

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

**Ponferrada, Spain**  
**Mon. 11 to Wed. 13 May 2015**

**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
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Mark Eberhard	Germany	KIT	Mark.eberhard@kit.edu
Ilkka Hannula	Finland	VTT	Ilkka.hannula@vtt.fi
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<b>Observers</b>			
Alberto Gómez-Barea	Spain	University of Seville	agomezbarea@etsi.us.es
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Bo Leckner	Sweden	Chalmers University	ble@chalmers.se
Juhani Isaksson	Finland	Valmet	Juhani.Isaksson@valmet.com

**Regrets for inability to attend** were received from: Antonio Molino, ENEA, Italy, Erik Winther and Morten Tony Hansen, Force, Denmark.

The Agenda of the Meeting was as following.

**IEA Bioenergy Agreement: 2013---2015**  
**Task 33: Thermal Gasification of Biomass**  
**1<sup>st</sup> Semi---Annual Task Meeting, 2015**  
**CIUDEN, Ponferrada, Spain**  
**Monday, May 11<sup>th</sup> to Wednesday, May 13<sup>th</sup>, 2015**

**Local Coordinator Contacts:**

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**Day 1 – Monday, May 11<sup>th</sup>: Task Business Meeting**

**Meeting location:** CIUDEN Facilities

Bus transport: Departure at hotel 11:30 am

*Agenda on next page.*

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**Day 2 – Tuesday, May 12<sup>th</sup>: Workshop and museum visit**

**Workshop “Symposium on Renewable Energy and Products from Biomass and Waste”**

**Location:** CIUDEN Facilities

Bus transport: Departure at hotel 09:00 am

*See separate schedule for details.*

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**Day 3 – Wednesday, May 13<sup>th</sup>: Workshop and visit to CIUDEN facilities**

**Workshop “Symposium on Renewable Energy and Products from Biomass and Waste”**

**Location:** CIUDEN Facilities

Bus transport: Departure at hotel 09:00 am

*See separate schedule for details.*

## Day 1, Mon 11

### **Task business meeting**

**Location: CIUDEN**

- 13:00 Welcome: Kevin and Alberto  
Introductions of Task Members and Observers (All)
- 13:15 Overview of bioenergy and biomass gasification in Spain  
(Alberto)
- 13:30 IEA Bioenergy Conference 2015 – Task 33 Session (Kevin)
- 13:45 2016---18TrienniumProposal
- Overview (Kevin)
  - Special Projects for 2016---18 triennium
    - Gasification of waste (Lars)
    - Hydrogen generation and use
    - Super---and sub---critical gasification of wet biomass o Tar sampling and analysis via SPA method (Kevin) o Gasification of bio---derived liquids
- 14:30 Updates on special projects for 2013---15 triennium
- Gasification facilities database and map (Jitka)
  - Performance Test Protocol White Paper (Martin)
  - Gasification of pyrolysis oil (Kevin, Mark)
  - Techno---economic assessment with T32, T34 (Bram)
- 15:00 Break
- 15:15 Country reports
- Austria
  - Finland
  - Germany
  - The Netherlands
  - Norway
  - Sweden
  - Switzerland
  - United States
- 17:15 Wrap---up and meeting closure

## Discussion on actual and future projects

### Next Task Meeting:

Next Task meeting will be held during the IEA Bioenergy conference on 27.-29. October 2015 in Berlin. Task business meeting is scheduled to Thursday 29.10. afternoon.

### Next workshop topics suggestions:

- Analytics (e.g. Tar analysis, Online measuring methods, Industrial applications and research, etc.)
- Synthesis gas applications

### Potential new participating countries:

- UK
- Canada
- France
- New Zealand
- Japan
- Brazil
- Spain

### Actual projects

- **Gasification Facilities Database and Map**
  - Regularly updated by Jitka
- **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
  - **Jitka needs updates from all countries regarding status of gasifiers**
  - Complete 2015
- **Performance Test Protocols white paper (2014)**
  - Acceptance test paper was published in 2000 and is available on the Task 33 web site
  - Martin leads the project
  - Focus on small scale gasifiers
  - Complete End 2015
- **Gasification of Pyrolysis Oil (collaborative with T34)**
  - Joint with Task 34 (pyrolysis of biomass)
  - Scope will be included in next triennium proposal on gasification of bio-derived liquids
  - Project to be completed

- **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
  - Bram leads the project
  
- **Gasification Lessons Learned report (2015)**
  - Project included in 2016-18 triennium

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

- Possible special projects (subtasks)
  - Possibly: Gasification-based RES hybrids
  - Others?
  
