Hydrogen production.

ALI, D.

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ROBERT GORDON UNIVERSITY ABERDEEN

Our Hydrogen Future - A Round Table Discussion on Future Strategy

Hydrogen Production

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Introduction

- Hydrogen has an energy density of approximately 120 MJ/kg, almost three times more than diesel or gasoline, while Natural gas has 53.6 MJ/kg. In electrical terms, the energy density of hydrogen is 33.6 kWh/kg versus 12–14 kWh/kg for diesel.
- Hydrogen is a source of clean energy that can replace natural gas with no carbon emissions when burnt, and can generate clean electricity through a Fuel cell with water & heat as by-products and no carbon emissions.
- Hydrogen can be used as an energy carrier, stored and delivered where needed.
- Green H2, as a form of renewable energy storage, allows clean fuel for transport or for making clean power and heat while absorbing intermittent power inputs; thus:
  - enables more renewables integration into the grid while eradicating energy wasting, constraint payments and costs of updating the electricity network capacity.
  - allows an added stabilizing capability that support grid, reduce its need for spinning reserve, avoid load shedding, provide peak demand support, and reduce transmission & distribution burden

Hydrogen Production and Color Code Nomenclature

Black/Grey Hydrogen

- Black H2 produced from coal; and Grey H2: produced via steam reforming of natural gas or methane
- 100% carbon emissions

Blue Hydrogen

- Blue H2 produced from steam reforming of methane or natural gas while utilizing CCS to negate emissions with 85-95% efficiency

Green Hydrogen

- Green H2 produced using renewable energy for electrolysis
- Zero-carbon emissions, ideally suitable for green energy transition

Pink Hydrogen

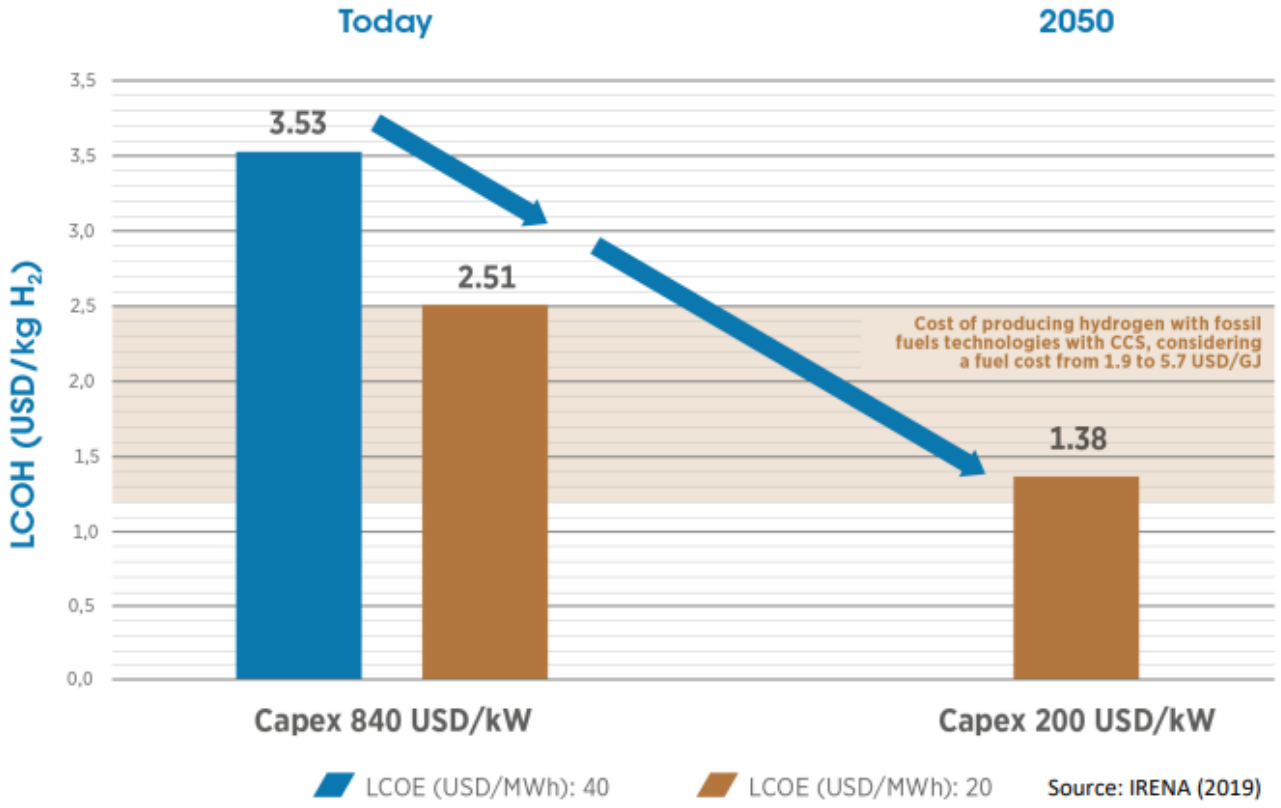
- Pink H2 produced from nuclear energy
- Zero-carbon emissions. Not commercialized yet

