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# Modelling hydrogen energy technology to facilitate increased renewable penetration.

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# Modelling Hydrogen Energy Technology to facilitate increased renewable penetration

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## Introduction

Started on the 01st February 2011, this research project has developed models for the innovative applications of Hydrogen (H2) production, storage and end-use technologies to facilitate the planned increase of renewable generation into existing electrical infrastructure.

The novel application of both economic and system performance modelling has demonstrated that state-of-the art H2 technology can be used as an enabling technology for increased renewable energy generation penetration .

Hydrogen production and storage models have been developed and verified against 'real-world' data collected from installed and operating systems in the field.

The reference system used for verifying the models is a state-of-the-art 180 cell, 5.33Nm$^3$/h 12 bar pressurised electrolyser connected to 2400L storage capacity. An outline of the system can be seen in figure 1.

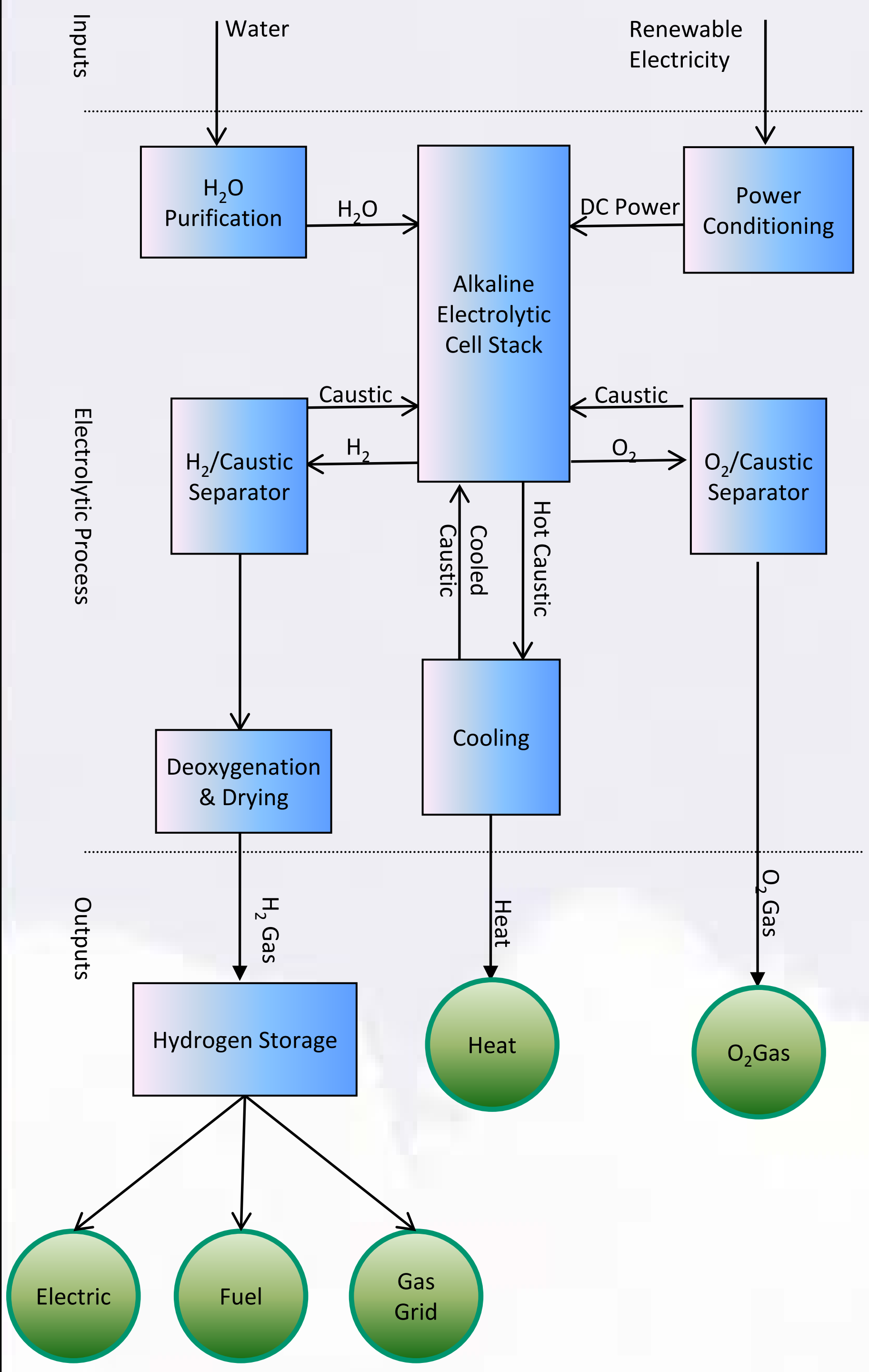


*Figure 1: Developed system model overview.*

## Economic Modelling

Economic modelling research on hydrogen energy storage systems has shown that H2 offers a much higher level of versatility over conventional energy storage systems.

