Green Hydrogen Production

Overcoming the Challenges of Intermittent Renewable Generation

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Introduction & Agenda

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- Process Engineer, Atkins Net Zero Energy Business
  - Industrial Decarbonisation
  - Green Hydrogen / Hydrogen-Derivative Projects

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- MEng Chemical Engineering – University of Edinburgh
- Process Engineer, Atkins Net Zero Energy Business
  - Green Hydrogen / Hydrogen-Derivative Projects

Presentation Agenda

- Introduction
- Why green hydrogen?
- Electrolysis process
- Case study – offshore wind farm
- Plant operation impact on the levelised cost of hydrogen (LCOH) and carbon emissions
  - Wind power
  - Curtailed wind power
  - Wind power + grid supply
- Summary

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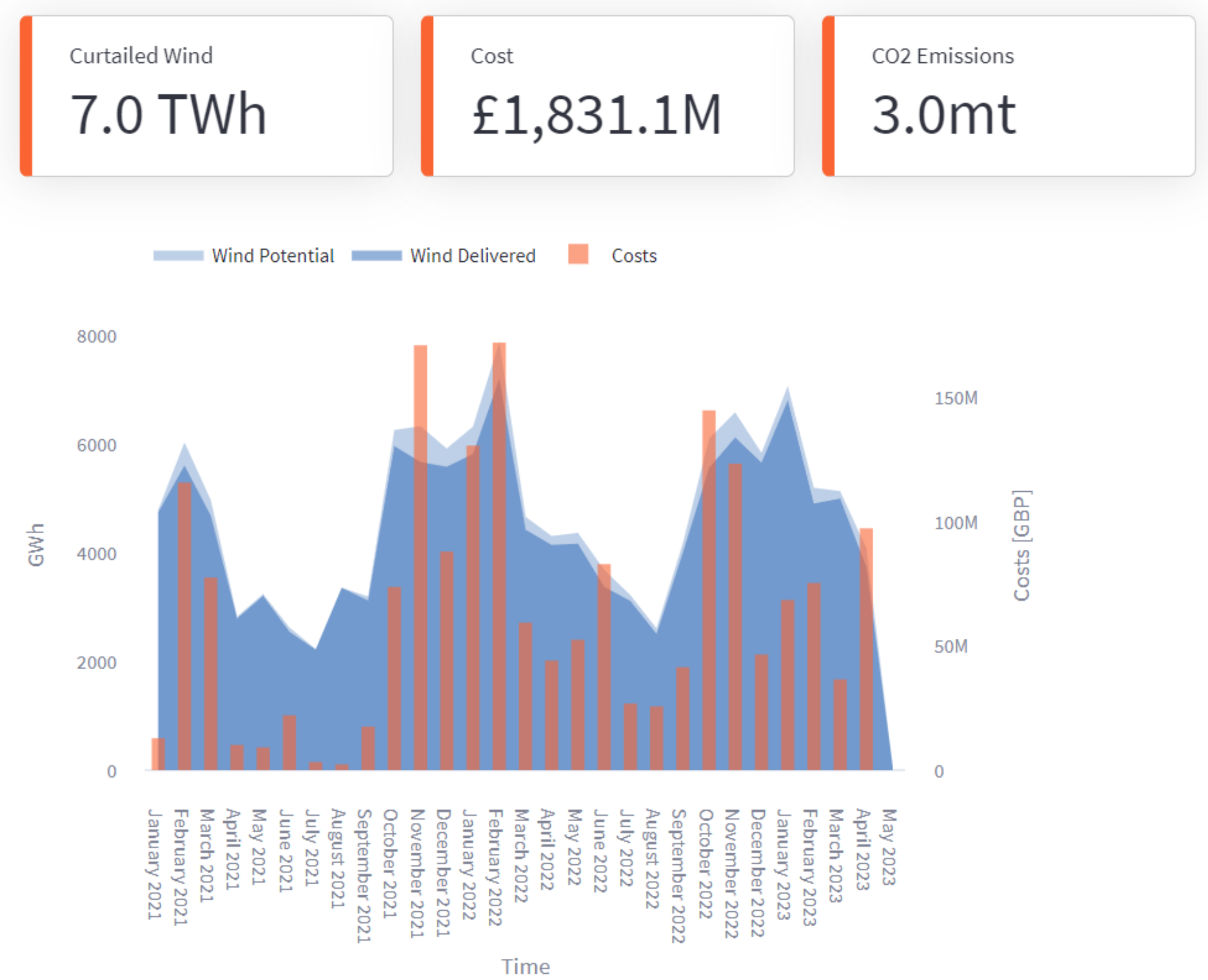
Why Green Hydrogen?

