# REWIRE

## SIF 2022 Discovery – Show and Tell

FRAZER-NASH CONSULTANCY
A KBR COMPANY

Imperial College London

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# Agenda

- The problem/project summary
- Headline messages
- Overview of work packages, including:
  - Activities through Discovery
  - Benefits
  - How thinking has evolved
- Look ahead
- Q&A

# The problem

**Innovation Challenge 3: Improving energy system resilience and robustness**
**Scope 2: Strengthening the UK's energy system robustness to support efficient rollout of new infrastructure**

Problem:

- Growing generation from distributed energy resources and electrification of heating and transport means that maintaining network resilience will require reinforcement.
- Vast quantities of low-cost renewable energy are curtailed when demand is low, indicating a requirement for increasing energy storage.

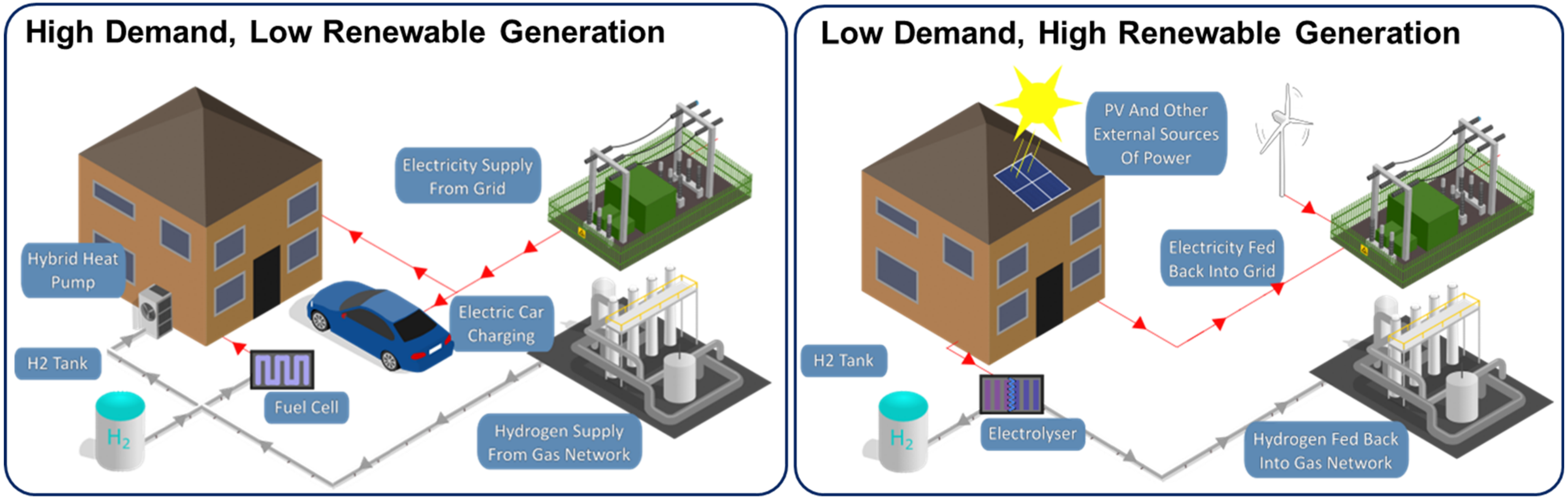
Solution:

REWIRE will improve energy system resilience through its development of innovative, domestic level, multi-energy systems.

# Project summary

The low wind, low solar at peak demand scenario on a decarbonised national grid would cause resilience issues. The low demand, high renewable generation scenario can cause resilience issues and costs for generation reduction. REWIRE is a domestic cross-vector storage system, exploiting power-to-gas and gas-to-power technology with integrated local hydrogen storage.

**Identify if it is technically and economically viable and beneficial to integrate vector conversion technology and energy storage at a domestic level to support national and local system resilience.**



# Headline messages

- The presence of a **hydrogen network makes the solution significantly more feasible**, due to limitations on domestic storage of hydrogen and electrolyser technology not being available at this scale.
- The **fuel cell**, utilised as a **CHP unit and coupled with thermal energy storage** (latent heat for intraday) and a top-up boiler, can be used to generate domestic power and heat, whilst additionally offering opportunity to export electricity during periods of high demand. This can result in **reduced consumer bills** that allow for a **payback period** comparable with a heat pump and Tesla Powerwall (fully electrified system).
- Excess solar PV energy can still be converted to hydrogen if large scale electrolysers are incorporated into the hydrogen network
- The solution has the potential to offer increased **electricity and hydrogen network resilience** via the fuel cell and storage, respectively.
- Imperial College analysis showed that the **gross system benefits** of 15 GW (10% domestic deployment) is **£2.95B/year,** i.e. £197/kW per year.
- Preliminary analysis shows that **rural areas present the greatest resilience risk**. In ENW's region, rural LSOAs where more than 75% of customers have a gas connection corresponds to ~10% of LSOA's, aligned with Imperials analysis. It should be noted that this doesn't suggest limiting deployment to rural properties.

