Hybrid hydrogen energy production and storage system model as a tool for real-world systems integrity assessment.

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Hybrid Hydrogen Energy Production and Storage System Model as a tool for Real-World Systems Integrity Assessment

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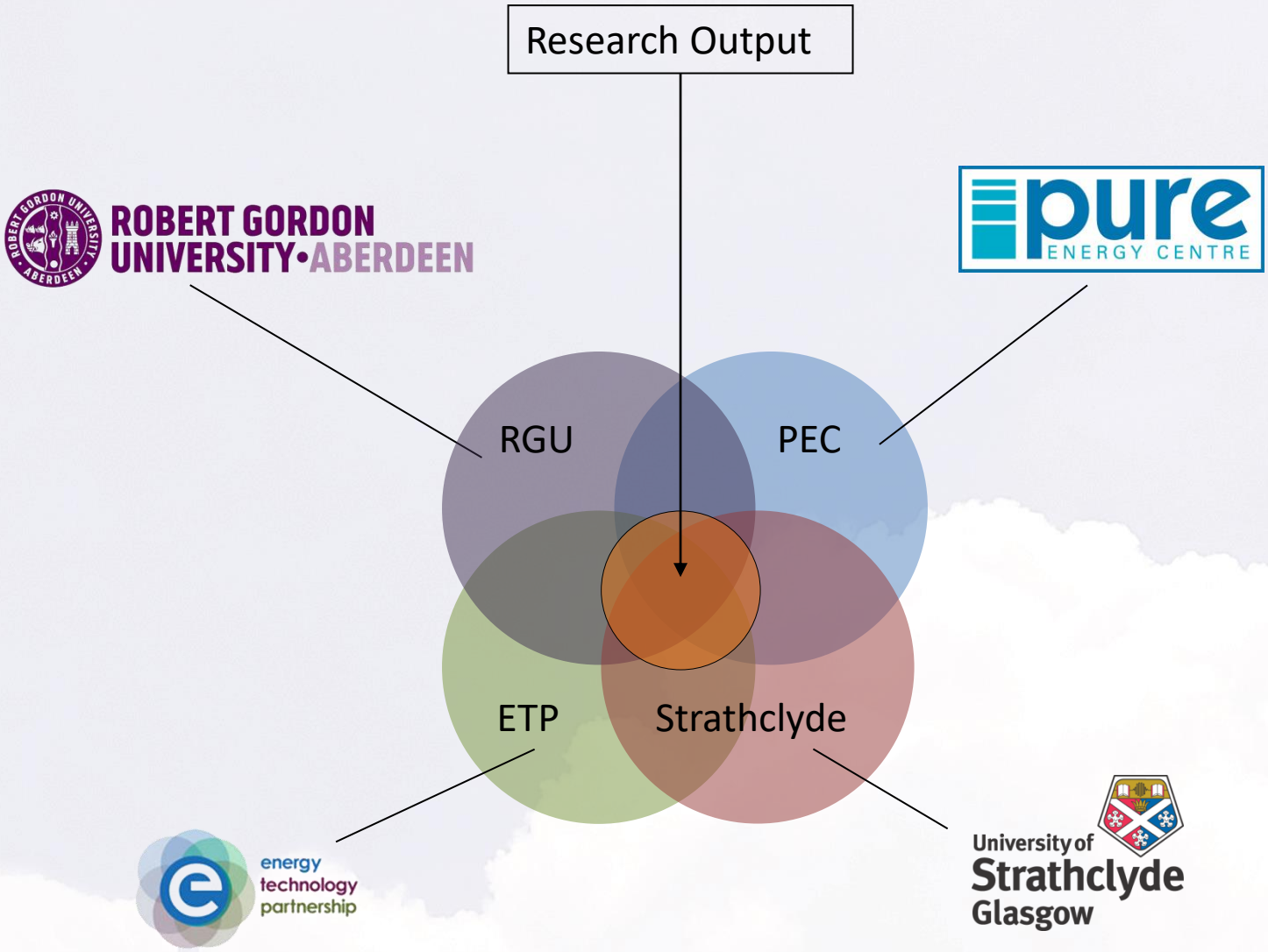
Overview

- Introduction
- Background
- Modelling
- Case study

Introduction

Research Partners



The Project Team

- People involved in the project:
  - Dr. Dallia Ali
  - Dr. Daniel Aklil
  - Dr. Stephen Finney
  - Ross Gazey

