

Biomethane for CNG and Grid Injection using Membrane Processes: New Developments and Technology Rollout

Michael Harasek

Vienna University of Technology
Institute of Chemical Engineering

michael.harasek@tuwien.ac.at

Task 39
IEA Bioenergy

Highlights der Bioenergieforschung
Wieselburg, 31.03.2011

- Short intro – why biogas upgrading?
- Quality issues
- Gas permeation process
- Scale-up to pilot and full scale - process integration
 - Two-stage grid injection (Bruck/Leitha)
 - Single-stage CNG production (Margarethen/Moos)
- Energy demand
- Biogas pretreatment (desulphurisation)
- Costs
- Technology roll-out & future

Why biogas upgrading?

- Standardised product „biomethane“ (compatible with natural gas)
- Higher efficiencies in energy utilisation than conventional gas engines without heat integration
- Access to new markets – the gas grid
- Automotive utilisation (CNG)

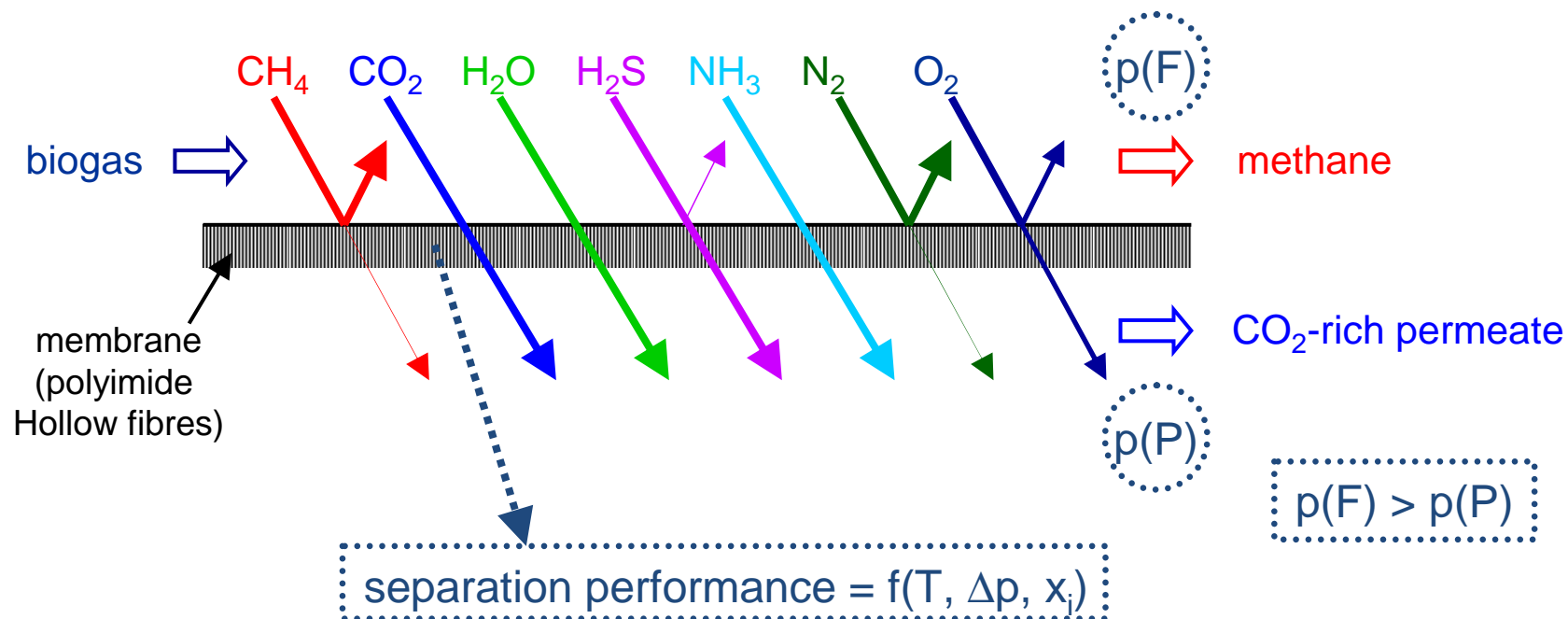


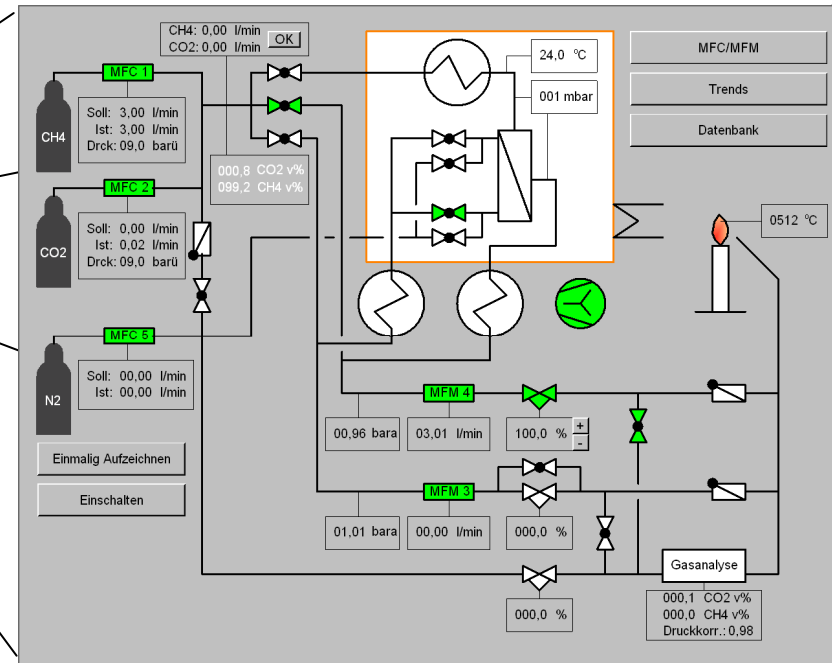
Parameter	Biogas	Quality according to Austrian Standard ÖVGW G31 / G33	Unit
Methane (CH ₄)	50 - 65	>97	[%]
Carbon dioxide (CO ₂)	25 - 45	≤ 2,0	[%]
Ammonia (NH ₃)	< 1.000	technically free	[mg/m ³]
Hydrogen sulphide (H ₂ S)	< 2.000	≤ 5	[mg/m ³]
Oxygen (O ₂)	< 2	≤ 0,5	[%]
Nitrogen (N ₂)	< 8	≤ 5	[%]
Water (H ₂ O) - Dewpoint	< 37 @ 1 bar	≤ - 8 bei 40 bar	[°C]
Upper Heating value	6,7 - 8,4	10,7 - 12,8	kWh/m ³
Wobbe-Index	6,9 - 9,5	13,3 - 15,7	kWh/m ³

ÖVGW G31 defines natural gas, **ÖVGW G33** specifies grid injection standards for biogases

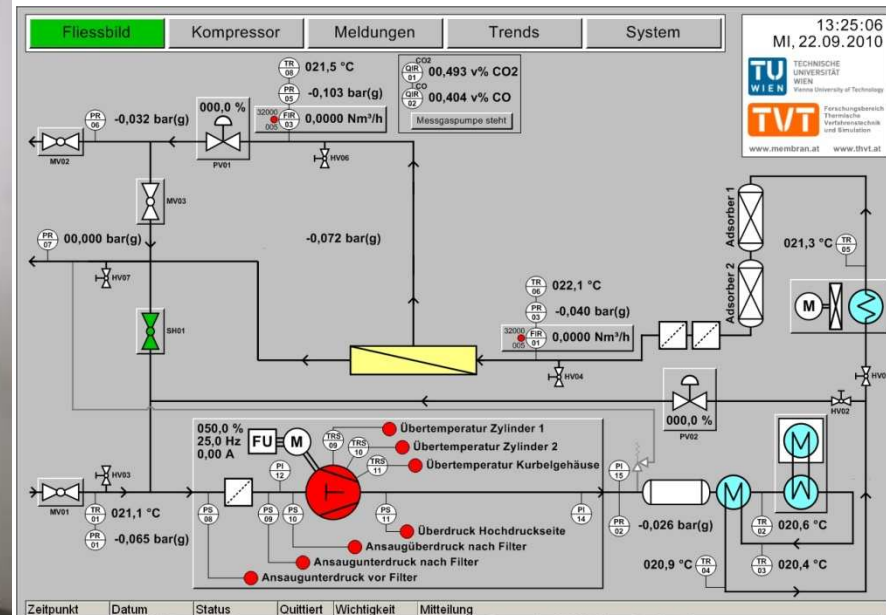
Upgrading of Biogas using Gas Permeation (GP)

- Separation principle: different permeabilities of methane and components to be separated.
- Important parameter: permeability ratio = selectivity.
- After compression biogas is fed to membrane modules.



