Drifterfarenheter från förgasnings-anläggningar av biobränslen

Nya rön om el och värme, SEBRA Energiforsk

2016-06-16

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The gasification potential relies on the availability

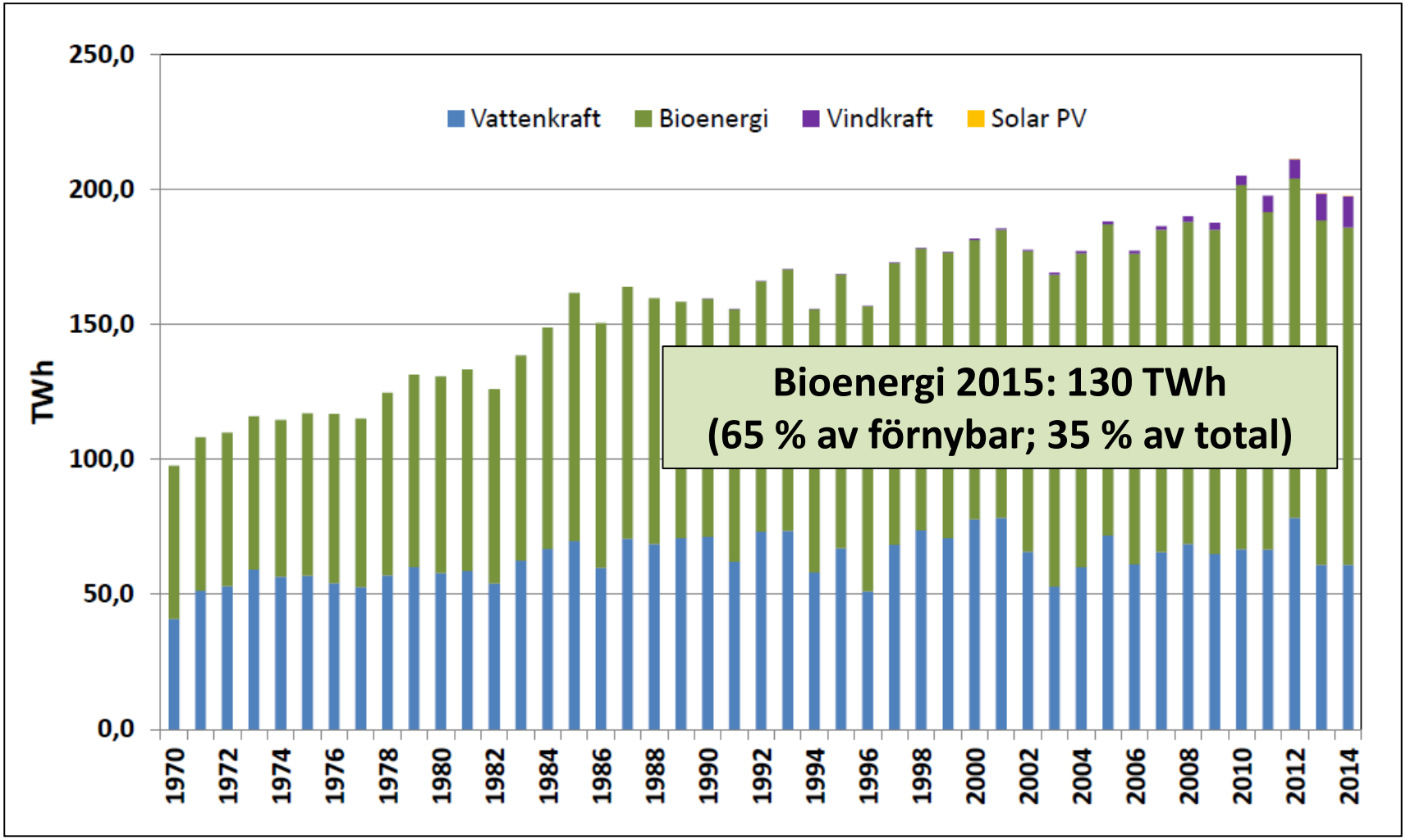
- **Report title: Operating experiences of biomass gasification plants for combined power and heat production and industrial applications**
- Authors: Tomas Ekbom, Erik Rensfelt and Eva Katrin Lindman
- The report has investigated 22 gasification plants with objective to increase knowledge of operating experience and technology competitiveness.

