

IEA Bioenergy Agreement: 2013-2015
Task 33: Thermal Gasification of Biomass
First Semi-annual Task Meeting, 2014

Ischia, Italy

Tue. 13 to Thu. 15 May 2014

Minutes

Prepared by Dr. Jitka Hrbek, Task secretary, VUT, Austria

The list of attendees, for the Task Meeting include:

Name	Country	Affiliation	email
Task 33 members			
Kevin Whitty	USA	UoU	kevin.whitty@utah.edu
Reinhard Rauch	Austria	VUT	rrauch@mail.zserv.tuwein.ac.at
Jitka Hrbek	Austria	VUT	jhrbek@mail.zserv.tuwein.ac.at
Morten Tony Hansen	Denmark	FORCE	mth@force.dk
Roger Khalil	Norway	SINTEF	Roger.khalil@sintef.no
Berend Vreugdenhil	The Netherlands	ECN	vreugdenhil@ecn.nl
Martin Rügsegger	Switzerland	EtECA	eteca@gmx.ch
Thomas Kolb	Germany	KIT	Thomas.kolb@kit.edu
Antonio Molino	Italy	ENEA	Antonio.molino@enea.it
Mark Eberhard	Germany	KIT	Mark.eberhard@kit.edu
Observers			
Andrea Duvia	Italy	Gammel&Duvia	a.duvia@gammelduvia.it

Regrets for inability to attend were received from: Ilkka Hannula, VTT, Finland; Lars Waldheim, VaC, Sweden.

The Agenda of the Meeting was:

IEA Bioenergy Agreement: 2013-2015
Task 33: Thermal Gasification of Biomass
1st Semi-Annual Task Meeting, 2014
Ischia Island - Naples, Italy
Tue, May 13 to Thu, May 15

Local Contact:

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Travel, Accommodation and Meeting Venue

Air Travel

Naples Capodichino International Airport, one of the most important in Italy, is located a few Km from downtown Naples city and port.

Naples Port

From the airport, you can catch either a shuttle bus (Alibus) or a taxi to the harbor. The taxi departs just outside the arrivals terminal and the cost is around € 40. The Alibus departs from the same stop as the taxi and tickets can be bought from the driver (as of June 2013, tickets now cost €3 each if bought at the airport shops, or €4 from the driver). It connects the airport to Naples Beverello Port: the bus stop is located in front of the ferry ticket booths. Hydrofoils regularly depart from Molo Beverello Naples port. The major operators are:

Alilauro (to "Ischia Porto") tel. 0039 081497 2238, www.alilauro.it

Caremar (to "Ischia Porto") tel. 0039 081551 3882, www.caremar.it

The hydrofoil takes about 50 mins to reach the island.

If you prefer travel by ferries, which takes 1 hour and 35 min, you can take:

Caremar (to "Ischia Porto") tel. 0039 081551 3882, www.caremar.it

Medmar (to "Ischia Porto") tel. 0039 081333 4411, www.medmargroup.it

from Naples Calata Porta di Massa Port, very close to Molo Beverello Port (located 5 minutes by foot).

Transport from Ischia to Hotel Continental

By foot 10 minutes from Ischia Port, but if you arrive from Casamicciola Port you can take the bus named "Circolare sinistra" .

Accommodation

Hotel Continental

Via M. Mazzella, 74

80077 Ischia Island port

Web: <http://www.hotelcontinentalischia.it>

Rate: special price of 240 Euro for a single room and for 3 days (breakfast and VAT included).

RATES for the period (lodging, breakfast, internet Wi-Fi, taxes 10% VAT Included)

City tax 1,50 Eur per person per day not included – to be paid at the hotel on departure

To benefit of this special price please print out, fill, sign, scan and e-mail the attached reservation form to the hotel before 31 March 2014.

Hotel Continental - Via M. Mazzella, 88 - 80077 ISCHIA (NA) Italy

Fax: 0039 081 3336276 – E-mail: booking@hotelcontinentalischia.it

Please note that there is also the possibility to book directly at the Hotel Continental the service for transfer from the airport to the Hotel.

Meeting Venue

The meeting venue will be Hotel Continental – Ischia Island.

Day 1, Tue, May 13

Task Business Meeting

Meeting Location: Hotel Continental – Ischia Island

09:00 – 09:15	Welcome (Antonio)
09:15 – 09:30	Introductions of Task Members and Observers (All)
09:30 – 09:45	Task business update (Kevin and Reinhard)
09:45 – 10:50	Updates on special projects <ul style="list-style-type: none">• Gasification facilities database and map (Jitka)• Gasification fact sheets (Berend and Kevin)• Combustion and co-firing (Berend and Kevin)• Gasification lessons learned (Kevin)• Biomass feeding and handling white paper (Kevin)• Performance test code white paper (Martin + Kevin)• Advances in biomass characterization with T32, T34 (Reinhard)• Gasification of pyrolysis oil (Thomas)• Techno-economic assessment with T32, T34 (Thomas + Kevin)• Commercialization of liquid biofuels (Kevin)
10:50 – 11:00	Requests from ExCo (Kevin)
11:00 – 11:30	Coffee and tea Break
11:30 – 11:40	Country update – Austria (Reinhard Rauch)
11:40 – 12:10	Country update – Germany (Thomas Kolb)
12:10 – 12:30	Country update – Italy (Antonio Molino)
12:30	Lunch
14:00 – 14:10	Country update – Norway (Roger Khalil)
14:10 – 14:40	Country update – Denmark (Morten T. Hansen)
14:40 – 15:10	Country update – Switzerland (Martin Rügsegger)
15:10 – 15:40	Country update – The Netherlands (Berend Vreugdenhil)
15:40 – 16:10	Country update – USA (Kevin Whitty)
16:10	Day wrap-up and after coffee and tea break

