Date of Submission

July 2016

Network Innovation Allowance Closedown Report

Notes on Completion: Please refer to the appropriate NIA Governance Document to assist in the completion of this form.

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.

Project Closedown

Project Title

Reactive Power Exchange Application Capability Transfer (REACT)

Project Reference

NIA_NGET0100

Project Licensee(s)

Electricity North West Limited, National Grid Electricity Transmission, Northern Powergrid, Scottish and Southern Energy Power Distribution, Scottish Power Energy Networks, UK Power Networks, Western Power Distribution

Project Start Date

May 2013

Project Duration

2 Years

Nominated Project Contact(s)

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Scope

The proposed project will form the first building block required to answer the following two questions.

- How can voltages at 400kV & 275 kV be kept within statutory limits?
- What factors and trends are there that could be making transmission voltage control increasingly more problematic and/or costly under low load conditions and how do these influence reactive power?

In addition, it will crucially allow DNOs to understand the technical aspects to be tackled in order to comply with the European Demand Connection Code that will in a few years limit GSP exchanges to 0MVAr for load up to 25% of the GSP capacity.

Objective(s)

The key objectives are to determine:

- The key factors behind the significant decline in reactive power demand and the corresponding increase in the DNO system reactive power gain as observed at the Transmission/DNO interface (i.e., Grid Supply Point). During periods of minimum loading the reactive power demand has reduced from circa 7500 MVAr in 2005 to 2100 MVAr in 2013.
- The key factors behind the significant decline of the reactive to active power ratio (Q/P ratio) during periods of minimum demand. During the last 5 years, there has been a fall of 50% of the reactive power demand followed by a corresponding non-proportional fall of 15% of the active power demand.
- The relationship of all factors affecting the decline in reactive power demand at these interfaces during the same periods.
- The link to the upcoming requirements from the European Demand Connection Code changes expected in Demand Connection

Code.

Success Criteria

The success criteria will consist of five progress reports with specific outputs, these include:

A Four-month Report

- Selection of GSPs according to the adopted main criteria (see modelling approach)
- Analysis of GSPs based on National Grid data (i.e., reactive power exchanges)
- Report on the extent of data gathered during the corresponding period

Eight-month Report

- Initial results from the investigation of key factors affecting reactive power exchanges. This will be based on steady-state models of DNOs from GSPs to BSPs (or even primary substations depending on data availability).
- Report on the extent of data gathered during the corresponding period

First Year Report Stage 1

- A description of the key factors affecting the decline of reactive power demand.
- The extent that each factor is likely to change on a year by year basis.
- A summary of the likely change overall to reactive demand over the next 2 years.

Second Year Six-month Report

- Production of suitable transmission and distribution network models to deliver further studies.
- Demand and generation characteristics and corresponding correlation with voltage profiles. Studies based on the above network models.

Second Year Final report Stage 2

- Knowledge gap and operational database established for longer term forecast (up to 8 years).
- Summary of the likely change overall to reactive demand over the next 2 and 4 years.
- Automation of data capturing process inclusive of technological change and generation pattern.
- Estimation of potential investment based on the proposed forecast (next 2 and 4 years).

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

Project Overview

As described in National Grid’s System Operability Framework, http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/System-Operability-Framework/, the transmission system voltage containment during low loaded conditions is becoming increasingly challenging to manage. There are two dimensions to this challenge- the variable reactive power gain as a result of progressively lower transmission flow conditions in certain areas over time and the effectiveness of peripherally located connections, some of which with offshore networks may export reactive power when lightly loaded- and the historically fixed effect of the reactive balance at the interface. National Grid and other onshore TOs are in the process of installing a further 2.86GVAR's of compensation by 2017 to mitigate the variable reactive power gain and the GSP reactive power exchanges as projected in 2014, however- year on year these reactive exchanges become more capacitive in nature at a faster rate to the reduction in Active Power being observed presenting a challenging whole system forecasting position.

To address the gap of understanding in the trends being observed at the Transmission- Distribution (T-D) interface, National Grid, collaboratively in association with all DNOs and onshore TOs via the Electricity Networks Association commissioned the REACT project. This project enabled firstly by reflection of historic behavior within networks and relating to end user trends the construction of a holistic picture of the factors, which have driven past changes in the Q, P and Q/P performance of the interfaces considered. From identification of these factors some consideration of those most critical to performance at the interface may be identified and from these projections made for future behavior and processes identified to support such forecasting. Finally mitigations may be considered to respond to these issues.

REACT was intended to build analysis confidence in whole T-D modelling of the reactive exchanges influencing transmission behavior to provide confidence for further next steps of analysis "beyond REACT" further supporting both the forecasting and management of the project.

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

There have been no modifications to the project to date. There was an extension of data capture to encompass Scottish DNO networks that occurred at the 4 month report stage, but this did not delay progress.

A further additional 3rd year of project work has been proposed by the researchers which would be DNO focused work with the researchers exploring work focused specifically on the question of what practical measures, operational, specification and investment could address the decline in Q/P observed and evaluated in the current project scope. This proposal and further "beyond REACT" measures are in the process of being developed under the ENAs' High Volts Working Group, to be included in recommendations of its final reporting.

Lessons Learnt for Future Projects

Knowledge relating to a range of data exchanges between DNO's, the GBSO and TO's has been facilitated by this project highlighting those changes and assumptions most material to modelling the management of high voltage containment in future years. The project has provided further validation confidence that the within distribution system monitored behavior may be translated accurately towards the behavior at the interface. This is combined with advice provided in terms of the optimum approach to achieving this. In particular the manner in which no-load susceptance data is generated at lower voltage and the importance in the accuracy requirements for cable penetration and network extension assumptions using cables have been highlighted.