Supervisory Team

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

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Background

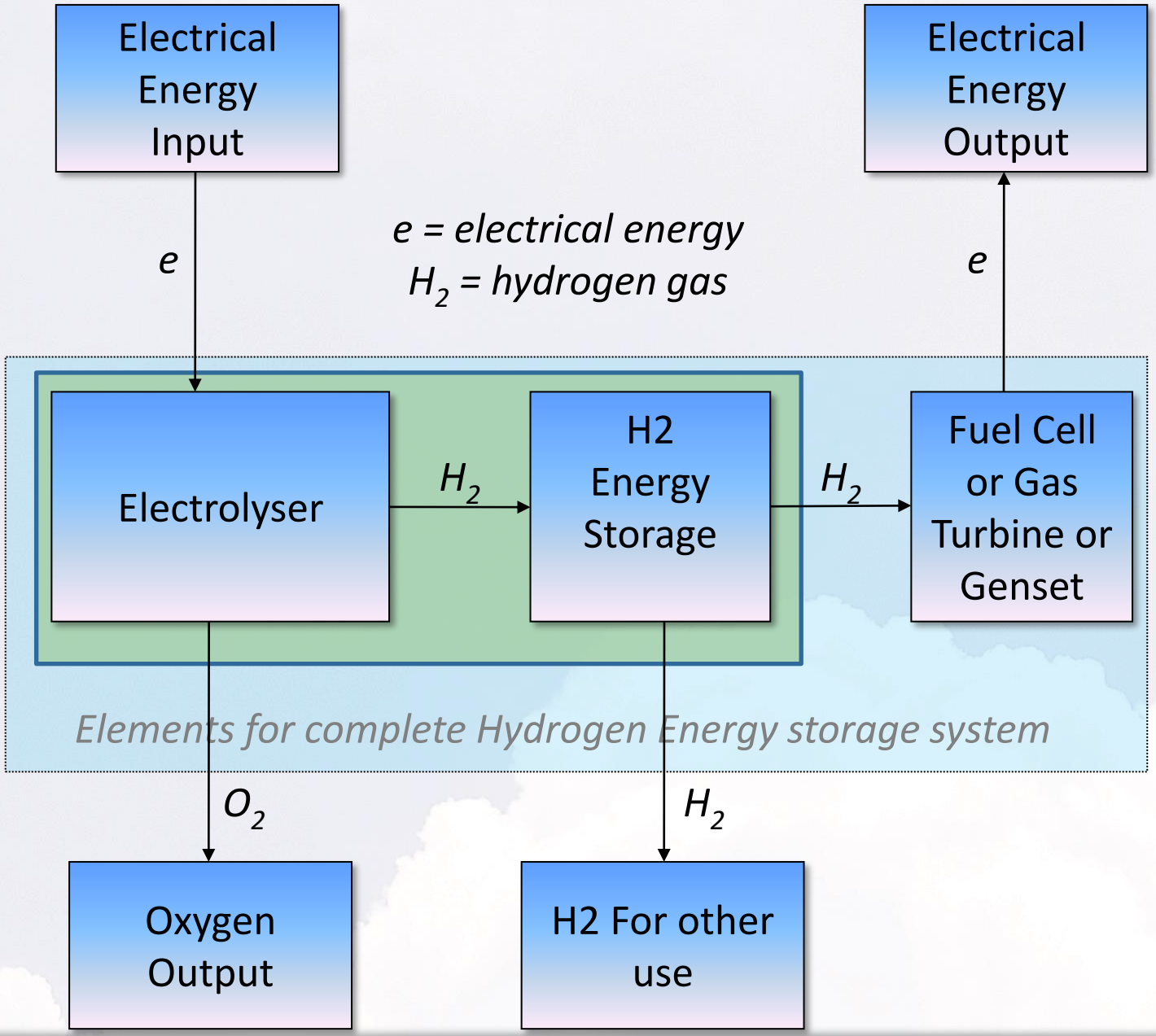
- Within Scotland ambitious national targets are focused on achieving renewable generation of 100% by 2020

- Existing electrical infrastructure is becoming Increasingly constrained

- Department of Energy & Climate Change also acknowledged:

  "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"

