WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Date of Submission

September 2016

NIA Project Registration and PEA Document

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form. The full completed submission should not exceed 6 pages in total.

Project Registration

Project Title

FREEDOM - Flexible Residential Energy Efficiency Demand Optimisation and Management

Project Reference

NIA_WPD_023

Project Licensee(s)

Wales and West Utilities, Western Power Distribution East Midlands, Western Power Distribution South Wales, Western Power Distribution South West, Western Power Distribution West Midlands

Project Start Date

Oct 2016

Project Duration

2 Years 3 Months

Nominated Project Contact(s)

Faithful Chanda – WPD Innovation and Low Carbon Networks Engineer & Oliver Lancaster – WWU Principal Environmental Engineer

Project Budget

£5,182,380

Problem(s)

The Climate Change Act passed in 2008 committed the UK to reducing emissions by at least 80% in 2050 from 1990 levels, meeting this target would likely require heat related emissions of CO2 from buildings to be near zero by 2050, both targets pose an enormous economic and environmental challenge to energy providers. In the recent past, the expectation from the government and others has been that gas networks would be switched off within the next 20-30 years, to be replaced by electrified heat. However, it is becoming clear that the electrification of heat brings with it many challenges – both technical and economic. It is imperative that the energy sector support research and invest in energy solutions that are affordable, reliable and safe for our customers.

In the UK, about 70% of all energy consumed is in the home, of which space heating and hot water production account for the bulk of the energy use. With the majority of the homes in the UK being heated by combustion of fossil fuels, a heat generating system that could improve domestic energy efficiency significantly has the potential to deliver dramatic reductions in primary energy consumption and CO2 emissions.

Electricity is the most expensive fuel available in the UK, an energy savings trust report in 2013 found that rising costs for electricity hit poorer households with electric heating the hardest. Gas boilers typically emit 2-4 tons of carbon per year, depending on boiler and house type. Converting 10,000 homes to hybrid heating could save between 10,000 and 20,000 tonnes of carbon per year. The hybrid heating system has the potential to help meet the EU’s ambitious environmental targets of achieving a 20% cut in greenhouse gas emissions compared with 1990 levels and a 20% reduction in energy consumption by 2020. The technology, which combines domestic gas boiler and air-source heat pump heating, has the capability to use either fuel or both and can be used as fully flexible loads capable of providing significant energy system value.

Using predictive control algorithms the technology manages the heating load and fuel type to achieve the best cost and carbon outcome based on real-time energy market prices without the consumer engaging in the market complexity. As well as not seeing an increase in their energy charges, the consumer wouldn’t have to pay for the hybrid system up-front. The use of aggregated load control helps reduce the peak demand, thereby having a disproportionate reduction on carbon intensity and system costs and increasing the security of supply.

These technologies may also provide an opportunity to support network management and may be suited to provide system services because of the flexibility in their operation. In this project, we shall:

1. Determine the technical potential and impacts for heat pumps to provide network services;
2. Look at the technical and commercial barriers to implementation;
3. Determine the potential benefit to asset owners and examine the possible commercial models for service provision;
4. Examine the necessary next steps in the wider deployment of heat pumps.

Deploying heat pumps on the WPD system may require processes to be developed with National Grid to identify where clustered uptake may result in issues on the distribution and the transmission network.

National Grid predicts an uptake of approximately 1200 heat pumps in homes by 2020 with a peak demand of 1-4 GW in the UK. These devices can be used as a way of enabling flexible energy supplies to deal with demand on the local electricity network, improve domestic energy efficiency, reductions in primary energy consumption and $CO2$ emissions.

The challenges of emerging technologies need to be understood to discover how cost effective, sustainable and practical they can be.

Method(s)

PassivSystems Limited and its partners have put together a proposal to deliver a technically and commercially successful innovation project to realise the benefits of using the hybrid heating system (heat pump and gas boiler) for our networks and our customers. The success of the work will depend largely on the location, housing types and type of heat pump. The trial will be conducted in domestic housing units in the Bridgend area to demonstrate potential solutions to the findings of earlier research projects such as Bridgend Future Modelling. A variety of liaison meetings between PassivSystems and the Local Authority as well as other interested organisations, to gain the support and ensure the deployment satisfies the given criteria, has been undertaken.