# WP1 – Domestic archetypes

Milestone: publication of a short report detailing the domestic archetypes including a financial viability assessment which can be used as an input to WP4

**Achievements**

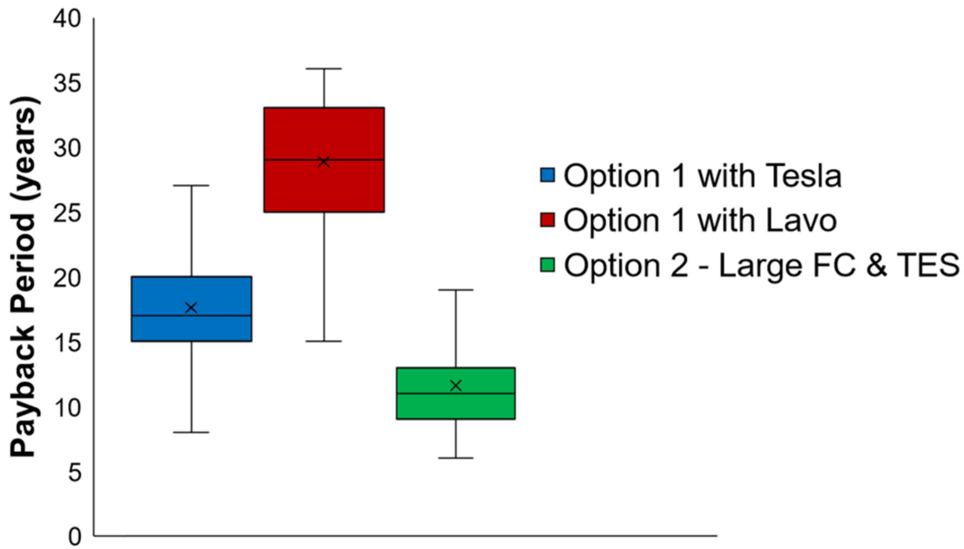
- Preliminary literature review into existing tech
- Technology viability assessment
- Financial viability – customer CBA and estimation of ROI period

**Key Findings**

- Hydrogen storage with vector conversion unlikely to compete directly with battery storage systems for fully electrified properties without connection to the hydrogen network
- LAVO-sized devices were not found to be competitive with batteries without a hydrogen network connection
- With a hydrogen network, oversizing the fuel cell and integrating with thermal energy storage to capture waste heat makes the ROI period more favourable

**Challenges**

- Component sizing – no commercial high TRL electrolysers or reversible fuel cells available at domestic scales
- Designing the system operation and control logic to work for the benefit of both the network and customer




*Customer CBA ROI estimates vs counterfactuals*

# WP2 – Network archetypes

Milestone: publication of report detailing the final network archetypes which can be used as an input to WP 4

**Achievements**

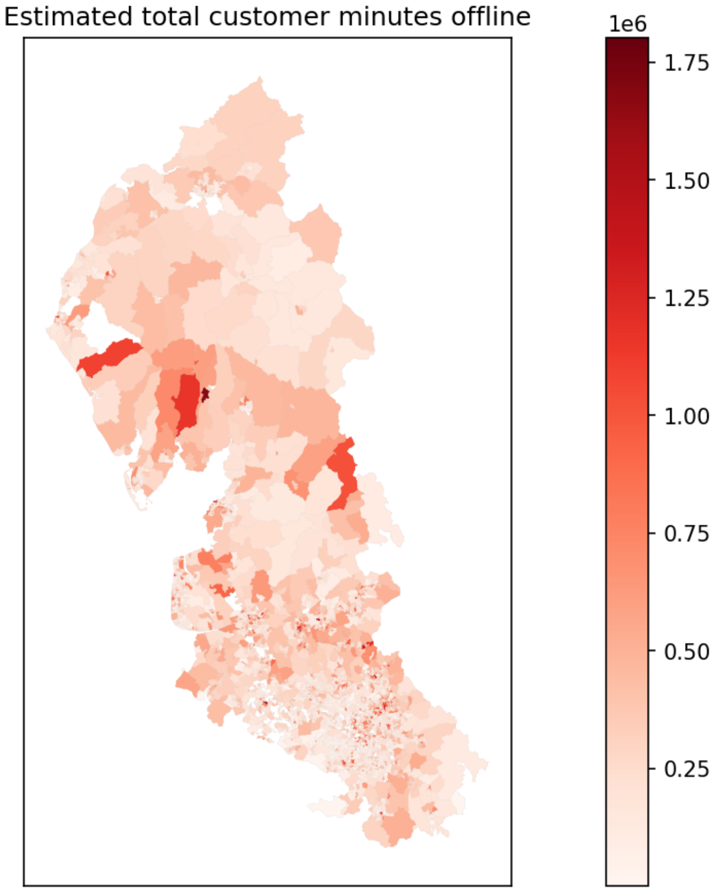
- Geographic distribution of outages within ENW region aggregated to LSOA regions
- Identification of high risk regions, based on LV outages, and analysis of their typical characteristics

