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.

NIA Project Registration and PEA Document

Date of Submission

May 2015

Project Reference Number

NIA_NGET0156

Project Registration

Project Title

DNO Investigation into Voltage Interaction and Dependency Expectation (DIVIDE)

Project Reference Number

NIA_NGET0156

Project Licensee(s)

National Energy System Operator

Project Start

April 2015

Project Duration

3 years and 3 months

Nominated Project Contact(s)

Ben Marshall

Project Budget

£376,000.00

Summary

The intent of the project (DIVIDE):-

1. Across FY 2015/2016 conduct (with participating DNOs) a set of trials which repeat the project Juniper voltage reduction trial in particular DNO areas at particular times of day in the daily load cycle, against differing expectations of embedded generation. Before the trial the consultant would be involved in modelling the DNOs network and the various load responses within it, combining that with anticipated embedded generator response and from this provide estimates of the level of active power reduction for the voltage reduction applied at the interface ahead of the trial. In each DNO area, a minimum of two trials, for high and low expected embedded generation levels shall be conducted against high and low overall anticipated demand levels for that DNO.

2. The consultant with NGET will standardise the process by which the trials would be executed, liaising with the DNO such that it is possible to clearly model the anticipated outcome of trial. Monitoring requirements both at the interface and within the DNO system would be identified and delivered by NGET within the DNO system. The intent would be to utilise existing portable monitors for this purpose, rather than to purchase additional monitoring.

3. On completion of the trial those findings then made available would be with the estimates above in the consultants simulation and any effects of significant embedded generation or other forms of voltage control (e.g. power factor correction) identified.

4. From the comparison of each trial event, the intention would be to improve the accuracy and understanding of the next one.

5. At the end of FY 2015/2016; the final aspect of work would be, having modelled what we can expect today from demand control-work out what changes to control systems across users, DNOs and embedded generators might improve future voltage response and consider the areas of enabling that achieve that, with the intent being to construct the business case for the DNO going forward to implement with its future users these changes.

Based on these assessments, in conclusion the consultant would across the FES (Future Energy Scenarios) scenarios, and with consideration to future specification and technology, forecast how our voltage control might evolve over the next ten year horizon.

Nominated Contact Email Address(es)

box.so.innovation@nationalgrid.com

Problem Being Solved

This project seeks to gain an improved understanding and modelling capability of the existing voltage dependant behaviour of Active Power demand as may be instructed by the GB System Operator in part of Demand control activities to secure the supplies upon the transmission system at the time. From this improved capability this project shall seek to identify future capability and strategies which would maximise this capability going forward.

National Grid ("NGET") discharges the role of System Operator within Great Britain, ensuring that system demand and generation are continuously in balance in order to maintain system availability and reliability. To this end it may be necessary at times of particularly adverse network stress to exercise a degree of demand control to maintain this balance. This is an area of control required to remain within the operators repertoire as per Grid Code Operational Code 6 (OC6).

Traditional approach under Grid Code OC6 has been to under such emergency scenarios seek to reduce the voltage target at the Transmission/ Distribution interface as a method of achieving a reduction in demand. The benefit of this technique is that, unlike demand shedding, no physical load is disconnected, rather encouraged to consume less power, and accordingly there are no customer minutes lost, and no issues in disconnection and reconnection of load. This approach is founded upon the voltage dependant behaviour of motor loads, coupled with the normal operational principle of the distribution system which is to define the cascaded voltage profile of the radial distribution system to the point of load connection relative to, in effect the voltage targets assumed at the Transmission/ Distribution interface.

The assumption has been that a voltage reduction of 5% delivers a 3% reduction in active power, but this assumption has been subject to limited practical trials since privatisation. Under "Project Juniper" conducted across October 2013, this effect was trialed in a series of trial activities with the DNO community with the following consequences/ impacts concluded:-

- A much lower average behaviour of 1.5% reduction was achieved across the trials but there was much variance across DNOs.
- Little clarity and consistency on trials or on process for demand control across interface.
- Little understanding as to why effect was so small or so variable.

Under GC050, NGET investigated with the DNO community next steps responding to the outcome of the trial. This lead to Grid code change to OC6 placing a time limit on the time for demand control via voltage reduction to be achieved and noting the 1.5% expectation. However both SO and DNO community are concerned over practical ability to sustain this technique of demand control due to the low level of understanding of the issue and confidence of its resolution.

