MINUTES
IEA Bioenergy
Task 33: Thermal Gasification of Biomass
Spring 2001, Task Meeting, April 4 to 6, 2001
Hotel Imperiale and ENEA's Trisaia Center, Nova Siri, Italy
Prepared by
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The first Task Meeting for the 2001 - 2003 triennium was held with assistance from ENEA at Hotel Imperiale and ENEA's Trisaia Center, Nova Siri, Italy. The list of attendees, consisting of Task Participants and invited experts and observers for the first day seminar on **Role of Biomass Gasification in the Production of Hydrogen for Sustainable Energy Supply**, is given below. The Agenda for the Task Meeting is shown in Attachment 3.

Attendance List

Name	Affiliation	Phone	E-mail
Suresh Babu	GTI	847-768-0509	suresh.babu@gastechnology.org
Richard Bain	NREL	303-275-2946	richard_bain@nrel.gov
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Lars Waldheim	TPS	46 155 22 1385	Lars.waldheim@tps.se
Kees Kwant	Novem	31 30 2303458	k.kwant@novem.nl
Huub Stassen	BTG	31 53 489 2897	stassen@btg.ct.utwente.nl

Apologies were received from N. Barker, AEAT, UK, Kyriakos Maniatis (KM), European Commission, Brussels, Esa Kurkela, VTT, Finland, and R. Buehler, Umwelt A+E, Switzerland for their inability to attend the meeting. The contact details for the Thermal Gasification of Biomass Task Participants and other related principals for the 2001 to 2003 triennium are given in Attachment 2.

April 4, 2001 : Seminar on "Role of Biomass Gasification in the Production of Hydrogen for Sustainable Energy Supply"

The opening presentation on "Hydrogen as an Energy Carrier" was given by Dr. Francesco Di Mario, Deputy Director of ENEA's Division TEA (Advanced Energy Technologies). He stated that the industrialized countries have the obligation to comply with Kyoto protocol guidelines. The options to implement the guideline goals include use of low-carbon fuels, capture and sequestration of CO_2 from power plants, improvement of the ecosystem to absorb more CO_2, etc., In general production of hydrogen from solid fuels facilitates CO_2 separation and

sequestration. Hydrogen, as a clean fuel, can also be used for transportation without air pollution. The options for CO_2 sequestration include injection into depleted gas wells and deep saline aquifers. The principal R&D needs to promote hydrogen use include, advancing the state of the art of current hydrogen production methods and related processing steps (such as electrolysis, reforming, photolytic conversion, gas and membrane separation, absorption, adsorption, cryogenic methods, enhancing biologic fixation of CO_2, hydrogen storage in nanofiber matrixes, etc.,). Hydrogen transportation, distribution and dispensing infrastructure needs to be developed. A review of thermochemical hydrogen production cycles show that the iodine-sulfur cycle, operating at 900° C may be an attractive option. The high temperature energy to sustain this process could be derived from nuclear heat or biomass/biomass derived fuels. Efficient use of Hydrogen for power generation has been demonstrated with fuel cells, gas turbines, combined power cycles. Transportation applications could involve fuel cells and IC engines. The estimated commercialization dates for stationary PEMFCs is 2002 and for transportation PEMFCs may be during the 2003 to 2005 time frame. Both MCFC and SOFC may not be commercial before 2005. The safety issues related to hydrogen production, storage, handling and utilization are not very different from conventional fuel utilization. For several decades town gas, containing more than 50% hydrogen, has been safely transported in pipe lines and widely used in many parts of the world. ENEA's budget for the hydrogen program is about $50 million for 3 years.

