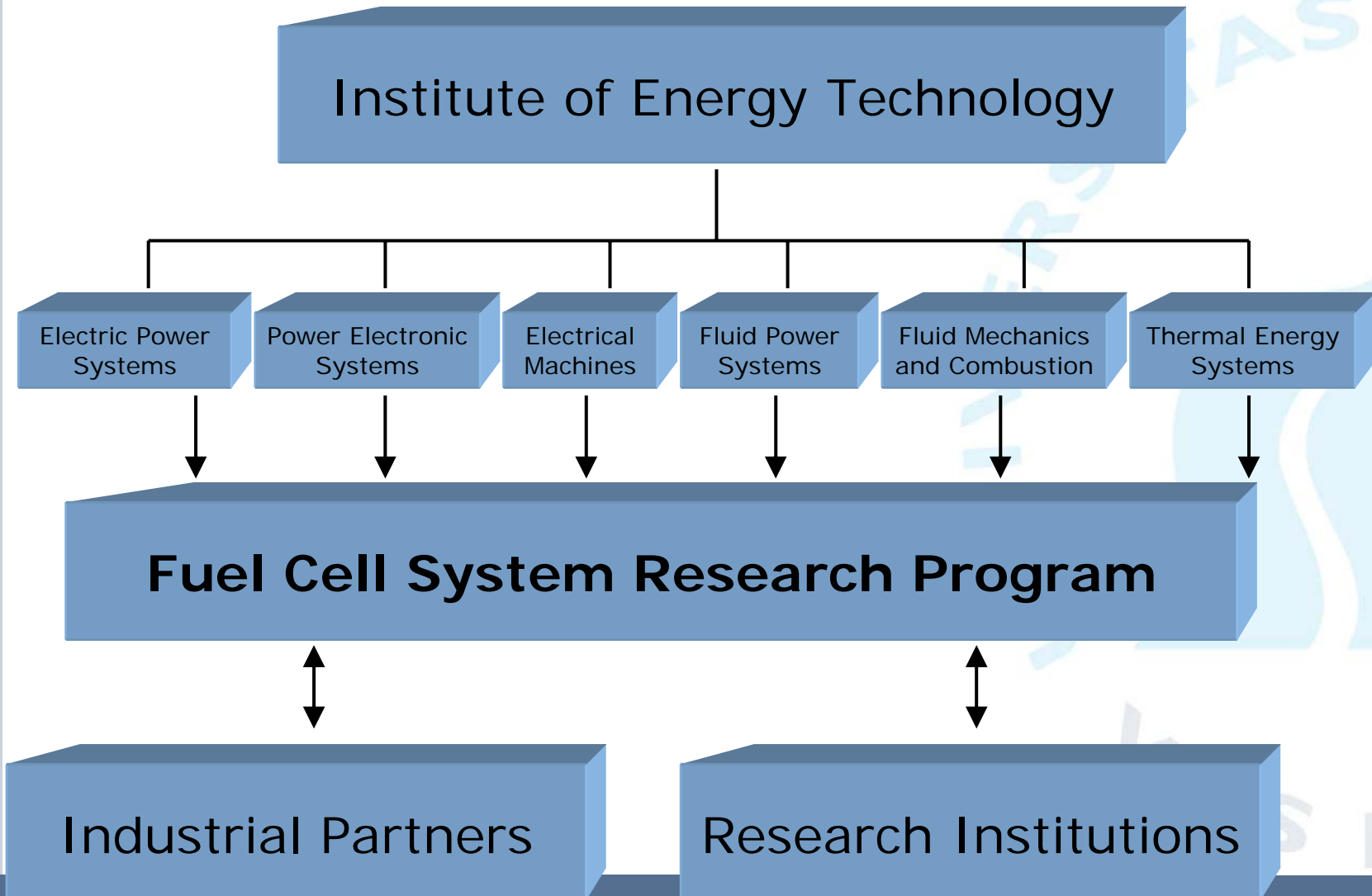


IET-AAU Fuel Cell System Research

Fuel Cell Systems & Optimization

Mads Pagh Nielsen
(Associate Professor, IET-AAU)

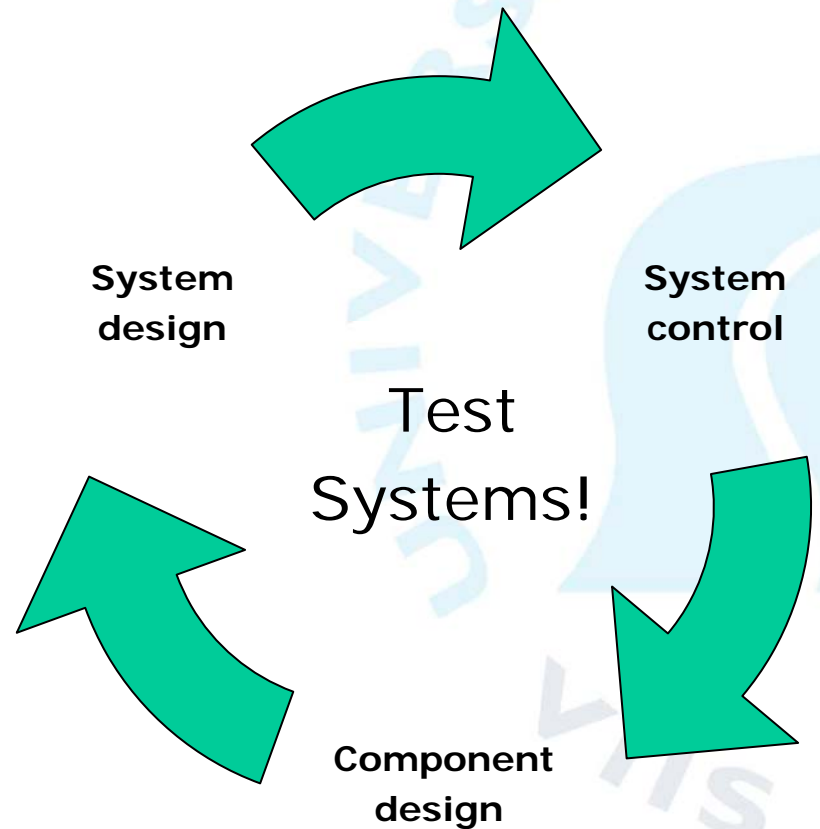


Mission

- To promote sustainable energy production by conducting definitive leading edge research at international level in fuel cell technology.

