X THE PLACE OF USEFUL LEARNING

University of Strathclyde Engineering

Mapping the contribution of wind-derived hydrogen to energy system resilience

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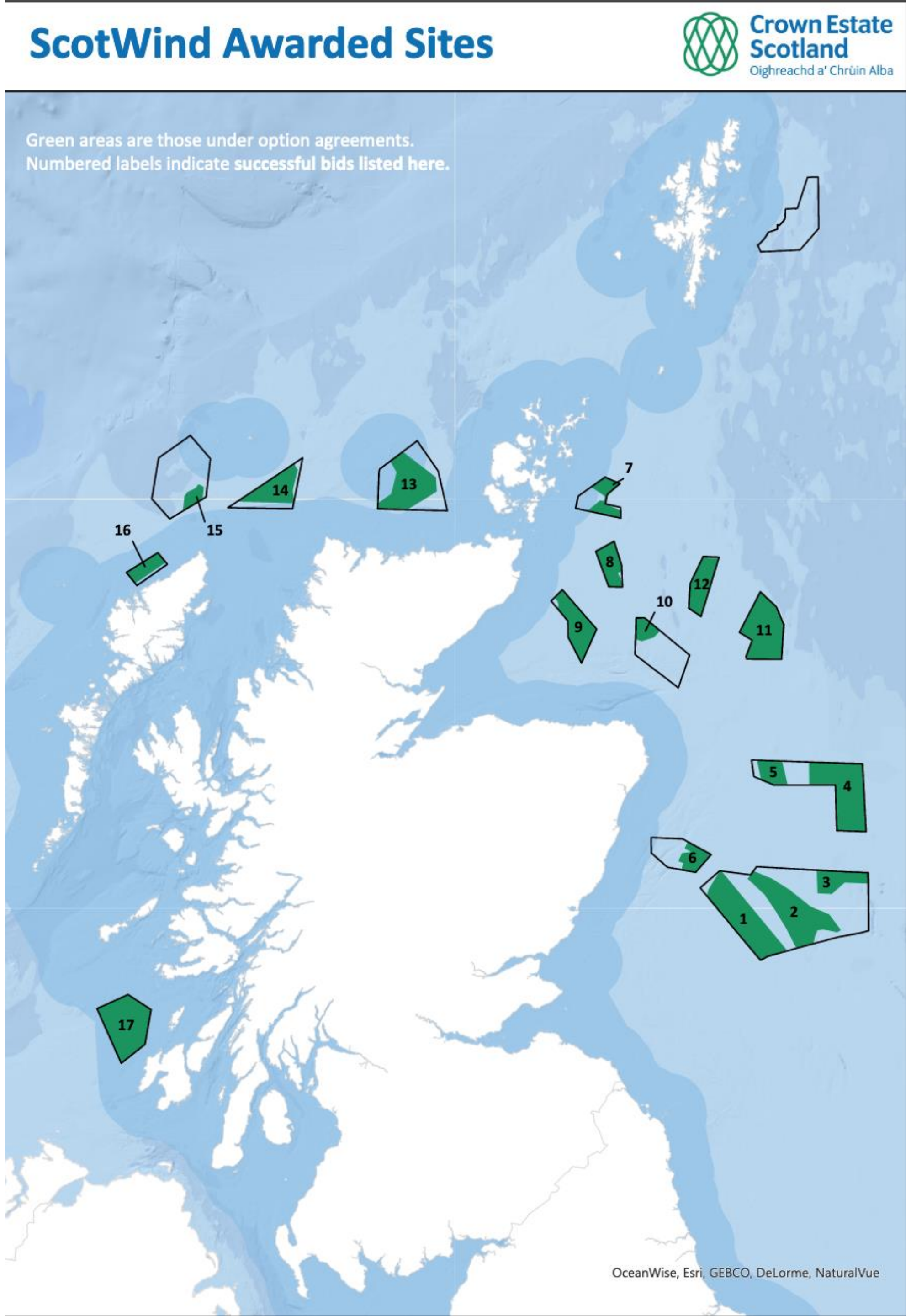
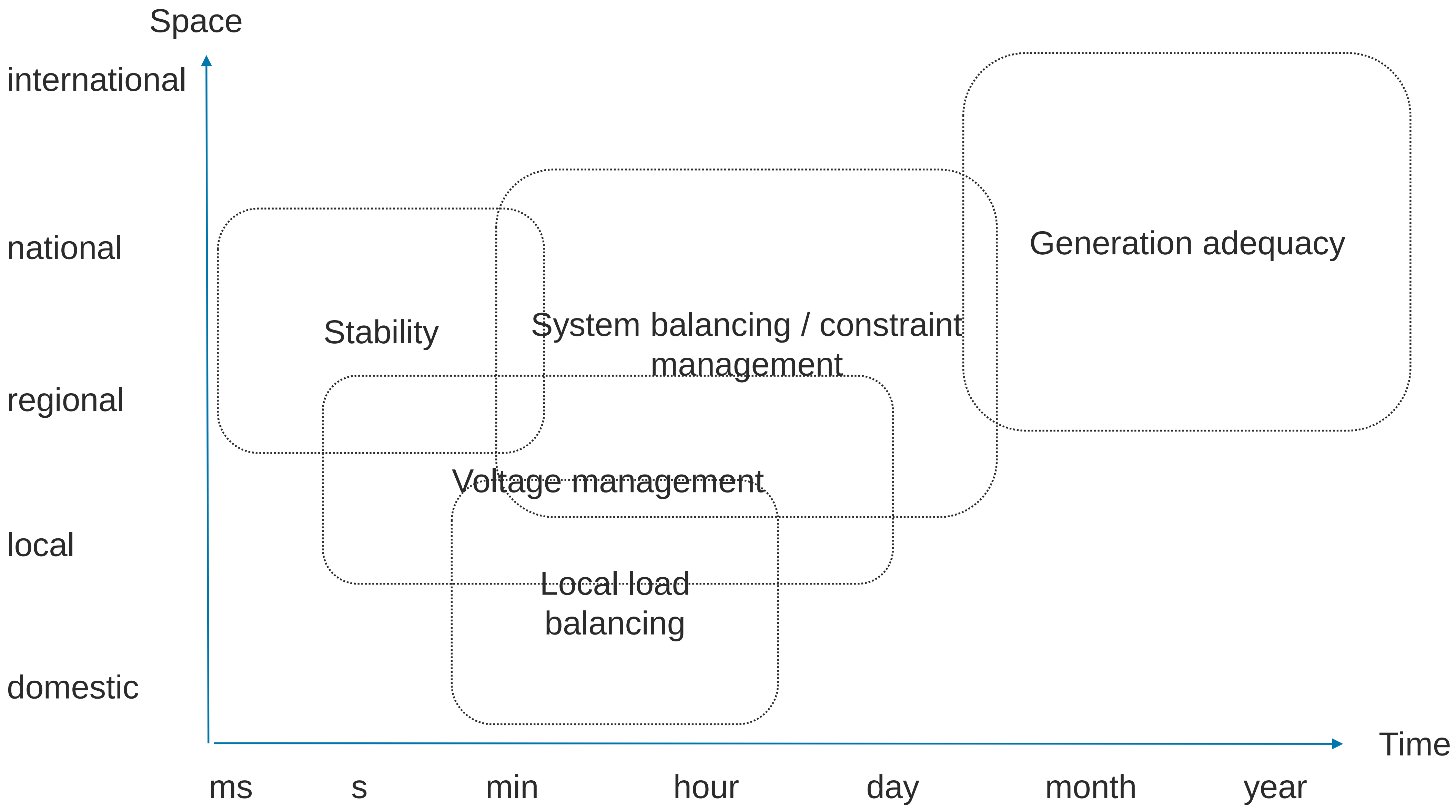
Supergen Risk and Resilience Day, 8th March 2023