The methodology for the delivery of this Project will follow the process below:

1. Selection of the area for the trial (customer engagement plan)
2. Selection of the type and size of the heat pump
3. Modelling
4. Mobilisation (procurement of equipment and services)
5. Trials or field test, including measurements (install equipment)
6. Connection agreements and policy
7. Analysis and close down (Analyse results, evaluate)

Scope

The proposed project runs for 27 months and has been broken down into two phases, which are defined in 14 work packages. The research objective is to better understand how hybrid heating systems can be:

- Affordable through using advanced algorithms to unlock value from energy markets;
- Trustworthy by building consumer trust in new technology whilst providing the same level of comfort in people's homes; and
- Developing appropriate user interfaces and information systems to help drive adoption.

All design and foundation development activities conclude in the first six months. Pilot installations are initially undertaken in four households before installations are rolled out to the rest of the trial properties, followed by a period of monitoring and experimentation phase which seeks to learn and then iteratively refine the heating and load management processes and the consumer interface and information provision over a full year.

The full size and scale of the potential solution will only become apparent when trials are conducted.

Objective(s)

The research objective is to better understand if hybrid heating systems are technically capable, affordable and attractive to customers as a way of heating homes. This project aims to investigate the feasibility of the use of heat pumps on both WPD's & WWU's network in order to:

1. Demonstrate the ability of the hybrid heating system to switch between gas and electric load to provide fuel arbitrage and highly flexible demand response services;
2. Demonstrate the consumer, network, carbon and energy system benefits of deployment of hybrid heating systems with an aggregated demand response control system; and

3. Gain insights into the means of balancing the interests of the consumer, supplier, distribution and transmission network when seeking to derive value from the demand flexibility.

Success Criteria

To collect a body of evidence to support this forward-looking concept. The research will document the outputs of the pilot installations, the system interfaces and customer feedback that will enable us to continue to the next steps towards a commercial solution.

The project will:

1. Present a comprehensive review of the technology;
2. Produce a case study of how the technology contributes to the reduction of carbon emissions and compares with previous energy bills for domestic consumers through increased heating system efficiencies and a reduced unit cost;
3. Identify if the solution can bring benefits to WPD’s & WWU’s networks;
4. Deploy trials subscribed to by up to 75 participants;
5. Produce a proven architecture for the hybrid heating system; and
6. Develop a business process (polices, standard techniques etc.) for the use of hybrid heating system.

Technology Readiness Level at Start	Technology Readiness Level at Completion
6	8

Project Partners and External Funding

This project is being funded by the Network Innovation Allowance (NIA). PassivSystems are providing a sum of £182,550 towards the project costs.

The project partners delivering this project and their role is as follows:

1. PassivSystems Ltd – project management, customer contact management, technical lead
2. Delta EE – energy consultant and technical support
3. Western Power Distribution – determine the technical potential and impacts to providing network services
4. Wales & West Utilities – determine the technical potential and impacts to providing network services
5. Imperial College – data analysis and modelling work
6. City University – customer needs and wants analysis

Potential for New Learning

The project will deliver a hybrid heating system that is able to support the electricity and gas network in the discovery of sustainable alternatives to help deliver the UK’s energy requirements. The project will consider whether the technology can defer network investments, remove network constraints and provide a fully flexible domestic heating load management service. The control enhancements will move well beyond current hybrid technology that makes a simple switching decision based on fixed tariff information and will provide accurate load forecasts by fuel type by quarter hour to the energy supplier. Consumers will for the first time be able to see a forecast of spend on heating for the coming period, based on their individual home, occupancy patterns, weather forecast and comfort settings. Other network operators within both the gas and electricity sector will also be able to gain a comprehensive understanding of hybrid heat systems after reviewing this project’s reports and results.

