

**IEA Bioenergy Agreement: 2013-2015**  
**Task 33: Thermal Gasification of Biomass**  
**Second Semi-annual Task Meeting, 2014**  
**Karlsruhe, Germany**  
**Mon. 03 to Wed. 05 November 2014**

**Minutes**

Prepared by Dr. Jitka Hrbek, VUT, Austria

The list of attendees, for the Task Meeting includes:

Name	Country	Affiliation	email
<b>Task 33 members</b>			
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
Erik Winther	Denmark	FORCE	ebw@force.dk
Bram van der Drift	The Netherlands	ECN	vanderdrift@ecn.nl
Martin Rügsegger	Switzerland	Eteca	eteca@gmx.ch
Thomas Kolb	Germany	KIT	Thomas.kolb@kit.edu
Ilkka Hannula	Finland	VTT	Ilkka.hannula@vtt.fi
Lars Waldheim	Sweden	WaC	lars.waldheim@waldheim-consulting.se
<b>Observers</b>			
Arthur Wellinger	Switzerland	Triple E&M	wellinger@triple-e-und-m
Bodil Voss	Denmark	Haldor Topsøe	bov@topsoe.dk
John Bøggild Hansen	Denmark	Haldor Topsøe	jbh@topsoe.dk

**Regrets for inability to attend** were received from: Roger Khalil, SINTEF, Norway and Antonio Molino, ENEA, Italy.

The Agenda of the Meeting was as following.

**IEA Bioenergy Agreement: 2013-2015**  
**Task 33: Thermal Gasification of Biomass**  
**2<sup>nd</sup> Semi-Annual Task Meeting, 2014**  
**KIT Karlsruhe, Germany**  
**Monday, November 3<sup>rd</sup> to Wednesday, November 5<sup>th</sup>, 2014**

**Local Contact:**

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**Day 1 – Monday, November 3<sup>rd</sup>: Task Business Meeting**

**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen, Building 430

Bus transport: Departure at hotel 08:30 am

**Day 2 – Tuesday, November 4<sup>th</sup>: Task Meeting / Workshop “Liquid Biofuels”**

**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen

Bus transport: Departure at hotel 08:30 am

**Day 3 – Wednesday, November 5<sup>th</sup>: Task Meeting / Site Visits**

**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen

Bus transport: Departure at hotel 08:30 am

## **Day 1 – Monday, November 3<sup>rd</sup>**

### **Task Business Meeting**

**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen

08:30 Departure bus from Hotel Kübler – transfer to KIT

### **Task Meeting**

09:00 Welcome: Kevin/Thomas

Introductions of Task Members and Observers (All)

Approval minutes last meeting

09:20 Brief overview of Task 34 activities and plans for the 2016-19 Triennium  
MAGNUS MARKLUND, Managing Director, Energy Technology Centre, Piteå, Sweden

09:40 New member countries for Task 33 (Kevin)

09:55 Discussion topics and possible work packages for next triennium (All)

- Gasification of waste / plasma gasification
- Gasification-based RES hybrids
- Hydrogen generation and use
- Super- and sub-critical gasification of wet biomass
- Tar sampling and online tar measurements
- Gasification of bio-derived liquids
- Substitution of fossil fuels with biomass in gasification systems
- Other?

10:50 Break

11:10 Updates on special projects

- 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)

12:25 Lunch

13:30 Country reports (5 minutes / 15 minutes each)

(countries scheduled to give longer reports this time are Austria, Norway, Sweden, Italy at least)

16:45 Next task meeting date

17:00 bus transfer to Hotel Kübler

20:00 Task Dinner – Badisch Brauhaus

**Day 2 – Tuesday, November 4<sup>th</sup>**  
**Task Meeting / Workshop “Liquid Biofuels”**  
**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen  
Bus transport: Departure at hotel 08:30 am

09:00 – 09:15 Welcome (Kevin/Thomas)

09:15 – 09:45 Introduction IEA Task 39: Commercializing Liquid Biofuels  
**MANFRED WÖRGETTER**

**Topic: BtL / BtG projects**

09:45 – 10:15 2<sup>nd</sup> generation biofuels – the bioliq technology and economic perspectives  
**THOMAS WURZEL** – Director Technology, Air Liquide Global E&C  
Solutions, Germany

10:15 – 10:45 Conversion of forest industry by-products to methanol and DME  
**RIKARD GEBART** – Coordinator LTU Biosyngas Program / Luleå  
University of Technology, Sweden

*10:45 – 11:15 Coffee and tea break*

11:15 – 11:45 Carbo-V – Biomass Gasification Technology – Status after Application of  
Sound Engineering Practices  
**SVEN PETERSEN** - Vice President Carbon and Energy Solutions, Linde  
Engineering Dresden GmbH, Germany

