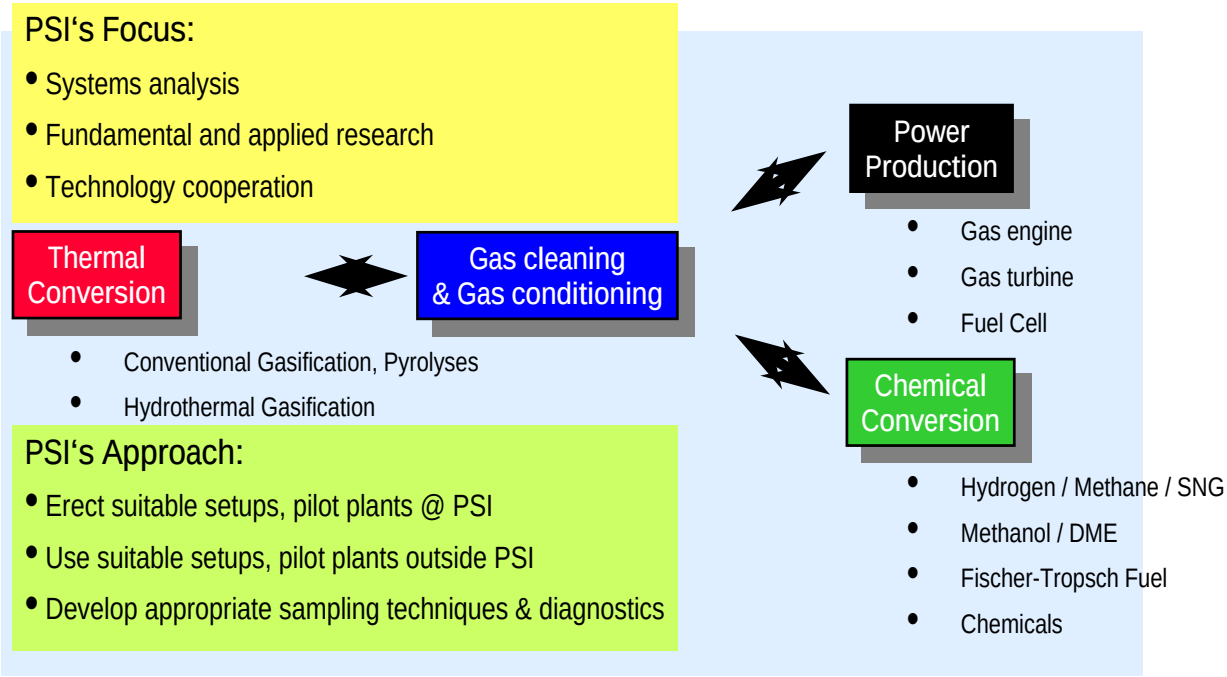
The range of power plants being offered by Dasagren include:

- Unit ratings of 200 - 600 kWe
- Multiple gasification units with common gas cleaning system for power plants in the MW range.

- Gasification plants for the supply of producer gas for thermal applications.
- Erection, commissioning, training of operators and supervision during start-up and commissioning of the power plant.
- Technical support for maintenance management.
- Time frame for commissioning is approximately 10 to 12 months, including approval of permits from local authorities.

Serge Biollaz, of Paul Scherer Institute (PSI) in Villigen presented the organization's R&D efforts related to BMG. The scope of PSI's BMG application R&D program is summarized in Figure 2.

Figure 2. Power & Chemicals from Biomass via Gasification Focus and Approach at PSI



The PSI BMG application R&D for SNG production includes both direct and indirect gasification of biomass. In the direct scheme biomass is gasified under pressure upto 30 atm, gas is cooled and cleaned prior to methanation over commercial Ni catalyst at 400^{o}C and at 30 atm. pressure. The indirect gasification scheme employs hydrothermal treatment to conduct simultaneous gasification and methanation. The ultimate objective is to produce SNG from biomass for distribution in the Swiss natural gas grid operating at about 25 atm.

European Commission: Maria Fernandez Gutierrez, New and Renewable Energy Sources, Directorate General for Research reported that the objective of the EC Energy theme is "…to transform the current fossil-fuel based energy system into a more sustainable one based on a diverse portfolio of energy sources and carriers combined with enhanced energy efficiency, to address the pressing challenges of security of supply and climate change, whilst increasing the competitiveness of Europe's energy industries".

The goal of the supporting Renewable Electricity Generation program is defined as 'the development and demonstration of integrated technologies for electricity production from renewables, to raise substantially the share of renewable electricity production in the EU.' Therefore, the EC sponsored research is focused on increasing conversion efficiency, enhance process reliability and further reduce the environmental impact. Emphasis is on photovoltaics, wind, and biomass.

The goal of the renewable fuel production program to supply the biomass feedstock is to 'develop and demonstrate improved technologies for the sustainable production and supply chains of solid, liquid and gaseous fuels from biomass.' Therefore, the EC sponsored research should ultimately improve overall energy efficiency, enhance technology integration, and use of multiple biomass feedstocks. Emphasis is on new types of biofuels, new porduction and distribution routes, and integrated biorefinery concepts.

