Experiences from the operation of a wind-hydrogen pilot unit

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16th World Hydrogen Energy Conference, Lyon, June 13th – 16th, 2006

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OUTLINE OF THE PRESENTATION

- Introduction
- Wind-hydrogen plant description
  - Hydrogen generation section
  - Hydrogen compressor & Filling station
  - Metal hydride tanks
  - Auxiliaries
  - Power and Control
- Results and Discussion
- Conclusions

INTRODUCTION

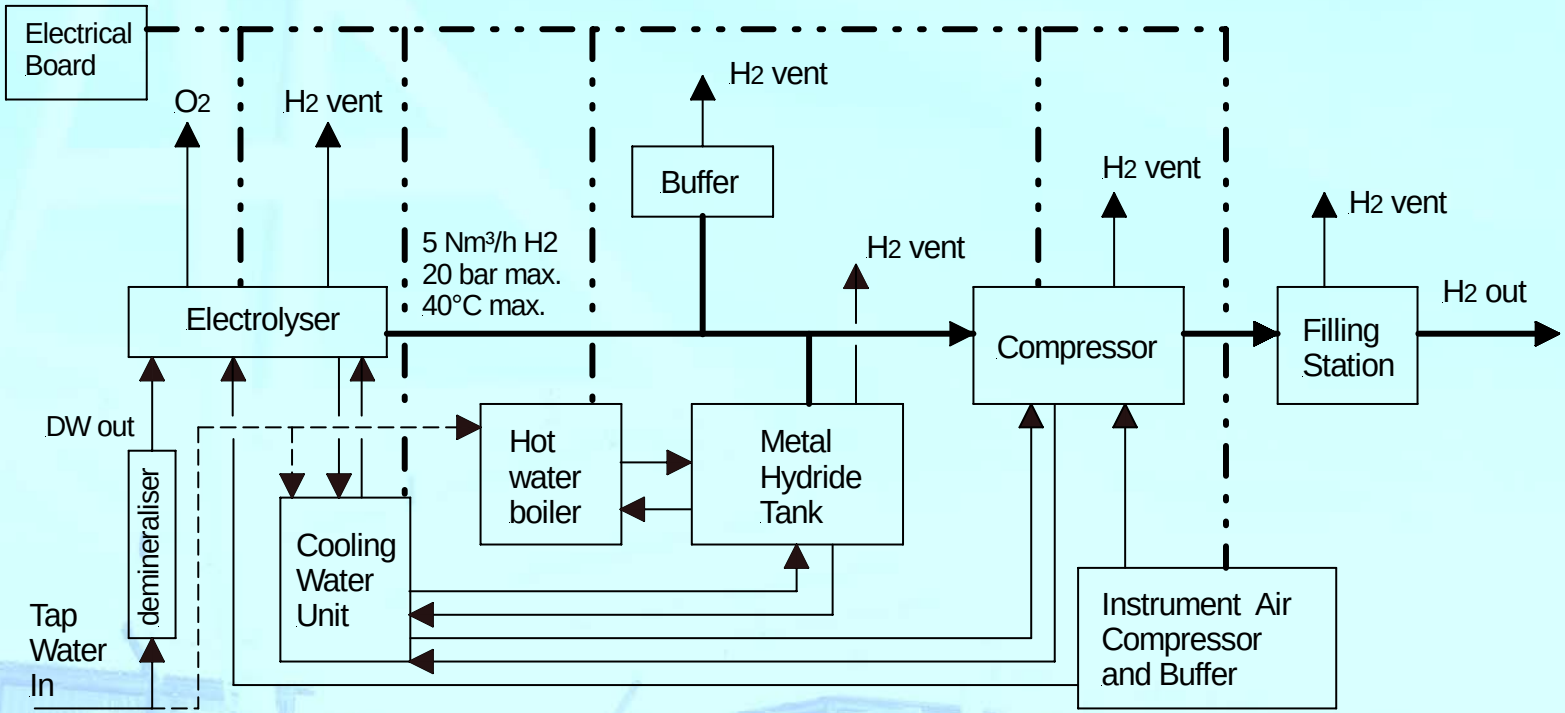
- Production of clean hydrogen fuel with the help of “renewable” electricity
- Comparison of different hydrogen storage technologies
- Performance study of the individual components and of the integrated system under various possible operating scenarios
- Identification of components and interfaces to be optimised

