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# Hydrogen office: modelling an energy storage system.

GAZEY, R., ALI, A., AKLIL, D. and FINNEY, S.

2011

# Hydrogen office: Modelling an energy storage system

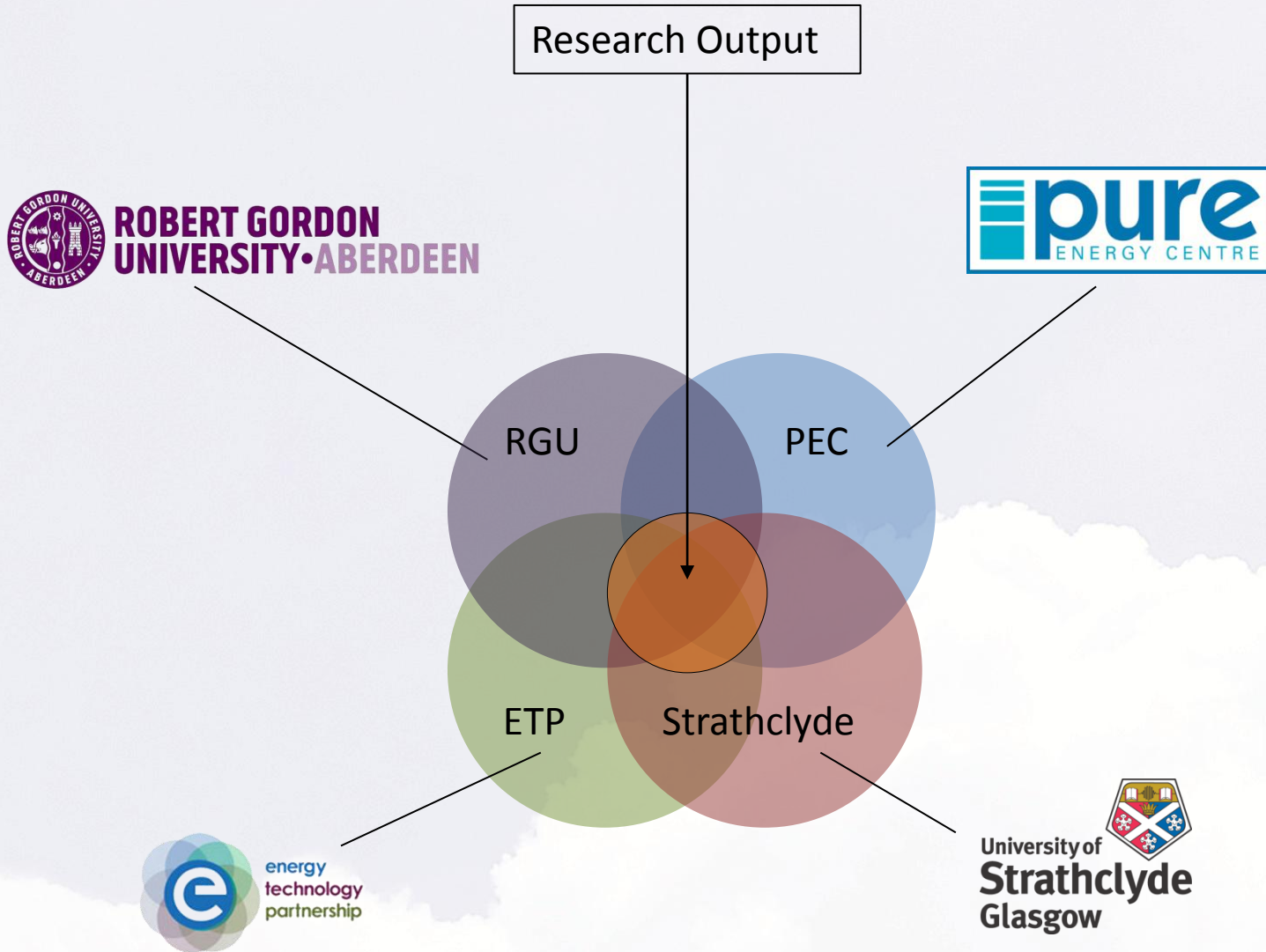
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PhD Research, Robert Gordon University

- Introduction
- Background
- Energy Storage
- The Hydrogen Office System
- Development of a modelling tool.