SVEBIO

- Swedish Bioenergy Association founded in 1980
- Interest organisation for companies and private persons
- Almost 300 member companies - producers, users, manufacturing firms, consultants and service companies etc.

Our mission is to increase the use of bioenergy in an economically and environmentally optimal way.

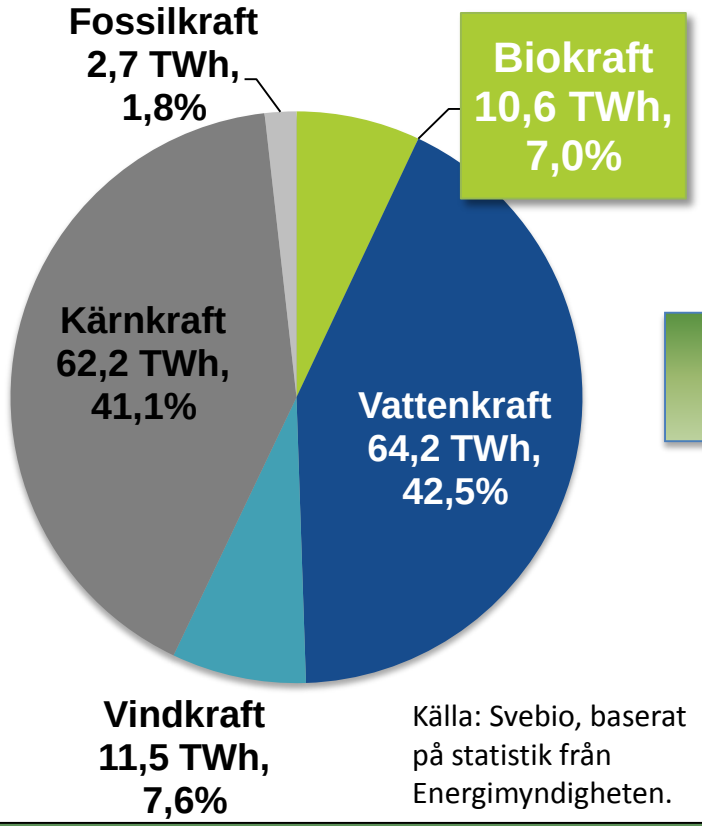
Total tillförsel av förnybar energi i Sverige, 1970-2014: 2015: 201 TWh eller 53 % av total slutlig energianvändning



Källa: Svebio, baserat på statistik från Energimyndigheten.

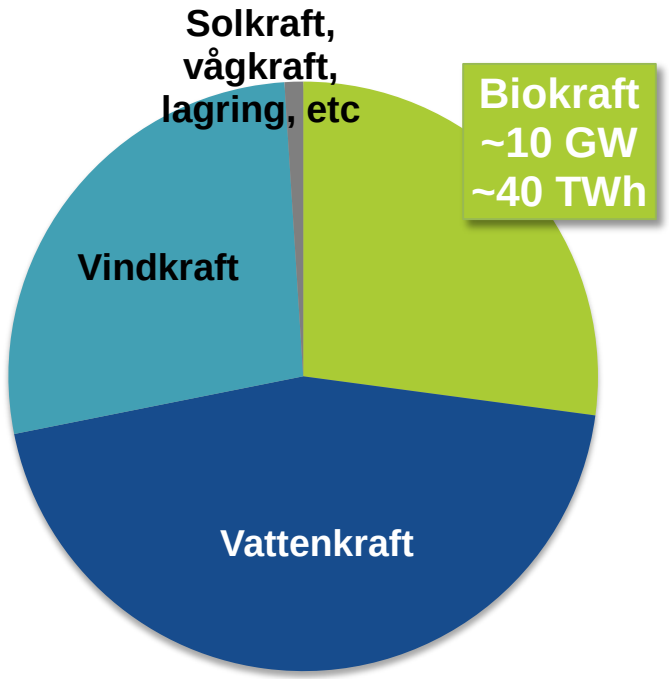
Biobränslebaserad kraftproduktion, nu och i framtiden:

Sveriges elproduktion 2014 (151,2 TWh):



Källa: Svebio, baserat på statistik från Energimyndigheten.

Sveriges elproduktion 2040?



Källa: Svebio

SVEBIO och Biokraftplattformens vision:

Biokraft år 2040 har 10 GW effekt som ger 40 TWh el per år!