Map reference	Lead applicant	Option Fees	Technology	Total capacity (MW)
1	BP Alternative Energy Investments	£85,900,000	Fixed	2,907
2	SSE Renewables	£85,900,000	Floating	2,610
3	Falck Renewables	£28,000,000	Floating	1,200
4	Shell New Energies	£86,000,000	Floating	2,000
5	Vattenfall	£20,000,000	Floating	798
6	DEME	£18,700,000	Fixed	1,008
7	DEME	£20,000,000	Floating	1,008
8	Falck Renewables	£25,600,000	Floating	1,000
9	Ocean Winds	£42,900,000	Fixed	1,000
10	Falck Renewables	£13,400,000	Floating	500
11	Scottish Power Renewables	£68,400,000	Floating	3,000
12	BayWa	£33,000,000	Floating	960
13	Offshore Wind Power	£65,700,000	Fixed	2,000
14	Northland Power	£3,900,000	Floating	1,500
15	Magnora	£10,300,000	Mixed	495
16	Northland Power	£16,100,000	Fixed	840
17	Scottish Power Renewables	£75,400,000	Fixed	2,000
Totals		**£699,200,000**		**24,826**

Spatial/temporal flexibility needs



Direct contributions from PEM electrolysers

Broad technical capabilities:

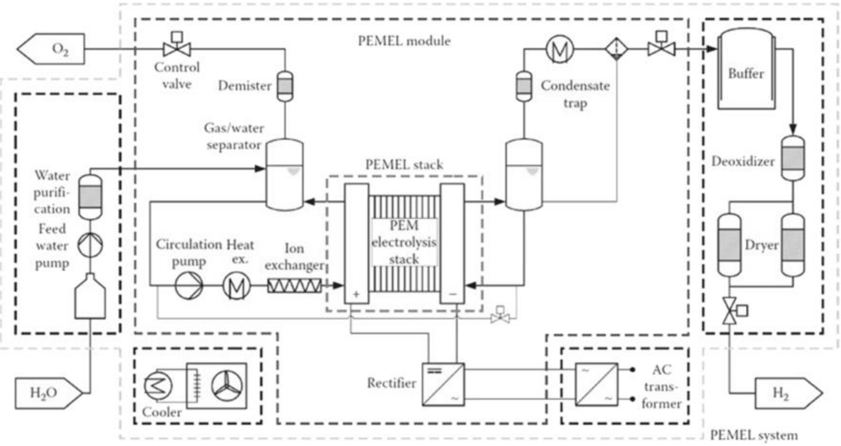
- Second to second load control (potentially faster response than conventional thermal generators)
- Primary and secondary response capabilities have been demonstrated

Potential limitations:

- Impact on conversion efficiency – primarily defined by current density and operating temperature
- Lifetime reduction from load cycling

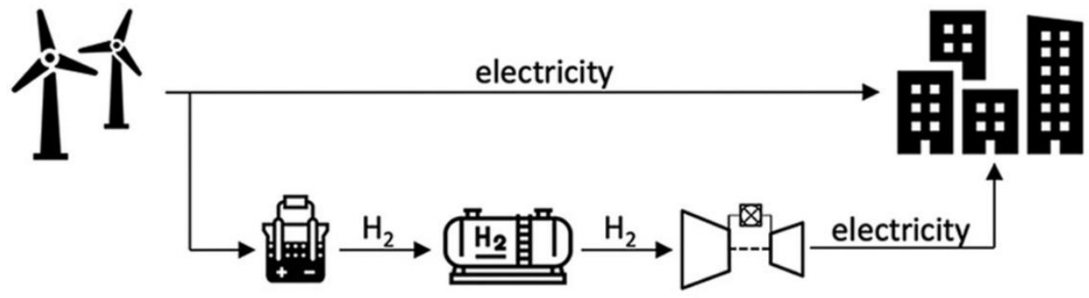
Little information from manufacturers:

- Impacts choice of catalyst/membrane chemistry
- Need to avoid repeating the mistakes of previous technologies optimised for energy only
- GridQualyS (H2020 project) provided recommendations for test protocols to European Commission

