

## Country report Sweden

IEA Task 33 meeting



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# Agenda

- Current status of Swedish biomass gasification plants
- Commercial initiatives under development
- Ongoing research programs
- Summary

# Swedish biomass gasification plants - current status

**Cortus WoodRoll 500 kW**  
Demonstration  
In operation

**Rettneros, planned**  
**100 000 t/a methanol**  
**NER 300 rejection 2014**

**Värmlandsmetanol AB**  
**100 000 t/a methanol**  
Planned

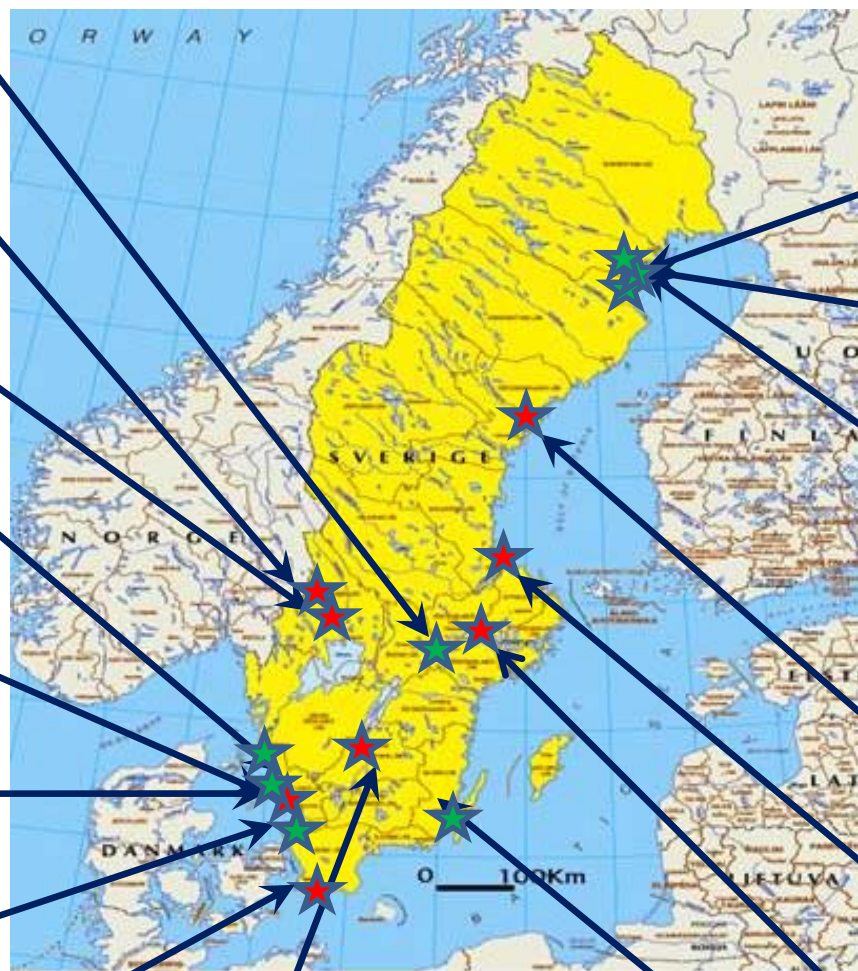
**GoBiGas**  
**20 MW SNG Mothball**  
**Scale-up NER300 2012**