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Coal based electricity generation in Europe

Ref: Eurostat [GWh]

	1990	1995	2000	2005	2010	2011	2012	2013
Total gross electricity production	2 594 780	2 742 951	3 035 193	3 325 137	3 364 421	3 296 044	3 296 551	3 261 537
Solid fuels	**1 019 429**	**945 866**	**933 855**	**960 571**	**830 156**	**851 472**	**901 699**	**871 835**
Anthracite	0	0	0	18 184	10 494	18 384	16 987	10 872
Coking Coal	52 696	59 159	37 874	37 092	16 232	18 570	24 142	5 338
Other Bituminous Coal	599 054	538 704	530 968	538 773	463 477	453 957	498 175	507 266
Sub-Bituminous Coal	7 679	10 640	6 380	5 771	3 378	5 631	5 292	4 289
Lignite/Brown Coal	337 807	320 479	344 081	341 162	313 652	333 501	338 213	323 717
Peat	5 137	7 843	5 902	7 486	9 402	8 346	6 768	6 012
Patent Fuel	0	0	0	0	0	0	0	0
Coke Oven Coke	837	0	0	0	2	4	3	2
Gas Coke	0	0	0	0	0	0	0	0
Coal Tar	0	0	64	100	19	6	3	4
BKB	1 510	765	923	2 715	2 455	2 166	2 411	2 925
Oil shale and oil sands	14 709	8 276	7 663	9 288	11 045	10 902	9 702	11 406
Peat products	0	0	0	0	0	5	3	4

Gross potential for replacement of coal: 3260 TWh el.

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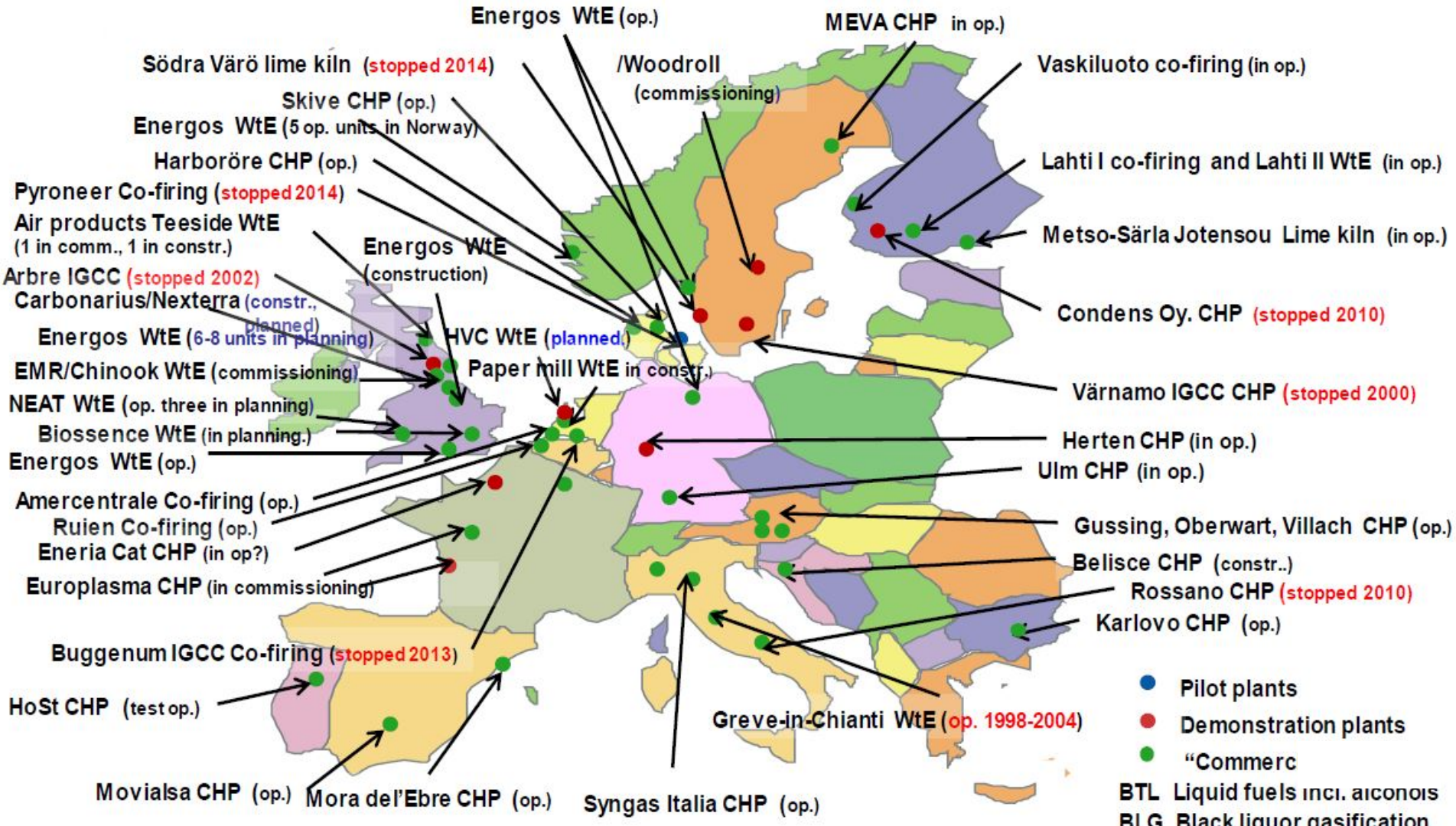
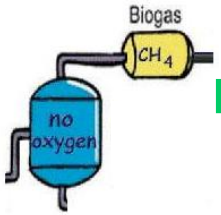
Biomass gasification plants in Europe