The wind-hydrogen unit was developed and constructed in the frame of the EC project RES2H2 (FP5)

WIND-HYDROGEN PLANT DESCRIPTION

- 500 kW gearless, synchronous, multipole Enercon E-40
- 25 kW alkaline electrolyser, 5 Nm^3/h H_2 at 20 bar
- Single stage hydrogen compressor up to 220 bar
- Filling station for high pressure cylinders, 120 Nm^3 H_2
- Metal hydride tanks, 42 Nm^3 H_2
- Water chiller and cooling water in closed circuit
- Instrument air compressor
- Power board
- Control unit based on Programmable Logic Controller

WIND-HYDROGEN PLANT DESCRIPTION



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HYDROGEN GENERATION SECTION

Alkaline electrolyser	25 kW
Power operating range:	20-100%
DC operation:	0 - 300 A, 0 - 120 V
Operating pressure:	20 bar
H_2 production:	0.45 kg/h (5 Nm^3/h)
H_2 purity (after purif.):	99.98%v.
Electrolyte:	KOH solution 30%w.

Demineralised water consumption 4.1 l/h

Casale Chemicals SA, Switzerland

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HYDROGEN COMPRESSOR & FILLING STATION

Single-stage hydrogen compressor

Triple metal diaphragm

Inlet pressure: 10 – 18 bar

Inlet temperature: 30 - 40°C

Outlet pressure: 220 bar

0.45 kg/h (5 Nm^3/h) at 14bar/40°C inlet

PDC Machines Inc., USA

Buffer: 360 L volume

Filling station: 10.7 kg H_2 (120 Nm^3)

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METAL HYDRIDE TANKS

Metal Hydride tanks: 6 cylinders

Metal alloy: $La_{0.75}Ce_{0.25}Ni_5$

Total capacity: 3.78 kg H_2

(42 Nm^3 H_2)

Total weight: 564 kg

Mass specific H_2 capacity:

1.28 %w (alloy)

0.66 %w (MHT)

FIT, Cyprus
Labtech SA, Bulgaria

Hot water boiler 4 kW_{el}

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AUXILIARIES

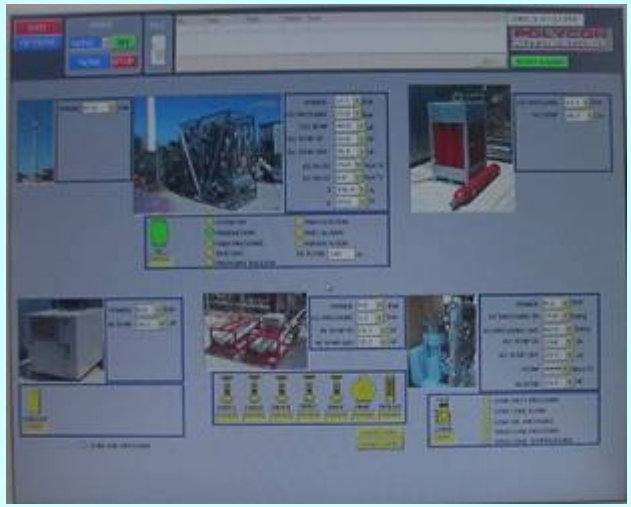
WATER CHILLER
Cooling water in closed circuit
Mean electrical power requirement: 1.5 kW

INSTRUMENT AIR COMPRESSOR
Pneumatic valve actuation
Mean electrical power requirement: 0.2 kW

