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 Close Down Report Document

Date of Submission

Jul 2021

Project Reference

NIA_NGSO0035

Project Progress

Project Title

Optimal Coordination of Active Network Management Schemes and Balancing Services Market

Project Reference

NIA_NGSO0035

Funding Licensee(s)

NG ESO - National Grid ESO

Project Start Date

June 2020

Project Duration

1 year and 1 month

Nominated Project Contact(s)

Tolulope Esan (NGESO) and Matthew Watson (WPD)

Scope

National Grid's Future Energy Scenarios (FES) and System Operability Framework (SOF) show that the installed capacity of Distributed Generation (DG) has increased to 31GW in 2018 and is set to rise to a level of 38 – 69GW by 2030 across all FES scenarios. This significant growth of DG together with the development and adoption of smart grid technologies means that network operators, both transmission and distribution, have the need and the means to more actively manage flows on their networks. Thus, network operators are introducing Active Network Management (ANM) schemes to manage network assets, generation and demand dynamically in real time to increase the utilisation of network assets without breaching operational limits, reduce the need for reinforcement, speed up connection timelines and reduce costs.

As network operators (most notably Distribution Network Operators (DNOs)) start taking a more active role in managing flows on their networks, greater collaboration and coordination with the Electricity System Operator (ESO) is required to efficiently manage the overall power system.

The SOF shows that there is an increasing number of constraints on DNO networks that are likely to be managed by ANM systems over the next five years. Meanwhile, wider access to the Balancing Mechanism has been introduced and the ESO is increasingly procuring ancillary services from Distributed Energy Resources (DER). Without coordination of activities between the ESO and network operators, there is potential for:

- ANM schemes to counteract the ESO's balancing actions or to cancel out the effect of system services (e.g. STOR, DSR) procured from DER

- DER connected to ANM arrangements to be unnecessarily blocked from participation in balancing services markets

Both could lead to increased costs to the consumer and pose a risk to security of supply if system services are not delivered when required.

Opportunity for optimal coordination between ANM approaches and balancing services

To this end, there is a need to deliver an optimally coordinated design approach between ANM schemes and balancing services markets. It is critically important to ascertain and understand the synergies and conflicts associated with the potential for ANM schemes in networks inhibiting the delivery of ESO system support services through DER. Hence, this project proposes to:

- Engage collaboratively with the ESO and the DNOs to understand:
    1. the range of existing ANM schemes and volumes of DER connected downstream of constraints managed by ANM schemes; and
    2. the restrictions placed on the participation in balancing services markets of DER connected behind constraints which are managed by ANM schemes under existing commercial arrangements.
- Identify issues which could arise from the participation in balancing services markets of DER connected downstream of constraints which are managed by ANM schemes;
- Evaluate the potential for DER connected downstream of an ANM managed constraint to participate in balancing services markets in a coordinated manner;
- Identify and define different approaches to coordinating ANM schemes with balancing services markets and their associated technical and commercial requirements;
- Quantify and assess the costs and benefits of the different approaches to coordinated ANM schemes from the perspective of whole system techno-economic efficiency to determine the optimal coordination approach(es);
- Identify a way in which that optimal coordination approach can be delivered through identification and proposed resolution of limitations and barriers in the existing approaches and commercial frameworks; and
- Develop whole system principles of operation and control hierarchies for the procurement of system services from DER in order to inform the development of best practice guidelines for delivering whole system coordination in respect of other services procured in the future.

Objectives

The key objectives of this work can be described as follows:

- To identify and define different optimal T&D coordinated ANM schemes, their associated technical and commercial requirements as well as compatibility with existing industry codes and regulatory frameworks;
- To develop test cases and evaluate the ability of DER to participate in the ANM functions of the distribution system or in whole system balancing actions in a coordinated manner;
- To identify and define solutions that will optimize the coordination of ANM schemes with the balancing services market;
- To develop a delivery plan for deployment of the solutions
- To disseminate findings and recommendations to other network licensees.