Scale of Project

The ambition is to provide both electricity and gas network operators with meaningful insights into the future evolution of the domestic heat sector, the impact on networks in the short and long term and steps that can be taken to best manage future network risk from a proliferation of hybrid heating technologies.

The project brings together the gas and electricity network operators and aims to provide both organisations with robust, field tested data which can make a meaningful contribution to long-term network planning and regulatory budget submissions. The cross sector scope makes this a unique project which aims to set the benchmark for holistic whole systems’projects, as articulated in Energy UKs Pathways for the GB Electricity Sector to 2030.

The project has been split in two separate phases (1 & 2), divided into 14 Work Packages (WP1-14). Phase 1 (WP1-9) covers all work required to produce the models, hypotheses, plans and recruitment actions required for the heat pump procurement and installation activity to commence. Phase 1 also includes a 4 home pilot installation which will assess the hardware and installation risk and collect the baseline data required for the advanced control development. Phase 2 (WP10-14) covers the work of installation, commissioning, aggregated control development, field experiments, data capture and analysis, reporting and knowledge dissemination, continued support and project shutdown.

Geographical Area

The trials will be undertaken in Bridgend in South Wales

Revenue Allowed for in the RIIO Settlement

Nil

Indicative Total NIA Project Expenditure

The total external cost of the project to WPD & WWU is being split equally between both companies.

- WPD share external cost £1,874,936
- £624,979 maximum internal expenditure
- **Total maximum WPD cost £2,499,915**

- WWU share external cost £1,874,936
- £624,979 maximum internal expenditure
- T**otal maximum WWU cost £2,499,915**

The total cost of the project is £4,999,830. The project value claimable under NIA (90% of total project cost) is £4,499,847

Project Eligibility Assessment

Specific Requirements 1

1a. A NIA Project must have the potential to have a Direct Impact on a Network Licensee's network or the operations of the System Operator and involve the Research, Development, or Demonstration of at least one of the following (please tick which applies):

A specific piece of new (i.e. unproven in GB, or where a Method has been trialled outside GB the Network Licensee must justify repeating it as part of a Project) equipment (including control and communications systems and software)	[x]
A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)	[x]
A specific novel operational practice directly related to the operation of the Network Licensees System	[x]
A specific novel commercial arrangement	[ ]

Specific Requirements 2

2a. Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees [x]

Please answer one of the following:

i) Please explain how the learning that will be generated could be used by relevant Network Licenses.

This is the first gas/electric collaborative innovation project investigating a multi vector approach to the carbon reduction of energy usage in homes & will run alongside other strategies that are being investigated.

When there is over generation from wind farms as an example, wholesale electric costs will be low & the heating system will use electric. If it's cold and windy, the gas will top it up and if it's cold and dark, then gas will provide the heat. The key is the technology that controls the heating system, which isn't done by the consumer but by PassivSystems (24/7/365). They will react to the price of electricity & effectively exploit the difference between wholesale and retail prices.

The learning generated is directly applicable to all Network Licenses in mitigating network constraints as well as managing investment deferral which are significant to our core business. A number of manufacturers are developing heating systems that can switch between gas and electricity fuel sources dynamically. The project will deliver a network level demonstration of domestic demand response using hybrid heating systems, which combine gas boiler and air-source heat pump technology, and can be used as fully flexible loads in domestic properties.

ii) Please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the Project.

N/A

2b. Is the default IPR position being applied?

Yes [x]

No [ ]

If no, please answer i, ii, iii before continuing:

i) Demonstrate how the learning from the Project can be successfully disseminated to Network Licensees and other interested parties

ii) Describe any potential constraints or costs caused or resulting from, the imposed IPR arrangements

iii) Justify why the proposed IPR arrangements provide value for money for customers

2c. Has the Potential to Deliver Net Financial Benefits to Customers ☒

i) Please provide an estimate of the saving if the Problem is solved.

The project aims to trial an alternative solution to lengthy overhead line reconductoring which is often quoted to customers for Distributed Connections. In an area where there are several Distributed Generation connections connected to the same primary or feeder implementing a scheme of this sort would be more cost effective. This trial is to demonstrate the technical benefits in allowing the use of heat pumps which can reduce the unit cost of connecting at the 11kV and therefore deferring the investment and mitigating against grid constraints that way.