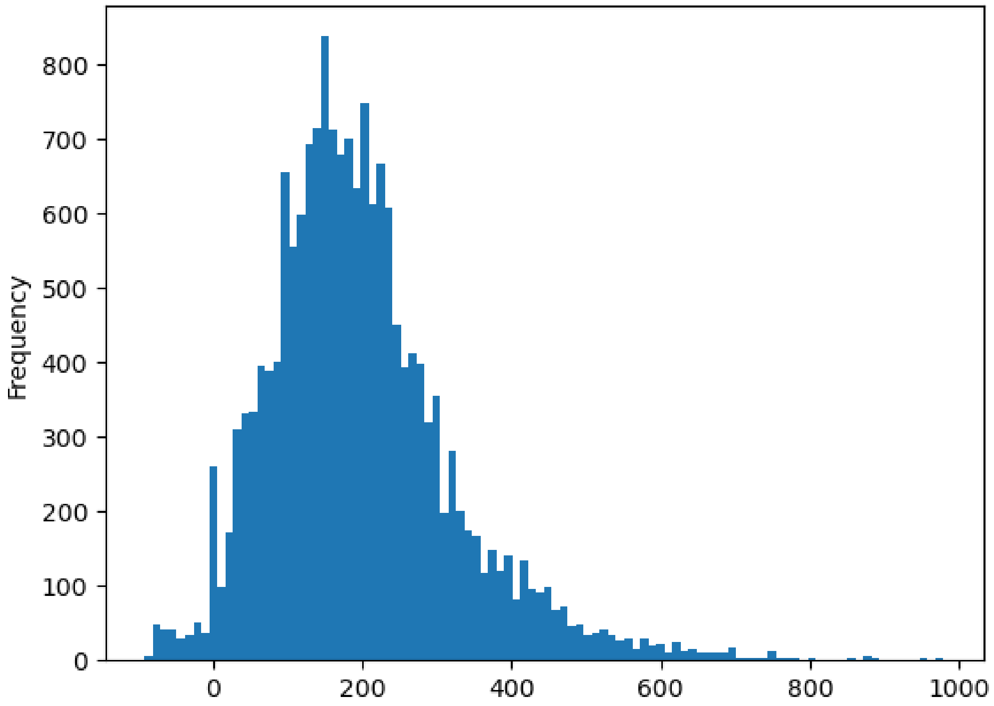


L. Allidières, A. Brisse, P. Millet, S. Valentin, M. Zeller, On the ability of pem water electrolysers to provide power grid services, International Journal of Hydrogen Energy, Volume 44, Issue 20, 2019 https://doi.org/10.1016/j.ijhydene.2018.11.186

