NG ESO and WPD

BROADER APPLICATION OF LEARNINGS FROM THE OPTIMISATION OF COORDINATION BETWEEN ANM SYSTEMS AND OPERATION OF BALANCING SERVICES PROJECT

MAY 2021

WSP

BROADER APPLICATION OF LEARNINGS FROM THE OPTIMISATION OF COORDINATION BETWEEN ANM SYSTEMS AND OPERATION OF BALANCING SERVICES PROJECT

TYPE OF DOCUMENT (FINAL) WSP

PROJECT NO. 70066637

DATE: MAY 2021

WSP

8 First Street
Manchester
M15 4RP

Phone: +44 161 200 5000

WSP.com

Cornwall Insight

51-59 The Union Building Level
Norwich
NR1 1BY

Phone: +44 1603 604400

cornwall-insight.com

Complete Strategy

71 Central St,
London
EC1V 8AB

Phone: +44333 987 3119

complete-strategy.com

QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2
Remarks	First issue	First Revision	Final
Date	19.04.2021	28.04.2021	10.05.2021
Prepared by	Stewart Hynds (WSP) Abdullah Emhemed (WSP)	Stewart Hynds (WSP) Abdullah Emhemed (WSP)	Stewart Hynds (WSP) Abdullah Emhemed (WSP)
Signature			
Checked by	Manuel Castro (WSP) Andrew Anzor (CI) Vince Goode (CS)	Andrew Enzor (CI) Manuel Castro (WSP) Vince Goode (CS)	Manuel Castro (WSP)
Signature			
Authorised by		Anna Ferguson	Anna Ferguson
Signature			
Project number	70066637	70066637	70066637
Report number	70066637 – D6.2	70066637 – D6.2	70066637 – D6.2
File reference	70066637 – D6.2 First issue	70066637 – D6.2 First revision	70066637 – D6.2 Final

GLOSSARY

Abbreviation	Meaning
ANM	Active Network Management
BaU	Business as Usual
BOAs	Bid/Offer Acceptances
BM	Balancing Mechanism
BS	Balancing Service
CBA	Cost Benefit Analysis
ENW	Electricity North West
DG	Distributed Generation
DNO	Distribution Network Operator
DSO	Distribution System Operator
EV	Electric Vehicle
GB	Great Britain
GEMS	Generation Export Management Systems
IDSO	Independent Distribution System Operator
NG ESO	National Grid Electricity System Operator
NIA	Network Innovation Allowance
SO	System Operator
TO	Transmission Owner
WPD	Western Power Distribution

CONTENTS

EXECUTIVE SUMMARY

Active Network Management (ANM) schemes are becoming increasingly widespread on GB distribution networks. The schemes vary in complexity and scale; however, they share a common objective to facilitate the connection of Distributed Generation (DG) to distribution networks in a quicker way and at lower cost. This is achieved by actively managing DG output to avoid breaching existing network constraints, rather than undertaking expensive network reinforcement measures.

In recent years, National Grid Electricity System Operator (NG ESO) has allowed and increased the use of distributed energy resources for the provision of Balancing Services (BS). This has caused an increased risk of conflict between BS and ANM schemes with respect to accessing and managing distributed energy resources. In some circumstances, ANM actions counteract the effect of BS procured by NG ESO. But in some cases, there are also unnecessary restrictions on the participation of ANM generators in BS, reducing market liquidity and increasing consumer costs.

This NG ESO and Western Power Distribution (WPD) Network Innovation Allowance (NIA) project undertaken by WSP, Cornwall Insight, and Complete Strategy intends to optimise coordination between ANM systems and NG ESO's operation of BS. The previous work of the project has identified a number of Test Cases to understand the potential conflicts between the provision of BS and ANM schemes; identified a shortlist of solutions to resolve those conflicts; and assessed the potential barriers to roll out of these solutions.

The solutions have been categorised into three main groups, covering:

- Reconfiguration of ANM schemes;
- Improved information exchanges; and
- Changes to market rules.

