

IEA Task 33 Meeting

Piteå, Sweden

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Country Update Sweden



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2009 Energy and Climate Bill

- Reduce GHG emissions 40 % by 2020 outside ETS sector
 - 20% done (rel. 1990), 30% by flexible mechanisms
 - Continued use of environmental taxation
 - Sweden independent of fossil transport fuels in 2030
- Follow EU ETS policies
- Minimum 50% Renewable Energy 2020
 - RE Certificate prolonged and target increased, +25 TWh rel. 2002
 - Wind power planning 20 TWh land-based+10TWh sea-based
- Energy Savings Plan
 - 20% reduction 2020
- Nuclear power
 - The reactor development law (SFS1984:3) is revoked
 - Up to 10 new replacement reactors can be accepted on present sites

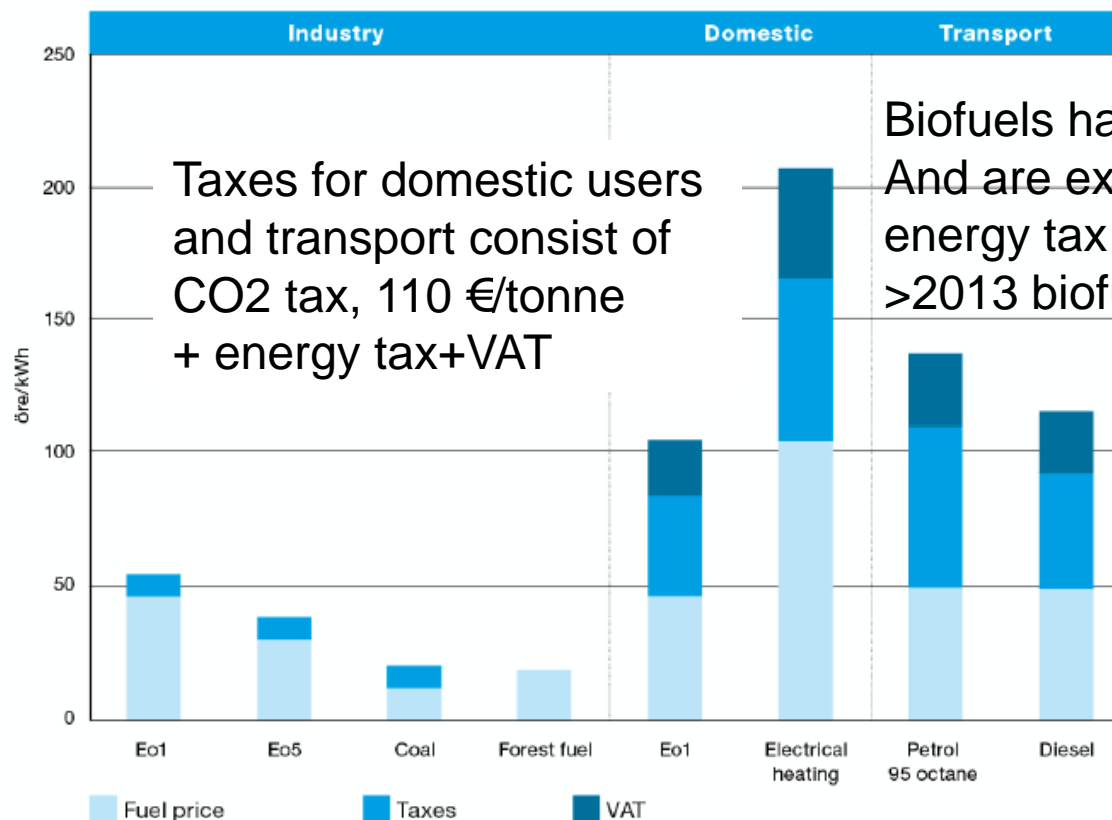
Proposition 2008/2009:162 and 163



Fuel prices and taxation



Total energy price for various customer categories, 2009



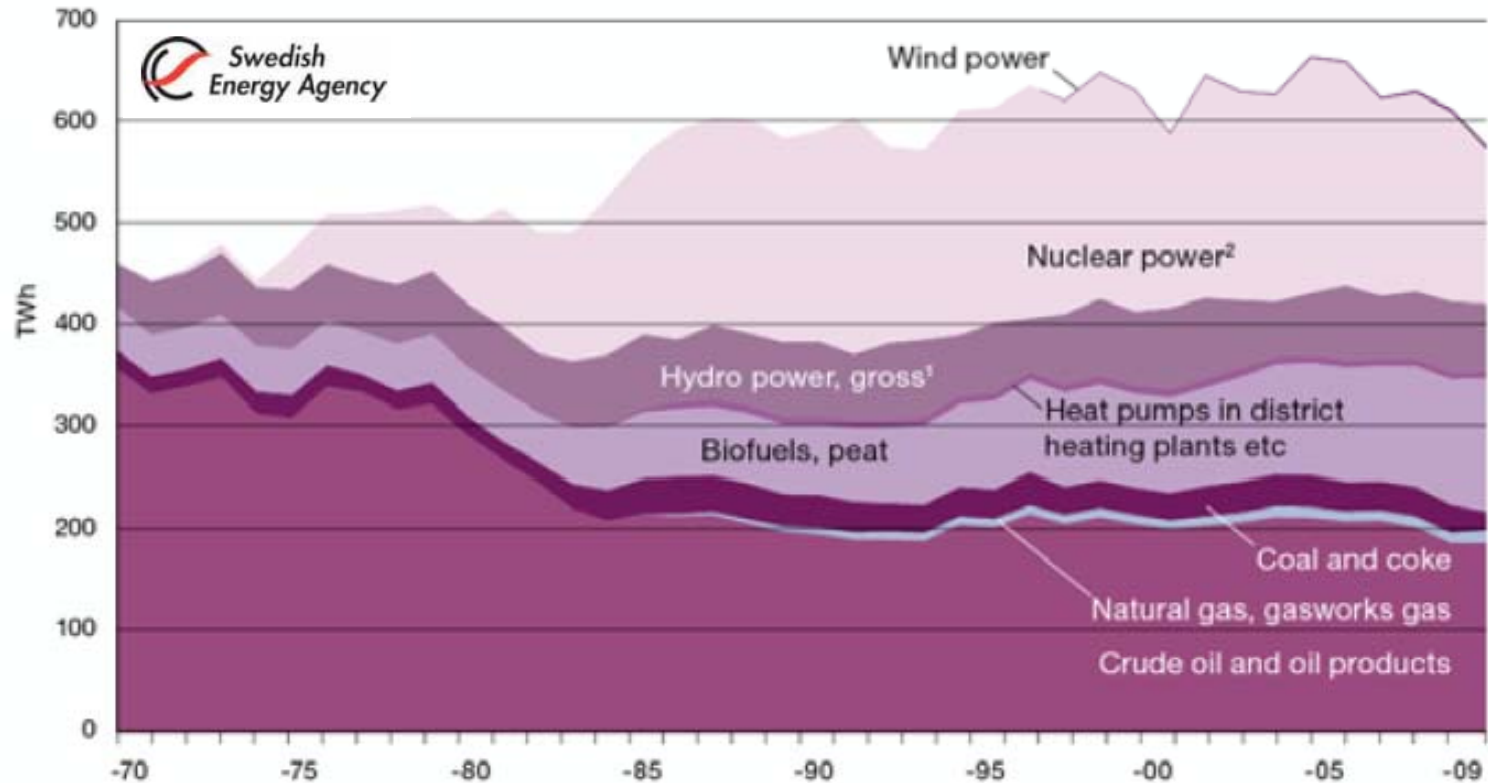
Taxes for domestic users and transport consist of CO2 tax, 110 €/tonne + energy tax+VAT

Biofuels have no CO2 tax
And are exempted from energy tax until 2013.
>2013 biofuel mandate???