EC has deployed a variety of RD&D programs to attain these goals :
1. Biomass Action Plan (BAP): The BAP sets out measures to promote biomass in heating, electricity and transport, followed by cross-cutting measures affecting biomass supply, financing and research. Key measures include-

- Steps towards EU legislation to encourage the use of renewable energy in heating (the Heating Directive)
- Campaign to inform farmers and forest owners about energy crops
- Review how fuel standards could be improved to encourage the use of biomass for transport, heating and electricity
- Possible revision of the Biofuels Directive, including the use of biofuels obligations and giving favourable treatment to second generation biofuels, and
- Investment in research, particularly for producing liquid fuels from wood and waste material in biorefineries.

2. EU Strategy for Biofuels: This Communication carries forward the biofuels component of the BAP and is accompanied by an Impact Assessment, which presents different policy options. Key measures include-

- Stimulate demand for biofuels (review the Biofuels Directive and the Fuel Quality Directive)
- Ensure environmental sustainability of biofuel feedstock production
- Expand feedstock supplies by:
  - ✓ making sugar production eligible for non-food regime on set-aside land, and for energy crop premium
  - ✓ promoting the energy use of forest material (Forestry Action Plan)
- Develop a Biofuels Assistance Package that can be used in developing countries that have a potential for biofuels
- Pursue a balanced development of both EU domestic production and enhanced import opportunities for biofuels and their feedstocks
- Support research and development

3. R&D Plan: The Commission shall-
   - Support research into the optimisation of agricultural and woody crops for energy purposes, and biomass to energy conversion processes
   - Give a high priority to research into the "bio-refinery" concept, finding valuable uses for all parts of the plant
   - Give a high priority to research into second-generation biofuels, with an aim to improve efficiency and cost-effectiveness
   - Encourage the development of an industry-led "Biofuel Technology Platform" and other relevant platforms
   - Support the implementation of the Strategic Research Agendas prepared by these technology platforms

4. EU strategy for sustainable and secure energy: This 'green paper' outlines how an European Energy Policy could meet the three core objectives of energy policy: sustainable development, competitiveness, and security of supply. The paper puts forward possible contents for an Action Plan on energy efficiency to be adopted by the Commission later this year. It also proposes the preparation of a new Road Map for renewable energy sources in the EU, with possible targets for 2020 and beyond in order to provide stable investment climate to generate more competitive renewable energy in Europe.

5. EU Forest Action Plan: The Commission is in the process of formulating an EU Forest Action Plan, which "...should provide a coherent framework for the implementation of forest-related actions and serve as an instrument of co-ordination between Community actions and the forest policies of the Member States..." which includes actions to promote the use of forest biomass for energy generation

Two new projects were highlighted:
a. BIGPOWER - Advanced Biomass Gasification for High Efficiency Power: The objective of this project is to develop fuel-flexible gasification technologies for second-generation processes (targeted electricity production cost <5 €cents/kWh by 2015) from a wide range of biomass resources. This project focuses on three promising European gasification technologies-

- air-blown fixed-bed gasifier for 0.5-5 MWe
- steam gasification in a dual fluidised bed gasifier for 5-50 MWe
- air-blown pressurised fluidised-bed gasification technology for 5- 100 MWe.

The performance and the technical and economic feasibility of the advanced gasification-to-power concepts will be assessed for different European regions. This project was started in September 2005, with a total budget of € 2,943,402 (EC contribution: €1,700,000). The project coordinator is Esa Kurkela, VTT, Espoo, Finland. (more information at: *http://www.vtt.fi)*

b. AERGAS II – Biomass Fluidised Bed Gasification with In-situ Hot Gas Cleaning: The objective of the AERGAS II (AER – absorption enhanced reforming) project is to develop a low-cost gasification process with integrated gas cleaning for subsequent power production. The proposed process uses *in-situ* CO2 capture and produces a gas

with low amounts of tar (<500 mg/m3), alkali and sulphur, a high concentration of hydrogen (>70%), and a high calorific value (LHV > 15 MJ/m3). The process should allow the use of problematic feedstocks. The process will be investigated in a continuously operated 100 kWth pilot plant. The project goal is to determine technology feasibility by conducting tests at the 8 MWth capacity FICFB plant in Güssing, Austria. This 3-year project was started in January 2006, with a total budget of € 2,652,614 (EC contribution:€1.8 million). The project coordinator is M. Specht, of Zentrum für Sonnenenergie- und Wasserstoff-Forschung, Stuttgart, Germany

The EC with the support of the Finnish Presidency is sponsoring a major EUROPEAN CONFERENCE on BIOREFINERY RESEARCH, on 19 and 20 October 2006 at the Marina Congress Center in Helsinki, Finland. Details are available at : http://ec.europa.eu/research/energy/gp/gp_events/biorefinery/article_3764_en.htm

SWEDEN: Lars Waldheim, TPS Termiska Processer AB, Nyköping, Sweden reported that in 2002, Sweden implemented tax exemptions for RE transport fuels until 2008. RE certificate trading has started in 2003 to raise the RE quota to 7% in 2003 and 17 % in 2010 (equivalent to 10 TWh). Programs were implemented to encourage production of RE electricity and the efficient use of energy in co-generation applications.