Round-cycle contribution from thermal plant

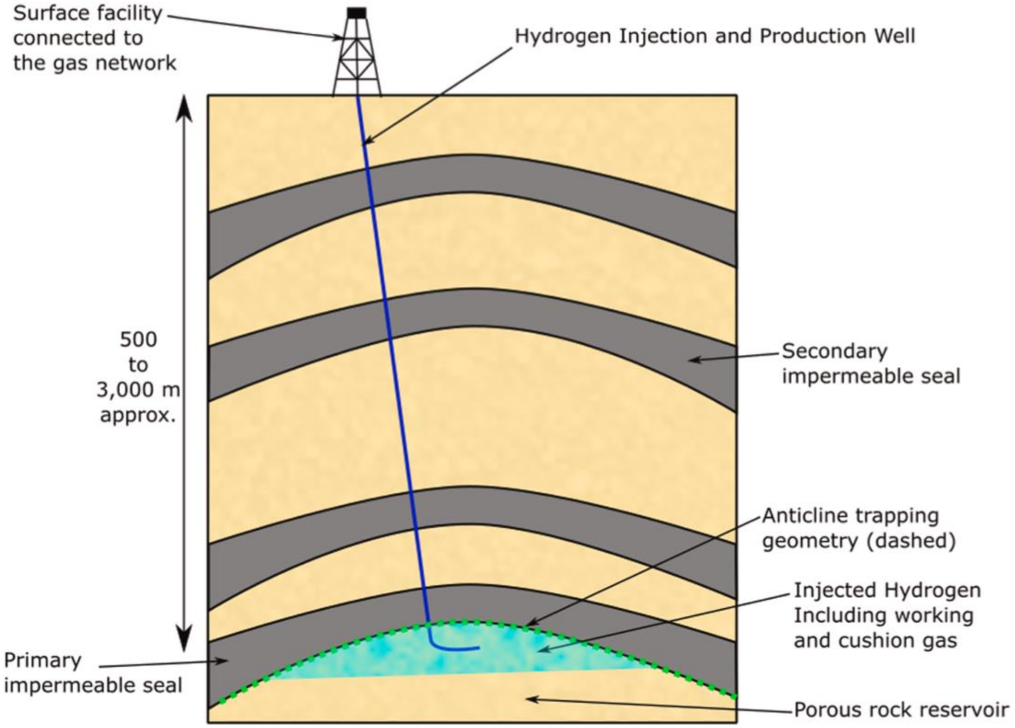


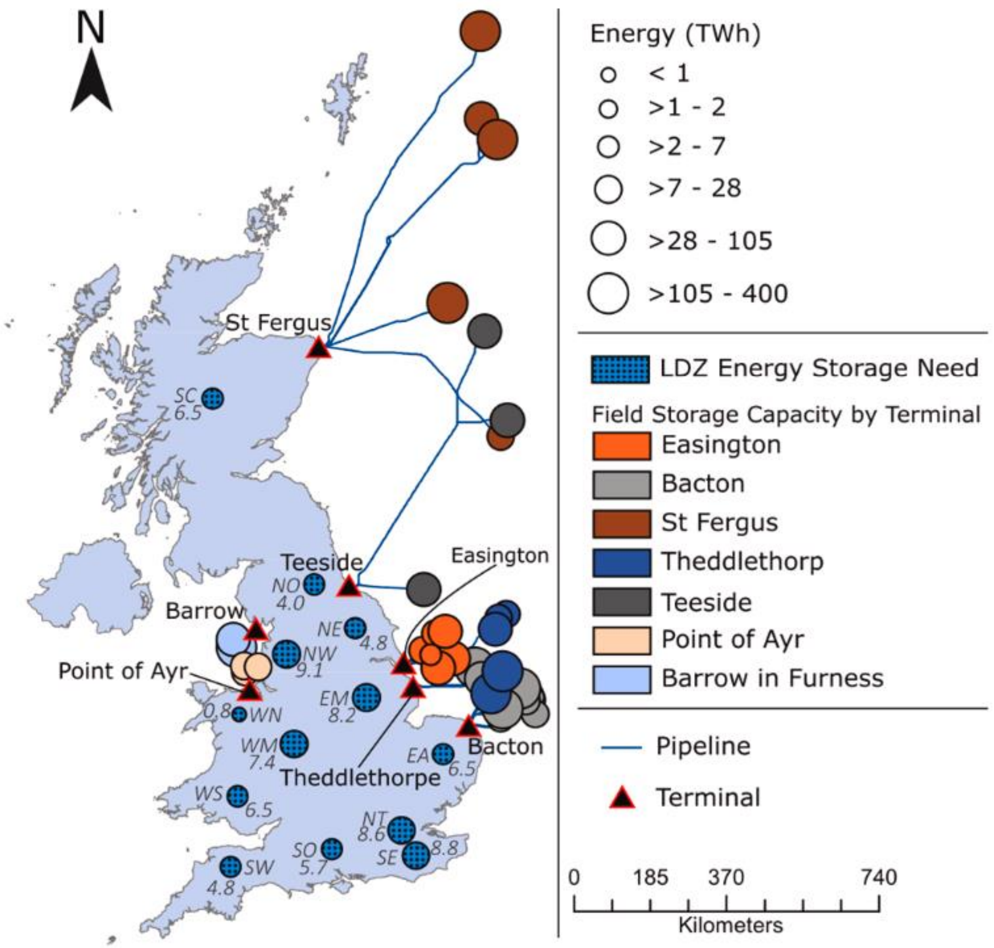
- Very low round-cycle efficiency (20-30%)
- But efficiency losses potentially outweighed by magnitude of imbalances and pricing
- Short-medium term imbalances competing with other technologies
- But little to provide seasonal adequacy
- Existing NTS will not provide equivalent linepack if converted to hydrogen use