17.00 Adjourn

20.00 PM Task Dinner – Hotel continental

Day 2, Wed, May 14

**Task Meeting/Workshop
Meeting Location Hotel continental**

Topic: Thermal Biomass Gasification in Small Scale

09:30 – 10:00	MARCO FANTACCI General Manager BIO&WATT GASIFICATION S.r.l. Energetical conversion of biomass through pyrogasification process: presentation of an industrial solution "
10:00 – 10:30	ANDREA DUVIA Gammel Duvia Engineering Srl Industrial experiences and innovative solutions
10:30 – 11:00	MARCEL HUBER Syncraft, Austria The floating-fixed-bed - status of a unique staged gasification concept on its way to commercialization
11:00	Coffee and tea break
11:30 – 12:00	GIOVANNA RUOPPOLO CNR – National Research Council Fluidized bed gasification and co-gasification of biomass and wastes
12:00 – 12:30	PAOLA AMMENDOLA Development of catalytic systems for tar removal in gasification processes
12:30	Lunch
14:00 – 14:30	FABRIZIO SCALA Relevance of biomass comminution phenomena in gasification processes
14:30 – 15:00	OSVALDA SENNECA Gasification kinetics of biogenic materials and wastes
15:00 – 15:30	SIMEONE CHIANESE University of Naples and TUV of Vienna H ₂ 4 Industries
15:30 – 16:00	NADIA CERONE ENEA - Gasification of fermentation residues from second generation ethanol for production of hydrogen rich syngas in a pilot plant
16:00	Coffee/tea break and photo of workshop participants

Day 3, Thu, May 15

Site Visits

08:30 AliBus departs from Ischia to Pozzuoli-Naples

10:00 Train from Pozzuoli to University of Naples, Federico II

10:30-13:00 Site Visit to Gasification Facilities, lab and small scale at University Federico II and National Research Council, Naples

13:30 Pizza special lunch

Day 1, Tue May 13
IEA Bioenergy Task 33 meeting

Representatives' introduction and approval of Agenda and Minutes

After introduction of Task 33 members and observer, the actual Agenda and Minutes from the last meeting in Gothenburg, Sweden were approved. Meeting minutes from Gothenburg meeting in November 2013 are already online at the Task 33 website.

New member countries

Turkey and NZ did not committed to T33 for 2014 and it was suggested to contact also experts from not member countries, e.g. Spain, UK, France, and Brazil and offer them membership in Task 33. This cooperation could be beneficial for all participants. Thomas Kolb suggested contacting partners in Brazil and Martin Rügsegger in GB and France.

Task Plans for 2014 Meetings 2

Meeting 2

The second Task 33 meeting in 2013 should be held in Karlsruhe, Germany. Thomas Kolb already confirmed the hosting. The date will be 03.-05. November 2014.
Workshop topic: Liquid Biofuels

Special and collaboration projects

- **Gasification Fact Sheet**
 - Project finished
 - Already available at Task 33 website in section "Publications"

- **Gasification Facilities Database and Map**
 - Regularly updated by Jitka
 - Details regarding information from member countries discussed

- **Worldwide Biomass Gasification Facilities Status Report**
 - A biomass gasification summary report (jointly authored by Task Lead and NTLs) in 2014 addressing BMG basics, BMG applications, outstanding technical and sustainability issues, gasification specific policies in member countries, and a directory of gasifier developers in member countries (information will include company, development status, projects locations, gasifier type, primary products, patents, publications).
 - **Jitka needs updates from all countries regarding status of gasifiers**
 - Complete early 2015

- **Task 33 website „refresh“**
 - The homepage of the Task website will get a new structure
 - Background colour will not be dark green, but light grey, green or blue...
 - The menu structure will be similar as at the IEA Bioenergy website to offer a clear overview

- To highlight the database the button for entering will be in the middle of the homepage
- **Biomass Feeding and Handling – White Paper**
 - Agreed during Gothenburg meeting that Kevin would follow up with Rich for guidance on this task. No response
 - Ilkka sent 1992 VTT report on biomass feeding into pressurized environments, which can be linked to from the T33 home page
 - U.S. DOE has project through Idaho National Labs focused on survey of biomass feeding characteristics
 - Kevin can explore opportunities for leveraging
- **Performance Test Protocols white paper (2014)**
 - Acceptance test paper was published in 2000 and is available on the Task 33 web site
 - Martin and Kevin will look at this
 - Focus on small scale gasifiers
 - Due 2014
- **Advances in Biomass Characterisation**
 - Joint with Task 32 (biomass combustion and co-firing) and Task 34 (pyrolysis of biomass)
 - Agreed at Gothenburg meeting that Reinhard will communicate with Ingwald Obernberger, who advanced the idea
 - Biomass characterization questionnaire and report on new characterization methods from Obernberger distributed to T33 members in January
- **Gasification Lessons Learned report (2015)**
 - Included in 2013-15 Proposal for Prolongation:
 - A gasification lessons learned report (jointly authored by Task Lead and NTLs) in 2015. This report will serve as a success/failure analysis that will identify common characteristics of successful development and common characteristics of unsuccessful development). This is a special topic and will require Task funding. The estimated Task funds to be used are US\$30,000.
 - Due 2015
- **Gasification of Pyrolysis Oil (collaborative with T34)**
 - Joint with Task 34 (pyrolysis of biomass)
 - Agreed at Gothenburg meeting to request an update from Thomas Kolb; he will speak with T34 and then distributes proposals
 - Roger Khalil promised to give more information about pyrolysis oil
- **Biomass Combustion and Co-Firing (collaborative with T32)**
 - Agreed during Gothenburg meeting to develop fact sheet on indirect co-firing of biomass, which T32 can post on their web site

- Fact sheet complete
- Kevin will inform Jaap Koppejan (T32 lead) regarding availability of fact sheet

- **Techno-Economic Assessment (collaborative with T32, 34)**
 - Agreed during Gothenburg meeting that T33's contribution can be existing TEA work that was developed by others previously for the task
 - Danish report on Best Practices
 - Michael Talmadge (USDOE)
 - Other NREL reports

Request from ExCo – Hydrothermal Carbonization

- At ExCo72 in November, Art Wellinger requested that Task 33 include reference to hydrothermal carbonization in its programme
- The paper regarding hydrothermal carbonization will be prepared by Reinhard and published at the Task33 website

Country Updates on Biomass Gasification:

Austria, Reinhard Rauch, VUT

Austrian research organizations and their activities were introduced:

- Graz University of Technology
- Joanneum Research Graz
- MCI
- Bioenergy 2020+
- Vienna University of Technology

Austrian companies active in biomass gasification:

- Andritz (now also owner of the Austrian part of Austrian Energy & Environment)
- AGT Agency for Green Technology
- Austrian Enviro Technologies
- Cleanstgas
- GE Jenbacher
- Güssing Renewable Energy (GREG)
- Ortner Anlagenbau
- Repotec
- SynCraft Engineering GmbH
- Urbas
- Xylogas
- ZT Lettner