11:45 – 12:15 GoBioGas Project – Experiences and Operational Progress

**MALIN HEDENSKOG**, Göteborg Energi, Göteborg, Sweden

12:15 – 12:45 An update on the BioTfuel Project and other activities of TKIS-PT in the area  
of biomass gasification

**RALF ABRAHAM** – Head of Process Group Gasification / UHDE GmbH,  
Germany

**NORBERT ULLRICH** – Chief Engineer / UHDE GmbH, Germany

*12:45 – 14:15 Lunch*

14:15 – 14:45 Haldor Topsøes biobased sustainable fuel production technologies

**JOHN BØGILD HANSEN** - Senior Advisor to Management / Haldor Topsøe,  
Denmark

14:45 – 15:15 Modified MtG-processes for BtL and Power-to-Fuels

**JÖRG SAUER** – Head of Institute / KIT - Institut fuer Katalyseforschung und  
-technologie (IKFT), Germany

*15:15 – 15:45 Coffee and tea break*

*15:45 – 16:15 Speciality chemicals from syngas fermentation*

**THOMAS BÜLTER** –EVONIK Industries AG, Deutschland

16:15 – 16:45 Technology for Fischer-Tropsch synthesis of liquid fuel in small scale

**PETER PFEIFFER** / KIT – Institut für Mikroverfahrenstechnik (IMVT),  
Germany

17:00 – 19:00 Site visit bioliq

**Day 3 – Wednesday, November 5<sup>th</sup>**

**Task Meeting / Site Visits**

**Meeting location:** KIT Campus North, Eggenstein-Leopoldshafen

Bus transport: Departure at hotel **08:30 am**

08:30 – 11.00 Bus transfer from KIT to Ulm

11:00 – 13:00 Site visit Holzgas-Heizkraftwerk Senden

13:00 Lunch

14:00- 16:30 Bus transfer from Ulm to Karlsruhe Main Station

## Day 1, Mon, Nov 03

### **Task Business Meeting**

**Meeting Location:** KIT, Karlsruhe

#### **Representatives' introduction and approval of Agenda and Minutes**

After introduction of Task 33 members and observers, the actual Agenda and Minutes from the last meeting in Ischia, Italy were approved. Meeting minutes from Ischia meeting in May 2014 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. Also the cooperation with countries as Canada, Japan, Korea, India, China and Belgium can be for the Task 33 could be very interesting.

#### **Task Plans for 2015 Meetings 1**

##### **Next meetings**

##### **Meeting 1**

The first Task 33 meeting in 2015 should be held in Leon, Spain. The host of the meeting will be CIUDEN, Ponferrada (León) Spain. The date is not fixed yet. Suggested was the date 11.-13.5.2015.

The Task leader already contacted the host to confirm the date.

##### **Meeting 2**

IEA Bioenergy Conference 2015

- 26-29 October 2015 in Berlin, Germany
- We can arrange Task meeting in conjunction with this

#### **Special and collaboration projects**

##### **Discussion on the project for the next Triennium**

- Waste gasification
  - In cooperation with T 36
- Gasification-based RES hybrids
- Hydrogen production from biomass and its use

- Super- and sub-critical gasification of wet biomass
- Protocol for tar sampling and analysis using SPA method
- Gasification of bio-derived liquids
- Substitution of fossil fuels with biomass in gasification systems
- Report on potential of gasification to contribute to BECCS (with Task 38)

## Actual projects

- **Gasification Facilities Database and Map**
  - Regularly updated by Jitka
  - Details regarding information from member countries discussed
- **Biomass Gasification Facilities Status Report in member countries**
  - 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
- **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**
  - Project complete
- **Gasification of Pyrolysis Oil (collaborative with T34)**
  - Not included in 2013-15 proposal for prolongation
  - Joint with Task 34 (pyrolysis of biomass)
  - Consider including in next triennium proposal on gasification of bio-derived liquids
- **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
  - Project complete
- **Techno-Economic Assessment (collaborative with T32, 34)**
  - Joint with Tasks 32, 34

- Included in 2013-15 Proposal for Prolongation:
  - Task will collaborate with Task 32 and 34 on development of techno-economic assessments of technologies for CHP and biofuel production. The techno-economic studies will primarily come from existing reports in member countries and should not require a major effort to develop. The Task will contribute US\$10,000 to this effort. Deliverable: A joint report will be published. The timing is to be determined.
  - Consideration 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
- **Biomass Feeding and Handling – White Paper**
    - Is the Task 33 able to contribute anything beyond what was by other groups developed?
- **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



