SIF Discovery Round 2 Close Down Report Document

Date of Submission

Nov 2023

Project Reference Number

10056144

Project Progress

Project Title

REWIRE (REsidential Whole system Integrated REsilience)

Project Reference Number

10056144

Lead Funding Licensee

ENWL - Electricity North West Limited

Funding Licensee(s)

ENWL - Electricity North West Limited

Project Start Date

April 2023

Project Duration

3 Months

Nominated Project Contact(s)

InnovationTeam@enwl.co.uk

Project Summary

Aim: REWIRE will explore the technical viability and economic benefit of integrating vector conversion and energy storage technology at a domestic level to increase whole system resilience.

Whole system resilience: The energy system's ability to recover from disruptive events will be significantly improved with the integration of localised storage, provided by REWIRE's multi-energy systems.

Context: The challenge of whole system energy balancing will grow with increasing penetration of intermittent renewables, with 50GW of offshore wind predicted by 2030, and 40GW of embedded distributed generation in the form of domestic solar predicted by 2050.

Growing electrification of residential transport and heat further increases the likelihood of system imbalances. The role of hydrogen as an option for decarbonising heat remains uncertain, with domestic demand forecasts ranging from 145 to 0 TWh, potentially leaving infrastructure redundant.

Additionally, climate change and geopolitical instability are increasing the likelihood of extreme weather and infrastructure attacks, respectively, further impacting system resilience.

Specifically, two scenarios – low wind, low solar at peak demand and low demand, high renewable generation – would cause resilience issues on a decarbonised national grid, with the latter incurring costs for generation reduction.

Solution: REWIRE is a domestic cross-vector storage system, exploiting power-to-gas and gas-to-power technology with integrated local hydrogen storage. REWIRE brings benefits for consumers through improved energy security, and for networks as a fast-response flexibility service provider.

The solution will alleviate network constraints by increasing availability of flexibility services for demand electrification, reducing reinforcement and system balancing costs. Additionally, low-pressure gas network infrastructure could be used for transporting hydrogen to point of use or as local energy storage, optimising the use of existing resources. This would enhance utilisation of existing assets, producing net cost benefit for networks and consumers.

Project Partners:

- Electricity North West Limited (ENWL) is lead partner and will lead WP2, using their understanding of consumer requirements to rank network archetypes based on their requirements for improved resilience.
- Imperial College London will lead WP3, applying their world-leading whole-energy system modelling expertise to analyse the resulting techno-economics and cost benefits.

Subcontractors:

- Frazer-Nash Consultancy will lead WP1 and WP4, using their experience of network innovation projects to assess the factors affecting implementation of REWIRE.

Cadent Gas Distribution Network have committed to joining the project in Alpha Phase. Their experience with gas network operation and future hydrogen transition activities makes them an ideal partner to aid the assessment of gas network integration.

Project Description

REWIRE aims to improve energy system resilience through its development of innovative domestic level multi-energy systems. By exploiting the cross-vector storage capability of gas-to-power and power-to-gas technologies, properties equipped with REWIRE systems will provide flexible demand profiles to alleviate network constraints and maintain security of supply. This Discovery phase project will explore the technical viability and economic benefits of these domestic level multi-energy systems, which will be specified, designed, prototyped and deployed in the Alpha and Beta phases.

REWIRE's innovation lies in the use of multi-energy systems at the domestic scale, rather than the larger-scale versions previously envisaged. Using a domestic scale solution will necessitate innovative combinations of technologies, and innovative management and operation of the distributed system. This innovative solution provides potential benefits around the speed and flexibility of energy system response, alongside the ability to provide benefit to distribution networks on a granular scale.

Future energy networks are expected to experience both low demand, high generation and high demand, low generation scenarios due to an increased prevalence of intermittent renewable generation. A wide deployment of REWIRE systems would enable demand to be artificially increased, alleviating resilience issues and curtailment of generation for the low demand, high generation scenario. Alternatively, in the high demand, low generation scenario REWIRE systems can preferentially use energy from storage or other vectors to alleviate demand and balance the network. This could include using existing gas distribution assets as energy storage, optimising the use of these assets. In addition to the network benefits, REWIRE systems will allow consumers to adapt their energy use around prices of localised renewable generation.

The benefits provided by REWIRE manifest in reduced costs for network reinforcement, generation curtailment and system balancing which, alongside maximising the use of existing gas distribution assets, would reduce costs to consumers. REWIRE would also increase local resilience and provide improved security of supply for domestic properties. Additionally, the ability for consumers to control the timing of their energy use and to fully leverage domestic generation will lead to further reductions in their bills.