Commercial FICFB gasifiers in Austria

Location	Usage / Product	Fuel / Product MW, MW	Start up	Supplier	Status
Güssing, AT	Gas engine	8.0 _{fuel} / 2.0 _{el}	2002	AE&E, Repotec	Operational
Oberwart, AT	Gas engine / ORC	8.5 _{fuel} / 2.8 _{el}	2008	Ortner Anlagenbau	Operational
Villach, AT	Gas engine	15 _{fuel} / 3.7 _{el}	2010	Ortner Anlagenbau	On hold/ insolvent
Senden/UlmDE	Gas engine / ORC	14 _{fuel} / 5 _{el}	2011	Repotec	Operational
Burgeis, IT	Gas engine	2 _{fuel} / 0.5 _{el}	2012	Repotec	Commissioning
Göteborg, Sweden	BioSNG	32 _{fuel} / 20 _{BioSNG}	2013	Metso/Repotec	Operational
California	R&D	1-2 MW _{fuel}	2013	Greg	Construction

Commercial CHP gasifiers and their current projects presented

- Urbas
- Cleanstgas
- Syncraft – new project were presented during the workshop

Table: Urbas CHP gasifiers

Location	Product kW	Start up
Ruden, AT	150el./300th. 70el./150th.	Development since 2001
Eberndorf, AT	2x120el. + 70el./650th.	2006-2008
Neumarkt, AT	2x120el./580th.	2008
Sulzbach-Laufen, DE	130el./280th.	2009
Neukirchen, AT	2x140el./600th.	2011
Konstanz, DE	140el./300th.	End of 2011
Mallnitz, AT	250el./550th.	11/2013
Balingen, DE	150el./280th.	12/2013
Berlin, DE	2x150el./560th.	04/2014
Cogen Srl., Terni, IT	199 el./350th.	07/2014
Calvello, IT	199el./350th.	09/2014

Germany, Thomas Kolb, KIT

SWU Stadtwerke Ulm

- CHP demo plant
- wood chips
- thermal load 15.1 MW_{th} (4.55 MW_{el})
- technology FICFB Güssing (repotec)
- additional gas treatment facility

Carbo-V biomass gasification technology

- 3-stage gasif. Technology for conversion of biomass into tar-free synthesis gas
- Status Feb. 2014: project with ForestBtl/VAPO/NER300 cancelled, Linde has elaborated numerous technical corrections of Carbo-V process design

- Highlights:
 - Cold gas efficiency more than 73% → well above competitors' comparable technologies
 - Tar-free and methane-lean raw syngas → unique feature of Carbo-V technology
 - Syngas with a CO/H₂ content of up to 75%
 - Highest possible carbon conversion rate (> 99.5 % by mass)
 - No biomass pretreatment necessary (except drying and chipping)
 - Plants with high installed capacity possible (scale up)
- Standard plant sizes:
 - 40 MW_{th} ⇒ 9,1 t/h dry* biomass ⇒ ~ 36 MW dry syngas (CO + H₂**)(9.100 Nm³/h)
 - 160 MW_{th} ⇒ 36,6 t/h dry* biomass ⇒ ~130 MW dry syngas (CO + H₂**)(36.500 Nm³/h)

* water content = 15 wt.%;
 ** after removal of H₂O and CO₂

BioTfuel

Target:

- Development and commercialisation of integrated process chain for the production of 2nd generation biofuels via thermochemical conversion

Budget:

- €112,7 million over 7 years

Update May 2014:

- Detailed engineering finalized
- Multi floor furnace for torrefaction
- Multi fuel feed
- FT design for 1 l/h
- Commissioning planned for 2017
- 4 years of operation planned in project

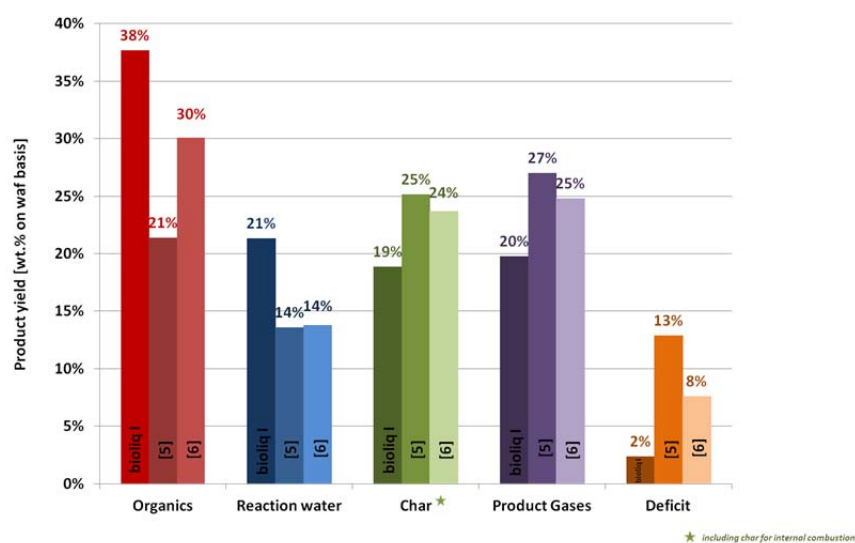
Bioliq

	Stage 1	Stage 2	Stage 3	Stage 4
Process	Fast pyrolysis	High pressure entrained flow gasification	Gas cleaning and Synthesis I	Synthesis II
Product	BioSyncrude	Synthesis gas	Dimethyl ether	Gasoline
Capacity	2 MW (500 kg/h)	5 MW (1 t/h)	150 kg/h	< 100 l/h
Realization	2005 - 2008	2008 - 2013	2009 - 2011	
State	In operation	In operation	Performance test 2013	

Fast pyrolysis – pilot plant results

[5] KIT, earlier results

[6] Bridgwater et al.



R&D on BioSyncrude

- Flow properties of slurries
- Varying heating values
- Equipment testing
- New metrology devices
- Materials selection and testing

Italy, Antonio Molino, ENEA

Renewable energy sources and targets were presented as well as ENEA's activity in renewables (biomass).