## 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 <sub>fuel</sub> / 2.0 <sub>el</sub>	2002	AE&E, Repotec	Operational
Oberwart, AT	Gas engine / ORC	8.5 <sub>fuel</sub> / 2.8 <sub>el</sub>	2008	Ortner Anlagenbau	Operational
Villach, AT	Gas engine	15 <sub>fuel</sub> / 3.7 <sub>el</sub>	2010	Ortner Anlagenbau	On hold/ insolvent
Senden/UlmDE	Gas engine / ORC	14 <sub>fuel</sub> / 5 <sub>el</sub>	2011	Repotec	Operational
Burgeis, IT	Gas engine	2 <sub>fuel</sub> / 0.5 <sub>el</sub>	2012	Repotec	Commissioning
Göteborg, Sweden	BioSNG	32 <sub>fuel</sub> / 20 <sub>BioSNG</sub>	2013	Metso/Repotec	Operational
California	R&D	1-2 MW <sub>fuel</sub>	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

Since 1.8.2014 new law regarding the renewable energy

- subsidies for 20 a 2%/a degression from 2016
- 100 MWel/a max new install
- flexibility:
  - subsidies for 50% installed power
  - 40€/kWhel for 20a (gas storage / CHP)

The power generation from biomass during the last 10 years in Germany was presented.

Details regarding Carbo-V, BioTfuel and the bioliq plant were presented in the workshop on the 4.11.2014.

## Denmark, Erik B. Winther, FORCE Technology

Government targets and agreements were presented.

- Till 2025 no coal at thermal plants
- Current feed-in tariff 15 €/kWh

Trends/headlines in policy were also presented.

### Babcock & Wilcox – Harbøre Plant (updraft, wood chip fired, 1 MW<sub>e</sub>, 1,4 MW<sub>e</sub> installed)

- 21 years gasifier operation
  - CHP operation for 14 years
  - 650 kW<sub>e</sub>
- 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

### Biosynergi – Hillerød Plant

- Open core downdraft for CHP
- New demonstration plant under construction in Hillerød
  - 300 kW<sub>e</sub>
  - wood chips
- Status
  - Building in place
  - Large hardware in place
  - Assembly of plant completed
  - Operation at the end of 2014
  - Financing challenges seem overcome

### Weiss plant in Hillerød

- Staged down draft for CHP
- Developed by DTU; scaled up by Weiss and DTU, licensed by COWI
- 600 kW<sub>e</sub> 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<sub>th</sub>
  - Loose wheat straw
  - Gas co-fired into coal boiler
  - Tests with various fuels
  - Ash used for fertilizer field tests
- 60 MW<sub>th</sub> demonstration plant
  - Expected operational in 2016-17

## Pyrenee project mothballed - Technology for sale

### **Andritz/Carbona plant in Skive**

- Europe's largest CHP
  - 20/28 MW<sub>fuel</sub>, 6 MW<sub>e</sub>
  - wood pellet fuelled
  - pressurized CFB - Carbona
- Co-financed by the US DOE/EU
- Stable operation since 2012:
  - Available 90% of the time due to
  - 2013: 26 GW<sub>e</sub> 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
  - Energy consumption for feed preparation and handling
  - Burner zone design
- Also project in France
  - Pressurized gasification
  - Wood waste
  - French aim: liquid fuels from H<sub>2</sub>

### **Other projects/technology tracks**

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

### **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

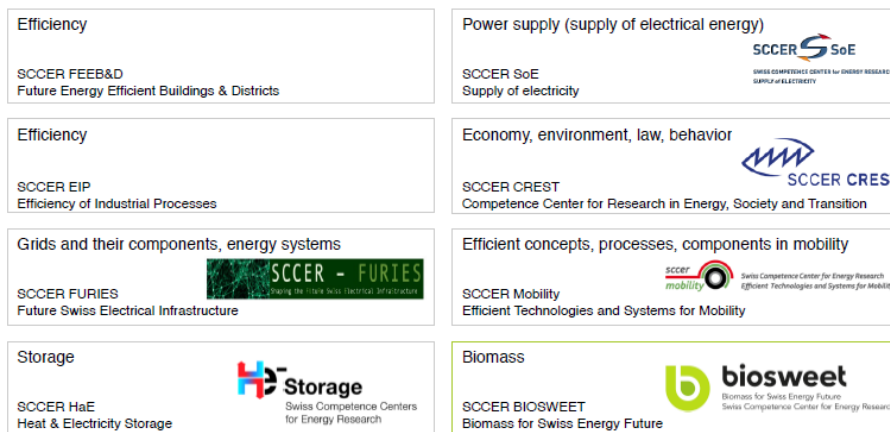
## Switzerland, Martin Rügsegger, ETECA GmbH