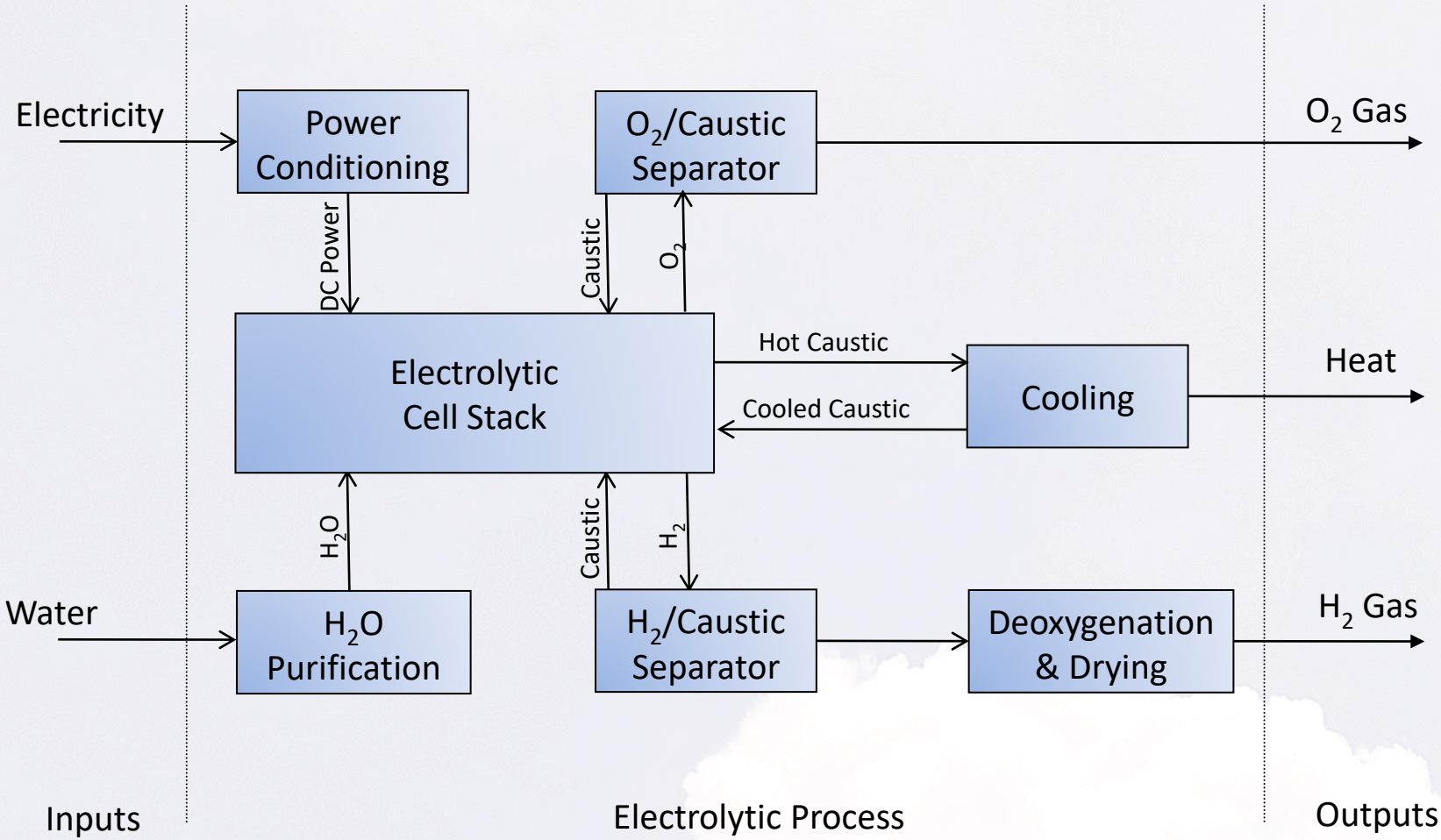
Elements of h2 energy system



Research Stages

- Economic modelling
- Application
  - Transport
  - ‘sector shift’ / power2gas
  - Energy storage
  - Industrial use
- System modelling
  - Renewable
  - H2 (electrolyser, storage, fuel cell, transport)