- Wind power will play a crucial part in meeting Net Zero

- Challenges with wind:
  - UK wind farm capacity factor 25% - 45%
  - Curtailment – constraint payments to cap renewable energy supply

- How can we minimise curtailment?
  - Upgrade transmission network
  - Energy storage
    - ***Hydrogen / derivative production and storage***



Total Curtailed Wind UK
January 2021 – May 2023
[UK Wind Curtailment Monitor (wind-curtailment-app-ahq7fucdyq-lz.a.run.app)]

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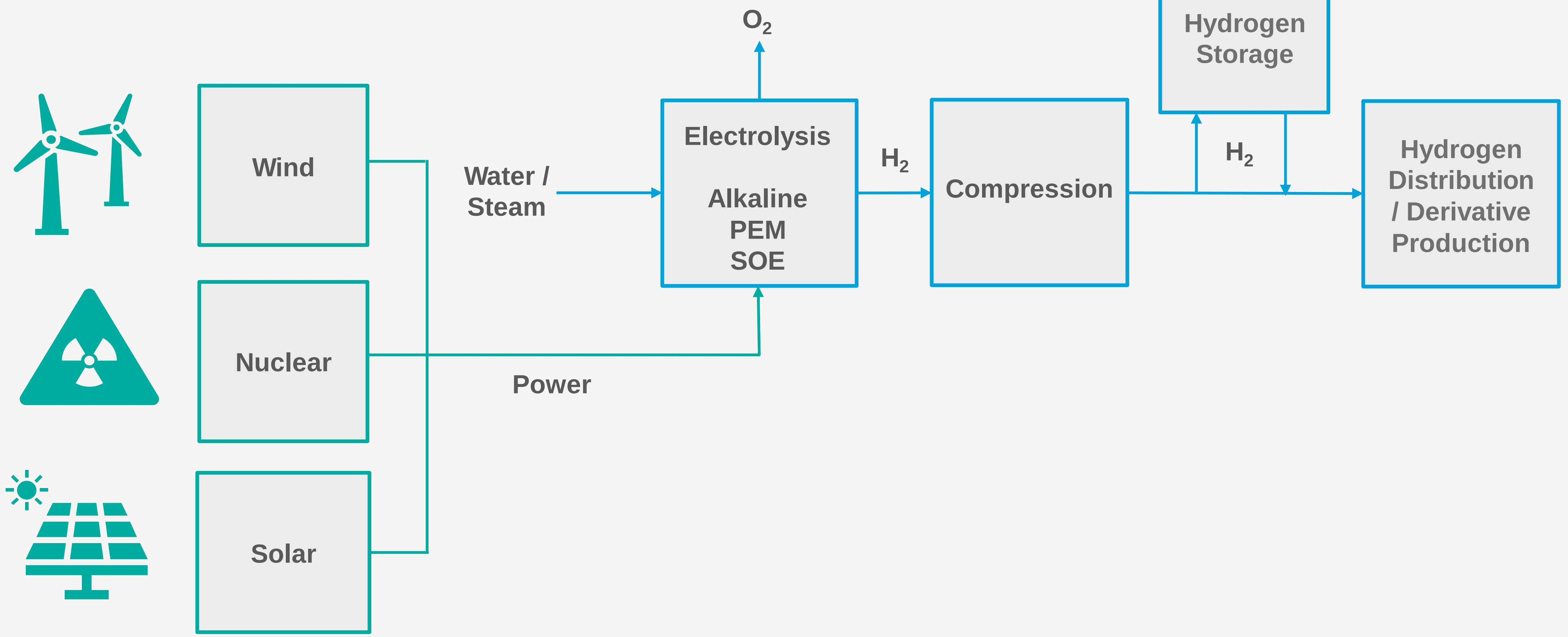
[Energy Trends and Prices statistical release: 26 January 2023 - GOV.UK (www.gov.uk)]
[How much of the UK's energy is renewable? | National Grid Group]