Method(s)

This project intends to address project objectives through the following Work Plans of activity:-

WP1.1 Review of the current demand basis and behavior based on available information.

WP1.2 Review of the current generation basis and behavior based on available information.

WP1.3 Simulation of response to voltage reduction anticipated from the current network

WP2.1 Assessment of DNO actions involved in trials

WP2.2 discussion and agreement with DNO to revised trial approach

WP3 Design, planning, and implementation of trials

WP4 Conclusions, proposals for improved control design, forecast of the future network challenge

Scope

The intent of the project (DIVIDE):-

1. Across FY 2015/2016 conduct (with participating DNOs) a set of trials which repeat the project Juniper voltage reduction trial in particular DNO areas at particular times of day in the daily load cycle, against differing expectations of embedded generation. Before the trial the consultant would be involved in modelling the DNOs network and the various load responses within it, combining that with anticipated embedded generator response and from this provide estimates of the level of active power reduction for the voltage reduction applied at the interface ahead of the trial. In each DNO area, a minimum of two trials, for high and low expected embedded generation levels shall be conducted against high and low overall anticipated demand levels for that DNO.
2. The consultant with NGET will standardise the process by which the trials would be executed, liaising with the DNO such that it is possible to clearly model the anticipated outcome of trial. Monitoring requirements both at the interface and within the DNO system would be identified and delivered by NGET within the DNO system. The intent would be to utilise existing portable monitors for this purpose, rather than to purchase additional monitoring.
3. On completion of the trial those findings then made available would be with the estimates above in the consultants simulation and any effects of significant embedded generation or other forms of voltage control (e.g. power factor correction) identified.
4. From the comparison of each trial event, the intention would be to improve the accuracy and understanding of the next one.
5. At the end of FY 2015/2016; the final aspect of work would be, having modelled what we can expect today from demand control-work out what changes to control systems across users, DNOs and embedded generators might improve future voltage response and consider the areas of enabling that achieve that, with the intent being to construct the business case for the DNO going forward to implement with its future users these changes.

Based on these assessments, in conclusion the consultant would across the FES (Future Energy Scenarios) scenarios, and with consideration to future specification and technology, forecast how our voltage control might evolve over the next ten year horizon.

Objective(s)

- Via further trials, improve modelling and understanding of the voltage dependant behaviour of load during periods of emergency voltage reduction
- Use this understanding to propose alternative control and design options for future connections
- Consider future challenges associated with new types of load/ generation connection and propose any alternative control strategies particular to these cases.

Use the improved modelling to further inform voltage dependent modelling and forecasting in representing the future range of control actions available.

Consumer Vulnerability Impact Assessment (RIIO-2 Projects Only)

n/a

Success Criteria

- To have WP1-3 completed in order to conduct trials across 2015/16 encompassing winter peak and summer minimum load conditions at high and low EG penetrations.
- To conclude upon alternative control approaches and confirm their technical viability in principle

Project Partners and External Funding

Not applicable.

Potential for New Learning

- Current Voltage dependent load modelling has not been updated since the 1970s- as such these models do not capture modern power electronic devices utilizing power factor correction and other constant current methods of dynamic control. The representation of “load” in this context, capturing micro and embedded generation also requires holistic understanding not being conducted elsewhere
- Demand control via voltage reduction whilst a recognized technical approach, equally is not frequently applied or trialed elsewhere in the world and in particular the experience in non-vertically integrated organisations is not strong. There is the potential for development of new process as well as modelling understanding. This understanding of process will improve confidence over the extent and timescales of practical delivery and provide valuable insight into areas of potential code change
- There are new challenges of different emphasis in the areas of voltage control today arising from embedded generation development, increased interconnection and greater power flow volatility, and the dynamics of power electronics controllers across periods of voltage control. There is potential for new learning, not only in better defining the space within voltage control occurs but also in defining the practical options for modifying voltage control
- There has been no previous activities in the area of the forecasting of demand responsiveness to voltage control in future years. Such analysis (proposed against the ETYS analysis timeframe of up to 2035) will inform and support future network forecasts, system operability and policy design.