Main Components of Alkali Electrolyser



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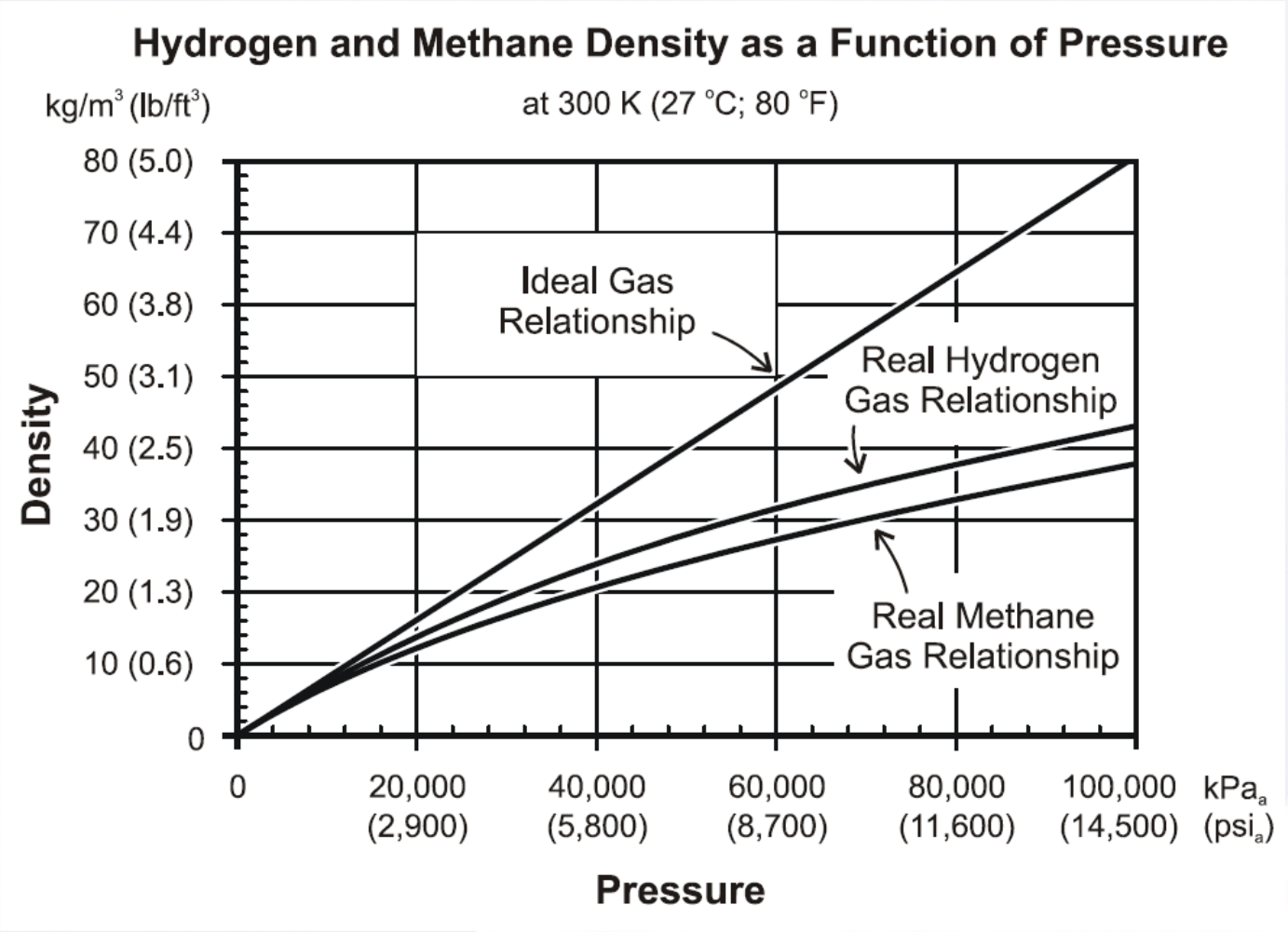
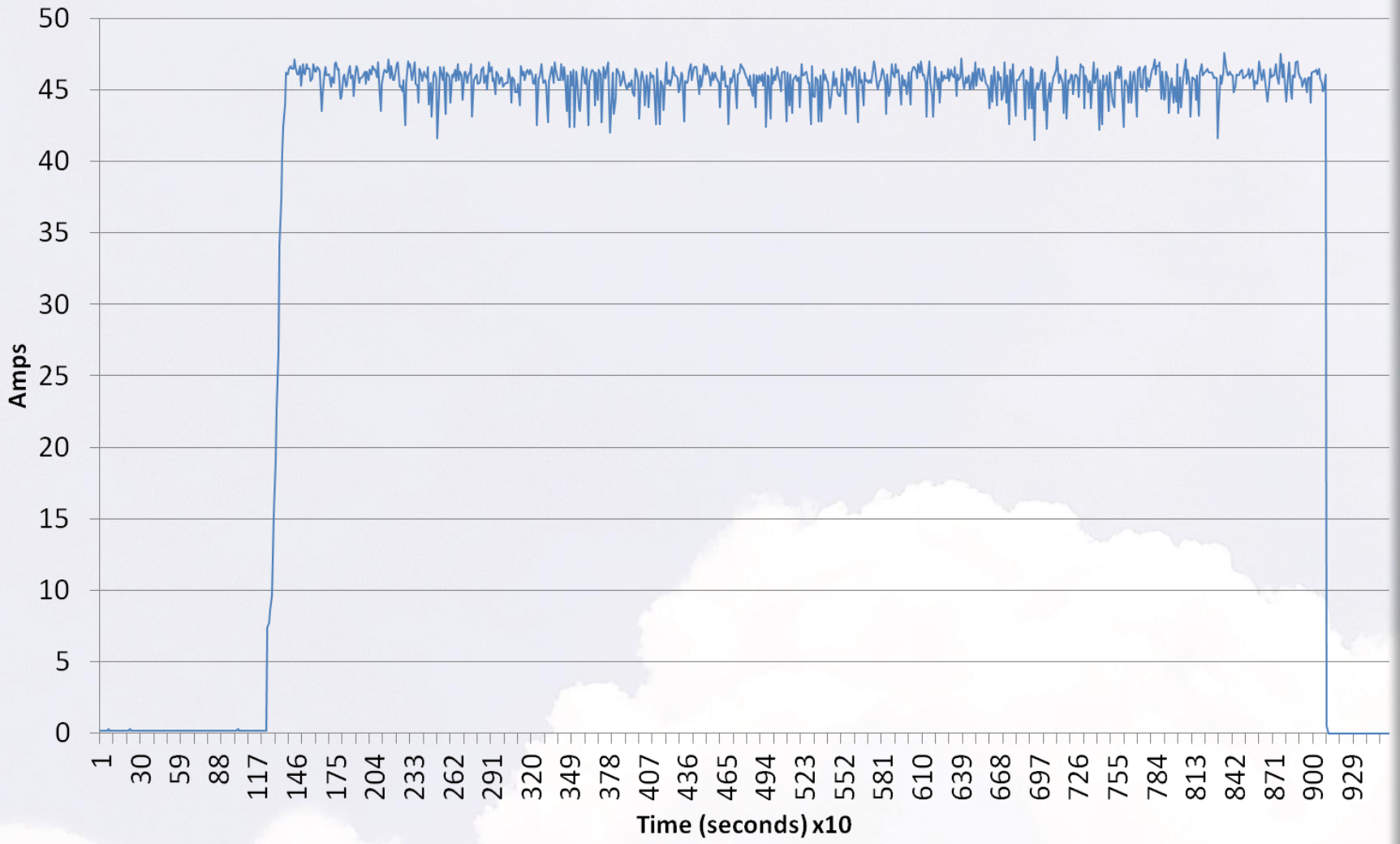
Electrolyser model

