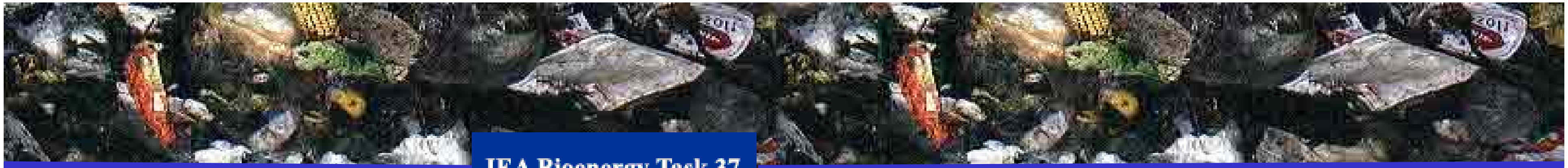
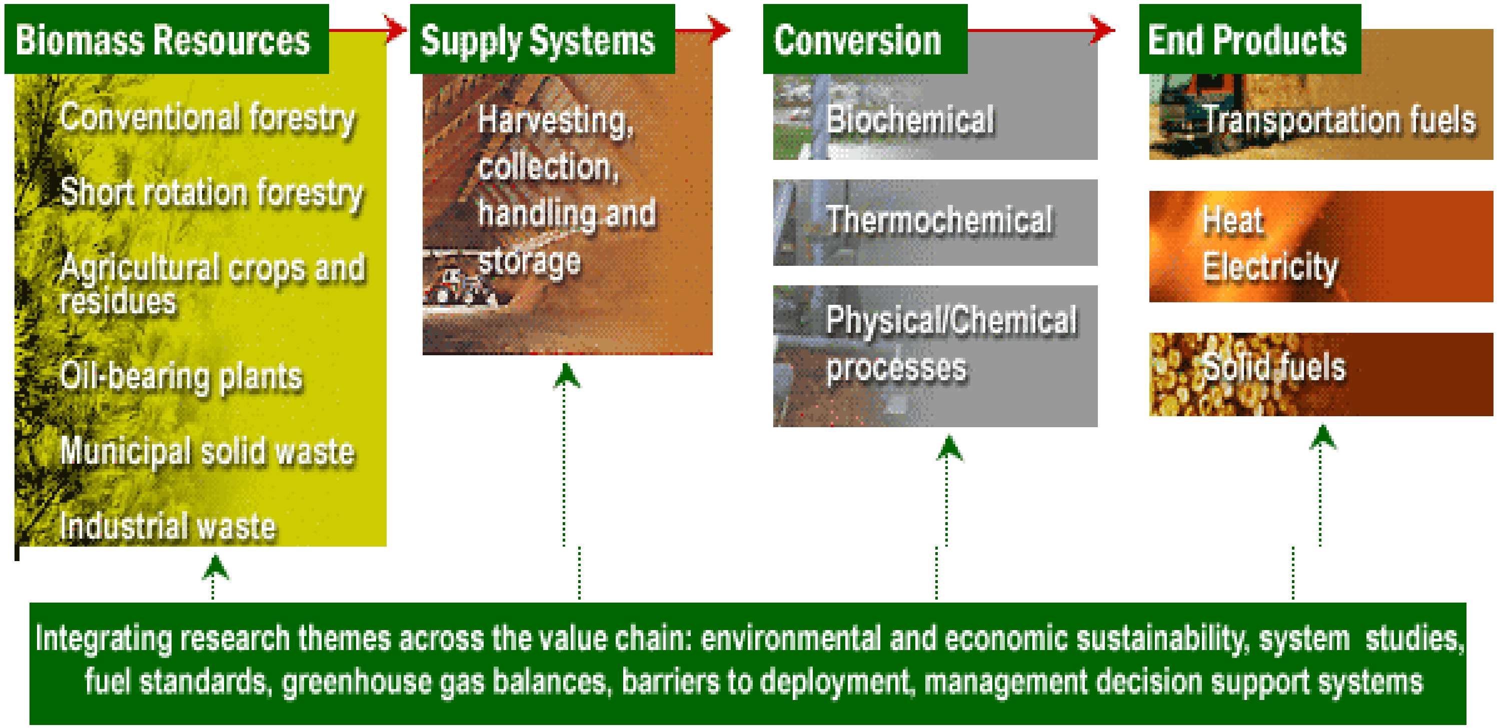


IEA Bioenergy Task 37

Biogas Upgrading - An Introduction

Arthur Wellinger
Nova Energie Ltd.
Leader Task 37

IEA Bioenergy



www.ieabioenergy.com

IEA Bioenergy presently engulfs 12 Tasks:

Task 29: Socio-Economic Drivers in Implementing Bioenergy Projects

Task 31: Conventional Forestry Systems

Task 32: Biomass Combustion and Co-firing

Task 33: Thermal Gasification of Biomass

Task 34: Pyrolysis of Biomass

Task 35: Techno-Economic Assessments for Bioenergy Applications

Task 36: Energy from Integrated Solid Waste Management Systems

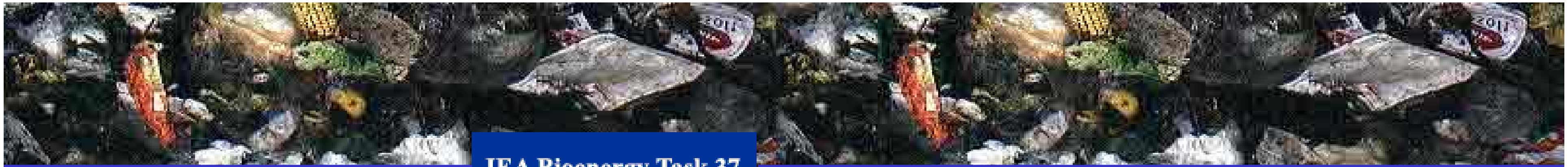
Task 37: Energy from Biogas and Landfill Gas