**Key Findings**

- The rural/urban classifier is the most statistically significant characteristic that impacts outage risk
- When considering the most at-risk rural regions, filtering LSOAs by the number of on-gas customers has a significant impact on the number of suitable LSOAs

**Challenges**

- LSOA regional analysis doesn't consider distinct LV networks, so inclusion of network asset data could provide a more robust analysis
- High risk rural regions tend to have more off-gas properties than urban areas, whilst WP1 suggested a hydrogen network would be required for a REWIRE solution



# WP3 – Resilience enhancement benefits

Milestone: publication of a document detailing the whole-energy system benefits of REWIRE solution

**Achievements:**

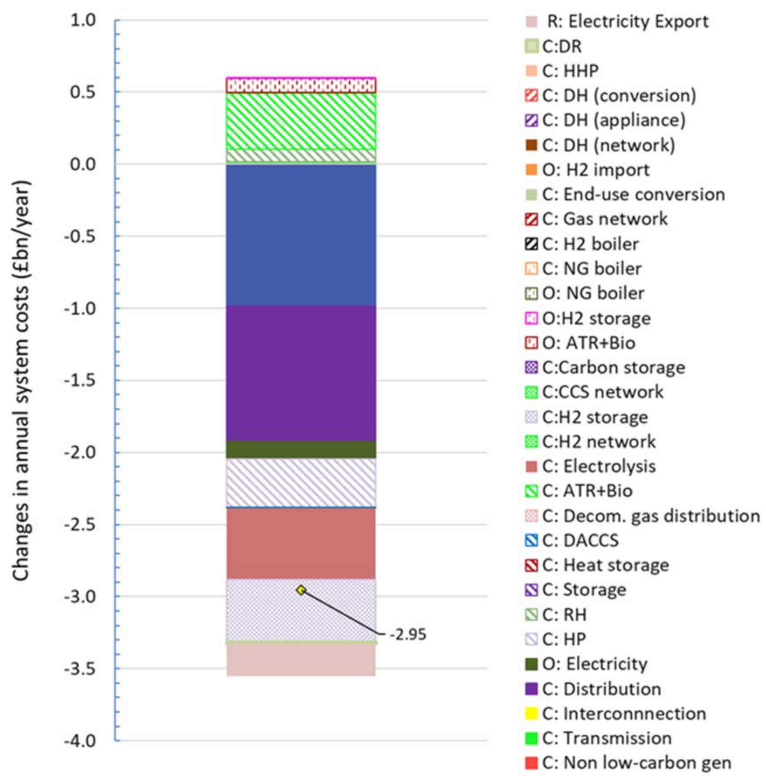
- Integration of REWIRE technologies to Integrated Whole Energy System model
- Studies evaluating the REWIRE's gross system benefits
- Documentation and presentation of the results (deliverable completed and reviewed)

**Key findings:**

- REWIRE offers an innovative solution to deliver cost-effective and resilient energy system with net-zero emissions.
- Gross system benefits of 15 GW REWIRE is £2.95B/year, or £197/kW per year
- Main savings: CAPEX reduction of low-carbon generation, distribution, large-scale electrolysers, hydrogen storage, and heating appliances.
- REWIRE improves system flexibility and supports more RES integration

