Bilateral
WOOD-TECH-Workshop:
Decentralised bio energy systems and sustainable wood based bio-technologies in the forest rich region of Tomsk, Siberia

Future ecological technologies based on the production of the improved biogas

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Object

Biogas is produced during anaerobic digestion of organic substrates, such as manure, sewage sludge, the organic fractions of household and industry waste, and energy crops.

The worldwide biogas production is unknown, but the production of biogas in the European Union was estimated to be around 70 TWh in 2007. The biogas production in the European Union has steadily increased over the last years

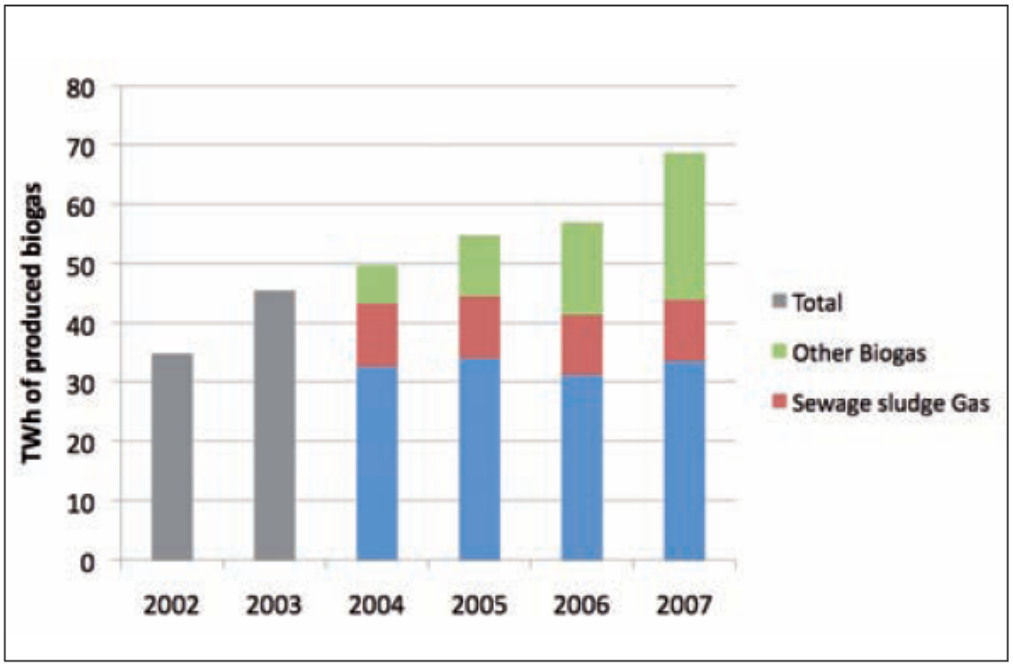


Fig. 1. Biogas production in the European Union between 2002 and 2007 (Biogas Barometer 2004–2008).

Making biogas

Waste can be turned into several types of biofuels and even biofertilizer.

- Biogas can be used to make electricity or heat homes. It is 60 percent to 65 percent methane and also contains carbon dioxide and traces of hydrogen, carbon monoxide and nitrogen.
- Biofertilizer sometimes is a byproduct of biogas. The liquid can be trucked to farms to use.
- Biogas can also be upgraded to biomethane by decreasing the proportion of carbon dioxide and contaminants in the gas through a separation process. It is the chemical equivalent of natural gas and can be used as fuel for cars and buses. It, like biogas, is a gas — not liquid like traditional gasoline.