Recent budget actions for 2006 show that in the interest of promoting renewable energy, Sweden will extend RE Certificates up to 2030 and the R&D programmes on biomass for fuels and power will be pursued through the demonstration phase. A high level stakeholder commission, chaired by the Prime Minister, for the substitution of the total oil consumption in 2020 has been established and is now working on measures to support and sustain the production of transport biofuels beyond 2008.

The latest impact on R&D includes reallocation of 100 MSEK (€11 million) in 2006. Between 2006 and 2008, 810 MSEK (~€90 million) per year will be spent on energy RD&D. More support will also be provided for demonstration on products and short-term impact than on long-term basic reserach. The formation of a cross-cutting strategic committee for gasification is chaired by Mr. Erik Rensfelt, a former member of Task 33.

The CHRISGAS project team includes representation - from Sweden: Växjö University (co-ordinator), Växjö Värnamo Biomass Gasification Centre (VVBGC), AGA-Linde, Catator, KS Ducente, Royal Institute of Technology (KTH), S.E.P. Scandinavian Energy Project, TPS Termiska Processer, (Valutec),Växjö Energi; from Denmark: TK Energi; from Finland: Valutec; from Germany: FZ Jülich, Linde, Pall Schumacher; from Italy: University of Bologna; from The Netherlands: Technical University Delft; and from Spain: CIEMAT. The EU grant for the project is €9.5 million, STEM provides €1.5 million, and €7 million is provided from other sources. In May 2005, the balance of financing of €28 million is requested from STEM.

The objectives and deliverables of the CHRISGAS project include production of hydrogen-rich synthesis gas from biomass fuels, at a scale of 3500 Nm^3/hr of H_2 equivalent, within 3 to 4 years.

The assessment of the condition of the Värnamo Plant was completed in September 2005, conceptual engineering to make system modifications was concluded in December 2005, and the basic engineering work for system modification should have been completed in June 2006. The BMG test program will include evaluation of catalysts, filters, gas cleaning systems etc., by conducting full-scale pilot tests in the Värnamo plant at a feed rate of 3-4 tonne biomass/hr. In addition, improved drying and feeder prototype systems will be tested. The test program should lead to useful information on fuel availability and cost, cost of liquid fuels production under the European standards and the preferred range of operating conditions to produce H_2 rich synthesis gas. In addition to these activities, the CHRISGAS project will support web based education and research for academic organizations.

NEW ZEALAND: Shusheng Pang, Wood Technology Research Centre, University of Canterbury, Christ Church, reported on New Zealand's -

1. Government Policy on Climate Change-
   - New Zealand Government issued a climate change policy package in 2002, which
     - Enables to achieve obligations for meeting greenhouse gas reduction target under the Kyoto Protocol;
     - Leads the country towards a sustainable energy future.
     - Increase RE supply by 22% to provide an additional 30 PJ of consumer energy by 2012.

   - Review of the Climate Change Policy in 2005 resulting in key decisions that
     - it will not implement a carbon tax of $15/ton of CO_2 that was to come into effect in 2007.
     - it will not proceed with any other broad-based carbon tax in the first commitment period under the Kyoto Protocol.

   The Climate Change Policy will be further reviewed in 2007 and 2010.

2. National Programs and Initiatives for Reduction of GHG Emission-
   - Incentive investments in renewable energy:
     - Government agency FIDA (Forest Industry Development Agenda) will invest $NZ 2.5million in the next 5 years on programs to encourage the use of woody biomass as a fuel through information provision, to develop engineering solution for recovering forest residues, and to support feasibility studies to illustrate commercial opportunities for woody biomass use.
     - FRST (Foundation of Research, Science and Technology) will invest $NZ 2.5million/year on renewable energy.
     - TIF (Technology for industry) has funds available for investment in small/new bunisses including bioenergy.
   - Encouraging plantation of new forests and reduction of deforestation.
   - Improving energy efficiency in transport and primary industry sectors.

- Assessing options for a narrow-based carbon tax on major energy users and emitters who do not meet (world's) best practice standards.

The major biomass resources in New Zealand include wood wastes from wood processing industry, pulp and paper wastes, and forest harvesting residues. Bioenergy currently contributes about 6% of New Zealand's primary energy supply; 25 PJ for wood processing and 4 PJ for domestic space heating. In the next 5 years, over 50PJ/year may become available from forest product industry, thus raising wood to about 10% of total energy supply.

On the commercial front, Page Macrae Engineering Ltd. has constructed a 2 MWth gasifier to convert wood processing wastes to energy used in a Plywood mill including steam supply for log conditioning. Since 1998, Fluidyne Gasification Ltd. which was established in NZ in 1976, has been working in Canada, Ireland and Australia, with plans to deploy Mega Class Series of gasifiers and gas engines of 300 kWe to 2 MWe capacity in Canada. Since 2000, Fluidyne is working in Northern Ireland to design Atlantic Class commercial gasifiers upto 80 kWe capacity. It is also providing a small Australian company, Ga, with design and operational training for a Tasman Class (15 kWe) wood gaisifier for remote location applications. Alternative Energy Solutions (AES), an engineering company, representing the Indian Ankur Scientific Technologies, is promoting commercialization of down draft, fixed bed gasifiers for biomass feed stocks including bark, sawdust, chips and other wood wastes generated at sawmills.