**Chalmers CIBG**  
4 MW pilot

**Värö 25 MW CFB**  
**Lime kiln gasifier, stopped**  
**2014**

**Höganäs**  
**Cortus WoodRoll 6 MW**  
Demonstration start 2019

**E.ON Bio2G**  
**Planned 200 MW SNG**  
**NER 300 2014**



**MEVA**  
**1.2 MW<sub>el</sub> CHP**  
In operation

**RISE 1 MW**  
**PEGB pilot**  
Operational

**LTU Biosyngas 3 MW BL**  
**EF pilot + DME/MeOH**  
Mothball

**Domsjö**  
**Chemrec demonstration**  
**Cancelled 2012**

**Vallvik Biofuel**  
**NER 300 rejection 2012**

**Västerås**  
**Waste gasification CHP**  
**Stopped 2010**

**Värname**  
**18 MW IGCC**  
**Stopped 2000, 2010**

**Emåmejeriet**  
40 kW CHP 2015

## GoBiGas

- The gasifier was operated **in total ~ 12 000 hours. 1 800 hours continuously** 2017-2018
- **100% bio-SNG production capacity** (20 MW) was reached for the **first time in the beginning of 2018**
- Approx. **65 GWh bio-SNG** was produced
- All performance **targets were reached**
- GoBiGas project was due to economic reasons stopped in March 2018 and is currently **in conservation state**





# GoBiGas

- Economic assessment of advanced biofuel production via gasification using cost data from the GoBiGas plant

## The GoBiGas Project

Demonstration of the Production of Biomethane from Biomass via Gasification

Process systems	Cost GoBiGas, MSEK	Reference cost 20 MW, C <sub>ref</sub> , MSEK	Scale factor low	Scale factor	Scale factor high
1 Fuel handling system	50 400	50 400			
1.1 External fuel feeding system			0.50	0.60	0.70
1.2 Internal fuel feeding system, including lock hoppers			0.40	0.50	0.60
2 Gasification and Combustion	29 490	29 490			
2.1 Reactors and refractory			0.60	0.70	0.80
2.2 Condensate treatment and steam generation			0.50	0.60	0.70
3 Primary product gas cleaning	23 780	23 780			
3.1 Product gas cooler			0.60	0.70	0.80
3.2 Product gas filter			0.60	0.70	0.80
3.3 Precipitating and particle handling system, including bed material storage and feed			0.50	0.60	0.70
3.4 Product gas scrubber			0.60	0.70	0.80
3.5 Product gas fan and secondary cooler			0.60	0.70	0.80
3.5 Analyzers			0.30	0.40	0.50
4 Flue gas system	18 930	18 930			
4.1 Flue gas cooler			0.70	0.80	0.90
4.2 Flue gas filter and flue gas fan			0.70	0.80	0.90
4.3 Ash handling system			0.60	0.70	0.80
5 Tar adsorption (AC filter)	10 620	10 620			
5.1 Activated carbon beds			0.70	0.80	0.90
5.2 Regeneration system			0.50	0.60	0.70
6 Compressor	34 590	34 590	0.60	0.70	0.80
7 Olefin hydroperoxide	9060	9060	0.60	0.70	0.80
8 H <sub>2</sub> S scrubber	9150	9150	0.60	0.70	0.80
9 Water Gas Shift reaction	5290	5290	0.60	0.70	0.80
10 Permethanation	5150	5150	0.60	0.70	0.80
11 CO <sub>2</sub> scrubber	17 570	17 570	0.60	0.70	0.80
12 Methanation	19 410	19 410	0.60	0.70	0.80
13 Drying and adsorption	4970	4970	0.60	0.70	0.80
TOTAL COST, PROCESS SYSTEMS, SEK	238 410	238 410			