- **Waste gasification**
  - In cooperation with T 36
  - Lars leads the project
  - Scope:
    - Definition of wastes
    - Market setting
    - Regulatory aspects
    - Gasification and gas cleaning technologies
    - State-of-the-art, example project
  
- **Protocol for tar sampling and analysis using SPA method** – Kevin Whitty leads
- **Super- and sub-critical gasification of wet biomass** – leader needed
- **Hydrogen production from biomass and its use** – Reinhard leads
- **Gasification of bio-derived liquids** – leader needed

Possibly: **Report on potential of gasification to contribute to BECCS** (with Task 38)

## Country Updates on Biomass Gasification

### Spain, Alberto Gomez Barea, University of Seville

#### Bioenergy Group of the University of Seville (BEGUS)

- Chemical and Environmental Department, University of Seville
    - Working on fuel conversion and gas cleaning from 1986
    - Biomass gasification in FB (from 2000)
    - Biorefineries (from 2004)
  - Main developments:
    - Synthesis of ethanol and higher alcohols by thermochemical route
    - FB gasification technology for biomass and waste
    - FB oxygasification (and oxycombustion)
- 12-years' experience
- Focused on:
    - Understanding the process
      - Lab studies to measure fuel conversion behavior
      - Modeling of the process: mechanisms, particle conversion and reactor simulation (own codes for simulation, CFD, Aspen)
    - Scaling and demonstration
      - Pilot plant
      - Demonstration plants

**Balance of the activity:** 2 M €, 2 lab FB (kW), 3 pilot plants (dozens of kW), collaboration in 3 demonstration (MW) plants, more than 50 international publications

#### Developments achieved

- **Air gasification in FBG:**
  - ready for thermal applications
  - tar removal system has been developed
  - first demonstration in 3 MW<sub>th</sub> plant in Seville for thermal applications
  - New development: for electricity from difficult wastes in developing stage (pilot)
  - MSW gasification in fluidized and three stage gasifier
- **Oxyconversion in FB**
  - **H<sub>2</sub>O/O<sub>2</sub> gasification in FBG:** a 2 MW<sub>th</sub> demonstration plant has been constructed by INERCO-US in CENER (Navarra, Spain)
  - **CO<sub>2</sub>/O<sub>2</sub> gasification in FBG** is an interesting option to consider: a 3 MW<sub>th</sub> demonstration plant has been constructed by INERCO-US in CIUDEN (León, Spain)

#### Gasification activities in Spain

- Research/pilot activities:
  - University of Seville, Zaragoza, Madrid, CIEMAT, etc....
- Pilot/demo activities
  - Inerco (three demo-scale gasifiers, a few MW<sub>th</sub>, CIUDEN, CENER, Seville)
  - Eqtec (Ciudad real various MWe, starting up in Bulgaria, various projects in Europe)
  - GreenE Waste to Energy S.L. (pilot)

- TaimWeser (pilot)
- Cynar (plastic pyrolysis, Various plants)
- Gasbi (pilot)

– Commercial plants

**Movialsa** (Campos de Cristana, 2 x 3 Mwe, Ciudad real)

<b>Reactor</b>	Bubbling Fludised Bed
<b>Thermal power</b>	3 x 2 MWe
<b>Application</b>	Electricity production
<b>Gasifying agent</b>	Air
<b>Operation Pressure / Temperature</b>	0,3 barg / 800°C
<b>Start up date</b>	2007-....
<b>Biomass</b>	Grape residues
<b>Location</b>	Campos de Criptana (Ciudad Real)

**IDERMA** Power Plant (2 Mwe)

<b>Reactor</b>	Bubbling Fludised Bed (technology original from CENER. Revamped by Inerco)
<b>Thermal power</b>	7,4 MWth (2 MWe)
<b>Application</b>	Electricity production
<b>Gasifying agent</b>	Air
<b>Operation Pressure / Temperature</b>	0,3 barg / 800°C
<b>Biomass load</b>	45 t/day
<b>Start up date</b>	2012
<b>Biomass</b>	Wood chips

<b>Location</b>	Ejea de los Caballeros (Zaragoza)
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### **Necer , (1.6 Mwe Xativa)**

<b>Reactor</b>	Bubbling Fluidised Bed
<b>Thermal power</b>	1,6 MWe
<b>Application</b>	Electricity production
<b>Gasifying agent</b>	Air
<b>Operation Pressure / Temperature</b>	0,3 barg / 800°C
<b>Start up date</b>	2010 ??
<b>Biomass</b>	?
<b>Location</b>	Xativa, Valencia

### **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

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 / H <sub>2</sub>	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
Senden/Ulm, DE	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, RevoGas	Operational
Göteborg, Sweden	BioSNG	32 <sub>fuel</sub> / 20 <sub>BioSNG</sub>	2013	Repotec/ Valmet	Operational
California	R&D	1 MW <sub>fuel</sub>	2013	GREG	Operational
Gaya, France	BioSNG R&D	0,5 MW <sub>fuel</sub>	2016	Repotec	Under construction
Thailand	Gas engine	4 <sub>fuel</sub> / 1 <sub>el</sub>	2016	GREG	Under construction

### Projects of bioenergy 2020+:

- SNG
- Liquid biofuels (FT fuels)
- Mixed alcohols
- Hydrogen production from biomass

