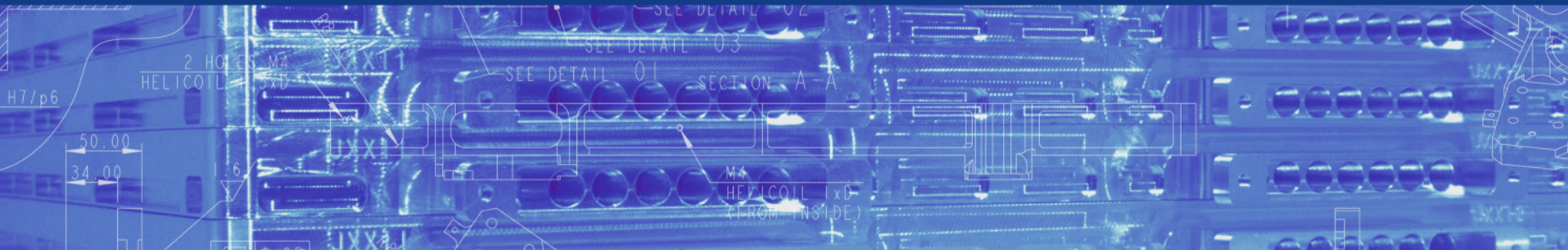


cmr Prototech



SOFC stack testing at Prototech

- measurements for stable stack operation

International Symposium on Diagnostic Tools for Fuel Cell Technologies

Trondheim, 23 June 2009

Helge Weydahl, Ivar Wærnhus, Tomas Ryberg, Jarle Farnes, Arild Vik

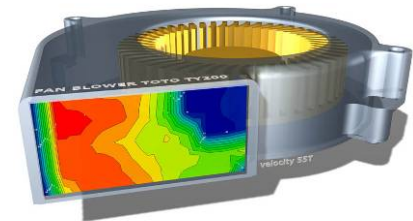
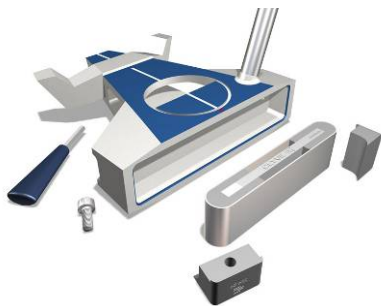
Prototech AS

Outline

- About Prototech
- Requirements for stable SOFC operation
- BioCellus
- BKK pilot plant
- Conclusion

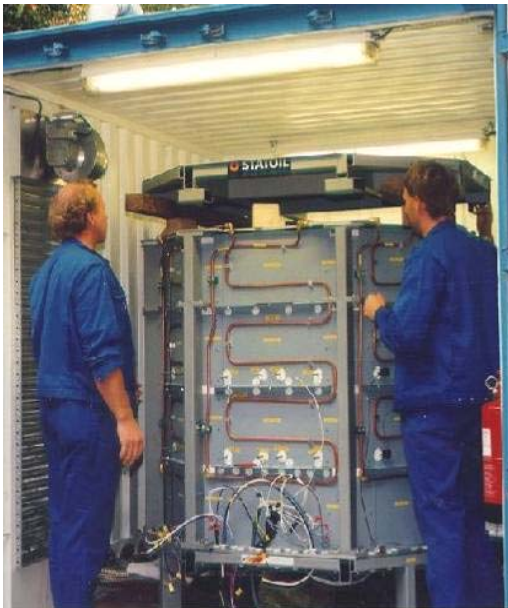
Prototech AS

- Prototech is a provider of technical solutions, product design and manufacturing services covering application areas from space to consumer products



Prototech

- A part of the Christian Michelsen Research (CMR) group
- Prototech has been involved in fuel cell development since 1991
- 40 employees, revenue 47 MNOK (5.3 M€)



