SIF Project Registration

Date of Submission

Mar 2022

Project Reference Number

10025660

Project Registration

Project Title

Fast Flex

Project Reference Number

10025660

Project Licensee(s)

SP Energy Networks Transmission

Project Start

March 2022

Project Duration

2 Months

Nominated Project Contact(s)

Michael Eves

Project Budget

£129,908.00

Project Summary

The discovery will quantify the value of the 'control approach' vs. the 'hardware approach' for guaranteeing stability in a decarbonised electricity grid:

- The control approach uses advanced monitoring and control techniques to access demand flexibility to support the grid, particularly flexible industrial loads and domestic loads such as electric vehicles.

- The hardware approach consists of investing in built-for-purpose assets such as grid-scale battery storage and synchronous condensers to provide ancillary services to the grid.

The control scheme offers regional sensitivity, particularly important in Scotland due to its low inertia. Customers could benefit from lower cost, and improvements to security and resilience of supply. For the benefits quantification, Imperial College's unique Ancillary-services Constrained Energy Scheduling (ACES) model will be used, in which regional ancillary-services dynamics are mapped into economic optimisation, enabling accurate quantification of the need for ancillary services in each region.

Investment efficiency is achieved through maximising the potential for existing grid customers and stakeholders to avoid large-scale investment in battery storage and synchronous condensers. Co-ordination of control and services across transmission, distribution, DERs and demand side delivers this benefit with minimal capital investment. Siting the response and controlling it in regional clusters minimises further network constraints that are a risk of the conventional approaches. Resilience is enhanced by the regional approach, providing a self-healing response by automatically rebalancing areas when severe weather events weaken the grid, while conventional approaches would leave large areas vulnerable to blackout if the grid is weakened or split.

SP Transmission plays a key role relating the whole system requirements of system operation with the distribution capabilities and the customers providing the flexibility. SP Transmission also has the most advanced transmission real-time monitoring system of the licensees and has established a worldwide reputation as an innovation leader in using this technology. Furthermore, the problem is particularly important in Scotland where the regional effects of inertia reduction are most critical.

GE will provide the design for the monitoring and control solution from its GB- based innovation centre for decarbonisation, specialising in fast wide area control as well as advanced transmission and distribution management.

Imperial College will provide the modelling and analysis expertise to assess requirements and benefits (technical and economic) for the proposed regional fast balancing service. The team will also specify the target participants for a follow-up demonstration.

The ESO, SP Renewables, SPD and SPM will all act as review authorities to verify the discovery outputs.

Third Party Collaborators

General Electric

Nominated Contact Email Address(es)

innovate@spenergynetworks.co.uk

Problem Being Solved

The future British power system will face a stability challenge due to the decreasing levels of inertia on the road to decarbonisation. Inertia, which refers to the rotating masses of synchronous generators, stores kinetic energy as it rotates to produce electric power; inertia is therefore a valuable energy buffer that helps maintain the grid in balance after an unexpected contingency, such as the loss of a large power plant. As coal- and gas-fired power plants retire or operate with lower load factors due to the increasing penetration of non- synchronous renewables (wind turbines and solar photovoltaic), this valuable energy buffer is reduced, potentially being close to zero during times of very high renewable power output. This presents a risk of instability in the future clean electricity grid.

New alternatives are needed to counteract the future low inertia, and an enormous opportunity is created by the electrification of demand: flexible loads ranging from large-scale industries to small domestic consumers could provide the necessary grid support to replace inertia in keeping the balance of the grid.

However, new control infrastructures and methodologies will be needed to access this demand-side flexibility, therefore an accurate quantification of the benefits from this approach is needed to unlock the necessary investment in this control infrastructure.

The urgency of using alternatives for grid stability is highlighted by the UK power blackout of August 2019. This event demonstrates that the threat to security of supply is increasingly significant as renewable penetration grows. This risk is even higher in weaker regions of the network, notably Scotland due to the wide deployment of windfarms replacing synchronous generators. Regional response to contingencies is becoming critical, which makes the current frequency stability services in GB inadequate. In this project, the benefits of the regional response approach will be quantified, considering a future competitive market design achieved by opening the market to future widely available assets such as electric vehicles. The main opportunity is to make use of existing devices in the demand side for supporting grid stability, a model that could be replicated in other grids outside the UK.