### Commercial CHP gasifiers

- Companies active in Austria

Company	Output kW el/th	Technology
Cristof Group REP	13/31 20/45	Fixed bed

Spanner RE <sup>2</sup>	20/48 30/73 45/108	Fixed bed
Syncraft	180/270 280/550	Staged gasification
Urbas	150/300 280/550	Fixed bed
Xylogas	50/105 220/410 440/870	Fixed bed
Holzenergie Wegscheid	125/230	Fixed bed
Fröling	50/107	Fixed bed
Burkhard	180/240	Fixed bed

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, Mark Eberhard, KIT

### Carbo-V process

February 2012	Linde Engineering Dresden GmbH acquires Carbo-V® IP
January 2013	Linde has elaborated numerous technical corrections of Carbo-V process design Linde and Forest BtL (Finland) sign agreement to apply Carbo-V process to provide Syngas for downstream Biodiesel and Naphta   Kemi, Finland
February 2014	ForestBtL / VAPO / NER300 canceled the project

### The B-XTL BioTfuel-Project

- 8 years partnership to realize a RD&D programme to develop a complete B-XTL process chain
- Total Project Budget 180 M€ / Commissioning January 2017

#### BioTfuel demo plants:

- Two multiple scale demo plants will be located in France
- to get scale-up data
- to validate various scheme/configurations

#### PRENFLO PDQ Integration in the BioTfuel process chain:

- Single-line capacity up to 1,200 MW<sub>th</sub>
- Dry powder feed (coal/biomass)
- Horizontal co-annular burners
- Long-life steam cooled reactor screen
- Direct water quench
- Compact gasification system

### SWU Stadtwerke Ulm CHP Demo Plant

- Plant Constructor AGO and SWU settlement out-of-court
- Retrofit an additional gas cleaning to reduce nitrogen oxides in flue gas
- Commissioning in Mai 2014
- Plant is in operation still not full electrical power generation

- In 2014 average 300 h/month in operation
- In 2015 average 500 h/month in operation
- Plant design is 600 h/month
- Up date May 2015





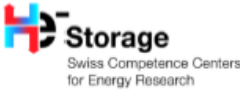

#### bioliq®-Project

- Successful integration of „hot gas cleaning“ and verification of specified clean gas values in ppb
- Hot commissioning of the process chain gasifier / hot gas cleaning /synthesis
- 9 h stable process chain operation with model fuel (Monoethylenglycol + 20% Straw coke from bioliq I)
- 9 h &12 h stable process chain operation with Wood oil
- ca. 124 h gasifier operation with slurry
- ca. 85 t slurry converted into syngas
- Production of > 200 l raw petrol
- 100h champaigne for the process chain in autumn 2015

### Switzerland, Martin Rügsegger, ETECA GmbH

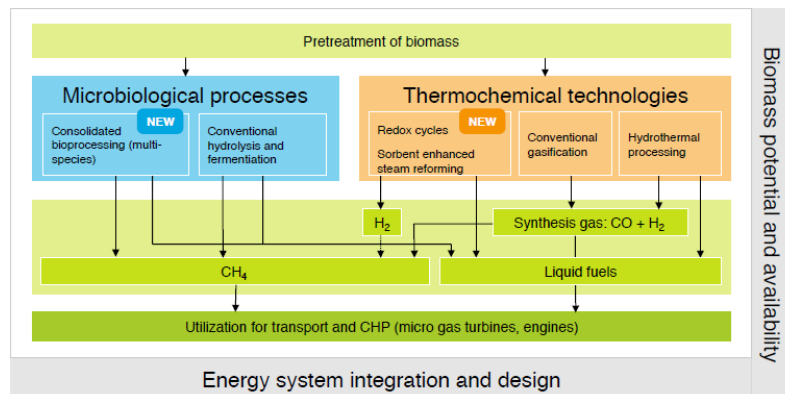
General Swiss energy consumption, policy and programs as well as energy strategy were presented. Federal council decision 25.5.2011 **to go out of nuclear power production**  
Federal office of Energy presents new **Energy strategy 2050**

## SCCER Action Areas

<p>Efficiency</p> <p>SCCER FEED&amp;D Future Energy Efficient Buildings &amp; Districts</p>	<p>Power supply (supply of electrical energy)</p> <p>SCCER SoE Supply of electricity</p> 
<p>Efficiency</p> <p>SCCER EIP Efficiency of Industrial Processes</p>	<p>Economy, environment, law, behavior</p> <p>SCCER CREST Competence Center for Research in Energy, Society and Transition</p> 
<p>Grids and their components, energy systems</p> <p>SCCER FURIES Future Swiss Electrical Infrastructure</p> 	<p>Efficient concepts, processes, components in mobility</p> <p>SCCER Mobility Efficient Technologies and Systems for Mobility</p> 
<p>Storage</p> <p>SCCER HaE Heat &amp; Electricity Storage</p> 	<p>Biomass</p> <p>SCCER BIOSWEET Biomass for Swiss Energy Future</p> 

