

EFFECTIVE

**Holistic Integration Of Molten Carbonate Fuel
Cells Technology Towards A Most Effective
Systems Compound Using Biogas As A
Renewable Source Of Energy**

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**BIO-ENERGY
ENLARGED PERSPECTIVES**

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What is biogas?

- A methane rich gas
- resulting from the anaerobic digestion of organic wastes in biogas plants which are common in
 - Waste water treatment plants
 - Agricultural farms
 - Anaerobic biowaste treatment facilities
 - Landfills

Biogas: Advantages

- Renewable energy with the highest potential (1) for green house gas reduction
- Decentralised energy production (<1MWeI)
- Cost reduction of waste disposal and new income for the agricultural sector
- Closing of the nutrient cycle (agriculture)
- Several directives encourage biogas utilisation

¹Greenhouse gas emissions (IEA Bioenergy Task 25, G. Jungmeier gerfried.jungmeier@joanneum.ac.at)

Biogas composition(s)

Gas type	H2 Vol%	CH4 Vol%	CnHm Vol%	CO2 Vol%	N2 Vol%	CO Vol%	H2S ppm	NH3 ppm	Others
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Biogas from fermentation									
¹ Biogas from agricultural biogas plants	0	55-70	-	30-45	0-2	-	500	100	Siloxane, Oxigen
Waste water gas	-	65	-	35	-	-	1000	100	Siloxane, Oxigen
² Landfill gas	-	50-60	-	40-50	-	-	0-50	-	Aromates, Chlor comp., Siloxanes

Biogene gas from thermal gasification									
³ Biomass-gasification	4,5	14,8	-	10,6	39,6	19,1	100	2000	Dust, Tar (3000ppm)

Fossil									
Natural gas	-	93	4,9	1	1,1	-	1	-	Inert gas

- Jensen, J.K., Jensen, A.B.: Biogas and natural gas – fuel mixture for the future, 1st World Conference and Exhibition on Biomass for Energy and Industry, Sevilla, 2000
- Christenson, T.H., Cossu, R., Stegmann, R.: Landfilling of Waste, Biogas, E&FN Spon, London 1996
- Kivisaari, T., Björnbom, P., Sylwan, C.: Studies of Biomass MCFC Systems, Journal of Power Sources, 104 (2002) p. 114-124

Why MCFC?

Low Temperature FC ← ● → High temperature FC

-Typ	PEFC 80	AFC 100	PAFC 200	MCFC 650	ITSOFC 800	TSOFC 1000
H ₂	F	F	F	F	F	F
CH ₄ , C _n H _m	IG	poison	IG	IG/F	F	F
CO ₂	IG	poison	IG	React.	IG	IG
CO	poison (<50ppm)	poison	poison (<500ppm)	F	F	F
H ₂ S, COS	nd	poison	poison (<50ppm)	poison (<0.5ppm)	poison	poison (<1.0ppm)
NH ₃	poison	F	poison	F	F	F

Analysis on siloxanes, halides, tar, dust, and other contaminants are missing!!!

F.....Fuel, IG..... Inert gas, React. Takes part in electrode reaction

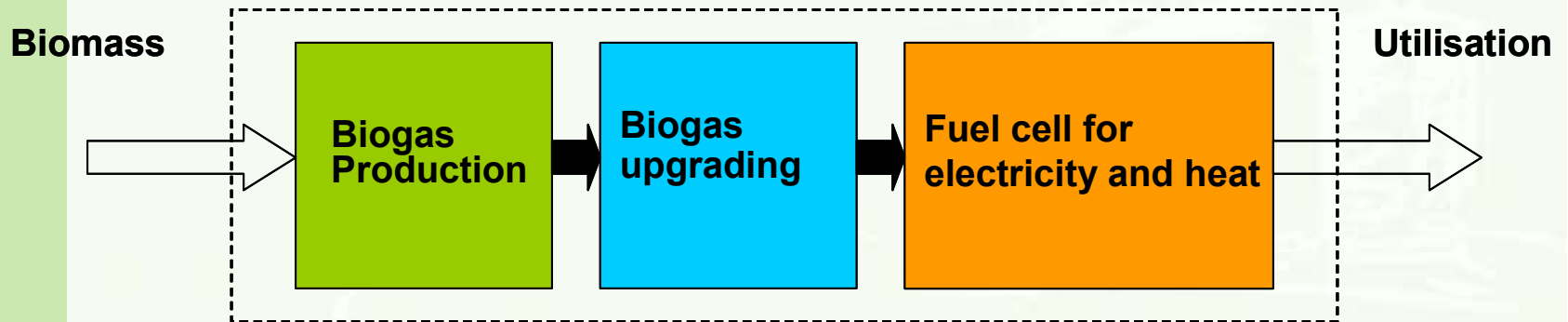
Why MCFC ?