Task 38: Greenhouse Gas Balances of Biomass and Bioenergy Systems

Task 39: Liquid Bio-Fuels

Task 40: Sustainable International Bioenergy Trade

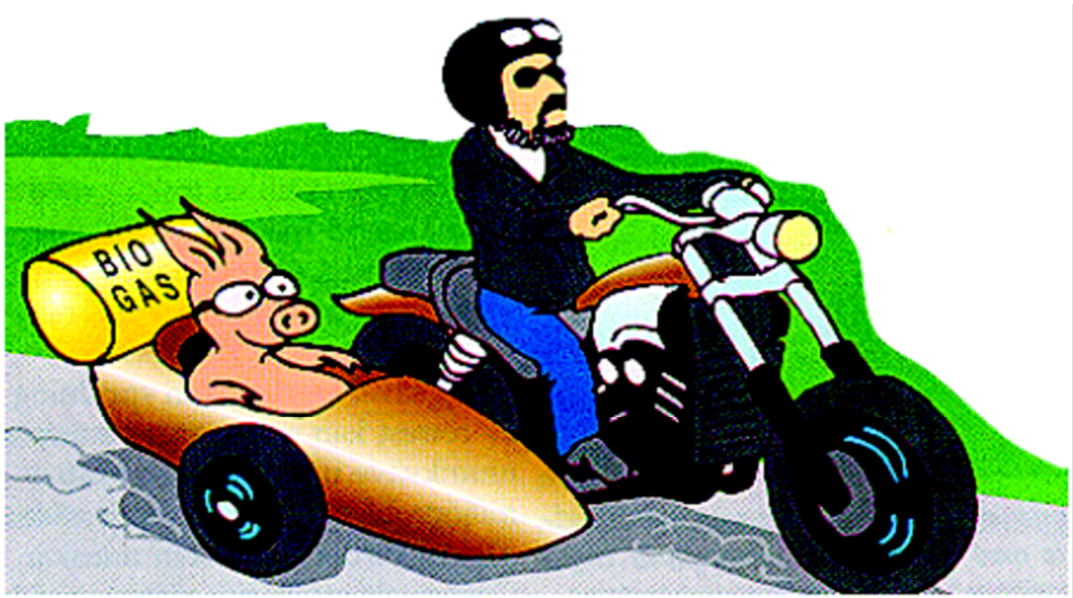
Task 43: Biomass feedstocks for energy markets



Member countries participating in Task 37: Energy from Biogas and Landfill Gas

Switzerland:	**Arthur Wellinger (Task Leader)**
Austria:	**Rudolf Braun**
Canada:	**Jody Anne Barclay**
Denmark:	**Jens Bo Holm-Nielsen/ Teodorita Al Seadi**
EC:	**David Baxter**
Finland:	**Juka Rintala**
France:	**Olivier Théobald, ADEME**
Germany:	**Peter Weiland, FAL**
Sweden:	**Anneli Petersson**
Netherlands:	**Mathieu Dumont**
UK:	**Claire Lukehurst**

Upgrading of Biogas



Definition

Biogas cleaning:

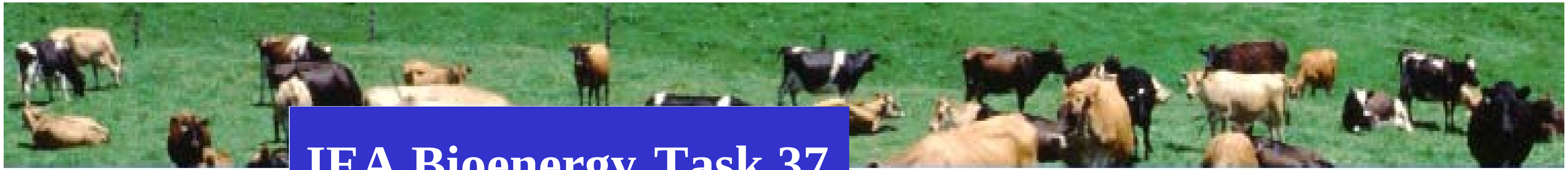
Removal of undesired trace substances from the biogas like minerals, sulphide, ammonia, etc.

Biogas upgrading:

Removal of CO2 to reach natural gas like quality

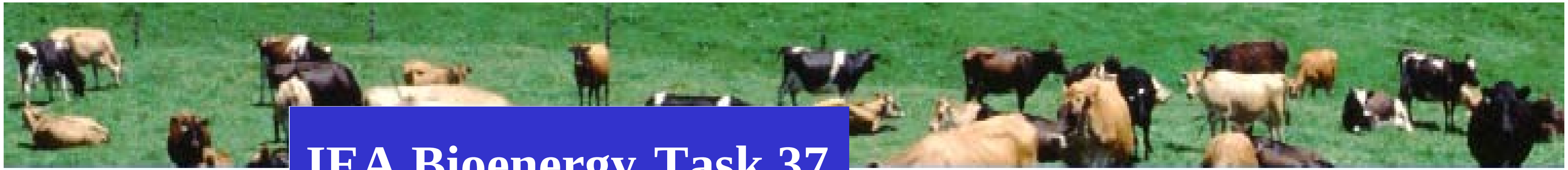
Biomethane:

Natural gas like, upgraded biogas for grid injection or vehicle fuel



Biogas conditioning: Requirements of utilizers

Application	H_2S	CO_2	H_2O	Silox-ane
Heating	< 1'000 ppm	no	no	no
Cooking	yes	no	no	no
Engine (CHP)	$\leq$ 500 ppm	no	no condensati on	yes
High pressure compression	yes	recommend ed	yes	no
Grid and fuel quality	yes	yes	yes	Event ually
Hot fuel cells	yes	No	No conden-sation	yes