#### 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 Center Energy and Mobility (PSI)**

- 3 Projects related to "Thermal Gasification of Biomass".
- ARRMAT (Attrition Resistant Reactive Bed Materials in Fluidised Beds)
- WOODGAS-SOFC II
- SYNGAS Diagnosis
- [http://www.ccem.ch/MediaBoard/CCEM\\_Annual\\_Activity\\_Report\\_2013.pdf](http://www.ccem.ch/MediaBoard/CCEM_Annual_Activity_Report_2013.pdf)

## 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**
  - Foster Wheeler AG in Baar Switzerland

- Foster Wheeler Engineering AG Basel

### CHP facilities actual status

	<b>Aerni in Pratteln</b>	<b>Holzstrom in Stans</b>	<b>A. Steiner + Cie. AG</b>	<b>J. Bucher AG Escholzmatt</b>
<b>Gasifier</b>	Wegscheid	8 Pyroforce	Spanner	Wegscheid
<b>Type</b>	downdraft	2-zone downdraft	downdraft	downdraft
<b>Gas engine</b>	1 x 130 kW Adapt. MAN	2 x 690 kW Jennbacher	45 kW el	140 kW
<b>Waste heat therm</b>	230 kW for district heating	1,2 MW for district heating	district heating	district heating drying wood chips
<b>extra Boiler</b>	2MW wood chip district heating	1,6 MW W'chips + 1,7 MW oil for district heating	yes	Yes
<b>Commissioning</b>	2009 first 2013 second	2007	2012/2013	1.4.2015 completed
<b>Remarks</b>	<b>CLOSED DOWN 2015</b>	<b>24h_7d p week operation</b>	<b>24h_7d p week operation</b>	<b>24h_7d p week operation</b>

	<b>Aerni in Pratteln</b>	<b>Holzstrom in Stans</b>	<b>A. Steiner + Cie. AG</b>	<b>J. Bucher AG Escholzmatt</b>
<b>Fuel</b>	Dry clean wood chips	Dry demolition wood/scrap wood chips	Dry waste wood chips	Dry waste wood chips
<b>Moisture</b>	8%	10%	Max 15%	

<b>Operating hours last 5 months</b>	Not declared	Block 1: 2747 Block 2: 3810	3819 h	600 h
<b>Declared revision / modification</b>	Gasifier	-	-	-
<b>Total live time operation h</b>	Since April 2013 1000h	BHKW 1: 35 197 BHKW 2: 43 348	11 342 h	600
<b>Remarks</b>	<b>CLOSED DOWN 2015</b>	<b>Plant in normal operation</b>	<b>Plant in normal operation</b>	<b>Plant in normal operation</b>

### CHP project news

- 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/Gansel)
- Several small scale gasifier CHP offered, decisions pending

### Summary

3 Plant in stable operation (Escholzmatt, Stans and Ettiswil)  
1 Plant closed down January 2015, equipment for sale (Aerni, Pratteln)  
1 Plant under construction (Köniz),  
1 Plant building permission requested (Riggisberg Balsiger (Xylogas))

Several small in discussion (Spanner, Burkhardt.....)

Facts of the past 6 years:

3 Plant closed down (Wila, Spiez, Pratteln)  
4 Projects abandoned (Empa, E Hup Baden, Brickfactory, PSI)  
2 Main Gasifier supplier 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 problems (earthquakes) caused by natural gas mining were presented.

More than 120 earthquakes was detected in 2013 in NL. The most of them with 3,5 degree and higher of Richter scale.

Power production in NL is based on gas (48%), coal (28%) and renewables (11%), that is why Netherlands are farthest off from Renewable Energy target.

Power price drops in NL

- 2013: 52 €/MWh
- 2014: 41 €/MWh

– Reasons:

- more interconnections and cheap power from Germany and Norway,
- additional production capacity (3 new coal power plants)

### Green gas subsidies

- Up to 0.118 €/kWh (1.16 €/m<sup>3</sup>) in 2015
- Results in initiatives:
  - 4 MW (input) demo plant in Alkmaar or Delfzijl by Gasunie, Dahlman, ECN
  - 14 MW (input), 4 plants in Zutphen and other locations
  - 25 MW (input) in Delfzijl by Torrgas, gas for industry

### ECN bioSNG developments

- MILENA gasifier
- OLGA tar removal
- HDS reactor
- Further gas cleaning
- Methanation reactors
- 70% energy efficiency from wood to bioSNG

Base case bioSNG process

- *Gasifier:* Fluidized Bed Gasifier operating at temperature below 1000°C
- *HDS:* HydroDeSulphurization (converting organic S molecules into H<sub>2</sub>S)
- *BTX:* Benzene, Toluene, Xylene (~90%/9%/1% in case of fluidized bed gasification at ~800°C)

Further ahead: BTX harvest

- First step after OLGA tar removal



- Liquid BTX product: first liter in 2014
- >95% separation
- BTX = 90/9/1
- Simplifies downstream process to green gas
- Improves the business case for green gas

## Sweden, Lars Waldheim, Waldheim Consulting

An overview on biomass gasification in Sweden was given, as well as policy and Swedish energy targets.