Source: SPI, Statistics Sweden and Swedish Tax Board.
Note: Prices for industry do not include any volume discounts.



Energy Supply



Source: Statistics Sweden and the Swedish Energy Agency.

Note: 1. Includes wind power until and including 1996. 2. Nuclear power is shown as gross power, i.e. as the

In 2009 biomass surpassed oil (less transport fuel) as input energy in Sweden
In 2010 biomass was 32%, 137 TWh, hydro+nuclear 107 TWh 2009



R&D and D (1)

- Second black liquor program ended 2010
- Two gasification projects selected in the 2009 EOI for demonstration of 2nd. generation biofuels and energy technologies (875 million SEK ~ 100 M€)
 - Black liquor gasification demo at Domsjö
 - GoBigas in Gothenburg after second round of selection
 - Both passed State Aid appraisal by DG Competition in Dec. 2010
- Energy intensive industry program 8 M€
- Bioenergy fuels program



R&D and D (2)

- 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
 - 58, 5 MSEK for first two years, then the same sum annually

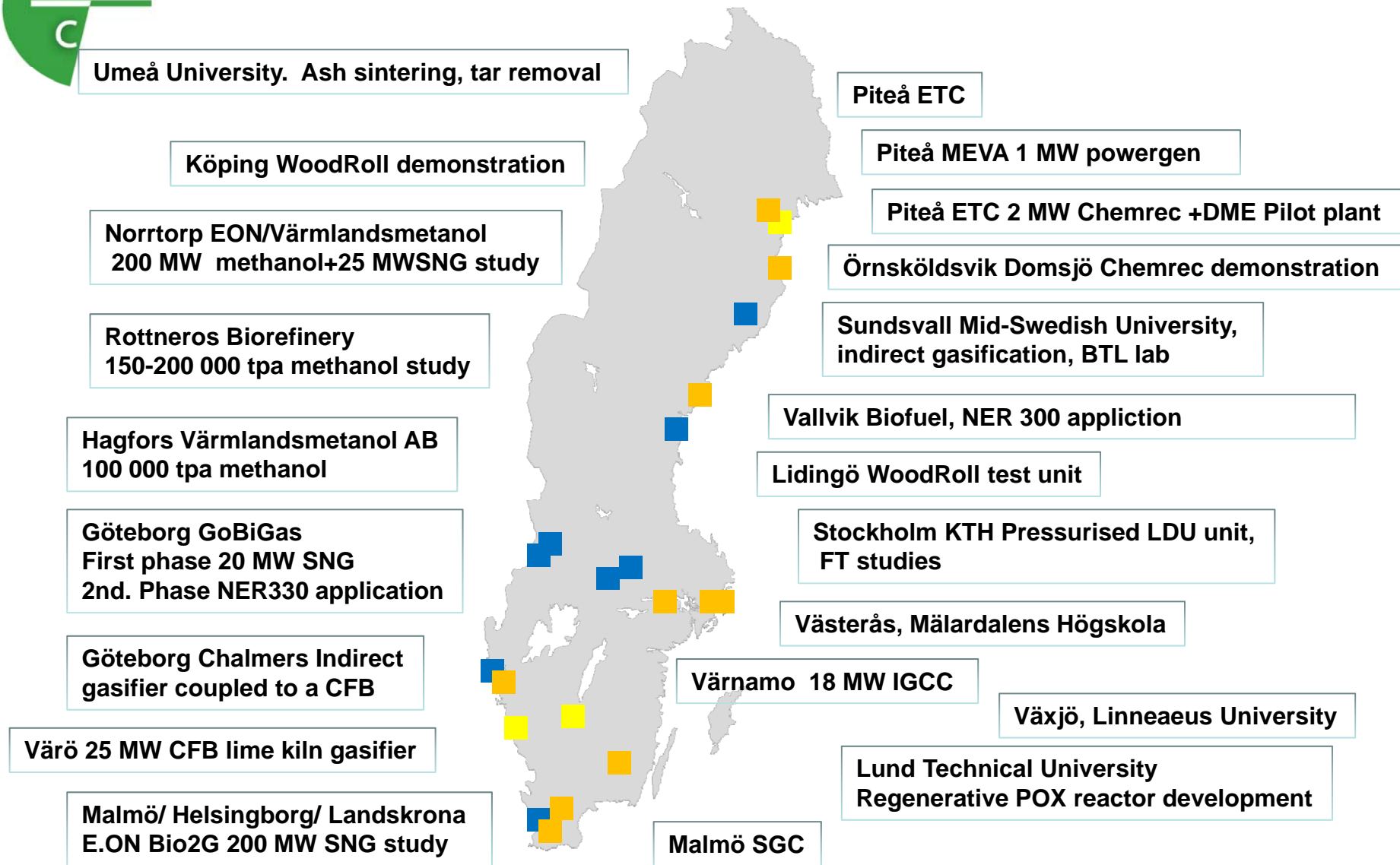


R&D and D (3)

- **NER300: bioenergy 5 out of 9 projects proposed to the EU**
 - Pyrogrot Billerud -Category: 40 kton/a pyrolysis oil or slurry
 - Vallvik Biofuel -Categories: 40 000 m³/a methanol via entrained flow gasification of i) black liquor, ii) pyrolysis oil or iii) torrefied wood
 - Rottneros Biofuel -Category: 150 000 m³/a methanol from lignocellulosic biomass
 - E.ON Bio2G -Category: 40 million Nm³/a SNG
 - GoBiGas 2 -Category: 40 million Nm³/a SNG
 - **Demonstration and SET-plan budget reinforced for FY 2012**
 - 83, 83 and 52 MSEK additional for 2012, 2013, 2014, respectively.
 - **Biorefinery Norrtorp prestudy initiated**
 - 200MW methanol +25 MW SNG
 - Partners SAKAB, E:ON, Värmlandsmetanol, and others
-