The implications of not taking this opportunity are significant: cost of ancillary services is projected to increase significantly by 2030 - to an estimated £1bn/year in GB. As such, this report will quantify the economic savings and carbon emission reductions generated by utilizing demand-side assets for these key services.

Project Approaches And Desired Outcomes

The Big Idea

The Big Idea is a regional fast-acting self-healing control for whole system stability that co-ordinates many distribution-connected devices to provide a predictable response to stabilise the system after disturbances. This is needed for low inertia system operation; existing alternatives are much more costly with less benefit.

This project's discovery phase will provide commercial and environmental justification for a new marketplace for participating demand, generation and storage. It enables a cost-efficient ancillary service market: saving consumer's money, reducing dependence on fossil-fuel burning generators and supporting renewable generation integration across Great Britain.

The approach applies established wide area control technology to sub-second transmission-based identification of events, real-time response needs, and distribution-based aggregation to deliver the response. Control is coordinated between the Energy System Operator, the Transmission and Distribution network operators, generators and demand.

Low inertia regions with long transmission distances carry higher risks than tightly meshed areas. Introducing the approach in Scotland is valuable because of its long lines and large renewable resources. In Scotland, regional blackout or separations can be caused by events smaller than the system-wide largest secured loss. Present frequency stabilisation solutions are expensive: non- locational battery storage responding to frequency changes and synchronous condensers with flywheels. The proposed regional solution can achieve superior technical performance with far less dedicated power equipment and cost.

Many customers have flexibility to offer services to the grid, and further electrification including electric vehicles and heating loads will extend flexibility resources. This project addresses current barriers to using flexibility to address low inertia issues:

1. Speed and proportionality: Flexibility is currently used in slow human-in-the- loop markets. The proposed system triggers response in sub-second timeframe and adapts to the level of inertia in the managed area to provide a response proportional to the disturbance.

2. Variable Power: Individual units cannot guarantee response but aggregating across many resources provides predictable response.

3. Variable Response Profiles: Different devices have diverse response time characteristics. Faster and slower capabilities combine to provide a well-defined overall response.

4. Regional Sensitivity: Present frequency responses are insensitive to disturbance location. Our approach delivers response where it is helpful for grid stability.

The Discovery phase delivers:

- Simulation-based reference cases illustrating the technical requirement for the locational approach.

- Cost-benefit analysis relative to present solutions

- Recommended plan for physical trials incorporating diverse resources

The project team is familiar with Ofgem's standard IP arrangements and will work within this framework.

Innovation Justification

There is previous work on novel strategies for operating low-inertia power grids. A major report commissioned by the Committee on Climate Change provided a projection of ancillary services costs in the path to decarbonisation by 2030. The low inertia challenge was faced in GB during the first COVID-19 lockdown in 2020, when ancillary services costs increased three times compared to the previous year . However, there is a significant gap in understanding the regional aspects of stability for low-inertia grids. Imperial College's ACES model has recently been enhanced to consider regional frequency variations, making it possible to analyse the business case for demand-side stability support with a regional focus.

Our key outcome will be a comprehensive analysis of the value of the 'control approach' with a regional focus on Scotland. Stability will be particularly compromised in Scotland due to its low inertia driven by the large penetration of wind generation and the small load compared to England. This quantification has never been done before.

As there is no regional market for response, there is no mechanism to engage in a project in this space outside the Strategic Innovation Fund. There is experience from innovation projects by the partners showing that a regional control approach can work:

• The Enhanced Frequency Control Capability (EFCC) project led by National Grid ESO demonstrated locational fast balancing control.

• The Icelandic System Operator deployed locational fast balancing in the EU Horizon 2020 MIGRATE project and continues to use the system for islanding defence and frequency control.

• In South Australia a wide area protection scheme is being implemented to prevent islanding, controlling grid-scale battery storage and sheddable loads. Similar to Scotland, a low inertia region is connected to a larger network. The system is particularly useful for complex multi-event disturbances.

• Distributed ReStart in GB (and a follow-on pilot in SPEN) uses fast balancing control of distributed resources in the context of a blackstart service. This provides experience on infrastructure, control and resource stacking.