Hydrogen Production Costs

Hydrogen production costs

IRENA insights WEBINAR SERIES

Hydrogen from renewables has a great potential but electrolyser costs need to further decrease



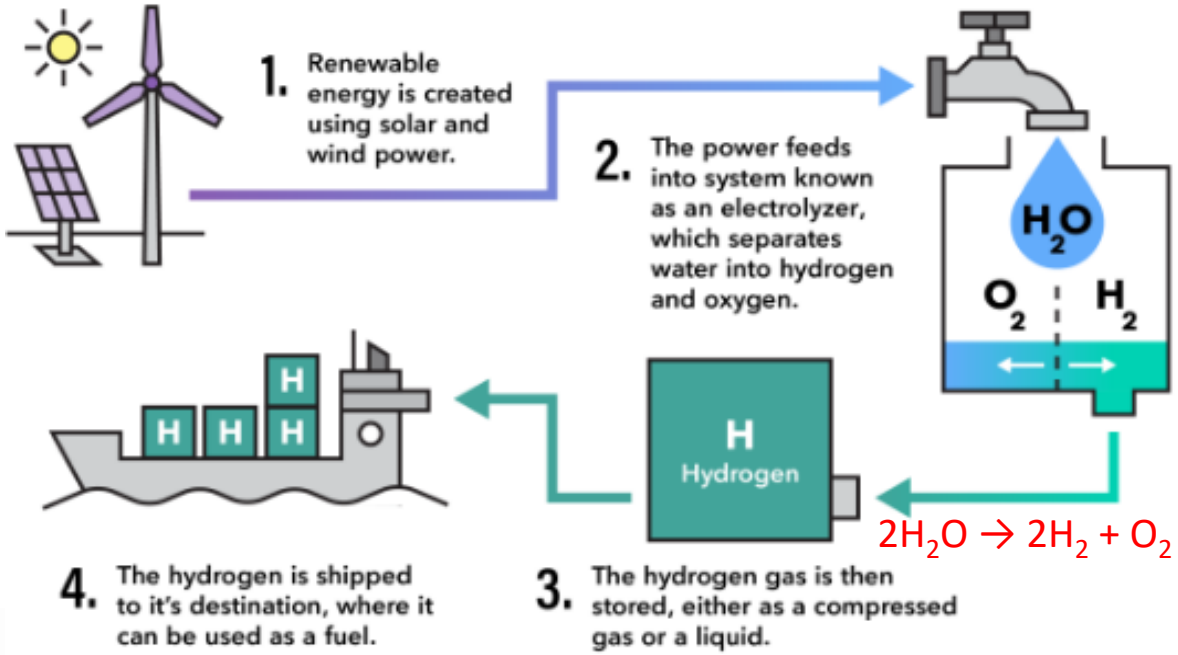
Main assumptions about electrolysers: Load factor: 4200 hours (48%), conversion efficiency 65% (today), 75% (2050)