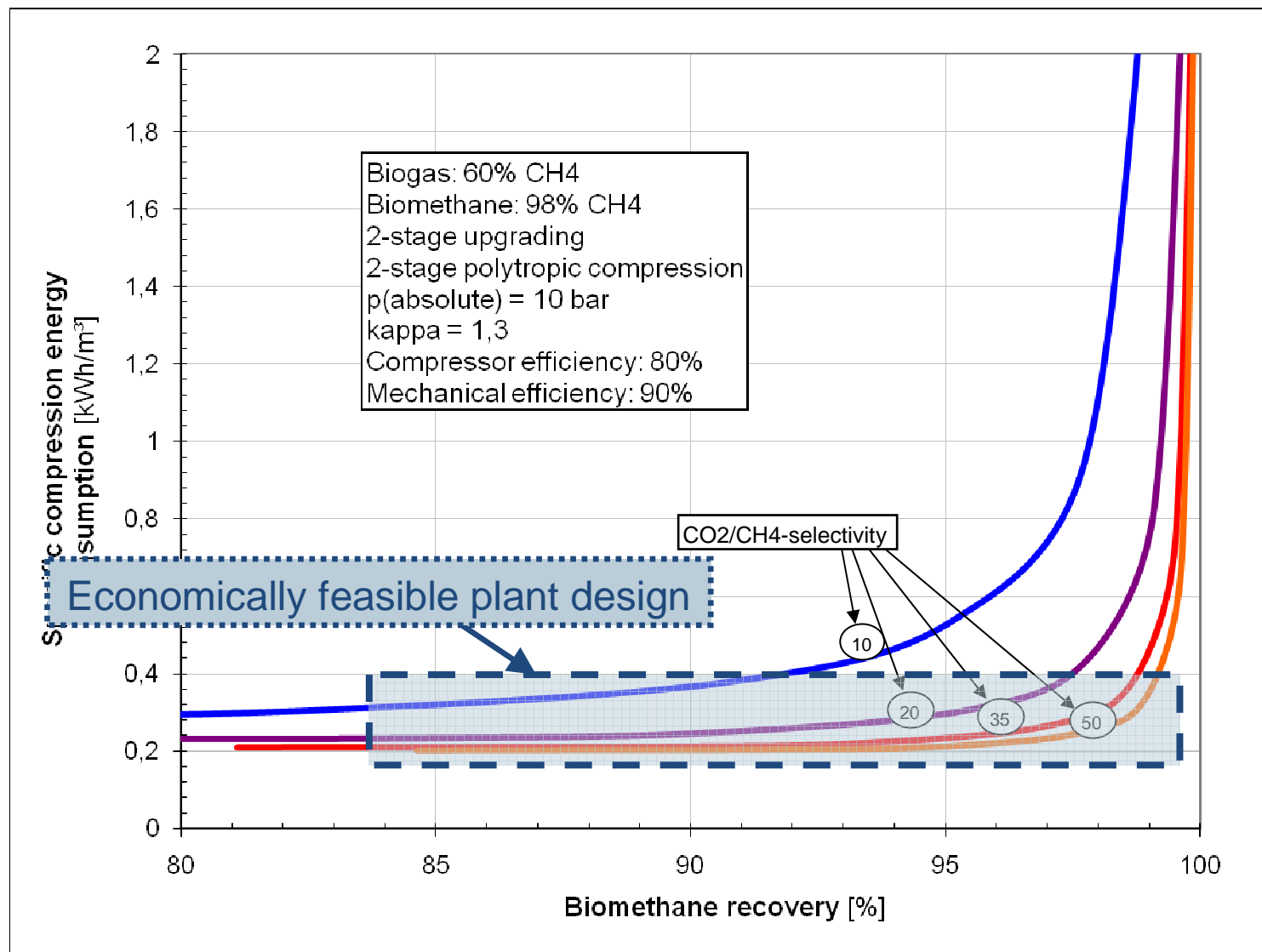


- Preparation of CO₂/CH₄/N₂ gas mixtures with mass flow controllers
- Thermostatic chamber
- Industrial NDIR gas analyzer for CO₂ and CH₄
- Test control, visualization and data collection using a PLC with HMI/SCADA system