NITROGEN
Inertisation of electrolyser and hydrogen circuit

EXPERIENCES FROM THE OPERATION OF A WIND-HYDROGEN UNIT

POWER AND CONTROL UNIT



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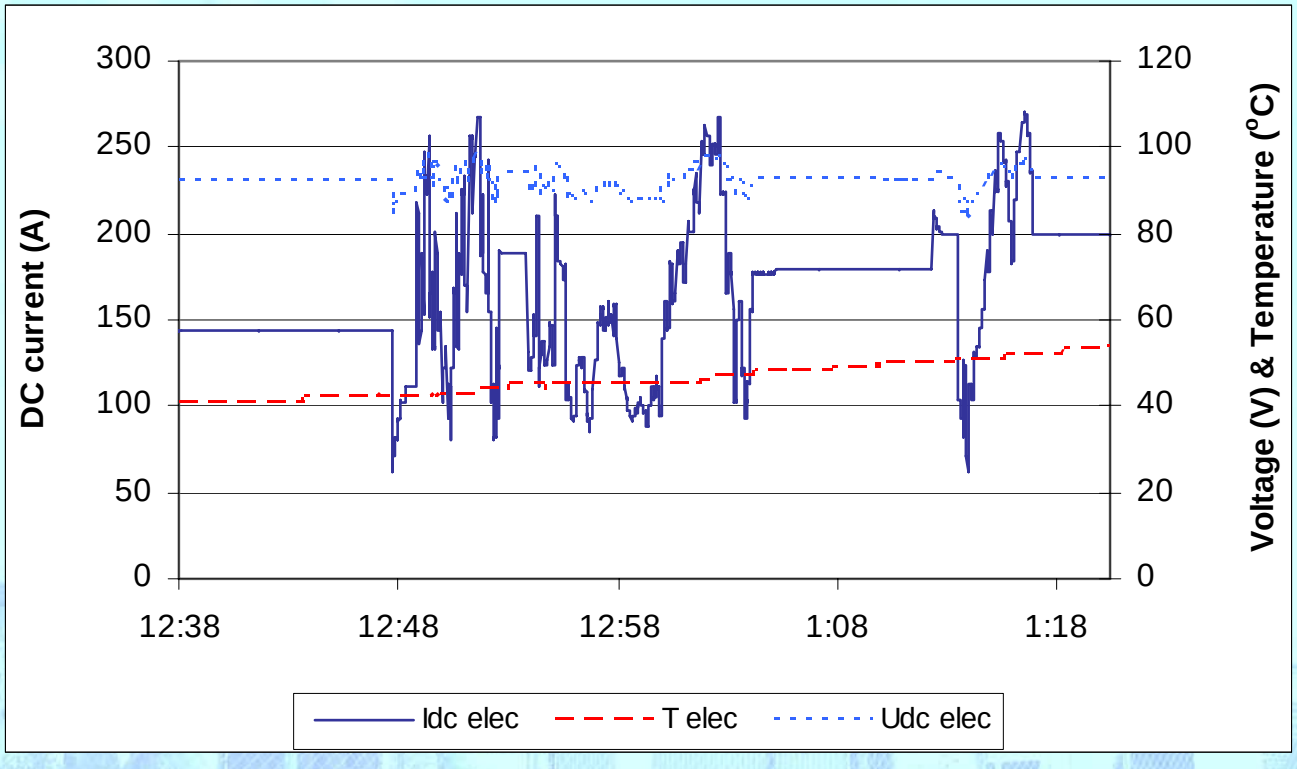
RESULTS and DISCUSSION

