

IEA Bioenergy Agreement: 2013-2015
Task 33: Thermal Gasification of Biomass
Second Semi-annual Task Meeting, 2013
Gothenburg, Sweden
Tue. 19 to Thu. 21 November 2013

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
Erik B. Winther	Denmark	FLSmith	erwin@flsmidth.com
Roger Khalil	Norway	SINTEF	Roger.khalil@sintef.no
Lars Waldheim	Sweden	WAC	Lars.waldheim@waldheim-consulting.se
Bram van der Drift	The Netherlands	ECN	vanderdrift@ecn.nl
Ilkka Hannula	Finland	VTT	Ilkka.hannula@vtt.fi
Martin Rügsegger	Switzerland	Eteca	eteca@gmx.ch
Shusheng Pang	New Zealand	UoC	Shushing.pang@canterbury.ac.nz
Observers			
Morten Drivsholm	Denmark	FLSmith	mdr@flsmidth.com
Krister Ståhl	Sweden	Ducende	Krister.stahl@ducende.se
Claes Breitholtz	Sweden	Metso	Claes.breitholtz@metso.com
Eva-Katrin Lindman	Sweden	Fortum	Eva.katrin.lindman@fortum.com

Regrets for inability to attend were received from: Serhat Gül and Hakan Karatas, TUBITAK, Turkey, Thomas Kolb, KIT, Germany and Antonio Molino, ENEA, Italy.

The Agenda of the Meeting was:

IEA Bioenergy Agreement: 2013 - 2015
Task 33: Thermal Gasification of Biomass
2nd Semi-Annual Task Meeting, 2013
Gothenburg, Sweden
Tuesday, 19 November – Thursday, 21 November 2013

Local Contact:

Lars Waldheim

E-mail: lars.waldheim@waldheim-consulting.se

Phone: +46 70 592 81 69

Day 1: Tuesday, November 19

Meeting Location: Chalmers University of Technology
Chalmers Teknikpark, Sven Hultins Gata 9

09:00 – 17:00 Workshop Day 1. See separate workshop agenda.
17:00-17:30 Visit to the Chalmers 4MW gasifier
19:30 Workshop Dinner courtesy of Göteborg Energi

Day 2: Wednesday, November 20

Meeting Location: Chalmers University of Technology
Chalmers Teknikpark, Sven Hultins Gata 9

08:30 – 12:00 Workshop Day 2. See separate workshop agenda.
12:00 – 13:00 Workshop lunch
13:00 – 17:30 Workshop Tour: Göteborg Energi's GoBiGas project
19:00 Task 33 Dinner. Hotel Panorama.

Day 3: Thursday, November 21

Meeting Location: Chalmers University of Technology
Chalmers Teknikpark, Sven Hultins Gata 9
Room Apollo/Artemis

- 08:30 – 10:15 Task Business Meeting
- Introduction of Acceding Task Chairman, Task Members and Observers
 - Review and Approval of Agenda
 - Review and Approval of Minutes from First Semi-Annual Task Meeting, May 2013, Golden, Colorado
 - Task Budget Update
 - Task Plans for 2014 Meetings 1 and 2
- 10:15 – 10:45 Coffee Break
- 10:45 – 12:30 Special and Collaborative Projects: The following projects are either active, in the Task 33 Triennium Plan or on ExCo's list of collaborative projects. The status and path forward for each will be discussed.
- Gasification Fact Sheet
 - Gasification Facilities Database and Map
 - Biomass Feed Handling and Feeding white paper (2013)
 - Performance Test Protocols white paper (2014)
 - Gasification Lessons Learned report (2015)
 - "Advances in Biomass Characterization" (collaborative with T32, 34)
 - "Gasification of Pyrolysis Oil" (collaborative with T34)
 - "Combustion and Co-Firing" (collaborative with T32)
 - "Techno-Economic Assessment" (collaborative with T32, 34)
 - "Commercialization of Liquid Biofuels" (collaborative with T39)
- 12:30 – 13:30 Lunch
- 13:30 – 15:00 Member Country Summaries: NTL's are being requested to provide maximum 15 minutes executive summaries of the country reports for the triennium and ion particular highlight recent developments in existing or new gasification projects or plants
- 15:00 – 15:15 Coffee Break
- 15:15 – 16:30 Member Country Updates, continued (max 15 minutes each)
- 16:30 – 17:00 Other business, meeting wrap-up and summary of actions
- 17:00 Meeting adjournment

Note: To accommodate travel schedules, no dinner is scheduled for Thursday evening.

Meeting Minutes

Day 1 and 2, Tue - Wed, November 19,20

Joint Workshop between IEA Bioenergy, Task 33, and IEA Industrial Energy-related Technologies and Systems.