- A labour-green minority government supported by a leftist party took over governing power from liberal-conservative 4-party coalition in October 2014 following a regular general election.
- Decision on any replacement of nuclear power plants is postponed beyond the mandate period of four years.
- The new government has formed a "broad" parliamentary energy commission with main focus on electrical power, to report in late 2017.
- Transport biofuels tax exemption retained to 2017, due to discussion on state aid with the EC.
- On-going negotiations with Norway to raise the common Green Certificate quota to 30 TWH for 2020.

### Nuclear power in Sweden – history

- Planning and investment decisions on reactors were taken in the 1960's
- Referendum to phase out reactors by 2010 in 1981
- The reactor development law (SFS1984:3) was put in force prohibiting building of nuclear power plants and the development of novel reactor technologies
- The reactor program of 12 plants fully attained in 1985
- The two reactors at basebäck were close 1999 and 2005
- The reactor development law (SFS1984:3) was revoked in 2012
- Up to 10 new replacement reactors can be accepted on present sites??????
- However, the new government has stopped planning by Vattenfall by an owner's directive in late 2014

However, Vattenfall in April 2015 announced the premature stop of two reactors in 2018 and 2020 for "commercial reasons"

### Renewable transportation fuels

#### Present situation

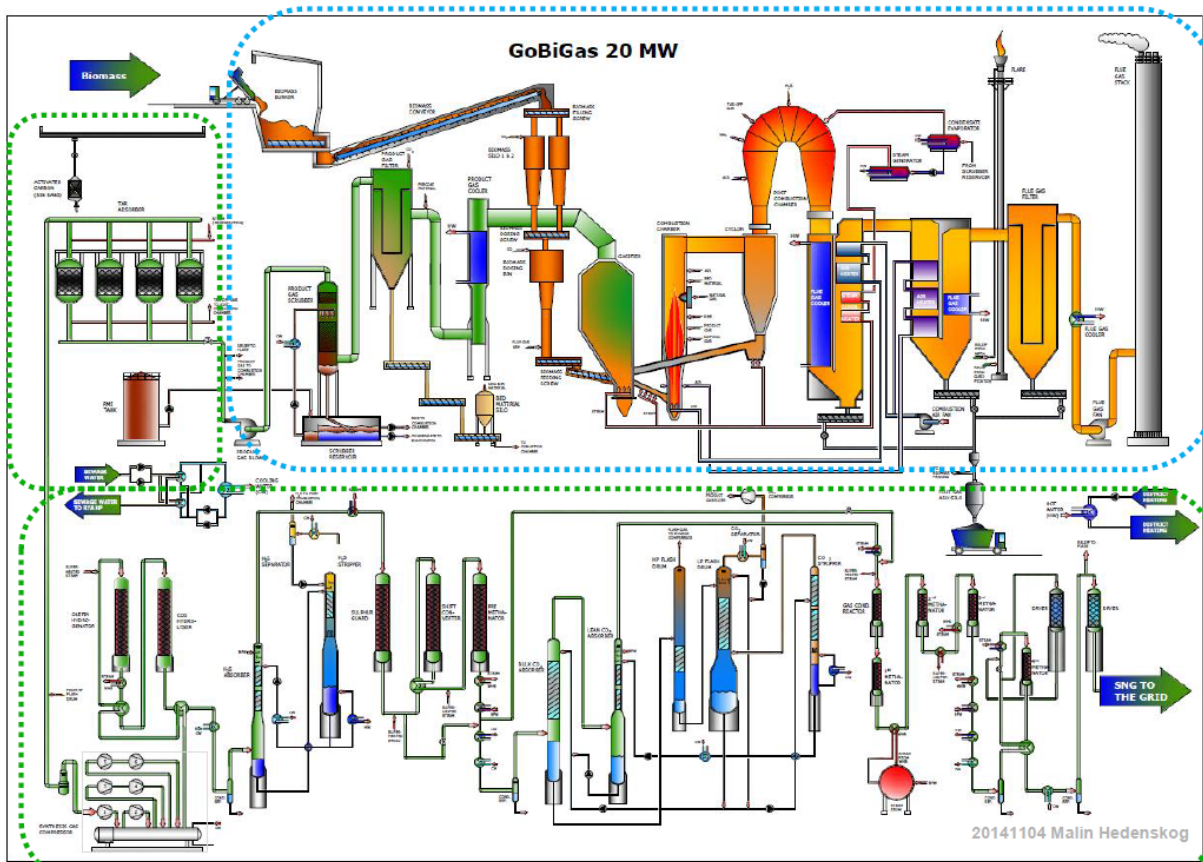
- 15.6 % RE transport fuels in 2013
- 5.9 % of all vehicles predominant RE fuels
- Energy taxes levied on low-level blends in gasoline and diesel
- as of 2013 to comply with EU state aid rules, but no CO<sub>2</sub> tax.
- Tax exemptions retained for high-level blends or neat fuels

- (e.g. E85, B100, CBG, but also for HVO < 15 % in diesel)
- Sustainability criteria to qualify as RE fuel and for tax exemptions
- Parliamentary commission on fossil-free vehicle traffic
- was reported December 16, 2013.
- Proposal for a price guarantee for second generation biofuels?