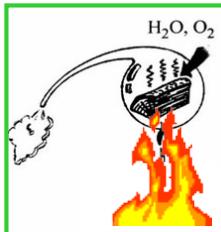
Ref: Lars Waldheim Waldheim Consulting

Gasification gives high flexibility in applications plus torrefaction and pyrolysis can be pre-steps


Torrefaction

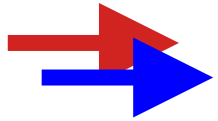


Pyrolysis, Carbonizer



Gasification


Power


Heat/Cool


Chemicals


Fuels

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4 Processes in Gasification

not necessarily in order

Drying	Pyrolysis	Combustion	Reduction
H_2O	Charcoal and Tar	H_2O and CO_2	H_2 and CO
			
biomass*(C H O)	biomass*(C H O)	tarry gas or charcoal	hot charcoal (C)
heat	heat no air	O_2/air	CO_2 and H_2O

* Biomass is a combination of C, H, and O ($C\ H_{1.4}O_{0.6}$)

The Reduction Reactions

The Heart of Gasification

C
carbon

INPUT

$CO_2 + H_2O$
carbon dioxide + water vapor

Red Hot Charcoal Bed

OUTPUT

$H_2 + CO$
hydrogen + carbon monoxide

REACTIONS

$CO_2 + C = 2CO$
carbon dioxide + carbon = carbon monoxide

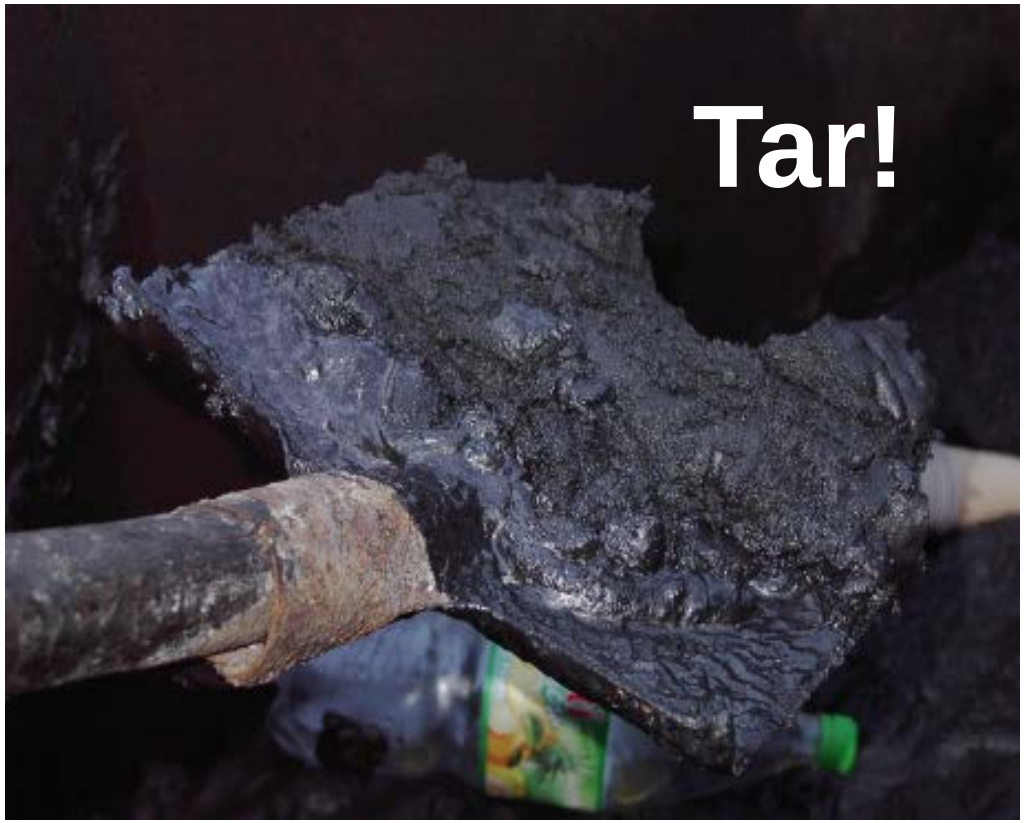
$H_2O + C = H_2 + CO$
water vapor + carbon = hydrogen + carbon monoxide