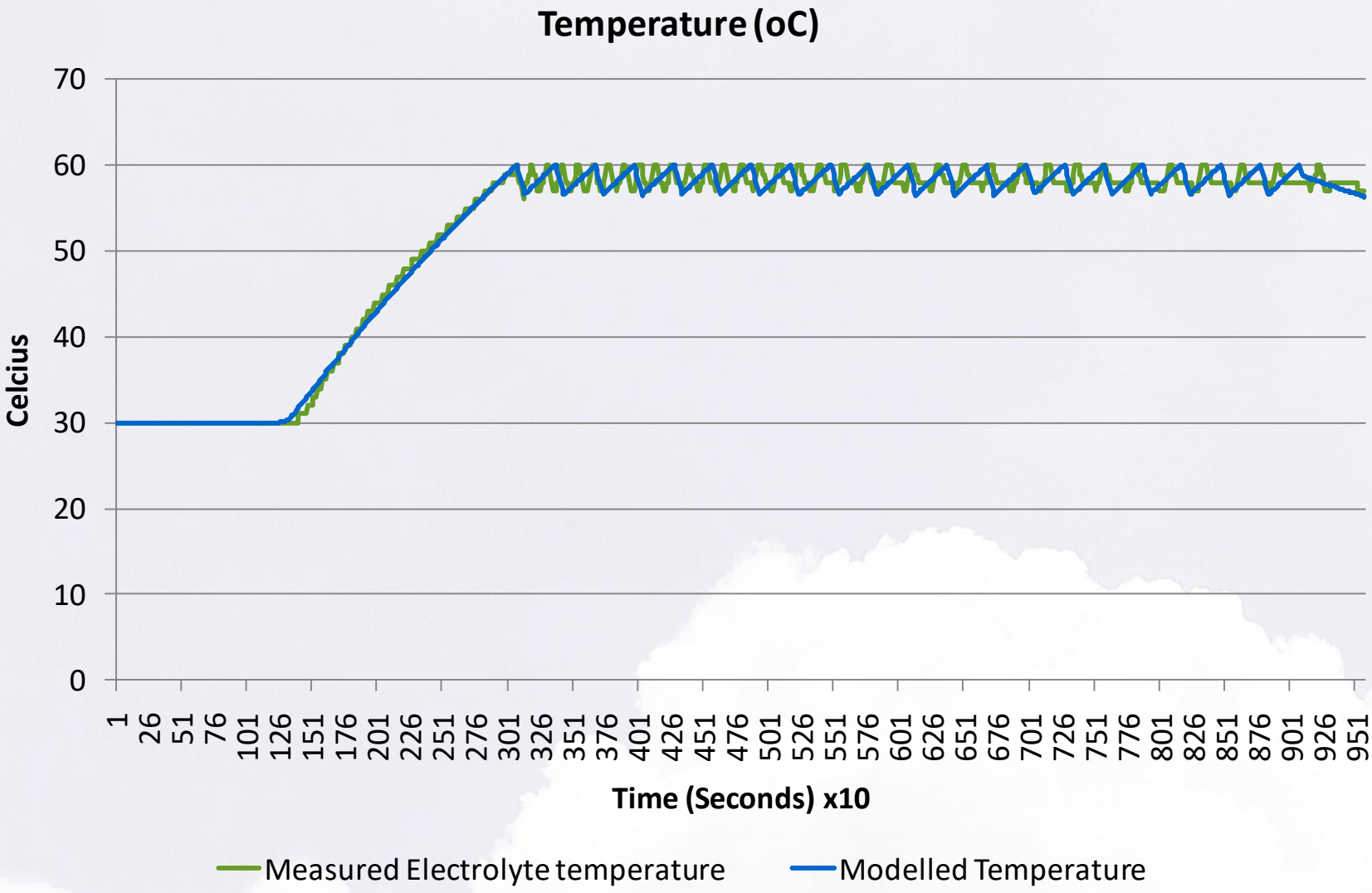
- Model incorporates:
  - Temperature dependant Voltage & Current relationship
  - Faraday efficiency
  - Faraday gas production
  - Thermal energy management