Results of the proposed Levelised Storage Cost (LSC) model are presented in figures 2 and 3. The LSC model has been developed to assess the economic performance of the H2 energy storage technology while using real world data of the reference system

Five LSC scenarios have been modelled in order to define which application has the most favourable return on investment.

In each scenario, hydrogen storage capacity has been defined as 5MWh pressurised gas storage.

**Scenario A:** 100% 02 & H2 sold as gases

**Scenario B:** 100% energy sale through 3MW FC, 100% 02 sold, no H2 sale

**Scenario C:** 50% O2 & H2 gas sold, 50% H2 sold as Energy through a 3MW FC

**Scenario D:** No FC (no energy sale), No 02 Sold, 100% H2 sold

**Scenario E:** 100% Energy sold (3MW FC), no O2 nor H2 sold

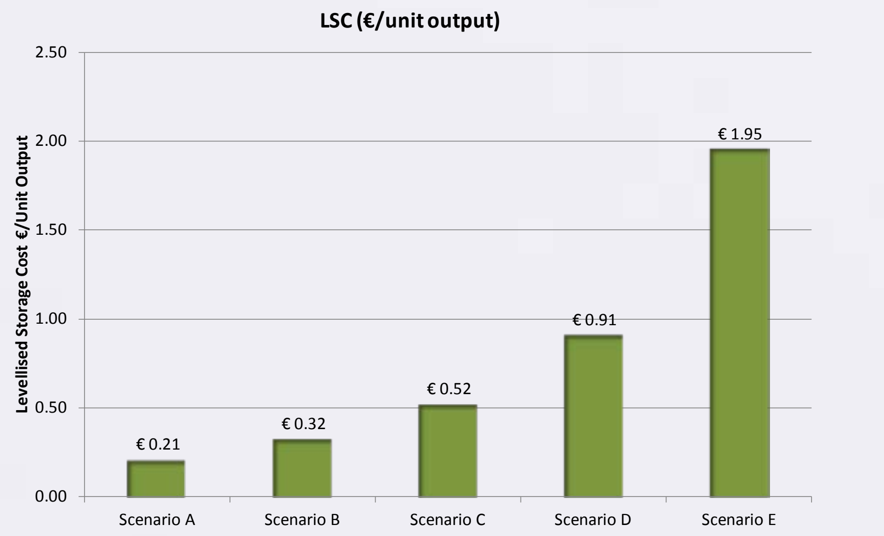


**Figure 2:** Levelised output costs for H2 energy storage system

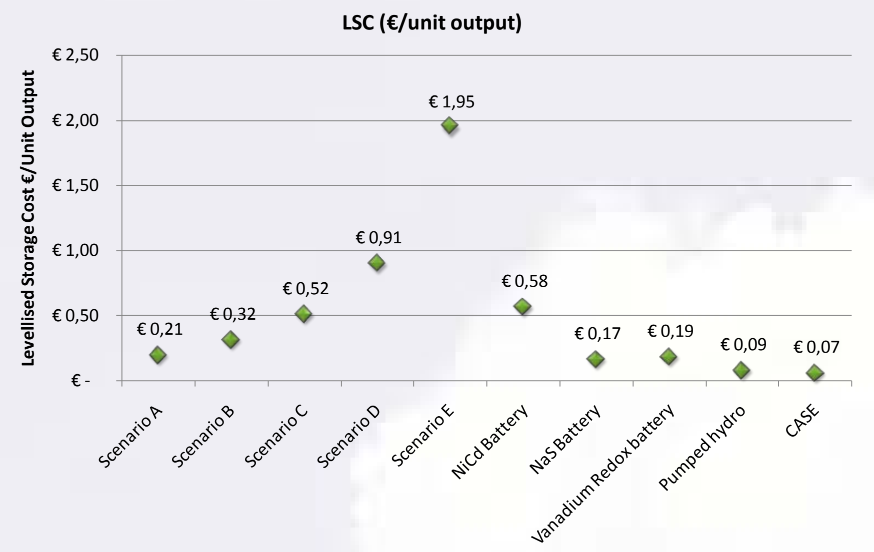


***Figure 3:*** *Levelised cost comparisons.*

**The best return on investment from Renewable H2 and O2 production system was found to be on selling H2 and O2 as gas (scenario A)**

## System Modelling

Figures 4 and 5 demonstrate that the developed Matlab/Simulink model provides comparable results to the data collected from the reference real world system.