Main Research Areas

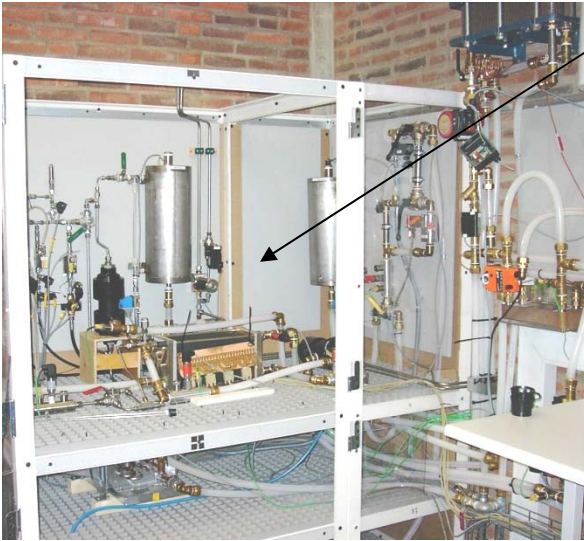
- Fluid mechanics
- System modeling and optimization
- Advanced system control
- Power electronics



Stack and system test facilities



IET-AAU Fuel Cell Research



Advanced stack tests
- Gas composition
- Humidity (anode, cathode)
- Heat management
(All Stack Types < 200°C)

- We tested several PEM stacks from the worlds major stack manufacturers.