Topic: “System and Integration Aspects of Biomass-based Gasification”

The aim of this workshop was to initiate a dialogue across the technology/system interface, as well as on methods and results for technical, economic and environmental evaluations of integrated biomass-based gasification systems. The other aim was to identify topics for further international cooperation in these areas.

Workshop presentations
19. November 2013
A. Gaspar, RAIZ Institute, Portucel Soporcel, Portugal IEA Industrial Energy-related Technologies and Systems. Annex XI
K. Whitty, University of Utah, USA IEA Bioenergy Agreement, Task 33: Thermal gasification of Biomass
H. Wagner, TU of Hamburg-Harburg, Germany Gasification of Urban Biomass Residues - Possibilities in Hamburg / Germany
M. Möller, DONG Energy, Denmark Status of DONG Energy’s Pyroener Gasification Technology for High Alkaline Fuels
C. Breitholz, Metso Power, Sweden Gasification of Biomass and Waste for Production of Power in Lahti and Vaasa
H. Thunman, Chalmers University of Technology, Sweden Beyond 80% Efficiency for Standalone Production of Bio-methane from Wet Biomass
T. Kolb, KIT, Germany Biomass gasification for BtL - The Bioliq Process
I. Landälv, Lulea University of Technology, Sweden Methanol as Energy Carrier and Bunker Fuel
R. Rauch, Vienna University of Technology, Austria Dual Fluidized Bed Gasification for CHP and Production of Advanced Biofuels
B. van der Drift, ECN, the Netherlands

Chemicals from Gasification

I. Hannula, VTT, Finland

Production of Synthetic Methanol and Light Olefins from Lignocellulosic Biomass

20. November 2013

S. Harvey, Chalmers University of Technology, Sweden

Assessing the Performance of Future Integrated Biorefinery Concepts based on Biomass Gasification

E.D.Larson, Princeton University, USA

Techno-Economic Systems Analysis of Jet Fuel and Electricity Co-Production from Biomass and Coal with CO₂ capture: An Ohio River Valley (USA) Case Study

M. Talmadge, NREL, USA

Techno-economic and Market Analysis of Pathways from Syngas to Fuels and Chemicals

A. Faaij, University of Utrecht, the Netherlands

Bio-CCS: Negative Emissions to Meet the Global Carbon Budget

General discussion

B.F. Möller, Eon, Sweden

Bio2G - A Commercial-Scale Gasification to SNG Plant Eon

All the workshop presentation will be summarized in WS report, which will be published at the Task 33 website.

Site visit: GoBiGas site in Gothenburg

The GoBiGas biogas project is about producing biomethane (Bio-SNG) by thermal gasification of forest residues as branches, roots and tops. The biomass is converted to a flammable gas in the gasification plant. This so-called synthesis gas is purified and then upgraded in a methanation plant to biogas with a quality comparable to natural gas to enable the two types of gases to be mixed in the gas network, until the natural gas is phased out. Since biogas is produced from renewable sources this does not contribute to increasing emissions of carbon dioxide as fossil fuels do.

Further information to this project

[http://www.goteborgenergi.se/English/Projects/GoBiGas_Gothenburg_Biomass_Gasification Project](http://www.goteborgenergi.se/English/Projects/GoBiGas_Gothenburg_Biomass_Gasification_Project)

Day 3, Thu November 21
IEA Bioenergy Task 33 meeting

Chairman introduction and approval of Agenda and Minutes

After introduction of new Task 33 chairman, Kevin Whitty and Task 33 members and observers, the actual Agenda and Minutes from the last meeting in Golden, CO, USA were approved. Meeting minutes from Golden meeting in May are already online at the Task 33 website.

New member countries

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.

Also the collaboration with IEA Industrial Energy-related Technologies and Systems was discussed.

Task Budget

In January 2014 the Task 33 budget will be transferred from Austria again in the USA, special account will be arranged. The budget report that is sent to ExCo will be circulated to the task members in the future.

Task Plans for 2014 Meetings 1 and 2

Meeting 1

Target dates for Task 33 meeting are Tues-Thursday, May 13-15

First choice: Italy if Antonio is able to host

- Short update: Antonio confirmed the hosting Task 33 meeting in Italy. Probably in Naples.
- Workshop topic: Small Scale Biomass Gasification for CHP

Second choice: Spain if suitable host can be found; Kevin sent an email to Alberto Barea from University of Seville, who attended the workshop associated with the meeting and who seemed interested in having Spain's involvement in T33.

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 discussed during the spring meeting.