Electrolysis Process



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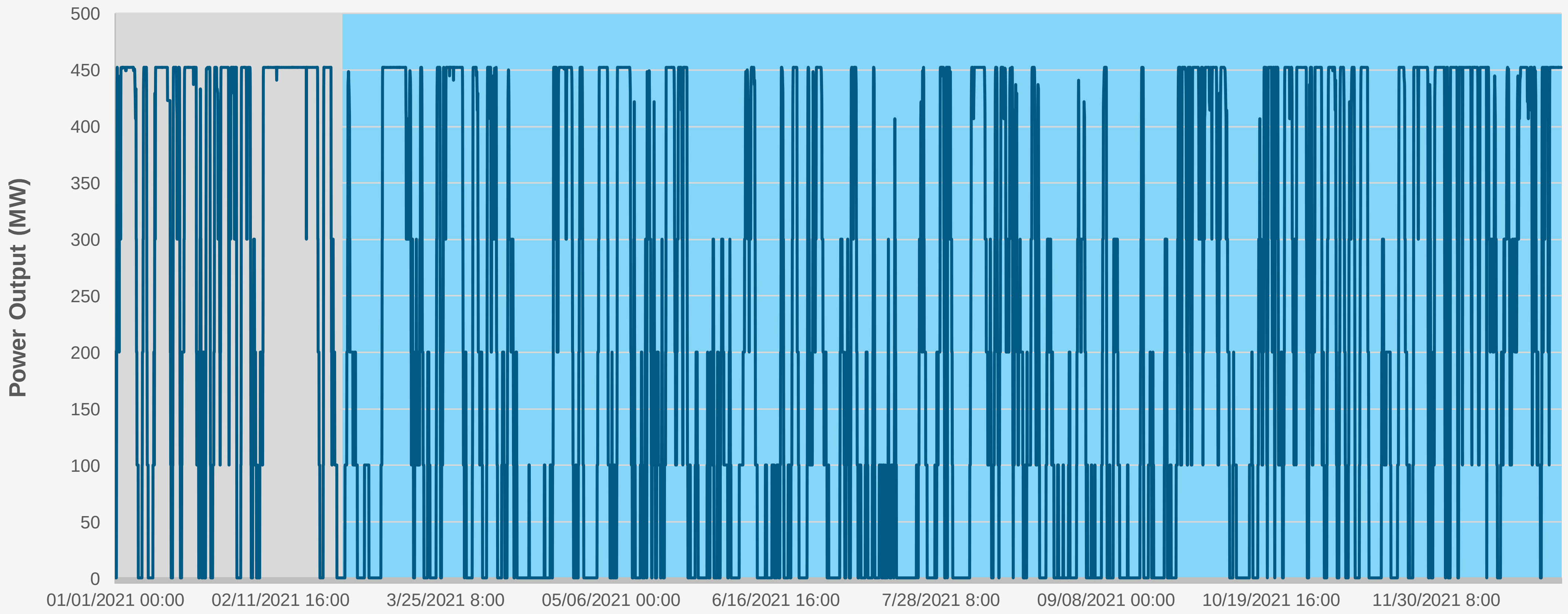
Case Study – 500 MW Offshore Wind Farm

Capacity Factor = 44%



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Example offshore wind power production profile

Techno-Economic Analysis – Three Scenarios

- Atkins in-house optimisation tool used to perform techno-economic analysis
- Optimisation of key electrolyser plant parameters
- Plant operation from 2025 to 2045

1. Renewable Wind Power → Hydrogen

- Optimisation of electrolyser capacity to achieve lowest LCOH

2. Curtailed Renewable Wind Power → Hydrogen

- Optimisation of electrolyser capacity and understanding of potential hydrogen production