Electrolyser operation under stable and variable power input



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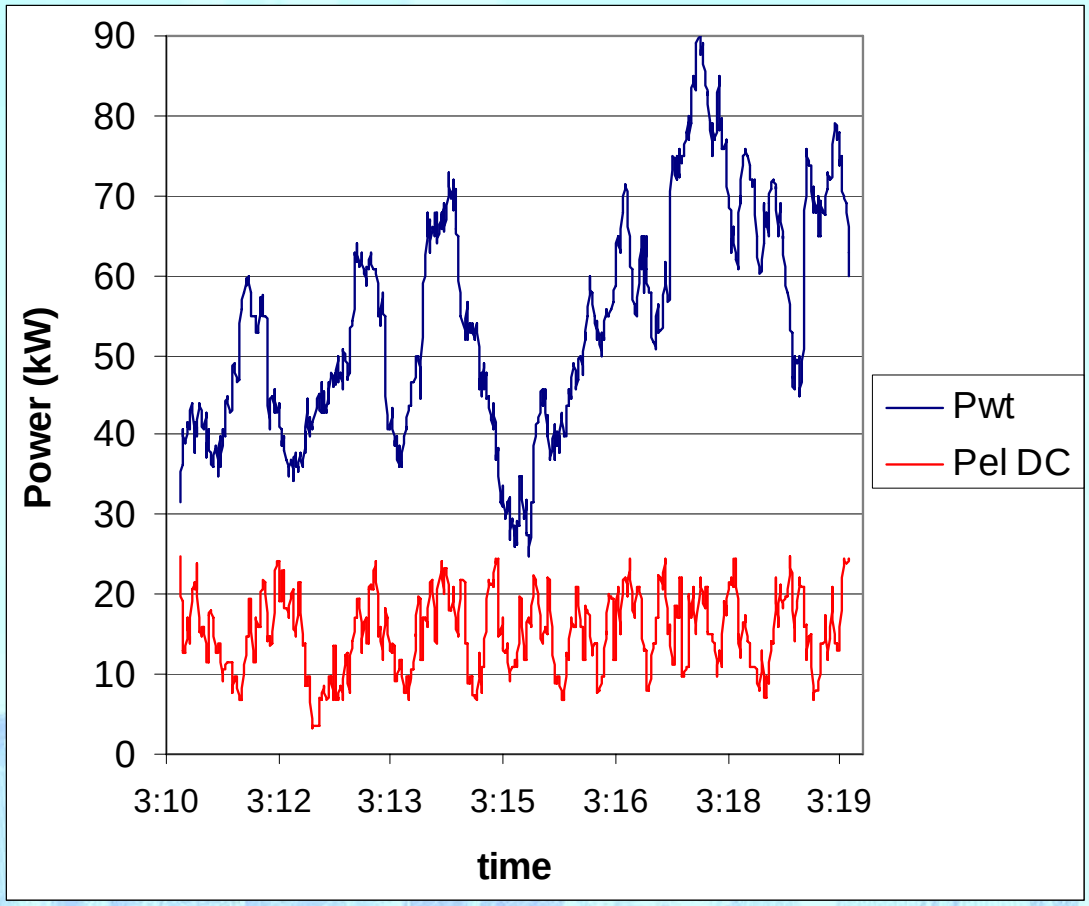
RESULTS and DISCUSSION



Electrolyser operation

Variable power input

“Excess power” scenario

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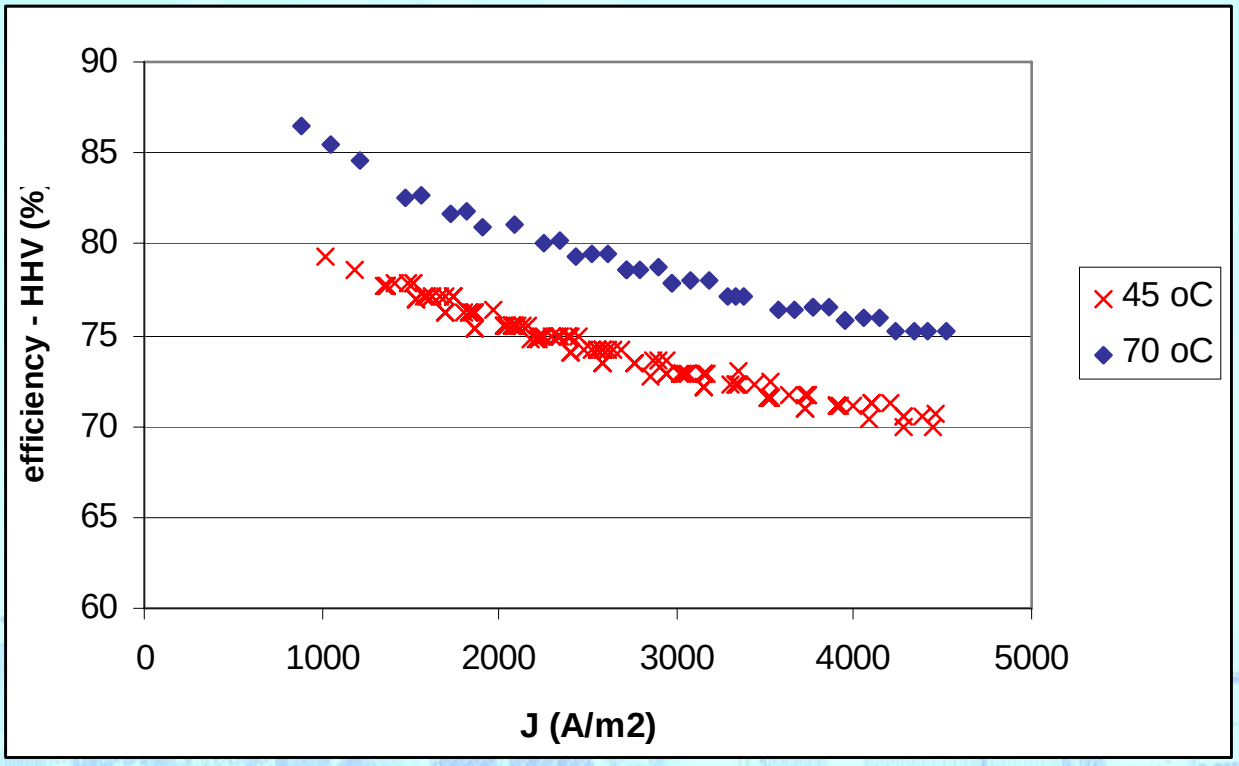
EXPERIENCES FROM THE OPERATION OF A WIND-HYDROGEN UNIT