# Introduction

## Research Partners



- The People:

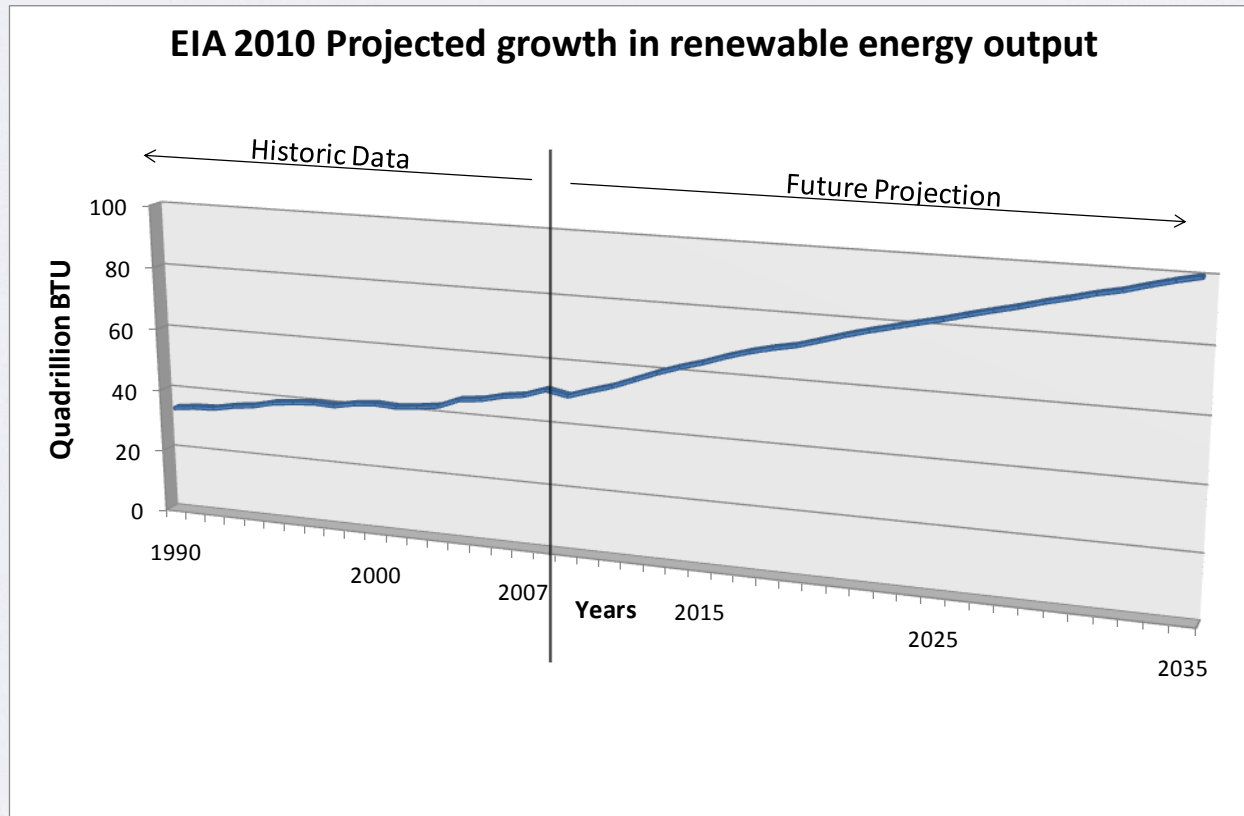
- Dr. Dallia Ali (RGU)
- Dr. Daniel Aklil (PEC)
- Dr. Stephen Finney (Strathclyde)
- Ross Gazey (RGU - PhD Research)

} Supervisory Team

- Acknowledgements to Energy Technology Partnership (ETP), Strathclyde University, Pure Energy Centre, and the Robert Gordon University IDEAS research centre

# Background

- United States Energy Information Administration (EIA) predict global renewable energy output to increase by over 50% (excluding bio-fuels) between 2010 and 2035



# Background

- Within Scotland alone, ambitious national targets are focused on achieving renewable generation of 80% by the year 2020

- BUT.....