Scale of Project

- The project encompasses-
- 2 ½ year project
- NGET project support, co-ordination across DNOs, control room and consultant. Validation and verification of study reports and models and model acceptance- 15 mandays/ year- 30 mandays in total
- Control room resource support- post event data, process and policy consideration & demand control activity Consultant cost & resource over the period.
- DNO support & facilitation of temporary system monitoring which may be installed on the distribution system. Note this scheme proposes no new system monitoring but will utilize existing temporary monitors as required.

(It may be noted that National Grid would periodically test its demand control via repeated trials and as such some of the control room resource in supporting the innovative trial form under DIVIDE, would subject to the success of DIVIDE, avoid the requirement for further Business As Usual trials, offsetting overall resourcing needs)

Technology Readiness at Start

TRL3 Proof of Concept

Technology Readiness at End

TRL4 Bench Scale Research

Geographical Area

National- various DNOs to be individually engaged over the trial

Revenue Allowed for the RIIO Settlement

None

Indicative Total NIA Project Expenditure

NGET NIA expenditure of £376,000

Project Eligibility Assessment Part 1

There are slightly differing requirements for RIIO-1 and RIIO-2 NIA projects. This is noted in each case, with the requirement numbers listed for both where they differ (shown as RIIO-2 / RIIO-1).

Requirement 1

Facilitate the energy system transition and/or benefit consumers in vulnerable situations (Please complete sections 3.1.1 and 3.1.2 for RIIO-2 projects only)

Please answer **at least one** of the following:

How the Project has the potential to facilitate the energy system transition:

n/a

How the Project has potential to benefit consumer in vulnerable situations:

n/a

Requirement 2 / 2b

Has the potential to deliver net benefits to consumers

Project must have the potential to deliver a Solution that delivers a net benefit to consumers of the Gas Transporter and/or Electricity Transmission or Electricity Distribution licensee, as the context requires. This could include delivering a Solution at a lower cost than the most efficient Method currently in use on the GB Gas Transportation System, the Gas Transporter's and/or Electricity Transmission or Electricity Distribution licensee's network, or wider benefits, such as social or environmental.

Please provide an estimate of the saving if the Problem is solved (RIIO-1 projects only)

The key benefit this project will provide is the value of improved understanding of current and future characteristics in demand response to voltage control which allow both DNO and GBSO to continue to effectively provide demand control as an alternative to demand disconnection as part of a suite of measures enabling the UK electricity supply to be economically and effectively managed.

Financial value may be quantified in the avoidance of demand disconnection and the attendant custom minutes lost cost saving potential which varies by DNO. Further value is derived from the modelling improvements which enable more streamlined TO investment to voltage issues more generally and more effective demand control and confidence in meeting Grid Code OC6 requirements, which whilst more difficult to quantify financially directly impact the planned resilience of the transmission system.

A cost estimate of the overall value of effective demand control can be estimated as up to £7m p.a. if it is possible in the development of the end measures under DIVIDE to get to the point of restoring active power reduction in response to voltage reduction from the current 1.5% to a previously expected 3% level. This value is calculated as follows:-

Demand reduction has the capability to avoid Energy Not Supplied in the two scenarios of 1) generation shortfall (£1m p.a.) and 2) in the event of an extreme frequency event which could lead to sustained demand disconnection (£6m p.a.). These costs are calculated based on the RIIO-T1 ENS incentive costing lost supply at £16k/MWHr.

For Scenario1, an annual likelihood of 0.016 (LOLE) is utilized consistent with the NGET 2014 Winter Outlook estimate of annual incidence, a notional benefit of 804MW- a 1.5% demand control benefit of the non-ACS corrected peak demand of 53.6GW (representing the median winter load) is calculated, together with a 5hr duration assumption for generation rescheduling of the event combine to produce the costs described above.

For Scenario 2, C17 annual reporting back to 1979 reports 45 events over the last 35 years where frequency has declined below 49.5Hz i.e. 1.3 events per year on average. Consistent with 2014 FES data illustrating a supplied volume of 347Twh currently an average demand across the year of 39.6GW may be calculated, and again the 1.5% benefit from demand control would translate to a notional benefit of 594MW of lost supply avoided. Based on the dynamics of frequency response, the duration for such lost supply would not be expected to exceed 30mins.