Dr. Johannes Anglehor, The Technical University of Munich, Munich, Germany reported on a study evaluating and comparing the following options to produce hydrogen: natural gas reforming, partial oxidation of petroleum fractions, coal gasification, biomass gasification, and electrolysis using PV, solar tower, and parabolic mirrors in Africa. Among the first 4 options, biomass gasification was the environmentally preferred method. However, the solar options resulted in the lowest CO_2 production and natural gas reforming resulted in the lowest cost for hydrogen production. Liquefied hydrogen is preferred for transportation applications. Decentralized hydrogen production is an attractive option. Solar insolation is measured at 2200 kW/sq. meter in North Africa while it is about 1700 kW/sq. meter in Southern Italy.

Mr. Giovanni Pede, Advanced Energy Technologies, ENEA spoke on hydrogen storage in its various forms and comparison with CNG. Dynetek makes the best CNG cylinders. The cylinder bursting pressure is 800 bar. CNG is the preferable option up to 300 km driving range. Liquefied hydrogen (LH_2) has the advantage for a driving range exceeding 300 km. LH_2 boil-off is estimated to be about 1% per day. Ventilation in closed parking areas is a concern. Some comparative information on H2 storage is given below:

	KWh/kg	kWh/l	wt% H2
HYDRIDES	2.6	2.2	7.9
MgH2	1.6	1.0	4.8
MgNiH2	0.4	1.1	1.2
Fe-Ti	0.33	1.1	1.0
80's Mercedes			
'97 Toyota RAV4-FCEV	0.66	2.0	
2.0			

For transportation beyond 150 km hydrides are not suitable. This is also the limit for battery-operated cars. A commercial hydrogen storage system is provided by OVONIC. Hydrogen

storage in carbon nano-tubes is a developing technology; trials so far have been limited to laboratory experiments. Hydrogen diffusion through metal walls is a concern. Hydrogen fuel cell vehicle is economically better than liquid hydrogen vehicle.

Mr. Marco Stefanoni, Advanced Energy Technologies, ENEA, spoke on safety issues related to hydrogen. Release of propane could be more harmful than hydrogen leakage. The low-density hydrogen is quickly dissipated while propane can settle to the ground level. Between 1900 and 1987, the estimated number of fatal accidents attributed to hydrogen is 145. The existing safety regulations for hydrogen use in industrialized countries are considered to be adequate. It is proposed that international collaboration to harmonize standards may help to reduce the prevailing high insurance costs. Existing standards include ISO TC197, EIHP, and IEC TC 1015 (for fuel cell applications).

Mr. Angelo Moreno, Advanced Energy Technologies, ENEA, spoke on hydrogen for fuel cell applications. MCFC may be a better fit for biomass gasification than SOFC. ANSALDO, during a Phase 1 program in 1999, has completed a seven-month demonstration with a 100 kW MCFC stack, with different feed gas compositions. The stack has also been tested with coal gasification product gas; the stack works well with 62% CO. In the Phase 2 program (mid 1999 to 2005), ANSALDO will demonstrate the Series 500, 500 kW MCFC stack for about 40,000 hours. It is anticipated that in Phase 3 (starting 2004), a low-cost (target $1500/kW) third generation MCFC stack should be ready for commercial production. The commercialization team includes ANSALDO, FN, BDT, BWZ, and Kemira. The end users include ENEL, CESI, AEM, EMI, Sota Carbo, AMG, Endesa, and Iberdrola. The EU sponsored programs include a variety of projects integrating MCFC stacks with moving bed gasifiers and anaerobic digesters. The TUV Fast Internal Circulating Fluidised Bed (FICFB) gasifier produces a medium calorific value (MCV) fuel gas with <5% nitrogen that could be cleaned and fed into an MCFC test stack. Some fuel gas specifications for MCFC: S & Cl <10 ppm, Particulates <5 mg/N cu.m, and tar <500 mg/N cu.m.