ENEA's activities regarding biomass:

- Biomass gasification and combustion
- LCA – Anaerobic digestion
- Biodiesel from algae
- WEB Geographic Information System of Biomass Energy Crops
- Biofuels 2nd generation

Table: New gasification plants realized

Location	kW(Power-Thermal)	Company	Type
Borgosesia(VC)	850 _{el} +1060 _{th}	Pyroxitalia – P850	Commercial plant - CHP
Lasa(BZ)	850 _{el} +1060 _{th}	Pyroxitalia – P850	Commercial plant - CHP
Mondovi(CN)	995 _{el} +1200 _{th}	Pyroxitalia – P995	Commercial plant - CHP
Ora(BZ)	2X200 _{el}	Motus Energy	Commercial plant - CHP
Trens(BZ)	5X200 _{el}	Motus Energy	Commercial plant - CHP
Accettura(MT)	30 _{el}	Stigliano	Demo plant

In Italy in the last 2 years were realized about 5-6 biomass gasification plant for a total power plant of about 15-20 MWe, mostly of these of small scale, with downdraft technology and coupled with a cogeneration system in order to obtain the thermal energy recovery.

The Gasification Technologies in ENEA Trisaia Research Center:

- **Fluidized bed gasifier with internal recirculation**
 - Enriched Air/Steam 1MWth
 - Suitable for the power generation both with ICE and fuel cells
- **Internally Circulating Fluidized Bed technologies**
 - Air/Steam 500kWth
 - Suitable for the power production both with MCI and fuel cells, or for biofuel production from Fischer Tropsch process
- **Fixed bed updraft**
 - Air/Steam 150kWth
 - Suitable for the power generation with ICE only if there's a good syngas cleaning
- **Fixed bed downdraft**
 - Air/Steam 150-450kWth
 - Suitable for the power generation with ICE

ENEA National Projects:

ENEPARK Project

- The project was funded by Basilicata Region with the EU Structural Funds PO FERS 2007-2013.
- The biomass used for the process derive from the routine maintenance of the Gallipoli Cognato's forestry
- A second step of the project provides the use of power energy for the service cars for the workers in the park

Industry 2015: HY-Tractor project

- project is funded by the Ministry of Economic Development (4.51M€)
- The initiative runs from October 2010 to September 2014.
- The project involves the construction of an innovative and ecological sub-surface seeder provided with electrical rather than pneumatic or hydraulic actuators. Electric actuators guarantee for higher level of control, which enable the development of advanced planting techniques, i.e. techniques including the use of GPS.
- The H₂ permeation through membrane allows to exceed the thermodynamic equilibrium of a traditional reactor:
- CO higher conversion in H₂ at the same temperature
- membrane allows to have an "intensified" process with a capital costs and plant size reduction

Digestion in SCWG condition 250 bar – 550°C

Advantages of the SCWG process:

- The presence of water in supercritical form promotes the reactions of hydrolysis, facilitating the ability to attack polymeric structures such as reducing the lignin to more easily processable oligomers;
- The SCW is a reagent, in fact up to 50% of the hydrogen product comes from the water;
- None pretreatment process for biomass, indeed its presence facilitates the process;

- It promotes the reactions of the water gas shift further enriching hydrogen in the syngas product;
- It can be used for sewage sludge.

End-uses of the syngas produced by the process SCWG

- Easily removal of CO₂ into syngas being already pressurized;
- Highest hydrogen content in the syngas;
- Cleaning of the syngas more efficiently and with lower processing costs;
- Using the syngas such (H₂/CO₂) in catalytic processes for the production of liquid biofuels;

Economical process also for sewage sludge

ENEA International projects:

UNIfHY Biomass-to-hydrogen

- The project started on October 2011 and will end in September 2015. Funded 2.97M€
- UNIfHY consists in the development of a demonstrator pilot scale for the production of pure hydrogen from lignocellulosic biomass by the gasification process developed and patented under the UNIQUE project. The system provides for the WGS stage as well as the adsorption stage by means of PSA.

BRISK - Biofuels Research Infrastructure for Sharing Knowledge

- The initiative runs from 1st October 2011 to September 2015
- 8.98M€ funded
- BRISK aims to develop a European Research Infrastructure for Thermochemical Biomass Conversion, supporting R&D on innovative processes to convert sustainable feedstocks (agricultural/forestry wastes and energy crops) into liquid, gaseous or solid fuels. The specific aim of BRISK is to overcome fragmentation in R&D facilities for thermochemical technologies, by enabling researchers to have access to high-level experimental facilities and services across Europe. The BRISK network will encourage and facilitate cooperative research in the specialised laboratories of project partners. The facilities are also open to researchers outside the project

Norway, Roger Khalil, SINTEF

Situation in Norway

- Norway has large unused biomass resources
- Still no economic advantages or incentives for biomass gasification
- Fundamental research at Universities
- No large scale gasification facilities
- Small-scale waste-to-energy applications
- Some interested larger companies (Statkraft, Akershus Energi, Avinor – BioJet-A1)

Companies – small scale applications

- ENERGOS
- AGDER BIOCOM

Both use two-step (gasification-combustion) technology for heat production

Biomass gasification in Norway:

- So far 2014 has been a busy year for project applications:

- An application has been sent to EEA (European Economics Area) grant with Romania (not a gasification project)
- EU projects
 - Leader of one initiative within HTL
 - Partner in another (gasification)
- In the process of applying for new competence building projects (deadline September 2014)
 - The bioenergy group will apply for 4 projects
 - One application will focus on gasification of biomass for liquid fuel production for the aviation industry

SINTEF Energy research

- Bench scale reactors for biomass reactivity and yield measurements
- Biomass gasification to second generation biofuels – entrained flow reactor
 - Design a vertical high temperature particle fed reaction cylinder
 - Capable of using a variety of feed materials and sizes
 - Of durable quality
 - With ease of maintenance
 - With interchangeable parts
 - MAKE IT CHEAP
- Torrefaction reactor
- New entrained flow reactor
 - Maximum fuel flow rate: 2 kg/h
 - Maximum number of operators : 2
 - Pressure: min 10 bar(g)
 - Wall heater temperature: min 1500 °C
 - Fuel particle size distribution: As large as possible
 - Continues operating time: 6 h
 - The reactor should be used to:
 - Study if a fuel is suitable for gasification
 - Study soot and tar formation from gasified biomass
 - Provide validation data to numerical models

Upcoming activities:

- HAZOP together with revision of existing P&ID
- Project meeting with manufactures of pressure vessels, refractory and heaters

Denmark, Morten Tony Hansen, FORCE Technology

Government targets and agreements were presented. Current feed-in tariff 15 €/kWh. Trends/headlines in policy were also presented.