### 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?

### GoBiGas project



### Current status beginning of May 2015:

- Gasifier operation close to 4 000 hours
- MCR load proven on pellets
- Gas quality (relative to design values) good
- Pellets are very clean and generates certain specific issues.
- Bed material activation has been a learning experience
- SNG product in a longer campaign in December 2014
- In 2015 periods of grid supply (days) on some occasions
- 60-70 % of design capacity
- Biogas quality better than design spec.

- Present situation is finding and overcoming bottlenecks limiting capacity or limiting duration (sequence optimization, control settings etc.)

**Future goals:**

- Continuous operation period from June to December
- Installation of chip feeding equipment on-going
- Expected switch from pellets to chips early 2016

**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

**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

**KTH School of Chemical Engineering**

- New transportable autothermal reformer housed in a transportable container

Features

- 5 Nm<sup>3</sup>/hr
- pressurised (30 bar)
- air or steam/oxygen
- partial oxidation burner
- catalyst beds
- gas analysis
- SPA tar sampling
- other analyses possible
- first test in March 2015

**SP ETC Gasification**

SP (Technical Research Institute of Sweden) acquired ETC in January 2015

- 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

**Energiforsk fka Swedish Gas Centre**

Four energi research organisations where merged to Energiforsk in January 2015 (Värmeforsk, Svenskt Gascentrum, Elforsk, Framsyn)

- **"Energy gas program"**

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

"Energy gas program"

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

A dozen projects approved in December 2014

### **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

### **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.

## **Norway, Judit Sandquist, SINTEF**

- Norway has large unused biomass resources
- Still no economic advantage or incentives for biomass gasification in Norway:
  - Fundamental research at Universities
  - Applied research
  - No large scale gasification facilities
- Small scale waste-to-energy applications
- Some interested larger companies – initiatives
  - Silva Green Fuel AS (Statkraft and Södra JV)
  - VikenSkog
  - Biofuels Development

### **Liquid biofuels for transportation - GAFT**

Gasification and FT-Synthesis of Lignocellulosic Feedstocks (**GAFT**)

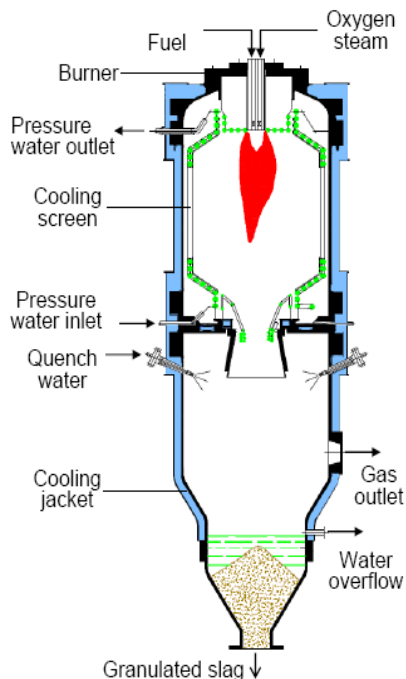
- Project Leader: SINTEF Energy Research – Bioenergy group
- GAFT is a new KPN Project that has been recently granted by the Research Council of Norway (NFR)
- NFR will contribute with 16 MNOK (1.9 MEuro) in total over a period of 4 years
- In addition, the consortium of industry partners will contribute with additional 4 MNOK (1 MNOK/year)
- The objective of GAFT is to contribute to accelerated implementation of liquid biofuels production in Norway

Reach of objectives:

- By identifying an implementation suitable for the Norwegian conditions:
  - By utilizing local biomass resources
  - By choosing an appropriate plant capacity (150 – 500 MW)
  - By making use of excess heat and other products in existing installations
- The concept innovation lies in reducing the production costs by having
  - A decentralized biocrude production
  - A centralized (existing refinery) biocrude upgrading to transportation biofuels
  - Heat recovery and utilization for district heating and industrial steam

## SINTEF

- **New EF reactor**
  - **Current status - manufacturing**



- Maximum fuel flow rate: 2 kg/h
- Maximum of operators : 2
- Pressure: 10 bar(g)
- Wall heater temperature: 1500 °C
- 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

- Top fired
- Oxygen blown
- Short residence time
- Small fuel particles
- Pressurized
- 800mm long with an inside diameter of 200mm
- Should be operated as, and contain the main components found in a commercial gasifier
- Should be flexible not only in fuel but in mode of operation