Single cell test facilities

- LT-PEM/HT-PEM
- DMFC

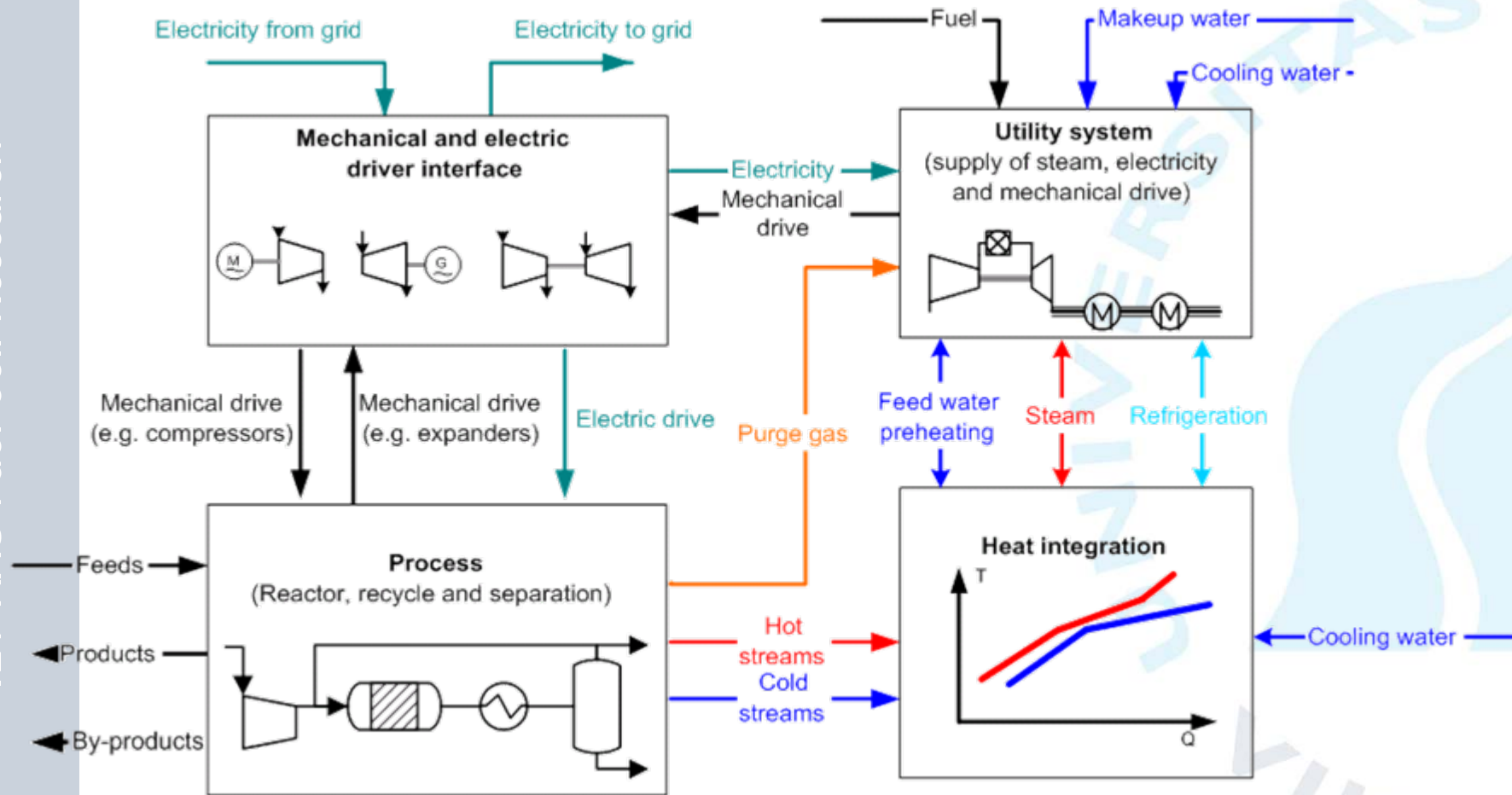


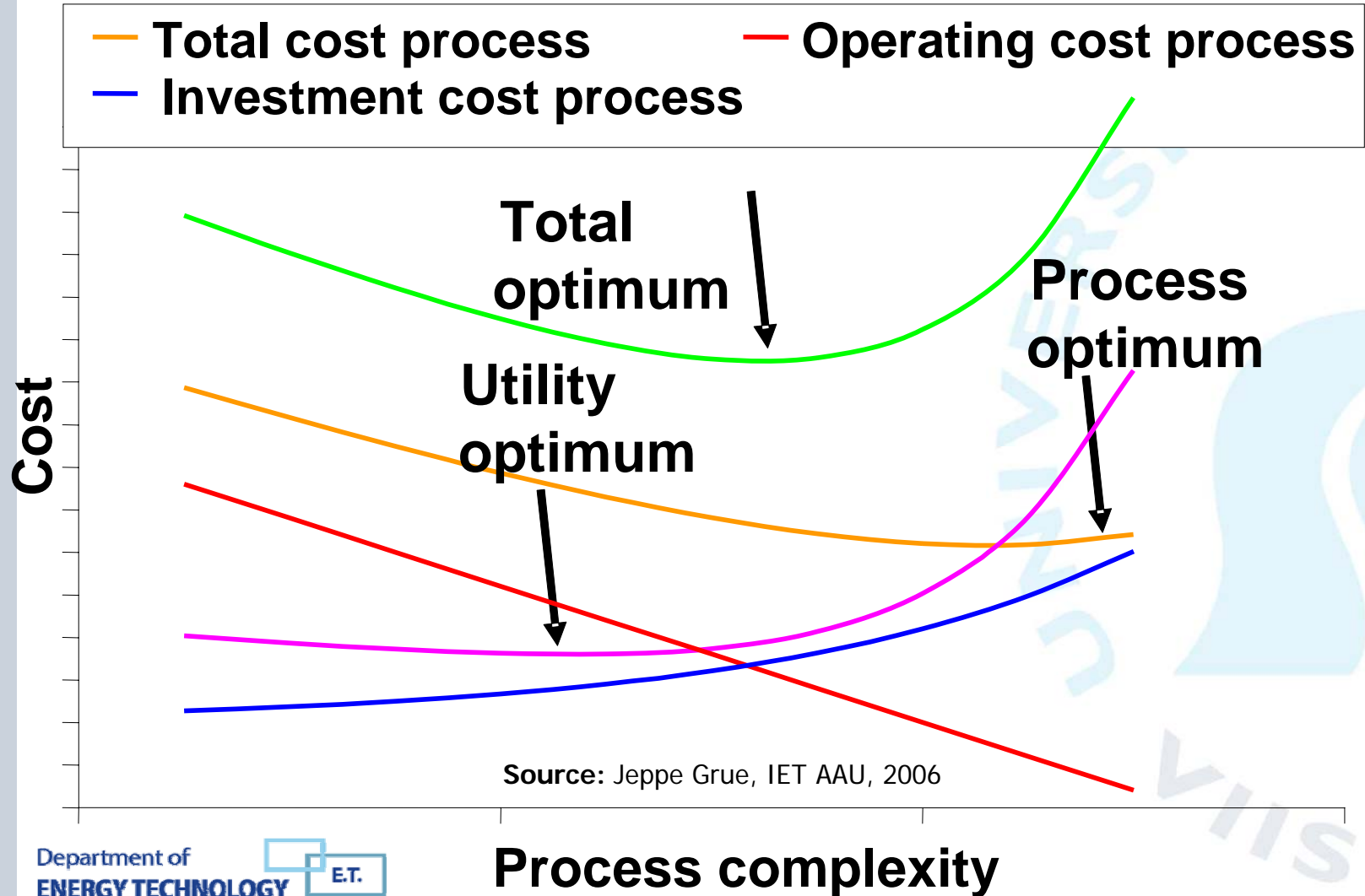
System test facilities
Including reformers

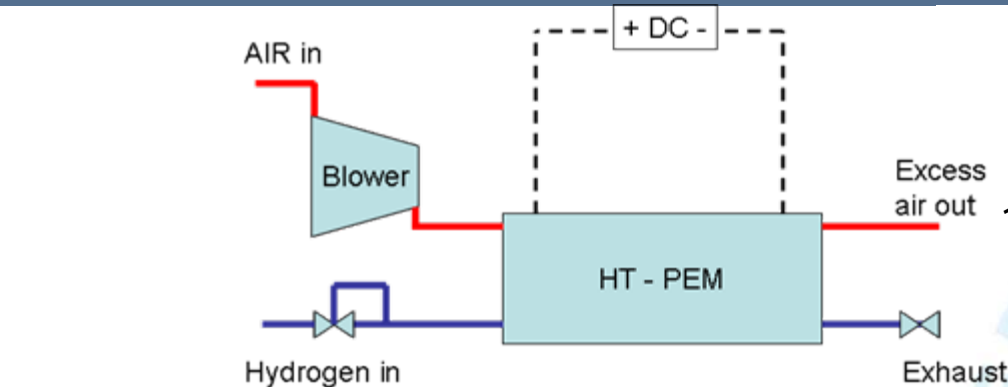


Department of
ENERGY TECHNOLOGY E.T.