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

### Swiss Energy Research

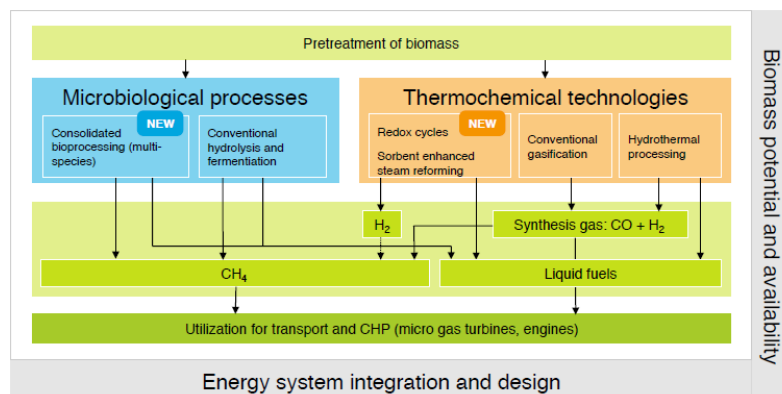
- Energy Strategy 2050
  - Solutions to problems arising from the "energy revolution"
  - Research plays a strategic role
- Coordinated Energy Research in Switzerland Action Plan
  - Swiss Competence Centers for Energy Research (CHF 72 million)
  - R&D projects in the energy field (CHF 46 million)
  - Funding schemes for young scientist (CHF 24 million)
- Swiss Competence Centers for Energy Research (SCCER)
  - Inter-university research networks
  - Seven predefined action areas
  - Supervised by the Commission for Technology and Innovation (CTI) and the Swiss National Science Foundation (SNF)

### SCCER Action Areas



### SCCER Biosweet

#### R&D field



## 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](http://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](http://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 facilities actual status**

	<b>Aerni in Pratteln</b>	<b>Holzstrom in Stans</b>	<b>A. Steiner + Cie. AG</b>
Gasifier	Wegscheid	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
Remarks	in testing operation	24h_7d p week operation	plant in operation
Fuel	Dry clean wood chips	Dry demolition wood/scrap wood chips	Dry waste wood chips
Moisture	8%	10%	Max 15%
Operating hours last 6 months	Not declared	Block 1: 2 494 Block 2: 2 843	2523 h
Declared revision / modification	Gasifier	-	-
Total live time operation h	Since April 2013 1000h	Block 1: 32 450 Block 2: 39 538	7523 h
Remarks	New wood dust remover	Plant in normal operation	Plant in normal operation

## CHP project news

### *Projects in preparation or evaluation:*

- Bucher Josef AG Escholzmatt Sawmill => under construction  
110kW el. /230 kW th Wegscheid Gasifier  
7500h warranty Commissioning 2014
- Gasification Riggisberg CHP unit for forest waste chip => building permission requested  
220kWel/436kWth EAF Austria/Xylogas.com  
Location Riggisberg
- Gasification CHP unit for forest waste chip => ready for final decision  
1-2 MW fuel input Gasifier typ in evaluation  
Location Köniz/Gasel

## Summary

### **2 Plant in stable operation (Stans and Ettiswil)**

#### **1 Plant in testing operation (Aerni)**

#### **1 Plant under construction (Escholzmatt Bucher (Wegscheid)),**

#### **1 Plant building permission requested (Riggisberg Balsiger (Xylogas))**

#### **Several small in discussion (Spanner, Burkhardt, Agnion)**

### **Facts of the past 5 years:**

#### **2 Plant closed down (Wila, Spiez)**

#### **4 Projects abandoned (Empa, E Hup Baden, Brickfactory, PSI)**

#### **2 Main Gasifier suppliers out of business (EKZ, Pyroforce)**

### **Politics: strong renewable energy promoting, but weak increase of projects**

### **Frame: - Cost-covering remuneration (KEV) existing**

#### **- Thermal gasification is technically complex (higher costs)**

#### **- Risk investments for biomass-energy projects not existing**

#### **- CO<sub>2</sub> -certificates, -contributions and -compensations unsecure in the future**

#### **- Public and private frames not in line with political visions**

#### **- Volatile biomass-fuel-price**

## **The Netherlands, Bram van der Drift, ECN**

The Energy Agreement was presented. Biomass has and will have dominant share in renewable energy in the Netherlands.