Special and collaboration projects

- Gasification Fact Sheet
 - Bram presented 6 fact sheets on biomass gasification and sent them to Task 33 members to get their feedback
 - The project should be finished at the end of 2013
 - The amount of 7 fact sheets is planned

- Gasification Facilities Database and Map
 - Regularly updated by Jitka
 - Details regarding information from member countries discussed
 - Task members are requested to send Jitka updated information at the end of the year
- Biomass Feeding and Handling – White Paper
 - Was included in Proposal for Prolongation for 2013-15 triennium
 - Rich Bain included this and was a proponent of such a study
 - Kevin will contact Rich for guidance on how to get this task completed
- 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
- Gasification Lessons Learned report (2015)
 - Together with workshop in 2015
- “Advances in Biomass Characterization” (collaborative with T32, 34)
 - Reinhard will contact Ingwald Obernberger from Task 32 to get more information
- “Gasification of Pyrolysis Oil” (collaborative with T34)
 - Thomas Kolb is leading this, so more information in the next Task 33 meeting
- “Combustion and Co-Firing” (collaborative with T32)
 - Task 32 did not recognize this as a particular project
 - Bram will have a fact sheet on Indirect Co-Firing of Biomass, which T32 can also put on their web site
- “Techno-Economic Assessment” (collaborative with T32, 34)
 - Considers comparative assessment of combustion, pyrolysis and gasification
 - 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
- “Commercialization of Liquid Biofuels” (collaborative with T39)
 - Task 39 has a report at the end of the triennium. When that is released, it will be sent to Task 33, which will perform a thorough review of assumptions, data, etc.

Country Updates on Biomass Gasification:

Denmark, Morten Tony Hansen, FORCE Technology

Government targets and agreements were presented. Current feed-in tariff 15 €/kWh
New R&D topics: biogas, liquid biofuels, hydrogen

Babcock & Wilcox – Harbøre Plant (updraft)

- 20 years gasifier operation
 - CHP operation for 12 years
 - 650 kW_e
- Tar challenge turned into flexibility advantage
- Operator very happy
- Need new demo plant
- Home market challenges:
 - Feed in tariff not designed for CHP
 - DH plant managers prefer simple heating plants
- Foreign markets:
 - Promising tariffs but heat of low value

Ammongas – Babcock & Wilcox Vølund

- FIRgas Alternating Gasifier
 - Twin bed filter
 - Aiming at straw
- Technology now under development 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 operation end of 2013

Weiss Viking 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
- Encountered various startup problems - taking half a year
- Continuous operation interrupted by mechanical problems in auxiliary equipment

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
 - Operated for design of full scale
- 50 MW demonstration plant
 - Expected operational in 2015
 - Further details presented at workshop

Andritz/Carbona plant in Skive

- Europe's largest CHP
 - 6 MW_e
 - wood pellet fuelled
 - pressurized CFB
- Co-financed by the US DOE
- Stable operation since 2012:
 - Available 70% of the time due to
 - New filters
 - New catalyst
 - Improved fuel quality + additive
- Liquid fuel generation tested
 - Tigas process from Haldor Topsøe

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

Stirling DK

- Biomass fired Stirling engine, developed for 20 years
- Updraft forest chips gasifier
- >10 plants in operation
- Bankrupt in Spring 2013
- Employees released
- Assets sold to REKA
 - Wood boiler solution
 - Gasifier solutions not promoted
 - No news on new engine design

Steeper Energy – Aalborg University

- Hydrothermal liquefaction
- Biomasses & wastes
- Test facility at the university
- 3 l/h biooil
- Full scale demonstration :
- 48.000 l/d
- Studies on-going
- 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
 - Expected operational in Q2 2013
- Supported from DEA/EUDP
- Strongly profiled plant

Frichs Sublimator Plant

- Pyrolysis/biochar unit
 - Straw fed
- Gasifier concept purchased
- Aims to gasify manure fibre
- Plant installed at farm Havndal
- No gas filtering/cleaning
- Currently not in operation

Other projects/technology tracks

- DALL Energy
 - Idea to proceed with gasification from succesful furnace
- FLSmidth
 - Pilot plant soon in operation at test site
- 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