The University of Canterbury leads an R&D programme on 'Wood IGCC' for wood industry. The 100 kWth laboratory-scale Fast Internal Circulating Fluidised Bed (FICFB) gasifier is undergoing tests and evaluation with *radiata* pine residues. Other research includes gas cleaning, pyrolysis, hydrogen, Fischer-Tropsch synthesis, liquid fuels, and development of GCMS and NMR analytical techniques for measurement of major and minor components in gasification streams. The ultimate objective is to build a large-scale BIGCC demonstration plant at a wood-processing mill.

UNITED KINGDOM: Nick Barker, Future Energy Solutions reported on changes since last update in Fall 2005 as follows:

- The 23 MWe FERCO installation proposed in Devon has had planning permission refused by the local administration. There may be an appeal.
- Exus Energy has restarted its business under the name Biomass CHP Ltd.
- The government response to the Biomass Task Force report has been published recommending greater support for biomass heat and CHP. Of the new funding scheme announced, the first grant of, £8 million, will be awarded in April 2007.
- In January 2006, a major review of UK energy policy was launched
- Biomass Engineering Ltd., continues to expand with several 250 kWe units installed, including one in Germany.
- On April 12, 2006 a further round of the Bio-energy Capital Grants Scheme, focussed on biomass heat and CHP, was launched. It will have at least £2 million available for new projects.

The market drivers for biomass utilization include, Renewables Obligation with an electricity price of approximately €10.8 cent/kWh, rising oil and gas prices, landfill directive increasing wood disposal prices, the Royal Commission on Environmental Pollution Report on Biomass which recommends further support for heat and CHP, the Biomass Task Force report reinforcing emphasis on heat and CHP, and the Biofuels Directive raising interest in transport fuels.

The support measures include:

- Market support for electricity through Renewables Obligation and tax exemptions for transport fuels.
- Renewables Obligation also supports waste gasification.
- The range of R & D programmes and capital grant support measures are:
  - –£66 million for bio-energy capital grants
  - –£29 million for energy crops scheme
  - –£3.5 million for infrastructure scheme
  - –£30 million for advanced energy from waste demonstrators
  - –£2 million/year of DTI R & D plus university funding

However, the following barriers for biomass energy development remain as hurdles to overcome:

- High investment cost
- The need for long term power purchase agreement which is difficult to obtain under the RO system
- Long-term fuel supply contracts, and
- Unfamiliarity with the technology

The UK industry has a definite need for small-scale CHP systems with low cost, fast build, and a good match between waste production /heat consumption. There is also an increasing interest in co-firing.

Basic Research: The most important vehicle for basic research in biomass R&D is the Supergen Consortium, with Aston University as the lead contractor involving a team of five other Universities and research institutes and five industrial partners (Web site http://www.supergen-bioenergy.net). This programme tackles the larger challenges of sustainable power generation and supply. Biomass, biofuels and energy crop utilisation are the primary themes. Within these themes, the research will investigate the potential for power generation systems using energy crops and agricultural crops whilst striving for a carbon neutral cycle. The work programme comprises of six work packages

1. Process and techno-economic assessment
2. Fuel specification and matching to conversion
3. Thermal reactor modeling
4. Minimisation of engineering risk
5. Co-firing and co-processing biomass
6. Network of British Biomass and Bio-energy Forum

Industrial and applied research: Biomass Engineering Ltd is a company specialising in small scale combined heat and power using downdraft gasification and pyrolysis. Three BMG power generation systems are in successful operation. Four projects have been completed successfully and final reports are in preparation:
1. Ceramic filter investigation
2. Integration of BMG and micro-turbine
3. Operational and environmental impact of fuel types in Downdraft gasifiers
4. Process scale-up to 250 kWe CHP units

Exus Energy has recently carried out two projects; commissioning of Blackwater Valley gasification power generation system and the catalytic clean up of IC engine exhaust.

Siemens Industrial Turbines, Lincoln is developing gas turbines for BMG applications. The work programme addresses combustion issues plus high mass flow power turbine technology. The focus is currently on MCV fuel gas applications due to increasing interest from the waste pyrolysis sector.

Rural Generation and Queens University Belfast are carrying out a project to investigate the integration of a downdraft gasifier with micro-turbines including a catalytic burner.

Following the successful development of Compact Power's waste gasification process, the company is planning to extend the technology to clean biomass and increase the throughput rate. This technology development research project will investigate the effect of preheat on gas production in pyrolysis and gasification processes by installing a preconditioning stage, ahead of the indirect gasification step.

Current and proposed BMG installations:
Biomass Engineering: At Lancashire farm, a 250 kWe plant has logged in 4,000 hours of operation. Biomass Engineering continues progress with manufacturing six small (250 kWe) commercial CHP units, while three other units are in operation or in commissioning. The Ecos Millenium Centre, Balymena, 75 kWe net gasification system, with wood preparation and modified diesel engine, has been in operation since 2000.

Rural Generation: The Brook hall, 100kWe plant has now exceeded 15,000 hours of operation.

Compact Power: The Bristol plant has completed three years of commercial operation on wastes with excellent emissions performance. The process is fully licensed for commercial use by the UK Environment Agency and was included in their annual report as an example of excellence. A new, 2 MWe demonstration is planned for next year.