- High temperature FC
- Ideally suitable for biogas (due to the biogas composition)
- High system efficiency (~49%), due to beneficial impact of carbon dioxide as well as internal reforming
- Near to market

Synergies Biogas – MCFC

- Utilisation of RES in FC Technology
- Efficient and clean energy conversion of valuable RES
- High user potential for utilising the process heat which is released from the MCFC-process

The EFFECTIVE Concept



The Effective Project

- Holistic integration of MCFC technology towards a most EFFECTIVE systems compound using biogas as a renewable source of energy.
- Project start: 07 / 2000
- Duration: 4 years
- Budget: ~ 3.5 Mio Euro
- Consortium: PROFACTOR (Co), Linz AG, Studia, MTU CFC Solutions GmbH, Seaborne, Ciemat, Urbaser, University of Nitra

Financing: Own contribution, EU - Commission, bm:bwk

EFFECTIVEs Approach

- Development and construction of 2 gas upgrading systems for H₂S removal
- Construction of two test beds:
 - One mobile system to be installed in Germany, Austria and Spain
 - One stationary system in which long term tests are made at the Univ. of Nitra (Slovakia)
- Tests (endurance and performance) with different gas qualities on basis of lab scale stacks (300 W)
- Socio technical integration of biogas-FC technology in Spain and Slovakia

EFFECTIVEs Biofilter

Biological biotrickling filter, built by Profactor:

18 month endurance operation, achieving the aim of less than 10 ppm H₂S in the outlet gas



EFFECTIVEs Chemical Filter

Chemical filter, built by Seaborne:

6 month endurance operation, also achieving the aim of less than 10 ppm H₂S in the outlet gas