RESULTS and DISCUSSION

Electrolyser stack efficiency as a function of applied current density



Operating temperature under variable power lies in the range 45-70^{o}C

Stack efficiency: 70-88% (HHV)

AC power efficiency: 60-75% (HHV)

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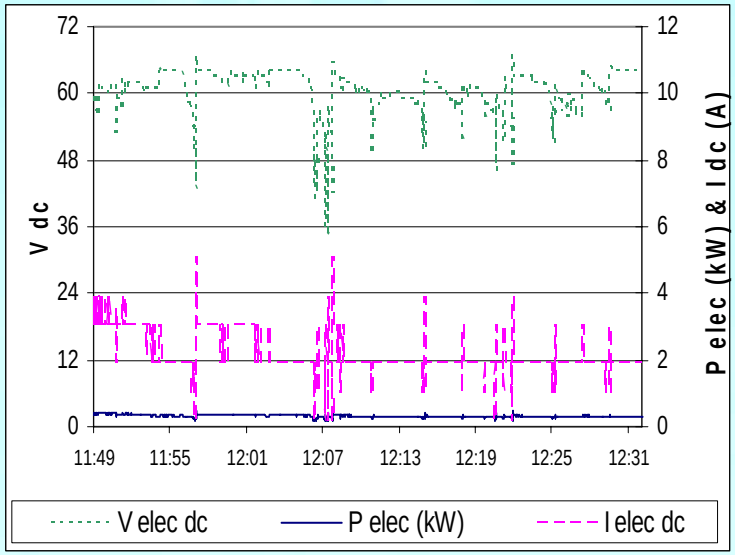
RESULTS and DISCUSSION



Electrolyser operation
Protective polarisation

Mean values:
DC current: 2.5 A
DC voltage: 61 V
DC power: 0.15 kW
AC power: 0.35 kW

Protective polarisation applied for 27 weeks consumes 1.6 MWh

➢ NO protective polarisation thanks to activated electrodes!