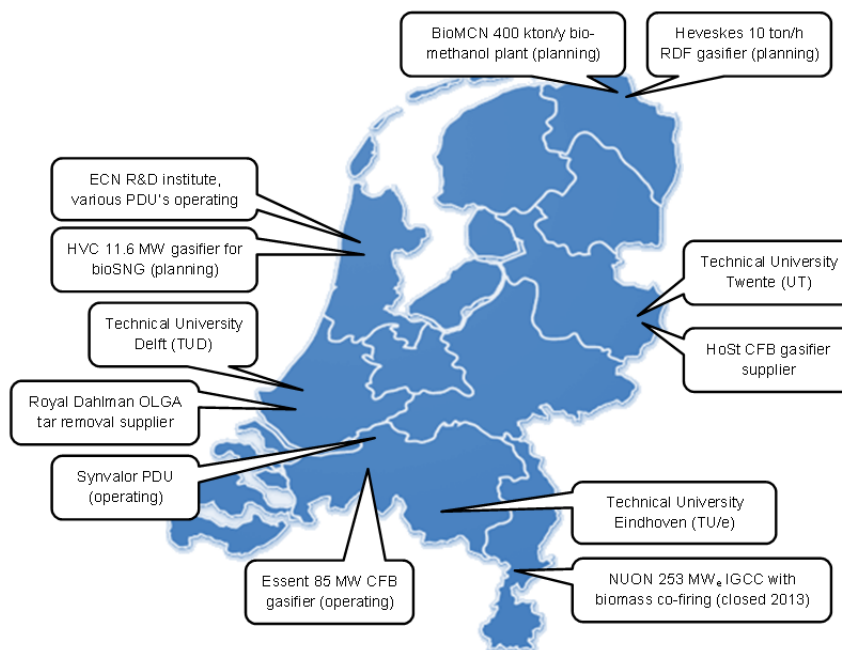
- Universities
 - Biomass Gasification Group at DTU/Risø has merged with DTU Chemical Engineering (CHEC)
 - Aalborg University with HTL
- Advanced Technology Group
 - Danish Technological Institute (DTI)
 - FORCE Technology
- Consultants
 - Danish Gas Technology Centre (DGC)
 - Aaen Consulting Engineers

The Netherlands, Bram van der Drift, ECN

ENERGY AGREEMENT *for sustainable growth (Sept 2013)*

- Agreement between 40 organisations: government, employers, trade unions, NGO's, financial organisations, ...
- The Dutch way: consensus to ensure it happens, but compromises on the ambitions
- Energy efficiency: 100 PJ in 2020
- Renewable energy: 14% in 2020, biomass forms majority part
- Close 5 coal power plants from 80s in 2016/2017
- The other 2 coal plants (90s) and 3 new coal plants (10s) will have co-firing (max 25 PJ) and CCS

Biomass gasification in the NL - overview



What is new in the NL:

- NUON/Vattenfall IGCC 250 MWe closed earlier 2013
- Essent/RWE indirect cofiring 85 MWth CFB gasifier is looking for a post-subsidy new life on waste
- Royal Dahlman acquired the license for MILENA gasification technology (Europe, N-America, and few SE-Asia countries)
- Woodspirit project (BioMCN, Siemens, Andritz) heading for 400 kton/a bioMethanol plant with torrefaction and entrained flow gasification (NER300 grant)
- HoSt preparing 15 MW plant on paper rejects
- Torrgas preparing 10-15 MW gasifier plant on torrefied wood
- Synvalor developing new technology, 50 kW pilot plant
- Heveskes developing green syngas network with waste gasifier

ECN

-different materials gasified at 850°C and gas composition presented

-oxygen transport in MILENA; olivine as bed material is capable of transporting O from combustion to gasifier

-new lab facility from biomass to bioSNG



MILENA gasifier



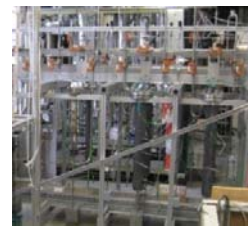
OLGA tar removal



HDS reactor



Further gas cleaning



Methanation reactors

Austria, Reinhard Rauch, VUT

Policy targets, energy consumption and changes in CO₂-equivalents from 1990 to 2011 in Austria were presented.

Austrian research organizations and their activities were introduced:

- Graz University of Technology
- Joanneum Research Graz
- MCI
- Vienna University of Technology
- Bioenergy 2020+; pressurized gasification and SOFC not further in focus
- FJ-BLT Wieselburg

Austrian companies active in biomass gasification:

- Andritz (now also owner of the Austrian part of Austrian Energy & Environment)
- AGT Agency for Green Technology – low temperature conversion=thermo-catalytic decomposition process operating without air supply
- Austrian Enviro Technologies
- Cleanstgas
- GE Jenbacher
- Güssing Renewable Energy (GREG)
- Ortner Anlagenbau – builds FICFB for CHP applications; future involvement in gasification unclear
- Repotec – builds FICFB gasifiers for CHP, SNG and other synthesis
- SynCraft Engineering GmbH
- Urbas – fixed bed gasification
- Xylogas - fixed bed gasification
- 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	Commissioning

Güssing – financial difficulties due to insolvency the plant was on hold between July and October 2013

Oberwart – high purity hydrogen produced; 3 purification stages, purity of 99,95 vol.%; usage in PEM fuel cell

