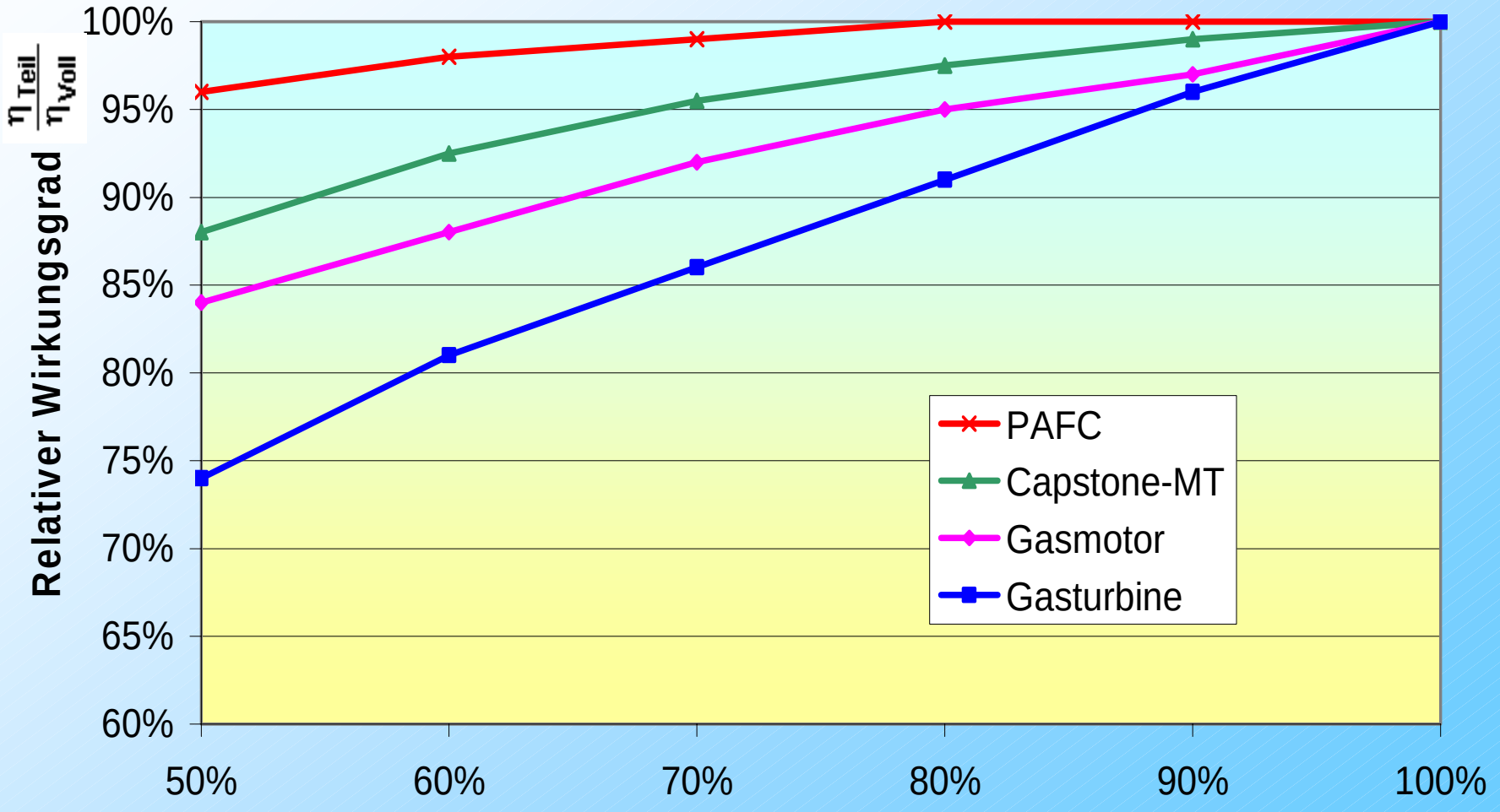
Micro Turbine using different gases and liquid fuels

Tarragona
Micro Turbine Workshop
21st October 2002

Relative Efficiency Curve



Using different fuels

- With Micro Turbines it is possible to use different fuels:
  - Natural Gas (Capstone, Bowmann, Turbec)
  - Diesel and Kerosene (Capstone, Bowmann)
  - Low BTU Gas (Capstone, Turbec)

  As example:

  To define special gases Capstone is working with a table for fuel parameters.