IRENA

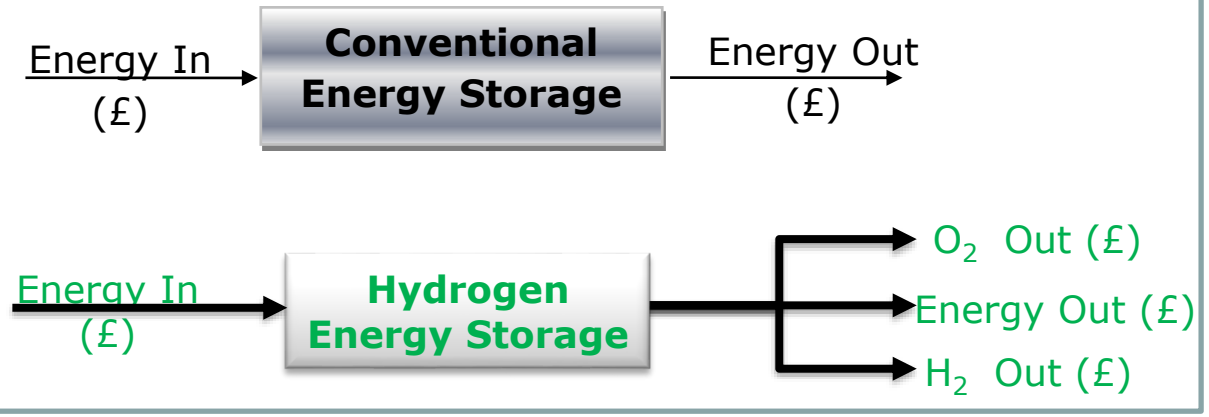
Green Hydrogen Production & Storage

GREEN HYDROGEN

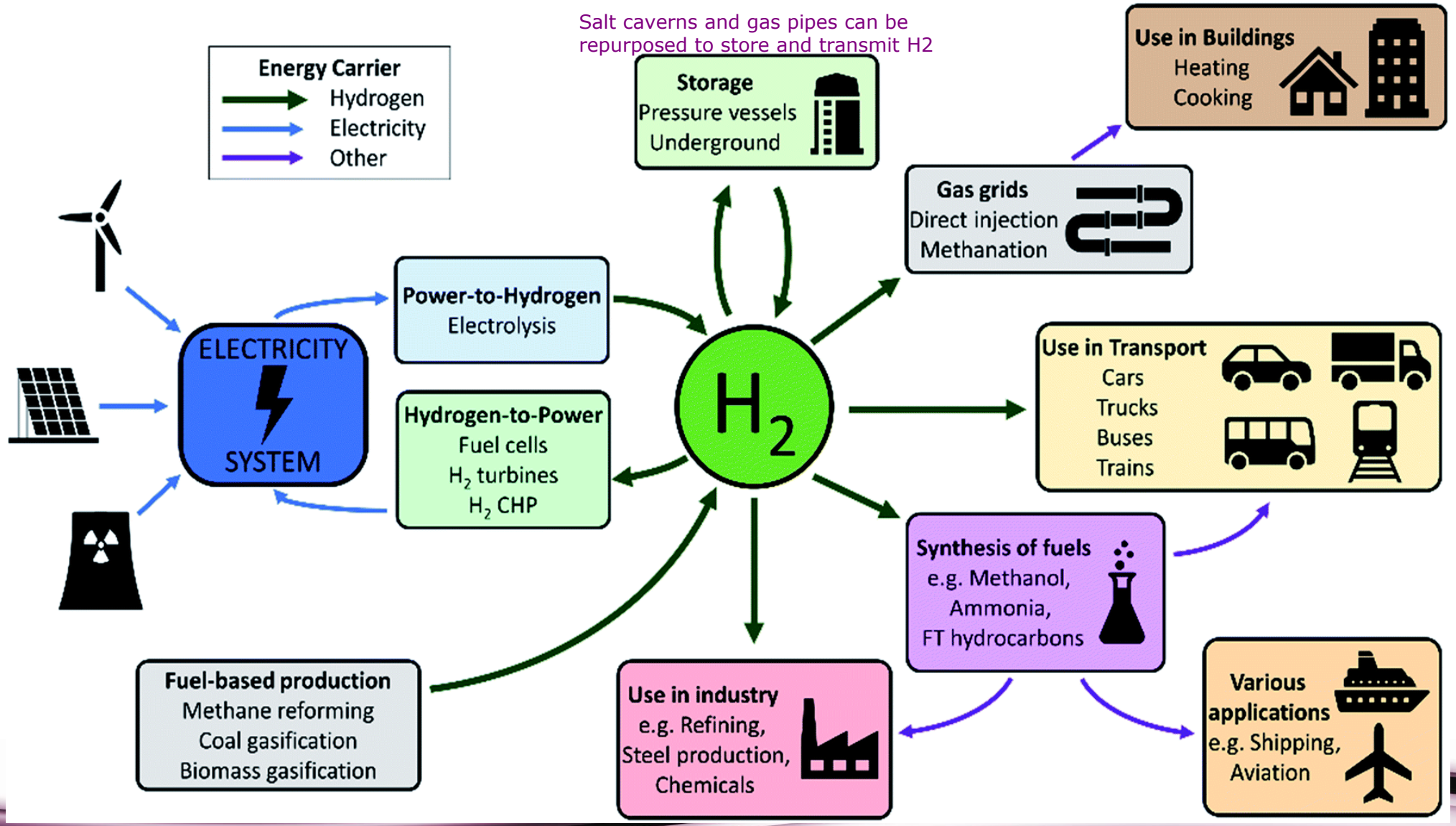
Green H2 is produced using renewable energy in water electrolysis to split water molecules into H_2 and O_2 with Zero carbon-dioxide emissions. H2 is stored and transported to the point of use. O2 can also be utilized to improve the energy efficiency