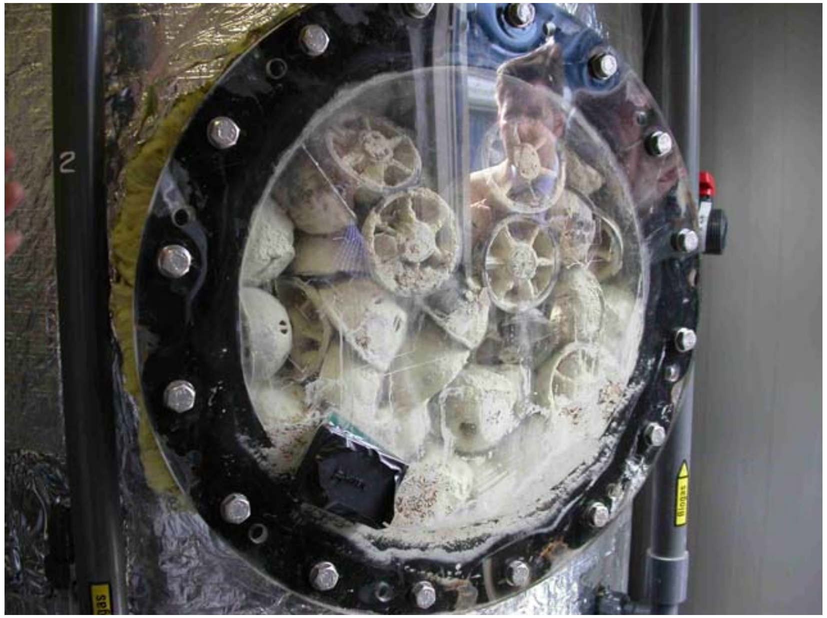


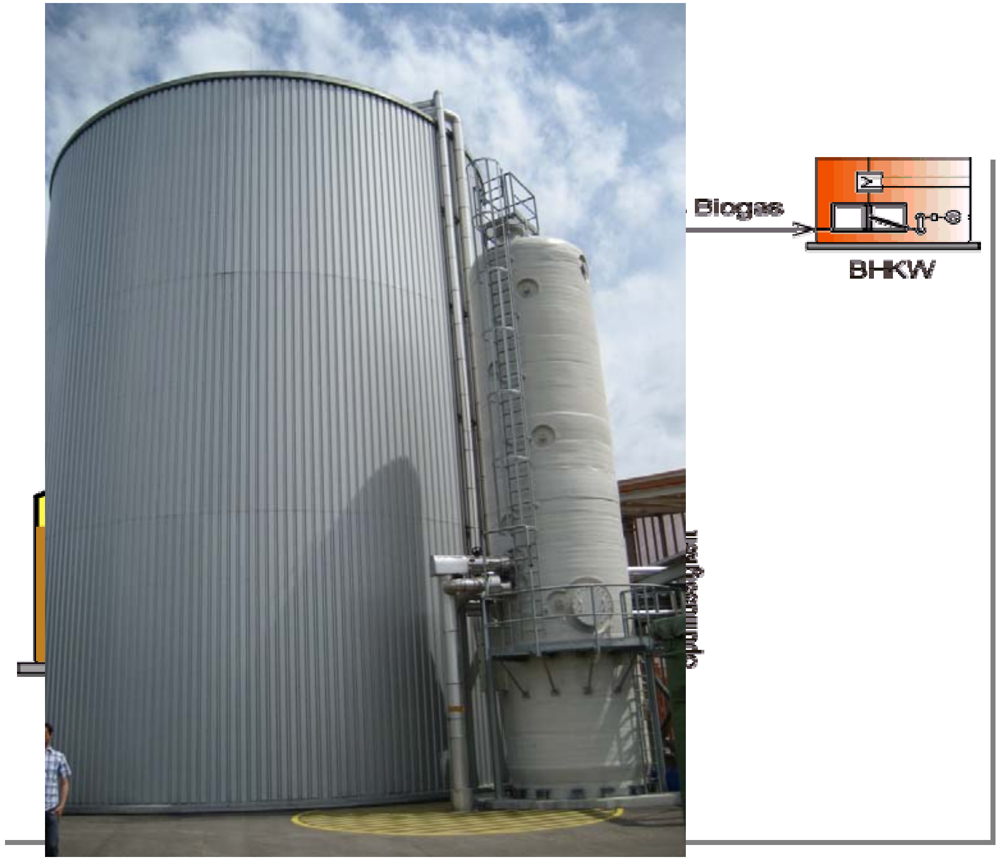
Hydrogene Sulfide Removal

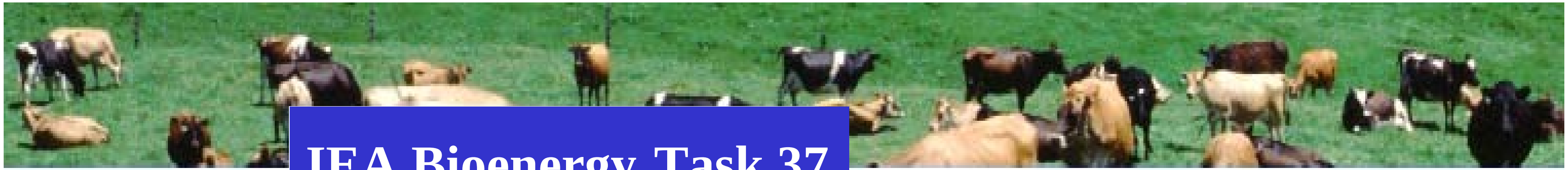
- Air/Oxygen dosing into the digester
- Biological oxidation on a filter bed
- Iron oxyde sponge
- Iron chloride dosing into the digester
- Activated carbon
- Scrubers (water, amines or glycoles)

Biological Oxidation

$$H_2S + ½\, O_2 = H_2O + S°$$

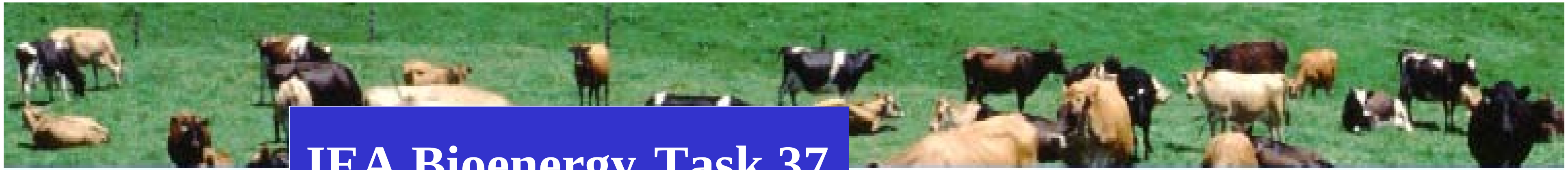






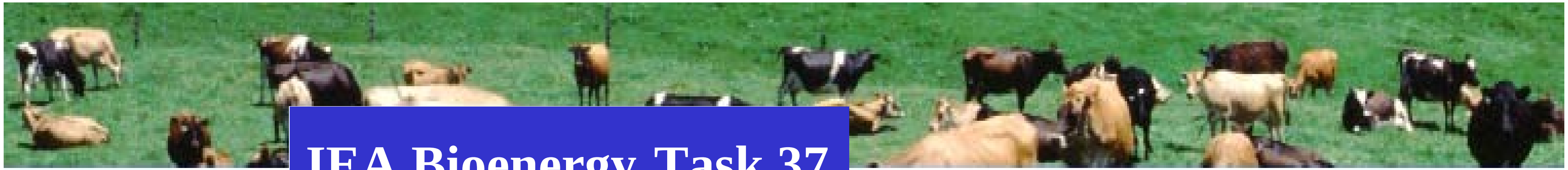
Chemical/physical removal:

- Iron chloride dosing into the digester
- Adsorption on iron oxide
- Adsorption on activated carbon

