

# Whole System Views on Integration of Hydrogen

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# Agenda

- ✦ Role of Hydrogen
- ✦ Electricity network and Hydrogen
- ✦ Gas network and Hydrogen
- ✦ Water requirements
- ✦ Role of PNDC

# Role of Hydrogen



As energy source –  
electricity and  
heating



Grid balancing  
services



Powering automotive



Powering portable  
electronic devices



Renewable energy  
storage

# Role of Hydrogen

- Hydrogen and carbon capture in Scotland, Scottish Affairs Committee, House of Commons, March 2023
- Hydrogen Champion Report, March 2023
- The role of hydrogen in achieving Net Zero, Science and Technology Committee, House of Commons, Dec 2022
- Hydrogen action plan, 2022

## Hydrogen is not a panacea for reaching Net Zero, warn MPs

19 December 2022



Hydrogen is not a panacea for reaching the Net Zero emissions reductions by 2050 but can grow to become “a big niche” fuel in particular sectors and applications, the Commons Science and Technology Committee concludes in a new Report.



Should electricity  
network operators  
be concerned?

# Colours of Hydrogen

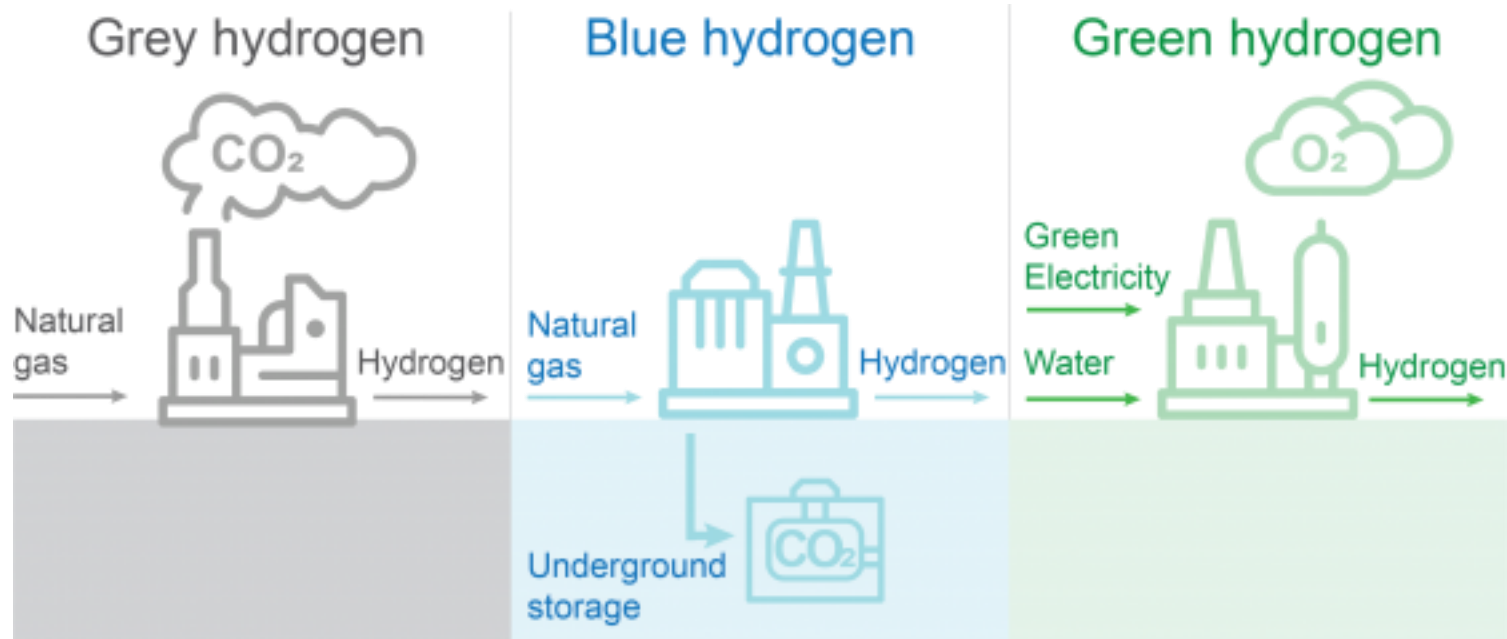


Image courtesy: [About Hydrogen | Hydrogen Energy Research Centre \(unsw.edu.au\)](https://www.unsw.edu.au/hydrogen-energy-research-centre)