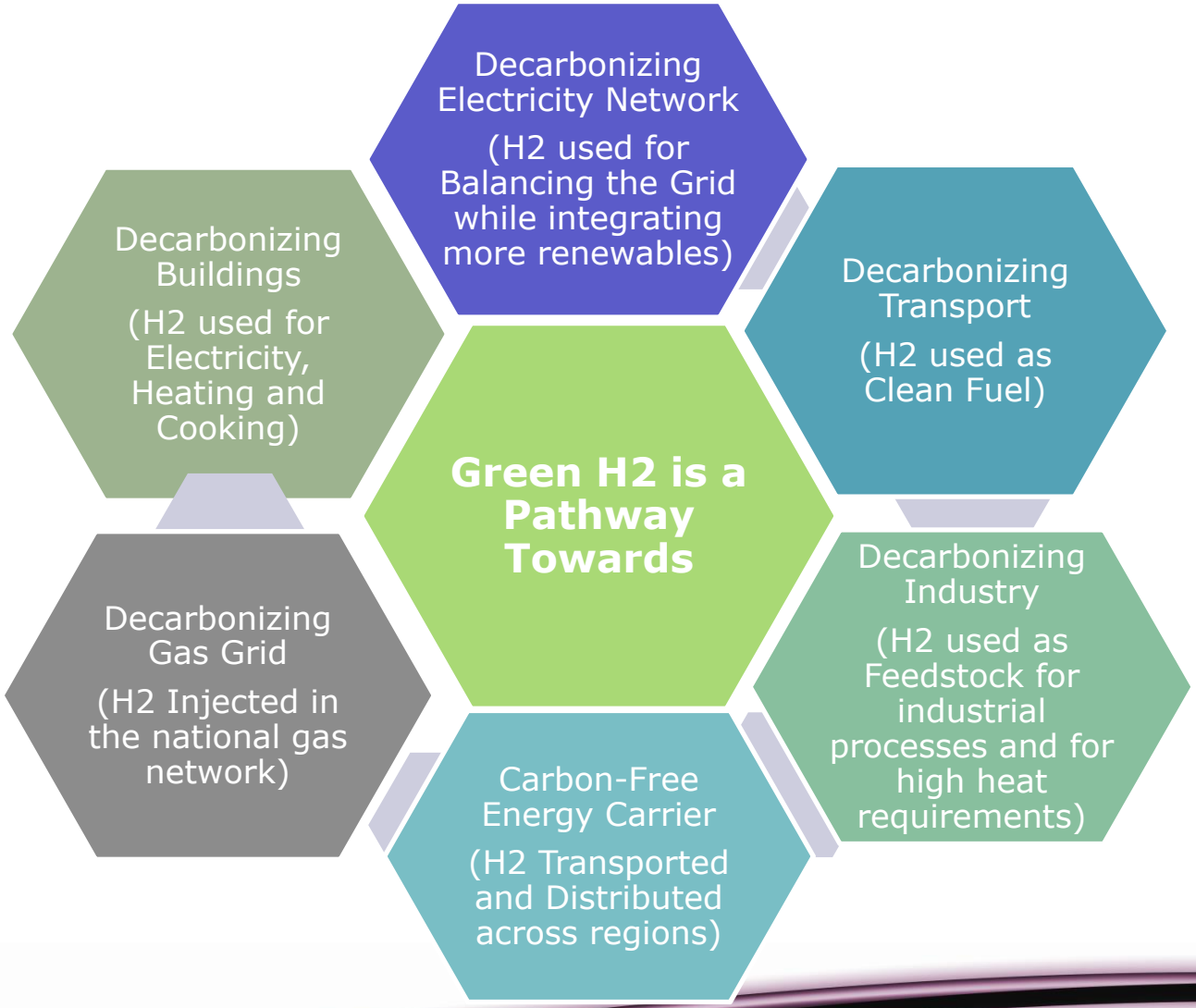
Possible Economic Revenue Streams for Hydrogen Energy Storage Compared to Conventional Energy Storage