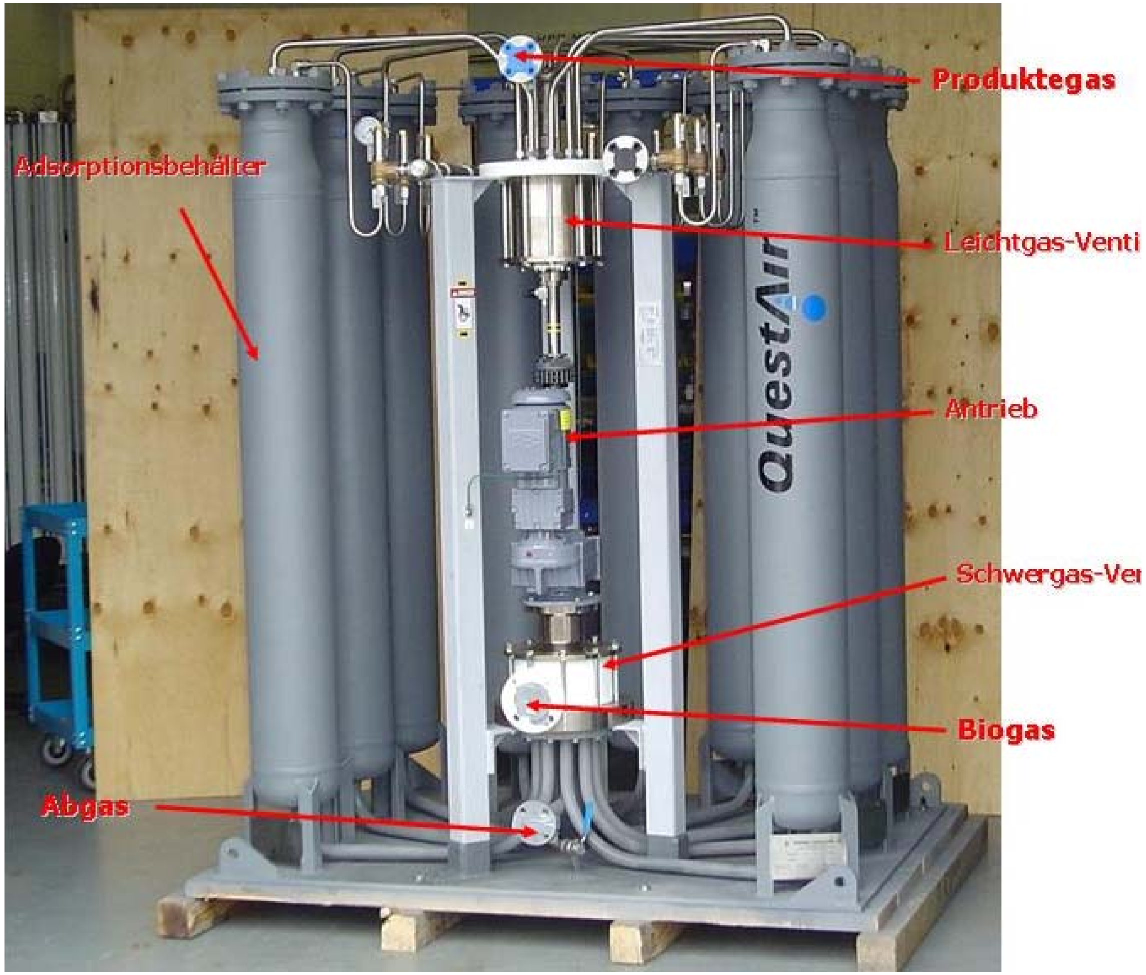


Biogas upgrading:

CO2 removal with physical scrubbers: Water & organic solutions

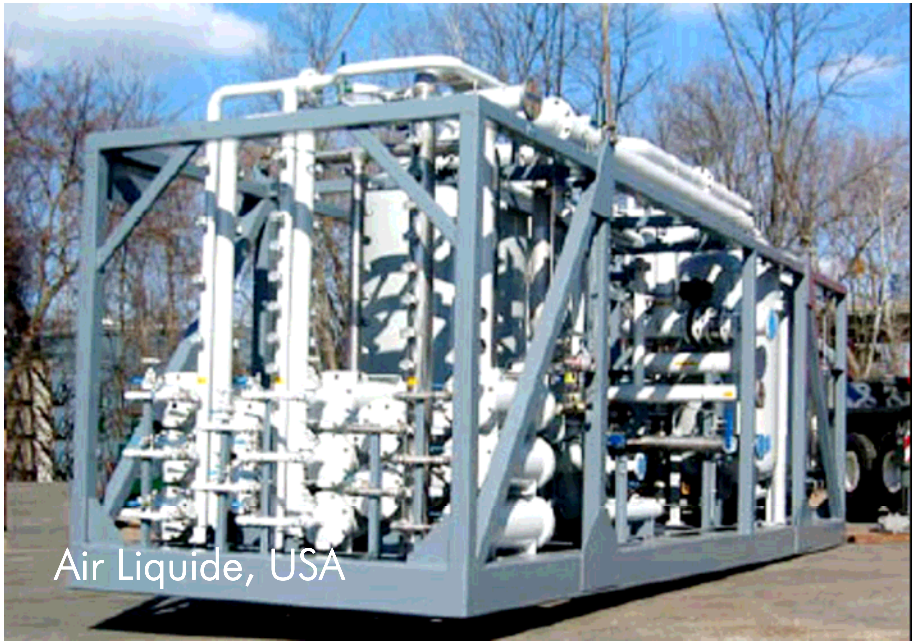


PSA with activated carbon



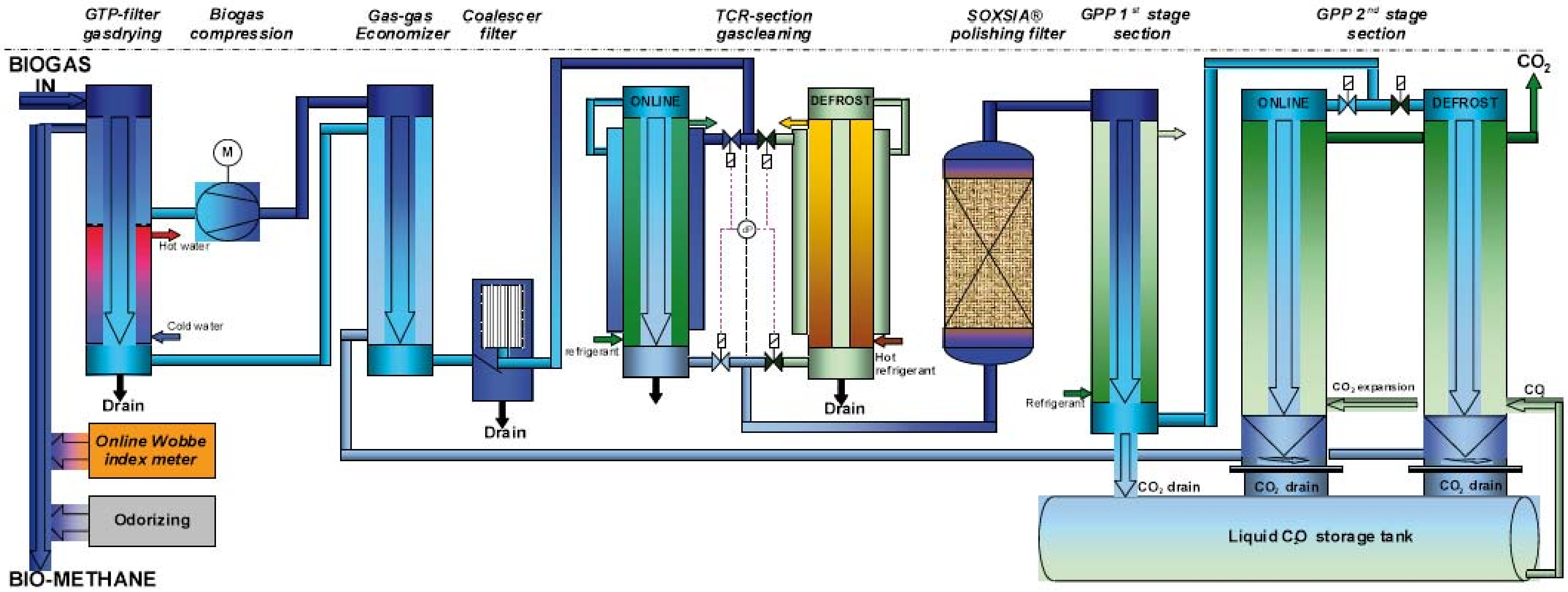
Chemical binding (MEA, DEA)

Membrane separation:


Air Liquide, USA


Bruck/L

Cryogenic gas upgrading

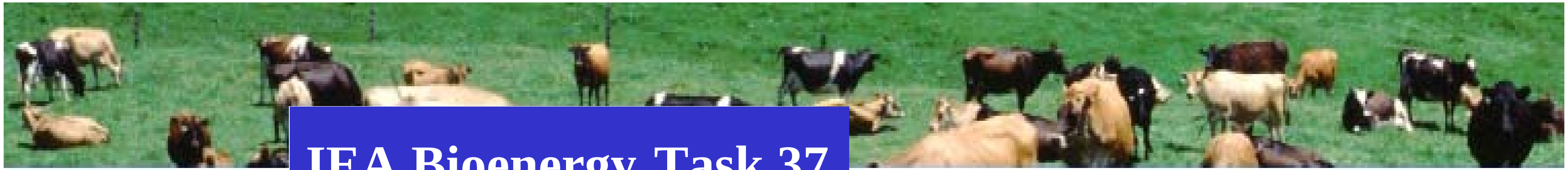


Compressed to 17-26 bar

Cooled to -25°C

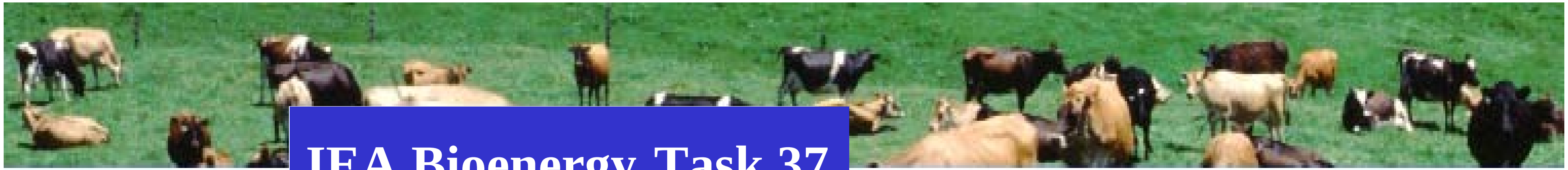
Removal of water, hydrogen sulphide, sulphur dioxide, halogens and siloxanes

Cooled to -50 to -59°C, then to - 65°C or lower



What are the bottle necks ?