Success Criteria

Success criteria for this project includes the following:

- Identification of the optimal T&D coordinated ANM schemes and their technical and commercial requirements;
- Identification and quantification of the costs and benefits from holistic T&D coordinated ANM approaches;
- Evaluation of the capability of DER to participate in ANM schemes on the distribution system and to contribute to whole system balancing actions in a coordinated manner performed and results and analysis verified with project partners;
- Framework for the techno-economic balance across distribution network management and whole system support service requirements produced;
- Solutions to optimise coordination of ANM schemes and balancing services market developed;
- Completion of real world consideration across an ANM design case study, including identification of barriers and limitations with integrating the ANM design with current commercial frameworks. Complement with simulation of potential solution performance; and
- Successful dissemination of acquired knowledge to the relevant industry sectors, including stakeholder workshops as appropriate.

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

National Grid Electricity System Operator ("NGESO") has endeavoured to prepare the published report ("Report") in respect of Optimal Coordination of Active Network Management Schemes and Balancing Services Market - NIA_ NGSO0035 ("Project") in a manner which is, as far as possible, objective, using information collected and compiled by NGESO and its Project partners

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Project Overview

NGESO's System Operability Framework (SOF) shows that there is an increasing number of constraints on DNO networks that are likely to be managed by ANM systems over the next five years. Meanwhile, NGESO's roll out of Wider Access to the Balancing Mechanism is increasingly procuring ancillary services from Distributed Energy Resources (DER). Without coordination of activities between the ESO and network operators, there is potential for:

- ANM schemes to counteract the ESO's balancing actions or to cancel out the effect of system services (e.g. STOR, DSR) procured from DER.
- DER connected to ANM arrangements to be unnecessarily blocked from participation in balancing services markets

As network operators (most notably Distribution Network Operators (DNOs)) start taking a more active role in managing flows on their networks, greater collaboration and coordination with the Electricity System Operator (ESO) is required to efficiently manage the overall power system.

This project looked to:

- To identify and define different optimal T&D coordinated ANM schemes, their associated technical and commercial requirements as well as compatibility with existing industry codes and regulatory frameworks;
- To develop test cases and evaluate the ability of DER to participate in the ANM functions of the distribution system or in whole system balancing actions in a coordinated manner.
- To identify and define solutions that will optimize the coordination of ANM schemes with the balancing services market;
- To develop a delivery plan for deployment of the solutions
- To disseminate findings and recommendations to other network licensees.

Project Plan

The project was structured into six distinct work streams (WS):
WS1: Identify and review current ANM schemes, their associated technical and commercial requirements, the risks which arise if ANM systems are uncoordinated with Balancing Services, and any coordination already in place

WS2: Develop test cases and high-level assessment of potential benefits of these test cases. Evaluate the ability of DERs to participate in ANM activities and develop network case studies reflecting different types of ANM schemes and the potential synergies and conflicts of DERs participating in ANM activities.
The final report for both WS1& 2 was delivered end of August 2020.There was a stage gate decision to made if there was merit in the potential benefits identified, to proceed to WS3. The go ahead to proceed was given by both NGESO and WPD.

WS3: Identification and definition of solutions to optimise coordination of ANM schemes and ESO balancing services market based on the Test Cases identified under WS2. The final report was issued at the end of October 2020. Another stage gate decision was needed to confirm the identified solutions were credible to proceed on to WS4. The go ahead was given to the project team.

WS4: Perform a cost benefit analysis of the network Test Cases and potential solutions through modelling and simulation. The final report was issued end of March 2021.

WS5: Delivery plan for practical deployment of feasible solutions. As determined under WS4, covering changes that would need to be made to the existing technical, commercial and market arrangements. The final report was issued mid May 2021.

WS6: Dissemination of findings and consideration of how those findings could be applied more widely to the simultaneous deployment of system services from DER by both DNOs and NGESO. The final report was issued mid May 2021 and an industry webinar was held

on 2nd June 2021.