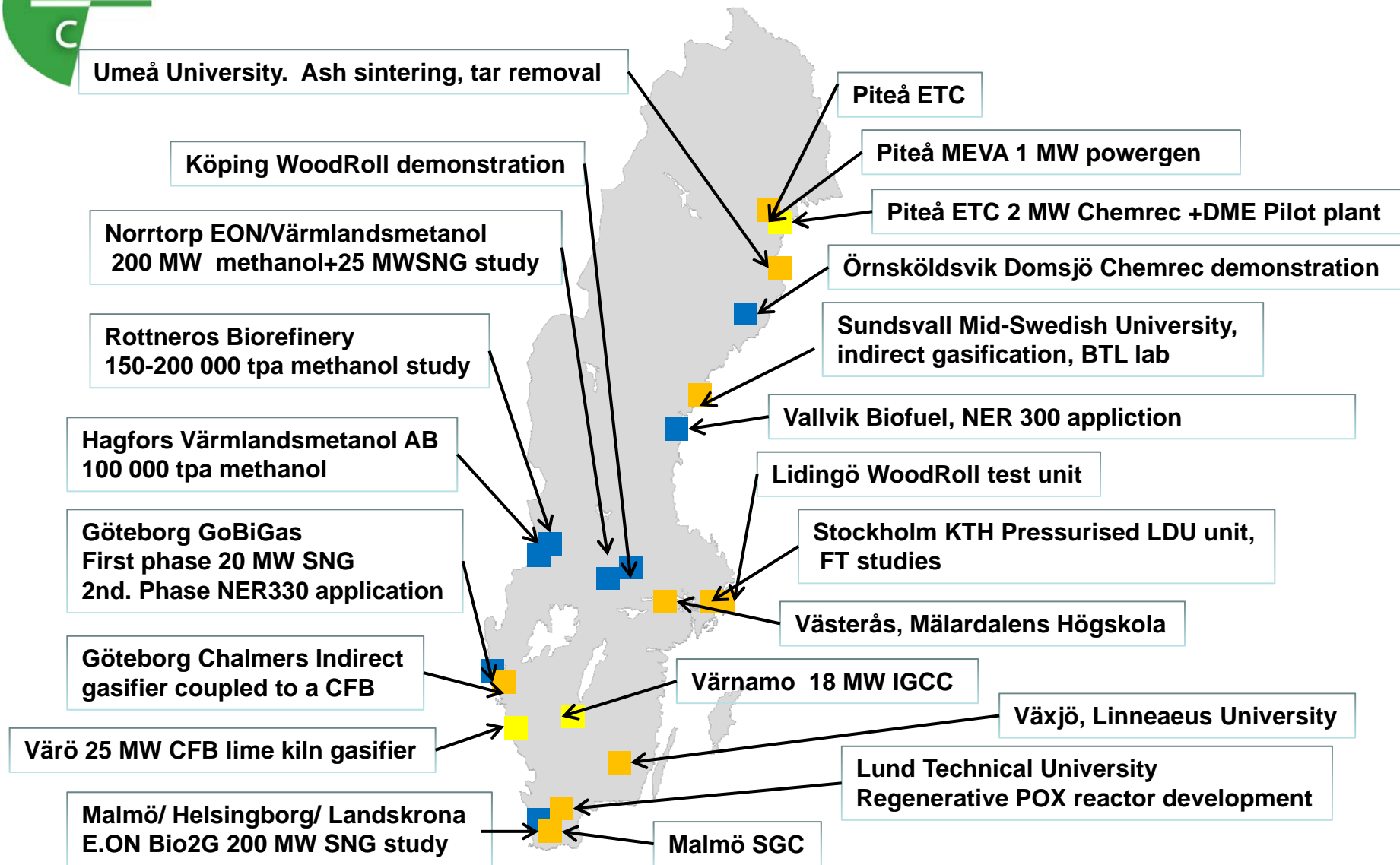


Biomass Gasification Sweden 2011





Biomass Gasification Sweden 2011





Swedish Centre for Renewable Fuels (f³)

"f3 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"

Universities

- Chalmers
- Royal Inst. Techn.
- Lund Inst. Techn.
- Swedish Univ. of Agricultural Science
- Bio4Energy*

Research institutes

- Swedish Tech. Res. Inst.
- Swedish Env. Inst.
- Innventia

**Budget for 2011-13
30 million SEK**

Industry

- Preem
- Perstorp
- Göteborg Energi
- Eon Sweden
- Sekab E-technology
- Volvo Technology
- Scania

Funding

- Swedish Energy Agency
- Region of Västra Götaland

* Cooperation between Umeå university, Luleå technical university and SLU in Umeå.

f3 has five different project areas:

- **System-wide studies**
- **Comparative studies of various systems for renewable fuels**
- **Analyses of synergies between plants**
- **Analysis of synergies between different technology platforms**
- **Method development for interdisciplinary studies in above four areas**

fossil free fuels f³



Swedish Gasification Centre (SFC)



CDGB - Centre for Direct Gasification of Biomass

CIGB – Centre for Indirect Gasification of Biomass

B4G – Biomass for Gasification, Entrained Flow Centre

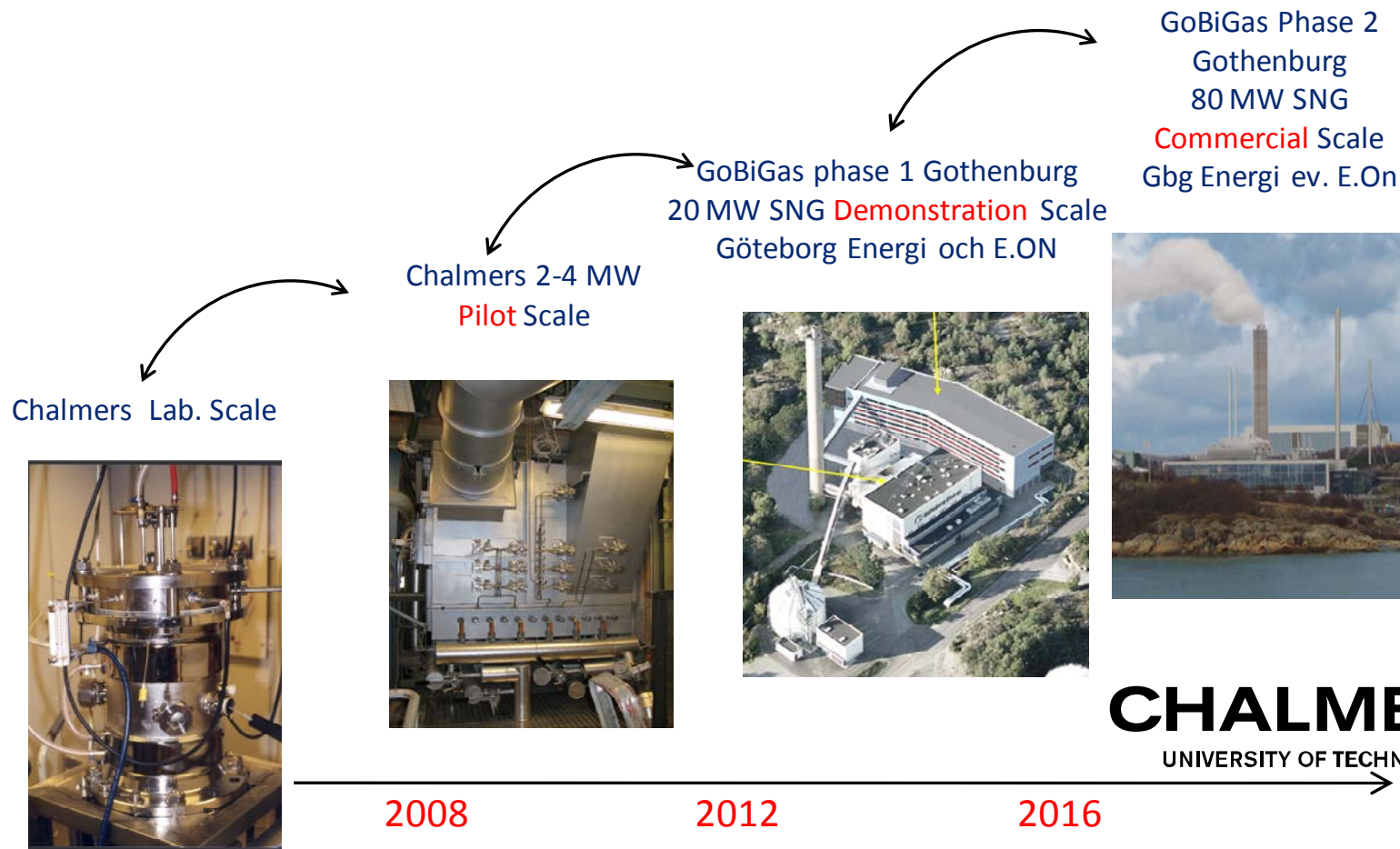
Academies Chalmers, Gothenburg Univ., KTH, Linnaeus Univ., Luleå Technical Univ., Mid-Swedish Univ., Mälardalen Univ., Umeå Univ.