# Green Hydrogen

- In 2022, 35.3 TWh of renewable electricity was generated<sup>1</sup>
- Equivalent to powering all households in Scotland for around 3.5 years
- Scottish government has 5 GW low carbon hydrogen production by 2030
- Assuming it is all Green Hydrogen
  - 1 MW electrolyser would approx. consume 1 TWh per year
  - 5 GW → 5000 TWh

<sup>1</sup><https://www.gov.scot/publications/energy-statistics-for-scotland-q4-2022/>

# Impact on electricity network

- More renewable generation → increased connection requests → increased network constraints
- Depending on capacity of electrolyser → transmission or distribution connected
- Co-located hydrogen production → power electronic devices → transients, faults, cold start, re-energizing
- Participation in markets → with battery to smooth the transients felt by the electrolyser; auxiliary equipment energy requirements → impact on transients

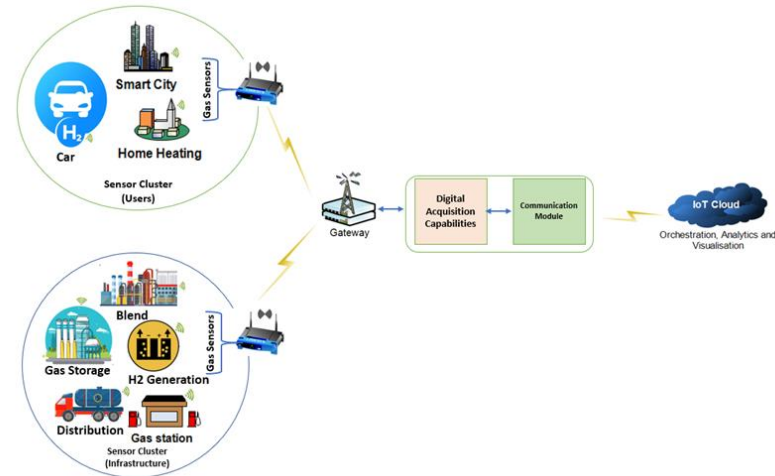




How about gas  
network operators?

# Gas in pipelines

- Existing pipelines are not sufficient
- Embrittlement
- Losses and thermal instability due to fluctuations in temperature
- Lack of fine control of the flow of hydrogen → valves; pressure controllers; sensors
- Ramp rates of demand can vary significantly from the existing slow rates



<https://smartgrid.ieee.org/bulletins/january-2023/intelligent-sensor-network-for-future-fuel-mix-detection-and-measurement/>

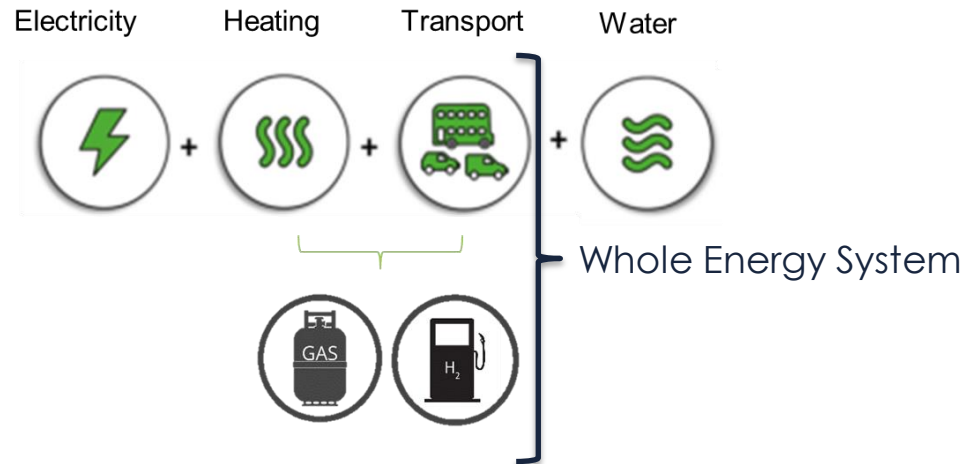


Water?