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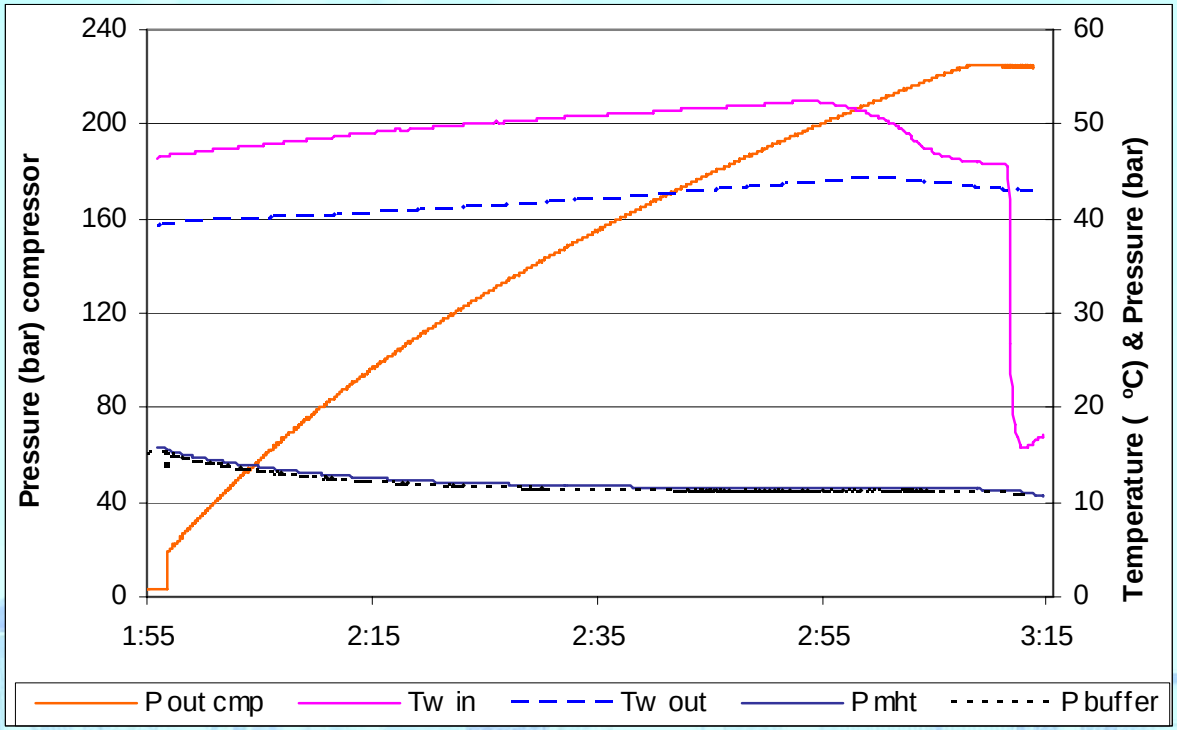
RESULTS and DISCUSSION

Hydrogen discharge from the metal hydride tanks



Mean H_2 rates:

Compressor 7.7 Nm^3/h

MH tanks 6.7 Nm^3/h

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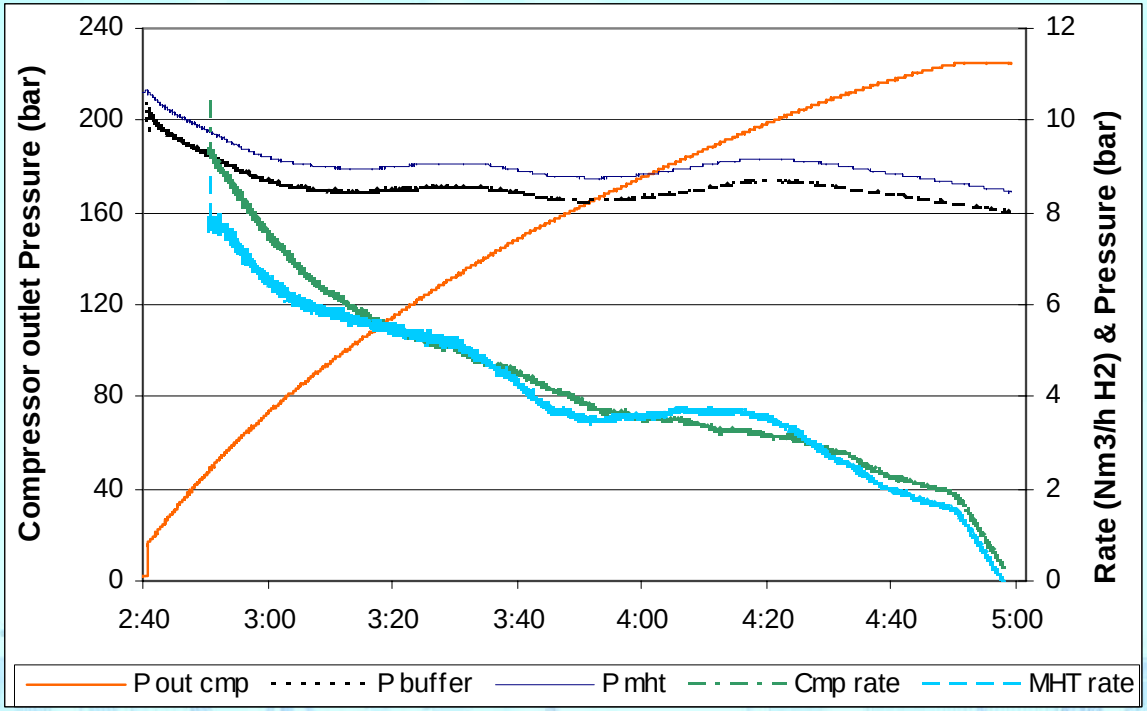
RESULTS and DISCUSSION