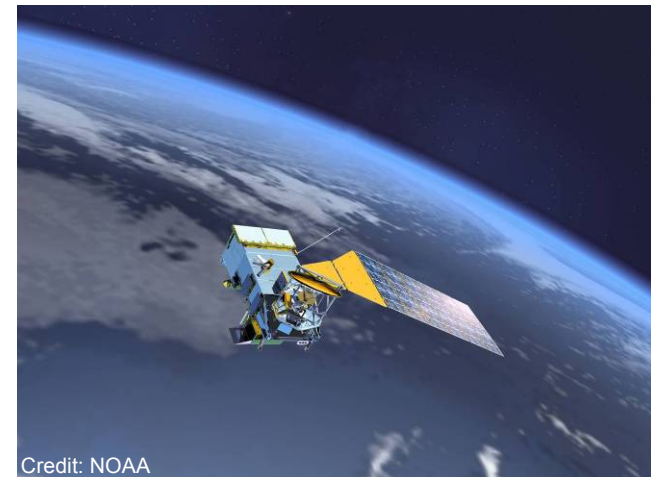
A selection of fuel cell activities

- Solid oxide fuel cells



A selection of fuel cell activities

- Solid oxide fuel cells
- Regenerative fuel cell (PEM) systems for telecom satellites



Credit: NOAA

A selection of fuel cell activities

- Solid oxide fuel cells
- Regenerative fuel cell (PEM) systems for telecom satellites
- High temperature PEM fuel cell system for small passenger ferry



A selection of fuel cell activities

- Solid oxide fuel cells
- Regenerative fuel cell (PEM) systems for telecom satellites
- High temperature PEM fuel cell system for small passenger ferry
- Production of electricity and hydrogen from natural gas with integrated CO₂ capture (ZEG)



Requirements for stable SOFC operation

- Sufficient air supply to cathode
- Sufficient fuel supply to anode
- Sufficient steam supply to anode



Control of oxygen partial pressure on anode:

- Low fuel supply → shift of equilibrium towards higher oxygen partial pressure → oxidation of anode
- Low steam supply → shift of equilibrium towards lower oxygen partial pressure → extraction of oxygen from ceramic interconnects