In their report to the Committee on Climate Change (Oct 15), Imperial College forecast annual value of flexibility to the UK at between £2bn and £8bn depending the on level of decarbonisation. Heat pumps are forecast to deliver 175TWh of domestic heating load per year by 2030 and can be a major contributing factor. The market currently lacks a competitive solution to a gas boiler. A hybrid system of heat pumps used alongside existing gas boilers presents the first real future of heat response to all three challenges of the energy trilemma.

ii) Please provide a calculation of the expected financial benefits of a Development or Demonstration Project (not required for Research Projects). (Base Cost – Method Cost, Against Agreed Baseline).

Installing more clusters of Low Carbon Technologies (LCTs) such as heat pumps would lead to the reinforcement of an LV feeder depending on volumes of deployment. The typical cost of reinforcing an LV feeder is £40,000 - £100,000, based on ground mounted substation and cable upgrades, as published by WPD in their East Midlands QAS (part of the Connection Charging Methodology). By way of example, a Transform Model® analysis of the impact of LCT growth on WPD's license areas from 2020 -2030 shows that WPD may have to invest up to £300m in that decade to reinforce LV networks affected by LCT penetration. For any feeder with sufficient heat pumps to trigger reinforcement the method (flexible demand Control) would provide a saving over a 10 year period. Consumption of an all-electric air source heat pump is estimated to be in the region of 7kW. A hybrid heating system is designed for the future and is expected to lower the number of peak periods on the electricity distribution system and reduce the constraint levels in the long term. This would lead to network investment deferral. If we estimated the consumption to be in the region of 3.5 - 4kW per hybrid heating system then we see huge savings in overall cost. Given this figure is likely to be lower than the average number of customers on a feeder (30), the method will provide a cost saving. An all-electric heat pump installation would be more costly to run than the hybrid heating system due to inability to switch between electricity and gas and adding to more constraints on the distribution system. EA Technology Limited's My Electric Avenue suggests that 44.4kW clusters of LCTs would be sufficient to trigger the reinforcement of an LV feeder. For this illustration, we are going to use a conservative £40,000 as the cost of reinforcing the LV feeder. On a per-feeder basis, this is equivalent to 6 Heat pumps (7kW per heat pump) or approximately £5700/heat pump connection or 12 hybrid heat pumps (3.5kW per hybrid heating system) or £3,300/hybrid connection.

Financial Benefit: If we consider the cost of an all-electric heat pump (Base Case Cost per Customer) to be £5,700 and the hybrid heat pumps (Method Cost per Customer) at £3,300, then the financial benefit is in excess of £2,000 per customer.ie. £5,700 - £3,300 = £2,400.00 per customer.

If this project's methods are successful and applied by DNOs then considerable savings on these predicted costs are expected

iii) Please provide an estimate of how replicable the Method is across GB in terms of the number of sites, the sort of site the Method could be applied to, or the percentage of the Network Licensees system where it could be rolled-out.

Suitable for use in all license areas.   11kV networks are prevalent in all areas.

iv) Please provide an outline of the costs of rolling out the Method across GB.

Unit costs for heat pumps are likely to fall significantly as the uptake of these devices increases. The project is formed on the premise that the consumer doesn't pay up front for the equipment and will not pay any more in energy charges than they currently pay. Of course, as energy prices (maybe driven by carbon taxation) rise, so would the charges for the service, hence making the future economics work.

The cost of deploying the hybrid heating system at one site is itemised below:

- Heat pump £6,900
- Installation cost £4,500

- Others £55,265 (Cost of software development, modelling, testing, commissioning and aggregated control development)
- **Total cost** **£66,665**

2d. Does Not Lead to Unnecessary Duplication ☒

i) Please demonstrate below that no unnecessary duplication will occur as a result of the Project.

This hybrid heating system is a unique device which has not been trialled anywhere else in the UK.

ii) If applicable, justify why you are undertaking a Project similar to those being carried out by any other Network Licensees.

N/A