- **“Scots windfarms paid cash to stop producing energy” – BBC News 01-05-11**
  - Renewable Energy Foundation (REF) revealed that £900'000 in payments were made to power companies for a few hours between 4<sup>th</sup> and 5<sup>th</sup> April to stop producing energy from their wind farms
  - Payments were considered to be 20 times greater than the energy value.



# Background - Grid Locked

- Why did this happen?
  - The National Grid said the network had overloaded because high winds and heavy rain in Scotland overnight on 5 and 6 April produced more wind energy than it could use.

# Background - Grid Locked

- Spokes Person from DECC said:
- “In future we need greater electrical energy storage facilities and greater interconnection with our EU neighbours so that excess energy supplies can be sold or bought where required”

# Energy Storage

- It is believed by many that an increased renewable penetration of over 40% can only be achieved through the parallel integration energy storage mechanisms within the electrical grid
- This research will seek to simulate and model solutions for electrical grid problems that can arise when using storage technologies in conjunction with renewable energy and electrical distribution networks.

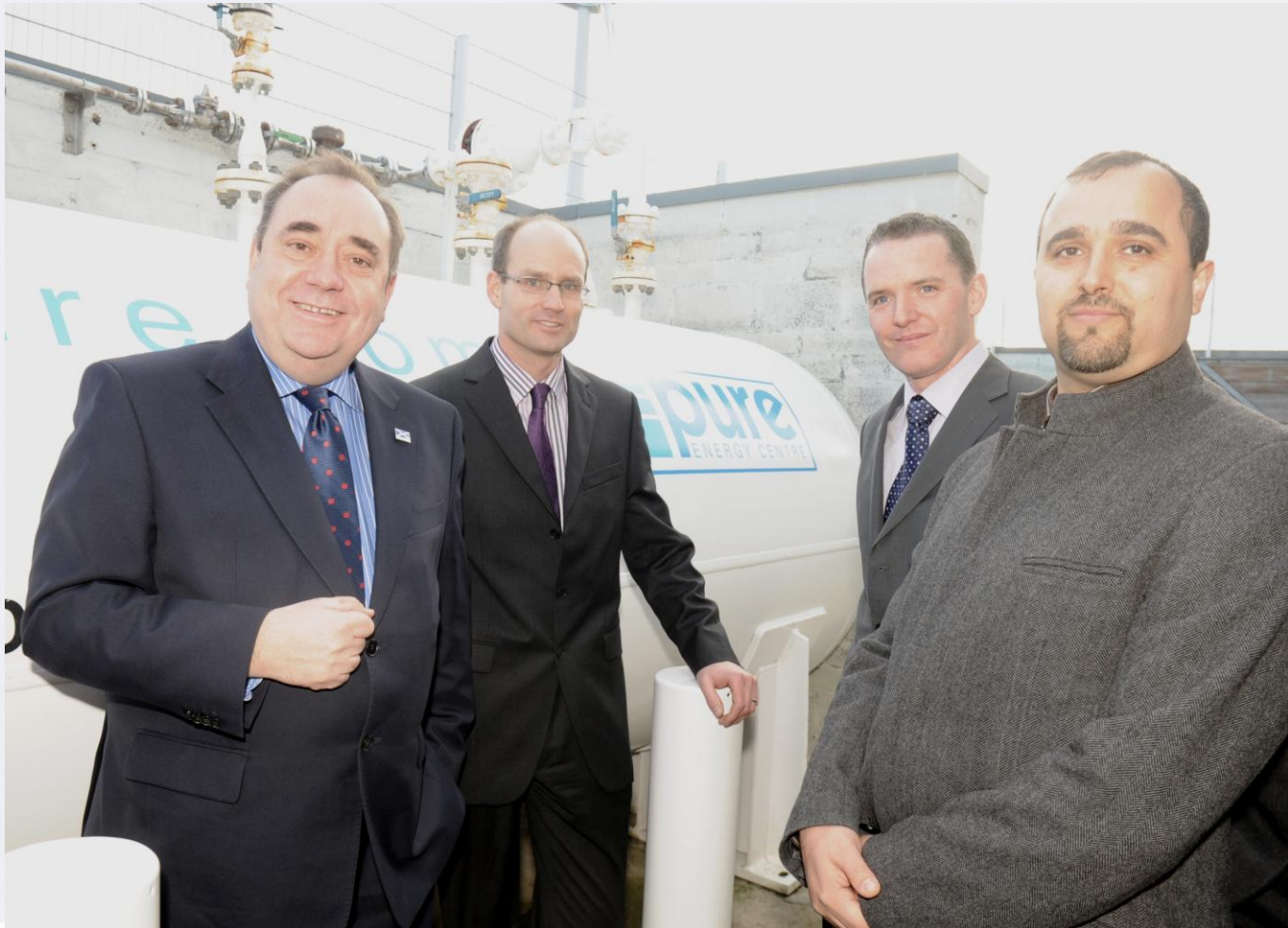
# Hydrogen Office – Case Study

- Hydrogen office Energy system offers the opportunity to develop and verify model development of a grid connected storage solution



# Hydrogen Office – Case Study

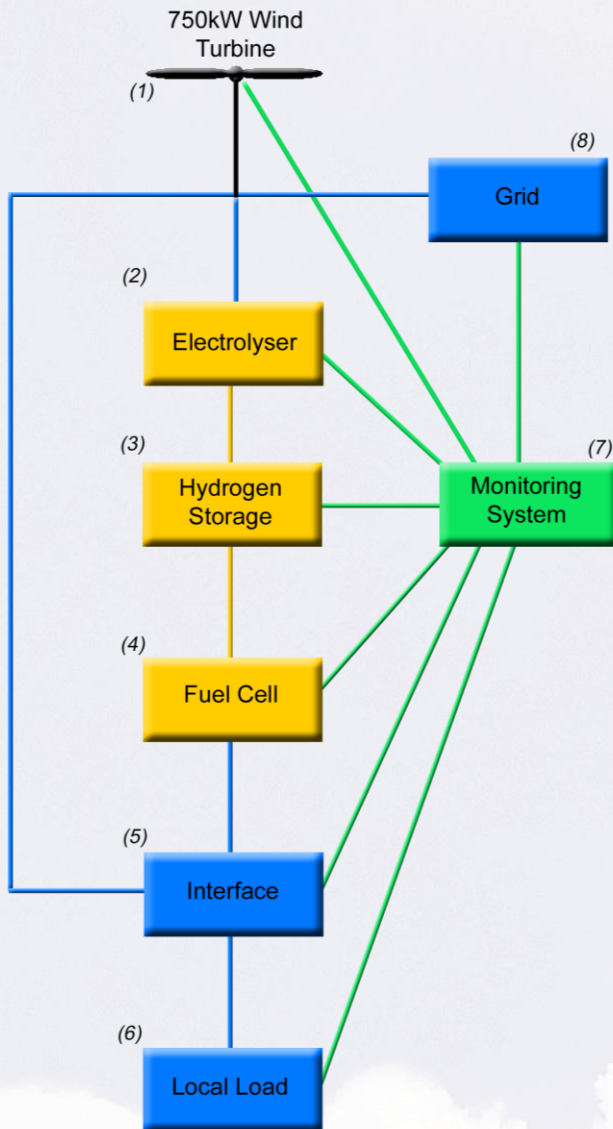
- Opened by the first minister for Scotland on 17<sup>th</sup> January 2011



# Hydrogen Office – How it works

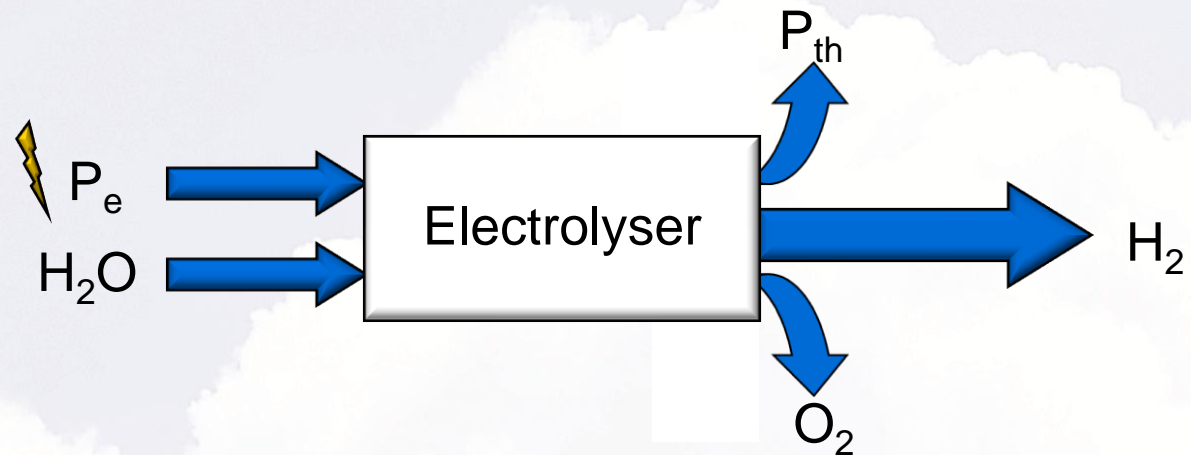
- The electricity generated from the wind turbine directly provides for the electrical needs of the Hydrogen Office
- Surplus electricity is used to generate hydrogen through the process of electrolysis
- The generated hydrogen is stored for periods where there is insufficient energy from the wind to meet demands
- During calm periods a fuel cell provides electricity for the Demonstration Centre.