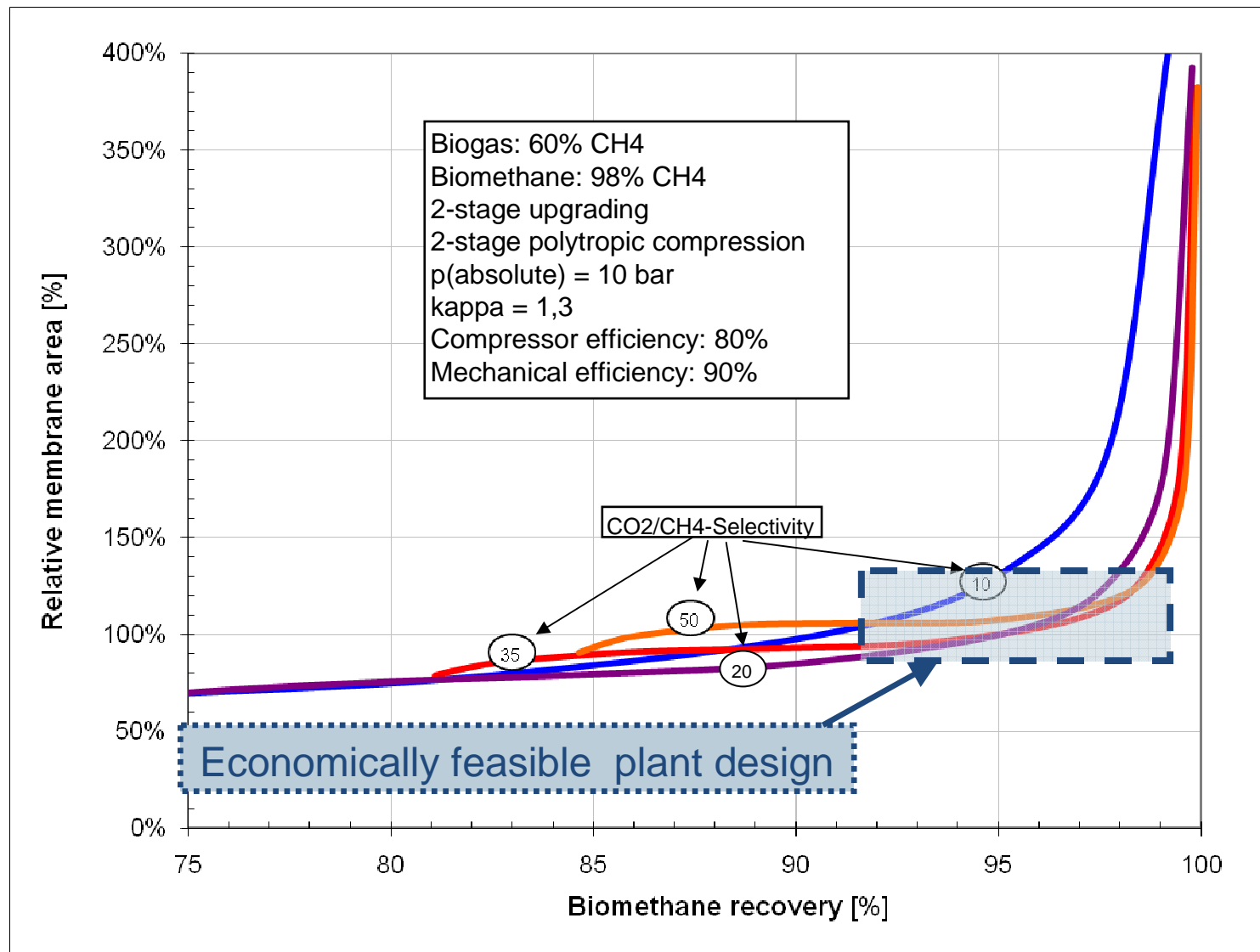


- Mobile pilot plant for flexible treatment of many gas mixtures including H₂
- Magnet-coupled two-stage piston compressor (up to 15 bar, 0-6 m³/h)
- Fully automated upgrading plant for remote operation (industrial PLC)
 - 3 adsorber fillings in series
 - Cryo condenser
 - Reheater
 - One/two stage membrane separation with/without gas recycling
 - NDIR online continuous gas