Fuel parameter

Fuel Index 1 und Fuel Index 2

by Capstone

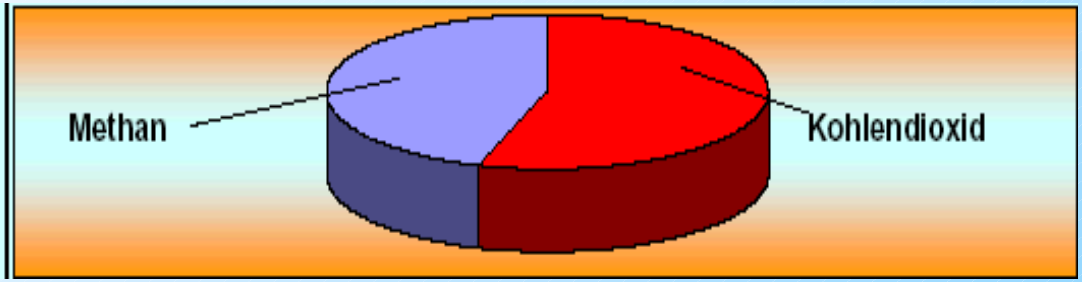
Gas Komponente	Symbol	(SG) (wrt Air)	HHV_{Vol} (Btu /SCF)	Konzentration (Volumen %)	(SG) (Reihe 3*Reihe 5)	HHV_{Vol} (Reihe 4*Reihe 5)
Wasserstoff	H2	0,0695	325	0	0,00	0,00
Kohlenmonoxid	CO	0,9672	322	0	0,00	0,00
Methan	CH4	0,5541	1013	84	0,47	850,92
Ethan	C2H6	1,0488	1792	4	0,04	71,68
Ethylene	C3H4	0,974	1613	0	0,00	0,00
Propane	C3H8	1,5624	2592	0	0,00	0,00
Propylene	C3H6	1,45	2336	0	0,00	0,00
n-Butane	C4h10	2,0666	3373	0	0,00	0,00
ISO-Butan	C4H10	2,066	3365	0	0,00	0,00
n-Pentan	C5H12	2,4872	4017	0	0,00	0,00
ISO-Pentan	C5H12	2,4872	4007	0	0,00	0,00
Schwefel-wasserstoff	H2S	1,1899	646	0	0,00	0,00
Kohlendioxid	CO2	1,5284		2	0,03	
Stickstoff	N2	0,9717		10	0,10	
Sauerstoff	O2	1,1053		0	0,00	
Wasser	H2O	0,6215		0	0,00	
	Total (Summe aller Reihen)			100%	0,64	922,60

FUEL I1	(SG)(1327/HHV_{Vol})	1,31	0,1-99,99
FUEL I2	HHV_{Vol}/(1688*(SG))	0,86	0,00-2,00

HHV_{Vol} :	Higher Heat Value	
BTU/SCF :	(British Thermal Unit)/ (standard cubic feet)	1[BTU/SCF]=39,96[kJ/m³]=0,01[kwh/m³]
SG:	Standard Gas	

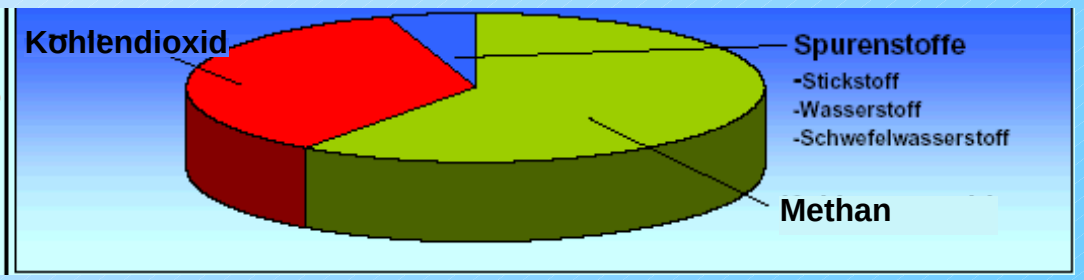
Different low BTU Gas

Deponiegas	Zusammensetzung
Methan:	55,0 Vol%
Kohlendioxid:	45,0 Vol%
Spurenstoffe	< 1,0 Vol%