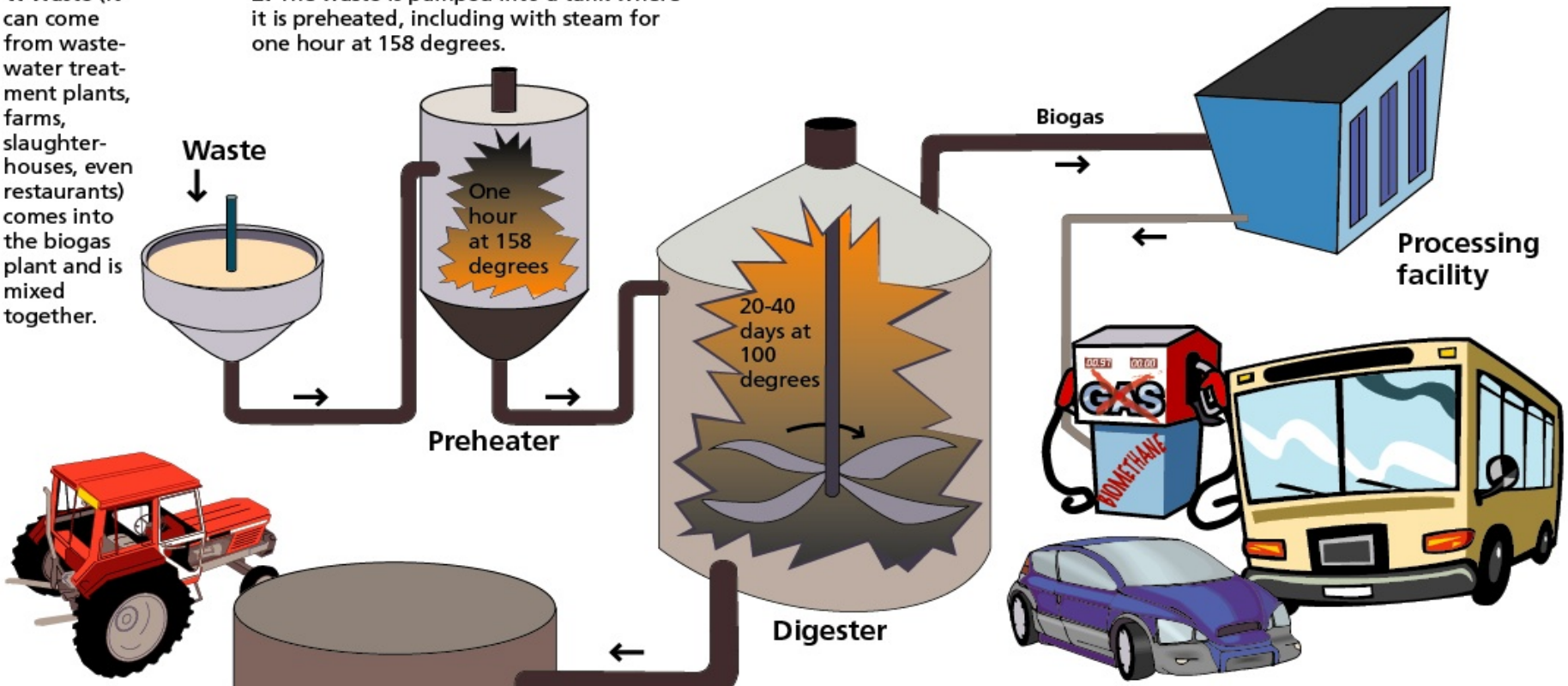
1. Waste (it can come from waste-water treatment plants, farms, slaughter-houses, even restaurants) comes into the biogas plant and is mixed together.

2. The waste is pumped into a tank where it is preheated, including with steam for one hour at 158 degrees.

3. The sludge created from the waste then flows into oxygen-free tanks where it remains for 20 to 40 days at 100 degrees. Microorganisms in the tank convert (or "digest") organic material into biogas and sometimes biofertilizer.*

* Waste from wastewater treatment plants remains in the tanks for 20 days while other forms of waste, such as that from slaughterhouses, remain there for 40 days.

4. To make biomethane, biogas is upgraded to a higher methane concentration of about 97 percent — the quality of natural gas.



5. Biomethane is used as fuel in about 1,000 vehicles such as buses, taxis and passenger vehicles in Linkoping, Sweden.

Sources: Swedish Biogas International, U.S. Department of Energy

What is biogas?

		Biogas	Landfill gas	Natural gas (Danish)*	Natural gas (Dutch)
Compounds	Methane (vol-%)	60–70	35–65	89	81
	Other hydro carbons (vol-%)	0	0	9.4	3,5
	Hydrogen (vol-%)	0	0-3	0	–
	Carbon dioxide (vol-%)	30–40	15–50	0.67	1
	Nitrogen (vol-%)	~0.2	5–40	0.28	14
	Oxygen (vol-%)	0	0-5	0	0
	Hydrogen sulphide (ppm)	0–4000	0–100	2.9	–
	Ammonia (ppm)	~100	~5	0	–
	Lower heating value (kWh/Nm^3)	6.5	4.4	11.0	8.8

*Average during 2007 (Energinet.dk).

