

IEA Bioenergy

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_{el} 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

Process systems	Cost GoBiGas, kSEK	Reference cost 20 MW, C ₂₀ , kSEK	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	29 400	29 400			
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 fuel 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 filters)	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 hydrogenation	9060	9060	0.60	0.70	0.80
8 H ₂ 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 ₂ 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, kSEK	Reference cost 20 MW, C ₂₀ , kSEK	Scale factor low	Scale factor	Scale factor high
A Auxiliary equipment	146 520	146 520			
A.1 Flare			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 ^a			
B1 Ground preparation			0.30	0.40	0.50
B2 Foundations			0.30	0.40	0.50
B3 Buildings, including lights			0.40	0.50	0.60
B4 Explosion protection walls			0.40	0.50	0.60
B5 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 ^b	0.50	0.60	0.70
E Services	400 330	368 264 ^c			
E1 Engineering			0.20	0.30	0.40
E2 Construction Services and Commissioning			0.20	0.30	0.40
E3 Start-up			0.20	0.30	0.40
E4 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			

The GoBiGas Project

Demonstration of the Production of Biomethane from Biomass via Gasification



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 top navigation bar includes 'LULEÅ UNIVERSITY OF TECHNOLOGY', 'EDUCATION', 'RESEARCH', 'MEET THE UNIVERSITY', and a search icon with 'STUDENT STAFF PÅ SVENSKA'. A left sidebar menu lists: 'Energy Engineering', 'News', 'Research areas +', 'Project archives', 'Third-cycle qualification', 'Publications', 'Postgraduate studies', 'Laboratories and equipment', and 'Contact us'. The main content area features a large image of an airplane in flight with the caption 'Wants to produce and test bio jet fuels on Swedish forest-based residue'. Below the image is the article title 'Researchers want to test-fly Swedish bio jet fuel 2021', published on 14 November 2018. The article text states: 'Luleå University of Technology has been granted funding by the Swedish Energy Agency for a preparatory study, and hopefully, within a few years, they can test to produce bio jet fuel on Swedish forest-based residues - and test-fly it on commercial flights in Sweden. The preliminary study will facilitate and risk minimize a first commercial plant for the production of aviation bio jet fuel on Swedish forest-based residues.' A small box on the right titled 'On-going projects about bio jet fuel' mentions that Luleå University of Technology is part of several projects concerning the development of bio jet fuel in Sweden, signed a Letter of Intent (LOI) in May 2018 with Södra, KLM, SkyNRG, Fores, and others.

<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 SB's 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 Mw_{el} and 2.4 MW_{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