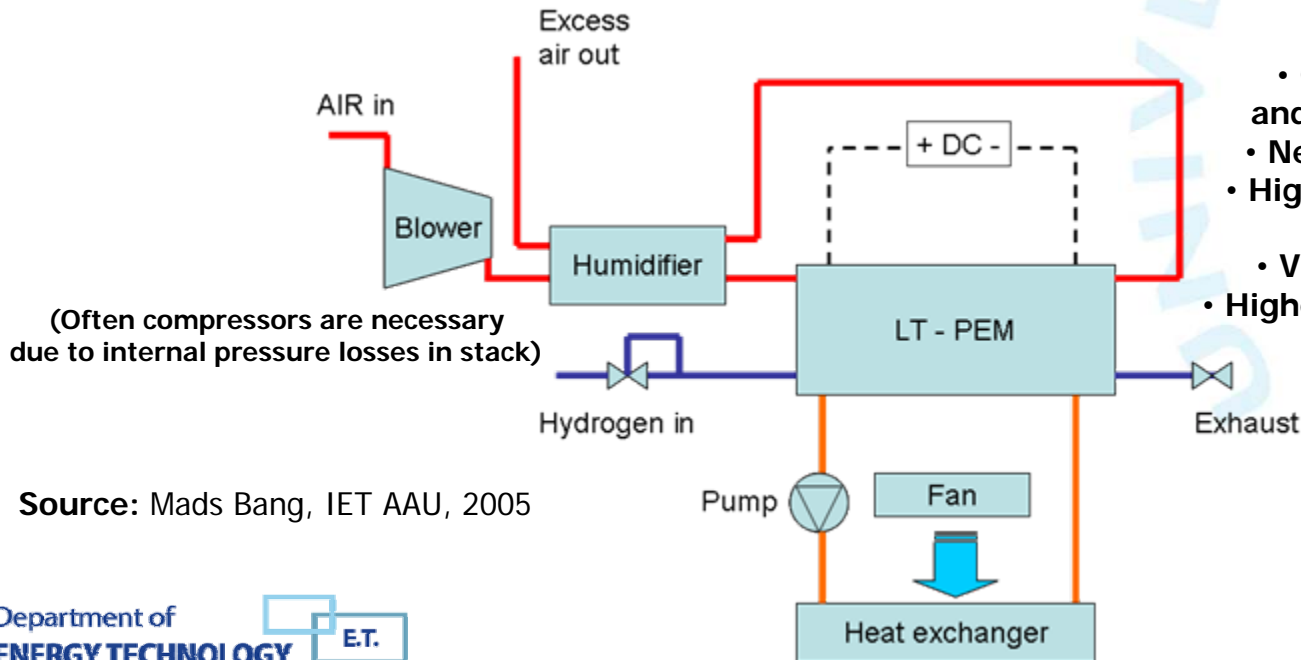






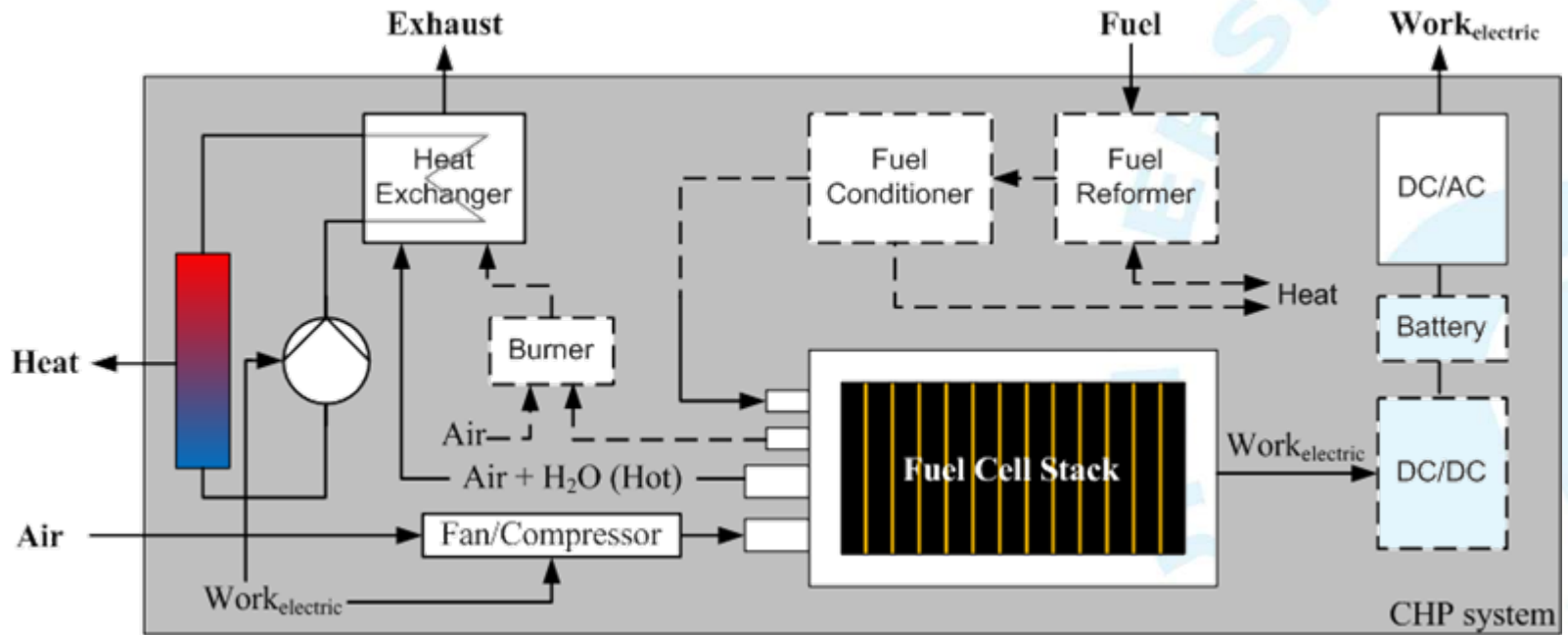


- Very simple system
- Cooling system can be simplified
- High CO tolerance (up to 1% by volume ~ 10000ppm)
- Excess heat could be utilized directly in a reforming system