Compression Energy Consumption per m³ Product

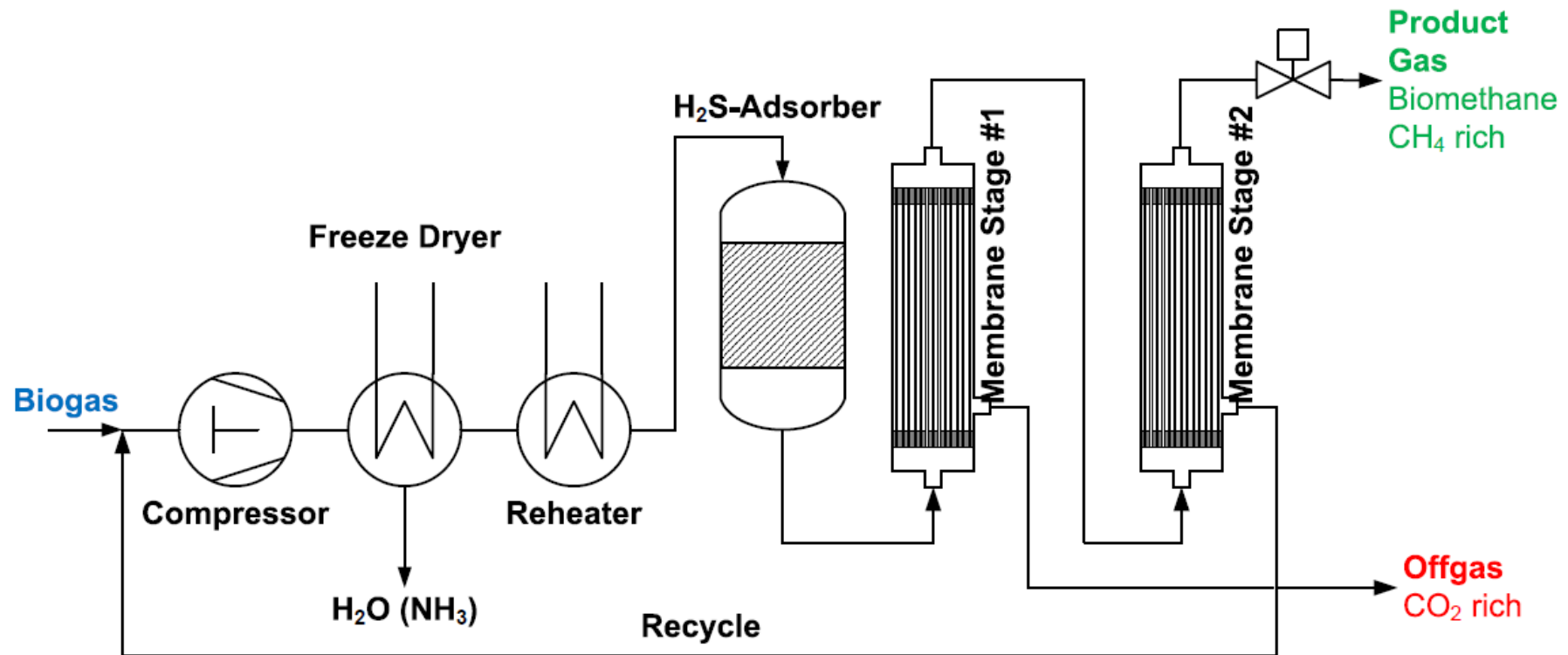


Membrane Area as Function of Recovery



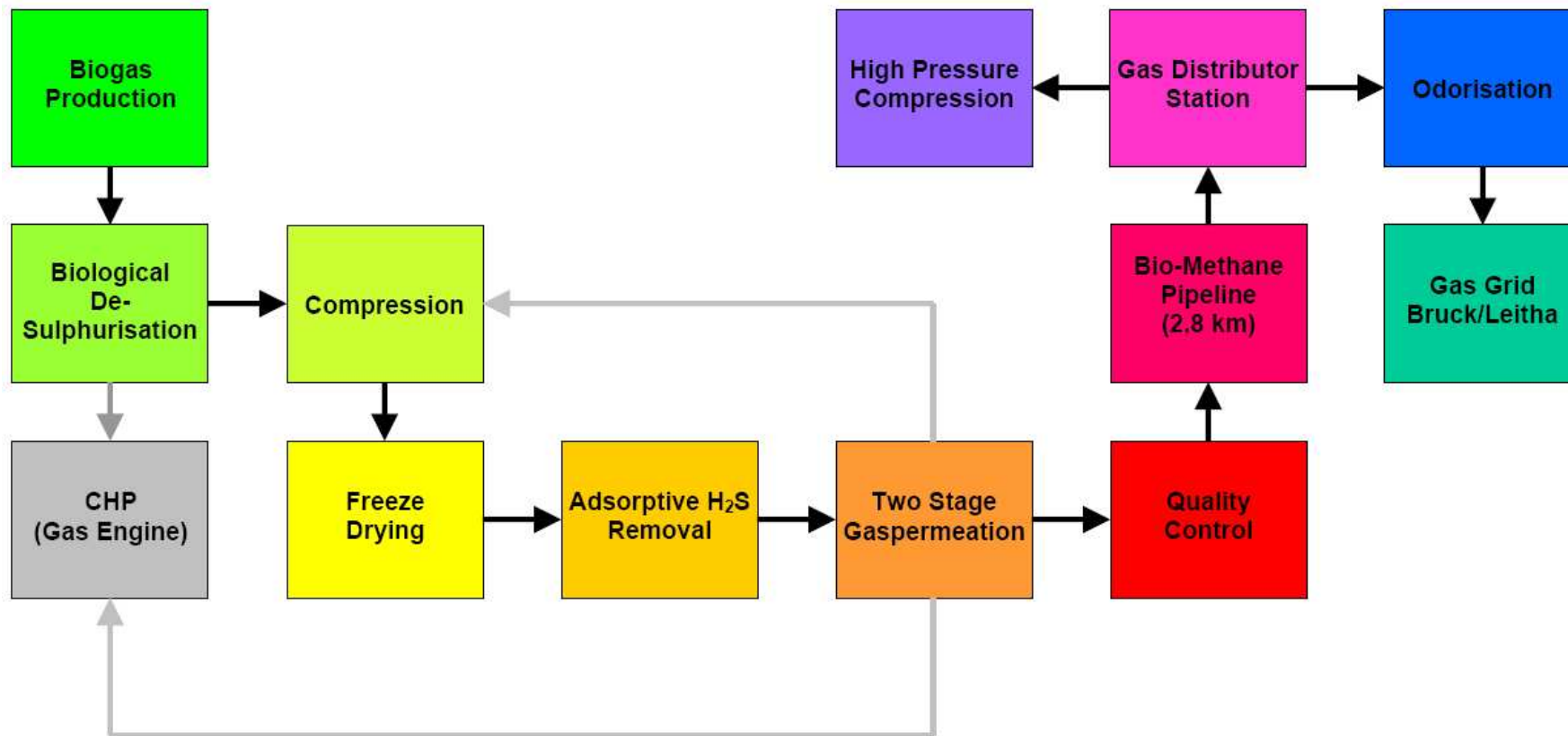
Process Scheme of a Two-stage Membrane System

- **Two-stage separation process** with recycle and a single compressor



Biogas Upgrading Plant in Bruck/Leitha (Austria)