Upgrading biogas up to biomethan

Pressure Swing Adsorption (PSA)

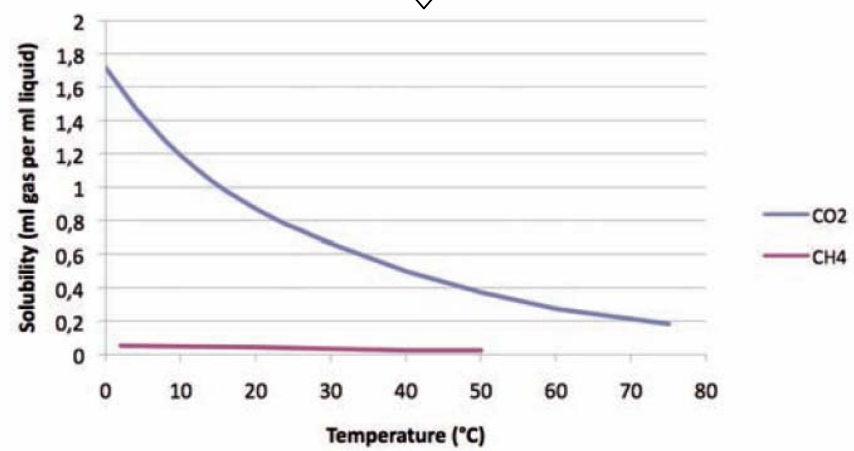
With this technique, carbon dioxide is separated from the biogas by adsorption on a surface under elevated pressure. The adsorbing material, usually activated carbon or zeolites.

⇨ Upgrading plant, Malmö Sweden, using the PSA technology of Carbotech

Upgrading biogas up to biomethan

Biogas Water scrubbing

Carbon dioxide has a higher solubility in water than methane. Carbon dioxide will therefore be dissolved to a higher extent than methane, particularly at lower temperatures.



Upgrading biogas up to biomethan

Membranes

Dry membranes for biogas upgrading are made of materials that are permeable to carbon dioxide, water and ammonia. Hydrogen sulphide, and oxygen permeate through the membrane to some extent while nitrogen and methane only pass to a very low extent. Usually membranes are in the form of hollow fibres bundled together. The process is often performed in two stages.
Before the gas enters the hollow fibres it passes through a filter that retains water and oil droplets and aerosols, which would otherwise negatively affect the membrane performance. Additionally, hydrogen sulphide is usually removed by cleaning with activated carbon before the membrane.