Project Activities

For each of the Work Streams (WS) listed above, the project delivery team worked through each WS planned objectives. A bi-weekly project review team (involving the project delivery team, WPD and ESO representative) also took place, to review the WS progress and give guidance to the initial findings by the project delivery team. Upon issuance of the WS draft report, the WPD and ESO reps had a two-stage review process to comment on the report. After which a final report was issued, incorporating all comments.

For WS1 & WS2, the objectives were delivered over the months of May – July 2020.The findings were taken to the July Advisory group meeting for comments, the group included representatives from all the six Distribution Network Operator (DNOs), all the three Transmission Owner (TOs), ANM provider representative and generator representative. Comments received were included in the final report which was issued on the 22nd July 2020.

For WS3, the outlined objectives were delivered over the months of August – October 2020.The proposed solutions developed and an agreed network background to simulate network test cases (as identified under WS1 &2) were discussed at the bi-weekly meetings with NGESO & WPD, where feedback and comments were given to the project delivery team.

The preliminary list of proposed solutions:

W1 – Parallel decrementing instruction to DER and ANM
W2 - Preparatory incrementing instruction to ANM
W3 – Bring forward ANM curtailment ahead of gate closure
X1 – Improved communication with generators
Y1 – Risk based balancing services valuation
Z1 – Class and ANM separate operation
Z2 – Class visibility of ANM and coordination

These were presented at the August Advisory Group meeting, with feedback and comments received incorporated into the report. The draft report produced went through the two staged review process with NGESO and WPD for comments. The final report, incorporating all received comments was issued on the 23rd October 2020.

WS4 – The objective for this workstream was to further explore the preliminary list of proposed solutions (identified and developed under WS3) by carrying out a technical and cost benefit analysis of the nominated test cases and respective solutions. Using a set of criteria (technology readiness level, regulatory readiness, commercial readiness, complexity and impact of curtailment level) to assess the viability and merit of the identified solutions (under WS3), a shortlist of solutions was created. This reduced the seven identified solutions down to five (W1, X1, Y1, Z1 & Z2). To carry out the technical assessment of some of the shortlisted solutions (W1 and Z), the 132/11kV distribution network (North Tawton Bulk Supply Point), in WPD's South West licence area was selected as a case study to model and simulate the effect of ANM counteraction avoidance. The remaining three solutions (X1 and Y1) didn't require modelling and simulation to demonstrate technical feasibility. The results from the Power factory simulation was able to demonstrate solution W1 not counteracting an earlier issued Balancing services instruction to generators, downstream of the ANM, even though headroom was detected, this was due to prior hold instruction the ANM had received. In the case of the Z solution, the ANM action was only seen when the voltage was outside of the acceptable voltage band (between 0.94pu and 1.1pu).

A CBA was carried out using the shortlisted solutions and based on balancing services data from 2019/2020. This assessment considered three balancing services – Balancing Mechanism (BM), Firm Frequency Response (FFR) and Short Term Operating Reserve (STOR) to quantify the reduced counteraction and increased liquidity benefits that these solutions could deliver to the GB end consumer.

The technical assessment results and CBA results were presented at the February 21 Advisory Group meeting, with feedback and comments received incorporated into the report. The draft report produced went through the two staged review process with NGESO and WPD for comments. The final report, incorporating all received comments was issued on the 22nd March 2021.

WS5 - The objective for this workstream was to draw up a delivery plan for the deployment of the solutions by assessment of barriers to implementing the solutions and actions required to overcome these barriers by different parties across the industry. A systematic framework for assessing the potential barriers was designed, this comprise of technological, regulatory, commercial, financial, organisational and process related sources of barriers. Each of the identified solutions was assessed using the systematic framework, from which barriers to implementation was identified for the following parties: Generators, DNOs, NGESO, Ofgem and third-party providers of ANM solutions.
Activities required for implementation were drawn up to overcome the identified barriers. These activities were also allocated to the different parties, to ensure timely implementation.