Sweden has long gasification experience

- **Studsvik (1983-1986):** TPS and KTH developed 2.5 MW Mino-gasifier intended for methanol production as alternative biofuel
- **Värnamo (1993-1999):** Sydkraft and Foster Wheeler built unique 18 MW gasification plant with combined cycle
- **Piteå (1997-2016):** Chemrec builds a 3 MW black liquor gasification pilot plant in 2005 and Bio-DME plant in 2009
- **Piteå (2009-):** Meva Energy builds a 4.5 MW cyclone gasification commercial demo plant for Pite Energi at Hortlax
- **Göteborg (2013-2020?):** Göteborg Energi builds the GoBiGas I pilot plant for 20 MW biomethane production
- **Hultsfred (2015-):** Emåmejeriet builds a commercial 0.5 MWth Volter gasifier plant with gas engine
- **Köping (2016-):** Cortus Energy demonstrates a 0.5 MWth pilot plant with pyrolysis and in-direct entrained-flow gasification

Tar is a major problem which have slowed the commercialization development

- Tars is common name for light and heavy hydrocarbons, like Benzene, Toluene, Xylene (BTX), Naphthalene, other light and heavy tars
- Tar fouls heat-exchangers and creates a waste water problem
- Tar contains valuable energy potentially lost
- Tar is difficult to handle and are hazardous as well as poses a risk for fire



Gasification concepts at different scales

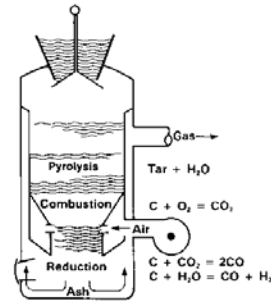
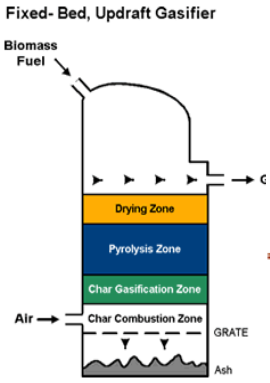
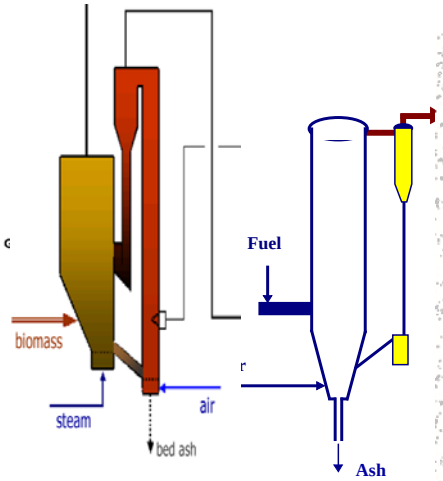
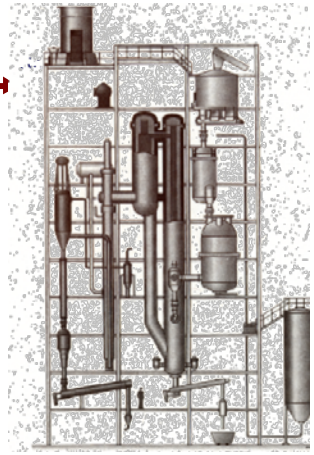
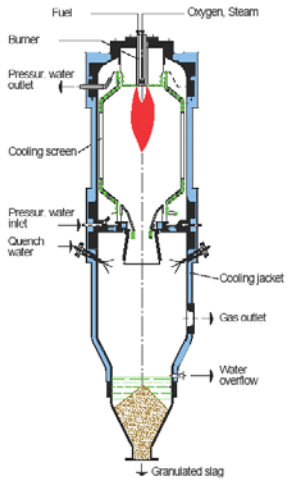