Hydrogen discharge from the metal hydride tanks (following one)



Mean H_2 rates:

Compressor 4.7 Nm^3/h

MH tanks 4.4 Nm^3/h

Metal Hydride Tanks considered empty!

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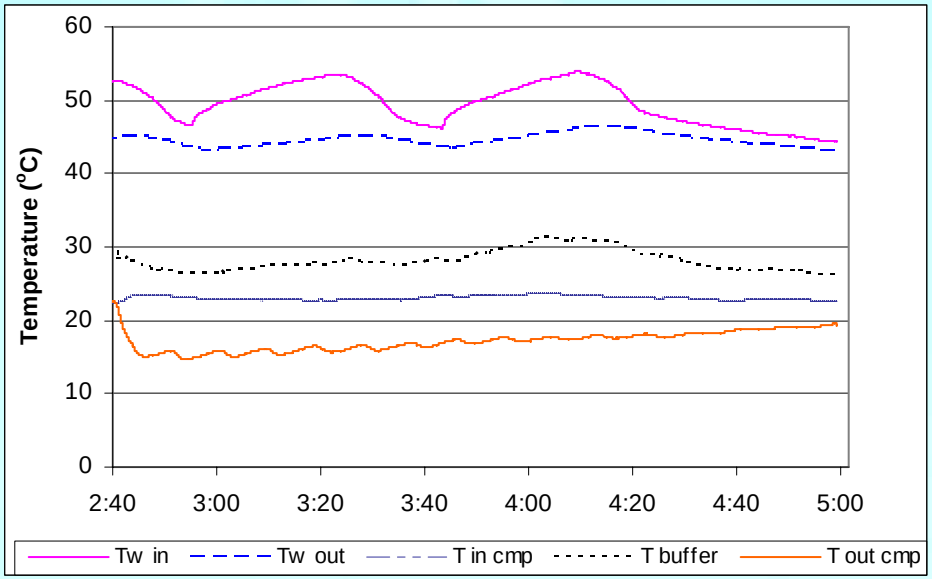

Metal Hydride Tanks operation
Preheating phase

Winter conditions
4 kW boiler operating 2 hours
P mht: 18 bar

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RESULTS and DISCUSSION

- System efficiency from AC power to compressed hydrogen fuel: 58% (HHV)
- MH Tanks may be charged intermittently but should be discharged once
- Only waste heat should be used to heat up the MH tanks
- Several lessons learned from the realisation and operation of the plant:

-Interfacing of the various units is key, in relation to hydrogen flow, electricity and information flow
- Minimisation of buffer tank volume
- Transportation and installation issues in remote areas with poor access
- PLC based control system is safer but less flexible than PC based
- Protection of hardware from nature's elements, theft and even wild animals
- Special care for the integration of auxiliaries, vital for safe operation

CONCLUSIONS

Wind-hydrogen systems such as the one installed at the wind park of CRES are a promising way to produce clean hydrogen

Important margins for efficiency increase

- power electronics of the electrolyser
- wind turbine – electrolyser interface
- optimisation of auxiliaries

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