Summary Key Findings

Domestic Archetype Development

Based on work completed during this work package, the following feasibility threshold responses can be concluded:

- It is technically feasible to integrate P2G, G2P and hydrogen storage technologies at domestic scale.
- There are combinations of property types, network characteristics and geographies where this could be deployed.
- The locally deployed solution can be implemented to improve resilience at national scale.
- There is at least one legitimate consumer use case for installation of the systems.
- The technology provides comparable consumer and network benefits with counterfactual systems, such as battery storage.

Network Archetype

Based on an analysis of LV outage incidents in the ENWL region:

- The rural/urban classifier is the most statistically significant characteristic that impacts outage risk.

- The selected risk metric has a significant effect on which regions are flagged as high-risk.
  - Minutes lost per customer tends to be higher in rural areas.
  - Average customers affected per incident is higher for urban areas.
- When considering all of the identified network archetypes, filtering LSOAs by the proportion of properties on-gas shows that greater than 90% consumers on-gas is required to have a significant impact.
- When considering the most at-risk rural archetypes, filtering LSOAs by the number of on-gas consumers has a greater impact.

Implementation Assessment and Roadmap

Based on work completed during Work Package 4 the following can be concluded:

- A series of barriers and enablers have been identified, with associated mitigation or exploitation activities, and these have been used to develop a roadmap for potential commercialisation of the REWIRE design.
- The REWIRE solutions explored could provide potential benefits to the network and consumer but the optimal solution is likely to be heavily dependent on external factors i.e. if hydrogen for heating is rolled out in the UK.
- The main consumer opportunities are flexibility service offerings and bill reduction, whilst the network similarly benefits from reduced outages, grid balancing and increased resilience supporting the shift towards a decentralised grid.
- However, with the UK's current hydrogen landscape, some barriers such as niche supply chains, lack of appropriately sized technologies and lack of UK hydrogen infrastructure may pose some development challenges.

Further information is available in our published deliverable reports.

User needs

The energy system's ability to recover from disruptive events will be significantly improved with the integration of localised storage, which could be provided by REWIRE's exploration of
multi-energy systems. The challenge of whole system energy balancing will grow with increasing penetration of intermittent renewables, 50GW of offshore wind predicted by 2030, alongside embedded distributed generation, 40 GW of domestic solar predicted by 2050.

Growing electrification of residential transport and heat increases the likelihood of system imbalances. The future role of hydrogen for heat remains uncertain, with domestic demand forecasts ranging from 0 to 145 TWh, possibly leaving infrastructure redundant. Climate change and geopolitical instability are increasing the likelihood of extreme weather and infrastructure attacks, respectively, impacting future system resilience.

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.

REWIRE Discovery phase investigated whether 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.

Impacts and benefits

Value and Role of REWIRE Technologies in Supporting Low Carbon Energy Future

- Gross system benefits of 15 GW REWIRE is £2.95B/year, i.e. £197/kW per year
  - With 30 years lifetime, the accumulated system benefits > £5900/kW
  - Main savings: low-carbon generation, distribution cost, hp, and large-scale electrolysers and hydrogen storage
- REWIRE
  - Has a capacity value and displaces firm capacity provided by H2 generation
  - Enables/needs some more investment in wind and PV
  - Displaces output from H2 CCGT, electricity storage, and gas CCS --
  - Support distribution network (reduce the need for distribution capacity)
  - Displaces capacity and output of large-scale electrolyser technologies
  - Improve system flexibility and therefore reduces the need of other distributed flexibility resource
- Challenge
  - Low capacity factor of REWIRE indicates lower energy efficience
    - Assuming high-end characteristics of the technology
  - Integration of electricity and hydrogen system

No changes identified in proposed impacts since application stage.

No changes made to the project during Discovery.

Risks, Issues and Constraints

No new risks identified during Discovery.

Working in the open

All work completed during the Discovery phase is publicly available on the Smarter Networks Portal and Electricity North West's website. This enables us to demonstrate the progress we have made during Discovery and share all project learning with stakeholders to ensure they can benefit from REWIRE if undertaking any further work in this area. Our contact details are also available on our website to enable any interested stakeholders to request further information if needed.

All stakeholders on the project team shared a drive where project documents were uploaded during the life of the project to promote an open culture on the team and ensure that everyone had access to the latest relevant information. This was deemed a more open way of working than using email to share documents with specific team members. This approach worked well, and we will continue to use it for future projects.

We held weekly project update meetings during which the project team was able to provide an update on their work and learn about the progress each partner had made that week. Again, this worked well and is an approach we will continue in future projects.

Costs and value for money

All funds were spent as planned in line with original forecasted budget for Discovery.

No variations or additional contributions were required over and above what was set out in the Project Direction.

The project has delivered value for money to consumers by advancing learning on the technical and economical viability and benefit to integrating vector conversion technology and energy storage at a domestic level to support national and local system resilience.

Special conditions

No project specific conditions were set out in the Project Direction for Discovery.

Documents uploaded where applicable

Yes