Companies E.ON, Metso, Göteborg Energi, Fortum, Mälarenergi, Cortus, Nynas, Eskilstuna Energi och Miljö, Nordkalk



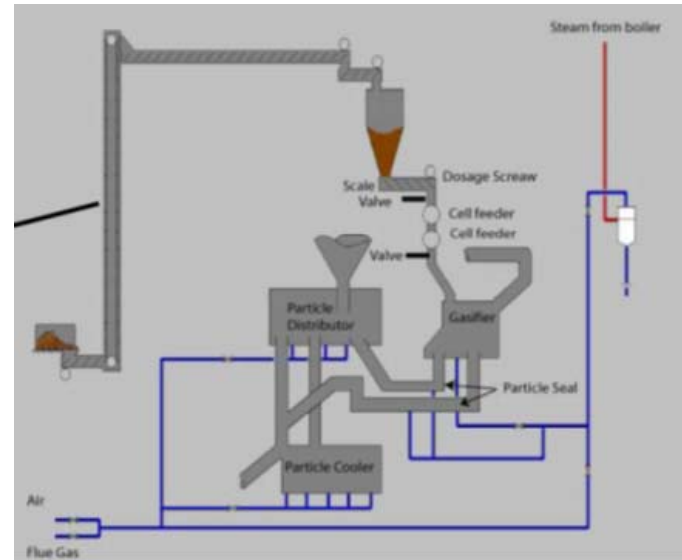
Chalmers

Biogas Production via Thermal Conversion - From Research to Commercial Production



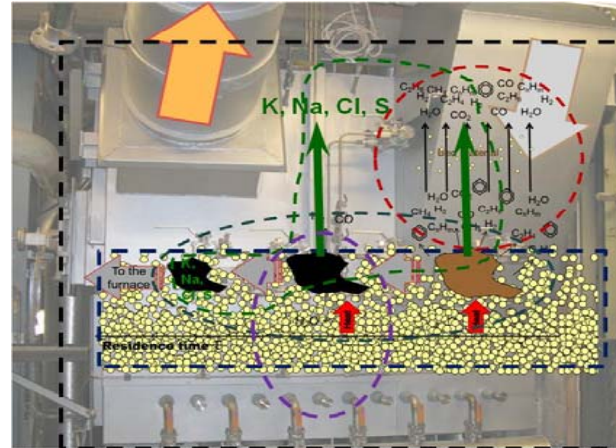


Chalmers Indirect Gasification



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.



CHALMERS
UNIVERSITY OF TECHNOLOGY



Chalmers Technology development

- Goal of activity
 - Demonstrate how an indirect gasifier could be built +100 MW_{fuel}
 - Demonstrate a robust method for catalytic reformation of the gas to a syngas containing only CH₄, H₂, CO, CO₂ H₂O
 - Demonstrate a energy efficiency for dry biomass to clean syngas >85%
- ~22 Researchers work at Chalmers. The activity is divided into:
 - The gasification process
 - The gas cleaning
 - High temperature corrosion

Support Activities

- **Process integration**
 - 2-4 Researchers at Chalmers with focus on integration of biomass gasification in various industrial processes
- Development of applications
 - 2-4 Researchers at Chalmers with focus on the development of engines for different gas qualities

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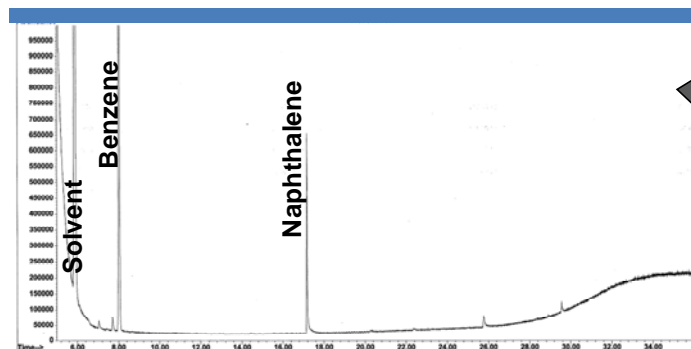
Chalmers Indirect Gasification



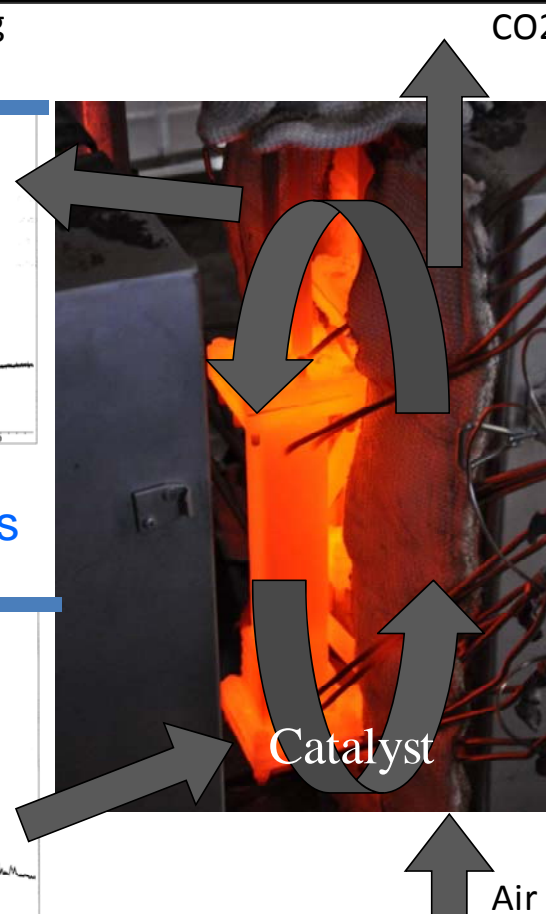
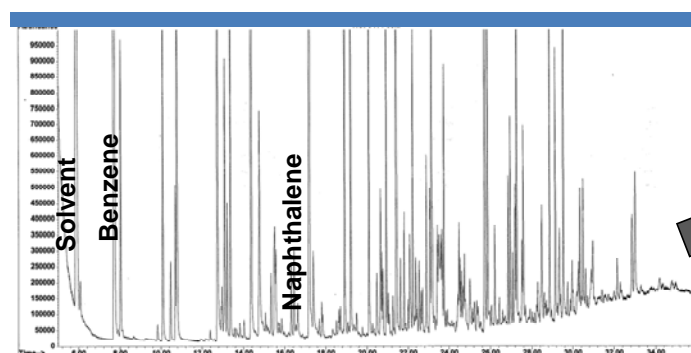
Chemical Looping Reforming

Gas Chromatogram before and after Gas cleaning

Residence time $\sim 0,4$ s $T \sim 850$ °C



Scale of tests: 2-3 l/min raw gas



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Swedish Gas Centre

On-going gasification related activities

- ***Gasification and gasifier database***
report and database on SGC homepage in 2011
- ***Co-production of SNG and FT diesel***
PhD work at KTH, results to be published in 2012
- ***International Gasification Seminar***
Malmö, October 28-29, 2011
- ***Particulate contaminants from indirect gasifiers***
In planning, Chalmers gasifier to be used as test berth
- ***Autothermal regenerative POX tar reactor***
In planning, Lund technical university





Thermo-chemical Conversion of Biomass

- Long experience of R&D within gasification. Activities started in the 1970s.