Winbeg 1: The proposed 22MWe, FERCO combined cycle Sylvagas gasification plant in Devon will employ a mix of energy crops, agricultural and forestry residues. Support comes from Capital Grant plus Renewable Obligation. The expected start date of 2006 has been set back by two years due to delays in permitting.

Charlton Energy: A 7MWe CHP plant using a rotating kiln gasifier is under construction in Gloucestershire. The plant will include Eco-tran equipment, reciprocating engines and it will use agricultural and forestry biomass as feed materials. Support comes from Capital Grant and Renewable Obligation. The plant will generate revenues from heat sale to nearby sawmill for drying wood. The anticipated start date for this plant is in 2006/7.

Further information on the UK research reports can be found at: http://www.dti.gov.uk/publications/ (Click on "Browse" then Energy - New and Renewable: biomass)

USA: Richard Bain, NREL, Golden, Colorado, reported the formation of the National Bioenergy Center (NBC), as a "Virtual Center" created to improve DOE research performance capabilities and to help achieve nationwide collaboration in bioenergy research. The purposes of setting-up NBC include:

- Reduce U.S. dependence on oil
- Build U.S. bioenergy industry
- Reduce global warming
- Provide a one-stop shop for DOE's industrial partners
- Coordinate multi-year planning and execution of R&D at all DOE Labs
- Fully leverage tax-payer investment in federal facilities

The NBC is sponsored by US DOE - EERE Office of the Biomass Program.

In 2004, the total US Energy supply was estimated to be about 100.3 Quadrillion Btu (10^{15} Btu) with 40% contribution from petroleum, 23% from natural gas, 23% from coal, 8% nuclear, and 6% from RE. The RE contribution is made-up of 47% from biomass, 45% from hydroelectricity, 5% from geothermal energy, 2% from Wind, and <1% from solar energy.

The breakdown of biomass consumption in 2004 in Quadrillion Btu, is as follows:
Commercial - 0.09, Residential - 0.41, Ethanol - 0.28, Electric Power - 0.44, and Industrial - 1.63, Total=2.85.

The present biomass energy RD&D programs are driven by the joint U.S. DOE and USDA resource assessment conducted in April 2005, known as the "Billion Ton Study" which reported that US forest resources produce 368 million TPY, agriculture produces 933 million TPY, which adds up to a total of 1301 million TPY. The 1.3 billion tons of biomass is estimated to have a heating value equivalent to 3.5 billion barrels of oil, which is also the peak production of oil back in 1970. In comparison, US produced about 2 billion barrels of oil in 2003. With efficient collection and utilization of the annual yield of billion tons of biomass, US is expected to reduce imports by at least 50% ***(???).*** Recognizing this potential, USDOE is now primarily focused on producing biofuels in advanced biorefineries that can significantly reduce the consumption of fossil fuels with many regional and national benefits.

In 2005, US produced 75 million gallons of biodiesel. The 81 commercial corn to ethanol plants produced 3.9 billion gallons of biofuel at a cost of ~$1.35/gallon of gasoline equivalent (gge). In comparison, the estimated cost of producing cellulosic ethanol is about ~$3.00/gge. USDOE projects that by 2012, refinements in bioconversion technology could reduce this to $1.42/gal.

In its recent strategic plans DOE has set a "30 by 30 goal" of replacing 30% of Today's gasoline by 2030 with biofuels.

Discussing an integrated biorefinery, combining bioconversion and gasification, it is reported that from 10,000 dry tonne of corn stover, 1,035,000 gal of ethanol and 2932 dry tones of lignin are produced. Lignin can be gasified and the resulting synthesis gas can be converted to mixed alcohols, at 260-350°C, 30-175 bar, using alkali promoted MoS_2 catalyst. The mixed alcohols is estimated to contain an additional 215,400 gallons of ethanol along with 7,900 gallons of methanol, 39,100 gallons of n-Propanol, 15,100 gallons of n-Butanol, and 6,900 gallons of n-Pentanol.

The concept of converting oils, fats & greases as bio-renewable petroleum refinery feedstock involved co-processing these materials with petroleum fractions, utilizing existing process capacity. Thus, there is a possibility to produce higher quality diesel blending components at a lower cost than producing FAME.

On the subject of biopower, it is reported that in 2004, US generated 10 Gwe, made-up of 5 GWe in the pulp and paper industry, 2 GWe from dedicated biomass power plants, and 3 GWe from MSW and landfill gas. The cost of the estimated 60 TWh of electricity produced in 2004, ranged from $ 0.08 – 0.10/kWh. In comparison integrated gasification combined cycle plants should be able to produce electricity at $0.04-0.06/kWh.

Austria: Reinhard Rauch, Vienna University of Technology, reported that Austria is now deriving 21-23% of its energy from renewable resources while biomass contributed roughly 12% (or 168 PJ or 0.16 Quads) of the primary energy demand. The national goal is to increase the production of electric power from renewables (excluding hydro power) to 4 % and to increase the share of renewable fuels to 5.75% in the transport sector by 2008.