Babcock & Wilcox – Harbøre Plant (updraft, wood chip fired, 1 MW_e, 1,4 MW_e installed)

- 21 years gasifier operation
 - CHP operation for 14 years
 - 650 kW_e
- Tar challenge turned into flexibility advantage – bio oil
- BWV would like new demo plant
- Home market challenges:

- Feed in tariff challenging in DK
- DH plant managers prefer simple heating plants
- Foreign markets:
 - Promising tariffs but heat of low value

Babcock & Wilcox Vølund - Ammongas

- FIRgas Alternating Gasifier
 - Twin bed filter
 - Aiming at straw
- Technology being developed by B&W Vølund
- Pilot plant 400 kW_{th}
 - Wood chips
 - In intermittent operation
- Application not yet clear
 - Fuel likely, not IC engine
 - Gas composition high on H₂ and CO, no N₂, low CO₂

Biosynergi – Hillerød Plant

- Open core downdraft for CHP
- New demonstration plant under construction in Hillerød
 - 300 kW_e
 - wood chips
- Status
 - Building in place
 - Large hardware in place
 - Assembly ongoing

Expect commissioning 2014

Weiss plant in Hillerød

- Staged down draft for CHP
- Developed by DTU; licensed by COWI
- 600 kW_e wood chips based demonstration plant started up in Hillerød November 2012
- Design for unmanned operation
- Continuous operation pending

Pyroneer – DONG Energy – Kalundborg

- Low temperature CFB
 - Developed by Stoholm/DTU
 - Pilot plant in Kalundborg
 - 6 MW_{th}
 - Loose wheat straw
 - Gas co-fired into coal boiler
 - Tests with various fuels
 - Ash used for fertilizer field tests
 - 60 MW_{th} demonstration plant
 - Expected operational in 2016-17
- Technology for sale

Andritz/Carbona plant in Skive

- Europe's largest CHP

- 6 MW_e
- wood pellet fuelled
- pressurized CFB - Carbona
- Co-financed by the US DOE
- Stable operation since 2012:
 - Available 70% of the time due to
 - 2013: 26 GW_e and 52 GWh heat
 - New catalyst in summer 2014
- Liquid fuel generation tested
 - Tigas process from Haldor Topsøe
 - Further investments are made

TK Energy – Køge

- 10 MW entrained flow plant
 - Slagging
 - Dried sewage sludge
- Current challenges
 - Fuel feeding
 - Burner zone design
- Also project in France
 - Pressurized gasification
 - Wood waste
 - French aim: liquid fuels from H₂

Steeper Energy – Aalborg University

- Hydrothermal liquefaction
- Biomasses & wastes; 300 bar/400°C
- Test facility at the university
- 3 l/h biooil
- Full scale demonstration vision
 - Frederikshavn
 - 50-150t/y S-free marine diesel
- Studies supposed to end 2013
- Strongly profiled plant
- Supported from DEA/EUDP etc.

Organic Fuel Technology - Ødum plant

- Catalytic LT Pyrolysis
- Straw for oil and gas (-> CHP)
- 29% oil - 20% gas
- New plant in Ødum
 - No updates on operation
- Supported from DEA/EUDP
- Strongly profiled plant

Frichs Sublimator Plant

- Flash Pyrolysis/biochar unit
 - Straw fed
- Gasifier concept purchased
- Aims to sublime manure fibre
- Plant installed at farm Havndal

- Currently under commissioning

Other projects/technology tracks

- DALL Energy
 - Idea to proceed with gasification from successful furnace
- Frichs - 1RGI - Gasification.dk
 - Project on optimised updraft gasifier/IC engine system
- GGC-TECH
 - Developing micro scale gasifier/gasturbine system

The Danish RD&D environment

- Universities
 - Biomass Gasification Group at DTU/Risø has merged with DTU Chemical Engineering (CHEC)
 - Aalborg University with HTL
- Advanced Technology Group
 - Danish Technological Institute (DTI)
 - FORCE Technology
- Consultants
 - Danish Gas Technology Centre (DGC)
 - Aaen Consulting Engineers
 - COWI

Switzerland, Martin Rügsegger, ETECA GmbH

General Swiss energy policy and programs as well as energy strategy were presented.

Research activities

- PSI
 - Gasification of dry biomass (SNG, CHP)
 - Co-firing in NGCC for power generation
 - High & low temperature fuel cells for CHP
 - Gas processing for SNG production
 - Gasification of moist biomass for SNG production
 - For SNG production
 - EU Infrastructure Project, collaboration with: BRISK
 - CCEM Competence centre Energy and Mobility
 - 3 projects (ARRMAT, WOODGAS-SOFC II, SYNGAS Diagnosis)
 - NFP66 – 3 projects rel. biom. gasification
 - Hot gas cleaning for production of bioSNG and electricity
 - Predicting the complex coupling of chemistry and hydrodynamics in FB methanation reactors for SNG
 - Distributed production of ultra-pure hydrogen from woody biomass

Swiss Industry

- BR Engineering GmbH CH-6006 Luzern www.br-engineering.ch
Engineering and commissioning of thermal Gasification plants and gasification components (involved with Holzstrom Stans)
- Schmid Energy Solution CH-8360 Eschlikon
 - Representation for Switzerland Burkhardt turnkey biomass gasifier plants (taken over from Öhlmühle Möriken)
- XyloPower AG www.xylopower.com
 - Supplier for turnkey biomass gasifier plants (BMG Technique similar to WILA)
- CTU <http://www.ctu.ch/de/home.html>
 - Supplier for turnkey biomass gasifier plants

- Foster Wheeler AG (only Offices)
 - Foster Wheeler AG in Baar Switzerland (published March 2010 Infos about BTL-Plant in Finland)
 - Foster Wheeler Engineering AG Basel
 - Foster Wheeler Management AG in Geneva Switzerland

CHP project news

Projects cancelled:

- EMPA EAWAG Dübendorf CHP gasifier Plant
- PSI: Biomethane Development => 20-80MW BM-to-SNG plant **in-discussion** based on BFB methanation technology

Projects in preparation or evaluation:

- Gasification CHP unit for forest waste chip =>
 - 1-2 MW fuel input
 - Location Köniz/Gasel
- Bucher Josef AG Escholzmatt Sawmill => 2x45 kWel Spanner Gasifier, commissioning 2013/14
- Gasification Riggisberg CHP unit for forest waste chip =>
 - 220kWel/436kWth EAF Austria/Xylogas.com
 - Location Riggisberg

Collaboration with BESTF 1 cancelled in within BESTF 2 eventually swiss industry participation in collaboration with NL

CHP plants - news

BR Engineering

-Reaktor SIRION – the 4. Generation gasifier developed out of the Stans Type 3 gasifier

- Fixed bed zone downdraft
- 764 kW heating power
- 571 kW Cold gas power
- 107 kW heating power HT>130°C
- 55 kW low heat power for drying
- 31 kW loss gas cleaning
- 75% cold gas power
- 89% overall without wood drying

- 96% overall with wood drying

Table: CHP facilities, Mai 2014

	Aerni in Pratteln	Holzstrom in Stans	A. Steiner + Cie. AG
Gasifier	1 Kuntschar modified	8 Pyroforce	Spanner
Type	Downdraft	2-zone downdraft	downdraft
Gas engine	1 x 130 kW Adapt. MAN	2 x 690 kW Jennbacher	45 kW el
Waste heat therm	230 kW for district heating	1,2 MW for district heating	district heating
extra Boiler	2MW wood chip district heating	1,6 MW W'chips + 1,7 MW oil for district heating	yes
Commissioning	2009 first 2013 second	2007	2012/2013
Total live time operation hours	n.a. due modification	Block 1: 29 956 Block 2: 36 695	5000 h
Remarks	in testing operation	24h_7d p week operation	Plant in operation

Facts today:

- 2 Plant in stable operation (Stans and Ettiswil)
- 1 Plant in testing operation (Aerni)
- 0 Project in construction
- Several small gasifiers in discussion (Spanner, Burkhardt, Agnion)

Facts of the past 5 years:

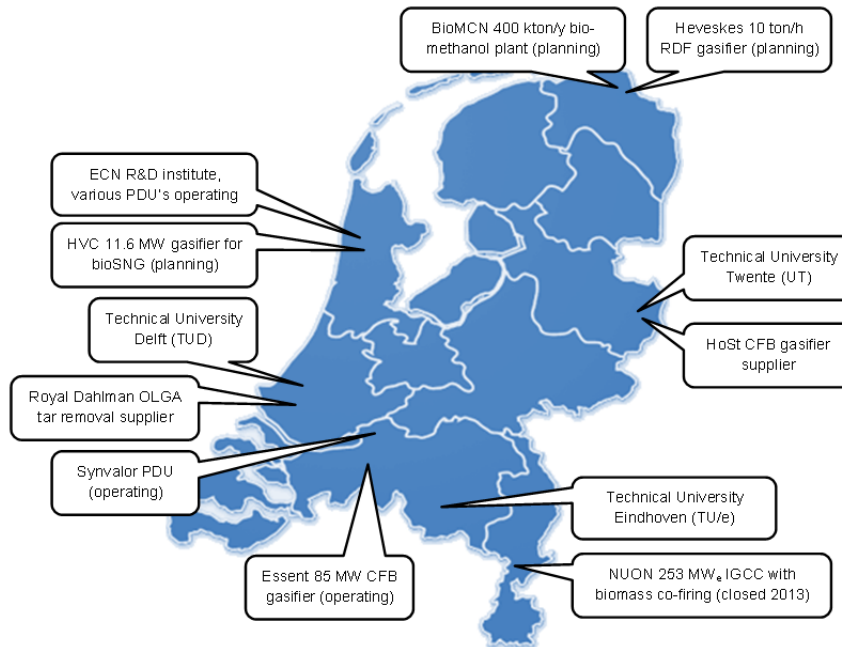
- 2 Plant closed down (Wila, Spiez)
- 4 Planned projects abandoned (Empa, E Hup Baden, Brickfactory, PSI)
- 2 Main Gasifier suppliers out of business (EKZ, Pyroforce)

Politics: strong renewable energy promoting but little increase in **new** projects

- Reality:
- Cost-covering remuneration (KEV) for new projects pending till 2015
 - Thermal gasification is technically complex (higher costs)
 - Risk investments for biomass-energy projects not existing
 - CO₂ -certificates, -contributions and -compensations unsecure in the future
 - Public and private frames not in line with political visions
 - Volatile biomass-fuel-price

The Netherlands, Berend Vreugdenhil, ECN

Biomass gasification in the NL - overview



Essent/RWE indirect cofiring 85 MWth CFB gasifier

- Subsidy ended, shift to cheaper feedstock: waste/RDF/SRF
- Test trials ongoing with up to 40% RDF with waste wood
- Focus on cooler fouling and bed agglomeration
- In total 2400 ton RDF has been gasified
- Gasifier temperature reduced from 840 to 750°C: cooler fouling reduced
- Bed material refreshment rate could be reduced by factor 3-4
- Gas heating value increased significantly
- Next: adapt feeding system, modify cooler, increase RDF/wood ratio

What is new in the NL:

- 4 MW wood to bioSNG plant in Alkmaar (NL) close to final decision
- 7 MWe waste-IGCC in UK close to final decision (ETI-programme)
- 1 MWe CHP in Portugal with HoSt CFB-technology and Dahlman OLGA-technology started up again, tests with RDF ongoing
- HoSt preparing 15 MW plant (NL) on paper rejects
- Torrgas preparing 10-15 MW gasifier plant on torrefied wood
- Synvalor developing new technology, 50 kW pilot plant with engine

ECN – developments (complete test system)

- Gasifier: www.milenatechnology.com
- Tar removal: www.olgatechnology.com
- New BTX scrubbing process

First BTX test results

- Stable operation downstream wood-operated MILENA gasifier and OLGA tar removal in ~1 Nm³/h test facility
- >97% benzene removal
- >99% toluene removal
- >90% organic sulphur removal

Next steps:

- Harvest bioBTX in liquid form
- Perform integrated test with bioSNG production to prove synergy (better value products, higher efficiency, simpler/cheaper process)
- Additional bio-ethylene removal
- Increase benzene and ethylene yield in gasifier (first test shows tripling of benzene)
- Combination with bioLNG and ultra clean syngas

Sweden, Lars Waldheim, Waldheim Consulting

An overview on biomass gasification in Sweden was given, detailed information can be found in the presentation.