Measured parameters

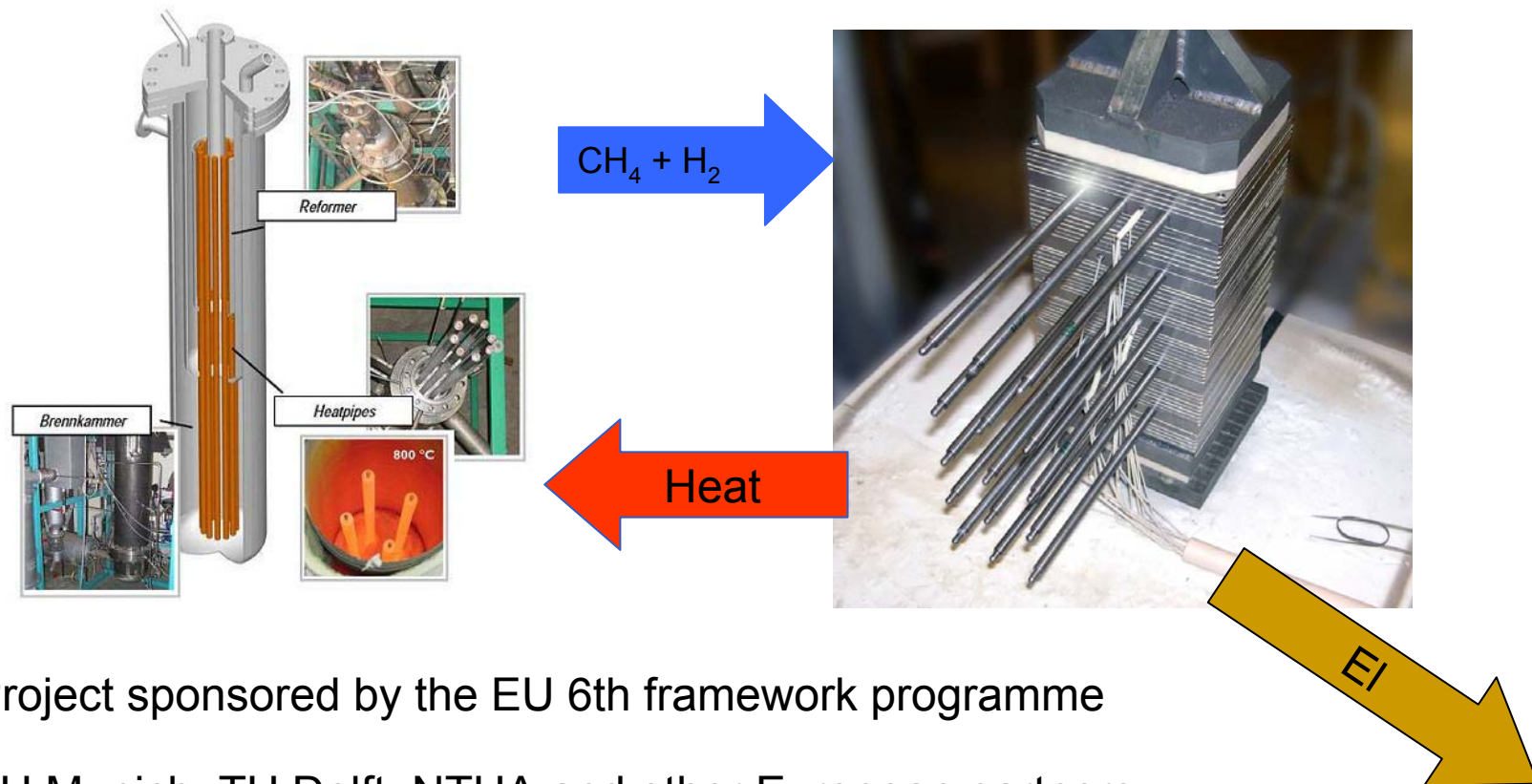
- Cell voltages
- Stack temperature

On the wish list:

- Gas flow distribution
- Gas flow composition



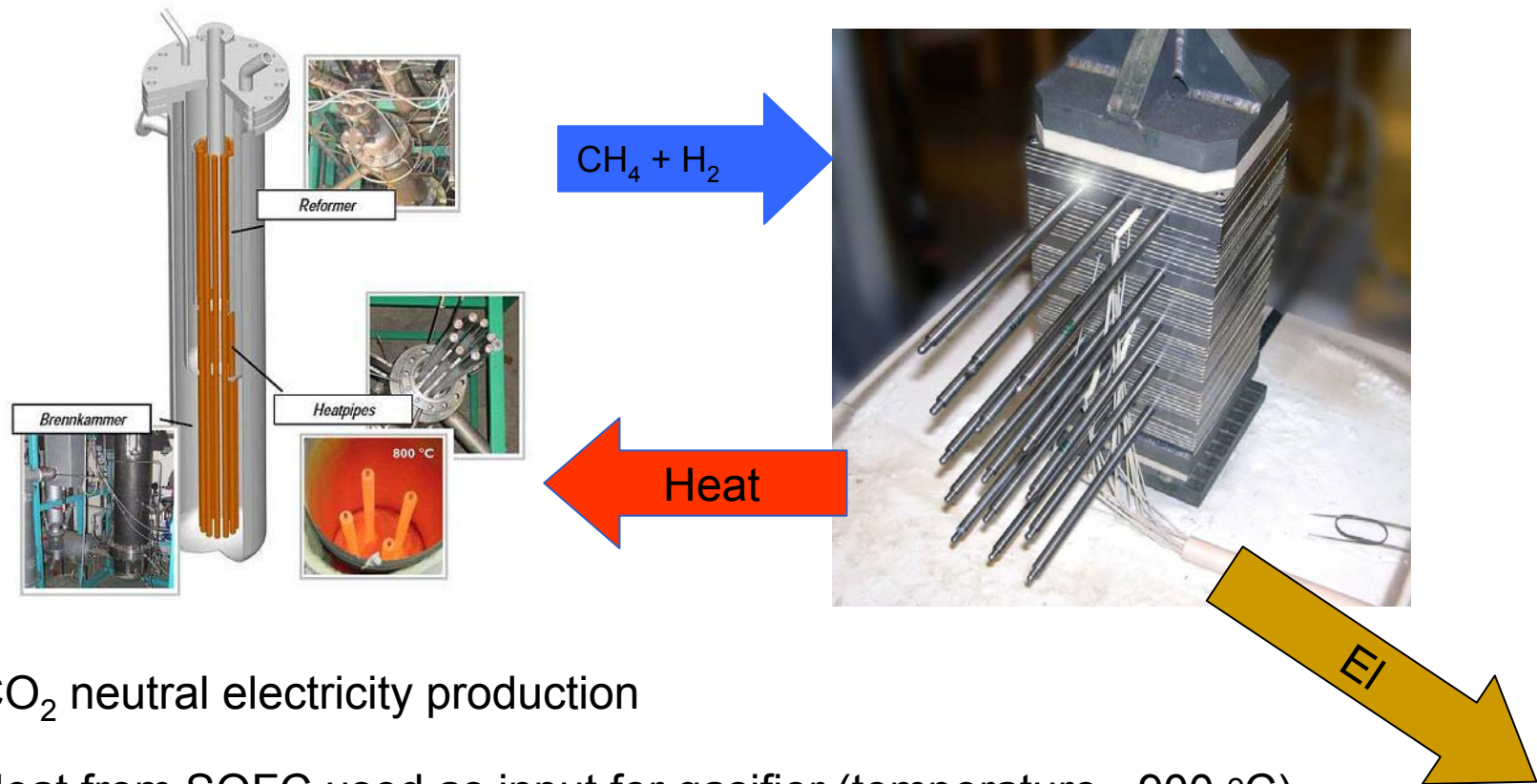
BioCellus - SOFC on biomass



- Project sponsored by the EU 6th framework programme
- TU Munich, TU Delft, NTUA and other European partners
- Develop and demonstrate SOFC operating on gasified biomass