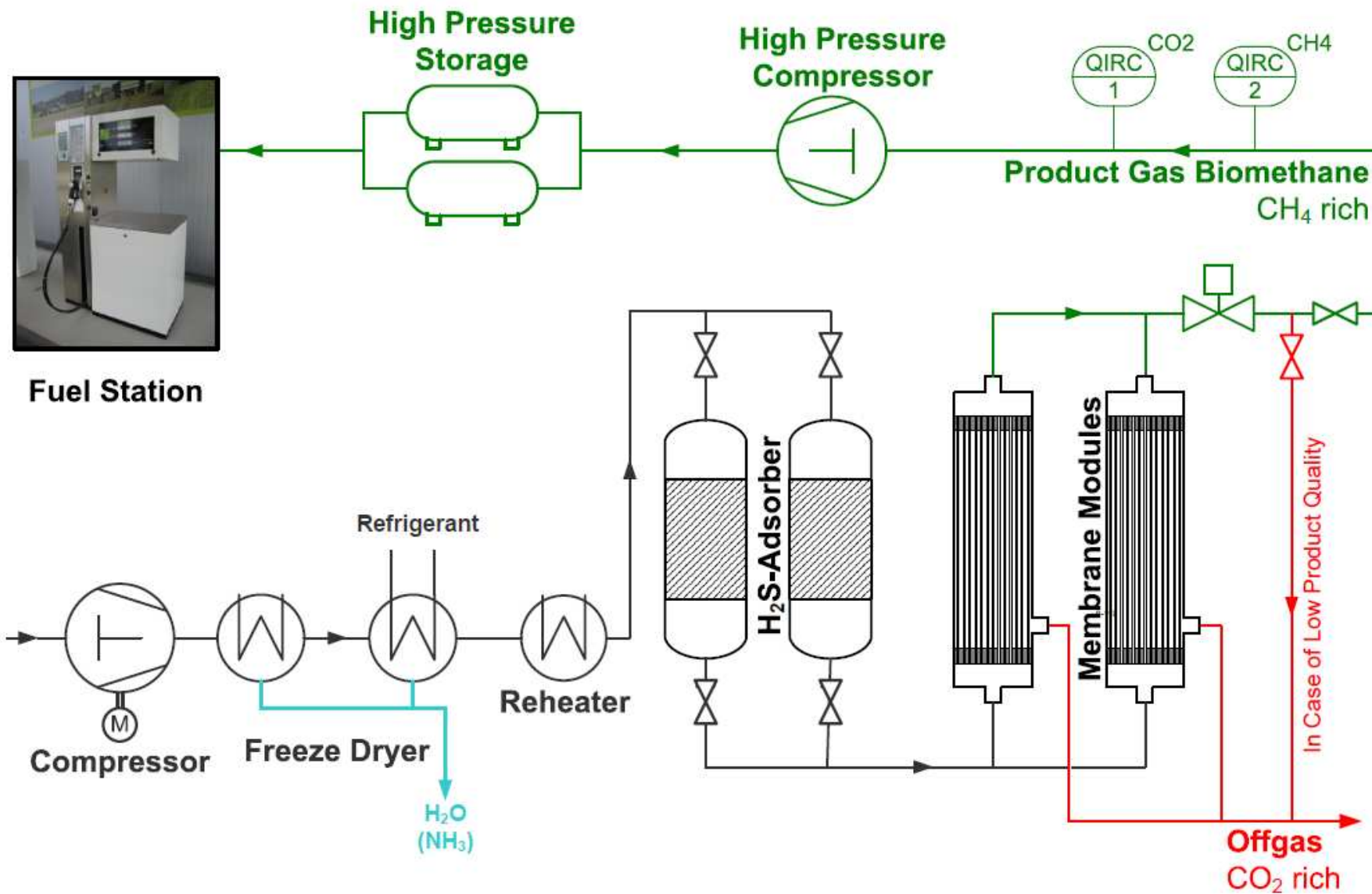




- Biological desulphurisation prior to membrane treatment
- Permeate is recycled to CHP plant – „zero methane“ emission of upgrading system

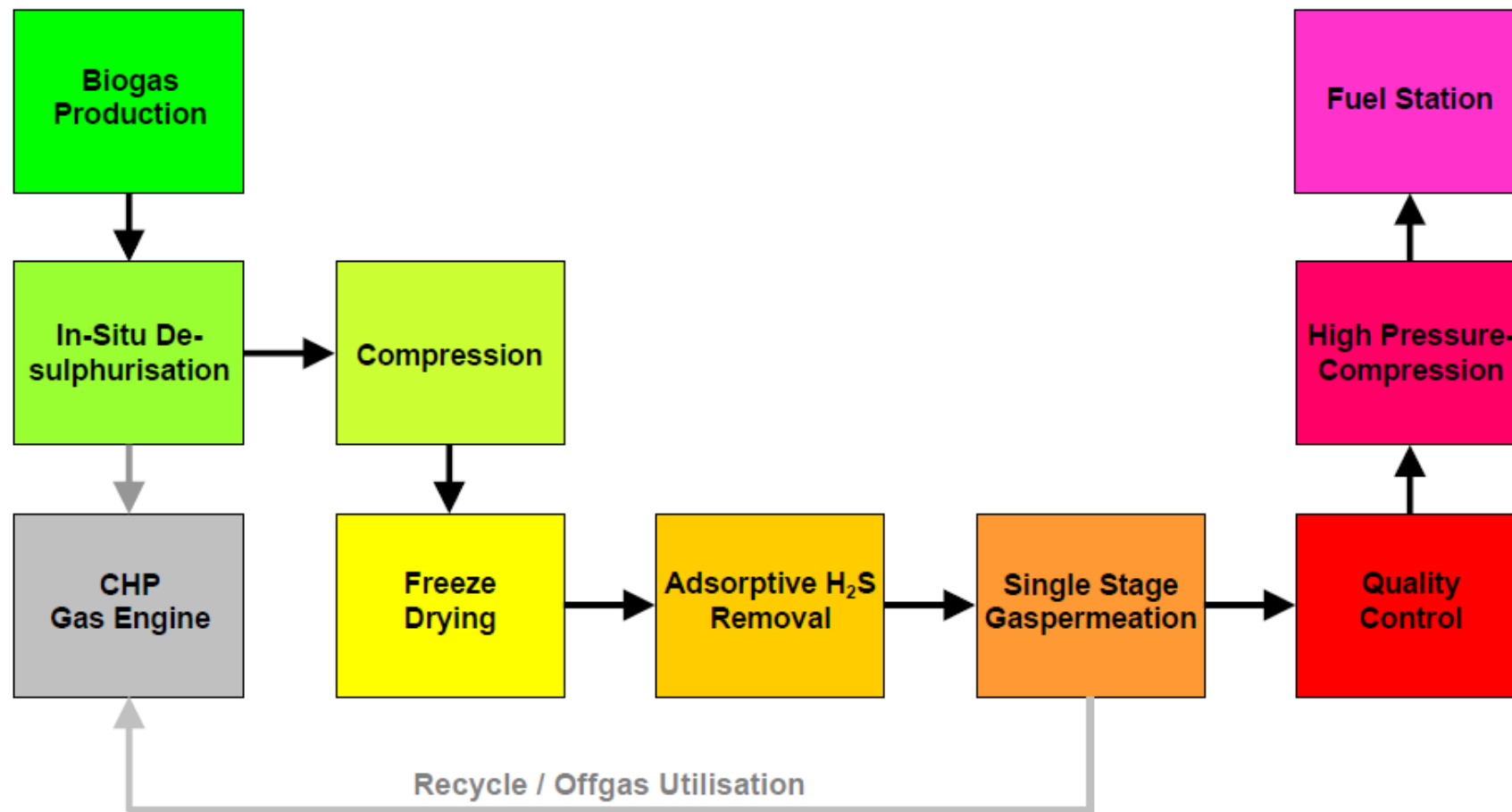
- **Main energy consumer of upgrading is the raw biogas compressor.**
- Energy demand for constant product gas quality and quantity depends also on raw biogas methane content.
- **Effect of plant layout** (number of stages) on energy consumption:
 - **Two stage gas grid injection plant:** 0,378 kWh/m³STP of product gas
 - **Single stage Bio-CNG-plant:** 0,280 kWh/m³STP of product gas
- Energy consumption of **<0,2 kWh/m³ STP of raw biogas** possible!
- Related to the methane content of the produced biomethane gas stream:
 - **Two stage gas grid injection plant:** 3,2% (98,1vol% CH₄)
 - **Single stage Bio-CNG-plant:** 2,8% (96,1vol% CH₄)
- All values are valid for a product gas delivery pressure of about 3 bar(g).