Policy areas requiring to be addressed

- Urban and societal planning to reduce need and improve efficiency in transport,
- Change in traffic modalities and infrastructure, i.e. more railway transports, improved railways etc.
- Drive train efficiency improvements
- Promote eco-driving
- Increased use of biofuels
- Introduce and deploy electric drive trains

Main recommendations for future policy actions

- Gradually increase the quota obligation to 2020
- Biofuel price guarantee to make investments more bankable
- Expand the use of electrical energy by charging infrastructure etc.
- Bonus-malus policies to improve efficiency
- Promote citizen change (from individual to collective transports, taxes, insurances, ecodriving etc.)
- Infrastructure and urban planning actions

Swedish Gasification Centre (SFC) – 8 Academies and 9 companies

- CDGB (Centre for Direct Gasification of Biomass)
- CIGB (Centre for Indirect Gasification of Biomass)
- B4G (Biomass for Gasification, Entrained Flow Centre)

Application for 4 year activity, 58 MSEK/year 2013-17 approved

Chalmers – indirect gasification

Chalmers 2-4 MW_{fuel} gasifier integrated on the return leg of Chalmers 12 MW_{fuel} CFB boiler.

Heating season end in May.

Accumulated operation time ~ 25 000 h, whereof ~ 3000 h experimental time with fuel gasification

Swedish Gas Centre

- ***"Energy gas program"***

New project period 80 MSEK, 9 M€ for 2013-2015

International Gasification Seminar Malmö, October 15-16, 2014

On-going gasification related activities

- *Particulate contaminants from indirect gasifiers*
- *Autothermal regenerative POX tar reactor*
- *On-line detection of water vapor*
- *CO₂ removal in indirect gasification*
- *Fuel tests in 500 kW Wood Roll prototype*

On-going, KTH, Cortus

Chemrec BLG

-LTU Biosyngas program

- The LTU Green Fuels (Luleå Technical University) has bought the Chemrec pilot plant and the bio-DME plant.
- Operating staff and some key Chemrec staff hired
- LTU Biosyngas program, approx. 250 MSEK, 2014-2016
- Objectives:
 - DME fuel for truck tests, other test activities
 - catalytic gasification of liquids
 - Develop to solid fuel gasification
 - Gas cleaning developments
 - Development of catalytic synthesis reactions

VÄRÖ gasifier

- was not stopped in 2013, it was operated until April 2014, longer than planned .
This was due to delays in the installation of the new lime kiln.

E.ON Bio2G

“Lighthouse” candidate for first-mover support,
i.e. NER300, EIBI, etc

GoBiGas

- Biomass to biomethane 65 – 70 %
- Energy efficiency > 90%
- Phase 1:
 - **Official start-up initiated**
 - **October 28, 2013.**
 - Demo plant, 20 MW generating 160 GWh/y
 - In operation early 2013, agreement with Swedegas for pipeline transition of product gas
 - Allothermal (in-direct) gasification
 - Gasification: cooperation between Metso Power and Repotec
 - Methanation: cooperation with Haldor Topsöe
- Phase 2:
 - 80-100MW generating 640-800 GWh/y
 - NER 300 grant for Phase 2

GoBiGas – status on May 6th, 2014

- Initial problems with fuel feeding and excessive tar formation (surprise!) have now been resolved to allow continuous op.

- The gasifier has been operated for well over hundred hours since Easter under stable
- conditions with on spec. gas, and operation is planned to continue for some time.
- The SNG unit has undergone functional tests with N₂. Commissioning to be initiated shortly and first SNG production is expected by the end of May

USA, Kevin Whitty, University of Utah

Biomass gasification research

- Universities
 - Iowa State University
 - University of Utah
 - University of California
- National Laboratories
 - NREL (National Renewable Energy Laboratory)
 - INL (Idaho National Laboratory)
- Commercial Research Organisations
 - GTI (Chicago, IL)
 - RTI (Raleigh, NC)
 - SRI (Raleigh, NC)

Technology providers

- Carbona
- Concord Blue
- Emery Energy
- InEnTec
- Sundrop Fuels
- TRI
- Others...

US gasification database

- U.S. Dept. of Energy recognized that existing database of U.S. gasifiers was outdated and commissioned BCS Inc. to research and update gasifiers
- Update conducted by Zachary Peterson and Michael Bernstein during Fall 2013 and Spring 2014
- Considered EIA database, GTC/DOE database, plus conducted independent research and contacted plants
- EIA database includes 13 commercial plants
- 32 additional plants identified by BCS
 - 20 confirmed operational
 - 3 confirmed in planning / development
 - 9 still waiting for response from plant operator

Updating continues

INEOS Indian River Bioenergy Center

- Feedstock: Vegetable and yard waste, MSW
- Products: Ethanol and power
- Scale: 300 tons feed/day
- Gasification technology: Proprietary oxygen-blown
- Cost: More than \$130 million

- Status: First biofuel production July 2013
- Update Dec 2013: ““Bringing the facility on-line and up to capacity has taken longer than planned due to several unexpected start-up issues at the Center. These efforts have highlighted some needed modifications and upgrades.”

GTI/ Haldor Topsøe pilot plant

- Feedstock: Wood chips
- Products: Gasoline
- Scale: 20 tons/day feed; 20 bbl/day gasoline
- Gasification technology: Carbona
- Cost: unknown
- Status: First gasoline production June 2013

Zechem Pilot Plant

- Feedstock: Poplar + others
- Products: Ethanol + intermediate chemicals
- Scale: 10 tons/day feed; 250,000 gal/yr ethanol
- Gasification technology: Proprietary; gasifies only lignin
- Cost: unknown
- Status: First ethanol production March 2013
- Status May 2014: Continued operation

Enerkem pilot plant

- Feedstock: MSW and wood residues
- Products: Ethanol and methanol
- Scale: 300 tons/day feed; 10 million gallons/year
- Gasification technology: Enerkem proprietary
- Cost: unknown
- Status: Under development
- Update May 2014: Still under development... Construction not yet started

Freedom Pines Biorefinery

- Targeting biofuel production through LanzaTech’s syngas fermentation technology
- Host site is old Range Fuels site in Soperton, Georgia. Acquired for Freedom Pines Biorefinery in January 2012
- Concord Blue chosen as gasification technology provider
- Rebuilding for new configuration still ongoing