EFFECTIVEs Testbed

**Designed and
constructed by
MTU CFC
Solutions**

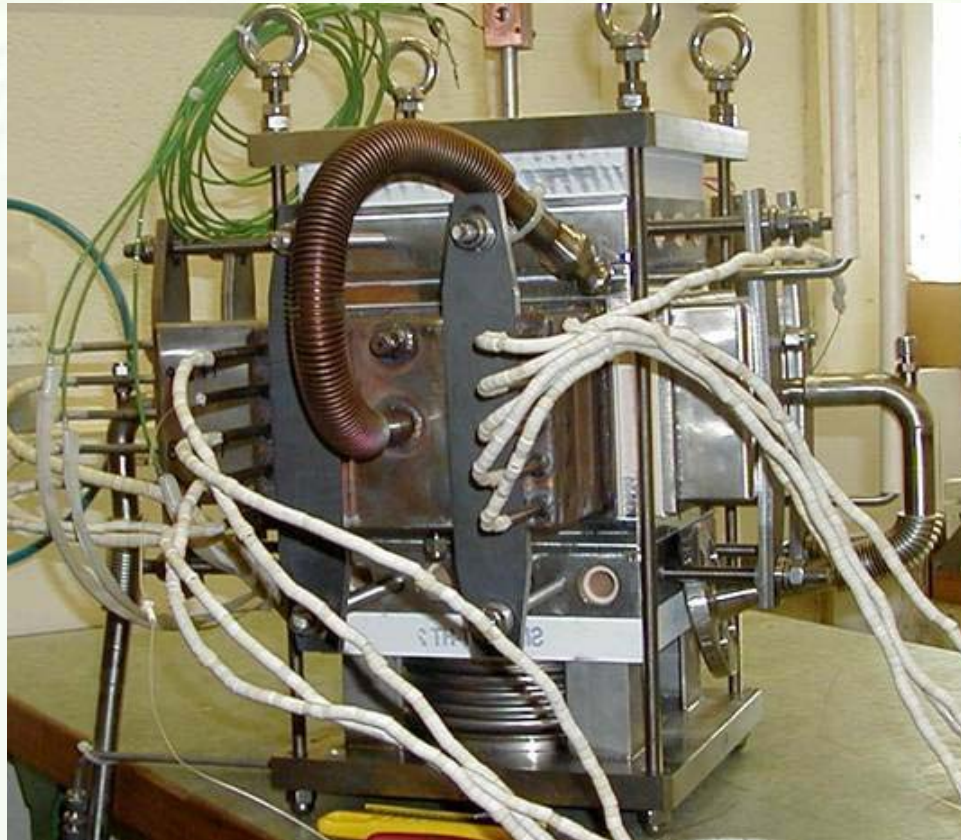
**Right
Control Unit**

**Center
Operator**

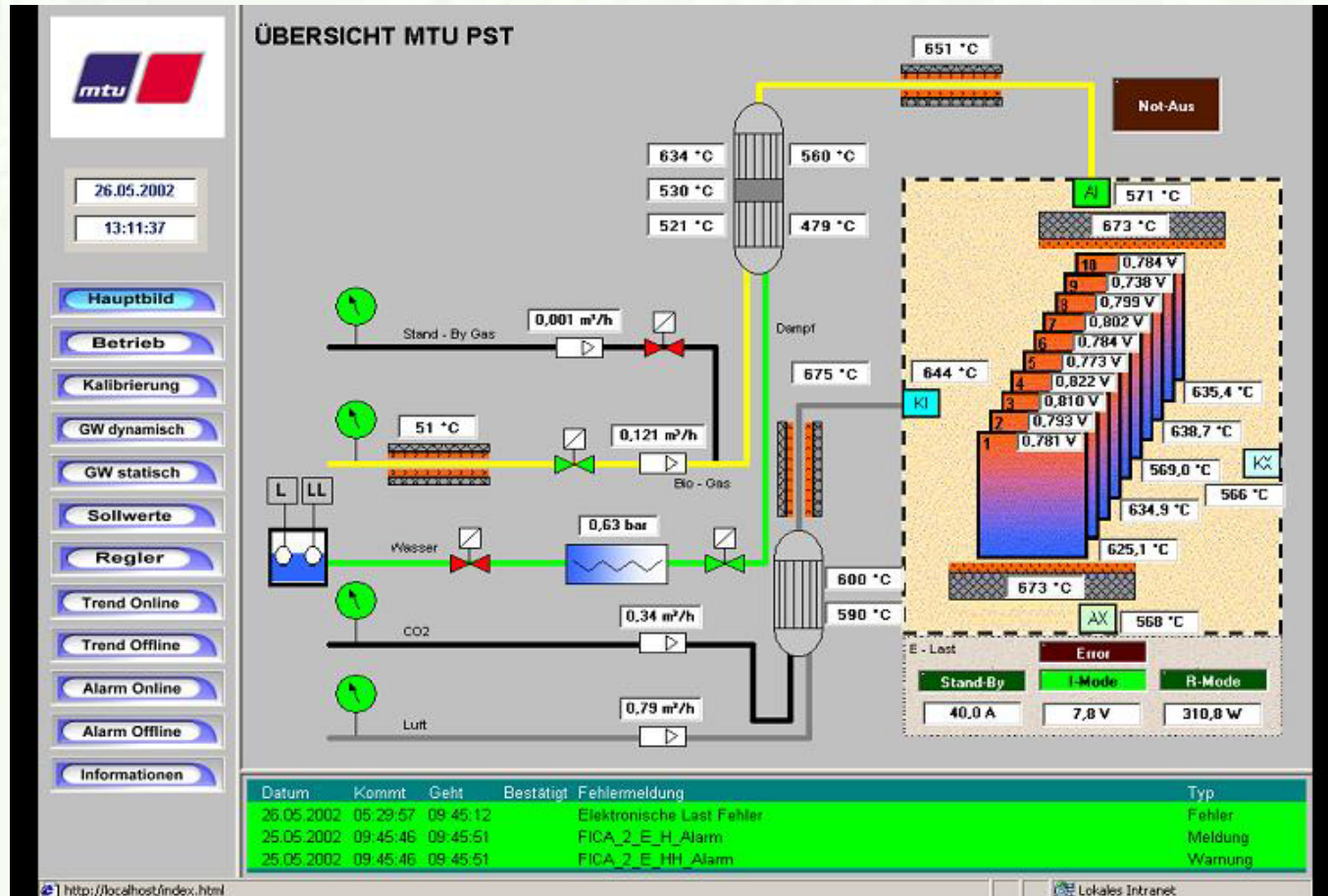
**Left
Operation Unit**



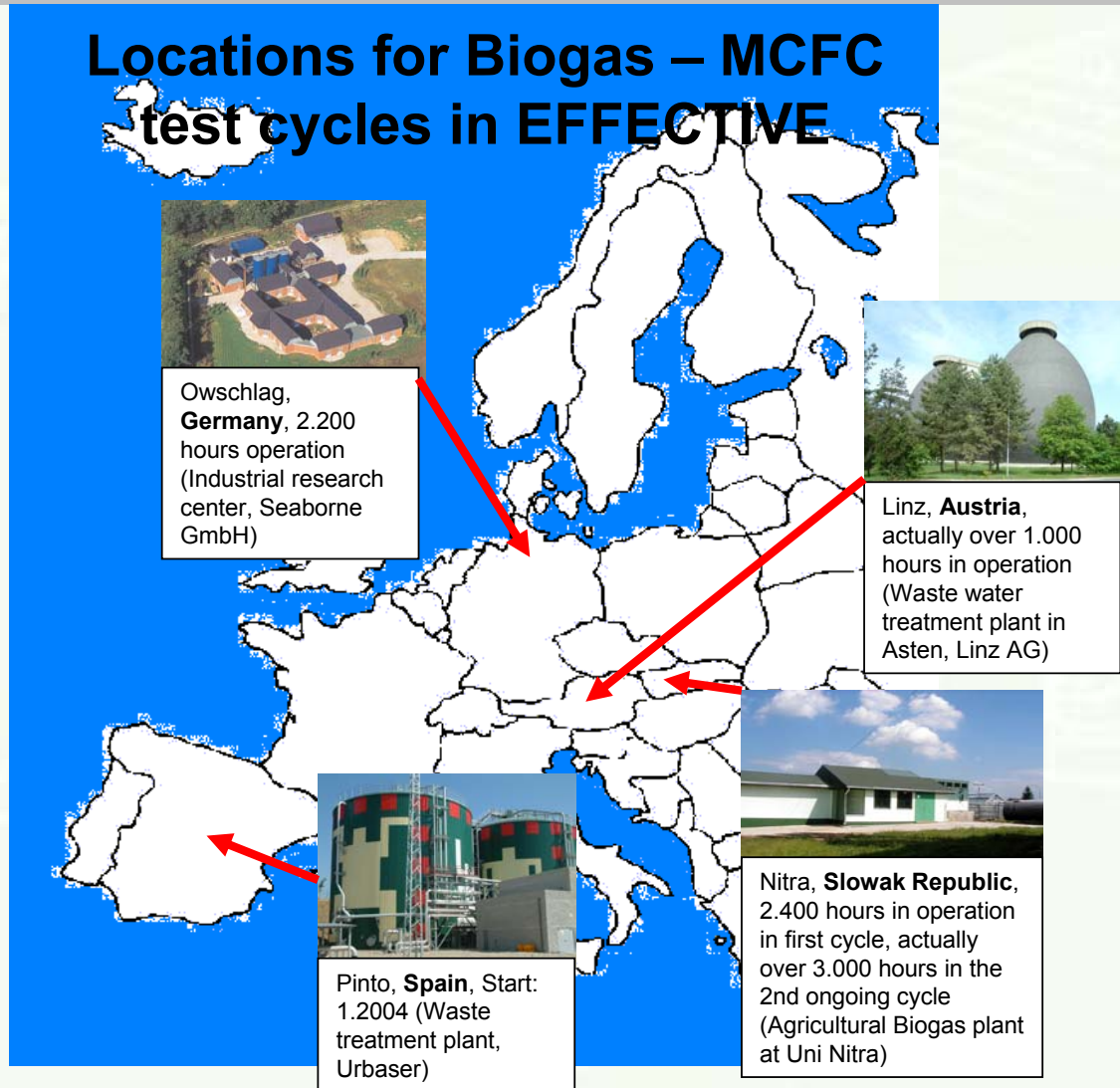
EFFECTIVEs Stack



EFFECTIVEs Process



Locations for Biogas – MCFC test cycles in EFFECTIVE



EFFECTIVEs Conclusions

- **Biogas Operation of MCFC without any Problems**
- **Posttest analyzes indicates no severe interaction between biogas and fuel cell system components**
- **NH₃ reduction by catalytic decomposition (labscale single cell experiments)**

Thank you for your attention