Commercial CHP gasifiers and their current projects presented

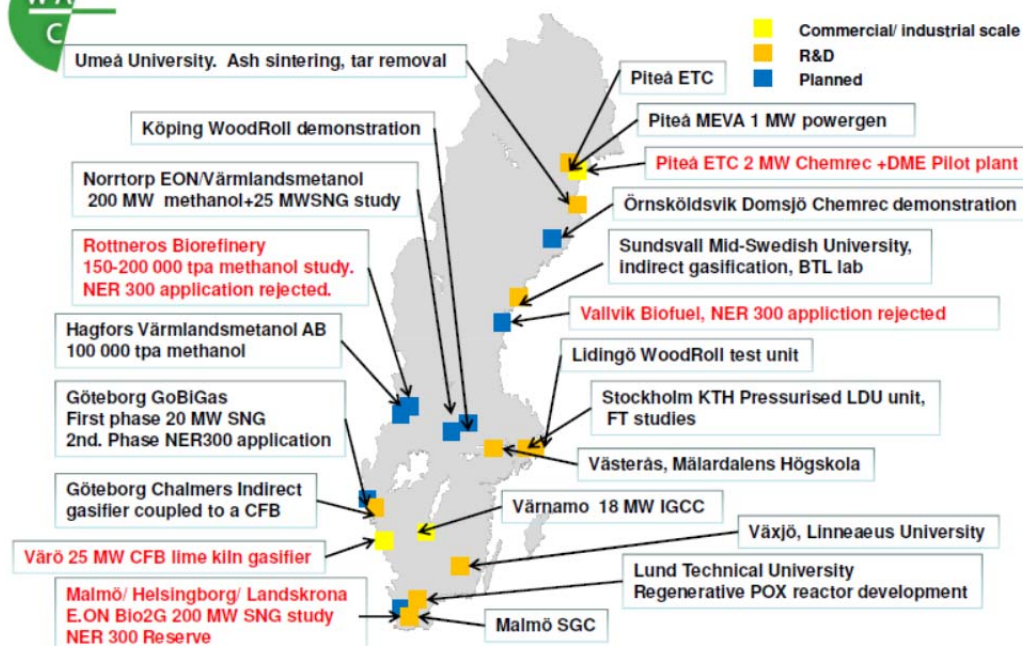
- Urbas
- Cleanstgas
- Syncraft

Sweden, Lars Waldheim, Waldheim Consulting

An overview on biomass gasification in Sweden was given (status 2011).



Biomass Gasification Sweden 2011



The information about energy supply, renewable energy fraction (target 2020 is 50%), fuel prices and taxation, energy and climate bill was presented.

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

- Pyrogrot Billerud- Category: 40 kton/a pyrolysis oil or slurry
- GoBiGas 2 – Category: 40 million Nm³/a SNG
- E.ON Bio2G – Category: 40 million Nm³/a SNG, reserve

National agencies confirmed approved projects

New round of applications in 2013

- E.ON Bio2G – Category: 40 million Nm³/a SNG

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

- Three nodes KTH/MdH/LNU, Chalmers/MiU/GU, LTU/ETC/UmU

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

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

Operation time ~ 8000 h whereof ~ 1300h experimental time with fuel.

KTH School of Chemical Engineering

- Long experience of R&D within gasification. Activities started in 1970's.
- Technologies at KTH
 - 75 kW pressurized (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
 - Online 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: Chemrec black liquor, biomass

VIPP gasifier: biomass, cyclone gasification, WESP, scrubber, engine CHP

PEBG: Pressurised entrained flow gasification, 1 MW, 15 bar

Synthesis gas: zeolithe membrane reactor/MeOH, one stage DME pilot

Black Liquor Gasification Activities

- Development plant for oxygen-blown high pressure BTL gasification (located at the Smurfit Kappa mill in Piteå, Sweden)
- 30bar, oxygen blown
- Capacity 20 metric tons/day of black liquor solids
- Used for technical development and design verification
- Started up 2005, now in operation, more than 12 000 operating hours
- Project end 2012, Staff have been given redundancy notice
- **The Luleå Technical University has bought the plant**
- **Operating staff and some key Chemrec staff hired**
- **LTU Biosyngas program, approx. 250 MSEK, under negotiation for period 2013-2015**

Värnamo – pressurized combined cycle:

- Supplier: Bioflow (Foster-Wheeler, Sydkraft)
- Fuel: 18 MW
- Power: 6 MW
- Heat: 9 MW

- 18 bar
- Typhoon GT
- Mothballed in 2000. > 8000 gasifier and 3600 hours of GT op.
- **Mothballed again since 2011**

GoBiGas

- Biomass to biomethane 65 – 70 %
- Energy efficiency > 90%
- Phase 1:
 - 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 Topsøe
- Phase 2:
 - 80-100MW generating 640-800 GWh/y
 - Technology not yet chosen

Project status –October 2011

- Funding: 222 MSEK granted for phase 1
Project application for phase 2 sent to EIB for funding
- Investment decision – Dec. 2010 by Göteborg Energi
- Gasification – cooperation between Metso Power and Repotec
- Methanation – cooperation with Haldor Topsøe
- Phase in operation – early 2013

Official start up initiated October 28, 2013, plant visited in Fall 2013 meeting.

