nationalgridESO

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.

Network Licensees must publish the required Project Progress information on the Smarter Networks Portal by 31st July 2014 and each year thereafter. The Network Licensee(s) must publish Project Progress information for each NIA Project that has developed new learning in the preceding relevant year.

NIA Project Annual Progress Report Document

Date of Submission

Jul 2021

Project Reference

NIA_NGSO0034

Project Progress

Project Title

SHEDD – System HILP Event Demand Disconnection

Project Reference

NIA_NGSO0034

Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

May 2020

Project Duration

2 years and 1 month

Nominated Project Contact(s)

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Scope

Frequency plays a very important role in power transmission and distribution in relation to the balance between the demand and generation requirements of the network. The maintenance of system frequency within set levels is required to maintain stability and prevent a full system collapse. Under normal operating conditions National Grid Electricity System Operator (NGESO) is obligated to maintain the system frequency between 49.8 and 50.2 Hz.

Under exceptional circumstances (e.g. loss of a large generator) the frequency should not deviate outside the range 49.5 to 50.5Hz for more than 60 seconds. In order to achieve this, NGESO contracts frequency response to secure the power system for a number of events. There may be certain circumstances where the contracted frequency response may not be sufficient to maintain the system frequency between the statutory limits where the total loss of generation exceeds the amount secured for and a deficit of generation arises.

In order to reduce the generation deficit (or excess in demand) to maintain stability, Distribution Network Operators (DNOs) have low frequency relays to disconnect demand (LFDD). To comply with the requirements of the Grid Code, Western Power Distribution as a DNO is obligated to install LFDD schemes. The schemes are designed to automatically disconnect at least 60% of the total DNO demand on a stage by stage basis at the time of the forecasted national electricity transmission system peak demand. The demand subject to automatic low frequency disconnection is divided into 9 predetermined discrete MW blocks which are disconnected at defined low frequency levels. Each block of demand is distributed across each license area, so far as reasonably practical, so that the demand at different Grid Supply Point (GSP) sites is reduced evenly.

The current LFDD schemes do not take into account the growth of distributed generation and decreasing system inertia. The growth of distributed generation connected on DNO networks at voltage levels below where the LFDD relays are installed is likely to impact on the effectiveness of the scheme. If the level of distributed generation output is high when the relay is triggered, the amount of demand disconnected may be lower than expected. In addition, levels of system inertia are decreasing (e.g. due to the closure of traditional generation) along with net transmission system demand.

This reduces the effectiveness of LFDD schemes as changes in frequency will be faster and larger. Should the frequency fall at a high rate, more than one LFDD stage could operate resulting in too much demand being disconnected. These increasing changes risk the effectiveness of LFDD, impacting security of supply, unnecessary customer interruptions and price impact. If the LFDD scheme does not deliver the demand reductions required, the whole system is at risk; while if the response results in sub-optimal economic disconnection of customers, the economic impact (and so cost to consumers) of High Impact Low Probability events will be higher than necessary. Furthermore, an ineffective LFDD scheme could increase the risk of rolling brownouts / blackouts.

For example:
• The LFDD scheme is simplistic in design and overestimates the demand reduction achieved by operating LFDD relays

- Evidenced by 9 August event
- Current approach to determining magnitude of demand reduction from each relay is simplistic
- Unknown what volume of DG is also lost when a relay operates

• Load shedding does not take into account the variation in Value of Lost Load (VoLL) for different customer types.
• Vulnerable customers and safety critical loads are also not sufficiently protected by the current LFDD scheme.
• The performance of the scheme is decreasing as the uptake of Distributed Generation increases, and system inertia falls. This degradation of performance is expected to worsen with time.

Objectives

The objectives of the project is to design and test a new LFDD scheme to maximise its future performance as the network continues to decarbonisation, Distribution Generation (DG) integration increases, and system inertia continues to decrease.

Success Criteria

The project will be deemed a success if a proposed new LFDD design is proven successful in simulations and examined to be viable by Subject Matter Experts.