# Water per kg of Hydrogen

- Steam methane reformation without carbon capture → 15-40 Litres
- Steam methane reformation with carbon capture → 18-44 Litres
- Electrolyser → 10-22 Litres
  
- 5 GW → 5-12 Million m<sup>3</sup> of water per year
- Scotland households altogether consume 1 Million m<sup>3</sup> of water per year

# Whole System View

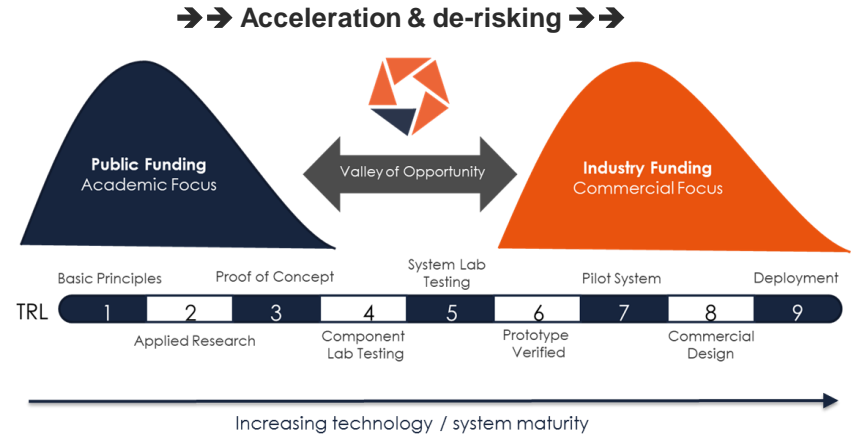




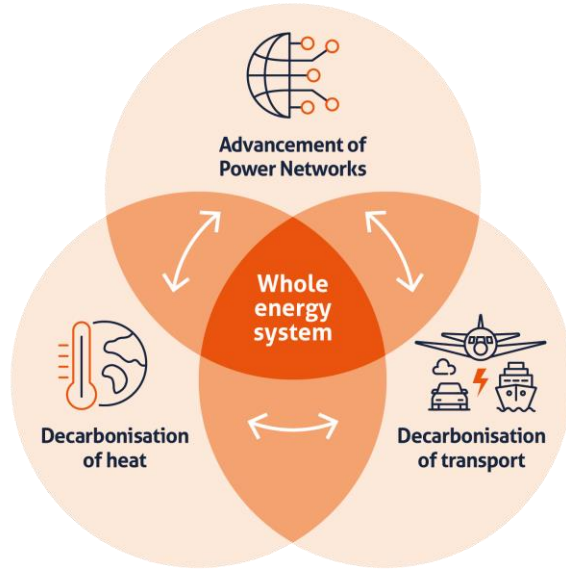
# Role of PNDC

# PNDC Overview

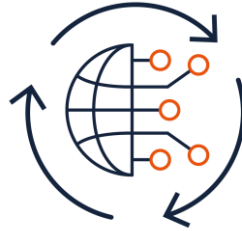
- Industry-facing innovation centre opened in 2013 and currently celebrating a decade of innovation
- Focussed on accelerating the development and deployment of novel energy, marine and aerospace technologies supporting net zero initiatives
- Multiple engagement models:
  - Collaborative programmes in partnership with members
  - Open access for supporting all industry
- Dedicated expert team (~ 50 staff)
- New cutting-edge whole systems facility due in 2024



# PNDC – A Whole Systems Approach



## Advancement of Power Networks



- ▶ Asset Management
- ▶ Digitisation
- ▶ Informatics
- ▶ Comms & Cyber Security
- ▶ Power Hardware in the Loop (PHiL)
- ▶ LV and 11kV network validation

## Decarbonisation of Heat



- ▶ Heat sources, e.g. heat pumps
- ▶ Heat storage
- ▶ Heat networks
- ▶ Cooling systems
- ▶ Hydrogen for heat