It is noted that against the above cost benefit, even if the DIVIDE project were only able to reinstate 0.075% of active power reduction during demand control (rather than the full 1.5% noted above), the savings in place of £350kp.a. from such improvement would more

than account for the project cost in the first year of saving alone.

Please provide a calculation of the expected benefits the Solution

Not required for Research Projects

Please provide an estimate of how replicable the Method is across GB

Improved modelling of demand enables a capability to further improve planning of £40m+ annual reactive containment costs across TO and DNO planning and operational study

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

Not appropriate. Publication and dissemination of knowledge at project completion will deliver this project's objective.

Requirement 3 / 1

Involve Research, Development or Demonstration

A RIIO-1 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 system software).

☑ A specific novel arrangement or application of existing licensee equipment (including control and/or communications systems and/or software)

☑ A specific novel operational practice directly related to the operation of the Network Licensees system

☑ A specific novel commercial arrangement

RIIO-2 Projects

☐ A specific piece of new equipment (including monitoring, control and communications systems and software)

☐ A specific piece of new technology (including analysis and modelling systems or software), in relation to which the Method is unproven

☐ A new methodology (including the identification of specific new procedures or techniques used to identify, select, process, and analyse information)

☐ A specific novel arrangement or application of existing gas transportation, electricity transmission or electricity distribution equipment, technology or methodology

☐ A specific novel operational practice directly related to the operation of the GB Gas Transportation System, electricity transmission or electricity distribution

☐ A specific novel commercial arrangement

Specific Requirements 4 / 2a

Please explain how the learning that will be generated could be used by the relevant Network Licensees

Learning will inform future NGET and DNO approaches across future demand control activity. Learning will further inform DNO on the range of control specification of demand and embedded generation that may support improved demand control characteristics. Finally both DNOs and NGET will benefit from the development of improved voltage dependent load modelling which results from this project.

Or, please describe what specific challenge identified in the Network Licensee's innovation strategy that is being addressed by the project (RIIO-1 only)

This project addresses the Voltage Control challenge identified in our System Operability Framework and supports the objectives of Grid Code OC6 and the feedback recently received to the consultation GC050 in relation to this area of Demand Control understanding

☑ Has the Potential to Develop Learning That Can be Applied by all Relevant Network Licensees

Is the default IPR position being applied?

☑ Yes

Project Eligibility Assessment Part 2

Not lead to unnecessary duplication

A Project must not lead to unnecessary duplication of any other Project, including but not limited to IFI, LCNF, NIA, NIC or SIF projects already registered, being carried out or completed.

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

There are no similar projects currently underway in UK or elsewhere in the world. Further, there is no overlapping between this work and work currently contemplated under national or European code review.

We note that this project is complementary to existing learning being generated under-

REACT- The consultant engaged will as appropriate work with REACT partners to build on learning developed in modelling the steady state behavior of the DNO networks subject to trial where the trial locations and the REACT study cases align. The development of voltage dependant models under DIVIDE suitable for Demand Control will also potentially have value in the later stages of REACT occurring coincidently and again where applicable this knowledge will be shared to best effect between projects.

CLASS- we are with ENW exploring at Bulk Supply Point and lower voltage transformation the potential value that may be obtained from deliberate modification of the voltage profile of the Medium Voltage systems. DIVIVE will build on the CLASS trials and modeling underway at present to identify how application of CLASS may effect Demand Control and also make use of the extensive data collected under this trial to ensure modelling and the resultant trials conducted under DIVIDE deliver optimal value.

Demand Side Response and broader Smarter Nework analysis- DIVIDE will in its trial provide further information on the increasingly dynamic behavior of Distribution networks and the factors which influence voltage dependant behavior. It is recognized that the end conclusions of the assessment where these pertain to new control or design assumptions will require broader industry engagement in these options and their implementation which will be achieved in the dissemination phase of the project following final reporting

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

n/a

Additional Governance And Document Upload

Please identify why the project is innovative and has not been tried before

n/a

Relevant Foreground IPR

n/a

Data Access Details

n/a

Please identify why the Network Licensees will not fund the project as apart of it's business and usual activities

n/a

Please identify why the project can only be undertaken with the support of the NIA, including reference to the specific risks(e.g. commercial, technical, operational or regulatory) associated with the project

n/a

This project has been approved by a senior member of staff

☑ Yes