Mr. Romolo Infusino, Advanced Energy Technologies, ENEA presented the following costs for H_2 production:

Methane reforming	5.40 - 7.50 ($/GJ)
Partial oxidation of HHC	9.50 - 10
Coal Gasification	10 - 12
Biomass Gasification	12 - 13 ($46.3/dry tonne biomass)
Biomass Pyrolysis	13 - 14
Pyrolysis w/co-products	9 - 10

The good news is that biomass could be gasified with steam to produce 76% H_2 and the bad news is it is expensive to produce pure H_2. Biomass with only 6% H_2, may not be a good feed stock to produce pure H_2. Mr. Infusino has also reported the published costs for H_2 production from NREL studies.

Dr. Reinhard Rauch, TUV, Vienna, Austria described the FICFB biomass gasification process that utilizes air as the oxidant and produces a MCV fuel gas or synthesis gas. The product gas has a heating value of about 13MJ/n cu.m. TUV is investigating the use of a Ni catalyst with ternary Perovskite structure, for steam reforming the raw gas directly in the gasifier. The catalyst

contains 2.8% Ni on Olivine and the operating temperature is in the range of 800-850° C. The steam to fuel ratio is 0.5. The attrition rate of bed material is ~0.3 %/hour.

Dr. Richard L. Bain, NREL, USA described the US hydrogen program. The USDOE FY 2001 hydrogen program has a budget of $25-26 million/year. The Bush administration budget for FY 2002 is reduced to $13 million/year. The NREL's biomass pyrolysis process followed by steam reforming of pyrolysis oil results in hydrogen production cost of $8.86/MJ (with by product credits) or $12.42/MJ with out any byproduct credits. In comparison, the cost of hydrogen production from electrolysis is $24.51/MJ. The fluidized bed steam reformer operates at 850° C, steam/carbon= 8/1, and a space velocity of 1300 to 4000/hr.

Mr. Kees Kwant, NOVEM, The Netherlands described Netherland's hydrogen program. Shell Hydrogen, is a newly created company in Amsterdam. Shell believes in hydrogen as an energy carrier and intends to develop innovative fuel processors, hydrogen storage, and related logistics. Other Dutch projects employ hyperthermophilic and photoheterophilic techniques for hydrogen production.

Dr. Suresh Babu, GTI, USA (SPB) distributed a recently (Feb. 20, 2001) published Economist article that makes a strong case for gaseous fuels in general and hydrogen in particular. This was followed by a presentation that delineated the outline of scope of work for a study on " Biomass Gasification to Produce Hydrogen or Hydrogen-rich Gas for High-efficiency Power Generation" by the IEA Bioenergy Agreement and the Task 33. Thermal Gasification of Biomass, as a part of the IEA Annex 16, Hydrogen program. A brief description of the classification of biomass gasification processes for hydrogen-rich gas for fuel cell applications was given. Preliminary calculations indicate that biomass derived hydrogen-rich gas is quite competitive with hydrogen produced from natural gas.

TASK MEETING

Thursday, April 5, 2001: Task members visited ENEA's Integrated Gasification Program (PIGA) projects at Trisaia center Technology hall for gasifiers and qualification of, related equipment, automation and measurement systems, gas sampling, gas collection and treatment, and gas analysis which include -

- 15 and 80 kW_e Downdraft Fixed Bed Biomass Gasification pilot plants
- 500 kWth "Hydrogen Rich Gas from Biomass Steam Gasification" (Joule III)
- Biomass Steam Explosion plant

Following the site visit, Suresh Babu (SPB) presented the Agenda for the remainder of the meeting and it was approved with minor changes.

APPROVAL OF MINUTES FROM SPRING 2000 TASK MEETING: The minutes from the Fall 2000 Task Meeting held from October 4 to 6 in York, UK were reviewed and approved with minor changes.

Subtask Study Reports and Task Deliverables for 1998-2000: The status of the last triennium's Task deliverables is summarized below:

1. Update surveys, reviews, and evaluation of national RD&D programs, national gasification projects (including pilot plants and demonstration plants), and commercial gasification technologies - Subtask Coordinator: Kees Kwant (KK), NOVEM, The Netherlands.