The R&D activities at the Graz University of Technology, Institute of Thermal Engineering include evaluation and optimisation of a fixed bed gasifier, gas cleaning system and gas engine, development of a two-stage gasification system, health, safety and environmental issues for gasification systems, and providing support to the Austrian Bioenergy Centre. The GrazUniversity of Technology -Institute for Apparatus Design, Particle Technology and Combustion Technology, is conducting research on gasification and combustion in a fixed bed of solid fuel, and fundamental research on biomass particles under gasification conditions. The JoanneumResearch, Graz-Department of Energy Research is evaluating the prospects for biofuels aunder the VIEWLS project.

The Vienna University of Technology, Institute of Chemical Engineering, (TUV) is leading BMG development in Austria. TUV is a scientific partner in RENET Austria (Network of Competence for Energy from Biomass), in Austrian BioenergyCentre, the EZ-P4 (Polygeneration) project, the EC projects on Renewable Fuels for Advanced Power Trains (RENEW), the BigPower, AER-Gas II and the BioSNG project and in the development of a pressurised gasification process in cooperation with the Austrian Bioenergy Centre. TUV is also investigating catalytic tar cracking, the use of the product gas from the in a SOFC, and to produce Fischer Tropsch diesel. Successful investigations will be scaled-up and tested at the Güssing plant.

On the demonstration front, the 8 MW_{th} FICFB CHP plant in Güssing is in continuous operation and the 2 MWth, down draft fixed bed gasifier at Wr Neustadt is undergoing commissioning.

FINLAND: Matti Nieminen, VTT reported the following updates on Finnish biomass and waste gasification activities:

1. Small-scale gasifiers for heat and CHP
   - most of the old Bioneers are still in operation
   - the 7 MWth, Novel updraft NOVEL gasifier at Kokemaki is in commissioning phase
   - the Puhdas Energia small downdraft gasifier is under testing and development with commercial installations in USA and Finland
2. Fluidised-bed gasifiers for boilers and kilns
   - the 60 MWth gasifier in Lahti is in continuous operation
   - a new waste-to-energy plant with 160 MWth capacity is in design phase for installation in Lahti which includes two CFB gasifiers, gas filtration system, and a new boiler with WID flue gas cleaning
   - the 40 MWth (Corenso/Varkaus) plastic waste gasifier is in continuous operation

3. The Carbona fluidized bed RENUGAS gasification plant is under construction in Skive in Denmark for CHP application using a Jenbacher gas engine.

The main Finnish R&D activities include:

1. investigation of firing lime kilns with fuel gas derived from CFB gasification of plastic and paper wastes
2. design and development of catalysts for tar decomposition for the Novel demonstration gasification plant
3. development of advanced ultra-clean synthesis gas production (UCG project) at VTT
4. integrated process concepts for pulp and paper industry
5. shakedown of the 500 kWth, pressurized fluidised bed PDU to be followed by first test trials in October 2006, at VTT.
6. improvement of the economics of fluidised bed BMG by advanced ash management (the recently completed GASASH project)
7. continuing research on the Lahti plant slip-streams, an EC TREN IP project

The NOVEL gasification process will be integrated with the existing Kokemäki district heating plant, which includes a grate fired biomass boiler and an oil fired boiler. The fuel for gasification is dryed to 10% moisture using low-temperature waste heat from the district heating plant. The estimated fuel capacity is 7200 kWth (6200 kWth without boiler). When successfully operated the plant will produce 1800 kWe and district heat output of about 4300 kWth (3100 kWth without boiler). An estimated 430 kWth low-level heat will be employed for fuel drying. The investment cost for the demonstration project is about € 5 million. Start up with one JMS 316 engine (600 kW) was planned for winter 2005. The second and third gas engines will be installed later in 2006. Future research will include slip-stream testing and evaluation of second generation gas clean-up catalysts and recycling process derived waste waters (the EC BiGPower project).

The present shake-down and commissioning of the NOVEL process plant at Kokemaki demonstration involves repeated calibrations of solids handling systems, fine-tuning of plant automation, improving reliability of fuel feeding, operation of gasifier during low-load (warm weather) periods, and modification of the Jenbacher engine's gas mixer.

VTT provided a preliminary techno-economic analysis of a biosyngas production and conversion process which is enclosed as Attachment 3.

NETHERLANDS: Bram van der Drift, ECN reported that the NL biofuel policy concerns the following:

- In 2006, introduce fiscal measures and incentives to bring 2% biofuels into the market
- In 2007, introduce the obligation for retailers to mix 2% biofuels in commercial sales
- Raise the share of biofuels to 5.75% by 2010.
- The government will spend € 60 million for the next 4 years, until 2010 to develop second generation biofuels.

The current news on large-scale BMG demonstrations is as follows:

- The 85 MW_{th} Amer-9 CFBG in Geertruidenberg, NL is operating successfully on demolition wood. Raw gas is partially cooled; dust removed in a cyclone and the gas is co-fired in a 600 MW_e coal-fired boiler. Following the adoption of EU legislation in Dec. 2005, the Amer-9 power station is now considered as a waste incineration plant with corresponding emission limits. The gasifier is temporarily stopped.
- In 2002, the 250 MW_e NUON power plant in Buggenum started co-gasification trials with biomass. In March 2006, the fraction of biomass is increased to 30wt % without any technical problems. The clean wood will soon be replaced with demolition wood. NUON is now developing plans to scale-up the Buggenum experience to build a 1200 MWe fuel flexible plant, to be named MAGNUM. The plant will have the ability to co-gasifying 50 wt.% of biomass and to separate and capture CO_2. The plant should be ready for operation by 2011.
- HOST is building a 3 MWth chicken litter gasification plant in Tzum. The plant will include a gas cooler, cyclone, boiler, and steam turbine. The initial tests conducted with dry chicken litter in January 2006 were successful while problems were

encountered high moisture content feed. Therefore, a dryer will be added to the system. It is anticipated that the plan will reach steady operation for ~7000 hours/year by the end of 2007. The current plant emissions show 100-150 ppm NO_x at 3% O_2. HOST has nearly 50 offers to build similar plants elsewhere.