E.ON

- Bio2G (Biomass to SNG)
 - Fuel input ~345 MW_{th} (including Power Island)
 - Biogas production 202 MW, ~21 000 m³/h
 - Biogas efficiency 60-65% (excl. ASU)
 - Total efficiency up to 80%
 - Power production 14 -23 MW (for internal use)
 - Heat production up to 55 MW (depend on fuel moist)
 - Total investment: ~450 MEUR
 - Possible production grant from EU (NER300) 2016-2020 (decision expected end of 2012).
 - Three good sites identified for E.ON Bio2G localisation (Malmö, Landskrona and Helsingborg)
 - Partnering opportunities with local utilities, fuel suppliers, pulp & paper industry and equipment suppliers for reference plant

MEVA

Test unit, 500kW thermal with 100 kW gas engine in operation at ETC, Piteå. A first commercial unit, 1.2 MWe is under commissioning at Hortlax, Piteå.

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

Cortus Wood Roll

Following 500 KW tests, the planned 5 MW unit has been postponed for economical reasons (low price of coal and emission rights)

Switzerland, Martin Rügsegger, ETECA GmbH

Policy in Switzerland is made by Swiss Federal Office of Energy (SFOE), high efficiency, increasing renewable energy.

Energy consumption in Switzerland was presented.

CO₂ Act (Kyoto)

- Emissions reduction of 10% by 2010 (not fulfilled)

Approved action plans by Swiss Federal Council 2008 // 2011

- 50% renewable energy to overall energy consumption
- reduce the consumption of fossil fuels by 20 per cent by 2020
- 2010 -2020 max 5% increase of electricity consumption
- After 2020 stabilise electricity consumption

Vision

- The 2000 Watt society is a long-term vision of sustainable per capita energy consumption

Federal council decision to leave nuclear power production 25.5.2011

- Federal office of Energy new Energy strategy 2050 (substitution with “other renewables”)

Policy & Programs:

- Energy efficiency improvement
- Renewable Production increase 2050
- Resting Demand to cover by fossil fuel for electricity, imports
- Energy mix foreseen to 2050
 - + Investment in efficiency
 - - Savings in energy costs/ imports
 - + Investments Costs of production
 - + Grid enforcement

Energy strategy 2050 – overview action plan 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

- EKZ (supplier for turnkey biomass gasification plants) – **out of gasification**
- XyloPower AG (supplier for turnkey biomass gasification plants)
- BR Engineering GmbH CH-6006 Luzern www.br-engineering.ch
Engineering and commissioning of thermal Gasification plants and gasification components (involved with Holzstrom Stans)
- Öhlmühle Möriken – represents in Switzerland and south Germany Burkhardt turnkey biomass gasification plants
- CTU Supplier for turnkey biomass gasifier plants <http://www.ctu.ch/de/home.html>
- Foster Wheeler
 - 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

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

BESTF funds will be used to support pre commercial bioenergy P+D plan that fit into the EIBI value chains:

- Synthetic liquid fuels and/or hydrocarbons and blending components via gasification
- Bio-methane and other synthetic gaseous fuels from biomass via gasification
- High-efficiency heat and power generation via gasification of biomass
- Bioenergy carriers via other thermochemical processes (e.g. pyrolysis, torrefaction)
- Ethanol and higher alcohols from ligno-cellulosic feedstock via fermentation
- Renewable hydrocarbons through biological and/or chemical synthesis from biomass containing carbohydrates
- Bioenergy carriers from CO₂ and sunlight through microorganism-based production and upgrading into fuels and valuable bio-products

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

Facts today:

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

Facts of the past 5 years:

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

Politics: Visions clearly for renewable energy and promoting of renewable energy but....

- 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

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

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

AVINOR project – BioJet production

- Feasibility study initiated by Avinor, SAS, Norwegian and NHO Luftfart fall 2011
- Study the potential for "Sustainable and commercially profitable production of sustainable bio jetfuel in Norway"
- Results from the project were published April 2013
- Research question: What is the cost of one liter of sustainable bio jetfuel in Norway in 2020 and 2025?
 - What is the effect on carbon emissions (in the whole value chain)?