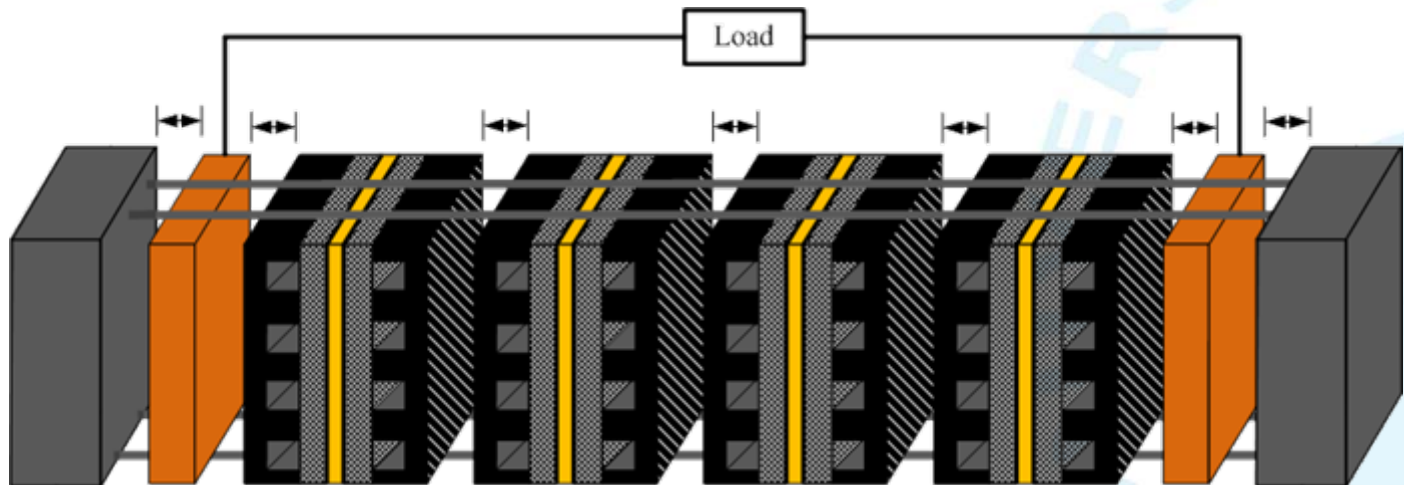


- Complicated heat and water management
- Need of humidifier(s)
- High air stoichiometries not allowable
- Very sensitive to CO
- Higher power density from stack