- The POLOW PROJECT, employing a 3.5 MWth gasifier based on Torbed technology (see www.torftech.com), employs ~1 cm demolition wood to produce a fuel gas for heat (drying) application.
- The 900 kton/y METHANOR, methanol from natural gas (two parallel lines) plant is now for sale due to high gas prices. Techno-economic studies (assuming methanol-price of 450 €/ton, related to bio-ethanol price) are in progress to turn it into a bio-methanol plant. One option under consideration is to install an entrained flow gasifier. Very soon the plant owners, AKZO-Nobel, DSM, Dynea, will decide on the next steps.

On the R&D front, the recent technology development pilot plant tests of 700 hours at ECN have been a great success. The biggest problem concerned fouling of the line between cyclone and the OLGA gas scrubber and it is tar-related. The information given at www.thersites.nl calculates tar dew point from given tar concentrations.

The University of Eindhoven is developing a plasma/corona tar reduction method as well as partial oxidation. University of Twente is investigating a steam/iron process with bio-oil, super critical water gasification (with BTG), "self-gasification", and gasification of ash-free pyrolysis products, which may offer the advantage of protecting down-stream catalysts. The university of Delft is investigating CFB- steam/oxygen gasification, high-temperature gas cleaning with ceramic filters.

Monday, June 12, 2006 : Workshop (WS) 5: Health, Safety and Environmental Issues of Biomass Gasification plants

A detailed report prepared by the WS coordinators, Messrs Ruedi Buhler, U+E, Switzerland and Hermann Hoffbauer, TUV, Austria is posted on the Task 33 website.

The summaries of WS 1thru WS 4 were presented at the Task Meeting by the WS coordinators and they are also posted on the Task Website.

Future Meetings: The final Task Meeting for the current triennium will include a workshop on Success Stories and Lessons Learnt from BMG Projects, from October 31 to November 1 or 2, 2006 at GTI in Des Plaines, IL and NREL in Golden, CO, USA.

ATTACHMENT 1

AGENDA

IEA Bioenergy Agreement: 2004-2006

Task 33: Thermal Gasification of Biomass

Spring 2006 Meeting

Dresden Hilton Hotel, An der Frauenkirche 5, 01067 Dresden, Deutschland

June 12-14, 2006

Day 1, Monday, 12 June, 2006

9 AM- Introduction, Suresh Babu/Eckhard Dinjus/Eberhard öettel

Review and Approval of Agenda

Review and Approval of Minutes from Fall 2005 Task Meeting held in Innsbruck, AT

9:30 AM - Detailed Country Reports (2.5 Hrs)

Finland, Matti Nieminen, VTT
The Netherlands, Bram van Der Drift, ECN
Sweden, Lars Waldheim, TPS
Switzerland, Ruedi Buhler, U+E
UK, Nick Barker, FES
USA, Rich Bain, NREL

NOON - Lunch

1 PM - Short Summary Country Reports (2.0 Hrs)

Indonesia, Architrandi Priambodo, DPSOLUSI (PT. Dwarakarsa Priamarta)
Austria, Reinhard Rauch, TUV
Denmark, Henrik Christiansen, DK/Erik Winther, DK
European Commission, Maria Fernandez Gutierrez, EC
Germany, Eckhard Dinjus, ITC-CPV
New Zealand, Shusheng Pang, U of Canterbury

Highlights of WS Reports (1.5 Hrs)

WS1: National Perspectives on Biomass Gasification, Suresh Babu
WS2: Gas Cleaning and Gas Engines for Small-Scale BMG Applications, Summary by Suresh Babu
WS3: Biomass Gasification: Hydrogen and Synthesis gas for Fuels and Chemicals, Bram van der Drift, ECN
WS4: HSE of Small-Scale Biomass Gasification Systems, Ruedi Buhler, U+E

4 PM: Feedback from May 17-19, 2006 IEA BEAgreement EXCo Meeting, Suresh Babu

Task Deliverables for 2004-2006

Review of Work Plan for 2007-2009, S.P. Babu

Other Business, OPEN

Next Task Meeting – Proposed dates: 16-19, October, 2006, GTI Chicago & NREL, Denver, USA

5:30 PM – Wrap-up for the Day

Day 2, Tuesday, 13 June, 2006
9 AM to 6 PM - Workshop No: 5: Biomass Gasification and Gas Clean-up

SMALL-SCALE BMG SYSTEMS: Moderators, Ruedi Buhler & Nick Barker

Opening Remarks

1. Small-scale BMG Systems in Germany, Eberhard öettel, FEE, DE
2. Gas Cleaning Operations with the Pyroforce Gasifier, Martin Schaub, CTU, CH
3. Gas Cleaning and Heat Recovery from Next Generation Moving Bed BMG systems: NOVEL Process, Matti Nieminen, VTT, FI