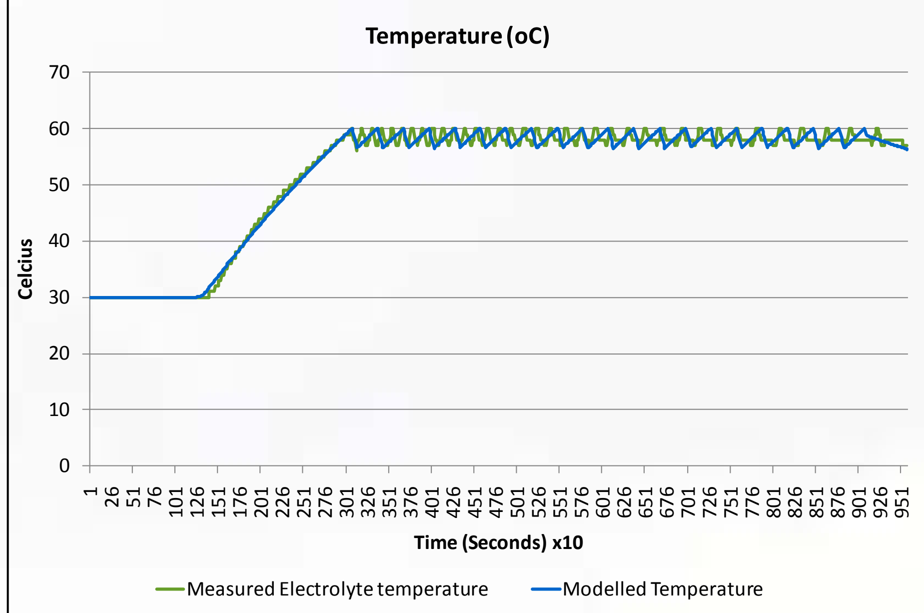


***Figure 4:*** *Thermal comparison*

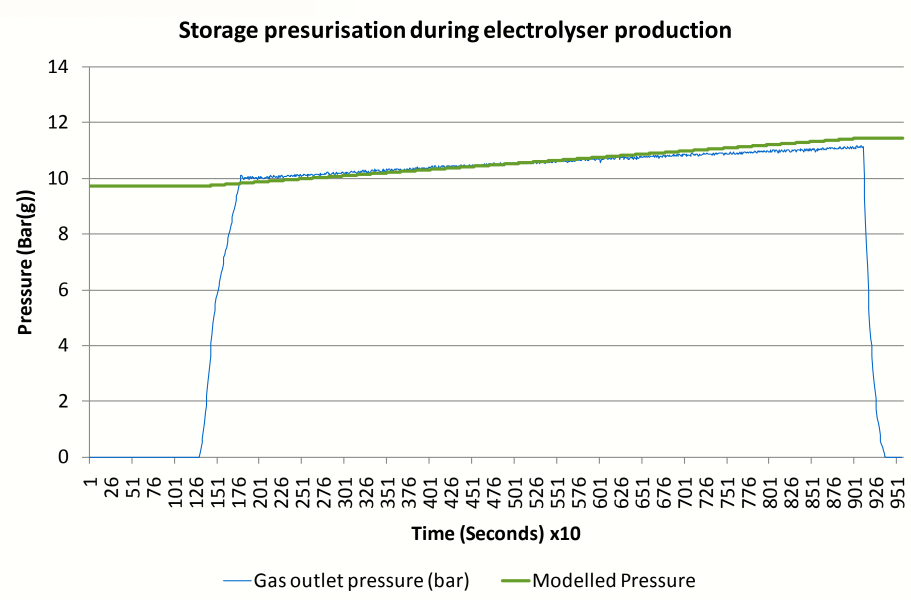


***Figure 5:*** *Pressure comparison*

## Novel Model Application

A novel use of the developed models has been applied in an industrial situation to compare data collected from a number of infield systems. The aim was to determine what was wrong with one system that did not perform as anticipated.

When the models were run and compared to the real-world data they revealed a possible performance issue due to a hydrogen leak within the installation being investigated.

The developed modelling revealed a hydrogen gas leak of about 10.89g an hour from the affected system. This loss equated to a 2.3% reduction in the overall system efficiency.

Based on the modelling results, a team of technicians has been sent onsite and investigation revealed a broken pipe fitting causing a leak.

This result clearly demonstrates the apparent benefit of the developed model in identifying the source of a problem and saving significant time from onsite investigation and equipment downtime.

**The proposed model and findings of this research can be applied to any other gas or liquid machinery, such as those in the oil and gas industry, to identify a leak and save the time required onsite prior to maintenance**

## Transport Fuel Case Study

Additional novel application of the developed modelling described has shown that a relatively small electrolyser of 5.33Nm$^3$/h can meet the daily fuel demands of a high duty cycle commercial delivery vehicle in a rural location.

This was achieved by configuring the electrolyser to produce when 'green' renewable energy is available and storing it in a cascade pressurised hydrogen storage system for rapid dispensing on demand.

Simulation of the cascade refuelling configuration also showed that the vehicle can achieve a 100% daily refuelling schedule.

## Conclusions

The novel application of the models developed In the Matlab/Simulink environment have:

- ✓ Provided a direct benefit to the industrial collaboration within this ETP research project.
- ✓ Shown that relatively small hydrogen production infrastructure can provide the needs high demand transport applications
- ✓ Shown that there is an economical pathway for hydrogen to be produced
- ✓ Provided a performance analysis tool for operational systems to reduce site down time during maintenance

## Acknowledgement

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