Auxiliary equipment and project costs	Cost GoBiGas, MSEK	Reference cost 20 MW, C <sub>ref</sub> , MSEK	Scale factor low	Scale factor	Scale factor high
A Auxiliary equipment	146 520	146 520			
A.1 Plant			0.60	0.70	0.80
A.2 Hot water system			0.40	0.50	0.60
A.3 Instrumentation and Control system (DCS)			0.30	0.40	0.50
A.4 Power distribution			0.40	0.50	0.60
A.5 Electrical and Instrument installation			0.30	0.40	0.50
A.6 Compressed air system			0.50	0.60	0.70
A.7 Fire protection system			0.50	0.60	0.70
A.8 Inert gas system			0.50	0.60	0.70
A.9 Safety and security			0.30	0.40	0.50
A.10 Laboratory and sampling system			0.20	0.30	0.40
B Civil	219 910	178 960 <sup>a</sup>			
B.1 Ground preparation			0.50	0.60	0.70
B.2 Foundations			0.30	0.40	0.50
B.3 Buildings, including lights			0.40	0.50	0.60
B.4 Explosion protection walls			0.40	0.50	0.60
B.5 HVAC			0.50	0.60	0.70
C Structural steel	48 000	48 000	0.40	0.50	0.60
D Piping, Mechanical equipment, and insulation	266 640	213 312 <sup>a</sup>	0.50	0.60	0.70
E Services	460 330	368 264 <sup>a</sup>			
E.1 Engineering			0.20	0.30	0.40
E.2 Construction Services and Commissioning			0.20	0.30	0.40
E.3 Start up			0.20	0.30	0.40
E.4 Other project services			0.20	0.30	0.40
TOTAL COST, AUXILIARY EQUIPMENT AND PROJECT COSTS	1 141 400	955 056			
TOTAL COST, GRAND TOTAL	1 379 810	1 193 466			



Göteborg Energi

Energimyndigheten

<https://www.goteborgenergi.se/om-oss/vad-vi-gor/forskning-utveckling/gobigas>

# LTU Green Fuels



Pilot BL gasification	Pilot methanol + DME	Field testing
3 MW, 20 t DS/d	4 t/d methanol/DME	Volvo Trucks DME
>28 000 h since 2005	>12 000 h since 2011	8 trucks, >1 500 000 km
Recovery of cooking chemicals without difficulties		DME and methanol in industrial applications
Opportunities for exp. campaigns 24/7, high availability		

# LTU Green Fuels



The screenshot shows the Luleå University of Technology website. The header includes the university logo, navigation links for Education, Research, and Meet the University, and a search bar. A sidebar on the left lists various categories under Energy Engineering, with 'News' selected. The main content area features a large image of a commercial airplane in flight, with the text 'Wants to produce and test bio jet fuels on Swedish forest-based residue' overlaid. Below the image is the article title 'Researchers want to test-fly Swedish bio jet fuel 2021', the publication date 'Published: 14 November 2018', and social media sharing icons. The article text states that Luleå University of Technology has been granted funding by the Swedish Energy Agency for a preparatory study, aiming to produce and test bio jet fuel on Swedish forest-based residues. It also mentions the preliminary study will facilitate and risk minimize a first commercial plant for the production of aviation bio jet fuel. A small box on the right side of the article mentions 'On-going projects about bio jet fuel' and lists several partners in the project, including SAS, BRA airlines, Dutch SkyNRG, RISE, German Inerac and Schmidtsche Schack, Smurfit Kappa Piteå, Sveaskog, Fly Green Fund, and Svebio. It also mentions Swedavia, owner of airports in Sweden and KLM has written support letters and will follow the progress of the project. The Swedish Energy Agency writes in the granted application that the project has the potential to contribute to the development and increase use of sustainable biofuels for airplanes in Sweden.

<https://www.ltu.se/research/subjects/Energiteknik/Nyheter-och-aktuellt/Forskare-vill-testflyga-svenskt-biobransle-2021-1.181623?l=en>



# Cortus WoodRoll® at Höganäs

- **Cortus 6 MW WoodRoll® gasifier** at the **Höganäs steel plant** was officially inaugurated **in June 2018**
- Replaces parts of the fossil natural gas use
- Issues with the installation solved
- **Full operation** scheduled during **2019**



# Cortus WoodRoll® & Engie

- Hydrogen production using **Cortus 6 MW WoodRoll® gasifier**
- Pre-project study H1 2018
- Project Study + pilot tests H2 2018
- FID expected 2019



# Cortus WoodRoll® & Swedish Biofuels

## Cortus Energy and Swedish Biofuels Cooperate for the World's First Bio-Jet Fuel Plant Based on Forest Resources

Cortus Energy AB (Publ) and Swedish Biofuels AB (SB) have agreed in a preliminary agreement about cooperating with the goal of during 2019, jointly projecting a first commercial plant for production of bio-jet fuel based on forest raw material and alcohols for the Arlanda airport needs.