These projects show that the control approach is feasible and strongly beneficial for the overall stability and resilience of the networks. There are outstanding challenges not addressed in the above projects, including:

- Implementing fast control infrastructure across the organisation layers of transmission, distribution and third-party resources
- Creating a predictable service out of many variable flexibility resources
- Developing a market-based approach to incentivise participation and reflect costs.

Project Plans And Milestones

Project Plan And Milestones

Work Package 1 (weeks 1-2) – Imperial

This WP will adapt Imperial's ACES model to run scenarios which consider feasible future implementations of the 'control approach' in the British electricity grid (i.e. using existing resources to provide flexibility). Furthermore, we will complete necessary enhancements to the model include considering demand-side resources within the stability-constrained scheduling, which currently considers only supply-side stability services with gas power plants as the main providers.

Work Package 2 (weeks 3 to 5) – Imperial

Using the enhanced ACES model (WP1), we will simulate relevant case studies to:

• Quantify the economic benefits of the control approach;

• Identify the regional needs for stability services in the future British grid;

• Analyse interactions between stability services with different characteristics such as inertia and frequency response, informing best practices to optimise service procurement; and,

• Quantify the volume of ancillary services needed if the 'hardware approach' was to be taken.

In parallel, we will analyse the existing data on investment costs for grid-scale battery storage and synchronous condensers from real experiences such as National Grid ESO Stability Pathfinder. This analysis will be used in combination with the results from ACES to provide a comparison of the costs of both approaches to stability.

Work Package 3 (week 6) – SPEN

A review of initial case results to identify gaps and needs for refinement, in advance of the final report. Results will include minimum cost towards stability from 'UK plc' and SPEN will provide comments to Imperial to inform WP4.

Work Package 4 (weeks 7 and 8) – Imperial

Run final case studies and consolidate the knowledge generated, with a comprehensive assessment of the estimated benefits from the control approach to stability under different scenarios.

Milestone 1 – The delivery of the report which will be the first accurate quantification done globally on the benefits from addressing regional stability needs through demand-side flexibility.

Work Package 5 (weeks 5 to 8) – GE

GE will develop a roadmap to a demonstration that applies the control approach to a representative set of resources and develops the methods to aggregate resources and deploy them as a single response. The Alpha phase will measure the response latency and availability of variable resources in a controlled response, and plan for the capacity of variable resources required in a Beta to deliver a stability response.

Milestone 2 – The delivery of the detailed roadmap to achieve a Beta demonstration.

Route To Market

The market potential for the proposed system is global and could be replicated in any system where renewable generation is becoming a major contributor. It targets the fast frequency control market (currently over £300M/Year in GB) - projections for 2030 estimate the cost of ancillary services around approximately £1bn/year. The UK could set a precedent for others to follow, the stability problems due to low inertia will be evident here at least 5 years before the US and other continental markets. This problem can be turned into an opportunity to place the UK as an international leader in this space.

To become business-as-usual, the approach requires a market for the proposed services to be integrated into the present nonlocational frequency control and constraint services. This requires a collaboration between National Grid ESO as the co-ordinator of the overall service to the system and at least one DNO/DSO to facilitate the service provision with flexible resources. It can then grow to incorporate more DNO/DSOs operating in different regions. To support disseminating the knowledge we gain through this project, the approach will be tested against a wide variety of scenarios through simulations to demonstrate effectiveness. The requirements for participation in the regional response market are not onerous and will be published to facilitate competition in services and accelerate the uptake across UK energy sector. The functions of this new control will be validated by key stakeholders such as renewable generators and prospective market service providers ensuring their engagement.

SP Energy Networks is an electricity network owner with a mission to use our network in a smarter, more flexible way and harness available capabilities to drive economic and environmental benefits. The proposed solution enables SPEN to deliver better outcomes for its customers, both generators and energy users, through reducing the need for reinforcements and new connections, establishing and extending DSO services, a rapidly developing UK market. Co-operation with NGESO enables a whole-system approach to be taken where the network stability service needs are controlled at system level while the control of individual distribution-connected resources is managed within the Distribution network.

The GE Digital team in Edinburgh has strong relationships with early technology adopters such as Landsnet, Iceland and Australia which would be strong candidates for the next stages of internationalisation through using established channels to the global market. A reference case in the GB system would support replication in many other networks worldwide.

Costs

Total Project Costs

129908

SIF Funding

112222

This project has been approved by a senior member of staff

☑ Yes