- Methane emission (slip)
- Market volume
- Trade
- Regulation



Methane emission – The solutions

Upgrading w/o slip

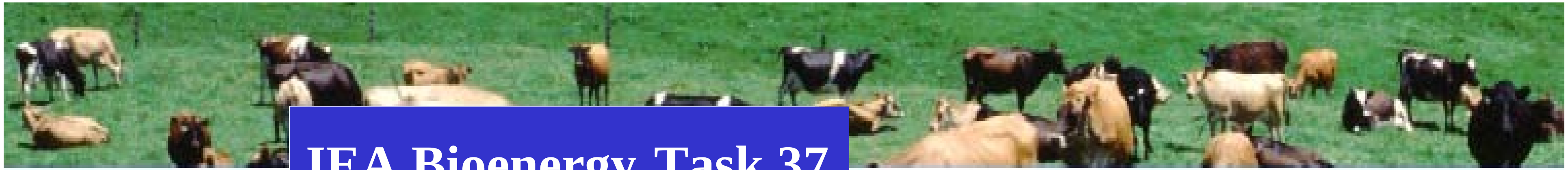
Flox burner
after PSA

Converter after water scrubing

Utilisation of CH4 in off gas

Market volume

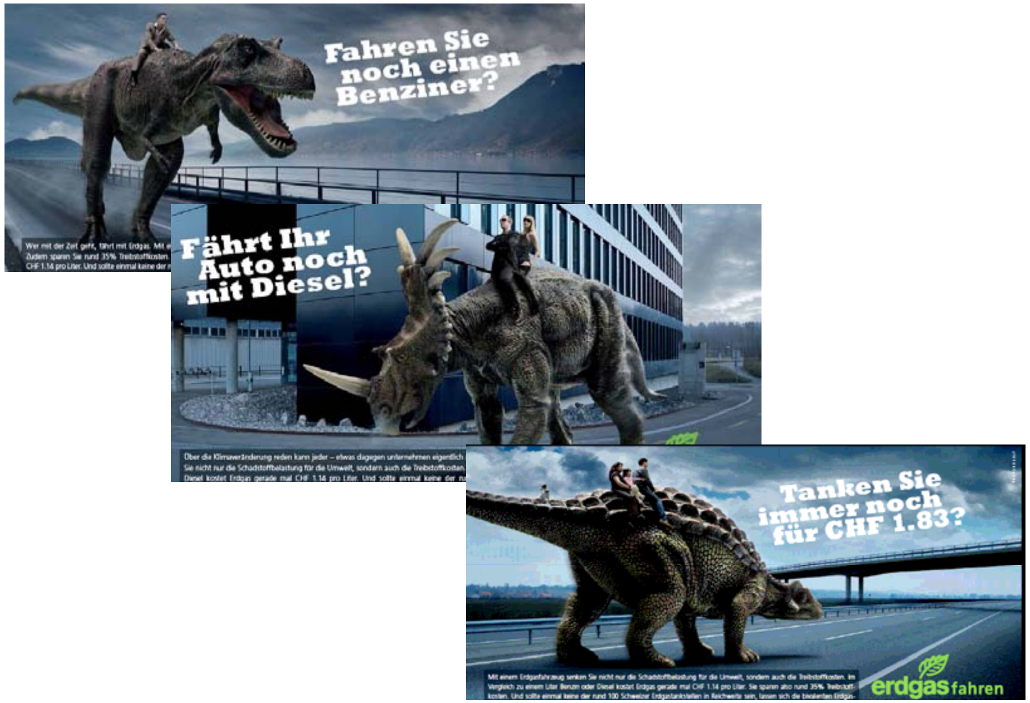
A low price helps a lot !



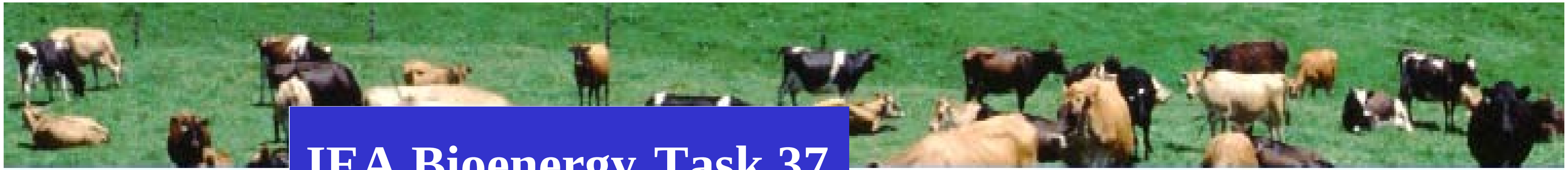
IEA Bioenergy Task 37

Marketing

Testimonials

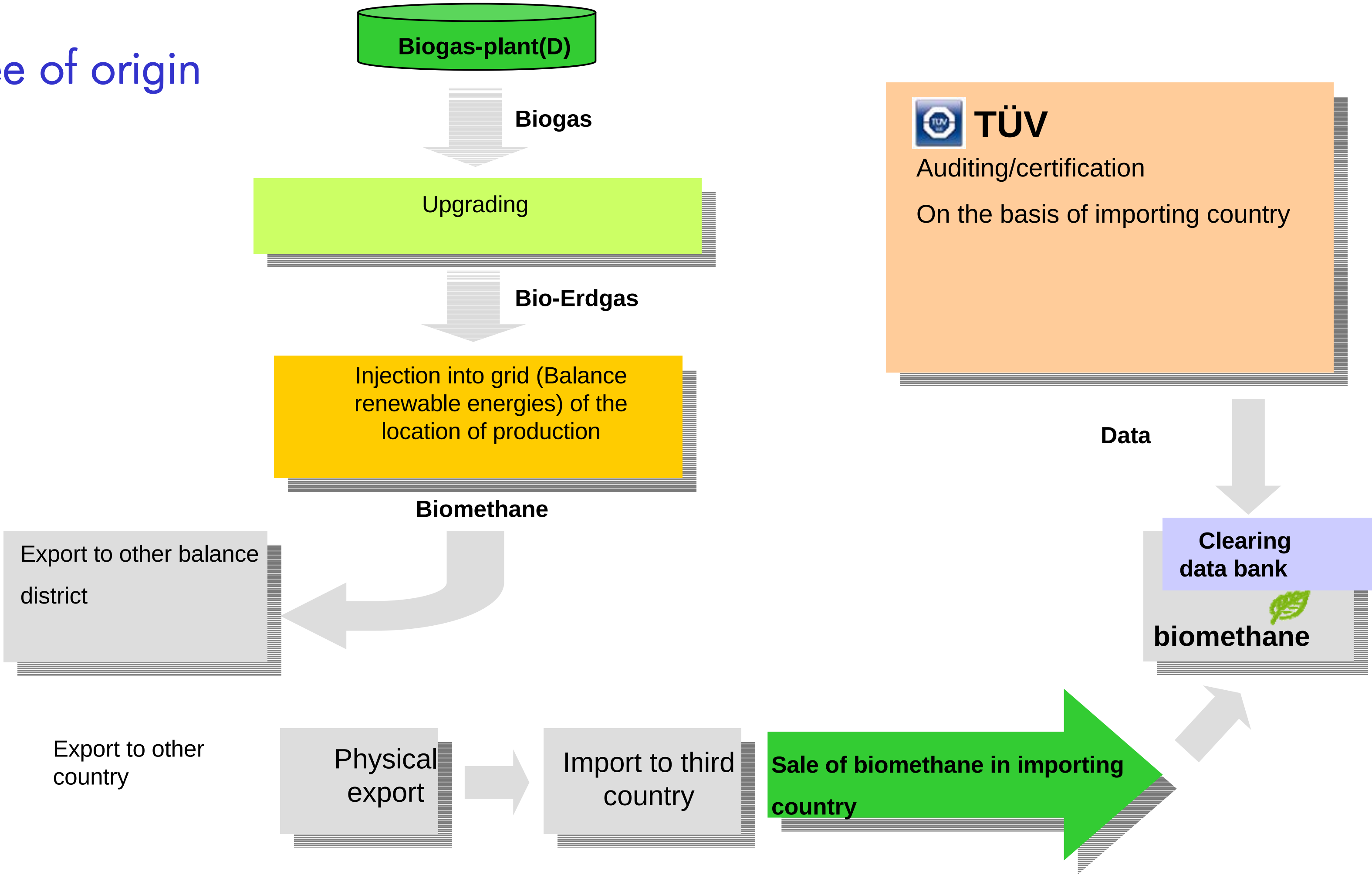


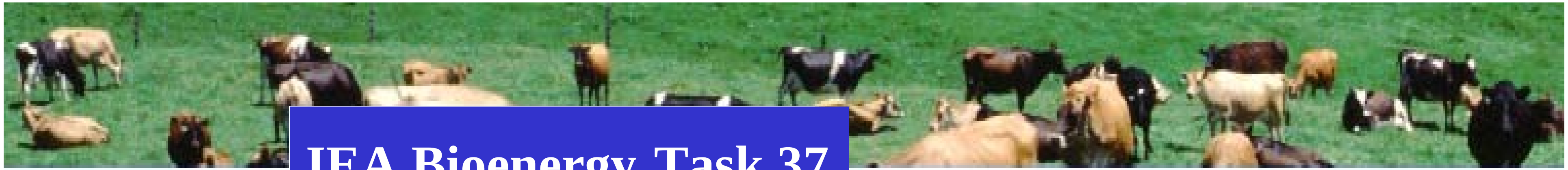
Are you old fashioned?