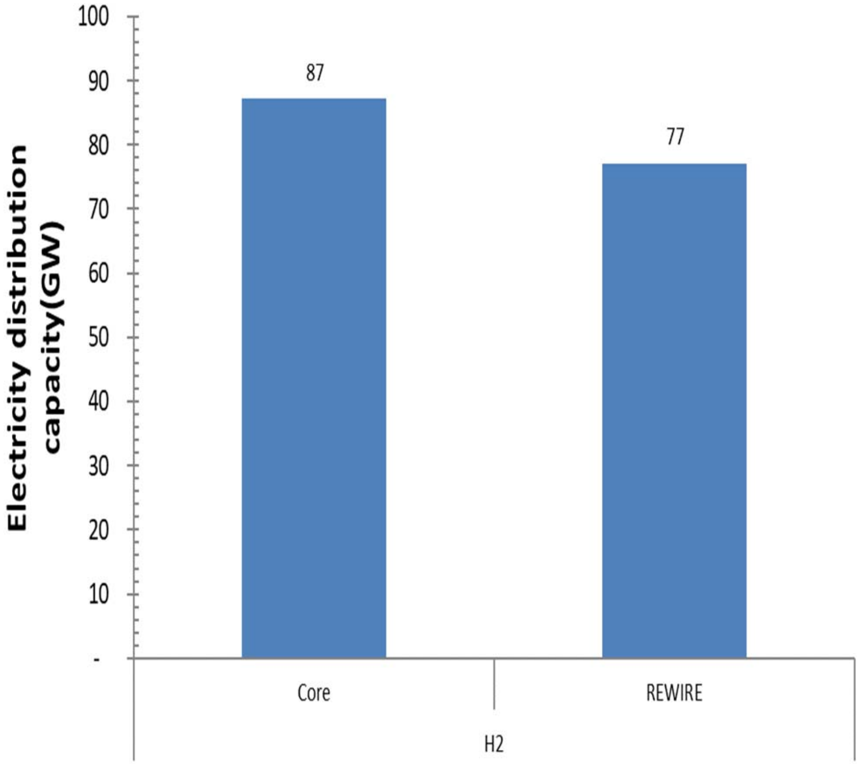
**Challenges:**

- Improving the efficiency of domestic electrolysers is important to reduce increase annual electricity demand because of REWIRE technology.
- Strong coordination between electricity and hydrogen system planning and operation need to be established

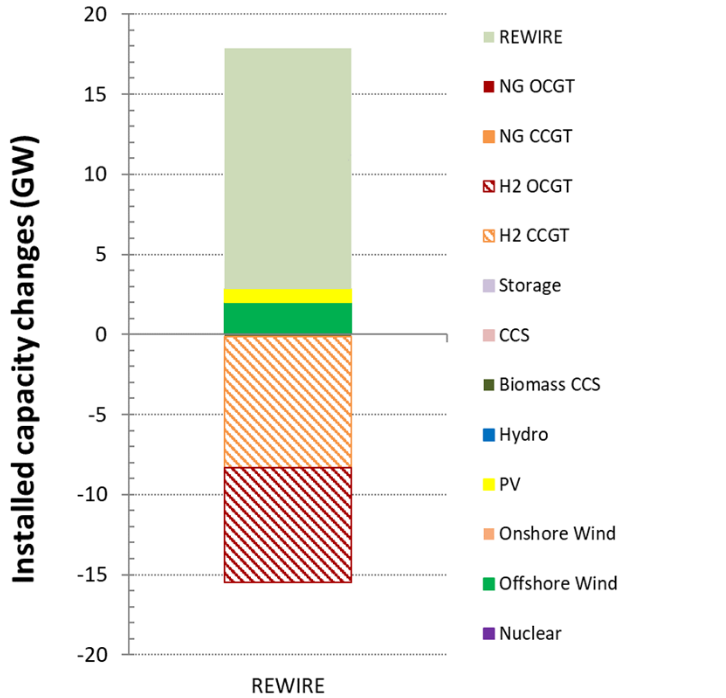



Cost changes attributed to REWIRE

# Whole-System Benefits of 15 GW REWIRE solution

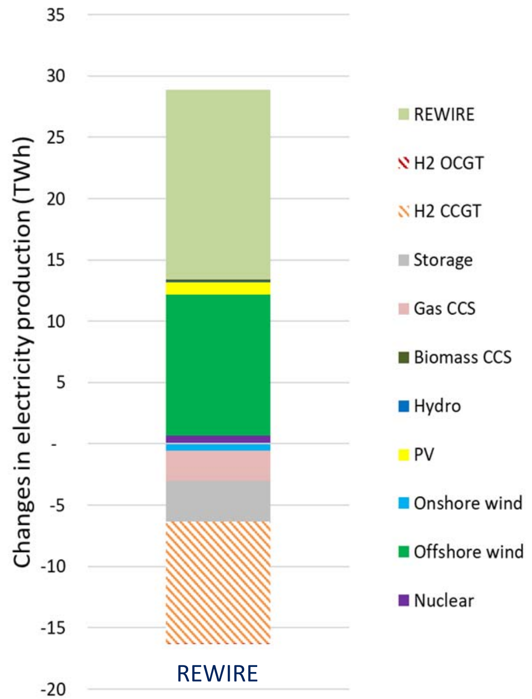



10 GW reduction in distribution capacity requirements




Displacing 15 GW large-scale hydrogen CCGT/OCGT

Provide firm generation capacity to support energy security and resilience against extreme weather