### **BioSNG plant in Zutphen, announced fall 2014**

- 8 mcm/y green gas, 14 MW wood input
- No details on technology, but words mentioned: fluidized bed (scheme suggests indirect gasifier), fabric filter, ESP, RME scrubber, amine scrubbing
- Public hearings with worries: 30 meter high, #trucks per day



## TORRGAS

- Torroidal gasification technology
- Torrefied wood gasification
- 0.5 MW plant in Alkmaar (planning)
- 25 MW plant in Delfzijl (planning)
- Final goal: chemicals and fuels

## Essent/RWE indirect cofiring 85 MWth CFB gasifier

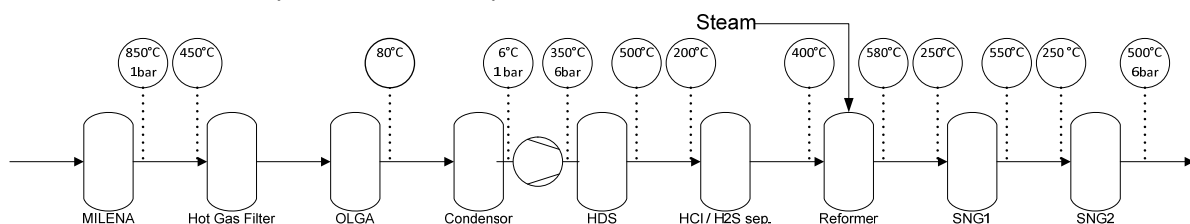
- Subsidy ended, shift to cheaper feedstock: waste/RDF/SRF
- Test trials ongoing with up to 40% RDF with waste wood
- Focus on cooler fouling and bed agglomeration
- In total 2400 ton RDF has been gasified
- Gasifier temperature reduced from 840 to 750°C: cooler fouling reduced
- Bed material refreshment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

## BIOBTX, jointly owned by KNN and Syncom

- Focus on bioBTX production from biomass and waste
- Closely cooperating with University of Groningen
- Several small-scale test facilities available
- Two-step approach:
  - Low-temperature gasification/pyrolysis
  - Production of bioBTX

## ECN – developments (complete test system)

- Gasifier: [www.milenatechnology.com](http://www.milenatechnology.com)
- Tar removal: [www.olgatechnology.com](http://www.olgatechnology.com)
- New BTX scrubbing process
- 500 hours of testing October 2014
- Complete lab-system with
  - ESME system for bioSNG production



*ECN's lab test facility for biomass-to-SNG. Upscaled plant would: not have hot gas filter, have amine scrubber for CO<sub>2</sub>-removal after reformer/before 2<sup>nd</sup> compressor, high-pressure methanation final step(s)*

- BTX scrubber operational, liquid bioBTX can be produced, integrated in total test facility in ECN's lab
- Attempts to increase BTX yield (5-10% in standard energy case) show that doubling is possible with little efforts. Also tripling has been reached.

- Translated to a bioSNG plant, this may give 25% bioSNG production costs reduction.
- ECN also develops SNG-processes with synergies: FT-SNG, fermentation-SNG, P2G-SNG, cryo-LNG-Methanol, ...

## Sweden, Lars Waldheim, Waldheim Consulting

An overview on biomass gasification in Sweden was given, as well as policy and Swedish energy targets. Detailed information can be found in the presentation.

### Renewable transportation fuels

- **Present situation**
  - 11.8 % RE transport fuels in 2012
  - 5.9 % of all vehicles predominant RE fuels
  - Energy taxes levied on low-level blends in gasoline and diesel as of 2013 to comply with EU state aid rules, but no CO<sub>2</sub> tax.
  - Tax exemptions retained for high-level blends or neat fuels (e.g. E85, B100, CBG, but also for HVO < 15 % in diesel)
  - Sustainability criteria to qualify as RE fuel and for tax exemptions
- **Future plans**
  - Quota obligation rise proposal to increase RE fuels from 4.8 % was withdrawn for governance reasons in early 2014.
  - Parliamentary commission on fossil-free vehicle traffic was reported December 16, 2013.
    - Proposal for a price guarantee for second generation biofuels?

### EU NER300: bioenergy 5 of 9 proposals, 3 retained

- Pyrogrot Billerud -Category: 40 kton/a pyrolysis oil or slurry project abandoned.
- GoBiGas 2 -Category: 40 million Nm<sup>3</sup>/a SNG  
Has grants from first round.
- E.ON Bio2G -Category: 40 million Nm<sup>3</sup>/a SNG  
Received second round support decision in August 2014.