Trade

Guarantee of origin





Trust

The **Swan Label** was initiated in 1989 in Sweden and Norway. The Label is managed by the Nordic Eco-labelling Board. It covers 25 product groups, e.g. washing machines, freezers, etc. Since 2008 Biomethane.

Advantage: Well established

Disadvantage: No independent audit,
no pure biomethane (min. 35%)

Bmp greengas is a private company. Trade since 2007 (trade platform). Created an own label. Audited by TüV

Disadvantage: No independent management

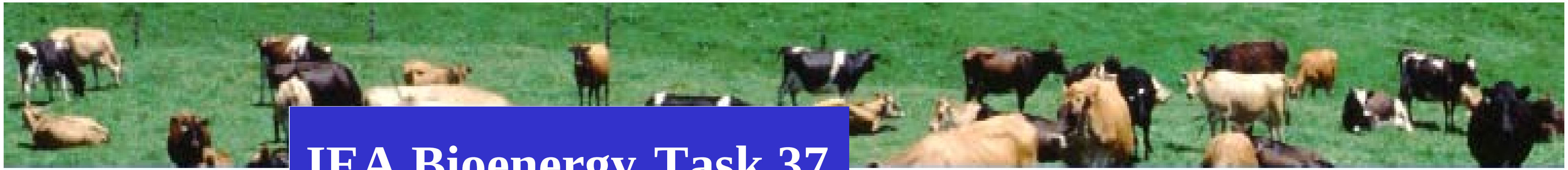
Europe‘s top label (together with o.k. power) for electricity. Since 2008 label for renewable heat and biomethane. Mangaged by an independent association. Audited and labeld by

TÜV SÜD – Mehr Sicherheit. Mehr Wert.

SQS

swiss TS

arsenal research – Ein Unternehmen der Austrian Research Centers



Regulatory restrictions

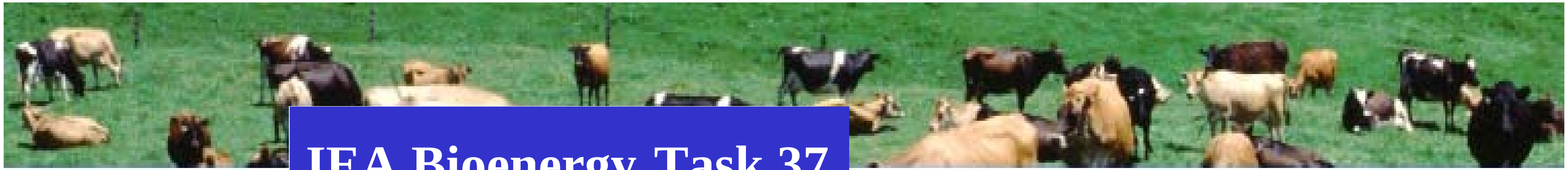
Germany: - Limited access due to feed-in tariff
- Preference for CHP

Italy: - No gas injection allowed so far

Austria: - Only biomethane from agricultural origin

U.K.: - Stringent requirements for oxygen (< 0.2%)

France: - Hygienic limits (no gas injection for WWTP & landfills
- Chemical restrictions
→ so far no gas injection possible



Quelle est la quantité de bactéries dans le biogaz

La quantité de bactéries est relativement peu variable, environ 10^6 bactéries totales / m^3 de biogaz.

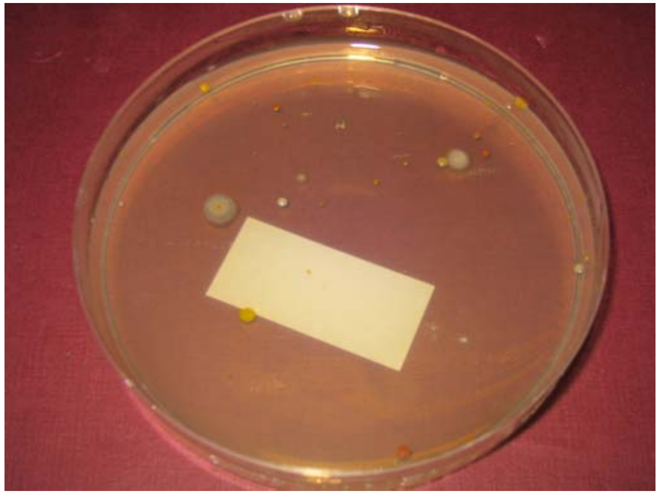
Environ une bactérie du digesteur sur 10^{12} se retrouve dans le biogaz.

Air: 10^7 bactéries par m^3

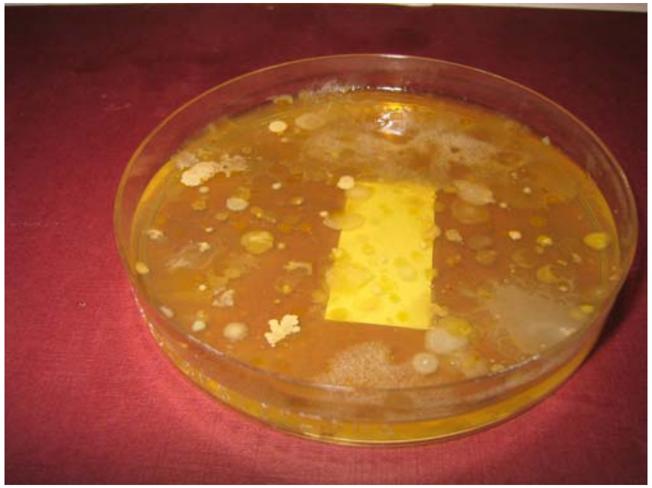
$1{,}5.10^3$ à $1{,}7.10^5$ UFC/m^3 dans le biogaz d 'un CET (rapport 2000, Réseau Santé Déchets).

Dans le biogaz, environ une bactérie sur 100 est cultivable.