## Finland, Ilkka Hannula, VTT

### Past large projects: Biomass and waste gasification for boilers and kilns

#### 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

#### Metsä Group will build a new next-generation bioproduct mill in Äänekoski

- Constructions are ongoing and are scheduled to be completed during 2017
- The mill will use a total of 6.5 million cubic metres of wood raw material annually
- Pulp output will be 1.3 million tonnes (800 ktons softwood, 500 ktons hardwood)
- Investment 1.2 billion euros
- The wood raw material used by the mill and all side streams will be fully utilized as products and bioenergy
- No use of fossil fuels
- All side streams from the bioproduct mill are planned to be utilized in the ecosystem that will be formed by various companies around the mill
- Valmet Oy and Andritz Oy will be responsible for the main equipment deliveries.
- The gasification plant (dryer, gasifier, lime kiln) is delivered by Valmet

#### UPM BioVerno renewable diesel

- Diesel from tall oil residue
- Investment 175 M€
- Production of renewable diesel 100 kton/a

#### 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 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

### **Industrial projects**

- Pyrolysis and gasification R&D
- Testing and piloting services
- Platform for new pilot plants

### **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>n/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**

U.S. renewable energy consumption, availability of forest and agricultural biomass, federal policy and incentives for biomass technologies were presented.

State policies in support of bioenergy

- Less than 15 states have policies specifically incentivizing biomass usage
- Most common types of incentive: incentives, tax credits, rebates
- Policies encourage:
  - Use of biomass in heating (excluding wood)
  - Industry production/collection of biomass
  - Funding of equipment, businesses, or homes using biomass
  - Installation of biomass CHP plants
  - Agricultural production for use in electrical generation
- Plant Construction or Equipment Incentivized
  - New Mexico
  - South Carolina
  - Illinois
  - New Jersey
  - Michigan

### **Technology providers**

- American Process
- Carbona
- Concord Blue
- Emery Energy
- InEnTec
- Phoenix Energy
- Radian Biofuels
- Sundrop Fuels
- TRI
- Many others...

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

- Have deleted (marked as no longer active) 10 projects so far
- Have identified four new facilities not yet in database
- Updating status of projects in database
- Also considering facilities in Canada

### **Technology spotlight: Phoenix Energy**



- Provides on-site biomass power plants
- Small plants: 1-3 MW
- Based in San Francisco, California
- Newest Facility Announced:
  - North Fork, CA
- Creates jobs for small community

#### **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
- Update Jan 2015: Has been shut down to receive upgrades to improve production reliability. Expected to re-start production soon

#### **LanzaTech Freedom Pines Biorefinery**

- Biofuel production through LanzaTech's syngas fermentation technology
- Concord Blue chosen as gasification technology provider. Gasifier installation began 2014
- Target to combine gasifier and fermentation in 2015

#### **Gasification research at University of Utah**

- "Project Treemobile" (<http://treemobile.chemeng.utah.edu/>)

**Day 2 and 3, Tue and Wed, May 12 and 13**

**Workshop “Symposium on Renewable Energy and Products from Biomass and Waste”**

**Meeting Location:** CIUDEN, Ponferrada

The list of attendees, for the workshop includes:

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## Workshop presentations – overview

### Session 1: Gasification, CO<sub>2</sub> capture and synthesis

Bo Leckner, Chalmers University of Technology, Sweden

#### **Thermal conversion of wastes: The separation of steps**

Jose Maria Sanchez Hervas, CIEMAT, Spain

#### **Process developments for CO<sub>2</sub> capture and valorization methods at CIEMAT**

Sylvie Valin, CEA, France

#### **CO<sub>2</sub> valorization in a biomass to fuel process: experimental gasification study and process evaluation**

Leif Gustavsson, Linnaeus University, Sweden

#### **Time-integrated greenhouse gas emissions in the thermochemical conversion of municipal waste and forest residues**

### Session 2: Design of new concepts of thermochemical biorefineries

Judit Sandquist, SINTEF, Norway

#### **Advanced biorefinery concept based on cultivated macroalgae**

Pedro Haro, University of Sevilla, Spain

#### **Thermochemical biorefineries with multiproduction: hydrocarbonylation of DME into fuels and chemicals**

Ilkka Hannula, VTT, Finland

#### **Doubling of synthetic biofuels production via hydrogen from renewable electricity**

### Session 3: Demonstration and commercialization

Juan Luis Cruz, INERCO, Spain

#### **INERCO technology for biomass gasification**

Juhani Isaksson, Valmet, Sweden

#### **Progress in commercial scale CFB gasification for waste and biomass**

Bram van der Drift, ECN, The Netherlands

#### **Commercialization of WtE through gasification technology developed by ECN**

Miguel Angel Delgado, CIUDEN, Spain

#### **Carbon capture challenges and CIUDEN**

Manuel Silva Perez, CTAER, Spain

## Development and demonstration of solar-biomass hybridization technologies

JJ Leahy, University of Limerick, Ireland

### Biomass and waste valorisation in an Irish perspective

Carlos de la Paz, Life, EU Commission

### The Life Programm as a driver for the development of more efficient technologies for carbon capture and biomass/waste utilization