The deadline for initiating construction has been extended by 2 years. (GoBiGas 2, end 2016, Bio2G end 2020)

### R&D and D

- Government Bill "A Boost to Research and Innovation"  
2010 gives support to 20 identified "Strategic Areas of Research" in 43 groupings for 5+5 years, 3 energy related

#### Bio4Energy (UmU/LTU/SLU)

- Biorefining of woody biomass 50 MSEK per year

#### Chalmers Energy Initiative (Chalmers,SP,Innventia)

- Energy Combines, electricity propulsion systems and hybrid vehicles, large-scale renewable electricity generation and grid integration, technology impact assessment, 58 MSEK/year

## **STandUP (UU/KTH/LTU/SLU)**

- Mainly electrical grid and vehicle technology, but also RE power generation

## **Swedish Centre for Renewable Fuels (f3) launched**

### **Swedish Gasification Centre launched**

The overviews of energy use, power production in 2000-2012, fuel prices and taxation, fuel use for power, RE power, biofuels use and fuels for heating were presented.

Parliamentary commission on fossil-free vehicle traffic 2013:

- **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<sub>fuel</sub> gasifier integrated on the return leg of Chalmers 12 MW<sub>fuel</sub> CFB boiler.

Heating season end in May.

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

Focus in 2014 on bed materials, catalytic effects of bed material and support to GoBiGas

## **MiUn BTL Research Laboratory, 150 kW ICFB**

- Integration of FT synthesis reactor
- Prove BTL integration
- System modelling
- Work on Fuel flexibility

## **KTH School of Chemical Engineering**

### **Technologies at KTH**

- 75 kW pressurised (30 bar) & air & steam/oxygen FB gasifier with secondary reactor
- 50 kW air & steam/oxygen FB gasifier
- 5 kW air & steam/oxygen FB gasifier
- Test rigs for catalytic deactivation and particle separation concepts

- Tar analysis equipment, On-line alkali analyses
- New major grant (500 000 €) for upgrading research infrastructure

#### Projects

- HT-SNG: Demonstration of improved catalysts and reactor designs for the production of SNG
- SNG for smart gas grids
- SYNCON: Novel synthesis process concepts for efficient chemicals / fuel production from biomass (SYNCON)
- DeMiTar: Development and market implementation of PID and FID tar analyzers

#### ETC Gasification Activities

- **Host for DP1:** LTU Biosyngas black liquor, biomass
- **VIPP gasifier:** biomass, cyclone gasification, WESP, scrubber, engine CHP
- **Synthesis gas:** zeolithe membrane reactor/MeOH, one stage DME pilot
- **PEBG:** Pressurised entrained flow gasification, 1 MW, 15 bar
- **Fuel tested:** Wood pellets, HT wood, peat, pyrolysis oil, lignin

#### Swedish Gas Centre

- **"Energy gas program"**

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

On-going gasification related activities

- *Particulate contaminants from indirect gasifiers*
- *Autothermal regenerative POX tar reactor*
- *On-line detection of water vapor*
- *CO<sub>2</sub> removal in indirect gasification*
- *Fuel tests in 500 kW Wood Roll prototype*

On-going, KTH, Cortus

#### 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

#### Swedish Centre for Renewable Fuels (f<sup>3</sup>)

"f<sup>3</sup> will be established as a nationwide knowledge platform and venue for cooperation in the production of renewable fuels and the related system aspects, with highest international credibility"

- *Budget for 2011-17 = 44 million SEK*

#### The Värö Gasifier

- The gasifier at Värö 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**

- A reference plant in Sweden for production of bioSNG by thermal gasification

Successful testing of gas filtering (as well as gasification and tar reforming) at GTI in Chicago – two viable technical options for gas cleaning at hand  
Experimental results from GTI have brought a better understanding of alkali behaviour and are important for further design considerations. It will also support further modelling work planned at SFC.

#### **GoBiGas**

- Biomass to biomethane 65 – 70 %
- Energy efficiency ca. 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

#### **Värmlandsmetanol**

- Permitting is on-going. No grant financing requested
- Private investors and public IPO expected to raise 3 000 MSEK (330M€)
- Planned construction start "as soon as permits are in place"

#### **MEVA Innovation AB**

A first unit, 1.2 MWe has started operation at Hortlax, Piteå.

Target market is co-gen plant, 2-20 MW heat, 1-10 MWe.

#### **Cortus Wood Roll, Köping**

- Fully integrated production of clean syngas from biomass
- Investment 1,2 Mio €
- Six months work finalized shortly
- All safety functions
- Six screen Siemens control system
- Remote operation as an overall goal

#### **Finland, Ilkka Hannula, VTT:**

### Metso's gasification projects:

- Vaskiluodon Voima – Substituting Coal for Bio,ass in a PC boiler
- Lahti Energia – waste gasification

### Small scale gasification

#### Volter

Model:	Volter 30 (40)
Fuel:	Wood chips (birch, spruce, pine, aspen)
Fuel moisture:	<18%
Particle size:	8mm ≤ P ≤ 50mm, fine particles (<3,15mm) <1%, all <63mm
Plant structure:	Steel frame, Insulated with paroc (or similar) panels
Generator:	Agco Sisu Power 4,9L, 4-cyl. (8,4L, 6-cyl.)
Output:	Generator output 30kW (40kW), thermal 80kW (100kW)
Max. o.t./a:	7000h