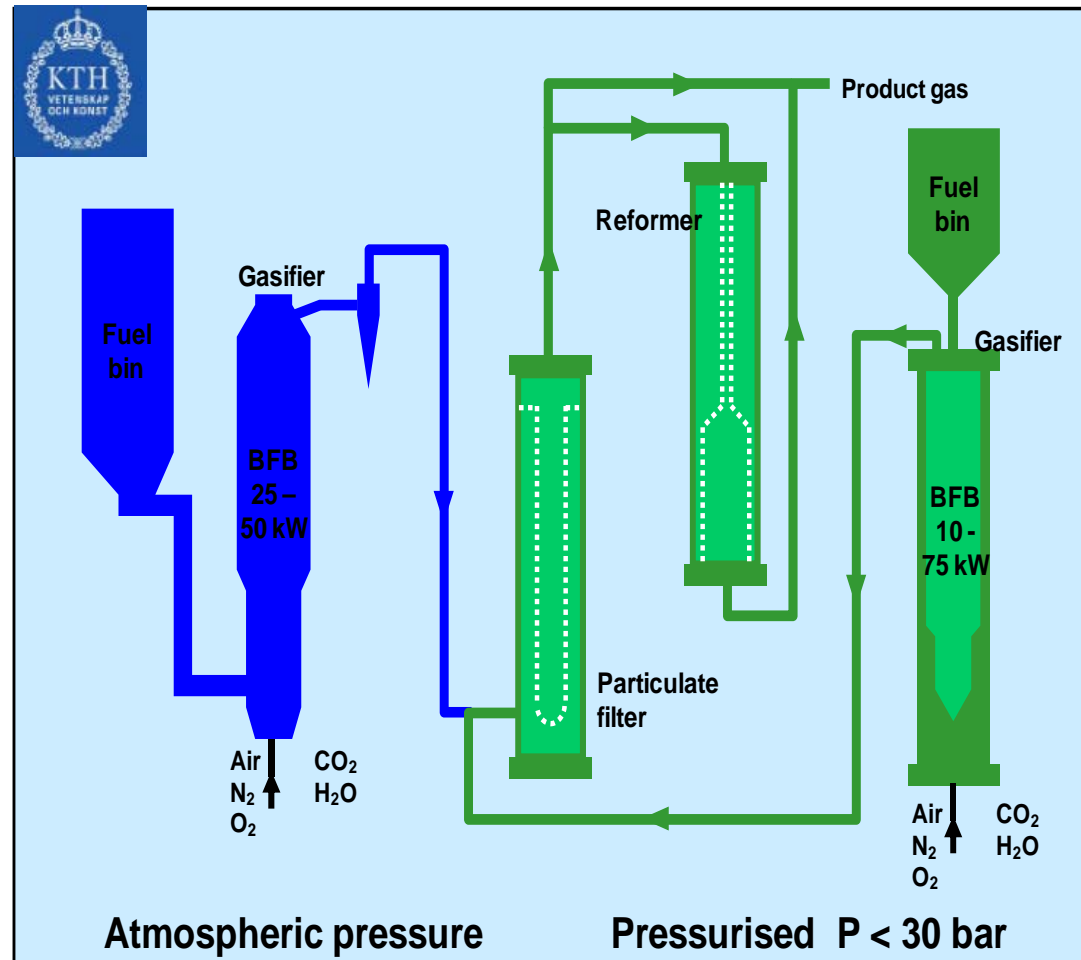
Technologies at KTH

- 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



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



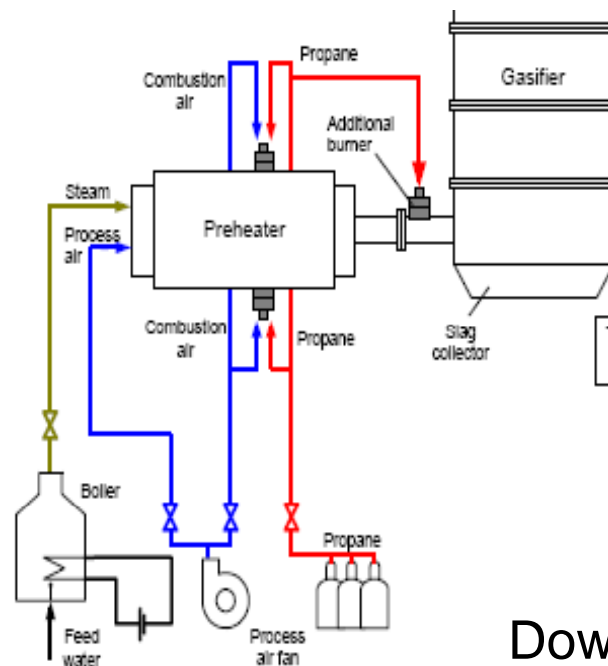


HTAG-High Temp Air Gasification



Gasification rights acquired by Boson Energy

Work on a HTAG biooil concept on-going



Gasification Installation (800 kWth)



Downdraft gasifier



Updraft gasifier



ETC Gasification Activities

Host for DP1: Chemrec black liquor, biomass

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

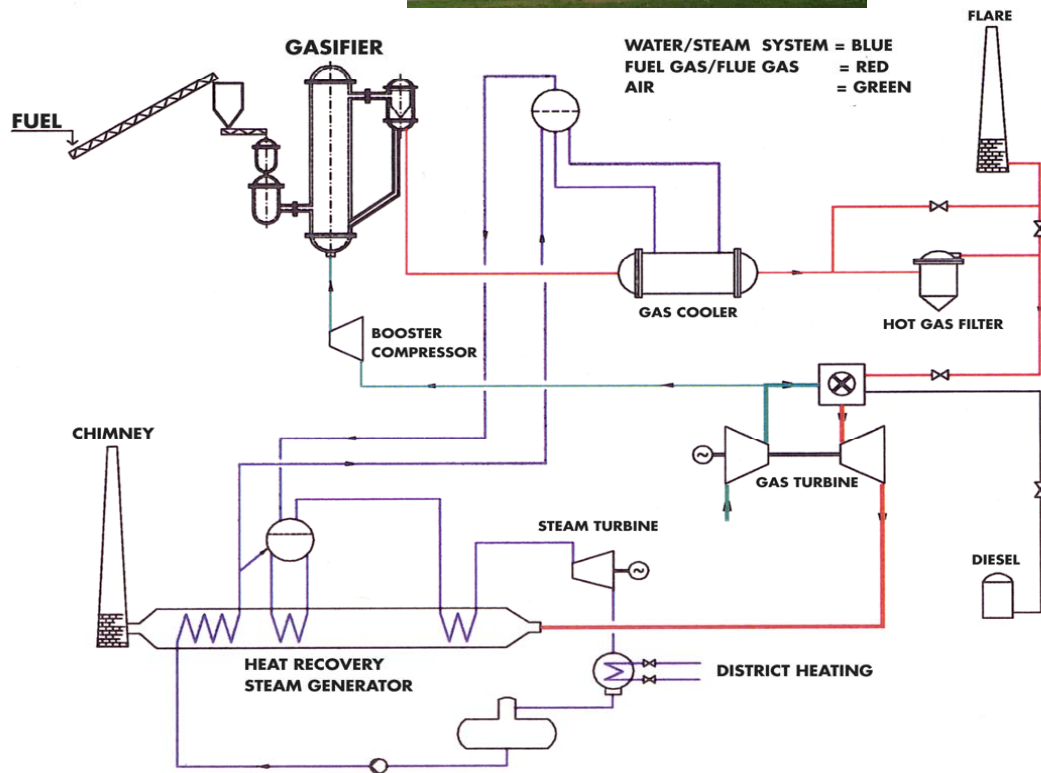
PEBG: Pressurised entrained flow gasification, 1 MW, 15 bar