West Biofuels

- Feedstock: Unspecified biomass
- 6 ton/day pilot
- Repotec dual bed gasifier
- Targeting electricity production

Research at the University of Utah

- Lab-scale characterization
 - High pressure TGAs (2)
 - High pressure wire-mesh heater
 - High temperature drop tube / LEFR reactors
- Lab-scale reactors
 - Indirectly heated 10 kW steam fluidized biomass gasifier

- New 10 kW dual bed system
- Semi-pilot / PDU-scale systems
 - 200 kW_{th} pressurized bubbling fluidized bed gasifier
 - 500 kW_{th} pressurized O₂-blown entrained-flow gasifier
- **Pressurized fluidized bed gasifier**
 - Gasifier**
 - Steam, air or O₂-blown
 - Bubbling bed system
 - Max 35 kg/hr biomass
 - Max temp: 860°C
 - Max pressure: 20 atm
 - 80 in-bed heaters
 - 32 kW power input
 - Gas Handling**
 - Internal cyclone
 - Hot particulate filter
 - Pressure control valve
 - Thermal oxidizer
- **Pressurized O₂-blown Entrained Flow Gasifier**
 - Max 1.5 ton/day (~500 kW)
 - 30 atm max pressure
 - Fuels processed
 - Coal slurry
 - Petcoke slurry
 - Petroleum liquids
 - Some bio-liquids
 - Laser-based monitoring
- **Chemical looping/Dual Bed Gasifier System**

Day 2, Wed May 14
IEA Bioenergy Task 33 workshop
Topic: Thermal biomass gasification in small scale

The list of attendees, for the workshop include:

Name	Country	Affiliation	email
Task 33 members			
Kevin Whitty	USA	UoU	kevin.whitty@utah.edu
Reinhard Rauch	Austria	VUT	rrauch@mail.zserv.tuwein.ac.at
Jitka Hrbek	Austria	VUT	jhrbek@mail.zserv.tuwein.ac.at
Morten Tony Hansen	Denmark	FORCE	mth@force.dk
Roger Khalil	Norway	SINTEF	Roger.khalil@sintef.no
Berend Vreugdenhil	The Netherlands	ECN	vreugdenhil@ecn.nl
Martin Rügsegger	Switzerland	Eteca	eteca@gmx.ch
Thomas Kolb	Germany	KIT	Thomas.kolb@kit.edu
Antonio Molino	Italy	ENEA	Antonio.molino@enea.it
Mark Eberhard	Germany	KIT	Mark.eberhard@kit.edu
Industry/Research			
Andrea Duvia	Italy	Gammel&Duvia	a.duvia@gammelduvia.it
Simeone Chianese	Italy	University or Naples	Someone.chanese@uninaz.it
Tiziana Marino	Italy	CNR	T.marino@itm.cnr.it
Marcel Huber	Austria	Syncraft	Marcel.huber@syncraft.at
Markus Huemer	Austria	MCI	Markus.huemer@mci.edu
Giovanna Ruoppolo	Italy	CNR	ruoppolo@irc.cnr.it
Osvalda Senneca	Italy	CNR	senneca@irc.cnr.it
Luciano Cortese	Italy	CNR	Luciano.cortese@irc.cnr.it
Marco Fantacci	Italy	Bioewatt	Marco.fantacci@bioewatt.com

Table: Overview of the workshop presentations

MARCO FANTACCI

General Manager

BIO&WATT GASIFICATION S.r.l.

Energetical conversion of biomass through pyrogasification process: presentation of an industrial solution

ANDREA DUVIA

Gammel Duvia Engineering Srl

Industrial experiences and innovative solutions

MARCEL HUBER

Syncraft, Austria

The floating-fixed-bed - status of a unique staged gasification concept on its way to commercialization

GIOVANNA RUOPPOLO

CNR – National Research Council

Fluidized bed gasification and co-gasification of biomass and wastes

PAOLA AMMENDOLA

CNR – National Research Council

Development of catalytic systems for tar removal in gasification processes

PAOLA AMMENDOLA

CNR – National Research Council

Relevance of biomass comminution phenomena in gasification processes

OSVALDA SENNECA

CNR – National Research Council

Gasification kinetics of biogenic materials and wastes

SIMEONE CHIANESE

University of Naples and TUV of Vienna

H₂ 4 Industries

SIMEONE CHIANESE

NADIA CERONE

ENEA

Gasification of fermentation residues from second generation ethanol for production of hydrogen rich syngas in a pilot plant

The aim of the workshop was to offer an overview about the thermal biomass gasification in small scale.

All the workshop presentations will be summarized into Worksop – report, which will be available at the Task 33 website as soon as possible.

Day 3, Thu May 15

Site visits: CNR – National Research Council

The Combustion Research Institute was founded in 1968 with the aim of establishing a public research body dedicated to the study of combustion processes, either relevant to energy conversion, or to the prevention and control of fires, explosions, accidental releases. In addition to the contribution to scientific advancement in these fields, the Institute has greatly contributed over decades to the progress of other disciplines falling in the chemical engineering and neighbouring areas: chemical reactor engineering, analytical methods, multiphase flow, heat and mass transfer, to cite a few.

The Institute counts today 53 permanent staff, half of whom hold a university (master/doctoral) degree. The current research activities are developed along the following lines:

- development of efficient and environmentally compatible combustion and gasification technologies
- utilization of alternative fuels (e.g. biomass, wastes and refuse-derived fuels)

- development of innovative intrusive and non-intrusive combustion diagnostics
- detailed modelling of reacting systems
- assessment of safety with the use of inflammable materials
- investigation of oxidation mechanisms and complex kinetics
- control and removal of pollutants in flue gases
- catalytic combustion/gasification and catalytic abatement of pollutants.

On the third day of the meeting the Task representatives had a possibility to visit CNR and take a look at several research facilities, e.g.

Fluidized bed gasifier

- 3 m height
- 14 cm inner \varnothing
- Fuel: spruce wood pellets; fed into the bed
- Fluid. Agent: steam, oxygen, air
- Bed of sand and nickel catalyst
- Materials tested: plastics, tyres, wood
- Feeding rate: 7 kg/h
- Feeding system: 2 screw feeders

Particle segregation laboratory

- Simulation of particle behaviour
- Interaction of particles and liquids

Cold fluid. model for study of hydrodynamics, solar energy combined with biomass combustion, etc.

END