### VTT

- VTT will move it's Gasification and Pyrolysis test facilities to an industrial area in Kivenlahti, Espoo
- New pilot plants will also be constructed
- Start-up at new site in Q4/2014-Q1/2015
- Efficient development from laboratory to industrial realization
- **Horizon 2020-projects, 2015-2020**
  - Biofuels for transport sector, renewable chemicals
  - Fuel gas & pyrolysis oil for CHP and industrial applications
  - Waste-to-Energy with material recovery
- **Pilot/PDU-scale Gasification Test facilities**
  - **Intermediate pressure CFB gasification pilot plant** (existing test rig)
    - Pressure 2-6 bar, fuel capacity max. 0.5 MW, gas flow rate 200 m<sup>3</sup>n/h
    - CFB-gasifier, fluidisation by air/O<sub>2</sub>/steam/recycle gas
    - High-temperature filter, tar and methane reforming, gas cooling
    - Slip stream or full stream testing of final gas clean-up and synthesis processes
    - Large-scale synthesis gas applications
  - **Dual fluidised-bed gasification pilot plant DFB** (present plant will be modified)
    - Fuel capacity max. 300 kW, Air gasification with single gasifier reactor (mainly waste gasification)
    - Dual-Bed steam gasification High-temperature filter, tar and methane reforming, gas cooling
    - Smaller size syngas applications 50 .. 150 MW to be integrated to forest industries and CHP
  - **Bench-scale gasification and gas cleaning facilities**
    - Atmospheric-pressure BFB gasifier with hot filtration and catalytic reforming (syngas & fuel gas) - *New*
    - Atmospheric-pressure CFB gasifier with hot filtration (fuel gas applications)
    - Pressurized BFB gasification reactor for fuel and bed material characterization - *New*
    - Pressurized filtration and reforming test facilities (operation with slip streams or with synthetic gas)

- Catalytic conversion R&D laboratory, Fuel reactivity and ash sintering R&D laboratory (at Otaniemi)
- **High-Pressure BFB gasification PDU** (new test facility, to be built in 2015)
  - Bubbling Fluidised-Bed gasification, fluidisation by air/O<sub>2</sub>/steam/recycle gas
  - max. pressure 25 bar, thermal capacity max. 0.5 MW, gas flow rate ca. 200 m<sup>3</sup>/h
  - High-temperature filter, tar and methane reforming, gas cooling
  - Slip stream or full stream testing of final gas clean-up and synthesis processes
- **Auxiliary equipment**
  - Gas boiler with two-way connection to DH network of Espoo
  - Fuel pretreatment unit, steam generators, compressors, sampling and analytical systems

#### **Pyrolysis Test facilities at Kiviruukki**

- Fast Pyrolysis CFB Pilot Plant (current PDU to be scaled-up and modified)
- Fast Pyrolysis BFB Bench-Scale Unit (current bench-unit to be modified)
- Batch Unit for Slow Pyrolysis
- Pyrolysis Bio-Oil Test Rig

## **USA, Kevin Whitty, University of Utah**

#### **Technology providers**

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

#### **Biomass gasification facilities – update**

- Multiple data sources
  - BCS Inc. commissioned by U.S. Dept. of Energy
  - EIA database
  - GTC/DOE database (Higman)
- Updating continues
  - No new plants identified since last update

Effort to confirm that all plants in the database are properly coded in terms of operating/on hold/stopped/canceled and dismantled

Current map



#### **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, but technical challenges since then.
- Update Sept 2014: “We fully expected to encounter new challenges as we scaled up this exciting new technology. We’ve taken the time to develop solutions that will enable reliable production of high quality bioethanol. The efforts moving forward will continue to focus on safe operations, optimizing the technology, and de-bottlenecking the plant to achieve full production capacity.”

#### **GTI / Haldor Topsoe 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
- Update Nov 2014: Nothing new and notable

#### **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 Nov 2014: New agreement for sugars production

#### **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 Nov 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
- Update Nov 2014: No new news on status of Freedom Pines

## Day 2, Tue, Nov 04

### **Workshop** **Topic: Liquid biofuels** **Meeting Location: KIT, Karlsruhe**

The list of attendees, for the workshop include:

Name	Country	Affiliation	email
<b>Task 33 members</b>			
<b>Kevin Whitty</b>	USA	UoU	kevin.whitty@utah.edu
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## Workshop presentations – overview