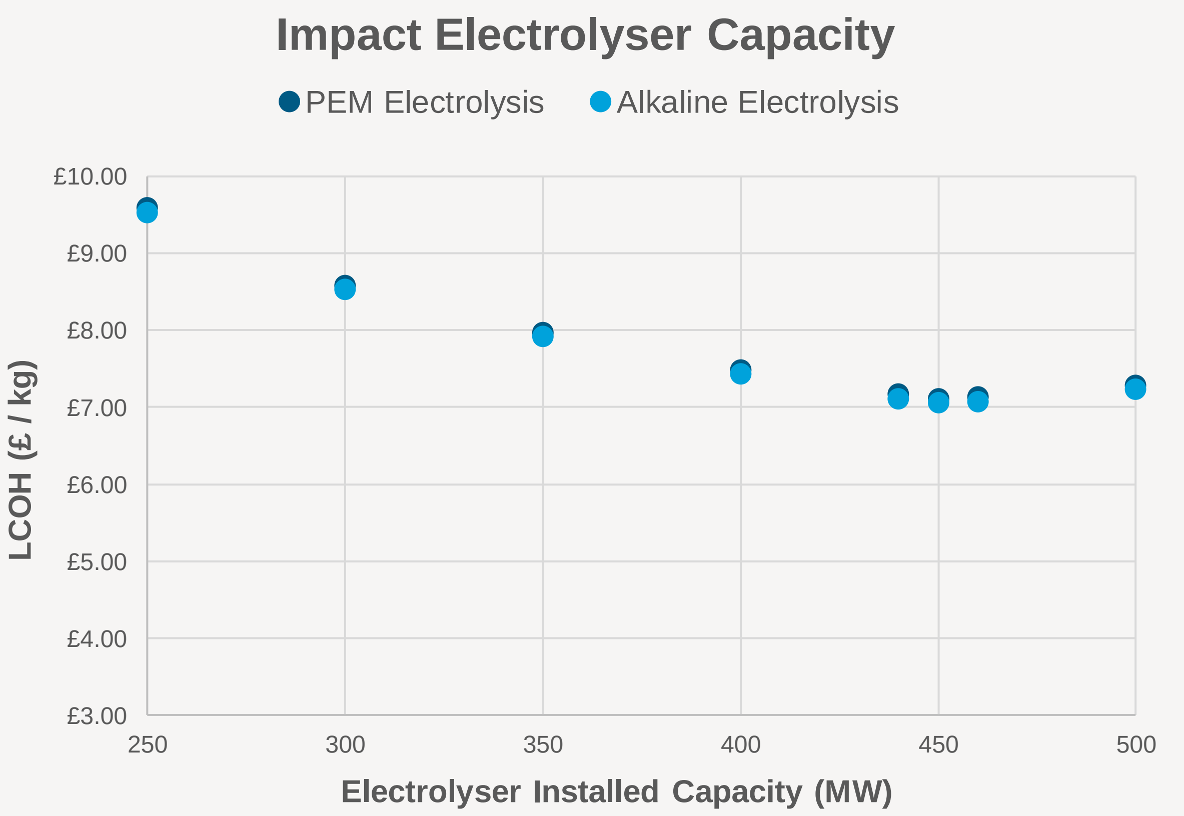
3. Renewable Wind Power + Grid Supply → Hydrogen

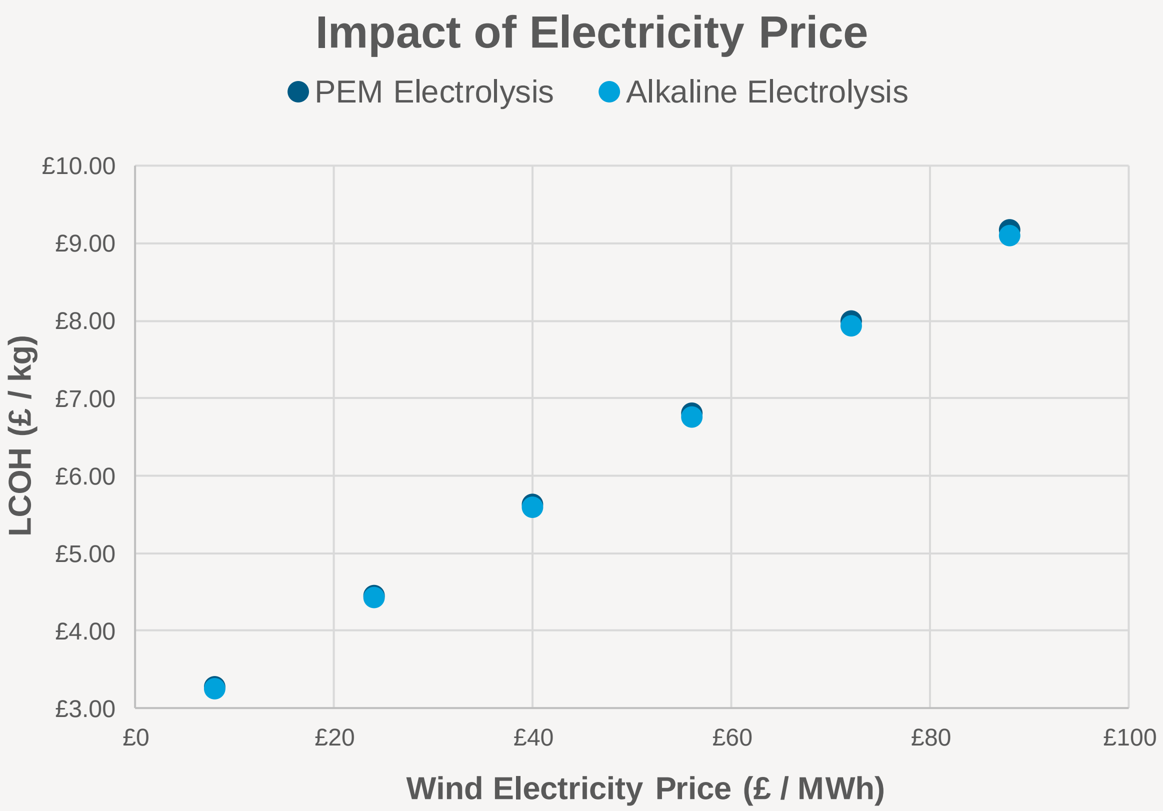
- Benefits of minimising intermittency and increasing plant utilisation
- Comparative impact of electricity cost and CapEx on LCOH