Biomethane Fuel Station: Single Stage Upgrading



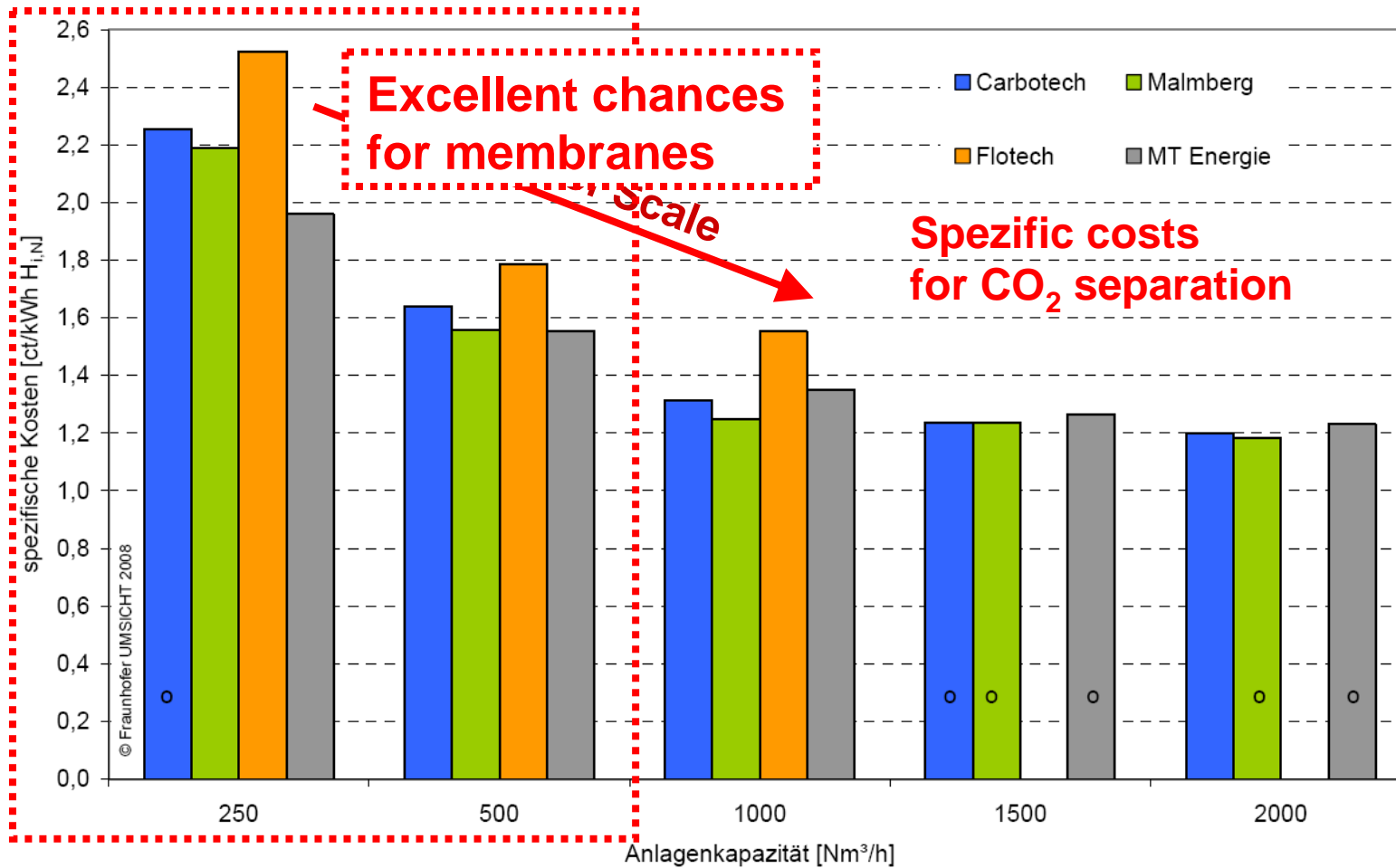


- Permeate recycle to CHP plant
- Further information: www.methapur.com
Biomethane fuel station Margarethen/Moos



- **In-situ desulphurisation (addition of iron salts into the fermentation broth to catch sulphides)**
- **Permeate is recycled to CHP plant – „zero methane“ emission of upgrading system**