Performance Compared to the Original Project Aims, Objectives and Success Criteria

Project Overview

The project sets out to identify the shortcomings of the current LFDD scheme and opportunities to improve its performance. It will undertake this by:

- Building on current literature and taking into account thoughts from network operators and research groups.
- Investigate a new methodology to assess the effectiveness of the LFDD scheme and design options for future LFDD alternatives.
- Techno-economic analysis for the alternatives to capture the wider impact of such changes.

The project objective is to create the technical specifications and identify the necessary changes of the codes and operational strategies.

Project Plan

- WP 1 – Identify performance issues with current LFDD scheme (Timescale: 1.5 months)
- WP 2 – Establish a new methodology to establish VOLL within LFDD (Timescale: 2 months)
- WP 3 – Create new LFDD designs (Short & Medium Term) (Timescale: 5 months)
- WP 4 – Modelling of LFDD schemes against HILP events (Timescale: 2 months)
- WP 5 – Testing of new LFDD process to simulated HILP events (Timescale: 4 months)
- WP 6 – Reporting, Dissemination, (incl. Project Management) (Timescale: 1.5 months)

Project Activities

LFDD Schemes Review

Identification of the GB LFDD schemes shortcomings and opportunities to improve, resulting in the initial proposal of 8 alternative options.

1. Optimisation of LFDD Relay Settings
2. Disabling LFDD Relays During Power Export
3. Relocating LFDD Relays to Lower Voltages
4. Active Adjustment of Relays Settings (medium term)
5. Responsive RoCoF – based Demand Shedding
6. Responsive RoCoF – based Frequency Settings
7. LFDD Support from DERs
8. LFDD Functionality Delivered by Smart Meters

Alternative LFDD Designs

Initial design and shortlisting LFDD design options for Short-and Medium-term solutions. The following provides a summary of the shortlisted alternative LFDD scheme options proposed in Work Package WP3 (D3.1 [4]) and later re-classified in Work Package WP4 (D4.2 [5]) based on their technical, commercial, societal, and environmental performance.

Short-Term Design Options (<5 Years)

The short-term alternative solutions for the LFDD scheme are defined as those which represent least disruption to current ways of working, allowing the solutions to be implemented by GB DNOs within five years and with relatively limited additional cost or resource requirements.

1. Optimisation of LFDD Relay Settings

"Optimisation of LFDD Relay Settings" scored the best in Deliverable 3.1 and 4.2. This solution focuses on the optimisation of key parameters and settings associated with the LFDD schemes to maximise its technical performance. These parameters include the percentage of loads connected to each under-frequency stage of the LFDD scheme, under-frequency thresholds associated with each LFDD stage, frequency dead-bands, and the relay time delay settings.

These parameters can be re-optimised based on the dynamic characteristics and strength of each protected region, the associated consumer impact, and Value of Lost Load (VoLL) to improve the technical and economic performance of the targeted LFDD scheme.

2. Disabling of LFDD Relays During Power Export

This alternative solution requires the LFDD relay to be deactivated temporarily when the network connected downstream of the relay-protected area is exporting power from Distributed Generation (DG) sources. This prevents large quantities of DG from being disconnected from the network which would worsen the frequency drop associated with any HILP event. The relay will then be programmed to return to a default position (normal) when the protected network area returns to be a net importer.

Medium-Term LFDD Design Options (> 5 YEARS)

The medium-term LFDD alternative solutions were defined as those which are relatively more complex and sophisticated than the short-term options, with a lower Technology Readiness Level (TRL) or increased barriers to implementation.

3. Relocation of LFDD Relays to Lower Voltages (with disabling during power export functionally)

An output of D4.2 was the reclassification and shortlisting of short- and medium-term solutions. D4.2 also identified the potential to improve the performance of the “Relocation of LFDD Relays to Lower Voltages” by combining it with the “Disabling during power export functionality”.

This alternative LFDD solution combines the two topologies, moving the LFDD relays visibility from the 33kV network to lower voltages (11kV). This results in the redirection of the LFDD trip singles to the circuit breaker of primary transformers or/and outgoing feeders’ instead of tripping the entire substation. The performance of the “Relocation to Lower Voltages” can then be improved by temporarily deactivating the LFDD relays when the network connected downstream of the relays is exporting power from DG sources.