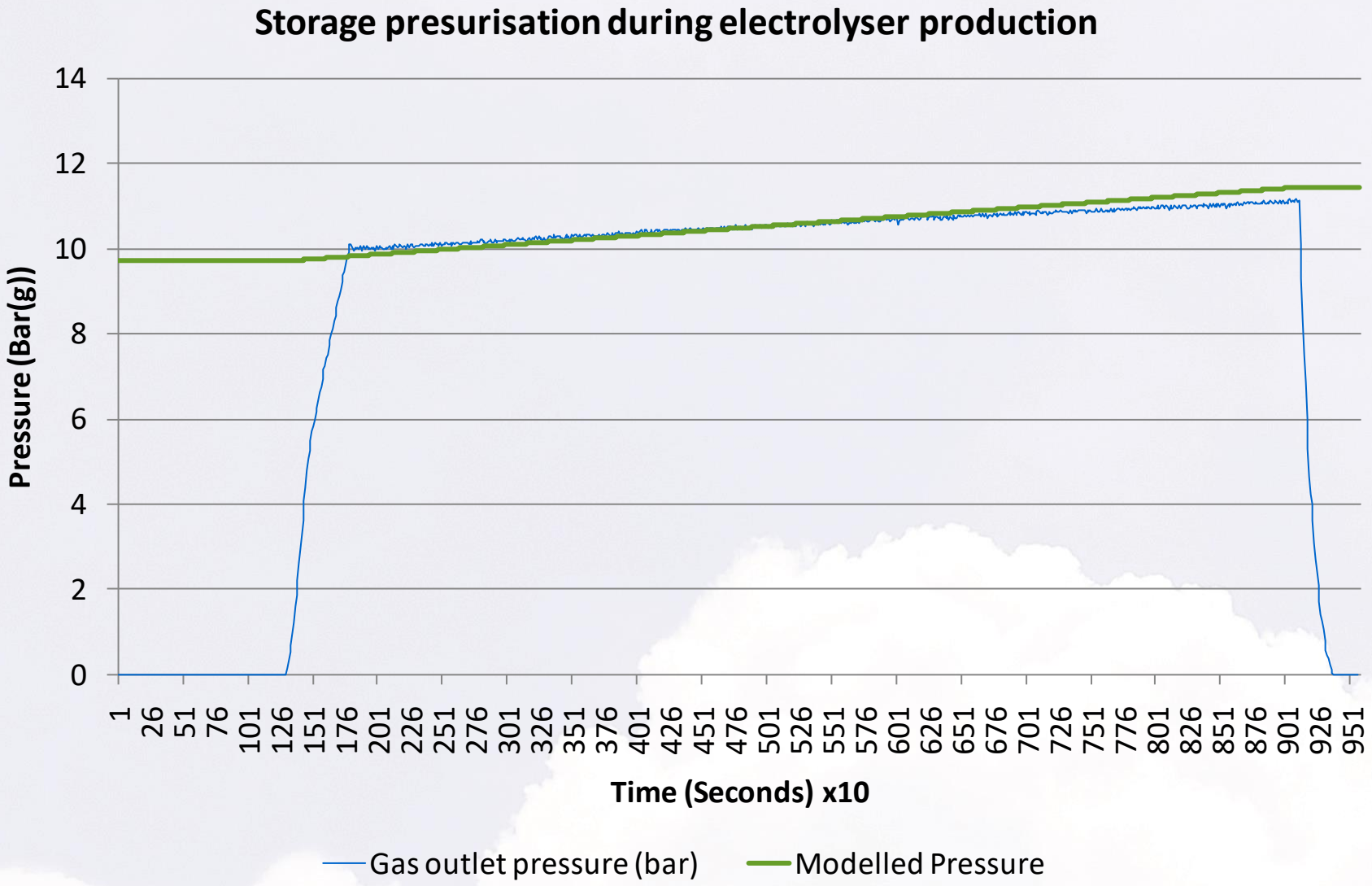
Pressure & storage model



$$Z(P,T) = \frac{P}{\rho RT} = 1 + \sum_{i=1}^{9} a_i \left(\frac{100}{T}\right)^{b_i} \left(\frac{P}{1}\right)^{c_i}$$


DC current consumed by electrolyser cell stack
Amps
0
5
10
15
20
25
30
35
40
45
50
1
30
59
88
117
146
175
204
233
262
291
320
349
378
407
436
465
494
523
552
581
610
639
668
697
726
755
784
813
842
871
900
929
Time (seconds) x10


Temperature (oC)
70
60
50
40
30
20
10
0
Celcius
1
26
51
76
101
126
151
176
201
226
251
276
301
326
351
376
401
426
451
476
501
526