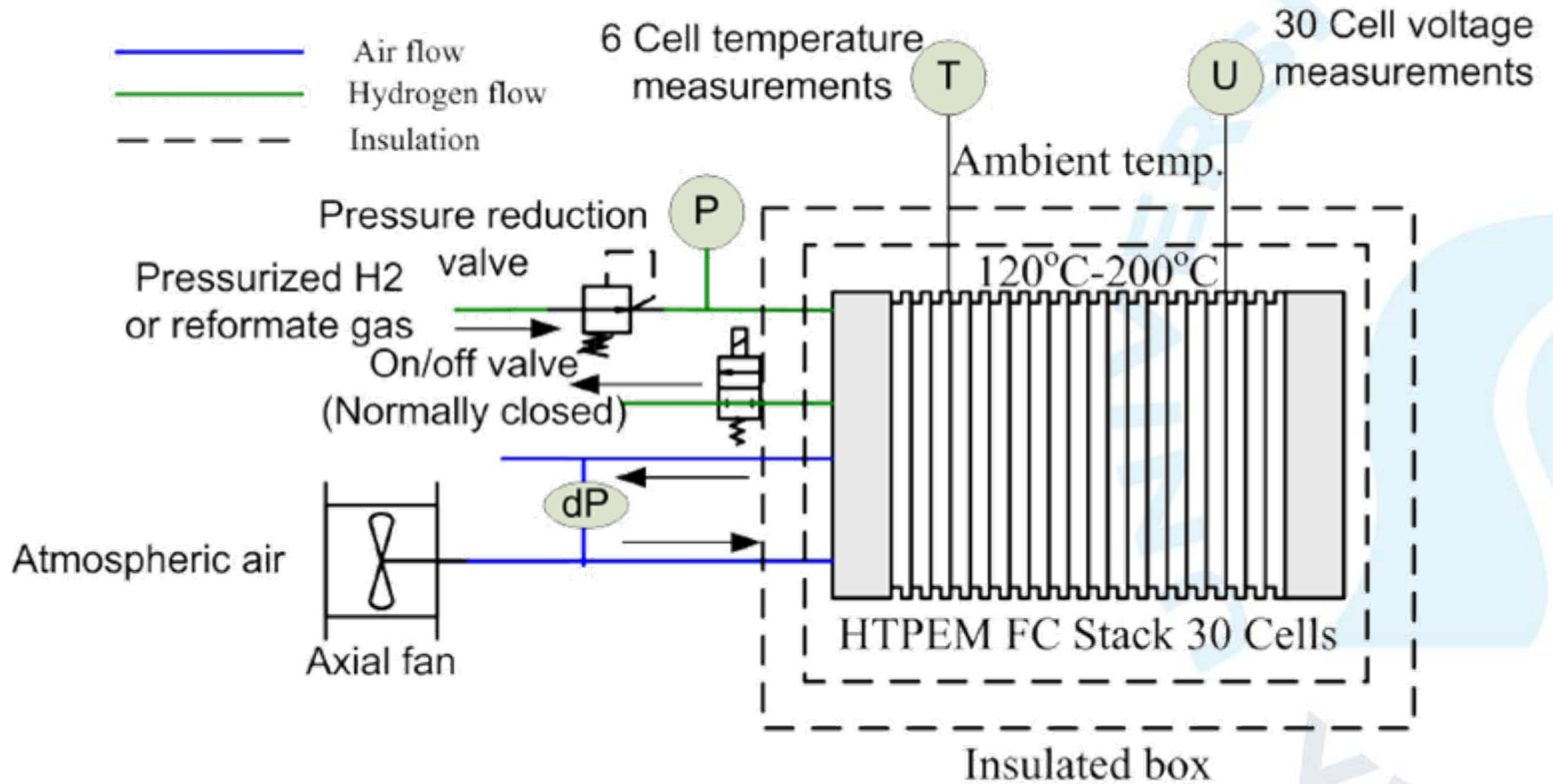
Source: Mads Bang, IET AAU, 2005

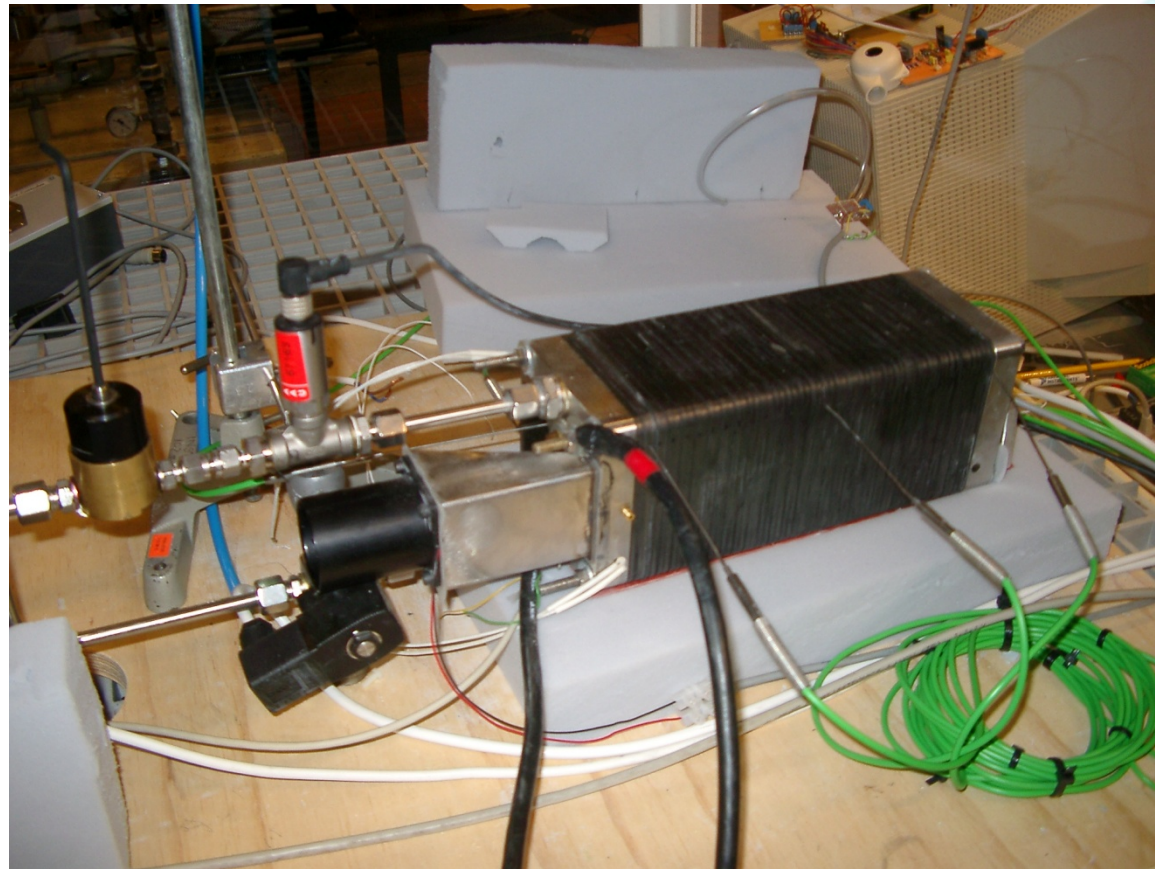


Source: Peder Lund Rasmussen, IET AAU, 2009



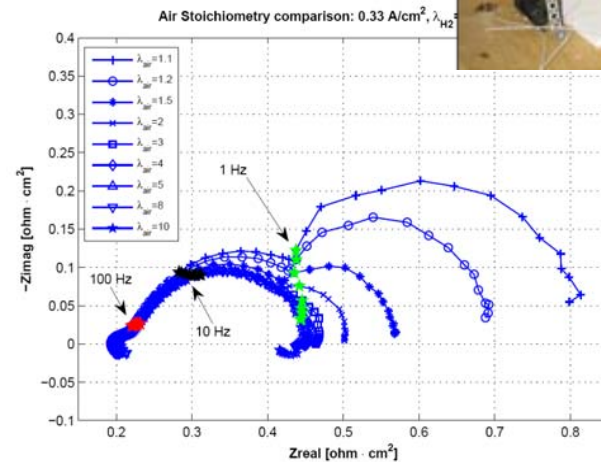
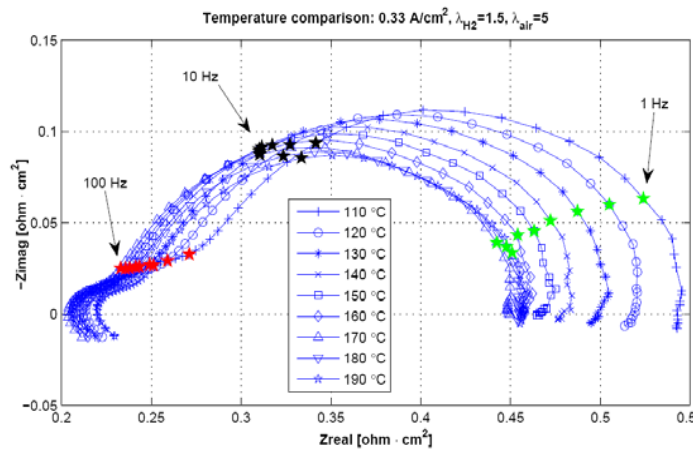
Source: Peder Lund Rasmussen, IET AAU, 2008





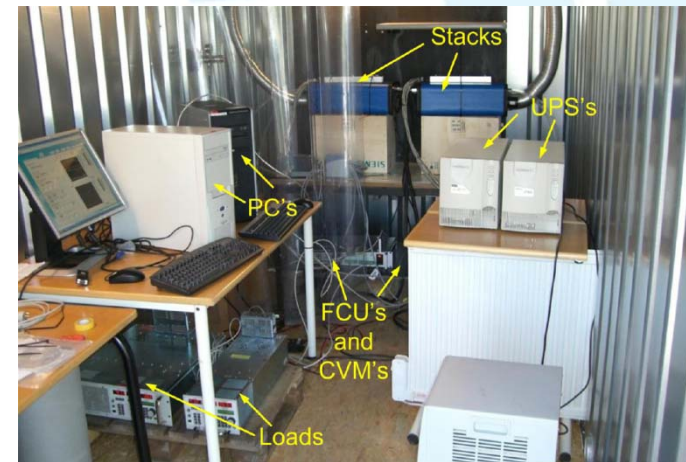
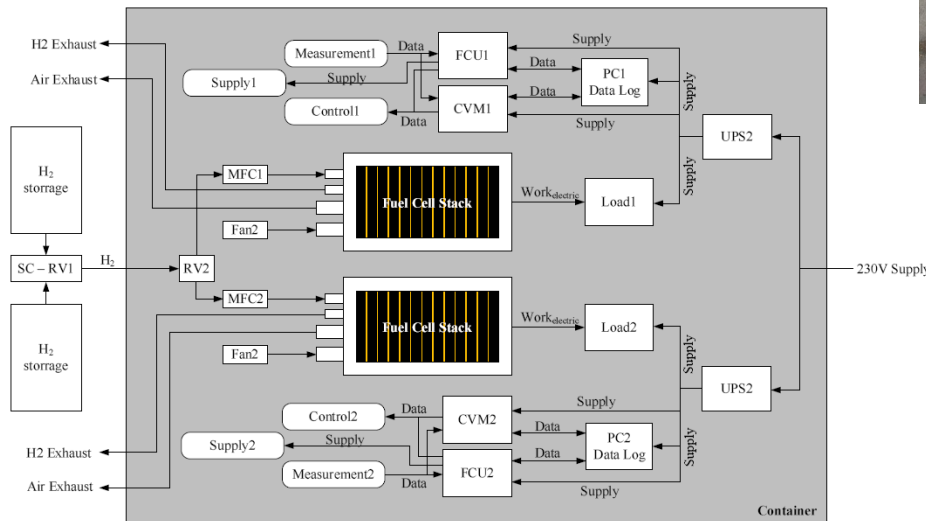
Research activities