1. Renewable Wind Power → H_2

Optimised Scenario

- **Installed Capacity = 450 MW (Alkaline)**
- **Electrolyser Utilisation = 49%**
- **34,300 tonnes H_2 production (Year 1)**



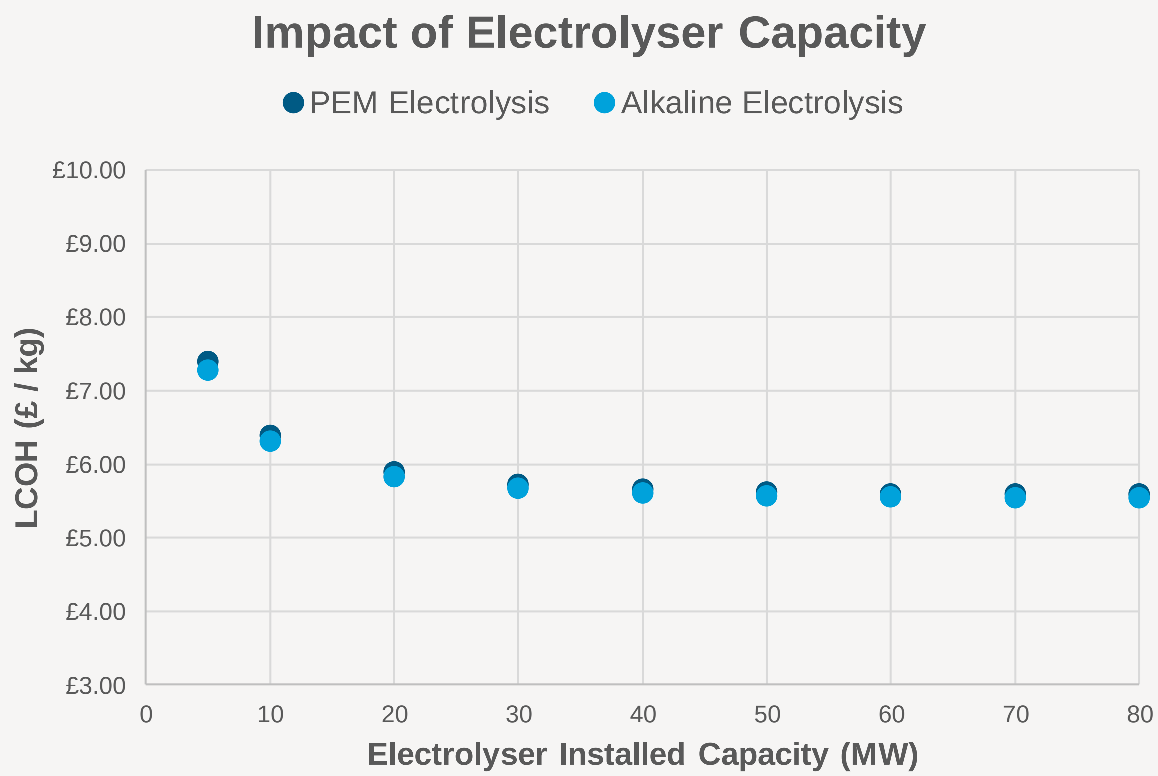


Atkins' in-house tool used to produce results from techno-economic analysis

2. Curtailed Wind Power → H_2

Optimised Scenario
- **Installed Capacity = 70 MW (Alkaline)**
- **Electrolyser Utilisation = 37%**
- **4,100 tonnes H_2 production (Year 1)**

- Based on wasted electricity from curtailment alone, there is potential for ~ 97,200 tonnes of H_2 to be produced each year in Scotland.
- The Scottish government 'Hydrogen Action Plan' states an ambition for 5 GW of renewable and low carbon hydrogen by 2030.
- ~ 13% of this target could be met using curtailed electricity alone.