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



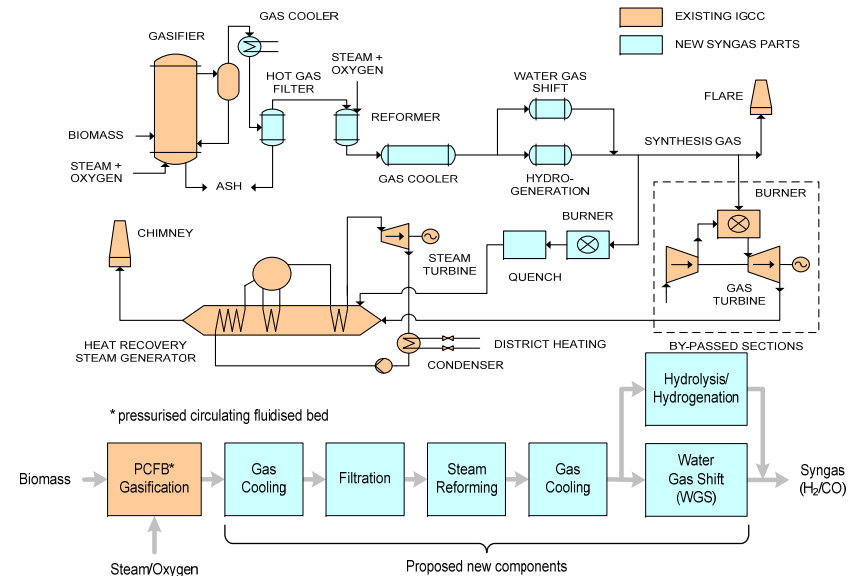
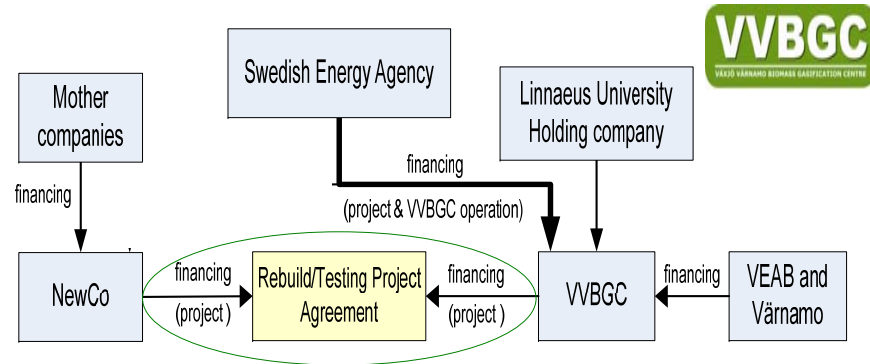
Värnamo - Pressurised combined cycle



- Supplier: Bioflow (Foster-Wheeler, Sydkraft)
- Fuel 18 MW
- Power 6 MW
- Heat 9 MW
- 18 bar pressure
- Typhoon GT
- **Mothballed in 2000.**
> 8000 gasifier and 3 600 hours of GT op.



VVBGC Project Status



Activities: Engineering initiated in January 2010.

Status: Project terminated in Feb. 2011 from difficulties to attract additional partners to close industrial funding targets.

Future: Most likely mothballing again.



Biomass to SNG: GOBIGAS

GoBiGas – step by step

- **Performance goals:**

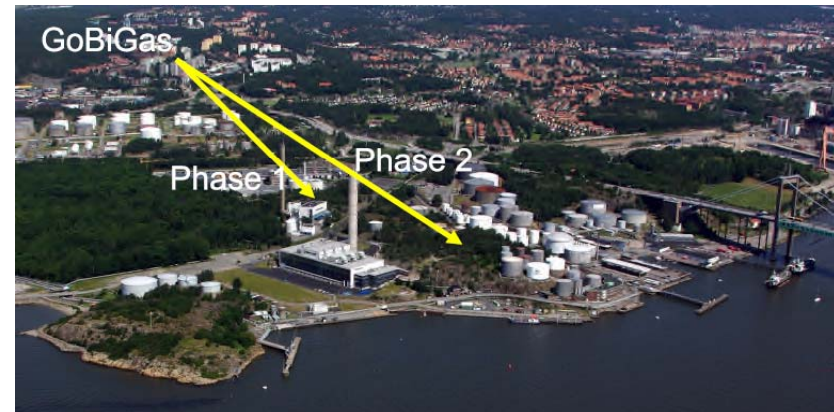
- Biomass to biomethane 65 - 70%
- Energy efficiency > 90%

- **Phase 1:**

- Demonstration plant
- Evaluation, R&D programme
- 20 MW generating 160 GWh/year
- In operation early 2013
- Allothermal (in-direct) gasification

- **Phase 2:**

- 80-100 MW generating 640-800 GWh/year
- In operation after evaluation of Phase 1
- Technology not yet chosen

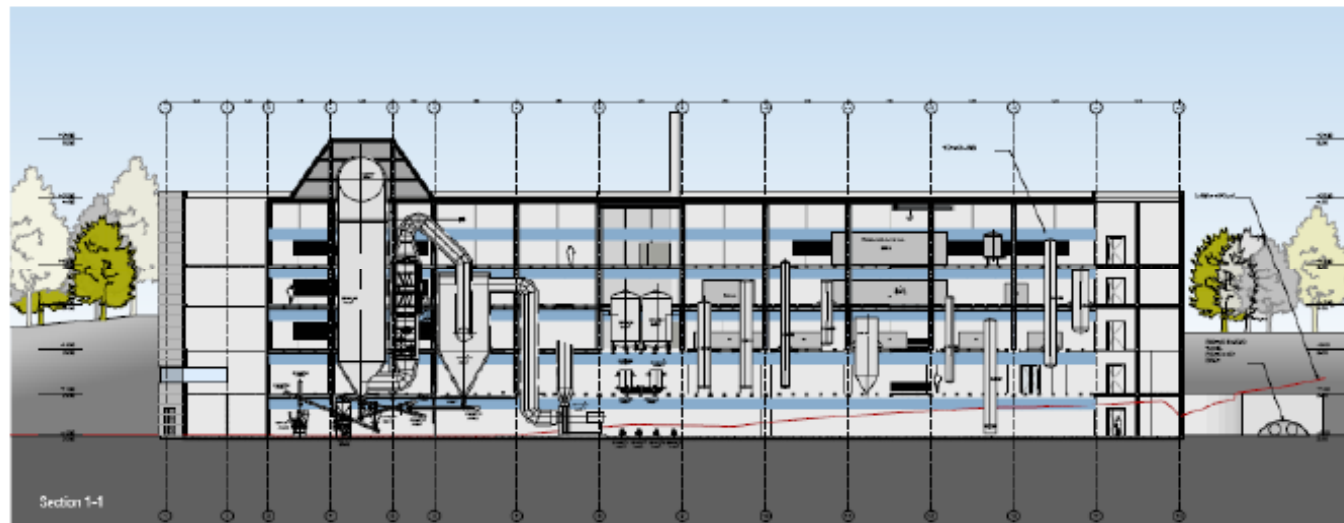




Biomass to SNG: GOBIGAS

GoBiGas – phase 1

Production:		Consumption:	
Bio-SNG	20 MW	Fuel (pellets)	32 MW
District heating	4 MW	Electricity	2,5 MW
Heat to heat pumps	8 MW	RME (bio-oil)	0,5 MW