The identified barriers and activities for parties to overcome these barriers were presented at the March 21 Advisory Group meeting, with feedback and comments received incorporated into the report. The draft report produced went through the two staged review process with NGESO and WPD for comments. The final report, incorporating all received comments was issued on the 12th March 2021.

WS6 – The objective for this workstream was to draw up wider applications of the learnings of the project and to disseminate the findings of the project. These were delivered with reports WS6.1 & WS6.2 over the months of April – May 2021.The reports went through a two stage review process by NGESO and WPD. The final report was issued on 10th May 2021.

A dissemination webinar to report findings from the project to a wider industry audience took place on 2nd June 2021. This was well attended with over 50 attendants. The presentation of the learnings of the project was well received.

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

Changes to scope and approach

There were no changes to initial agreed scope and approach used to deliver the project. There was a minor scheduling change to bring forward some of the modelling work that was included in WS4 so that it could inform WS3.

Changes to cost and programme
No change to cost and programme.

Lessons Learnt for Future Projects

Interim project outcomes

From the 5 shortlisted solutions (W1, X1, Y1, Z1 and Z2), only three (W1,X1 and Y1) were considered to be taken forward into implementation. Z1 and Z2 were not considered, due to limited benefit case from WS4 and the limited relevance of CLASS to wider industry.
For the three identified solutions to be implemented, an assessment framework, made up of six broad areas (Technological, Regulatory, Commercial, Financial, Organizational and Process related) was used to identify barriers and corresponding actions to overcome the barriers.

Below are the identified barriers and actions required for each of the solutions that will need to be addressed by different parties, for these solutions to be implemented as BaU:

1. A major change needed for solution W1 (parallel decrementing instruction) is secure communications infrastructure (where not already in place) between NG ESO and DNOs. There are also a number of regulatory and commercial reforms. The required actions for implementation would include:
   - Establishment of communication links consistently across GB with sufficient security (particularly if NG ESO interfaces directly with ANM controls), plus the associated investment and organisational changes required to accommodate communications.
   - Regulatory changes to allow and ensure compliance with NG ESO instructions to ANM systems.
   - Possible amendments to DNO forecasting of curtailment risk, and reflection of this in connection agreements.
   - Adaption of existing ANM systems if necessary to create functionality for holding headroom
2. One of the major changes required under solution X1 is detailed forecast information from DNOs to individual generators to enable them to make more informed commercial decisions regarding their participation in Balancing Services. From stakeholder engagement work, it is understood that this represents a significant change in existing DNO forecasting capabilities and will require industry participation to understand the limits of such forecasts. Key required actions for implementation would include:

- Communication links between DNOs and generators to allow for the provision offorecasting information, with appropriate security.
- Likely significant development of curtailment forecasting capabilities by DNOs.
- Regulatory changes to cover the frequency and quality of DNO forecasts, and risk tolerances around these.
- Process changes for generators to take account of DNO curtailment forecasts in commercial decisions.

3. The most significant change for solution Y1 is the creation of a risk-based framework, under which NG ESO would evaluate submissions made by generators to account for the potential risk of curtailment. This represents a fundamental change to the existing procurement of Balancing Services, and alongside technological considerations to ensure communications can take place, there are significant regulatory and commercial barriers to overcome. These include:

- As for solution W1, direct communication between NG ESO and DNO control rooms to provide information on ANM curtailment, with appropriate security in place.

- As for solution X1, DNO forecasting of curtailment risk to provide information to NG ESO, alongside ex-post identification of generators defaulting on Balancing Services due to network constraints. This is a significant organisational challenge to DNOs.
- The development of a risk-based framework by NG ESO – a fundamental change to existing arrangements – and the management of risk by NG ESO on behalf of consumers that was previously borne by generators. This represents a significant organisational challenge.
- Commercial risks around the process of NG ESO pricing in risk not being sufficiently transparent for industry participants, or treating generators fairly.