Initial contacts around land, logistics, fuel and licensing has been taken during the winter. Cortus and SB's joint facility for bio-jet fuel will be first of its kind and with a great global market potential. SB's bio-jet fuel now complies with current standards jet fuel, and it has been successfully tested by the US and Swedish defense forces and for civil aviation over the past ten years.

In addition to green jet fuel, the plant will be able to produce other valuable products such as liquid transport fuels and chemicals. The technology planned for the plant is a combination of Cortus WoodRoll® process and SBs catalytic process for bio-jet fuel. The WoodRoll® process converts wood into synthesis gas which, along with alcohols, is the raw material for SB's catalytic process for green jet fuel.

"Our joint project for bio-jet fuel from forest raw material represents everything we have worked for, for almost twenty years. Because we have already met current standards for jet fuel with our technology, we now see a possible commercial breakthrough for green aviation fuel, first in Sweden and then further out in the world" says Angelica Hull, CEO and founder of Swedish Biofuels.

Cortus PM, Feb 2019



# MEVA CHP-plant in Hortlax



- Energy outputs  $1.2 \text{ Mw}_{\text{el}}$  and  $2.4 \text{ MW}_{\text{th}}$
- **Entrained flow cyclone gasifier** emanated from research at Luleå University of Technology
- **Small fraction fuels** (sawdust, wood fibers and agricultural residues)
- **Applications:** CHP, fossil process gas replacements and industrial drying processes



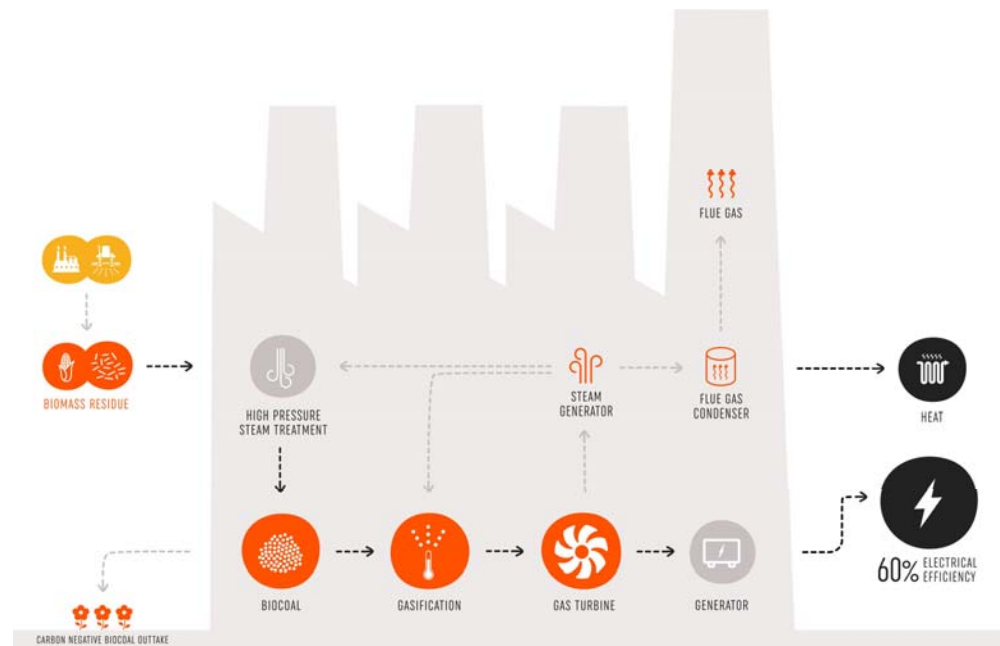


# Commercial initiatives under development

# Phoenix Biopower



- The Biomass-fired TopCycle - the BTC - high-pressure steam treatment and entrained flow gasification
- Gas turbine for power generation
- Aiming at electrical efficiency of up to 60 %



