

SIF Round 3 Project Registration

Date of Submission

May 2024

Project Reference Number

NPG_SIF_009

Initial Project Details

Project Title

Fuel Cell Renewable Energy Equity (FREE)

Project Contact

Chris Goodhand

Challenge Area

Novel technical, process and market approaches to deliver an equitable and secure net zero power system

Strategy Theme

Net zero and the energy system transition

Lead Sector

Electricity Distribution

Other Related Sectors

Gas Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

NPg - Northern Powergrid (Northeast) Limited

Funding Licensee(s)

NPg - Northern Powergrid (Northeast) Limited

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

Northern Powergrid

Technology Areas

Heat Pumps

Hydrogen

Modelling

Distributed Generation

Energy Storage

Resilience

Project Summary

The project will explore how fuel cell micro Combined Heat and Power (CHP) systems can provide UPS functionality for individual homes as well as support other nearby homes which depend on direct electrification to provide heat, power and mobility.

Fuel cell technology can generate at efficiencies equivalent to the highest efficiency central generation plant even at micro-generation level. Its location within the LV network further ensures that system losses are minimised, by product heat can be utilised, and local balancing is more easily achieved.

This results in increased resilience and lower operating costs for consumers and the energy system.

Add Third Party Collaborator(s)

EA Technology

Lane Clark and Peacock LLP

Project Budget

£130,157.00

SIF Funding

£112,827.00

Project Approaches and Desired Outcomes

Problem statement

With the objective to deliver a fully Net Zero Power System by 2035, increasing attention has been given to resolving how to provide clean electricity during the most challenging periods when demand might be high and renewable generation is low.

As highlighted at the ENA basecamp, the problem is exacerbated by our increasing dependence on electricity as the only energy vector at the point of use to meet not only existing loads but additionally to decarbonise heat and mobility for residential customers, and the consequently increasing importance of providing a resilient electricity system.

The Committee on Climate Change and UK government policy both recognise that in a net zero electricity system, we cannot rely entirely on intermittent renewables and in addition to short-duration storage we will require some form of fuel-based generation to meet peak (winter) demands.

Conventionally this would be from central peaking plants. These tend to be low efficiency OCGT. As we transition to low carbon gas this will represent an ever increasing cost burden. These plants also tend to be remote from the loads they serve and thus impose additional burdens on the distribution network in order to meet the increasing burden of electrification.

However, it is becoming clear that in order to deliver a net zero electricity system, it will also be necessary to consider whole system issues including arbitrage between energy vectors.

This needs to be considered not only from a technical perspective but also from the perspective of vulnerable customers who require a resilient supply of heat and power which is also affordable.

We therefore ideally require a solution which:

- Provides long-duration resilience and reliability of supply
- Supports the electrification of heat, mobility and home working
- Provides customer choice for low carbon heating
- Defers LV reinforcement
- Increases LV asset utilisation
- Facilitates new connections
- Is a more efficient alternative to central peaking plant
- Generates electricity very near demand reducing line losses and reinforcement
- Makes effective use of "waste" heat further increasing primary energy efficiency

In this proposal we address all these problems by introducing fuel cells providing heat and power from low carbon gas (including hydrogen at some point) into individual homes or apartment blocks. This approach has proven both technically and economically in other markets such as Japan where entire communities are being served by high efficiency fuel cells embedded within homes, but supporting the whole community.

Video Description

<https://youtu.be/JvstZFjRNcE>

Innovation justification

Various approaches to providing a secure power system have considered how demand response, hybrid systems, and electrical

storage might mitigate the challenge of aligning variable renewable generation with increasing electrical demand.

However, challenges remain concerning the interseasonal misalignment of renewable generation with the substantial winter demand for comfort heating. The appendix describes a number of precursor projects which have addressed specific aspects of the problem including short term resilience, interseasonal storage and multi-vector solutions. One project (Panasonic, Fujisawa, Japan) appears to comprehensively address all of the issues for the defined use case of new build housing.

The concept of fuel cell micro-CHP in homes has been demonstrated in over 100,000 installations in Japan. In Fujisawa the generators are co-ordinated to provide a resilient supply both to the individual homes in which they are located, but also to the wider community in the event of grid failure.