Klärgas Faulgas	Zusammensetzung
Methan:	65,0 Vol%
Kohlendioxid:	35,0 Vol%
Schwefelw.stoff	1,0 Vol%

Biogas	Zusammensetzung
Methan:	60,0 Vol%
Kohlendioxid:	35,0 Vol%
Spurenstoffe :	5,0 Vol%
Stickstoff	
Wasserstoff	
Schwefelw.stoff	



Specification of the low BTU gas

- The problem of low BTU gas are the inertial gas particles.
  - Biogas: moister and sulphur.
  - Dump gas: higher hydro carbons, fluorides, chloride, dust
  - Sewage gas: silicon in fuel gas, higher hydro carbons and sulphur
  - Mine gas: high oxygen and nitro part – based on CH_4 as fuel gas.
  - Pyrolyse gas: high part of hydrogen

Experiences with low BTU gas

- First results in test runs show that it is possible to run the turbine with Methane content lower than 40%.
  - The turbine is pretty sensitive to pressure oscillations
  - The fuel index must be right to get best start properties

- Capstone tested a turbine on a sewage plant
  - Build up of sand in the turbine chamber
  - Problems with the lifecycle of the fuel injectors

Demanded gas quality

Contaminant	Units	Max	Min	Test Method	Notes
Lubricating Oil	ppm mass	2	0	-----	(Note 1)
Particulate	Size Microns	10	0	-----	-----
Particulate	Qty ppm mass > 10 micron	20	0	-----	-----
Water	% Mass liquid	0	0	ASTM D5454	-----
Fluorine	ppm mass	TBD	0	TBD	-----
Chlorine	ppm mass	1,500	0	TBD	-----
Sodium plus Potassium	ppm mass	0.51	0	ASTM D3605	-----
Vanadium	ppm mass	0.5	0	ASTM D3605	-----
Calcium	ppm mass	0.5	0	ASTM D3605	-----
Lead	ppm mass	0.5	0	ASTM D3605	-----
Hydrogen Sulfide	ppm volume	5 or 70,000	0 or 0	ASTM D3588	(Notes 2/3)
Sulfur, other	TBD	TBD	0		
Siloxanes	ppb volume	5	0	TBD	-----
Ammonia	ppm volume	TBD	0	TBD	-----
Other	ppm mass	0.5	0	-----	(Note 4)

Note 1: Oil contamination may emanate from the following two areas: (1) a fuel gas compressor (if used to compress the fuel supply pressure from a low-pressure supply to the pressure required by the MicroTurbine), or (2) any other source.

Note 2: Sulfur limitations may be lower depending on the exhaust emission requirements.

Note 3: Values above 5 and up to 70,000 ppm Volume are permissible on Capstone MicroTurbine Models C30 SG, C30 SC, and C30 L/DG.

Note 4: If other contaminants are present at more than 0.5 ppm by mass, they may need treatment, precautions, and/or modifications. These items must be detailed to Capstone for additional consideration.

Application problems

- Fuel injector:
  - Expanding of moister gas
    - Condensation und setting of particles
    - Injector block
    - Cavitation problems of expanding water drops

- Running tests in USA have shown that injectors do not run longer than 1000 hours.

Application problems

- Turbine, Recuperator:
  - Silane turns to siliciumoxid (glass, sand)
    - sublimate close to turbine and recuperator.

    (drop out at nearly 250°C)
    - abrasive wear at the turbine blade

    (low Temperature)
    - Settings on the recuperator lower the efficiency, because siliciumoxid works like an isolation.

Auxiliary equipment for using low BTU Gas

Necessary Equipment

- Gas supply
  - Increase the mass flow to reach the same power
  - Higher pressure (higher mass flow)
- Gas cleaning
  - To reach the limits for life cycle of the machine
  - To prevent some exhaust gas toxics