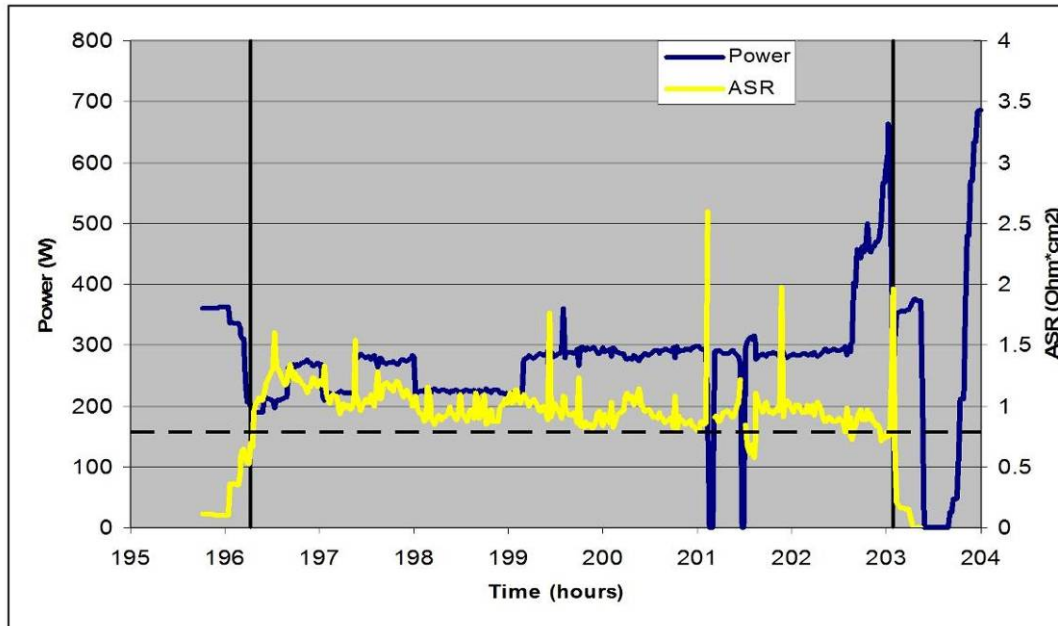
BioCellus - SOFC on biomass



- CO_2 neutral electricity production
- Heat from SOFC used as input for gasifier (temperature $\sim 900\text{ }^\circ\text{C}$)
- Plant efficiency (biomass to electricity): 50% (60% with steam cycle)



BioCellus – SOFC on biomass



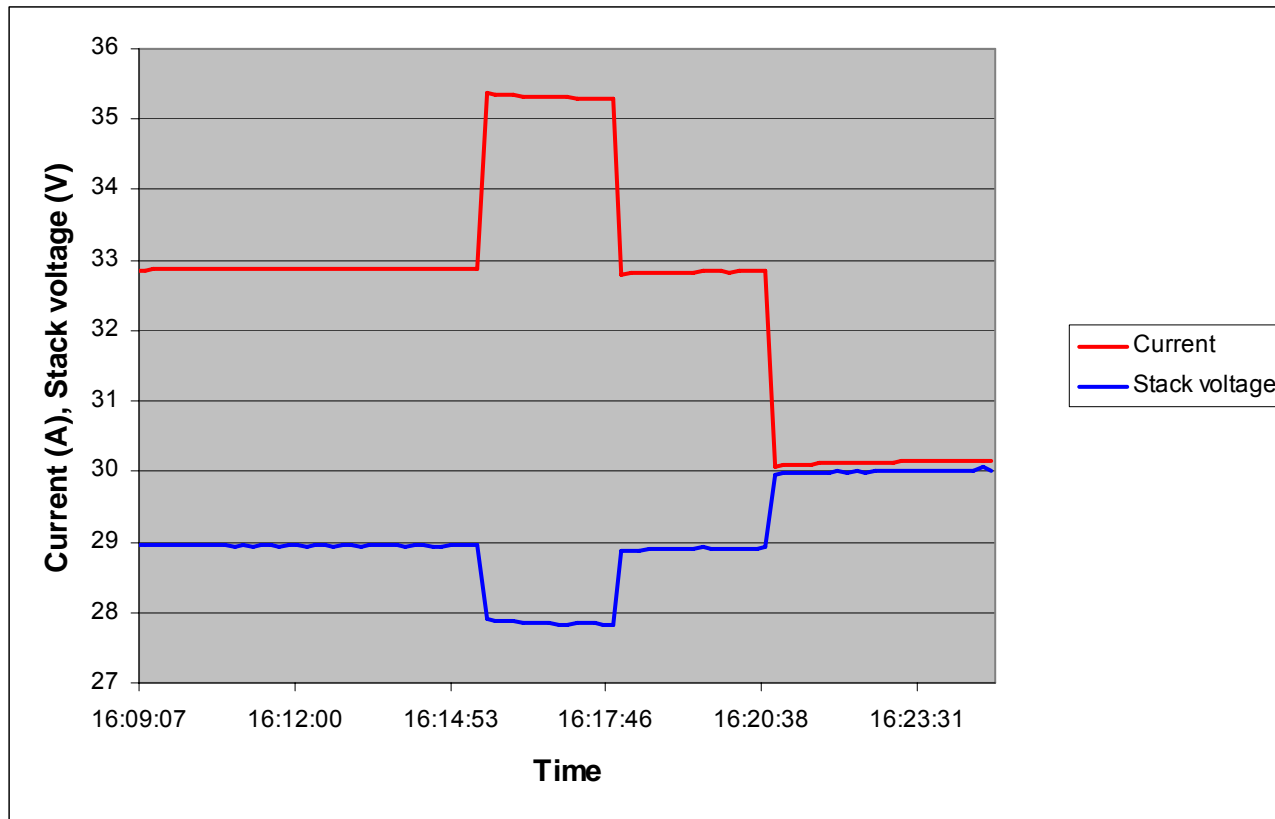
- First SOFC stack operated on real woodgas
- About 12 hours operation on woodgas
- No degradation observed during test