The lessons learnt which could be applied to future projects include:-

- Prior work to better facilitate data transfer and data availability ahead of project start.
- The process of embedding post-doc resource within the partner organisations in the early stages of data acquisition supported effective subsequent analysis of the data provided- promoting more knowledge sharing between project stakeholders and Universities, particularly focused on the practicalities of real network operation.
- Given the scope of the projects ambition and the volume of data obtained, in order to focus on delivery of the projects core modeling and forecasting understanding it was necessary for less emphasis to be given to more subjective considerations of the underpinning nature of changes within distribution systems driving those factors being trended in forecasting. Further work in this area may underpin "beyond REACT" work.
- Project REACT outcomes have been widely reported in paper submissions to international bodies, for example CIRED where the work underway has been identified as world leading, and has further together with subsequent German, Italian and French papers on this subject progressed the importance of this topic particularly within a European context.
- The open, collaborative approach across TOs, DNOs and the GBSO has yielded significant learning across a challenge of whole system dimensions and forms a potential template for future such engagements.

Specific to the objectives of this project, the following are key areas identified from learning that may be further developed under future projects

Analysis to date, focusing on critical GSP's has identified that the decline in Q/P at the transmission system interface is coincident with Q/P decline at lower voltage interfaces metered closer to the load within the DNO systems. The analysis on the network behaviours can demonstrate by modelling up to the GSP that the trend of decline observed may be modelled by the DNO systems provided studies of sufficient network granularity and sufficiently accurate and comprehensive metering is available. Further the criticality of accurate modelling of Distributed Generation effects has been identified as have methods to infer its historical operation where limited actual data is available so as to complete the network modelling picture.

Additionally , and potentially most significantly-it has been demonstrated that actual Q/P flows can only accurately reflect what is seen at the GSP transmission system interface if the submitted network data in planning exchange is significantly modified to increase the primary voltage(s) (33kV-132kV as applicable) network line susceptance values by between 15-20%. The original primary network data, it has been noted represents either historic CEGB data founded upon peak loading expression, or is of an incomplete nature where susceptance data has needed to be added to the study based on generic equipment data tables not including more modern conductor designs. Furthermore, it has been noted that in certain geographic areas there have been significant levels of network undergrounding and/or asset replacement of cable. Fundamentally the core conclusion has been that the degradation of Q/P can be modelled but that there needs to be a focus on model improvement within the DNO community to sustain & embed these techniques and that the most significant focus is on primary voltages (lower voltage network data accuracy is seen to be far less material). Further review of overhead line pi equivalents and cable parameters has been stimulated by this work. Finally the project has concluded that the GSP tap-changers, and those at lower voltages have not in general reached the point where there is no further range to support the growing high voltage containment problem, and that as such the imbalance in reactive power demand and generation arising within the DNO system is being transferred via tapping action to transmission level. The year on year degradation of tap range is however suggestive of this being an eventual issue which should be clarified in the forecast methodology to be developed.

In conclusion those factors most pertinent as identified from the work, Distributed generation assumptions and the undergrounding of associated network extensions, other network modifications affecting the gain of the EHV system, the changes in energy efficiency of supplied demand, can be combined with core predictions of active power supplied to generate bottom-up holistic forecasts, which have where there is overlap with current Future Energy Scenarios identified analogous levels of overall reactive compensation requirement from that separate work. Finally the optimality of the network location and operation of reactive compensation has been studied noting automated or time variant control can effectively minimize the effect the switching of compensation would otherwise have in losses and via optimal location of compensation within distribution systems provide up to 50% additional solution benefit over sub-optimally located solutions addressing the within distribution system trends.

Relative to the above, work is being initiated within NGET in the NIA South East Smart Grid project and the NIA project DIVIDE will support further developments and trends in load models and their voltage dependencies, together with a number of DNO sourced LCNF projects- for example the ENW CLASS project, UKPN Embedded Generation tool, WPDs network evolution work which further the core knowledge being generated within the REACT project. As discussed above the ENAs High Voltage Working Group was formed in May 2015 following initial REACT outcomes to pull together work across these areas to formulate a range of technical approaches to high voltage mitigation, and to recommend next steps of innovation work “Beyond REACT”. The findings of REACT are also being fed into the ENAs broad ranging review of P2, the demand security standard as is currently underway.

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 Reports provided at each stage and copies of salient CIRED and other reports on the work are included via the attached link. http://www.smarternetworks.org/Project.aspx?ProjectID=1460

This project meets in full overall NIA projects objectives.

Planned Implementation

1. Planned implementation is via planned data improvements as part of the GC042 changes in data exchange, and has further fed into the Embedded Generation project work NGET has initiated and the process as described in Grid Code working Group GC091 in GB implementation of the EU Demand Connection Code requirements surrounding reactive power exchange at the interface.
2. The REACT project has fed into industry work- most notably the ENA HVWG work which will further inform “beyond REACT” work.

Other Comments

The Project outcomes and results contain confidential information and intellectual property rights that cannot be disclosed in this Report due to their proprietary nature. Should the viewer of this Report (“Viewer”) require further details this may be provided on a case by case basis following consultation of all Publishers. In the event such further information is provided each and any Publisher that owns such confidential information or intellectual property rights shall be entitled to request the Viewer enter into terms that govern the sharing of such confidential information and/ or intellectual property rights including where appropriate formal licence terms or confidentiality provisions. Dependent upon the nature of such request the Publishers may be entitled to request a fee from the Viewer in respect of such confidential information or intellectual property rights.