Consumer Impact

Through Work Package 2 Cornwall Insight have been assessing potential options to account for consumer impact within the LFDD scheme. The intention is to understand whether it is appropriate and possible to change how consumers are considered in the decisions about where LFDD relays should be placed.

In Deliverable 2.1 we noted there are a number of ways that consumer impact could be reflected. These were broadly categorised into two groups:

- Quantitative approaches – where Value of Lost Load (VoLL) data is used to determine the location and ordering of LFDD relays. VoLL is an administratively determined value to estimate the value that consumers may place on continued security of supply
- Qualitative options (non-VoLL based options) – where other approaches could be taken to differentiate between different customer types, including whether it would be possible or appropriate to differentiate customers that are defined as critical or essential, domestic or vulnerable

In Deliverable 2.2 we assessed these options on both a standalone basis, and against the technical LFDD options. We noted that:

1. In practice, DNOs are already accounting for customers in their placement of LFDD relays;
2. There is ongoing thinking by Government to progress two actions from the E3C report related to customers in the LFDD; and,
3. Recognising the nature of the LFDD scheme and the available technologies, quantitative options such as reflecting VoLL in the placement of LFDD relays would face a number of issues and be subject to a number of caveats and assumptions. For these reasons we do not believe VoLL should be used as an initial decision metric, but that it could be used in a ‘tie-breaker’ situation.

In Deliverable 2.3 we are setting out a methodology that could be used to assign substations with a value based on VoLL. This is based on the following assumptions:

- It would be appropriate to differentiate between different customer types in this way
- DNOs would welcome an additional decision-making tool based on VoLL to support their decisions
- VoLL data is available, and that data is appropriate for use in LFDD outages

The methodology is based on available data flows to estimate demand by different customer types for different substations.

Required Modifications to the Planned Approach During the Course of the Project

There have been no changes to scope, cost or approach.

Lessons Learnt for Future Projects

Interim project outcomes

The project has identified the shortcomings and opportunities to improve the LFDD scheme and nine alternative solutions have been proposed initially. These designs have been shortlisted and categorized into short and medium term solutions. The project then moved into the investigation of the performance of the designs in the technical, commercial and societal and environmental aspects. The results have been disseminated to the E3C workgroup and DNO workshops.

Review of benefits case

The project can improve the security of the system in the HILP event and also enable economic optimization to minimize disruption in such extreme events. Feedback gained from the dissemination event has been positive and there is potential for trial and implementation.

Next steps

Technical Specification & Barrier for Implementation (WSP):

Development of detailed technical specifications for the final shortlisted LFDD solutions, including a gap-analysis to fully understand the barriers to implementation while also presenting mitigation actions.

Consumer Impact (Cornwall Insight):

Development of a new methodology that can be used to establish an “up to date” view of the economic impact of disconnecting different customer groups and/or feeders during a HILP event and the practicalities of using this methodology.

Note: The following sections are only required for those projects which have been completed since 1st April 2013, or since the previous Project Progress information was reported.

The Outcomes of the Project

The project has identified the shortcomings and opportunities to improve the LFDD scheme and 8 alternative solutions have been proposed initially. These designs have been shortlisted and categorized into short and medium term solutions.

The project then moved into the investigation of the performance of the designs in the technical, commercial and societal and environmental aspects. The results have been disseminated to the E3C workgroup and DNO workshops (presentation attached).

Data Access

Details on how network or consumption data arising in the course of a NIC or NIA funded project can be requested by interested parties, and the terms on which such data will be made available by National Grid can be found in our publicly available “Data sharing policy related to NIC/NIA projects” and https://www.nationalgrideso.com/future-energy/innovation.

National Grid Electricity System Operator already publishes much of the data arising from our NIC/NIA projects at www.smarternetworks.org. You may wish to check this website before making an application under this policy, in case the data which you are seeking has already been published.

Foreground IPR

The following reports are expected to be released on to the Smarter Networks Portal:

- E3C workshop presentation.

Following completion of the project, the project deliverables will also be uploaded alongside the project completion report.