551
576
601
626
651
676
701
726
751
776
801
826
851
876
901
926
951
Time (Seconds) x10
Measured Electrolyte temperature
Modelled Temperature


Storage presurisation during electrolyser production
Pressure (Bar(g))
0
2
4
6
8
10
12
14
1
26
51
76
101
126
151
176
201
226
251
276
301
326
351
376
401
426
451
476
501
526
551
576
601
626
651
676
701
726
751
776
801
826
851
876
901
926
951
Time (Seconds) x10
Gas outlet pressure (bar)
Modelled Pressure

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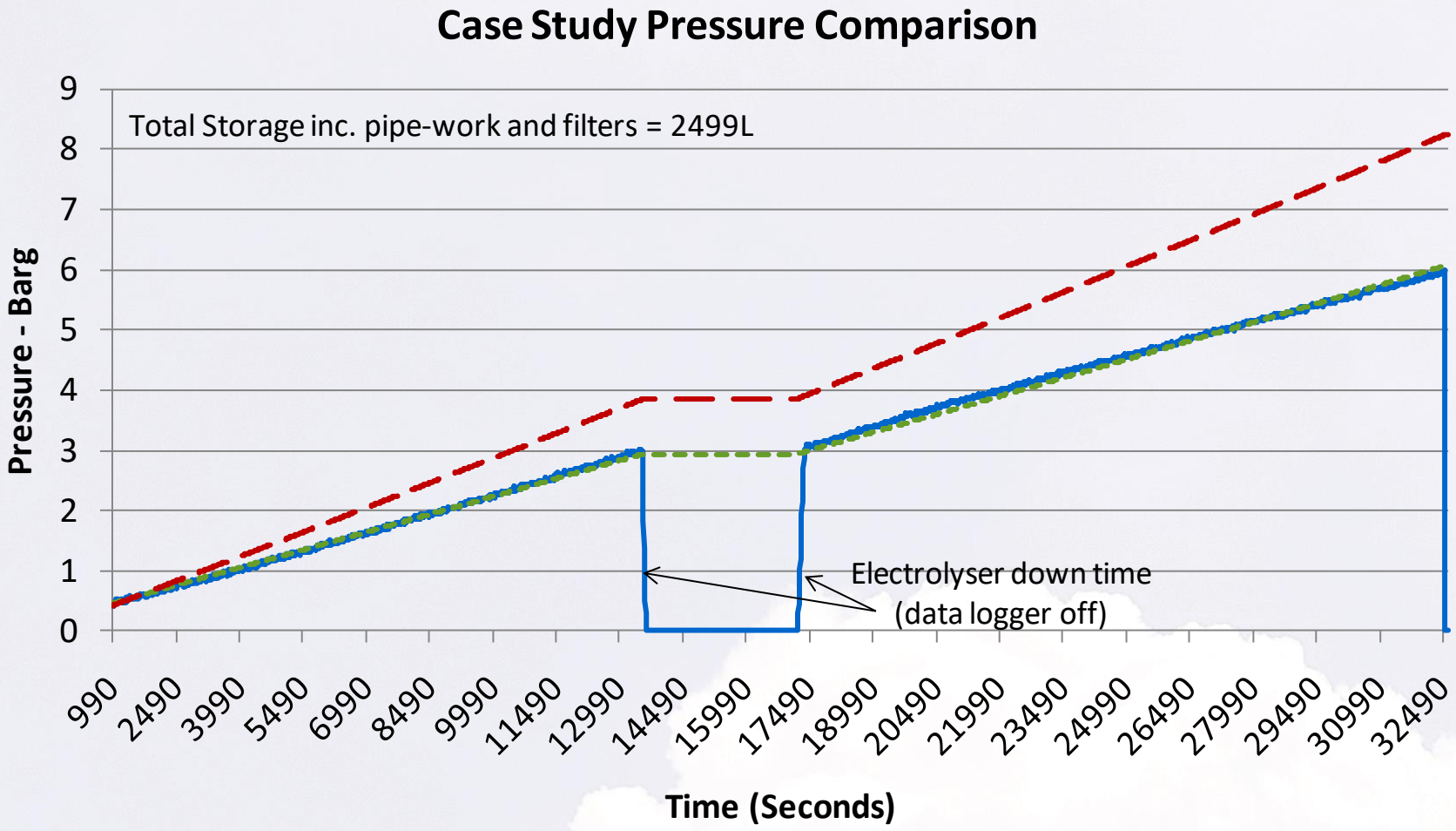
Case Study