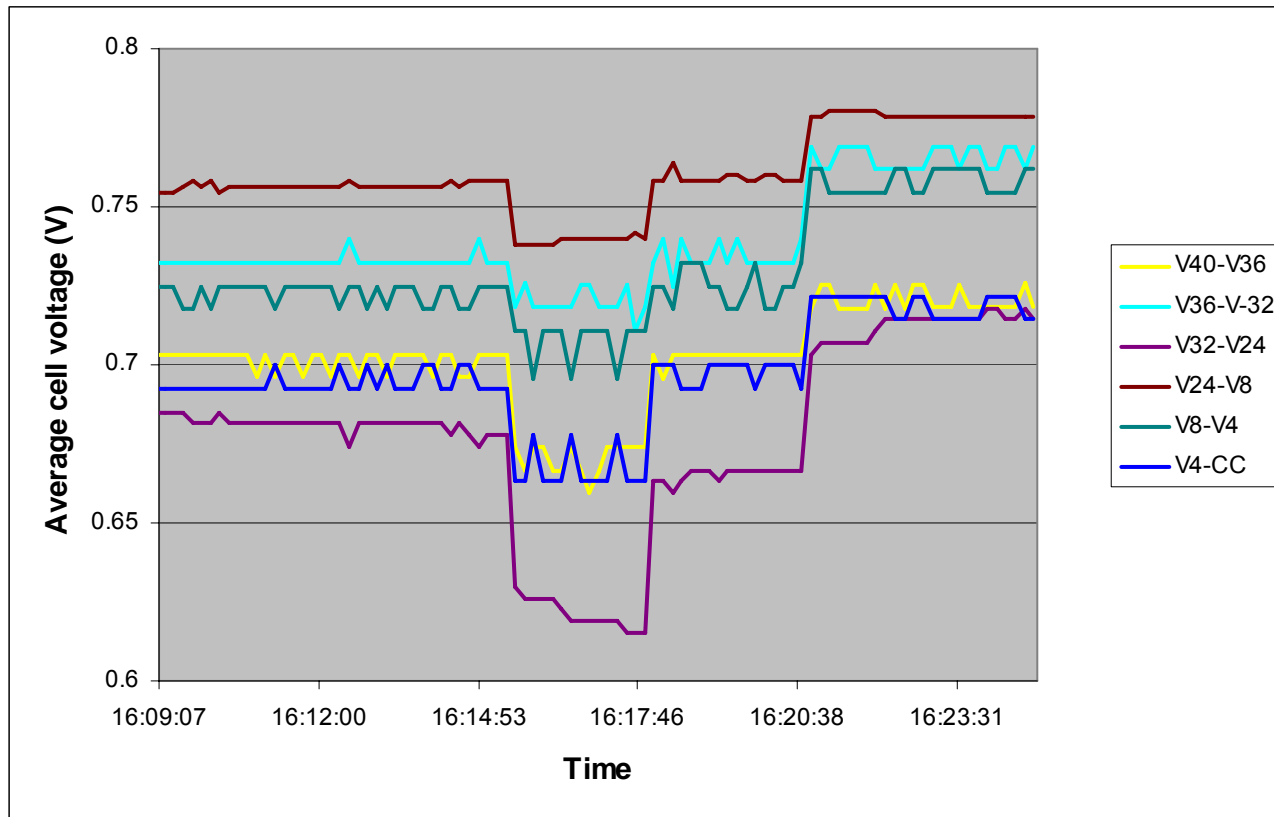
BioCellus – SOFC on biomass

- Stack voltage and current upon increase in load



BioCellus – SOFC on biomass

- Decreasing trend in cell voltage indicates insufficient fuel supply from the gasifier