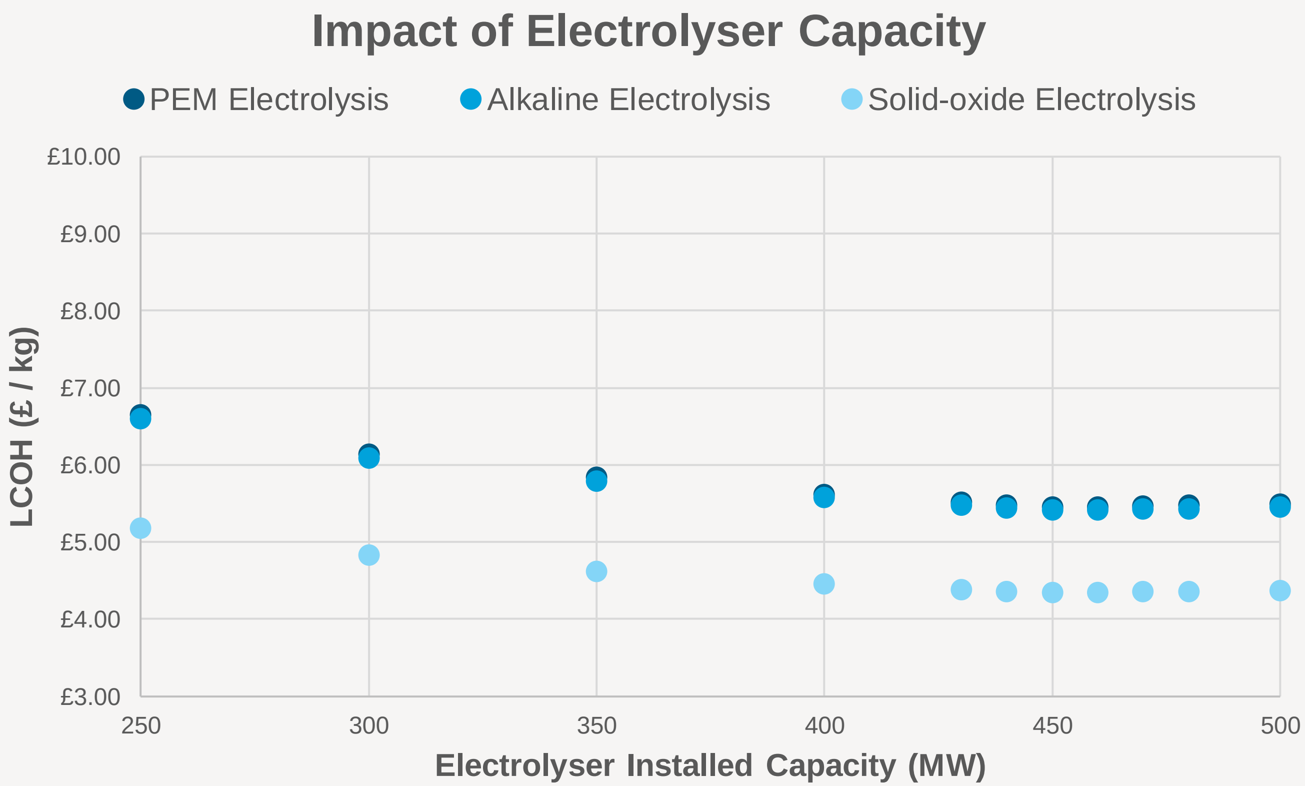


Atkins' in-house tool used to produce results from techno-economic analysis
https://www.scottishrenewables.com/our-industry/statistics
Realising Hydrogen's potential - gov.scot (www.gov.scot)

3. Renewable Wind Power + Grid → H_2

Optimised Scenario

- **Installed Capacity = 450 MW (SOE)**
- **Electrolyser Utilisation = 97%**
- **95,600 tonnes H_2 production (Year 1)**