CONVENTIONAL GAS CLEANING: Moderators, Bram van der Drift & Maria Fernandez Gutierrez

Opening Remarks

4. Fluidized Bed Gasification of Biomass and Gas Cleaning for Gas Engine and FT-Synthesis Applications, Reinhard Rauch, TUV, AT
5. Entrained Gasification of Black Liquor and Gas Cleaning for Synthesis of Fuels, Ingvar Landälv, Chemrec, SE

ADVANCED GAS CLEANING: Moderators, Lars Waldheim & Eckhard Dinjus

Opening Remarks

6. Advanced Gas Cleaning for BMG, Olaf Schulze, CHOREN, DE
7. Perspectives on BMG Gas Cleanup, Lars Waldheim, TPS, SE
8. High Temperature Gas Cleaning and Heat Recovery, Andy Bevis, Porvair, UK
9. Gas Cleaning R&D in USA, Rich Bain, NREL, USA
10. Hot Gas Cleanup R&D at Forschungszentrum Karlsruhe, M. Leibold, FZK, DE.
11. Gas Cleaning with Partial Oxidation and Plasma Arc Technologies, Guus Pemen, Tue, NL

(Coffee breaks around 10:30 AM and 3 PM, Lunch at Noon)

6 PM: Adjournment

Day 3, Wednesday, June 14, 2006: Plant Visit to Freiberg

8:30 AM to 11:30 AM – Sustec/ SVZ (Schwarze Pumpe) : Entrained flow gasifier & Synthesis Gas Cleaning

LUNCH

2:30 to 4:30 PM – CHOREN

Timings for bus departure from Dresden Hilton and the bus return to Dresden Hilton and Airport will be provided on June 12 in consultation with Prof. Eckhard Dinjus.

Day 4, Thursday, June 15, 2006: Optional Visit to Forschungszentrum Karlsruhe, Institut fur Technische Chemie Bereich Chemisch-Physikalische Verfahren, Karlsruhe (Please Contact Prof. E. Dinjus: Eckhard.Dinjus@itc-cpv.fzk.de, Ph: 49 16090 758 773)

ATTACHMENT: 2

List of Attendees (June 12-14, 2006)

1 "Bain,Richard" <richard_bain@nrel.gov>,
2 "Vann Bush"< vann.bush@gastechnology.org>
3 "Nick Barker" <nick.barker@aeat.co.uk>,
4 "Erik Winther" <ebw@e2.dk>,
5 "Eckhard Dinjus" <Eckhard.Dinjus@itc-cpv.fzk.de>,
6 "Matti Nieminen"< matti.nieminen@vtt.fi>
7 "Shusheng Pang" <shusheng.pang@canterbury.ac.nz>,
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10 "Henrik Christiansen" <HFC@ENS.dk>
11 "Lars Waldheim" <Lars.waldheim@tps.se>
12 "Reinhard Rauch"<rrauch@mail.zserv.tuwien.ac.at>,
13 "Ruedi Bühler" <rbuehler@mus.ch>,
14 "Drift,A. van der" <vanderdrift@ecn.nl>,
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16 "Maria Fernandez-Guitierrez"<Maria.FERNANDEZ-GUTIERREZ@cec.eu.int>
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29 "Olaf von Morstein"<Olaf.vonMorstein@thyssenkrupp.com>
30 "ATZ Eggenstein Uwe Dipl.-Ing." <eggenstein@atz.de>,
31 "E & D Göttlicher Gerold Dr." <g.goettlicher@enbw.com>,
32 "FNR Stanev Andrej Dr.-Ing." <a.stanev@fnr.de>,
33 "Edmund Henrich" <Edmund.Henrich@itc-cpv.fzk.de>,
34 and 35. "Gail and David Glass" <DGlass6796@aol.com>

ATTACHMENT: 3

VTT provided the following illustration of techno-economic analysis of a biosyngas production and conversion:

Plant Capacity: 300 MWth of feedstock (LHV basis)
Annual operating time: 8000 hrs
Interest on capital: 10 % for 20 years
O&M costs: 4 % of investment
Base values for purchased/sold energy (other values applied in sensitivity case studies):
Feedstock: € 10 /MWth (LHV)
Electricity: € 30/MWhe
HP steam: € 16/MWth of transferred heat
MP and LP Steam: € 13/MWth of transferred heat
Fuel gas: € 14/MWth (LHV)
The estimated investment costs are:
Fischer-Tropsch (F-T) primary liquids; once-through synthesis: € 210 million
F-T primary liquids with reforming loop: € 230 million
Methanol: € 220 million
Synthetic (Substitute) Natural Gas (SNG): € 200 million
Hydrogen, either via traditional method or via PSA separation: € 195 million

Note: Steam refers to HP and LP steam produced in synthesis gas cooling and MP/LP steam produced in synthesis and water-gas shift. The overall efficiency of F-T is exceptionally high (by recovering heat of condensation of product liquids and heat of condensation of part of product H2O recovered as LP steam) by implementing several process integration methods. In comparison, the overall efficiency of methanol synthesis is low.