Dissemination

A dissemination webinar to present the learnings of the project to a wider industry audience took place on the 2nd June 2021.A link to the recording of the session and copies of the slide pack presented has been shared with all who registered for the webinar.

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's outcomes were delivered through six workstreams as detailed below:

WS1 looked to identify and review current ANM schemes, their associated technical and commercial arrangements, and the risks which arise if ANM systems are uncoordinated with Balancing Services. It also assessed any coordination between ANM systems and Balancing Services currently in place, and the planned future development of ANM schemes.

RANGE AND SCALE OF ANM SCHEMES:

Desk top research found that ANM schemes are becoming increasingly widespread on GB distribution networks, alongside the development of some schemes on the transmission network. The schemes vary in complexity and scale, but all have a similar purpose: to enable generation to connect to the transmission or distribution network more quickly and at lower cost by actively managing generation output to avoid breaching existing network limits, rather than undertaking network reinforcement.

Data provided by DNOs shows, as of January 2021, 6.7GW of generation was connected, or had accepted an offer to connect, to distribution ANM schemes. Most of that generation is renewable (primarily wind and solar) but there are some other technologies including gas generation. There is also at least 7GW of generation connected to the distribution network behind ANM constraints but whose output is not managed by the ANM system

RISKS OF UNCOORDINATED ANM SCHEMES

Coordination risks arise in instances where NG ESO procures Balancing Services from distributed assets that are behind network constraints managed by ANM schemes. Issues are most notable if the ANM scheme takes an action to manage generation in a given area which directly counteracts the effect of a Balancing Service procured by NG ESO – for example one generator increases output as instructed by NG ESO but in response the ANM scheme curtails another. This presents a risk to security of supply. It also increases costs to consumers as NG ESO must instruct another generator elsewhere to increase output to achieve the outcome it requires.

The main risks identified are:

- Risk of non-delivery by ANM generators
ANM generators may be curtailed when called to provide Balancing Services, and as such could be exposed to non-delivery penalties (depending on the service).
- Risk of unnecessary restrictions
ANM generators could be unnecessarily restricted from participating in Balancing Services (a recent example being ODFM, which explicitly excludes ANM generators). Actual curtailment levels may be very low, and a generator may in theory be able to participate in the service with little or no impact on delivery due to ANM. This restriction on market liquidity could increase costs for consumers.
- Counteraction risk
Non-curtailable generators can provide Balancing Services, but NG ESO may see the effect of procuring services from such generators counteracted by an ANM scheme curtailing (or realising curtailment on) an ANM generator. The non-curtailable generator does not face non-delivery penalties, but the net effect is not that desired by NG ESO, so further services will have to be called, increasing consumer costs. Risk of over-reaction

In some instances, a generator ramping output to provide a Balancing Service may do so faster than an ANM generator can ramp down. In this case, the ANM system may be forced to trip the ANM generator entirely and allow it to come back on the system when it is safe to do so.

EXISITNG COORDINATION

Where existing examples of coordination were identified, these broadly fell into two categories:

- Restrictions on the participation of ANM generators or non-curtailable generators in an ANM area in Balancing Services markets; and
- Coordination between network companies

A number of examples of restrictions on ANM generators participating in Balancing Services markets were identified. A key example was frequency response services. In a previous (2016) invitation to tender for Enhanced Frequency Response12 (EFR), it was clearly stated that to participate, “assets must not be in an existing area of Active Network Management”. This creates some ambiguity, specifically regarding whether it applies to non-curtailable generators in an ANM area, or just ANM generation. Engagement with DNOs revealed that non-curtailable generation in an ANM area will not always be aware that an ANM system is in place. In many cases it is likely that generators will be aware of the ANM scheme as the DNOs typically undertake proactive stakeholder engagement, but there is no formal requirement for those generators to be informed. Hence any restriction that excludes generators in an ANM area may not have the desired effect under current arrangements as the generator would not always be aware that it is excluded.