Results of the technology assessment

- SINTEF Energy Research has carried out a technology assessment for bio jetfuel production
- Only 3 technologies were considered in details, only two technologies considered suitable for Norway
 - Gasification → Fischer-tropsch:
 - Price: 11 NOK/L (2012), 7 NOK/L (2025), 5 NOK/L (price for by-products, included)
 - GHG reduction: 81%
 - Bio alcohols to jet
 - Price: 27 NOK/L (huge – 50% - uncertainty, no information obtained about by-products)
 - GHG reduction: 65%

The report concludes that **it is possible to produce sustainable and cost efficient bio Jet-A1 in Norway by 2025.**

Synthetic Fischer – Tropsch (FT) fuels

- Fuel derived from wood energy crops, agricultural and forestry residues, algal biomass, waste
- Large feedstock flexibility → gasification process → similar syngas quality
- Certified since 2009 by ASTM to be blended with conventional Jet A-1 up to 50%

SUMMARY

- Until now, there are only **small scale waste/biomass-to-heat gasification** plants in Norway
- Norway has good competence and strong position within petrochemistry
- Medium/large scale **biomass gasification to BioJet** is a new opportunity for Norway
- **SINTEF Energy Research** has relevant **competence and tools** to help pave the way for **biojetfuel**
- A solid, **tight dialogue** with the most central national industrial partners has been established, as well as the **coordination of the research** effort

Finland, Ilkka Hannula, VTT:

Biomass and waste gasification for boilers and kilns (Andritz/Carbona, Metso) and for fuels and chemicals (NSE Biofuels, Andritz/Carbona) was presented.

UPM to build the world's first biorefinery producing wood-based biodiesel

- UPM is to invest in a biorefinery producing biofuels from crude tall oil in Lappeenranta, Finland
- The biorefinery will produce annually approx.. 100,000 tonnes of advanced second generation biodiesel for transport
- Construction should be completed in 2014
- Total investment about 150 million EUR

CHP applications

-Volter 30

- Output generator 30 kW, thermal 80 kW

Updated Techno-economic assessment

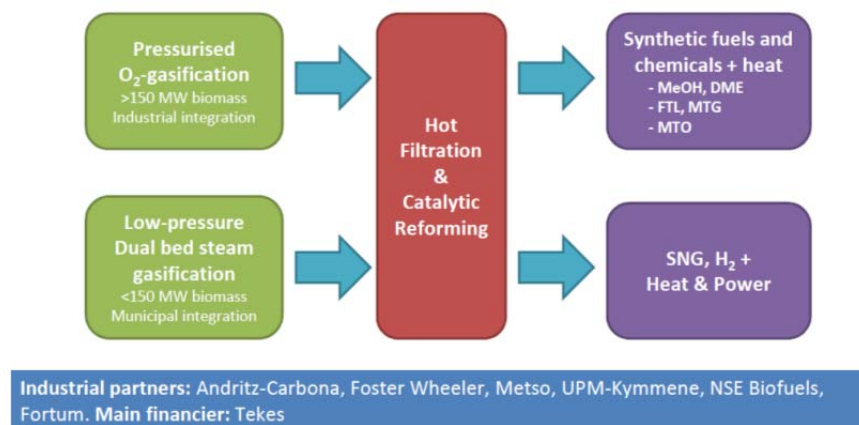
- Detailed evaluation of 20 individual plant designs
- MeOH, DME, FTL and MTG
- Based on technically proven process
- Estimated impact of further R&D to the overall economics
- Large scale: 300 MWth of biomass
- Nth plant economics
- Available for download
- <http://bit.ly/192V13G>

Reforming of tars and light hydrocarbon gases

- VTT's reformer is based on staged reforming without soot formation
- Different catalysts from alternative suppliers can be used
- Complete tar and C₂-hydrocarbon conversion
- CH₄ conversion depends on temperature, catalyst type and reactor volume

2G-Biofuels 2020 Project

- Budget 7,2 M€ in 2012-14, second piloting phase in 2015-17; gasification task 4,2 M€



Biomass-to-Syngas R&D at VTT

- 2G 2020 Biofuels 2012-14
- Production of SNG of H₂ from biomass 2011 – 14
- Nordsyngas 2010-14
- Gasification reactivity 2011-14

2G Biofuels and RES-Infra of VTT

- VTT will move and reconstruct its pyrolysis and gasification test facilities to a new industrial site at Espoo
 - o Main test facilities:
 - Flash pyrolysis pilot plant and bench-scale pyrolysis facilities
 - Dual fluidized-bed steam gasification pilot plant
 - High-pressure O₂-blown/air-blown gasification PDU plant
 - Atmospheric-pressure CFB gasification pilot plant for waste fuels
 - Bench-scale gasification and gas cleaning equipment
 - Synthesis testing in slip streams and with simulated gases

USA, Kevin Whitty, University of Utah

Projection thought 2040 for domestic natural gas production and liquids consumption by light duty vehicles, energy-related CO₂ emissions, renewable electricity generation by type and primary energy consumption by fuel were presented.