   A draft report has been prepared and KK has requested that all updates should be submitted to him by April 13, 2001. SPB should provide electronic photographs of selected gasification technologies to KK for inclusion in the report. The possibility of including the US Prime Energy, Canadian Biosyn, PRC gasifiers, and India's open-top gasifier was discussed. If Kees cannot receive this information soon from the Task members, description of these gasifiers may be deferred to country reports to be prepared during the current triennium (2001-2003).

2. Gas clean-up and gas processing for small-scale gasification plants, treatment, minimization, and utilization of process waste streams, and commercial gas clean-up and gas processing technologies - Subtask Coordinator: Henrik Christiansen (HFC), DEA, Denmark.

   HFC reported that the draft report should be ready by the end of April. An electronic copy will be distributed to the Task for review, and comments should be returned to HFC before finalizing the report.

3. Gas clean-up and gas processing for large-scale gasification plants, treatment, minimization, and utilization of process waste streams, and commercial gas clean-up and gas processing - Subtask Coordinator: Richard L. Bain (RLB), NREL, USA.

   RLB has completed a review of gas cleanup and hot-gas conditioning systems. The draft report should be ready for review and finalization by May 1, 2001.

4. Gas utilization and energy conversion: commercial gas utilization and energy conversion technologies - Subtask Coordinator: Nick Barker (NB), ETSU-AEA.

   The report published during the previous triennium (1995-1997) will be updated with presentations from the Seville Workshop and the invited presentations from the seminar on Thursday, October 5, 2000 at the Fall- 2000 Task Meeting. The focus will be on power generation. The synthesis gas conversion presentations from the Enschede, Netherlands Spring 2000 Task meeting will not be included in the report. A draft report should be ready for review and finalization by the end of May 2001.

5. Innovative systems, system improvements, research needs, and future applications - Subtask Coordinator: Kyriakos Maniatis (KM), EC, Belgium.

   KM will provide by the end of April 2001 an update on when the report may be completed**.**

6. Sampling, measuring, and testing procedures:

6a. Tar measurement protocol - Subtask Coordinator : Kyriakos Maniatis, EC, Belgium, WGM : NB, Esa Kurkela (EK), VTT, FI, and John Neeft, ECN, NL.

The cooperative study involving participation from NL, UK, FI, SE, and DK on the development of a Unified Tar Measurement Protocol for small-, medium-, and large-scale gasification systems is proceeding. The progress of this subtask has been reviewed in meetings attended by the project participants at VTT, Espoo, Finland and in Stockholm. The final report should be complete by the end of 2001. The preliminary publication on the tar measurement protocols for small- and large-scale gasification systems in Biomass and Bioenergy Journal should be considered as one of the publications of this Subtask. The prospects of holding a workshop on this topic at one of the future Task meetings will be explored.

6b. Fuel gas heating value - Subtask Coordinator: Lars Waldheim, TPS

The draft report, based on a survey conducted by Lars Waldheim, will be reviewed by Reinhard Rauch, TUV, Austria, KK, RLB, and Morten Fossum, SINTEF, Norway.

6c and d: Evaluation of gasification systems - Subtask Coordinator: Gert Huisman, Consultant, The Netherlands

A draft report has been prepared and distributed by Gert Huisman. SPB and KK will review and revise the draft with RB and decide on a publication date.

7. Gasification Feedstocks Data Base - Completed by H. Hoffbauer and R. Rauch, TUV, Austria

8. Co-combustion of Biomass-Derived Fuel Gases With Natural Gas - Completed by J. Hustad et.al, NTNU, SINTEF, Norway

9. Biomass Gasifier "Tars": Their Nature, Formation and Conversion - Completed by N. Abatzoglou et.al, University of Sherbrooke, Canada

10. IEA Bioenergy Agreement Annual Report – 1999 (Completed)

11. Task Meeting Minutes - Suresh Babu will distribute final copies.

Proposed Program and Workplane for the Next Triennium (2001- 2003): SPB reviewed the results from the survey of the biomass gasification technology development and commercialization issues conducted at the Fall 2000 Task Meeting in York, U.K. Based on these results and the inputs received from Messrs. Kyriakos Maniatis, Nick Barker, Esa Kurkela, and Pekka Simmell, the following topics were identified for further discussion. Based on the discussions the following items in *italics* were tentatively selected for Task study and investigation.