Distribution of imbalance prices (£/MWh), 2022

Seasonal storage capacity

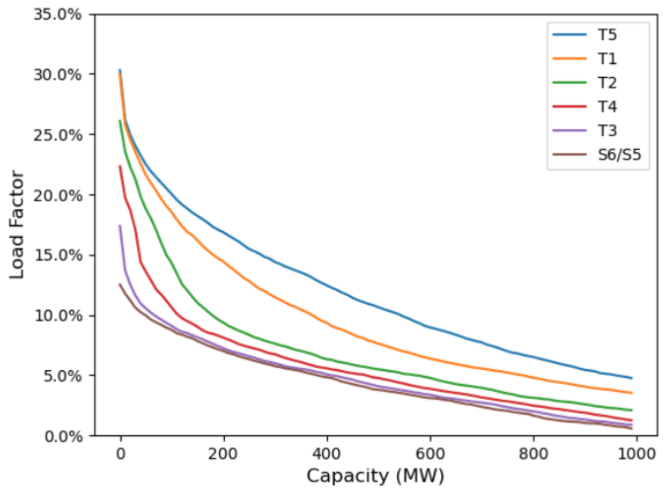




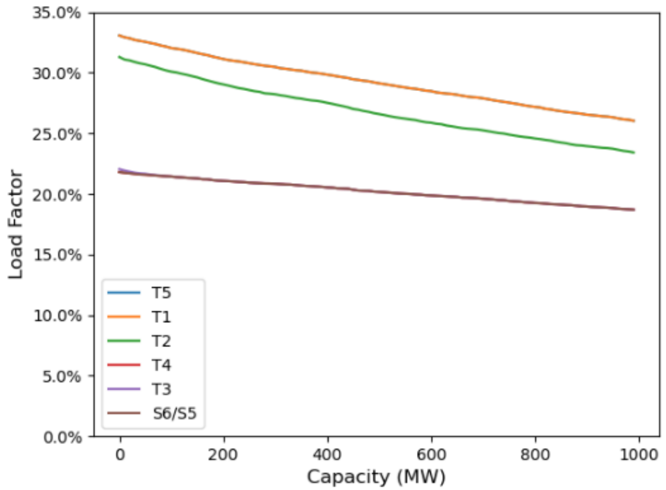
Julien Mouli-Castillo, Niklas Heinemann, Katriona Edlmann, Mapping geological hydrogen storage capacity and regional heating demands: An applied UK case study (2021). Applied Energy, 283, 116348, https://doi.org/10.1016/j.apenergy.2020.116348