In this report, the focus is given to identifying if learnings developed throughout this project have wider reaching application for Distribution Network Operator (DNO), Distribution System Operator (DSO) and NG ESO operational aspects. In order to demonstrate the wider benefits that may be ascertained, as well as the impacts on the future advancement of the power network and its operation, this report employs the ENA future worlds model as a reference/benchmark[1].

[1] ENA, "Developing change options to facilitate energy decarbonisation, digitisation and decentralisation," 2018, available at: https://www.energynetworks.org/industry-hub/resource-library/open-networks-2018-ws3-14969-ena-futureworlds-aw06-int.pdf

The report has reviewed and highlighted the key conflicts associated with progressing to the future worlds model of operation. Subsequently, each of the solutions taken forward into Workstream 5 (WS5) of this project were referenced and the aspects which could be used to alleviate some of the major transitional issues were highlighted. The key conclusions are as follows:

- The methodology employed in reconfiguration of ANM schemes (Solution W1) could be harnessed to reduce conflicts between ESO and DSO's when dispatching DG, either in the form of System coordination and operation and/or Flexibility market arrangements, as it helps alleviate issues with automatic response of generators as well as assisting in keeping ESO and DSO aware of system operational conditions/requirements.

- Solution X1 mainly concentrates on the communication between DNOs and ANM generators for curtailment forecasting. Whilst this report mainly focuses on ESO and DSO related conflicts/solutions, information is essential to all stakeholders to make informed decisions (i.e., generation companies have invested and/or are potentially thinking of investing in a part of the network). As networks become more congested, the level of information granularity required will need to increase to assist in quantifying financial return. The learnings of this solutions show potential promise to feed into the developments of streams of work that enhance prognostic forecasting to give more granularity to generators and system operators.

- Finally, solution Y1 entails the development by NG ESO of a risk-based framework for the dispatch of BS based on granular forecasts from the DNO on the risk of ANM curtailment. If a risk model could be used to assist in the procurement of BS and ANM to avoid conflict, a similar approach could be applied to other services too. For instance, this solution could potentially be used as a framework for other services in order to minimise risk of procuring generation and thus increasing the likelihood of conflict avoidance and economical/efficient generation dispatches.

1 PROJECT OVERVIEW

WSP[2], Cornwall Insight[3] and Complete Strategy[4] are undertaking a Network Innovation Allowance (NIA) funded project on behalf of National Grid Electricity System Operator[5] (NG ESO) and Western Power Distribution[6] (WPD). The project investigates the optimal coordination of Active Network Management (ANM) schemes on both the distribution networks with Balancing Services (BS) markets.

1.1 BACKGROUND

NG ESO's Future Energy Scenarios[7] (FES) and System Operability Framework[8] (SOF) show that the installed capacity of Distributed Generation (DG) increased to 31GW in 2018 and is set to rise by a further 38GW to 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 manage flows more actively on their networks.

DG often connects in clusters on the distribution network, in many cases due to natural resources and land availability (e.g., high concentrations of solar in the South West and high concentrations of wind in Scotland). As a result, it has the potential to breach operational limits on both the local distribution network, where it is connected, but also on the upstream transmission network in that area.

The volatility of renewable power generation makes the process of balancing the network more challenging and this is likely to be intensified as more sources are incorporated into the power network to meet net zero.

ANM is one of key technologies widely adopted on the GB electricity network to enable connection of DG and renewables to distribution networks quicker and at lower cost. ANM schemes are normally designed and operated to control the output of DG to avoid breaching existing network limits, while avoiding the need for expensive network reinforcement solutions.

However, as the number and scale of ANM schemes increases, so does the volume of existing distributed resources which are not controlled by ANM schemes (so called non-curtailable generators[9]) connected within the networks managed by ANM schemes. This gives rise to an increased risk of conflict between delivering BS and ANM schemes. ANM actions can counteract the effect of the BS procured by NG ESO from non-curtailable generators.

2 https://www.wsp.com/en-GB
3 https://www.cornwall-insight.com/
4 https://complete-strategy.com/
5 https://www.nationalgrideso.com/
6 https://www.westernpower.co.uk/
7 http://fes.nationalgrid.com/
8 https://www.nationalgrideso.com/insights/system-operability-framework-sof
9 It refers to generation which is downstream of a constraint being managed by an ANM scheme but is not itself controlled by that ANM.