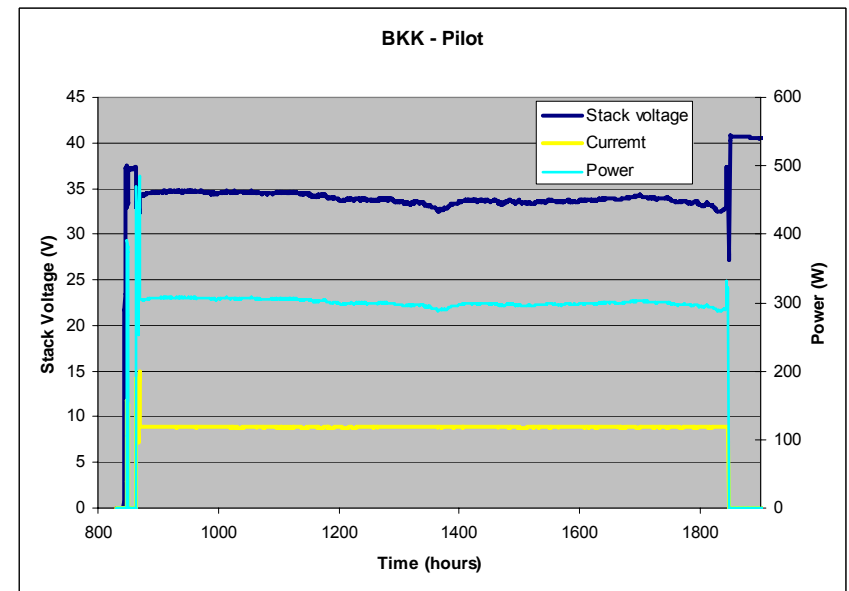
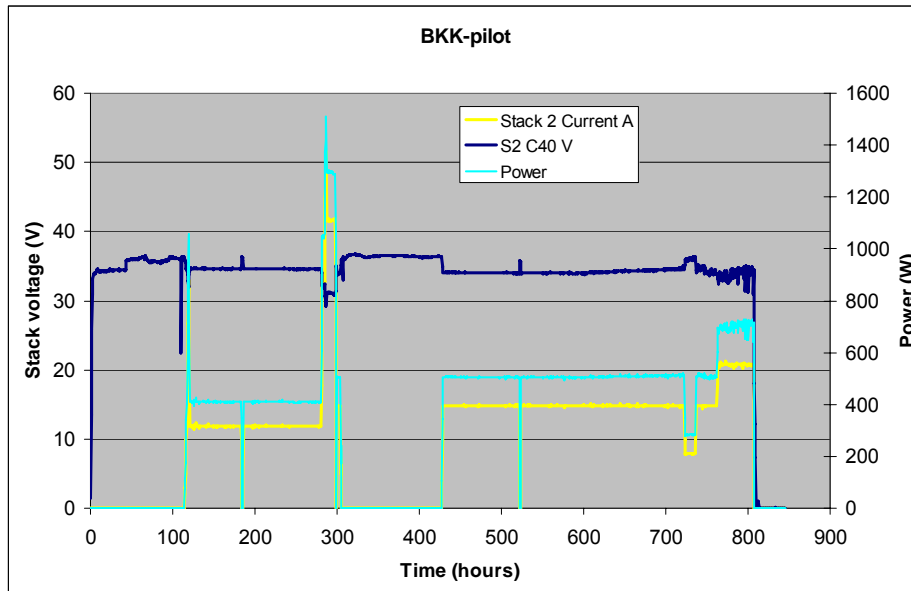
BKK pilot plant - SOFC for CHP

- 3+3 kW SOFC plant for combined heat and power - designed and manufactured by Prototech
- Sponsored by BKK and Innovation Norway
- Operating on natural gas at Kollsnes Industrial Park (LNG plant at the west coast of Norway)