1. *Fuelgas Co-firing (Joint study with Task 32, Biomass Combustion and Co-firing)- Start with problems and interfacial issues, define raw gas compositions, burner specifications, solution to problems, staged combustion for NOx, CO, and THC reduction (Proposed Coordinator - NL)*

2. *Emissions and Effluents, Process Waste Water from All Sources, Emissions Regulations, Permitting, Toxicology and Environmental Issues (Proposed Coordinator - DK)*
3. *Hydrogen (Joint study with IEA Annex 16 - Hydrogen) (Proposed Coordinator - USA+AT)/Synthesis Gas conversion to chemicals and liquid fuels (Proposed Coordinator - AT)*
4. *Energy conversion devices: Fuel Cells, gas turbines, gas engines and emissions, Publish update in 2003 - (Proposed Coordinator - Italy)*
5. *Gas Cleaning for Moving Bed gasifiers, hot gas cleaning for CFB and FB gasifiers,Catalytic/Non-catalytic Tar Cracking, Gas Engines, CO and Other Emissions, Electrostatic precipitation, Small Gasifiers and CHP (Proposed Coordinator - FI, SE, Ulrik will help with ESP data)*
6. *Tar Protocol (on-going multinational study, led by Mr. John Neeft, ECN, The Netherlands)*
7. *Country Reports (Proposed Coordinator - EU Thermonet/Gasnet)*
8. Bottle necks, R&D Needs/solutions (Proposed Coordinator - EC)
9. How to promote commercialization of biomass gasification processes (Proposed Coordinator – Prof. H. Stassen, NL)
10. *Municipal Solid Waste / RDF Gasification and Energy Recovery (Joint study with Task 36, Energy from Integrated Solid Waste Management Systems and Techno-economic Assessment for Bioenergy Applications) – (Proposed Coordinator - NB, UK)*
11. Solids Feeder for Mixed Feeds and Low Density Feeds (NL study sponsored and initiated by NOVEM at BTG)
12. Text book on Biomass Gasification (May require substantial financial commitment from sources such as EC; The Netherlands may lead such an effort with financial support; KM is requested to propose his thoughts on what the book should contain; one suggestion is to include contributions from all participating countries that documents experience and lessons learnt from respective national RD&D projects)
13. Characterization and Standards
14. Process economics and market study
15. Recycled Char and Contaminant Liquids
16. Systems Integration and Analysis (Complete 1998-2001 report)
17. Integration/mixing with Natural Gas
18. Modification of Ash Fusion
19. Black Liquor Gasification

Future Meetings**: Second Task Meeting** (Summer/Fall 2001) - Option 1: Find one full day or 2 half days during the FIFTH BIOMASS CONFERENCE OF AMERICAS, Sept 17-21, 2001, Orlando, FL.
Option 2: Meet two days before the FIFTH BIOMASS CONFERENCE OF AMERICAS, Sept 17-21, 2001, Orlando, FL.

(Due to the events of September 11, 2001, The Second Task Meeting has been postponed and subsequently held in Dresden, Germany November 21-23, 2001.)

Special Topic: Germany's biomass programs

Third Task Meeting (Spring/Summerl 2002): Right before or during the EU Biomass Conference from June 17-22, 2002 in Amsterdam, NL.

Fourth Task Meeting (Fall 2002): Visit PRC biomass gasification plants and/or the MSW gasification plants in Japan, Meet in PRC or Japan. Takuma Co., has given preliminary consent to host the meeting in Japan.

Fifth Task Meeting (Spring 2003) OPEN

Sixth Task Meeting (Fall 2003) OPEN