- Detailed durability studies
- Optimization of operating cond.
- Advanced measurements
 - Impedance spectroscopy
 - In-situ thermo sensors
 - Flow, gas composition



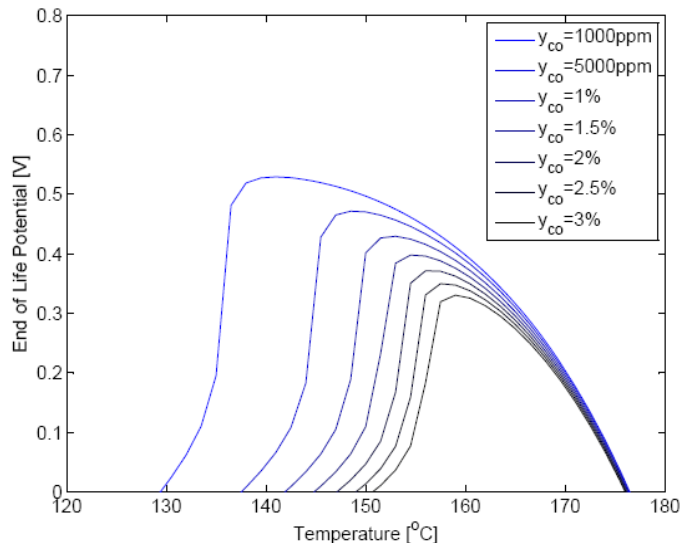
Isolated test facility

- Continuous hydrogen supply
 - Uninterruptible power
- Investigated parameters
- Temperature
 - Operating point



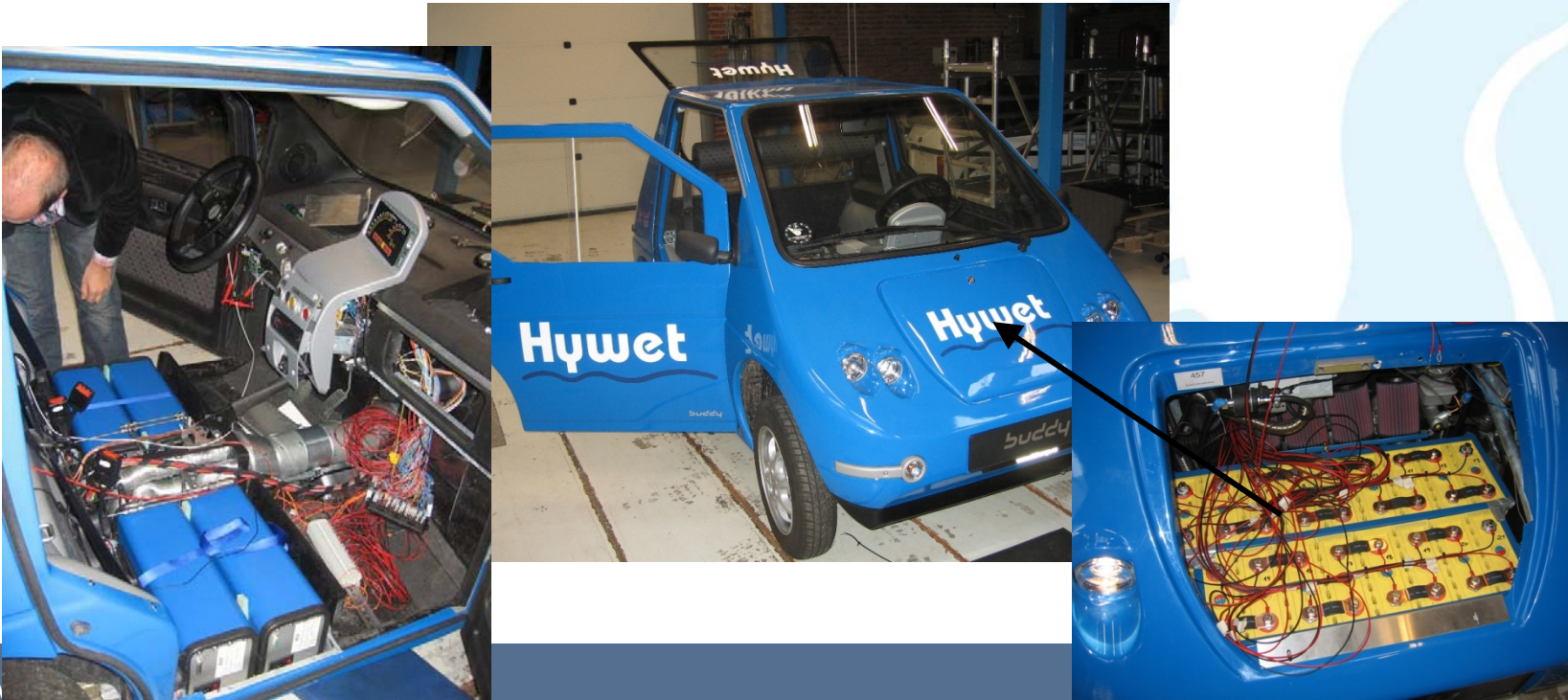
Stack performance-/degradation tests

- Hydrogen and synthesis gas operation
 - H_2 , CO_2 , CO , N_2 , H_2O (steam reforming, ATR, CPO)
 - Anode stoichiometry
- Optimum operational temperature
 - Theoretical description of main degradation mechanisms
 - CO tolerance vs. degradation (Pt agglomeration+carbon corrosion)