## Plagazi®

- The Plagazi® Process aims at hydrogen production from Municipal Solid Waste (MSW), Auto Shredder Residue (ASR), car tires, Refuse Derived Fuel (RDF), industrial waste, wood chips or mixtures thereof
- Conceptual design for a waste-to-energy plasma gasification plant (40 tons per hour = 350,000 tons waste per annum)
- Plasma technology (Westinghouse Plasma) with three cleaning stages
- Company status unclear

# Research activities

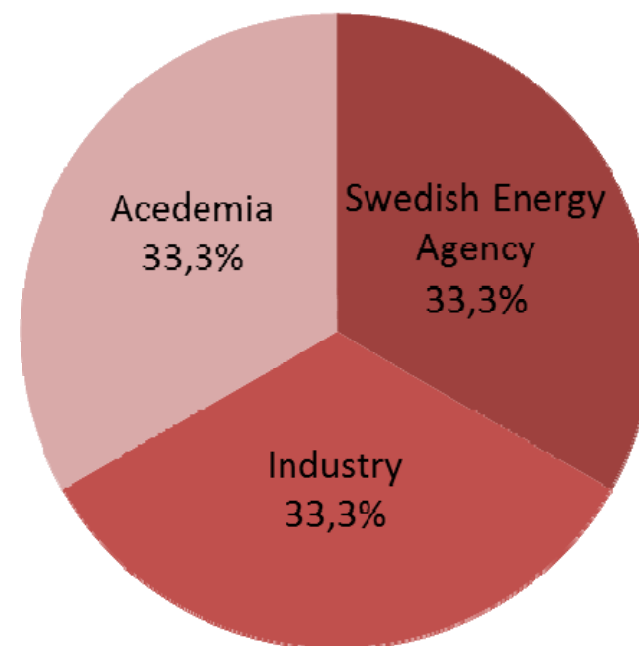


# Ongoing Swedish Gasification-related R&D Programs

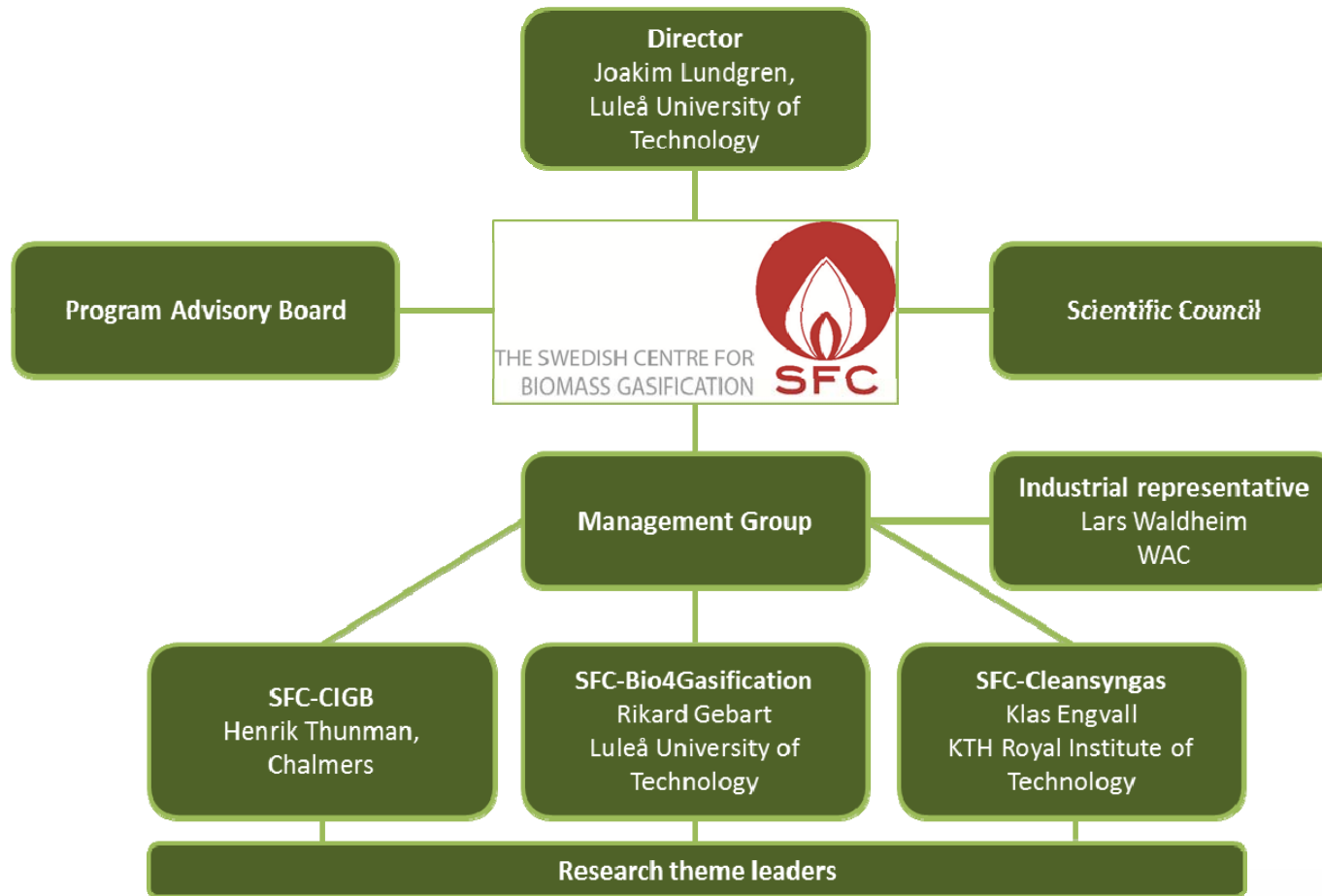
- **Swedish Gasification Centre (SFC):** 2011-2021, budget 54 M€
- **Swedish Knowledge Centre for Renewable Transportation Fuels (f<sup>3</sup>):** New phase 2018-21, budget 3.3 M€