Calculations by Fraunhofer Institut UMSICHT (2008)



- **Offgas treatment** depends on process integration:
 - Mixing with biogas and utilisation in CHP plants
 - Thermal oxidation (flameless oxidation systems or direct combustion of low-cal gas)
 - Catalytic oxidation
 - Further treatment using additional membrane separation stage
- **Specific costs of upgrading** (depends on plant capacity):
 - **Investment** (depreciation 10 years, 8%):
 0,05 – 0,08 €/m³ biomethane
 - **Operation** (> 8000 h/a):
 0,10 – 0,14 €/m³ biomethane

Compatible:

- External biological desulphurisation in combination with pure oxygen injection
- In-situ desulphurisation using iron salts
- **External chemical scrubber with oxidation using NaOH/H₂O₂, recommended for fluctuating H₂S concentrations in the biogas**
- Adsorptive desulphurisation technologies with low excess of O₂ (impregnated activated carbon adsorbents)

Not suitable / incompatible:

- Air injection
- External biological desulphurisation with air injection



In operation:

- since 2004: Pilot plants (up to 6 m³/h biogas, Vienna University of Technology)
- 2007: Bruck an der Leitha (180 m³/h biogas, 100 m³/h biomethane)
- 2007: Margarethen am Moos (80 m³/h biogas, 35 m³/h bio-CNG)
- Start-up 05/2010: Kißlegg / Baden-Württemberg, Germany (500 m³/h biogas)

Start-up:

- Feed-in operation starts in 03/2011: Wiener Neustadt (220 m³/h biogas)

Supplier:

Axiom Angewandte Prozesstechnik GmbH



Recent Start-up of First AXIOM Plant in Germany



- Capacity 500 m³/h biogas, 300 m³/h biomethane, approx. 8 km pipeline for grid injection and high pressure compression to 60 bar

Recent Start-up of First AXIOM Plant in Germany

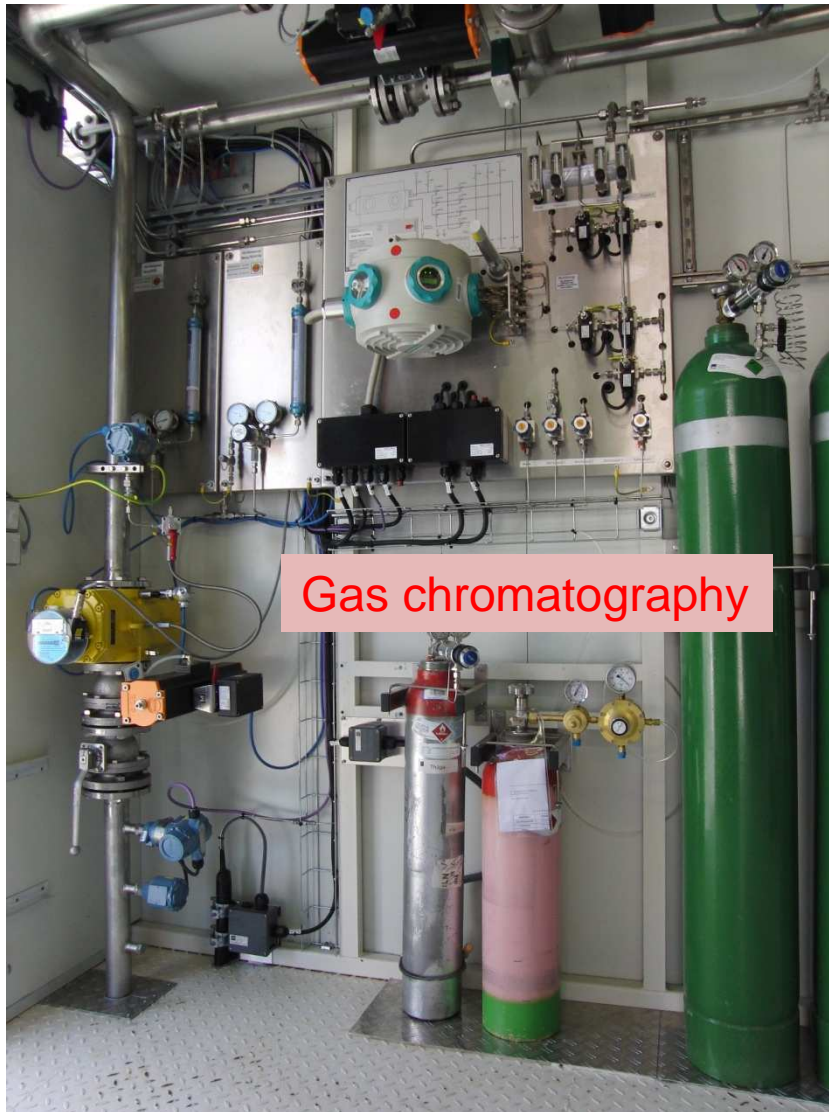


Recent Start-up of First AXIOM Plant in Germany



Membrane modules

Recent Start-up of First AXIOM Plant in Germany



- Contact & WWW:
michael.harasek@tuwien.ac.at
www.virtuellesbiogas.at
bio.methan.at
- Technology (turn key plants):
**Axiom Angewandte
 Prozesstechnik GmbH**
office@axiom.at



Construction site of upgrading plant in Wiener Neustadt (Lower Austria)

Thank you for your attention!