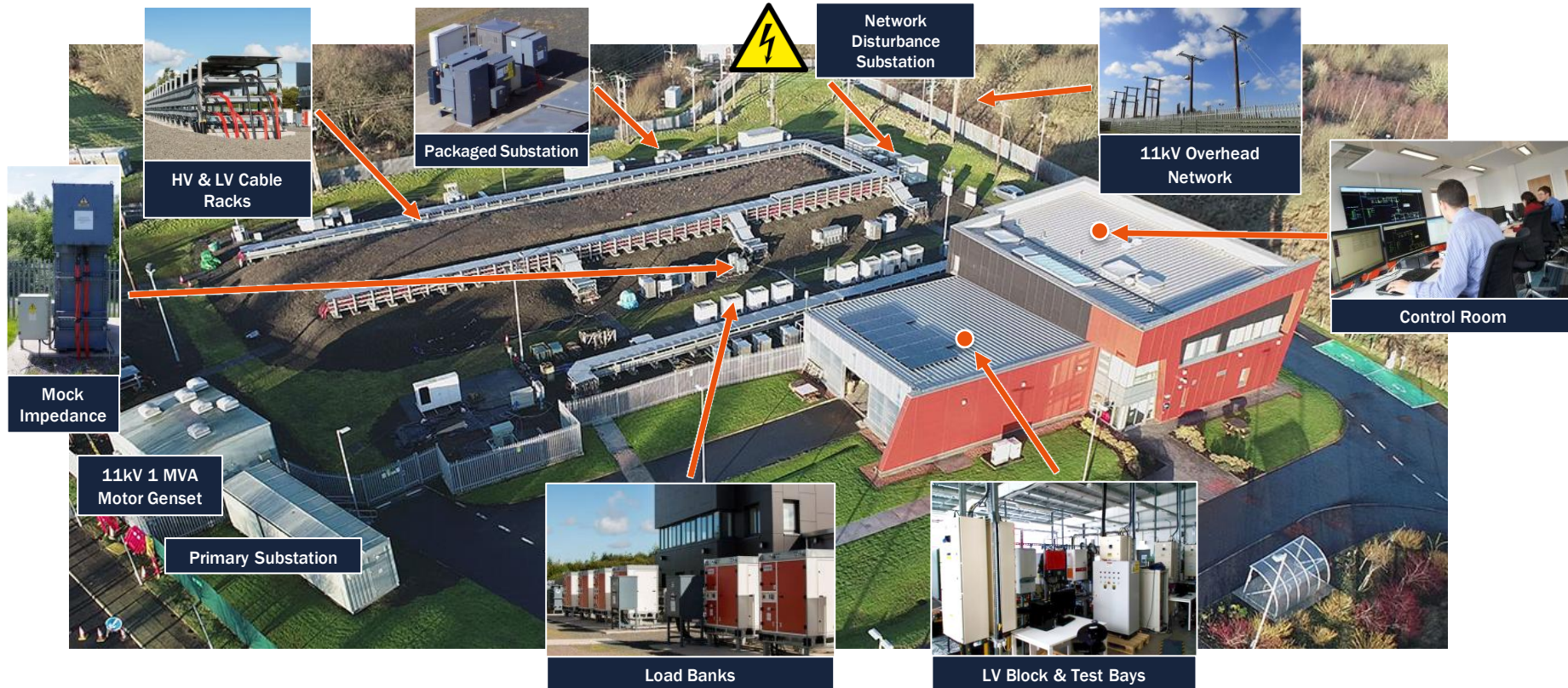
## Decarbonisation of Transport



- ▶ HGV, marine, aero and rail systems
- ▶ Power electronics convertors
- ▶ LVA and LVDC systems
- ▶ Drive trains
- ▶ Electrification infrastructure



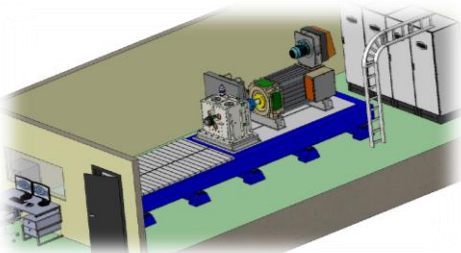
# Existing Facilities (Wardpark)



# Whole Systems Facility – New Technical Capabilities

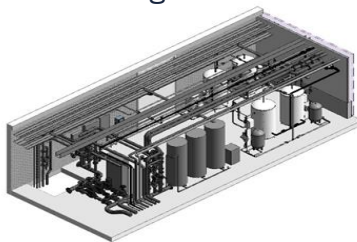
## Electrical equipment (in procurement)

- ✚ 11kV distribution network
- ✚ 2.5MVA s/stn & LV network
- ✚ 1MVA DC power supply
- ✚ 1MVA AC power supply
- ✚ Real-time digital simulation
- ✚ 2 x 1MW dynamometers



## Thermal facility (awaiting funding decision)

- ✚ For low carbon heating, cooling, thermal storage and heat recovery system testing and validation
- ✚ Scalable up to ~750kW, 5-90°C flow temp, system  $\Delta T$  5-40°C
- ✚ Heat and cooling emulators to mimic building heat demand



## Hydrogen facility (existing + to be upgraded)

- ✚ Existing facility - 80 kg H<sub>2</sub> storage, 12 bar supply pressure, 9kg/hr max flowrate
- ✚ Upgraded facility - 160 kg H<sub>2</sub> storage, 20 bar supply pressure, 30kg/hr max flowrate



← Whole system capability →

# Thank you

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