This project builds on the NPg Resilient Customer Response which demonstrated the potential for customers' behind the meter (BTM) assets to contribute to a resilient local network. In this case, the duration of resilience is enhanced by

incorporating not only storage but also dispatchable generation in the form of fuel cell micro CHP giving rise to new innovation:

- By integrating the energy vectors of heat and power we expect to achieve significant operating cost benefits from the more efficient use of input fuel. This will benefit vulnerable customers in particular.
- By selecting hydrogen as the input fuel, we address the challenge of interseasonality in the long term. (Natural gas may be substituted as a transitional fuel in the short term to avoid implementation challenges to the project.)
- By incorporating all three energy vectors we substantially reduce the risks of dependence on a single energy vector and are further able to support electrification of heat in adjacent properties.

The concept has thus demonstrated both the resilience and cost benefits for residential consumers. In the UK context, these same challenges may be similarly addressed whilst also mitigating other impacts of our increasing dependence on a single energy vector to meet our net zero targets.

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Financial - cost savings per annum for users of network services

Environmental - carbon reduction – direct CO2 savings per annum

Environmental - carbon reduction – indirect CO2 savings per annum

Revenues - improved access to revenues for users of network services

New to market – products

New to market – processes

New to market - services

Impacts and benefits description

FREE will deliver a commercially viable technology solution to the resilient and low carbon electricity supply to individual homes regardless of the status of the distribution network. This goes beyond previous UK resilience trials involving home or communal energy storage, or back-up fossil fueled generation, instead providing long duration embedded electricity supply to individual homes based on high efficiency low or zero carbon fuels.

The project will initially deliver a concept study including a CBA evaluating the customer and system benefits of the resilient energy system concept.

Alpha and Beta stages would undertake detailed technical and economic analysis followed by a demonstration pilot local energy

system development (up to 100 homes) equipped with an appropriate mix of fuel cell generation and direct electrification solutions.

Although this project will demonstrate both short-term stability and longer-term (interseasonal) resilience, it also provides the potential for additional system benefits and economic value streams which benefit all customers, but particularly vulnerable ones:

- Resilience is no longer an afterthought or a reactive response; embedded generation provides a continuous long long-duration electricity supply at all times without delay. In Resilient Customer Response (NPG SIF2 Discovery), the NPV was £1.1M benefit per substation over 25 years using battery storage, and we would expect the NPV from FREE to be higher for the same customer groups due to long-duration supply capability and increased capacity.
- Dispatchable generation in individual homes can be aggregated to capture significant system flexibility values using innovative business models.
- The highly distributed nature of the fuel cell generators can support DSO flexibility and mitigate the impact of electrification of heat and mobility for example, providing additional headroom of 0.5kW per home (33% increase on typical ADMD).
- The CHP operation mode enhances economics for the householder at a significantly lower cost than from grid supply. We calculate that FREE could deliver £850 per year energy saving per home, giving 47% reduction to the baseline of hydrogen boilers. Corresponding CO2 savings are approx. 40 – 50% assuming long-term emissions factors.
- The fact that fuel cells will be generating power when it is most needed by heat pumps in other homes supports the (direct) electrification of residential heat.

When considered as a system benefit with multiple value streams, fuel cell micro CHP could be capable of providing value for money as a transitional and long term technology solution.

Teams and resources

Northern Powergrid and Partners

Northern Powergrid is the electricity distributor for the Northeast, Yorkshire and

Lincolnshire of England delivering power to 3.9 million homes and businesses across. NPg is responsible for owning and maintaining the cables and assets in its licence area.

Role: NPg will lead this project and be responsible for overall project management (WP1) and dissemination of information across the industry.

LCP Delta

LCP Delta is a leading consultancy in new energy. They work with energy suppliers, network operators and others to address the challenges presented by the transition to a sustainable energy system. Our previous work exploring the potential for mitigating the impact of electrification on distribution networks as well as our ongoing engagement with energy communities, solution providers and network operators (for example in the Community DSO NIC project) will contribute to our ability to deliver this project.

Their expertise in end-use technologies and the customer meets the project needs of an understanding of the respective merits of the technology solutions to be considered. Our ongoing activities with energy communities will enable us to fully explore innovative solutions to the direct supply of renewable generation over the public distribution network.

Role: LCP Delta will support NPg with the overall project management for Discovery. In addition, they will be responsible for the stakeholder workshops, technology assessment, commercialisation and cost-benefit analysis. LCP Delta is to lead project reporting, dissemination and the exploitation of the Free project.