Coordination between DNOs and NG ESO was investigated through the stakeholder engagement work, which revealed limited interaction between parties on existing schemes. However, communication links (in the form of ICCP links) are being put in place as part of the Regional Development Plans (RDPs).

WS2 sought to define test cases against which to find solutions, based on the risks identified in WS1 of ANM schemes that were not coordinated with Balancing Services.

Identified Test Cases were split into three categories:

- Test Case 1: counteraction of Balancing Services by ANM systems.
- Test Case 2: ANM systems counteract Balancing Services provided by DNOs using the CLASS system.
- Test Case 3: Non-delivery of non-participation by ANM generators in Balancing Services due to ANM risks.

WS3’s aim was to set out solutions that would d be assessed further, based on the Test Cases set out in WS2.The identified solutions broadly fall into four categories:

- Reconfiguration of ANM schemes (solutions W1-W3)

These solutions focus on modifying the design, where necessary, of existing and new ANM schemes to either allow for NG ESO instructions to the ANM scheme, or alignment of ANM curtailment timescales with Balancing Services timescales.

- Improved information exchanges and coordination (solution X1)

This focuses on improving communication between ANM schemes and ANM generators, allowing generators to take informed decisions which avoid the issues identified in the Test Cases.

- Changes to market rules (solutions Y1 and Y2)

These solutions look to market-based remedies, either by accounting for non-delivery risk due to ANM in the processes used for procurement of Balancing Services, or broader changes to implement a market-based framework for allocating network capacity.

- Coordination with CLASS systems (solutions Z1 and Z2)

These solutions focus on aligning information between ANM and CLASS schemes, coordination of actions to avoid conflicts and apportioning compensation where necessary.

WS5 considered three solutions: W1,X1 and Y1, to assess the barriers to implementation, actions required to overcome these barriers and set out a proposed implementation plan. The solutions related to CLASS (Z1 and Z2) were not considered further, due to the limited benefits case from WS4 and limited relevance of CLASS to wider industry, with only one DNO adopting the technology to date.

More details on the barriers, actions and implementation plan are covered in the Planned implementation section below.

WS6 delivered on disseminating the learnings from the project to the wider industry through a webinar hosted on 2nd June 2021.

Data Access

Details on hownetwork 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:

WS1 and WS2 – Report on workstream one and two: review of current ANM schemes and development of test cases
WS3 – Report on workstream three: identification of solutions
WS4 – Technical & cost benefit analysis of the nominated test cases and respective solutions.
WS5 – Implementation plan: resolving conflicts between ANM and Balancing Services
WS6.1 – Report on workstream six: project learnings dissemination
WS6.2 – Broader application of learnings from the optimisation of coordination between ANM systems and operation of balancing services project

Planned Implementation

To deliver the three shortlisted solutions into BaU, this will require NGESO working with different stakeholders within the industry. The identified stakeholders are: Generators, DNOs, Ofgem and third party providers of ANM solutions.

IMPLEMENTING SOLUTION W1 - Most steps identified to support the implementation of solution W1 are envisaged to require action from NG ESO and DNOs. This reflects the direct communication between the two that sits at the heart of this solution. Table 2-1 (Project addendum), summarises the range of actions identified, and the responsible party to deliver the related actions.

IMPLEMENTING SOLUTION X1 - The actions identified for Solution X1 require significant effort on the behalf of generators. DNOs also have a large role to play in the implementation of this solution, reflecting the fact that the provision of forecast information to generators underpins this solution. Table 2-2 (Project addendum), summarises the range of actions identified, and the responsible party to deliver the related actions.

IMPLEMENTING SOLUTION Y1 - Most steps identified to support the implementation of solution Y1 are envisaged to require action from NG ESO and DNOs. This reflects the direct communication between the two that sits at the heart of this solution. Table 2-3 (Project addendum), summarises the range of actions identified, and the responsible party to deliver the related actions.

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.

Standards Documents

Not applicable.