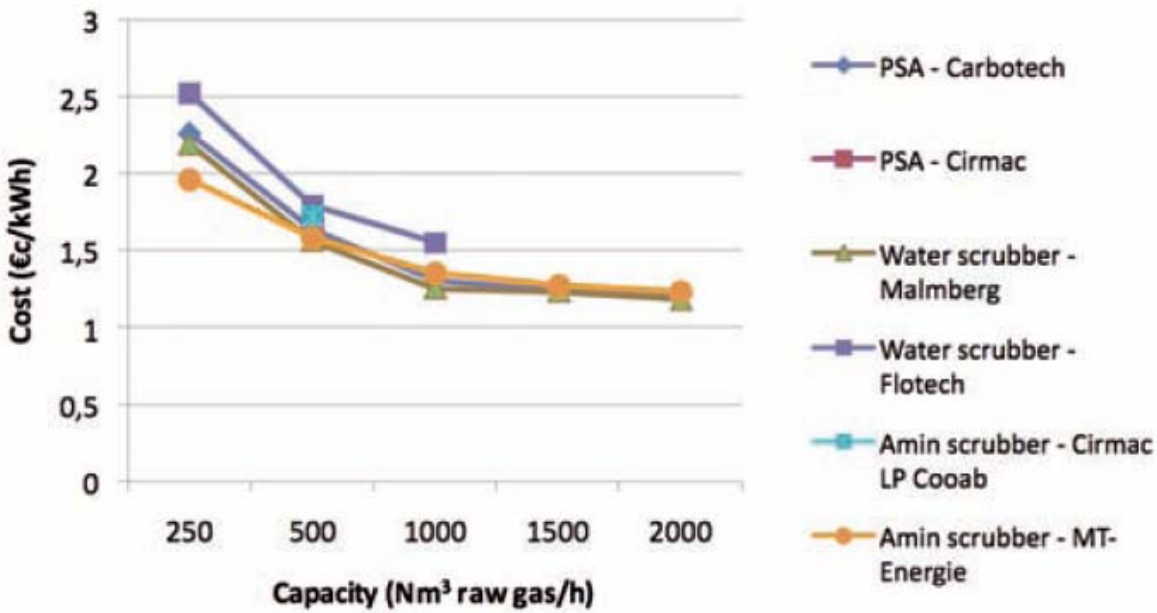
Upgrading biogas up to biomethan

Chemical scrubbing

Chemical scrubbers use amine solutions. Carbon dioxide is not only absorbed in the liquid, but also reacts chemically with the amine in the liquid. Since the chemical reaction is strongly selective, the methane loss might be as low as <0.1%. Part of the liquid is lost due to evaporation, and has to be replaced. The liquid in which carbon dioxide is chemically bound is regenerated by heating. Two types of compounds are used: mono ethanol amine (MEA) and di-methyl ethanol amine (DMEA).

Upgrading biogas up to biomethan

Cost of upgrading



Upgrading biogas up to biomethan

List of biogas upgrading plant providers

Company	Technology	Website
Acrona-Systems	PSA	www.acrona-systems.com
Air Liquide	Membrane	http://www.airliquide.com
CarboTech	PSA, chemical absorption	http://www.carbotech.de
Cirmac	PSA, Chemical absorption, membrane	www.cirmac.com
Flotech Sweden AB	Water scrubber	www.flotech.com
Gasrec	PSA/Membrane	www.gasrec.co.uk
GtS	Cryogenic	www.gastreatmentservices.com
HAASE	Organic physical scrubbing	www.haase-energietechnik.de
Läckeby Water Group AB	Chemical absorption	www.lackebywater.se
Malmberg Water	Water scrubber	www.malmberg.se
MT-Energie	Chemical absorption	www.mt-energie.com/
Prometheus	Cryogenic	www.prometheus-energy.com
Terracastus Technologies	Membrane	www.terracastus.com
Xebec (QuestAir)	PSA	www.xebecinc.com

An updated version of plant providers can be found on www.iea-biogas.net.

New technologies of upgrading biogas

Cryogenic upgrading

Cryogenic upgrading makes use of the distinct boiling/ sublimation points of the different gases particularly for the separation of carbon dioxide and methane. The raw biogas is cooled down to the temperatures where the carbon dioxide in the gas condenses or sublimates and can be separated as a liquid or a solid fraction, while methane accumulates in the gas phase. Water and siloxanes are also removed during cooling of the gas.

Boiling points at atmospheric pressure (Gas Encyclopaedia).

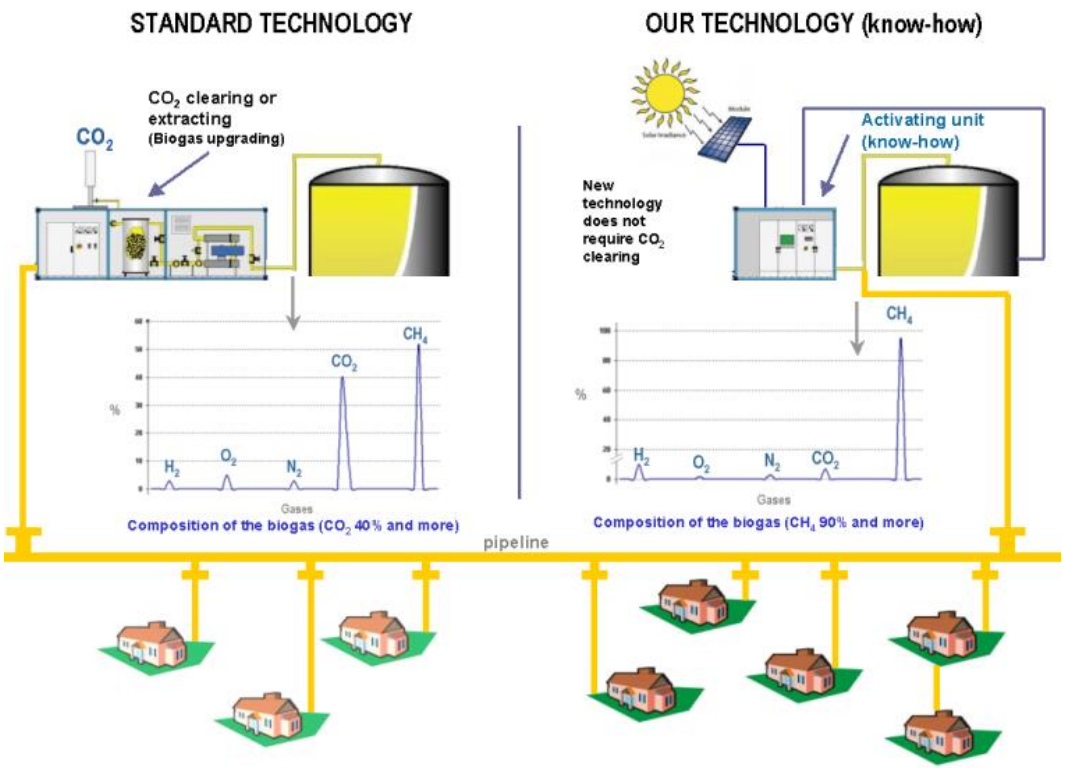
Compound	Boiling point (K)	Boiling point (°C)
CO_2	194.65*	-78.50*
Methane	111.63	-161.52
Oxygene	90.18	-182.97
Nitrogen	77.347	-195.803