 Göteborg Energi



GOBIGAS Status

Project status – October 2011

- **Funding**
 - 222 MSEK granted for Phase 1 from the Swedish Energy Agency and approved by the EC, December 2011.
 - Project application for phase 2 sent to EiB for funding – under due diligence
- **Investment decision** December 2010 by Göteborg Energi
- **Gasification**
 - Cooperation between Metso Power and Repotec - design and procurement of equipment
- **Methanation**
 - Cooperation with Haldor Topsøe
 - EPCM (Engineering Procurement Construction Manager) - Jacobs
- **Permits**
 - Environmental permit and applications building permit granted for Phase 1
 - Preparatory work for environmental permit and building permit for Phase 2
- **Phase in operation** early 2013





Black Liquor Gasification Activities

Pictures from site March 2011



(In commissioning! First BioDME expected first part of May)



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Energy to Succeed



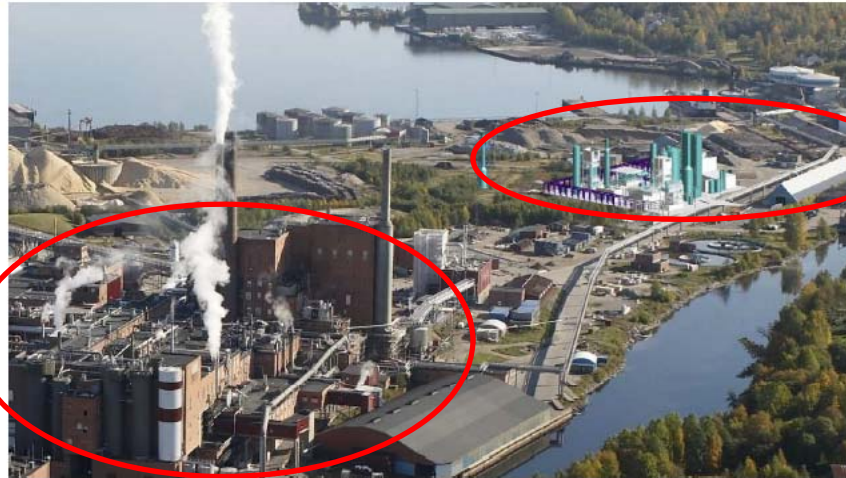
Black Liquor Demonstration Activities

Current project status of Domsjö project

Feed: 200 MW of sodium sulphite liquor;

Products: 100 000 t/y of DME or 140 000 t/a of Methanol or a mix of the two.


&
CHEMREC
in collaboration



BLG –DME/MeOH
Plant

Sulphite mill

- Domsjö mill sulphite thick liquor gasified successfully in DP-1
- 500 MMSEK (~ 50 MM€) investment grant approved by Swedish Energy Agency. EU's DG Competition approval received January 26, 2011.
- Feasibility report complete (May 2010)
- Key technology suppliers selected
- Front-end Engineering Design contractor selected
FEED to start shortly
- Likely plant start-up H2 2014

SEKAB EtOH plant
And 2nd. Gen EtOH
Pilot on same site.

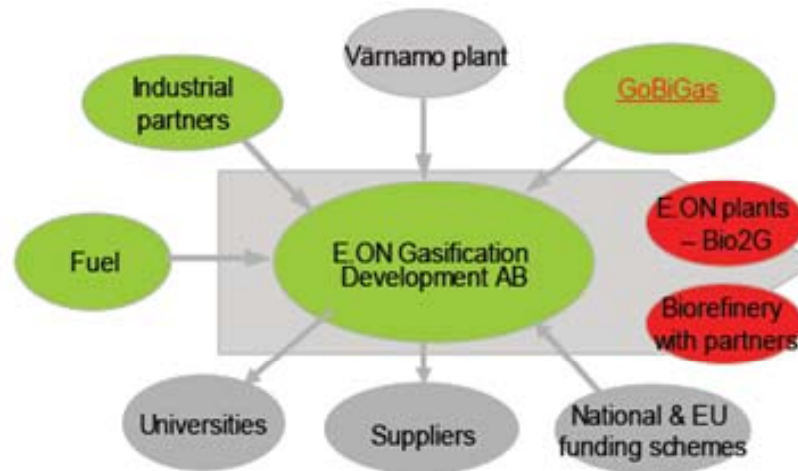
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Energy to Succeed



Biomass to SNG: E.ON

e-on

- E.ON Management
 - New strategy 2010: "Cleaner and better energy"
 - CEO @ General Meeting 2011 "Gas & Renewables growth markets"
- E.ON Gasification Development AB



- Build knowledge
- Show suppliers – we are ready to invest
- Co-operation with others stake-holders
- Design and engineering of the first commercially sized plant – [Bio2G](#)
- Find viable business cases