# Hydrogen Office – Case Study



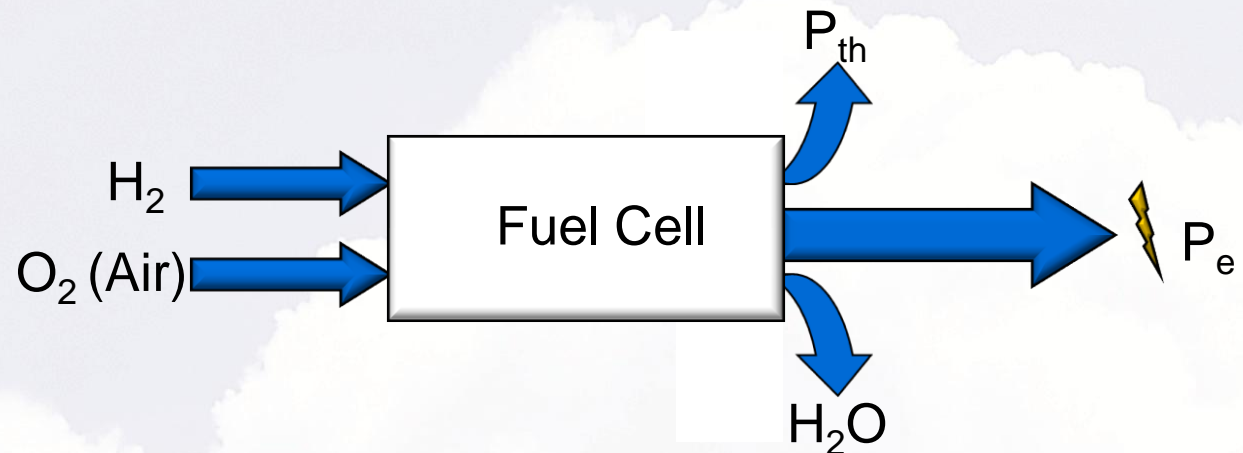
1. 750 kW grid connected turbine
2. 30 kW alkaline electrolysis system
3. 126Nm<sup>3</sup> gaseous hydrogen storage
4. 10kW Proton Exchange Membrane (PEM) Fuel Cell
5. Power factor correcting power electronic interface
6. Hydrogen Office and demonstration centre
7. System wide monitoring and automatic control
8. Export/Import Grid connection

- What is an Electrolyser?
  - An Electrochemical device the converts electrical energy and pure water into hydrogen
  - By-products are:
    - Oxygen ( $O_2$ )
    - Waste heat ( $P_{th}$ )
  - Typical Efficiency Range 55% to 90%





- What is a Fuel Cell?
  - An Electrochemical device that converts energy in hydrogen into electricity
  - By-products are:
    - Water vapour ( $H_2O$ )
    - Waste heat ( $P_{th}$ )
  - Typical Efficiency Range 40% to 60%