* Sublimation point

Biogas improved technologies*

We have technology of production biogas improved (biomethane) and working model of activation unit. Upgrading of standard biogas plant by using activation unit and technology will allow

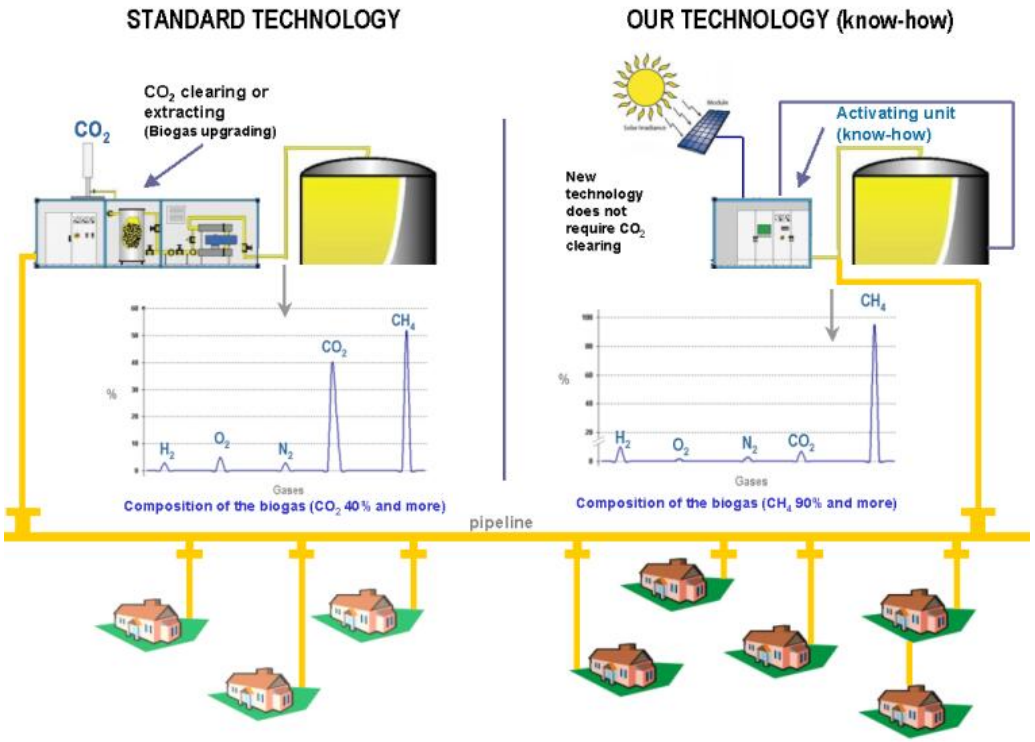
- increase substrate conversion
- increase methane content up to 99%
- decrease CO2 content up to 0%
- effectively use solar panels
-increase complex thermal & electricity output up to 40%



Modernization via our technology will be no more 30% of biogas plant project investment.

*by Alexander Yagovkin

Offer to cooperate



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Thank you!

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