Hydrogen as an Energy Carrier



Green Hydrogen – The Path to Net-Zero Ambition



Example: H2 Pathway to Decarbonize Transport

Transport accounted for (34%) of UK CO2 emissions in 2019, implementing H2 fuel in transport can reduce or eliminate this emissions.

Aberdeen City Council Hydrogen Fleet

H2 trains allow hybrid configurations of batteries and fuel cells thus increasing performance and range

Hydrogen tank and Ballard fuel cell system on CRRC-Sifang light rail
https://blog.ballard.com/fuel-cell-trains

Fuelling a H2 train is faster than charging a battery-based train

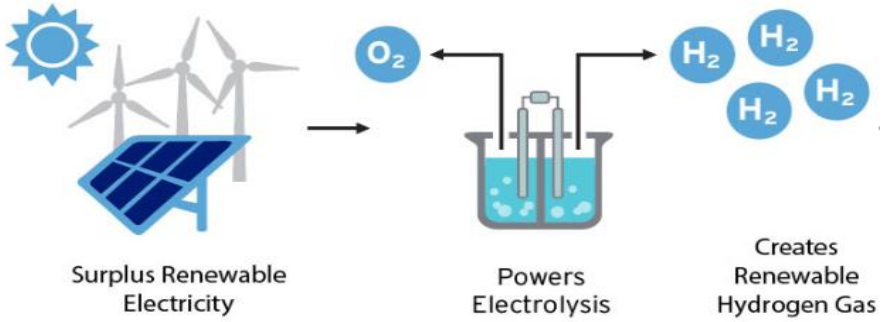
H2 trains have high-performance and are as versatile as diesel-powered trains with a similar range

Small-Scale Demonstration Project: Solar-Hydrogen Farmhouse Decarbonisation

Project Overview

This project aimed decarbonising a grid-connected farmhouse while avoiding its grid power import/export. A Zero-carbon Solar-hydrogen system was proposed to achieve this aim.

- A 24kW/h Solar PV capacity is installed to supply the farmhouse power needs during summer, and the excess in its summer generation is stored in the form of Green H2 to be utilized during winter to reduce/eliminate grid power import/export.
- The needed green H2 generator (electrolyser) was sized based on the farmhouse power demands and on the excess in solar generation during summer for the given PV location and prevalence of diffuse light. H2 storage tanks were sized based on the generated H2 from electrolyser, the storage pressure, and on for how long the storage is required (e.g. daily, weekly, monthly, etc.)
- The proposed system was simulated to show the hydrogen production over the different months based on the PV supply to electrolyser



Large-Scale Demonstration Project: Hydrogen-Based Buildings Decarbonisation

Project Aim

This project aims developing an energy optimization model for realizing a Zero-Carbon Hydrogen-Based Grid-Connected Building-Scenario to be implemented on RGU campus as a case-study