Supports more RES to displace natural gas / hydrogen

# WP4 – Implementation assessment and roadmap

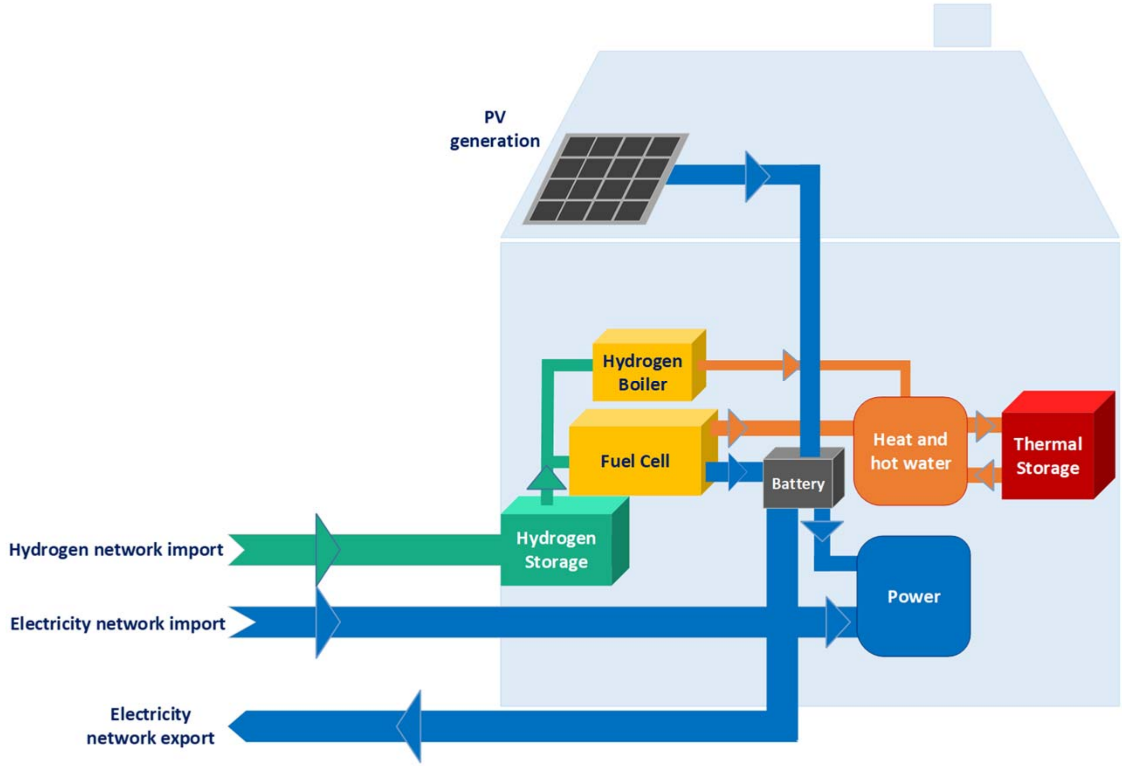
Milestone: publication of a short report detailing the feasibility of the solution and the implementation roadmap including recommendations for Alpha phase

**Achievements:**

- STEEPLE analysis of enabler and barrier factors
- Roadmap of technological developments and influential commercial factors to achieve widespread adoption
- High-level project risk analysis that could impact future deployment

**Key findings:**

- Most influential factors and risks were found to be:
  - Component costs and consumer affordability
  - Uncertainty in the future variable tariff
  - Unstable energy costs in future
  - Tech component and device efficiency




*Proposed Alpha phase system configuration*

# Next steps

- Considerations for Alpha
  - Formalised drafting of stakeholder and system requirements
  - Design of prototype system for Beta phase
  - Detailed policy, market and consumer analysis
  - Advanced domestic and network CBA, carbon benefit assessment, supply chain assessment
- Partner requirements and progress – additional energy network licensee
  - Alpha requirements:
    - Consumer Representative Group – Sustainability First
    - Additional energy network licensee – Northern Gas Networks
  - Proposed partners moving onto Alpha include
    - Frazer-Nash Consultancy
    - Cornwall Insight
    - Imperial College London
    - Northern Gas Networks
    - Sustainability First

# QUESTIONS & ANSWERS

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Please contact us if you have any questions or would like to arrange a one-to-one briefing about our innovation projects