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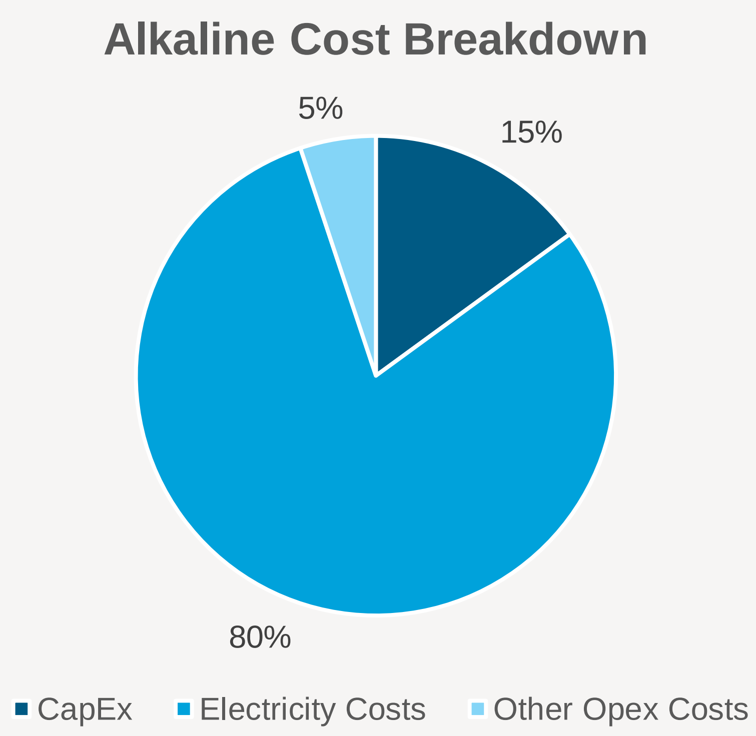

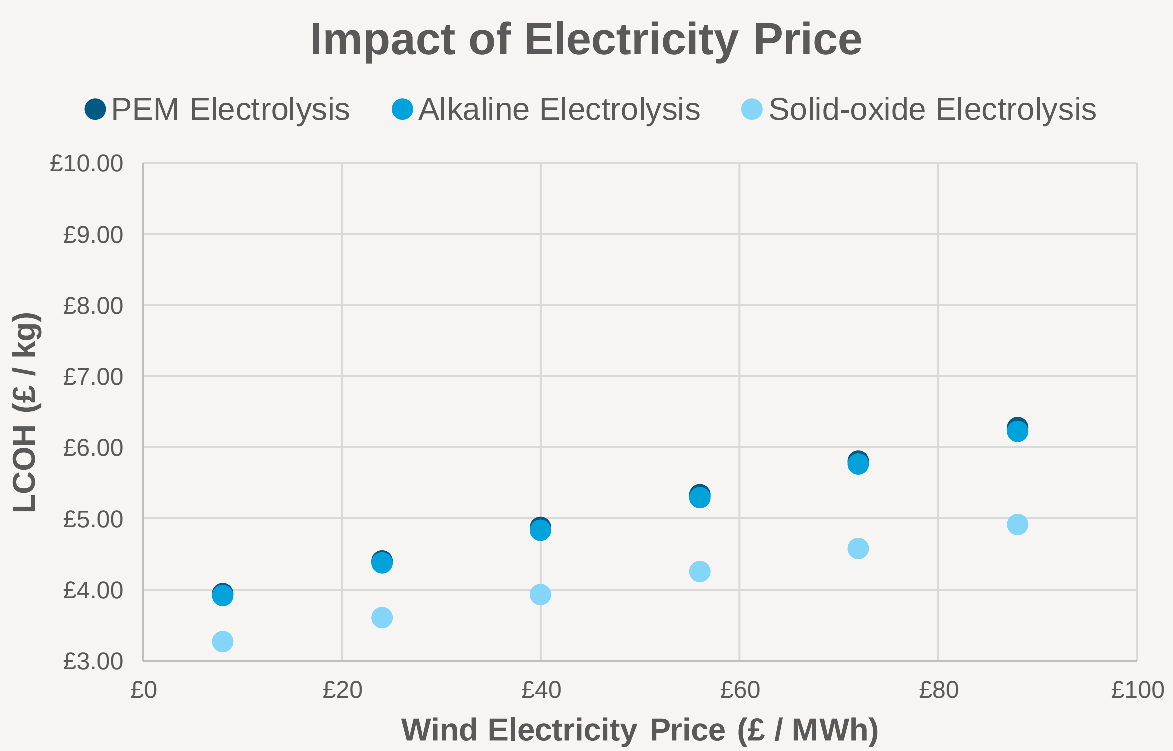

Due to greater efficiency for SOE electricity costs drop to ~70% of total discounted costs