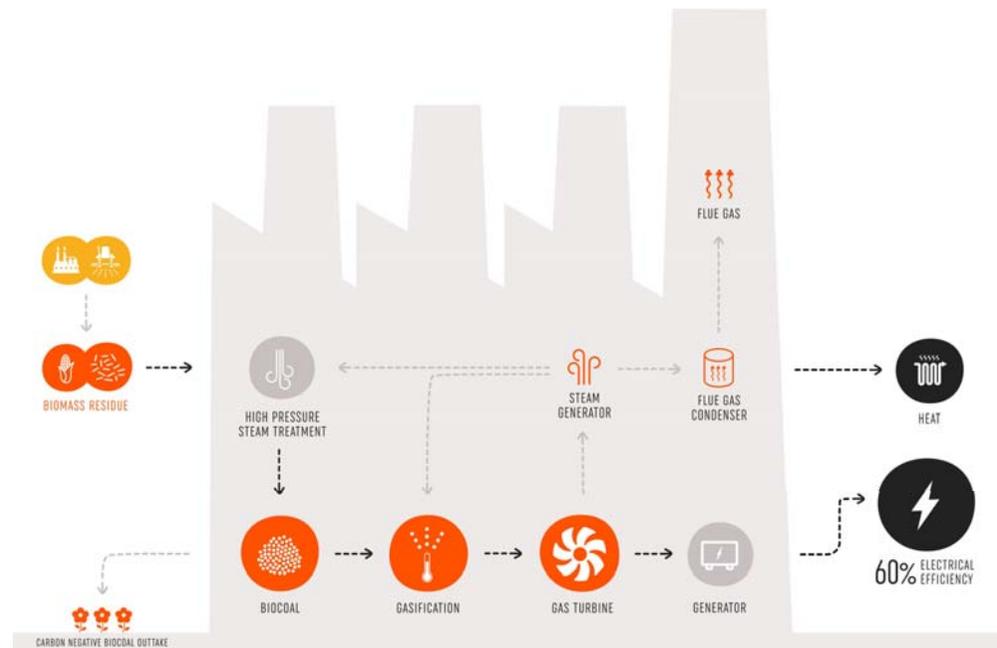


Commercial initiatives under development

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

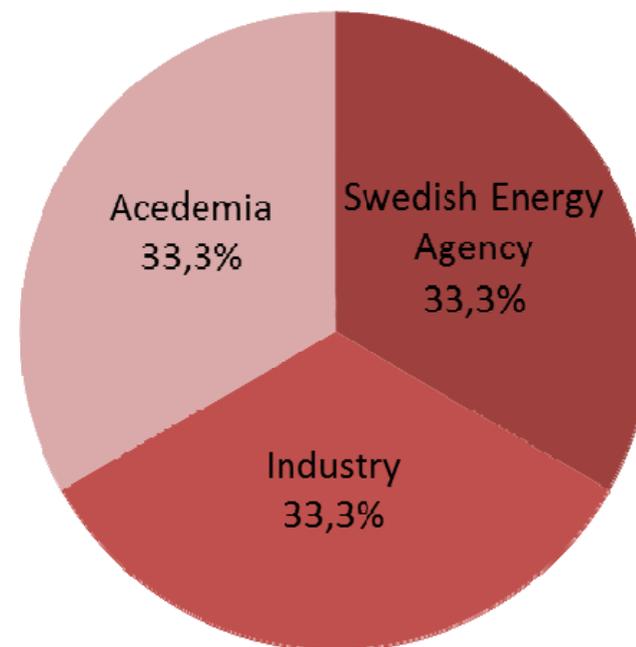
Research activities

Ongoing Swedish Gasification-related R&D Programs

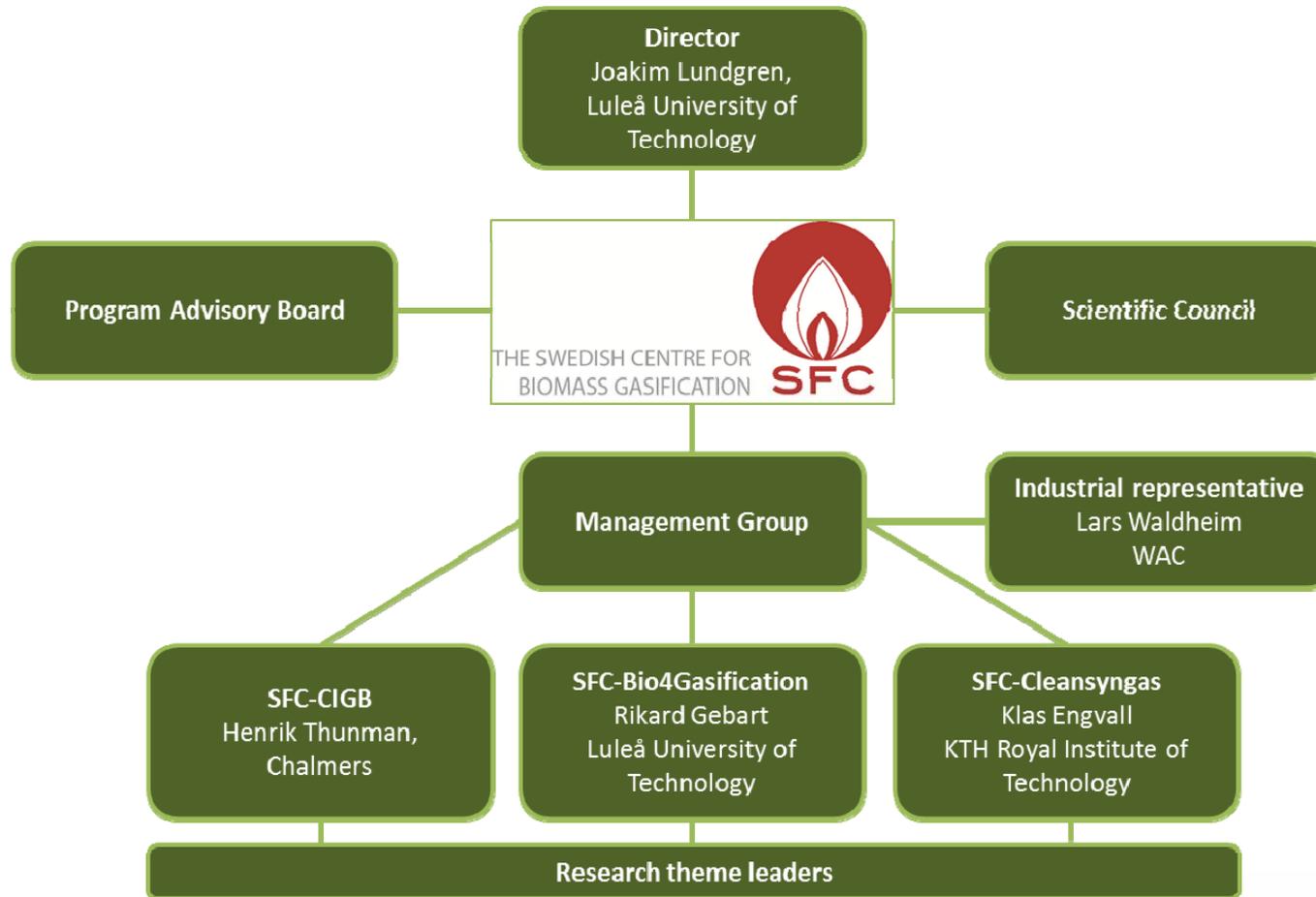
- **Swedish Gasification Centre (SFC):** 2011-2021, budget 54 M€
- **Swedish Knowledge Centre for Renewable Transportation Fuels (f³):** New phase 2018-21, budget 3.3 M€
- **Swedish Energy Agency's biofuel program:** Ongoing 2017-21. Both thermal and bio-chemical conversion, budget 18 M€
- **SEBRA (CHP):** 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)