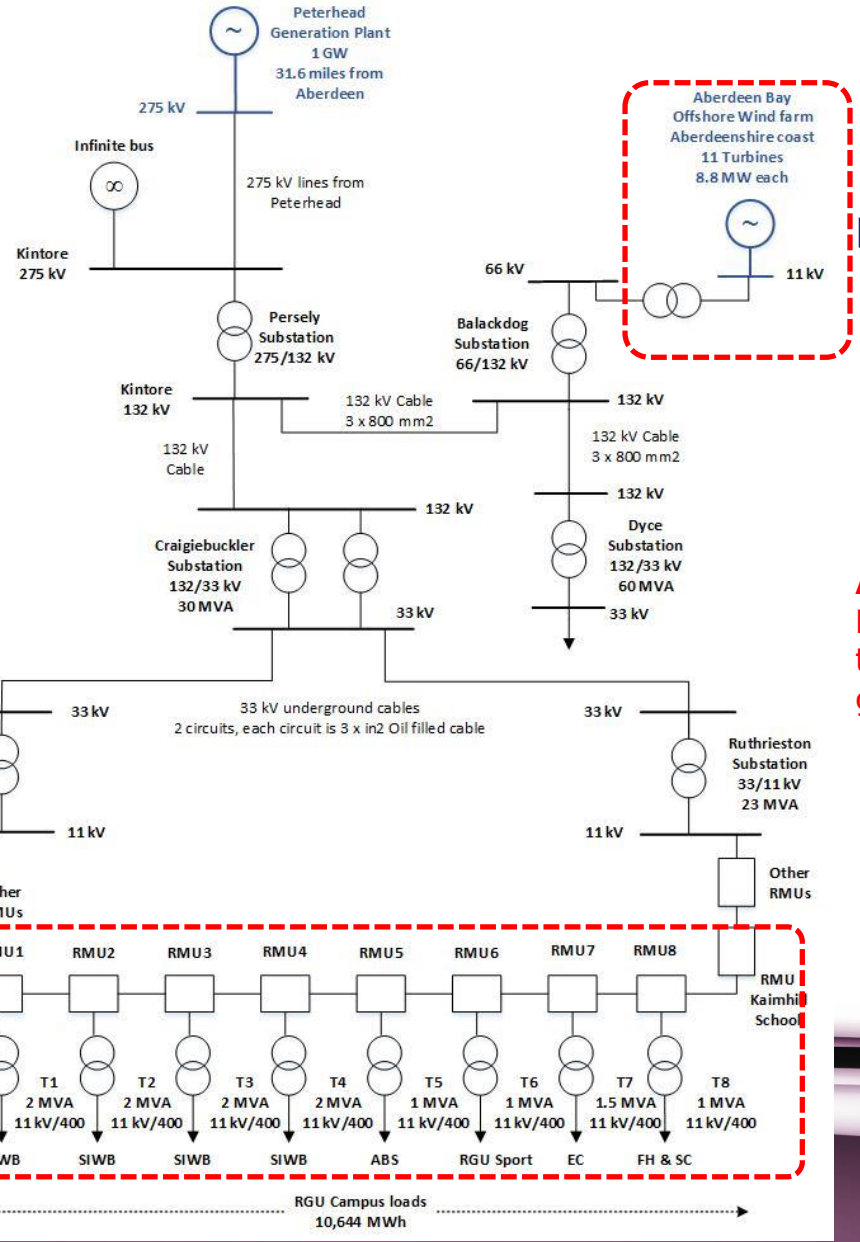
Project Objectives

- Sizing the capacity of the H2 electrolyser and storage needed to complement the currently installed Solar facility at RGU
- Developing an energy optimization model for achieving an optimal scheduling scenario for the H2 generation, storage and utilization with the installed solar facility and the grid
- Developing a simulation-model for the proposed scenario
- Identifying the economic and environmental benefits of the proposed scenario
- Sizing the capacity of the extra renewable facilities required to achieve the building Net-Zero by 2050

Implementing Hydrogen-Based Grid-Connected Buildings as Embedded Storage for Supporting Wind Farms Integration

Project Overview

This project aims investigating the implementation of hydrogen-storage within Aberdeen complexes (universities, industries, exhibition-center, airport…etc.) as grid-embedded storage to support the city increased offshore wind integration.



Aberdeen Bay Wind Farm is selected as the case study Wind generation plant

Replicating this scenario throughout the UK will allow decarbonizing buildings while supporting the large-scale integration of renewables

RGU campus is selected as the case-study complex

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Conclusion

- Hydrogen will play a pivotal role in achieving Clean Energy Transition and the Net-Zero Future.
- To allow a Hydrogen-based Economy, the following is needed:
  - Long Term Strategy
  - Favourable Government Policies
  - Reduced Market Uncertainty
  - Development of Skilled Workforce and Service Infrastructure
  - Further Research, Analysis and Modelling that allows the effective deployment of hydrogen in the different sectors.

Thank You