**Day 3, Wed, May 13**

## Site visits: CIUDEN plant

One of the European large scale projects was carried out by Foundation *Ciudad de la Energía* (CIUDEN). Firstly, worth mentioning is the layout of CIUDEN's plant in order to have a clear idea about the size of the installations and, consequently, the representative results that could be obtained. In general term, CIUDEN's installation includes following main process units (see fig. 1):

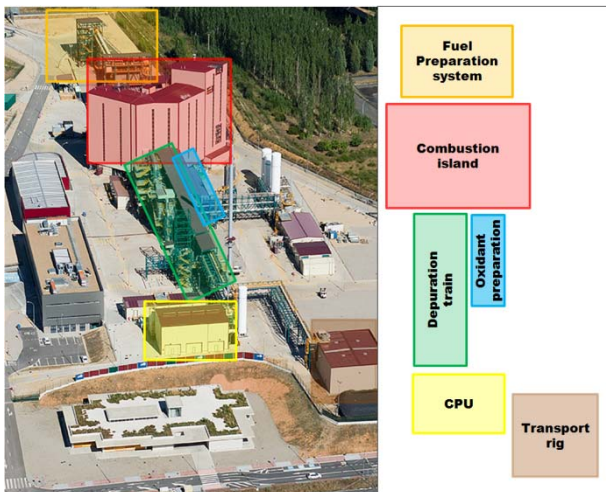


Fig. 1 CIUDEN's layout

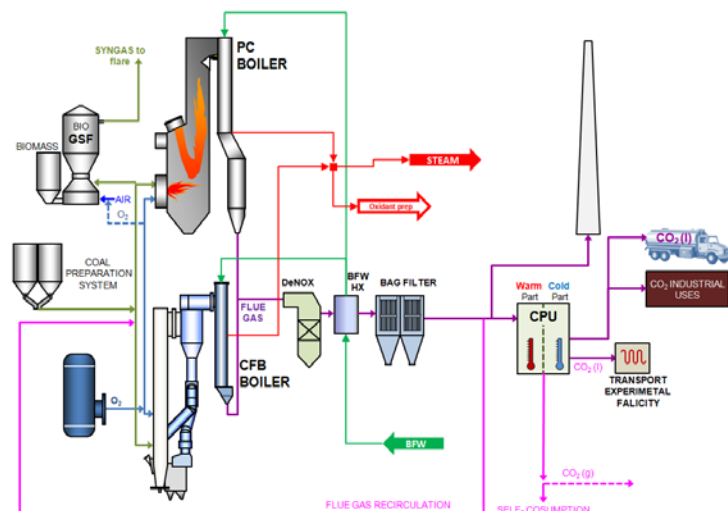
- Fuel preparation system, including a 15 t/h crusher and a 5 t/h ball mill. This process unit is designed to treat different fuels such as anthracite and petroleum coke (petcoke), among others.

- Combustion island: 20 MWth pulverized coal (PC) boiler and 30 MWth circulating fluidized bed (CFB) boiler. In particular, the present paper will be focus on the CFB boiler.

- Oxidant preparation system using steam. In CIUDEN's plant, the sensible heat from flue gases is recovered using a liquid-gas heat exchanger (BFW HX) with boiler feed water (BFW) whereas the comburent preparation train uses steam to increase the oxidant streams

temperatures.

- Combustion gases heat recovery system (BFW HX).
- Flue gas purification train that includes the multi-cyclones (not represented in the figure 2) prior to selective catalytic reactor (hereinafter, SCR) and bag filters to decrease the particulate concentration to less than 15 mg/Nm<sup>3</sup>. On the other hand, a system for collection, transport and storage of solid residues and fly



ashes is also included; regarding the solid residues, made-to-measure hermetic containers were designed for the bottom-ash in the CFB boiler as the residues are obtained at 300 °C (after the refrigerated screw) whereas for the PC boiler, opened containers are used due to a wet rindler is installed to extract the bottom ashes.

- CO<sub>2</sub> compression and purification unit.
- CO<sub>2</sub> transport test rig including recirculation pump and heat exchanger systems in order to set operation pressures and temperatures within the range of 80 -110 barg and 10 - 30 °C respectively. With the aim of operating the test rig in thermal conditions similar to those expected in CO<sub>2</sub> transport pipelines (mainly buried), the facility will be located inside a highly thermal isolated building with thermal control.
- Auxiliary service systems (oxygen, compressed air, LNG as auxiliary fuel, raw water, demineralised water, cooling water, CO<sub>2</sub> as inert fluid, etc.) necessary for the operation of the TDP.

**END**