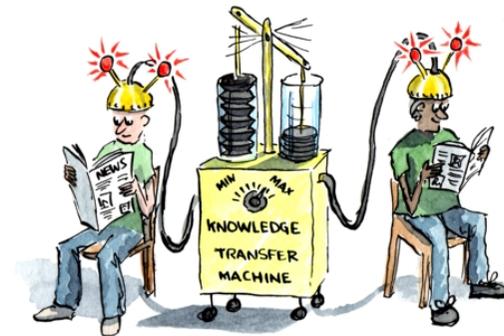


SFC Organisation



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



GÖTEBORGS UNIVERSITET



LUNDS
UNIVERSITET
Lunds Tekniska Högskola



IEA Bioenergy

www.ieabioenergy.com

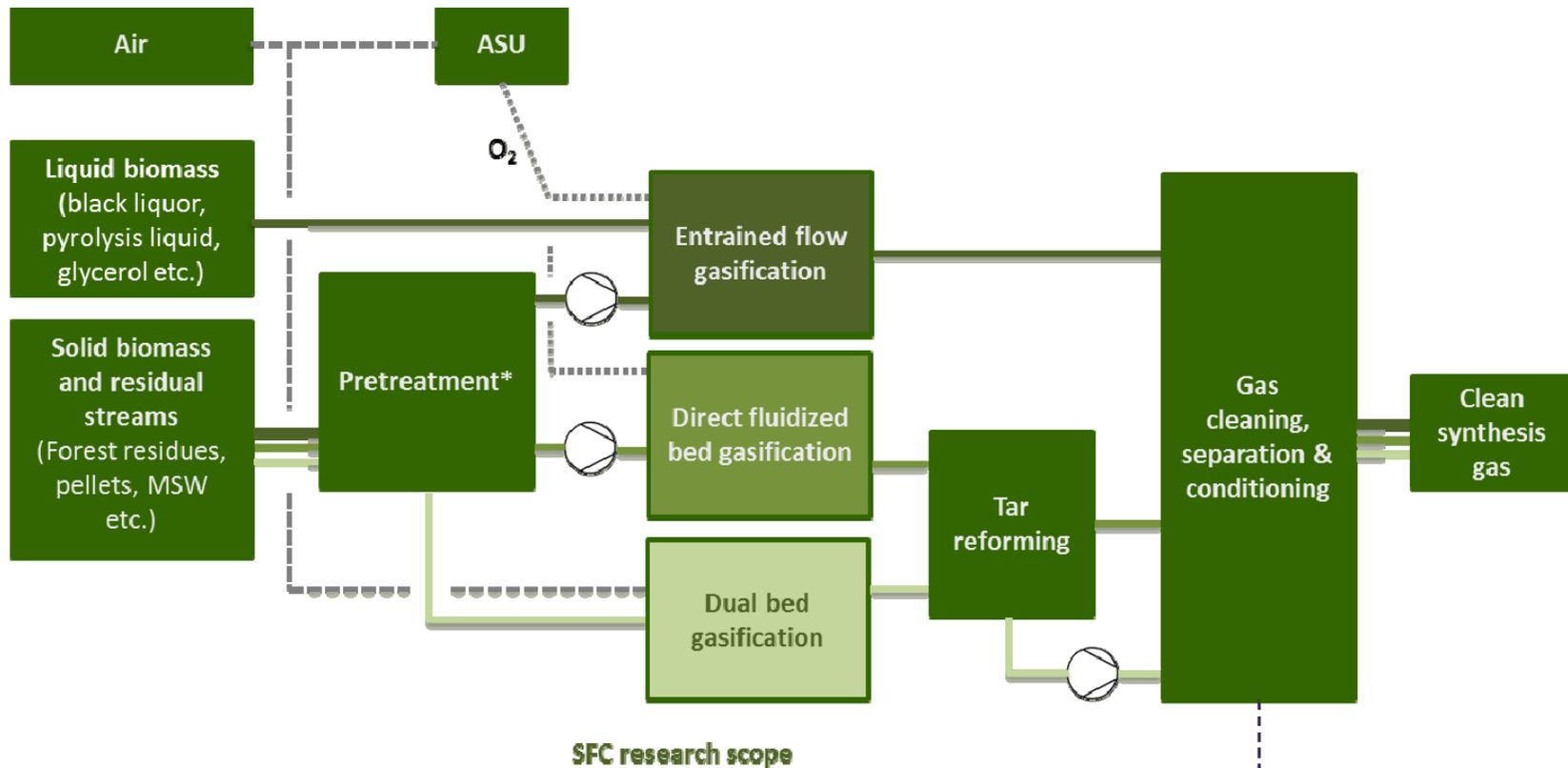
SFC Company partners



IEA Bioenergy

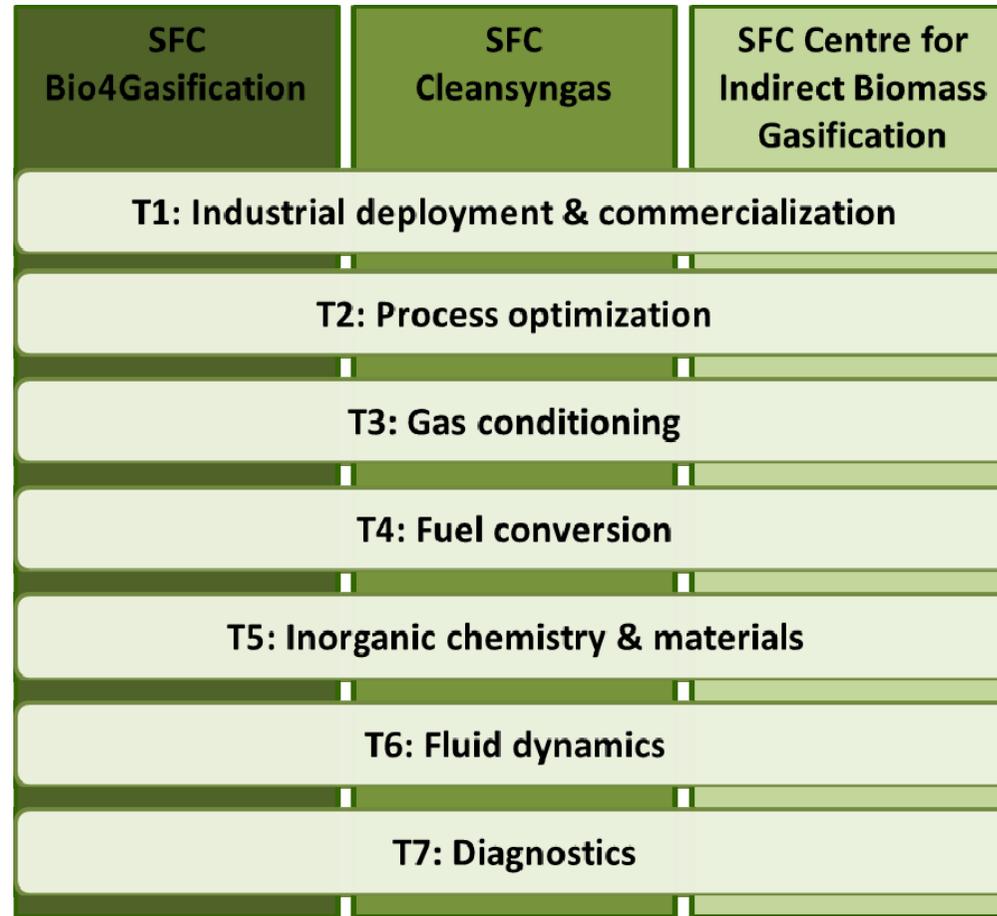
www.ieabioenergy.com

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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