Atkins' in-house tool used to produce results from techno-economic analysis

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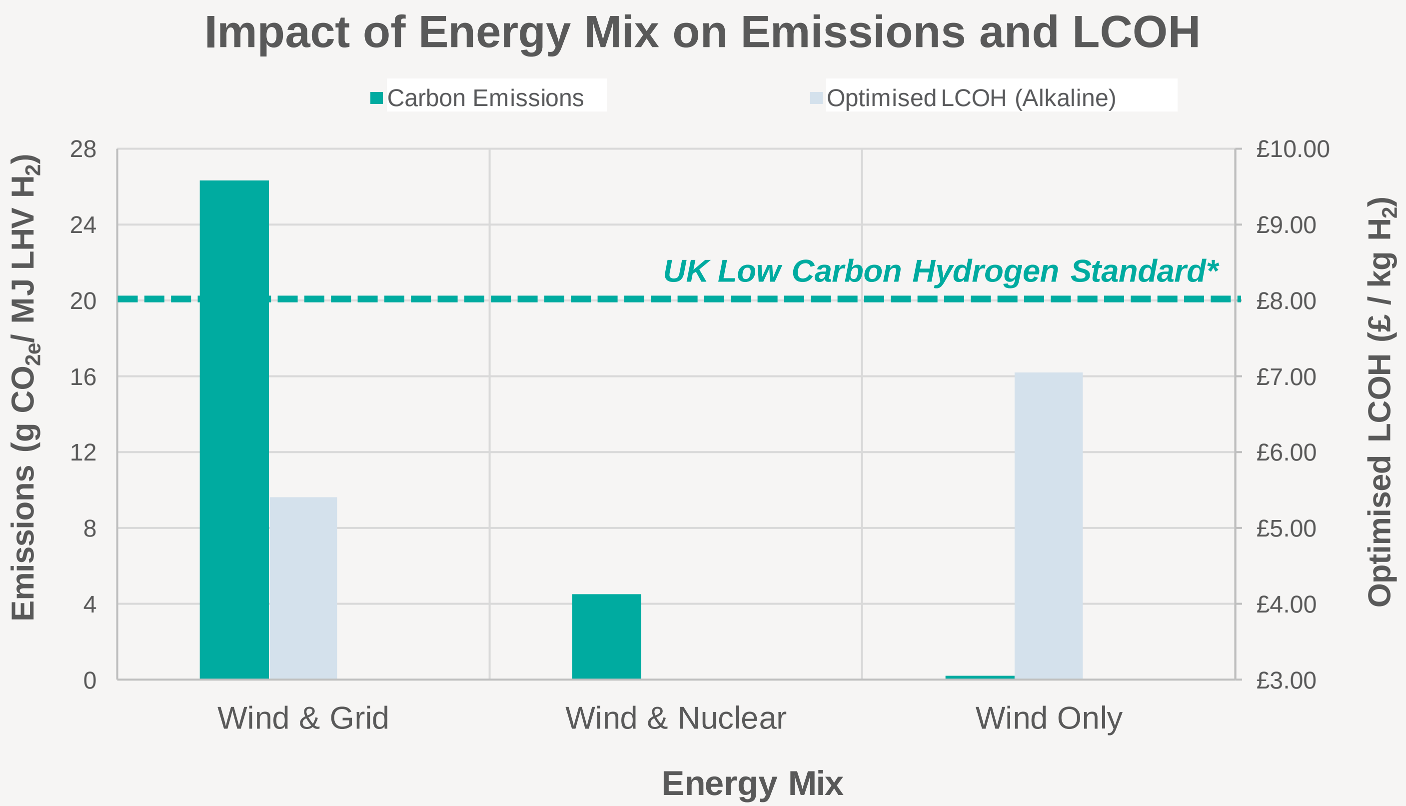
Carbon Impact

› This graph shows the importance of having a low carbon baseload electricity supply to the electrolyser plant to maximise plant utilisation and minimise carbon emissions.



- UK Low Carbon Hydrogen Standard version 2, April 2023: guidance (publishing.service.gov.uk)

** Wind electricity price: $75/MWh
Grid electricity price: $88/MWh

Summary

- Hydrogen can play a key role in reducing wind farm curtailment.

- Key electrolyser plant considerations:

  - *Electrolyser selection should be assessed on a case by case basis.*
  - *Electrolyser utilisation of ~50 – 60% typically gives the most optimal solution for renewable fed plants.*
  - *Electricity price is a greater driver for economic viability than CapEx.*

- Atkins in-house modelling tool can be applied to analyse different concepts including various renewable sources and derivative products.

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SOLAR
NUCLEAR
WIND

CLEAN HYDROGEN PRODUCTION
ELECTROLYSIS
REFORMING WITH CARBON CAPTURE
PYROLYSIS

DISTRIBUTION
PIPELINE
SHIPPING
PORTS
ROAD

STORAGE
UNDERGROUND/CAVERN
LIQUIFICATION
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