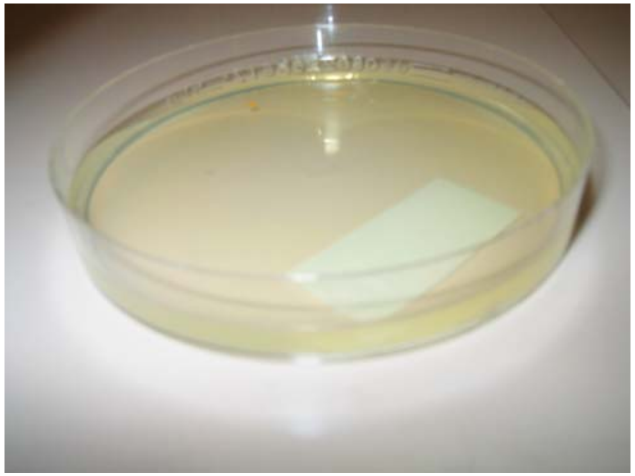
Source: Marina Moletta



0.4 m3 natural gas

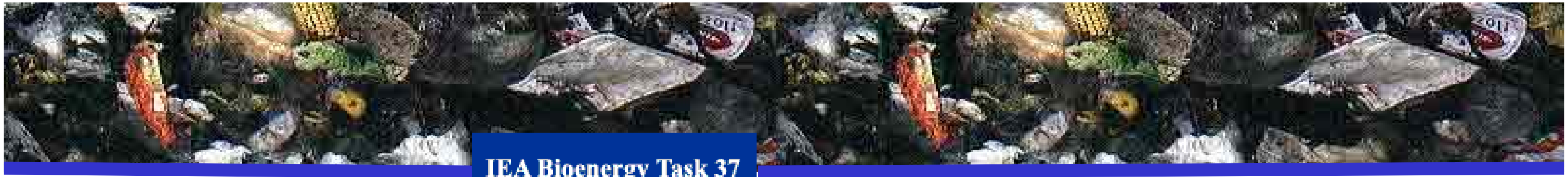


0.4m3 air during test



Source: University of Lund & SGC

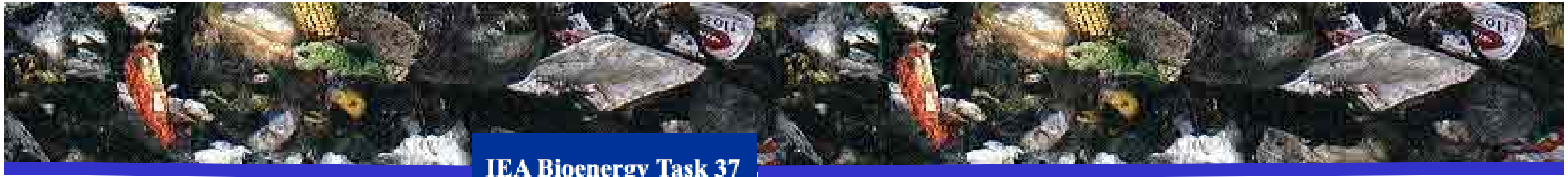
0.5 m3 upgraded biogas



Microbes in biogas from landfills & WWTP

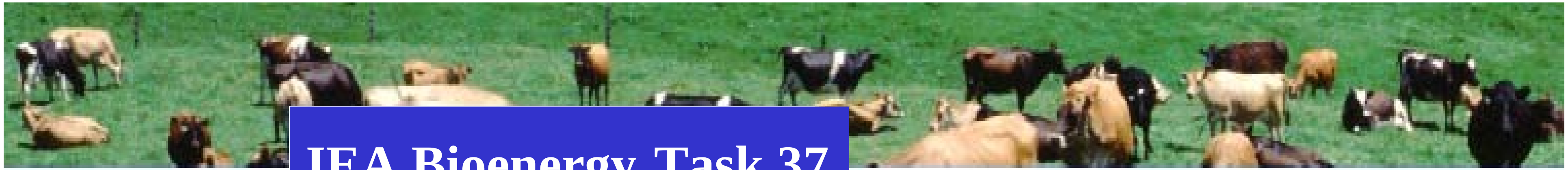
- Biologicals were found in both natural gas samples and biomethane samples from nearly all sources. However, it appears that there are more live bacteria in natural gas samples than in biomethane samples.
- Spores are present in both natural gas and biomethane samples.
- Total bacterial counts indicate that MIC bacteria are present in both natural gas and biomethane.

Source: Diane Saber, GTI



GTI looked also in the dangerous chemicals

Category	LF2 Biomethane	LF3 Biomethane	NG	WWTP1 Biomethane
Ammonia	BDL(<0.001%)	BDL(<0.001%)	BDL(<0.001%)	BDL(<0.001%)
Extended Hydrocarbons				
-Cycloalkanes	Cyclopentane; Methylcyclopentane; Cyclohexane	Cyclopentane; Methylcyclopentane; Cyclohexane; Methylcyclohexane	Cyclopentane; Methylcyclopentane; Cyclohexane; Methylcyclohexane	BDL (< 0.0001 mol%)
-Aromatics	BDL (< 1ppmv)	Benzene	Benzene; Toluene; Ethylbenzene; m,p-Xylene; o-Xylene; C3 Benzenes	BDL (< 0.0001 mol%)
-Paraffins	Hexanes	Hexanes; Heptanes	Hexanes; Heptanes; 2,2,4-Trimethylpentane; Octanes; Nonanes; Decanes	BDL (< 0.0001 mol%)
Organic Silicons	BDL (< 0.5 ppmv Si)	BDL (< 0.5 ppmv Si)	BDL (< 0.5 ppmv Si)	BDL (< 0.5 ppmv Si)
TO-14 Halocarbons	Dichlorodifluoromethane (CFC-12); 1,2-Dichlorotetrafluoroethane (CFC-114); Trichlorofluoromethane (CFC-11); Chloroethane; Chloroethene (Vinyl Chloride);	Dichlorodifluoromethane (CFC-12); 1,2-Dichlorotetrafluoroethane (CFC-114); Trichlorofluoromethane (CFC-11); Chloroethane; Chloroethene (Vinyl Chloride);	BDL (< 0.1 ppmv)	BDL (< 0.1 ppmv)
Mercury	BDL (< 0.02 µg/m3)	Yes*	BDL (< 0.02 µg/m3)	BDL (< 0.02 µg/m3)
Volatile Metals	Zinc	BDL (< 30 µg/m3)	Zinc	Zinc



The future for biomethane looks bright –

but there is still a long way to go !

Thank you