- **Swedish Energy Agency's biofuel program:** On-going 2017-21. Both thermal and bio-chemical conversion, budget 18 M€
- **SEBRA (CHP):** 2016-19, budget 6 M€
- **Biofuels for Sweden 2030:** 2017-20, budget 0.6 M€

# Swedish Gasification Centre (SFC)

- Annual budget 6 million Euro per year in 10 years until 2021
- In total, 20 companies, 8 universities and one research institute
- 25-30 senior researchers and 30-35 PhD students (>20% funding from SFC)

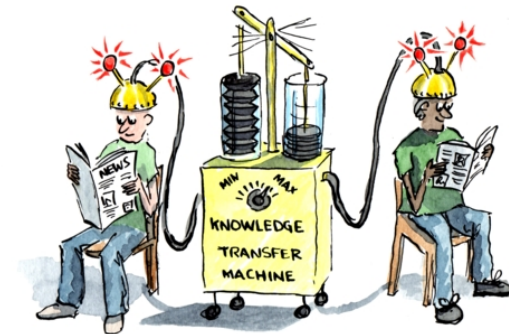


# SFC Organisation



# The main roles of SFC

- Strengthen and coordinate Swedish gasification R&D and foster a new generation of gasification competence in Swedish academy and industry
- Serve as a national network for knowledge transfer and problem solving within the field of gasification
- Facilitate commercialization of advanced gasification of biomass and waste