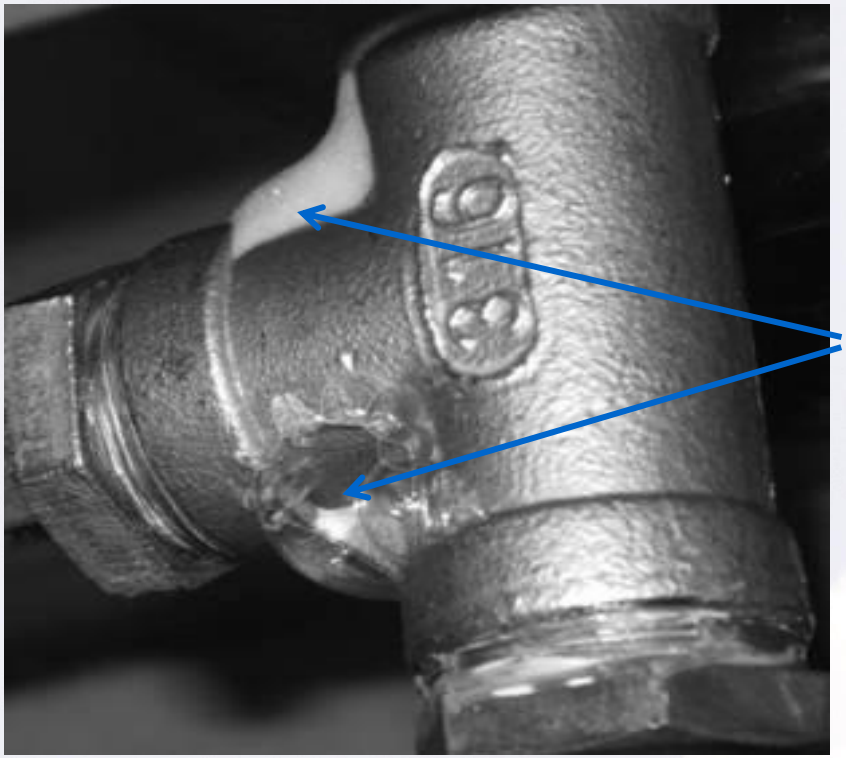
- Application of Model as a tool for Real-World Systems Integrity Assessment


Case Study Pressure Comparison
Total Storage inc. pipe-work and filters = 2499L
Pressure - Barg
0
1
2
3
4
5
6
7
8
9
990
2490
3990
5490
6990
8490
9990
11490
12990
14490
15990
17490
18990
20490
21990
23490
24990
26490
27990
29490
30990
32490
Time (Seconds)
Electrolyser down time
(data logger off)
Measured gas pressure (bar)
Modelled pressure (corrected for leak)
Modelled pressure

- Model revealed a hydrogen gas leak of about 10.89g/hour from the system.

- This loss equated to around 2.3% reduction in the overall system efficiency.

The Leak!



Fitting cracked around top of casting causing H2 leakage.

(See white bubble foam)

Conclusion

- Model has been developed in matlab/simulink
- The matlab/simulink model has proved useful in identifying possible gas leaks
- The model has also enabled the quantification of an identified leak.

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pure ENERGY CENTRE

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energy technology partnership

...Thank you...