## *Stage 1*

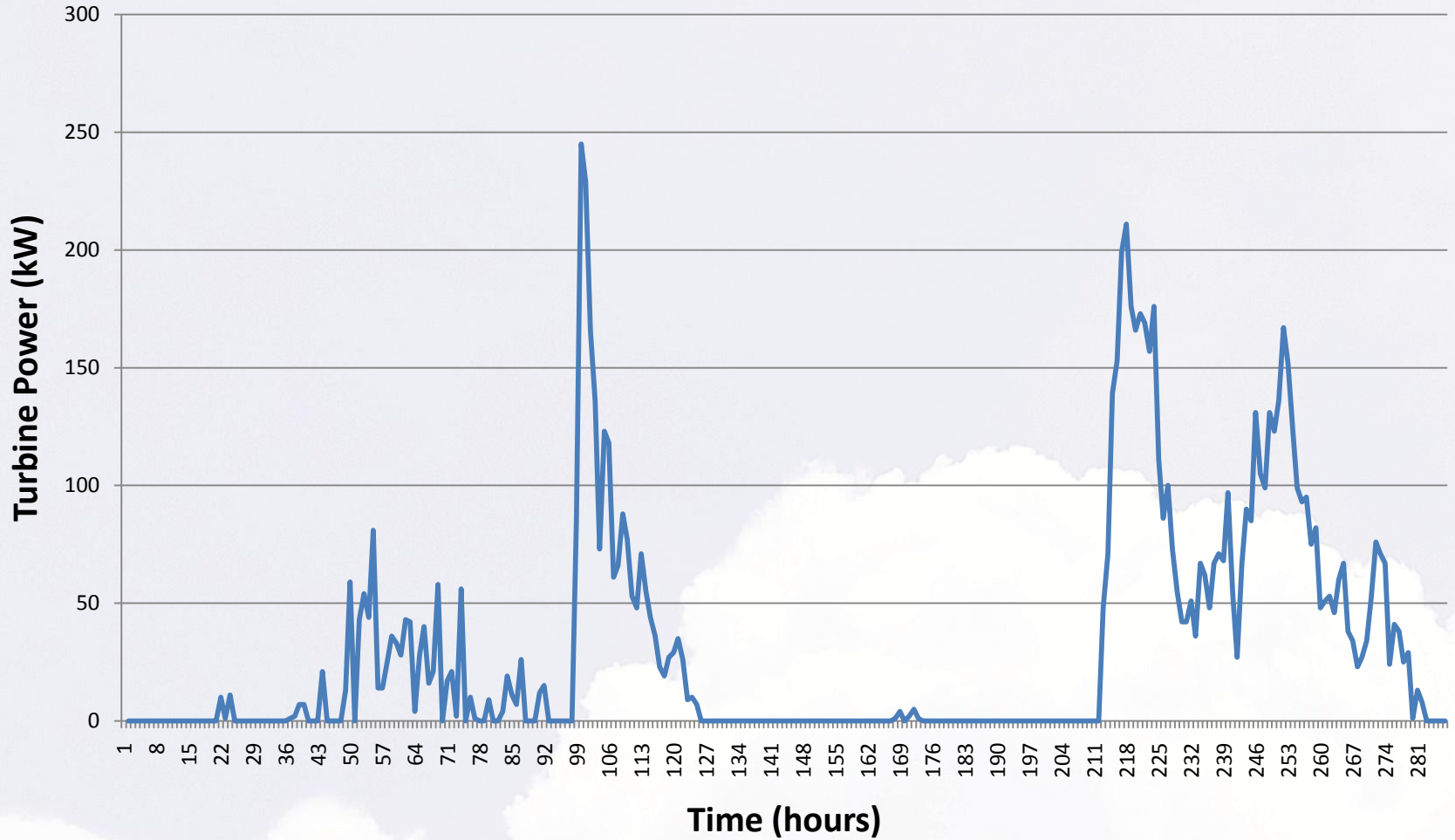
Renewable  
Resource

Stochastic  
model and  
Monte  
Carlo  
simulation

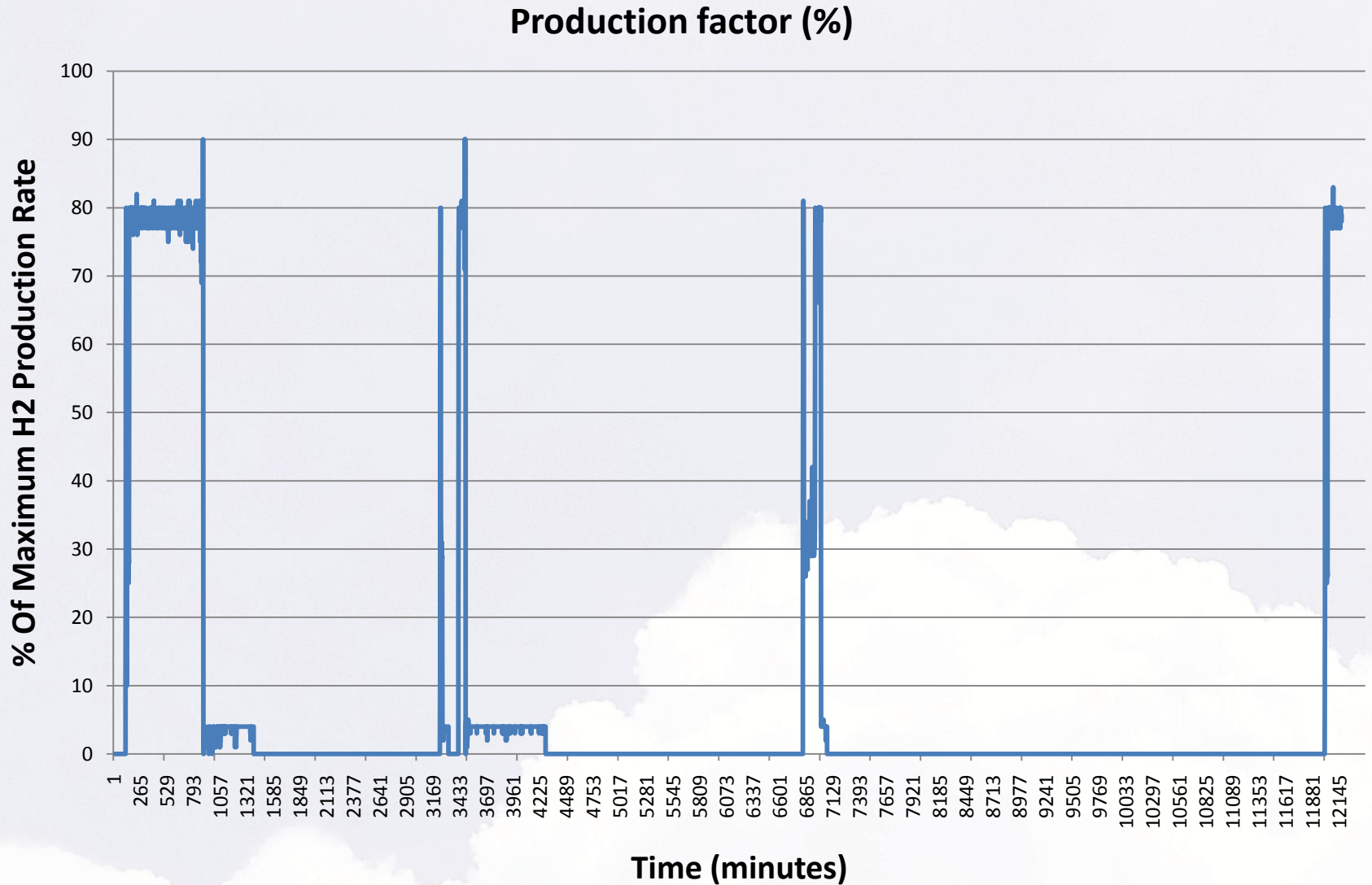
- Present progress:
  - Data logging operational system in real world use
    - Local Load
    - Wind turbine
    - Electrolyser
    - Fuel Cell
- High level of detail achievable
  - Cell level recording achievable
  - Fine tune data loggers to synchronise recording.

# Sample Data

## Wind Turbine Power (kW)



# Sample Data



- Next steps:
  - Consolidate the energy model
    - Help to determine optimum sizes for FC, Electrolysis & Storage etc.
  - Dig deeper into the electrical ‘side effects’ of energy storage
    - Harmonics
    - Distortion
    - Surge Capacity.
  - Investigate the financial aspects of energy storage
  - Integrate this into modelling tools

- There is a need to develop networked energy storage systems
- Also a need to develop the modelling tools to assist in decision making
  - Where to put it
  - How large should it be
    - Power
    - Energy
- H2 Office is a good example of what is possible.

...Thank you...