E.ON Bio2G



- 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

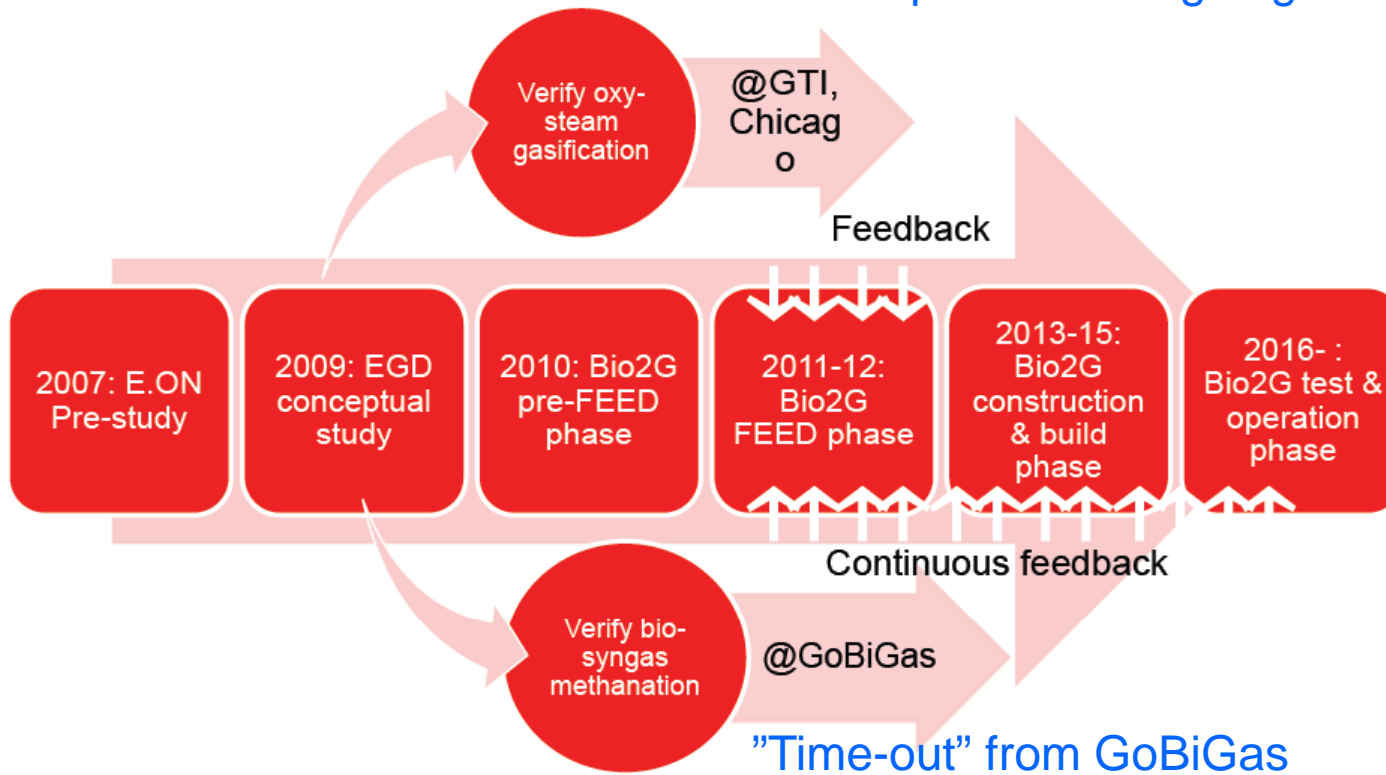


E.ON Bio2G



Roadmap Bio2G

Studies with Carbona and Haldor Topsøe are on-going





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".

VärmlandsMetanol, Sweden HTW Biomass to Methanol Project

- Uhde selected as technology supplier and EPC contractor
- **Plant Capacity:**
100,000 t/a of fuel grade methanol + district-heating 15 MW_{th}
- **Feedstock:**
Domestic forest residue, ~25 t/h
- **Process:**
Fluidized bed gasification (HTW)
(eq. 111 MW_{th})



Flygfoto: Lars Nilsson Montage: Ströcker

VärmlandsMetanol AB

Uhde



ThyssenKrupp



Rottneros

Rottneros Biorefinery AB

(Rottneros AB, Sven Tyrén's foundation and 2Gen AB)

BioMethanol opportunities for Rottneros

Our investment consideration

- 150-200 kton BioMethanol via wood or blackliquor gasification
Ø 1 % of Swedish petrol consumption, 200 MW Biomass
- Capital expenditure of some SEK 3 billion per project
- Possible NER contribution corresponding to some 25 %
- Equity of ~ SEK 1 billion. Rottneros minority
- Very solid EPC-contractor guaranteeing functionality
- Debt financing sweetened by NER contribution to serve interest
- High profitability

*SEB_Enskilda_Biofuel_
Seminar_Sep_28_2011*



MEVA Innovation AB

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

VIPP-VORTEX®, Gasification system

VIPP Cyclone
Gasifier

VORTEX INTENSIVE
POWER PROCESS



VIPP-ECP®, Gas cleaning system

Multistage cleaning

- cyclone
- gas cooling
- RME scrubber
- WESP

Gas engine

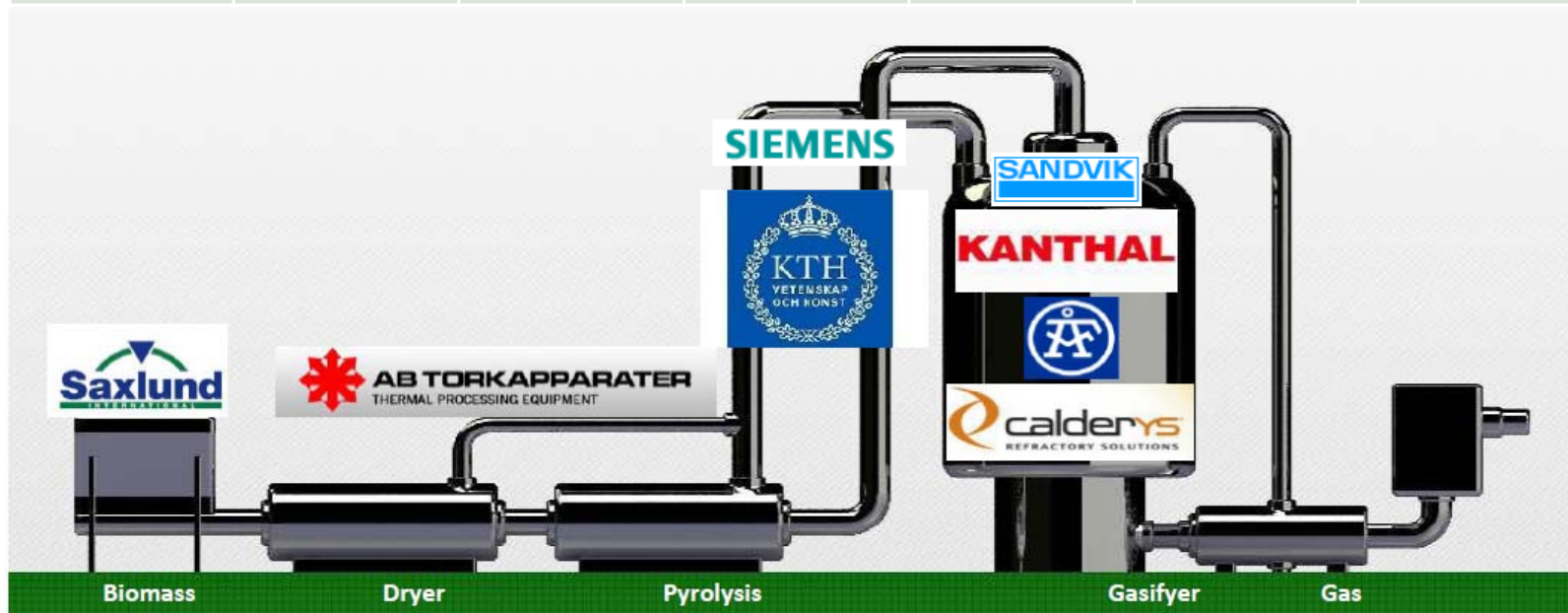
Cooperation on specially designed gas engines with supplier Cummins Power Generation Ltd., UK.





Cortus Wood Roll

Saxlund International / Opcon AB	Torkapparater AB	KTH Royal Institutue of Technology	Sandvik Heating Technology AB – Kanthal	ÅF	Calderys AB	Siemens
Saxlund International / Opcon delivers biofuels feeding equipment to the WoodRoll® process	Torkapparater delivers dryer and pyrolysis equipment to the WoodRoll® process	KTH has provided equipments and facilities for Cortus to run tests on over 20 different fuels	Kanthal delivers radiation tube burners for indirect heating to the WoodRoll® process	ÅF provides Computational Fluid Dynamics modeling for system optimization	Calderys delivers refractory materials to the gasification reactor in the WoodRoll® process	Siemens delivers Control systems and instrumentation





Cortus Wood Roll

The 500 kW plant

- Indirectly heated gasification in industrial scale
- Successful Syngas (CO/H_2) production during autumn 2011
- Financed by the Swedish Energy Agency, Swedish Iron and Steel Society (Jernkontoret), Movexum, AGA Gas AB and Cortus AB
- Relocation to Köping planned.



Construction of the plant



WoodRoll® technology in action





Cortus Wood Roll

DETAILS OF THE DEMO PLANT

Location	Southeast Sweden
Power	5MW (Future: 25MW)
Fuel	30 TPD DS of Biomass
Product	1 550 Nm ³ /h synthesis gas
Investment	€6,5 Million
Unit Price	20 € per MWh (2 + 10 year supply contract)
Environmental permit	Granted in December 2009
Energy supply contract	Signed in July 2010

EXPANSION – STAGE 2 = 25MW



Photo of industrial area of customer site in Sweden.