Figure 8-7. Schematic Diagram of Downdraft Gasifier









Updraft fixed bed

Downdraft fixed bed

Indirect double bed

CFB or BFB

CFB

Pressure > 1 MPa

Entrained-Flow

100 kW **1 MW** **10 MW** **100 MW** **Fuel**

The potential relies on the availability

- There is a large potential of wood fuels gasification for multitude of high-value products.
- However, the general knowledge in the energy industry of this is often low. One reason may be the limited number of commercial plants been built.
- Several gasification concepts show high power yields at competitive costs and a most promising market is small-scale power plants.
- However, the plant operation availability is of great importance for new production plants.
- The gasification plants can be analysed by their respective gas cleaning: **limited** or **advanced** or **deep gas cleaning**.

Visited plants with plant tours and deep interviews, part 1 (2)

Visited plants with plant tours and deep interviews, part 2 (2)

High availability for plants with simple gas cleaning, while advanced cleaning takes time…

Project/plant	Process	Normal	First 12 months	Tot avail.	Current avail.	Accumulated hours
Värö	CFB	8300 h?	No data	No data	No data	>90 000 h
Bioneer	Updraft	8000 h	No data	>99%	>99%	200 000 h on each gasifier
Harboöre	Updraft	8000 h	No data	>95%	97% gasifier, 95% engine	150 000 h gasifier, 65 000 h per engine
Kymenjärvi I	CFB	7000 h	No data	98%	96-99%	27 000 h
Corenso	CFB	No data	No data	90-95%	90-95%	23 000 h (Dec 2005)
Güssing	FICFB	7500 h	3200 h gasifier, 1300 h engine	>7000 h = 93%	7700 h (2012)	>80 000 h gasifier, >80 000 h engine
Skive	BFB	(+90% for new plant)	(+80% for new plant)	70-80%	80-90%	20 000 h
Oberwart	FICFB	7500 h	1530 h = 20%	82% (goal 86%)	7500 h	26 200 until Dec 2013
Westbury	BFB	8000 h (design)	No data	No data	95-96%	+5000 h
Varkaus	CFB	4740 h (calc from %)	94.3% gasifier 47.2% slipstream	70% (average)	96% gasifier 93% slipstream	Gasifier 9000 h, Gas cleaning 5500 h
Hortlax	VIPP	8000 h, >85%	<5%, very low	<5%, very low	Reported as good	A few hundred hours
Vaasa	CFB	6500 h	97%, 5000 h (first season)	98%	99%	>9000 h
Gobigas I	FICFB	8000 h	2400 h first 12 months??	No data	No data	>1200 h (Oct 2014)

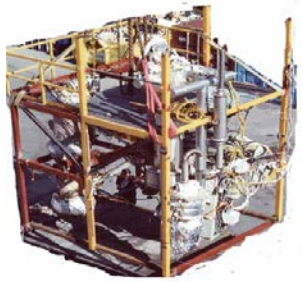
Total: 3000 h as of April 2015

Small-scale gasification plants show promising market potential

- There are plenty of gasifiers around the world, but most of them are coal based. Biomass systems are commercially available only in last years (except CFB limekiln and fix-bed updraft Bioneer).
- One-step gasifiers without further gas cleaning can be reliable and rather quickly started up even with fully automatic operation.
- The experience with multistep processes with advanced gas cleaning is much more difficult. Even demonstration for a very long time, there are still many costs still to be taken.
- However, the Enerkem technology is now taking the step to commercial scale. This show that development to commercial scale only to a minor part is technology based.