HTEPEM hydrogen system

- Integration in a battery/fuel cell hybrid system
 - 4 kW HT-PEMFC
 - 11 kWh Li-Ion batteries
 - 13 kW electric drive system
- 80 km/h and approx. 160 km range

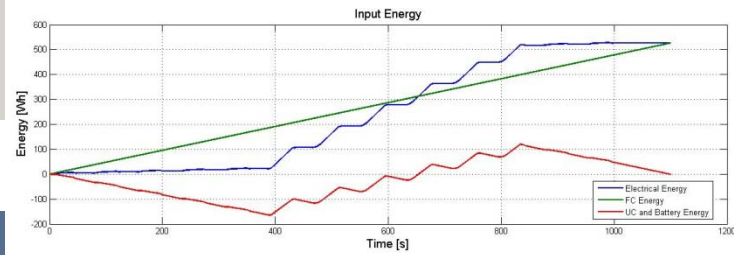
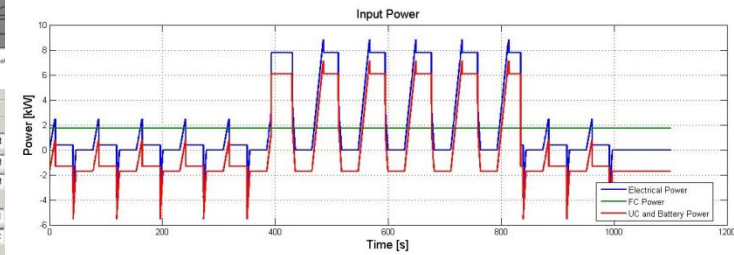
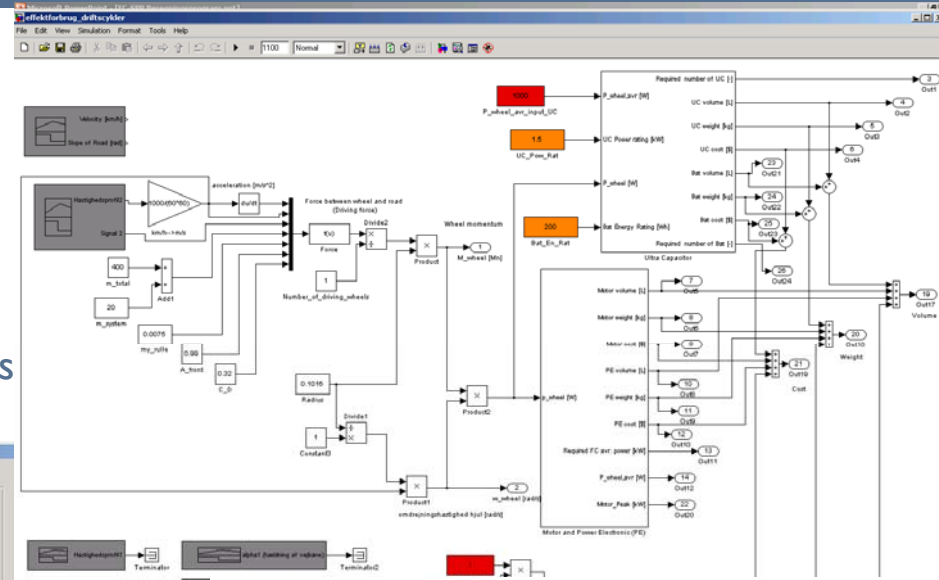


Design of system configuration Sizing of main components

- Battery
- Supercaps
- Fuel cell system
- Dynamic response and limitations of each component

The screenshot shows the FCSP (Fuel Cell Sizing and Power) software interface. It is divided into several sections for input and results:

- Input - Mobile Application:** Weight of Vehicle-Payload-FCSPP (400 kg), Wheel Radius (0.1016 m), Friction coefficient (0.0075), Drag Coefficient (0.32), Frontal Area (0.99 m²).
- Input - Ultra Capacitors:** Power Rating of One UC (1.5 kW), Specific Power - UC (3.5 Wh/kg), Cost - UC (16 \$/kWh), Power Density - UC (4.5 Wh/L).
- Input - Fuel Cell:** Desired Current Density (0.2 A/cm²), MEA area (50 cm²), System Efficiency (0.9), Power Density - Fuel Cell (1 L/kWh), Power Density - BoP (1 L/kWh), Specific Power - Fuel Cell (1.5 kg/kWh), Specific Power - BoP (1 kg/kWh), Cost - Fuel Cell (1000 \$/kW (peak)), Cost - BoP (800 \$/kW).
- Input - Batteries:** Energy Rating of One Bat (200 Wh), Energy Density - Bat (75 Wh/L), Specific Energy - Bat (38 Wh/kg), Cost - Bat (65 \$/kWh).
- Input - Motor:** Motor Efficiency (0.9), Power Density - Motor (3.5 Wh/L), Specific Power - Motor (1 Wh/kg), Cost - Motor (15 \$/kW).
- Input - Power Electronics:** PE Efficiency (0.97), Power Density - PE (11.5 Wh/L), Specific Power - PE (11 Wh/kg), Cost - PE (6 \$/kW).
- Results - Ultra Capacitors:** Number of Ultra Capacitors, Volume of Ultra Capacitors, Weight of Ultra Capacitors, Cost of Ultra Capacitors.
- Results - Power Electronics:** Volume of Power Electronics, Weight of Power Electronics, Cost of Power Electronics.
- Results - Fuel Cell System:** Fuel Cell System Power, Number of Fuel Cells, Volume of Fuel Cell System, Weight of Fuel Cell System, Cost of Fuel Cell System.
- Results - Total:** Volume of FCSPP, Weight of FCSPP, Cost of FCSPP, Convergence run 2, Convergence run 3.
- Simulation:** Run, Power and Energy Plots, Reset, Close.
- System Configuration:** Show System, Drive Profile.



Thank you for your attention!