# SFC Academic and governmental partners



**CHALMERS**



**IEA Bioenergy**

[www.ieabioenergy.com](http://www.ieabioenergy.com)

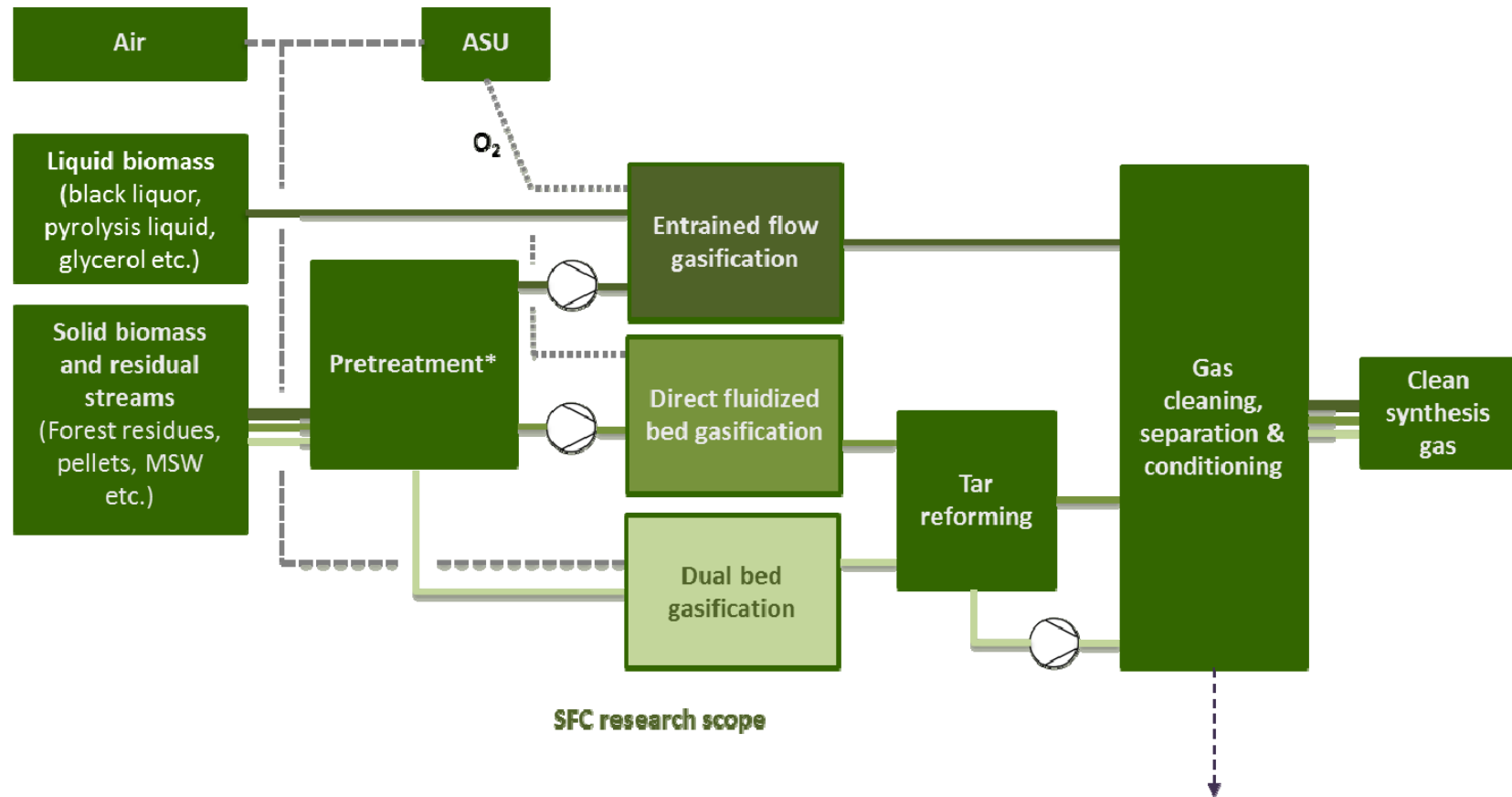
## SFC Company partners



IEA Bioenergy

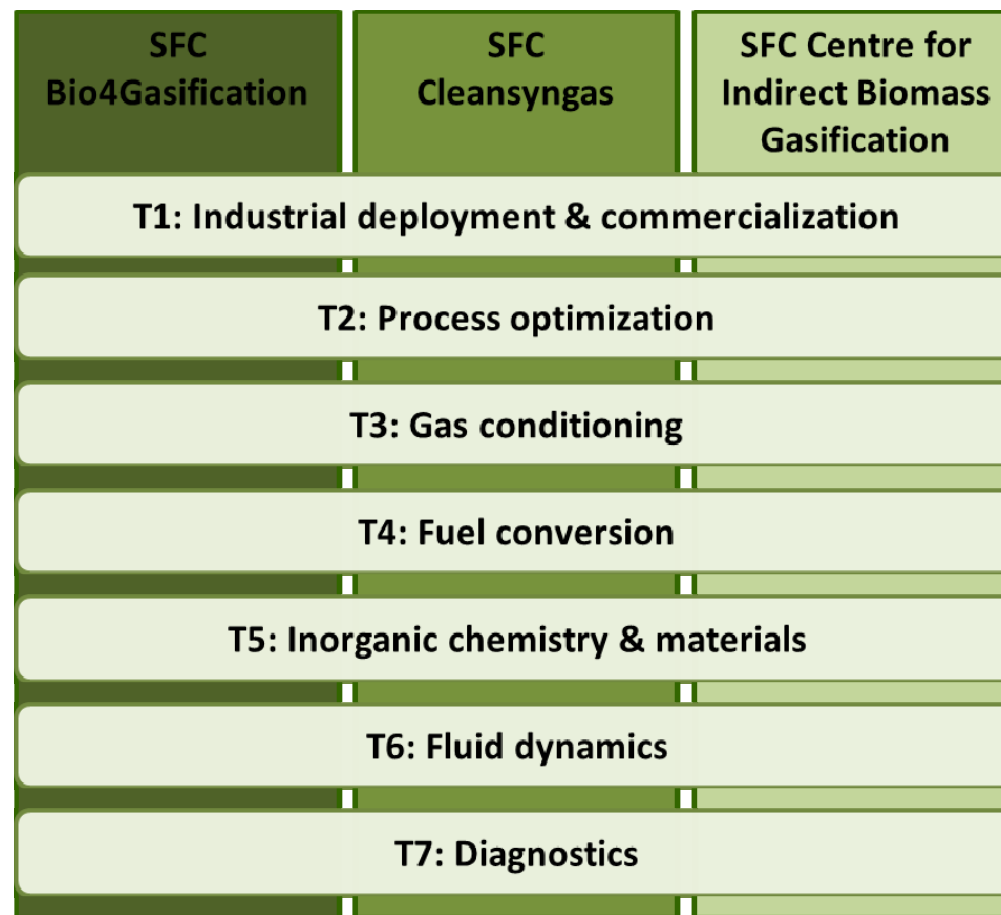
[www.ieabioenergy.com](http://www.ieabioenergy.com)

# Swedish Gasification Centre (SFC)



\*Only pretreatment research with strong connection to biomass gasification  
(I.e fuel impregnation, Integrated pyrolysis, etc)

# Swedish Gasification Centre (SFC)





## Summary

- The GoBiGas and LTU Green Fuels plants are technical successes – both currently in conservation state
- With lacking long term policies, strong efforts are put on gasification research and education (SFC)
- Stronger focus on waste feedstocks
- Several gasification projects in Swedish steel industry and for aviation applications. Also interest from the chemical industry

*Thanks!*

IEA Bioenergy



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