The development path to reach full potential should not be underestimated

1-10 kg/hr



100-1000 kg/hr

Mino pilot

Pilot plant

Proof of concept

Main process units

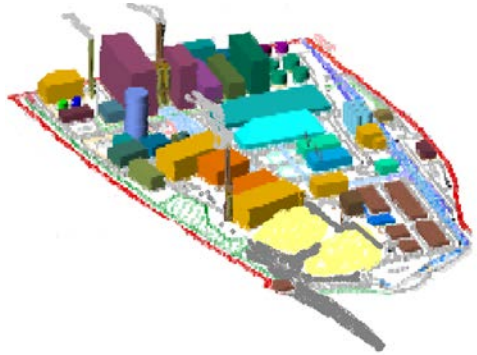
1-10 tonnes/hr

Demo plant

Scale-up intermediate

Non-fully integrated

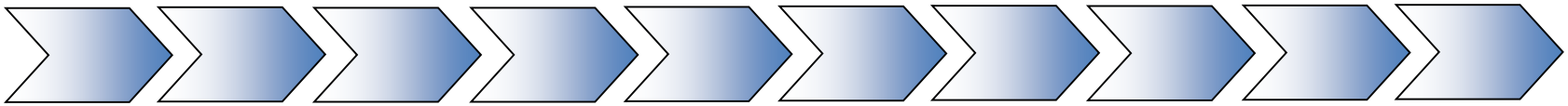
10-100 tonnes/hr



Industrial Prototype

Fully integrated

At industrial scale



The potential can not be reached if plants are to be shutdown and knowledge is lost…

- The **Gobigas I wood gasification plant** in Gothenburg is under audit and the owners has decided to cancel the Gobigas II project for commercial biomethane production.
- The **LTU Green Fuels black liquor gasification plant** for biomethanol and bio-DME in Piteå has just been shutdown.
- The **Oberwart gasification plant** which also tested hydrogen production and fuel cell is under discussion for closure.
- **Andritz** have laid off all employees in the Finnish gasification business unit, only offering plants for lime-kilns.
- Many gasification companies last years were bankrupt or faced plant closures: **Coskata, Chemrec, Choren, Battelle, Range Fuels, TPS**…

The plant availability can approach 100%

- It differs extremely between technologies for first 12 months of operation. Availability can be assumed to be low for a new demonstrated technology, most possibly below 40%.
- For well-known technologies (e.g. fixed-bed gasifiers with limited cleaning) the availability can be very high, approaching 100%.
- Commercial demo plants show first years of troublesome operation. After lessons learned, availability can be acceptable 80-85% and for a couple even >95%.
- All gasification technologies have potential for high availability **if the process difficulties are corrected**.
- Availability is of great importance, not only for economics but also as such to compete with other tech's in new plant investments.

Europe’s newest gasification power plant?

Sweden’s first commercial micro-gasifier

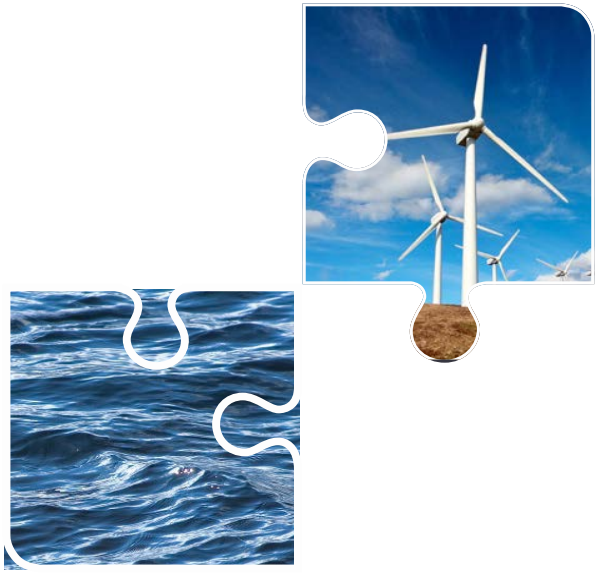
Inauguration: 28 Oct 2015: Emåmejeriet in Hultsfred

Technology: Volter gasifier and gas engine

Capacity: 40 kW power, 150 kW heat

CAPEX: 3 million SEK

Förgasning kan bidra till en framtid till 2040 för biokraft med mål 10 GW installerad effekt som ger 40 TWh elenergi per år!



***Biokraft*, Vattenkraft, Vindkraft och Solkraft –**
fyra pusselbitar i framtidens 100 % förnybart energisystem.

SVEBIO