Biofuel production projection notes

“While total liquid fuels consumption falls, consumption of domestically produced biofuels increases significantly, from 1.3 quadrillion Btu in 2011 to 2.1 quadrillion Btu in 2040, and its share of total U.S. liquid fuels consumption grows from 3.5 percent in 2011 to 5.8 percent in 2040. The increases are much smaller than those in *AEO2012*, however, as a result of diminished FFV* penetration, a smaller motor gasoline pool for blending ethanol, and reduced production of cellulosic biofuels, which to date has been well under the targets set by the EISA.[†] (EPA issued waivers that substantially reduced the cellulosic biofuels obligation under the RFS for 2010, 2011, and 2012.) In addition, the production tax credit for cellulosic biofuels is scheduled to expire at the end of 2012.”

* Flex-fuel vehicle

† Energy Independence and Security Act of 2007

U.S. integrated biorefinery projects



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

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

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

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

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
- Still sorting out configuration of plant
- Gasification technology has not yet been chosen

Conclusions

- Limited activity in biomass gasification in the United States
- Only a handful of smallish plants
- Most target biofuel production
- Minimum power generation
- Enormous availability of inexpensive shale gas reduces interest in biomass-based energy
- Possible upcoming CO₂ legislation could provide a driver for more biomass energy

New Zealand, Shusheng Pang, University of Canterbury

NZ total primary energy supply, characteristics of renewable energy, NZ energy strategy 2011-21, climate change response and NZ bioenergy strategy 2010 were presented.

Commercial biomass gasification

- **Fluidyne gasification:** active overseas with its downdraft gasifiers (100 kWe – 2 MWe)
 - 100kWe Andes Class development programme in California, to replace LPG to heat the CalForests Forestry Tree Nursery
 - Gasifiers with larger gas outputs of 250-500 kWe are to be built 2013-15
 - One example is the gasifier in West Biofuels, Woodland, California (shown here)
 - The technology is currently licensed for sale in Australia through Flow Force Technologies

Demonstration of biomass gasification

- **Windsor Engineering**
 - Windsor™ is a manufacturer of wood processing equipment, mainly timber drying kilns.
 - A 1.5MW Agder Biocom (Norway) gasifier is in operation in Rotorua, NZ, through a joint venture of Waiariki Institute of Technology (WIT) and EECA. It will be used as:
 - A training facility for wood processing students at the WIT.
 - R&D test facility.
 - To replace natural gas for existing boiler to generate steam for two Windsor timber drying kilns.

Gasifier

- Updraft type
 - Thermal output: 1.17 MW with 78% energy efficiency
 - Fuel: wood processing residues (sawdust, barks, chips, shaving) with MC of up to 35%.
 - Particulate emissions: less than 50mg/Nm³.
- **Others**
 - Norske Skog and Z energy (Shell NZ) are doing feasibility studies on bioliquid fuels from wood. Norske Skog closed down one pulp mill in New Zealand and plans to invest on new products.
 - LanzaTech is a New Zealand based company who invested heavily in China and US, on fermentation of H₂ and CO₂ or H₂ and CO to ethanol. Initially they developed technology for steel plants or coal power stations to convert CO₂ to ethanol. Now they apply the technology in biomass gasification syngas (USA).

R&D on Biomass Gasification

- **CRL Energy**
 - 200 kW bubbling fluidized bed gasifier with gas cleaning system on gasification of coal and biomass for hydrogen production
 - Currently collaboration with UC research team on co-gasification of biomass and coal
- **University of Canterbury**
 - Government funded program from 2008 to 2014
 - A 100kW_{in} (20kg/hr dry biomass) DFB gasifier
 - Optimisation of the DFB gasifier operation conditions
 - Co-gasification of pine wood and lignite
 - Development of gas cleaning technologies

- Feasibility analysis of technology, economic and sustainability
- Hot catalytic reactor to clean NH₃ and H₂S (results presented)
 - Bubbling fluidized bed (fixed bed)
 - The reactor has double functions
 - Cracker to crack NH₃
 - Adsorber to adsorb H₂S
 - Catalytic bed materials
 - Silica
 - Calcined iron sand
 - Other catalysts.
 - Bed inventory – 250g (initial bed height ~ 85-90mm)
 - Gas residence time
 - Bed – 0.4-0.5 s
 - Freeboard – 2.5-3.8 s
- Other work at UC
 - Development of entrained flow gasifier.
 - Micro-channel FT synthesis.
 - Pyrolysis of biomass and oil upgrading.
 - Mathematical modelling of the gasification, co-gasification in DFB gasifier.
 - System modelling for sustainability analysis and feasibility studies.

END