EA Technologies

EA Technology is a global, independent provider of end-to-end power engineering solutions, supporting customers in managing and operating electrical assets reliably, safely and efficiently.

Their innovative work on developing smart grid solutions has helped many Distribution Network Operators as well as the industry in general begin to understand, plan and implement practical solutions to future networks. These include the Transform Model, Thames Valley Vision, and Customer-Led Network Revolution.

Role: EA is responsible for identifying the key barriers and opportunities for the electricity distribution operators focusing on low voltage networks to support microCHP fuel deployment.

Project Plans and Milestones

Project management and delivery

The Discovery work packages proposed are:

WP1: Project Management [Northern Powergrid]

- Aims: To deliver the project on time, to budget, and to check that project objectives and learnings are achieved.
- Success criteria: Project delivered on time, in budget and to quality

WP2: Stakeholder mapping and engagement to scope requirements [LCP Delta]

- Aims: Develop problem statement and requirements with stakeholders.
- Success criteria: All stakeholders mapped and levels of interest & influence defined

WP3: Establish technical and non-technical evaluation framework and modelling approach [LCP Delta]

- Aims: Develop an evaluation framework and modelling approach to assess the ability and value of solving the problem.
- Success criteria: Evaluation framework and vessels in scope are defined

WP4: Develop a cost benefit analysis [LCP Delta]

- Aims: Develop Cost Benefit Analysis for assessing the problem and impact.
- Success criteria: CBA for several scenarios, along with related assumptions (including business models).

WP5: Understanding regulatory constraints [EA Technology]

- Aims: Explore policy and regulatory challenges
- Success criteria: Understanding trends in power requirements, policy, regulations & guidance and learnings from other projects

Key outputs and dissemination

The project will deliver a commercially viable technology solution to the resilient and low carbon supply of electricity to individual homes regardless of the status of the distribution network. This concept goes beyond previous UK resilience trials involving energy storage (either individual home or communal) or back up generation using large, fossil-fuelled gensets, and will instead provide long duration electricity supply to individual homes based on high efficiency low or zero carbon fuels.

In the first instance, the project will deliver a concept study including a cost-benefit analysis evaluating the customer and system benefits of such a resilient energy system concept.

If successful, subsequent stages will undertake detailed technical and economic analysis followed by a demonstration pilot local energy system development including up to 100 homes equipped with an appropriate mix of fuel cell generation and direct electrification solutions. This could feed into the ongoing Community DSO project as one of the four proposed field trials.

Following the initial study to be completed by the end of 2023, we would expect a trial to be underway by the end of 2024 with learnings emerging shortly afterwards. These learnings could be implemented at an increasing scale from 2025 onwards as a solution for existing homes in vulnerable locations and elsewhere in due course.

though this project is focused on resilience solutions, it is likely that the other benefits to the household (reduced energy bills etc) will accelerate the uptake of the technology for other reasons as well. For those installations, there will still be

indirect benefits to the ONO as embedded generation will mitigate the impact of electric heat pumps as a key heating technology.

Dissemination will involve a variety of initiatives by the various partners expected to participate in the alpha and beta project phases.

NPg will promote the learnings both internally, to key stakeholder groups and to the wider ONO community.

In addition we expect manufacturing partners to engage in promotional activities intended to increase product sales in relevant new build housing and retrofit applications. Given the demonstration of the benefits of the technology to households we would expect to see scaling of the technology as it emerges as one of a portfolio of technology solutions offered by heating appliance manufacturers to meet the variety of customer needs and preferences.

Commercials

Intellectual Property Rights (IPR) (not scored)

The parties agree to adopt the default IPR arrangements for this project as set out in Section 9 of the SIF Governance document.

Value for money

The total project costs for Free Project are £130,157

The total SIF funding requested is £112,827

There are no sub-contractor costs, nor funding from other innovation funds. Partners will leverage their own facilities (e.g., offices and IT).

Supporting documents

File Upload

Fuel Cell Renewable Energy Equity (FREE) - Show Tell v2 (004).pdf - 477.4 KB
Fuel Cell Renewable Energy Equity (FREE) - Final report.pdf - 1.6 MB
FREE - Network Modelling Results V1.0 .pdf - 661.2 KB
EA26747-TR02-V1.0 - FREE - Policy and Regulation Review.pdf - 613.3 KB
SIF Round 3 Project Registration 2024-05-15 10_30 - 56.9 KB

Documents uploaded where applicable?