BKK pilot plant - SOFC for CHP

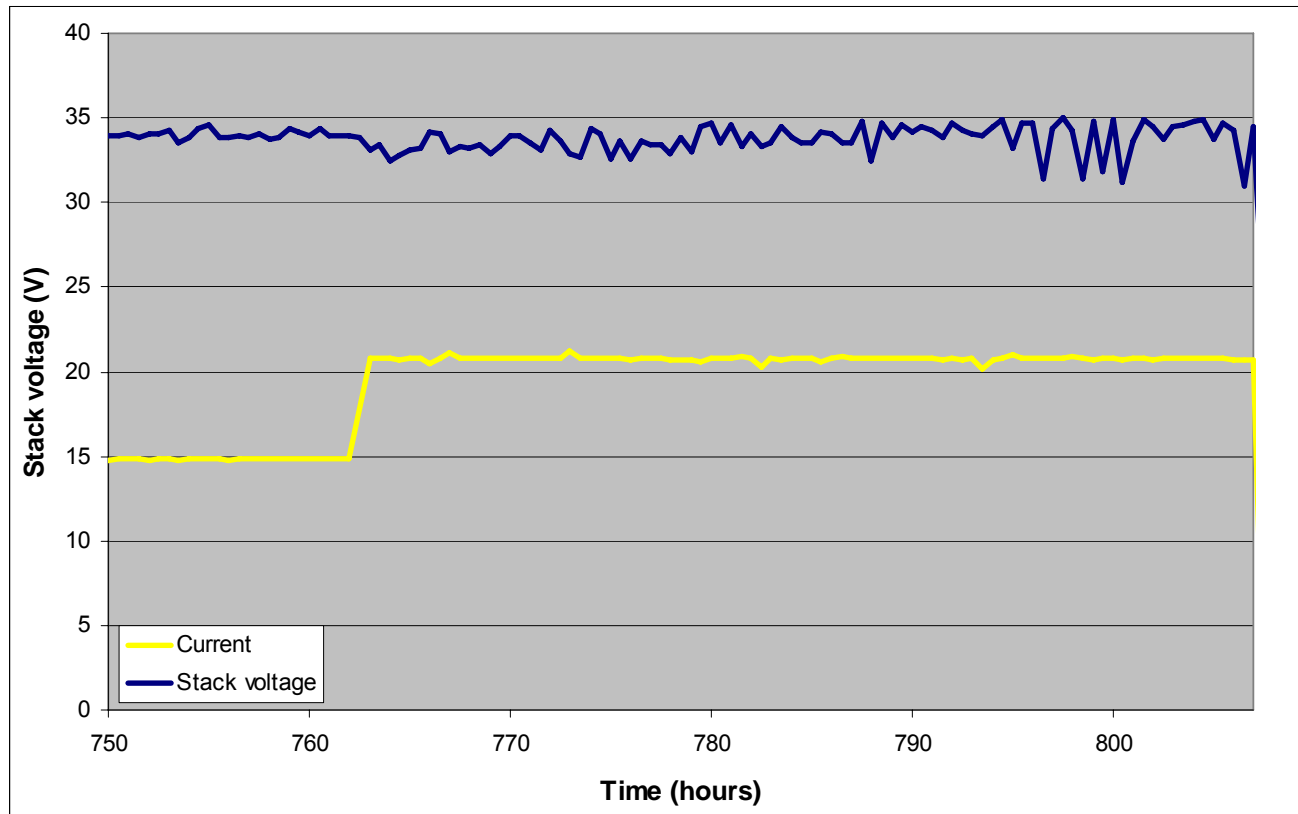


- 1800 hours of operation
- Max. temperature ~ 800 °C
- Stable SOFC performance under regular operating conditions



BKK pilot plant - SOFC for CHP

- Unstable water supply to reformer (clogged water filter) resulted in fluctuating stack voltage



Conclusion

- Stable operation under regular operating conditions
- Monitoring of cell voltage and temperature is sufficient to ensure stable operation of SOFC stacks
- Monitoring of fuel supply distribution and composition would be a useful tool for optimisation of stack design