MANFRED WÖRGETTER, bioenergy 2020+, Austria

**Introduction IEA Task 39: Commercializing Liquid Biofuels**

THOMAS WURZEL, Air Liquide Global E&C, Germany

**2<sup>nd</sup> generation biofuels – the bioliq technology and economic perspectives**

RIKARD GEBART, Luleå University of Technology, Sweden

**Conversion of forest industry by-products to methanol and DME**

SVEN PETERSEN, Linde Engineering Dresden GmbH, Germany

**Carbo-V – Biomass Gasification Technology**

MALIN HEDENSKOG, Göteborg Energi, Sweden

**GoBioGas Project – Experiences and Operational Progress**

RALF ABRAHAM, NORBERT ULLRICH, UHDE GmbH, Germany

**An update on the BioTfuel Project and other activities of TKIS-PT in the area of biomass gasification**

JOHN BØGILD HANSEN, Haldor Topsøe, Denmark

**Haldor Topsøes biobased sustainable fuel production technologies**

JÖRG SAUER, KIT - Institut fuer Katalyseforschung und -technologie (IKFT), Germany

**Modified MtG-processes for BtL and Pwer-to-Fuels**

THOMAS BÜLTER –EVONIK Industries AG, Deutschland

**Speciality chemicals from syngas fermentation**

PETER PFEIFFER / KIT – Institut für Mikroverfahrenstechnik (IMVT), Germany

**Technology for Fischer-Tropsch synthesis of liquid fuel in small scale**

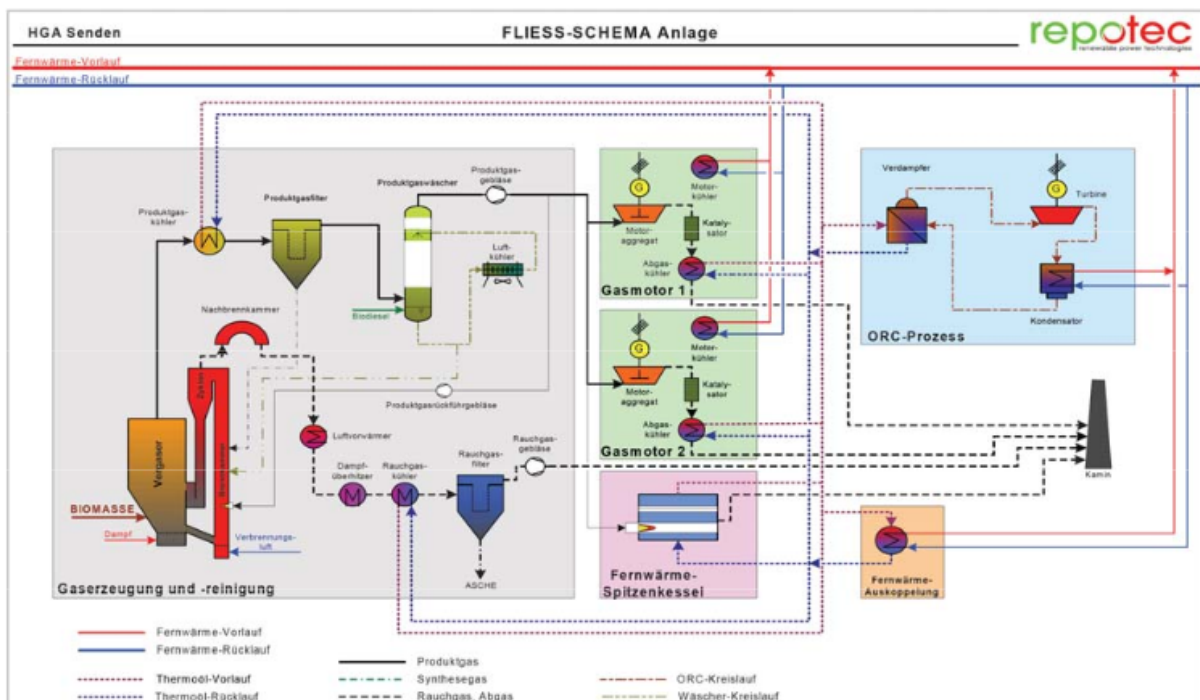
All workshop presentations can be found at the Task 33 website.  
The workshop report will be published as soon as possible.

**Day 3, Wed, Nov 05**

**Site visits: Thermal biomass gasification facility in Senden/Ulm**

In 2006, the order was placed for a concept and erection of a wood gasification plant – as an optimized version of the biomass-plant Güssing.  
An efficiency increase from 25% to 35% (electrically) was managed by integrating a biomass drying unit and an Organic Rankine Cycle module.

The thermal load of the plant is 15.1 MW th (4.55 MW el).



The plant provides power for 21.000 inhabitants of Senden.

**END**