Auxiliary equipment I

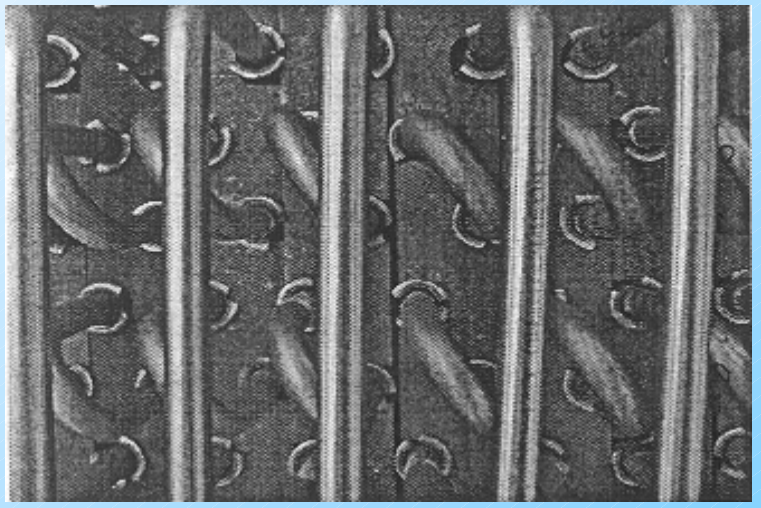
- Compressors for higher mass flows
  - Screw compressor
  - Piston compressor
  - Membrane compressor
- Criteria for the compressor for a 30kW Turbine
  - Pressure between **4** and **6 bar**
  - Volume flows between **12 m^3/h resp. 30 m^3/h** according to gas specification
  - Gas exit temperature of the compressor < **30°C**
  - Constant exit pressure about a wide volume flow
    - Non or really small **pulsations.**
  - Compressor should be oil free resp. slippage <5 ppm/m^3
  - Standard inspection after approx. 8000h (same as Turbine)

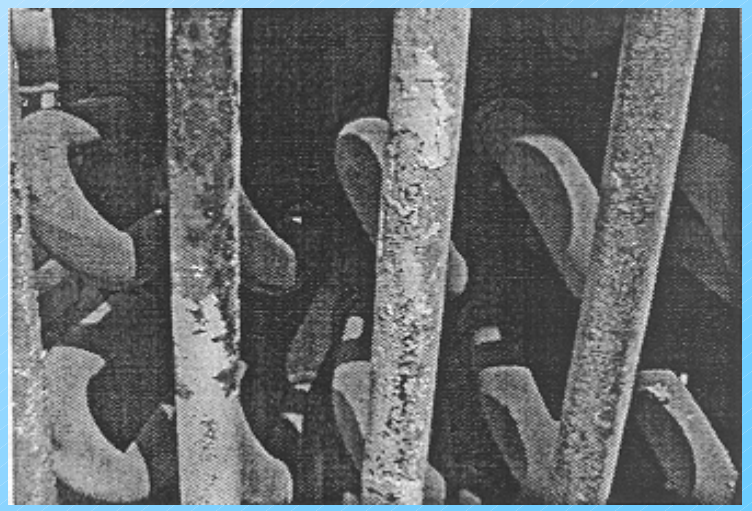
Auxiliary equipment II

- Gas cleaning:
  - Gas drying
  - Catalytic oxidation
  - Adsorption catalyse
  - Absorption
  - Centrifugal separation (Cyclone)
  - Membrane

Experience gas preparation

- For example Gas dryer:
  - During the drying process settings of silane occur at the condenser, they lower the efficiency and the lifecycle of the machine.
  - It also shows the problems by using the turbine without cleaning.





Projects for examination by using low BTU Gas

- Test with different technical gas mixes
  - Observation of the turbine behaviour for optimisation
  - Changing different equipment units
  - Search for points which should be tested with using low BTU Gas
- Building a test container for applications on dump and sewage plant corporation between NOWUM - G.A.S. Energietechnik GmbH
  - Observation of the gas quality
  - Observe the turbine during long time operation
  - Test of different auxiliary equipment (compressor, Cyclone, cooler and so on.)

Liquid Fuels

- The turbine includes a gasifier for operating with liquid fuels
- Different liquid fuels also require the fuel parameters
  - they are listed on a special table for liquid fuels

- Problems by using liquid fuels
  - Most times more than 1 start is necessary
  - After 4 missed starts an internal burning could occur during the cool down, then the turbine exit temperature gets >900°C
  - Pressure should be constant
  - Filter for particle size lower than 10µm is not standard

Future steps

- Highest potential of the micro turbine
  - Low BTU gas where it is difficult to use engine CHP
  - In nature conservation districts
    - Oil free
    - Clean exhaust
- Test a automatic system for changing the fuel parameter
  - Gas measurement and remote computer calculate the fuel parameters for automatic adaptation by changing gas quality
- Micro turbine with pyrolyse burning chamber
- Trying to use bio diesel or rape seed oil as liquid fuels.

Thank you for your attention

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