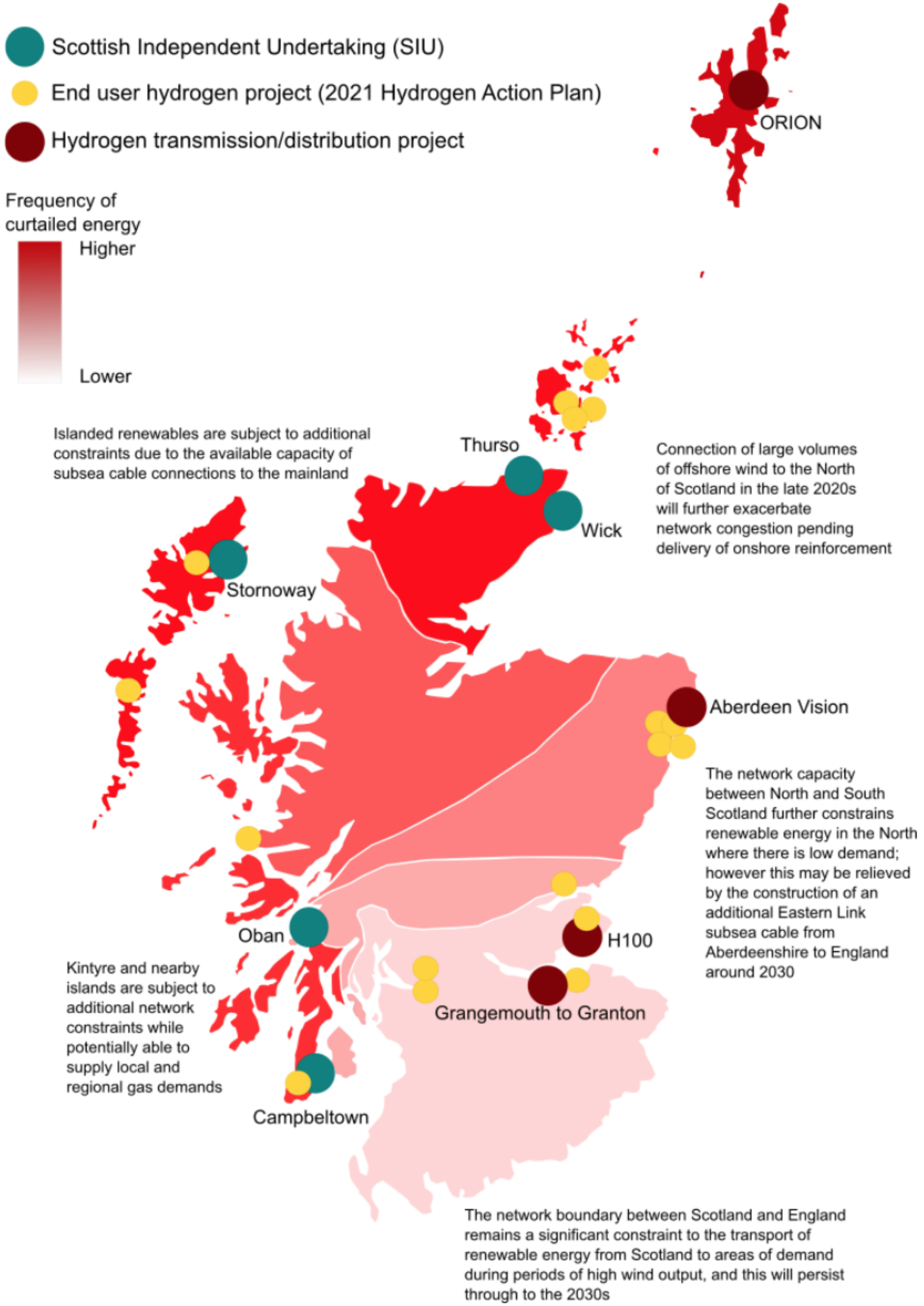
Use of curtailed energy

2021



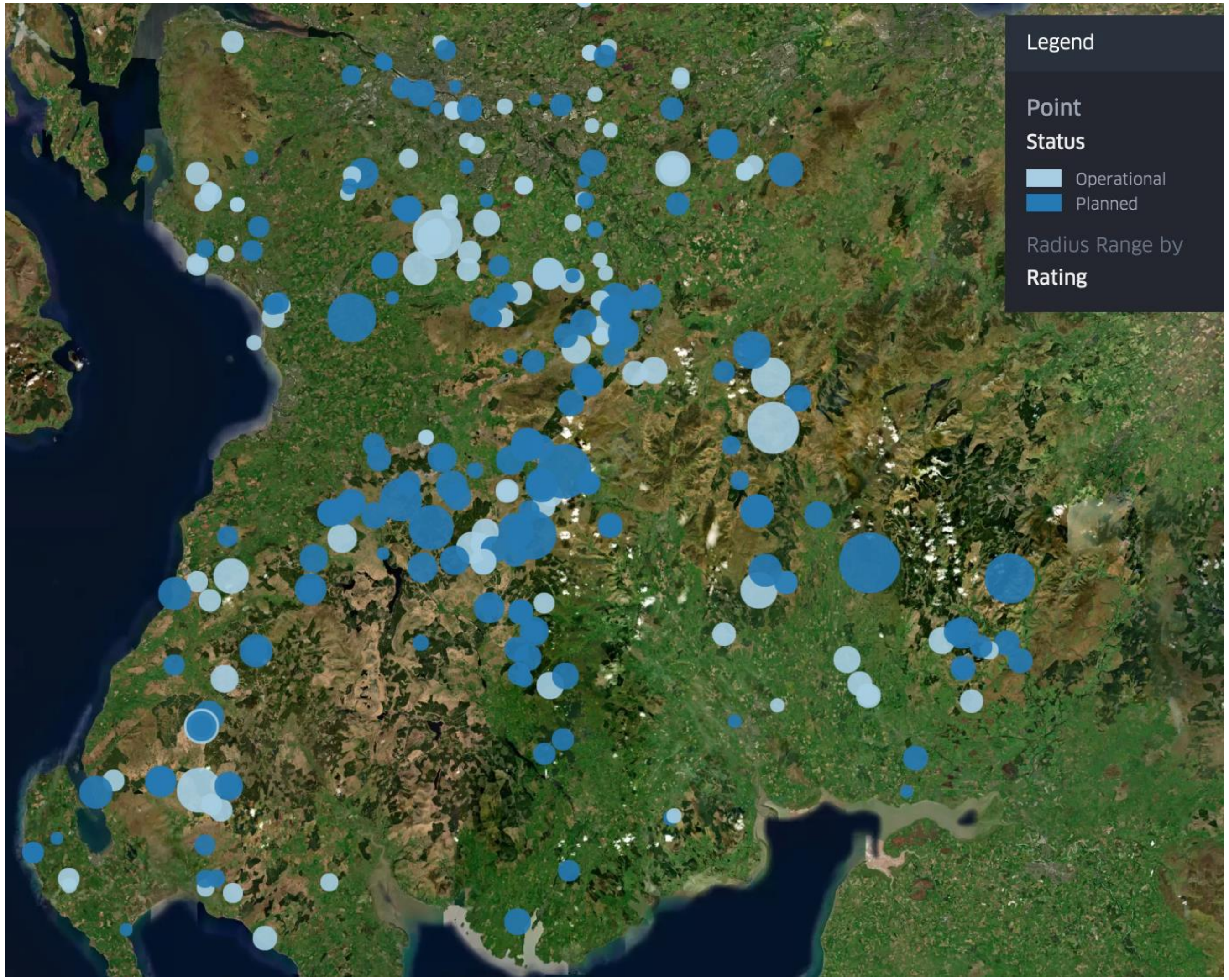
2035
Including 20GW
Scotwind

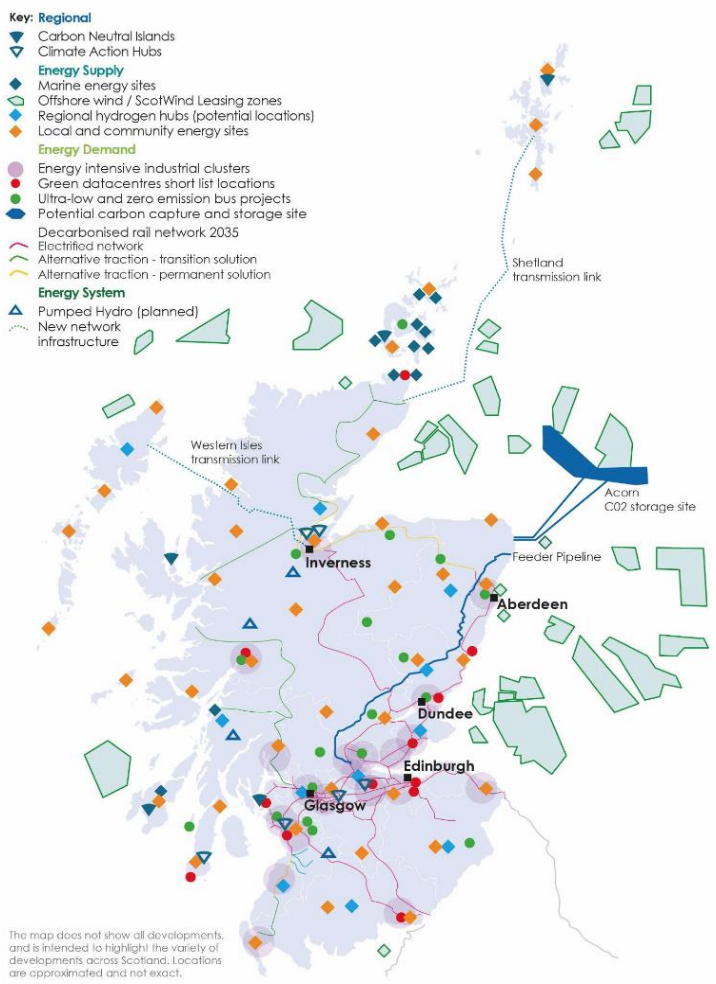




G. Hawker, G. Oakley (2022) The potential for hydrogen to reduce curtailment of renewable energy in Scotland, ClimateXChange http://dx.doi.org/10.7488/era/2940

Co-ordinating development: SW Scotland





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