1.2 PURPOSE OF THIS REPORT

This report concludes part WS6-2 of Workstream 6 (WS6).

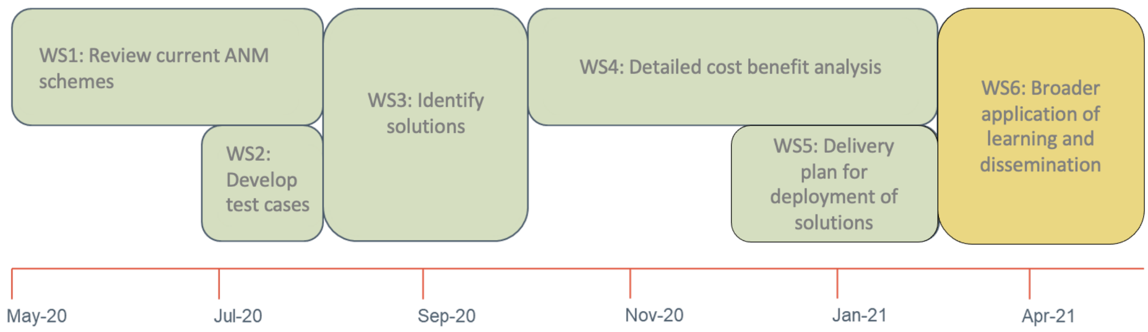

Figure 1-1: Project Workstreams

This report focuses on the broader application of learnings conceived during this project.

1.3 REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2: presents an overview of ENA future worlds which provides a reference and aids in quantifying the transferable benefits of the projects' learnings.
- Section 3: provides a description of potential conflicts that are associated to a selected future world scenario.
- Section 4: highlights solutions to conflicts via learnings.
- Section 5: summarises key conclusions of the report.

2 OVERVIEW OF ENA FUTURE WORLD SCENARIOS

This section provides an overview of ENAs' Future Worlds which will be used as a benchmark to define how knowledge gained via this project can be applied to other applications and aid in the development of energy markets of the future[1]. Firstly, a brief overview of different cases (i.e. Future Words) will be provided. This will then be followed by the selection of one 'world' which will be considered as a test case to demonstrate the wider application of learnings.

2.1 OVERVIEW OF FUTURE WORLD SCENARIOS

The ENA Open Networks Project consulted industry on a number of potential future market models. The models considered how future industry structures could best deliver flexibility markets providing services from distributed energy resources (DER) for both national and regional (at transmission and distribution levels) requirements.

The Worlds (i.e. models) take a whole system view and illustrate the impacts on a wide range of stakeholders for a given 'world'. Five future worlds were developed which represent a wide range of potential options, and focus was given to aspects such as grid connections, commercial arrangements, flexibility market arrangements, system coordination and operation, and network design and development[1].

The Worlds are summarised as follows:

World A: DSO Coordinates - a World where the DSO acts as the neutral market facilitator for all DER and provides services on a locational basis to NG ESO.

World B: Coordinated DSO-ESO procurement and dispatch – a World where the DSO and NG ESO work together to efficiently manage networks through coordinated procurement and dispatch of flexibility resources.

World C: Price-Driven Flexibility – a World where changes developed through Ofgem's reform of electricity network access and forward-looking charges have improved access arrangements and forward-looking signals for Customers.

World D: ESO Coordinate(s) – a World where NG ESO is the counterparty for DER with DSO's informing NG ESO of their requirements.

World E: Flexibility Coordinator(s) – a World where a new national (or potentially regional) third-party acts as the neutral market facilitator for DER providing efficient services to NG ESO and/or DSO as required.

Future worlds A, D and E have the potential to avoid the conflicts identified under this project, by ensuring a single party is responsible for dispatching flexible resources. World C can be thought of as a "layer" on top of all other worlds – Ofgem's network charging reforms may well introduce sharper cost signals, but they will likely need to co-exist with flexibility procurement. World B is closest to status quo, with the ENA having identified that other Worlds are only likely to develop in the longer term, as shown in Figure 2-1.

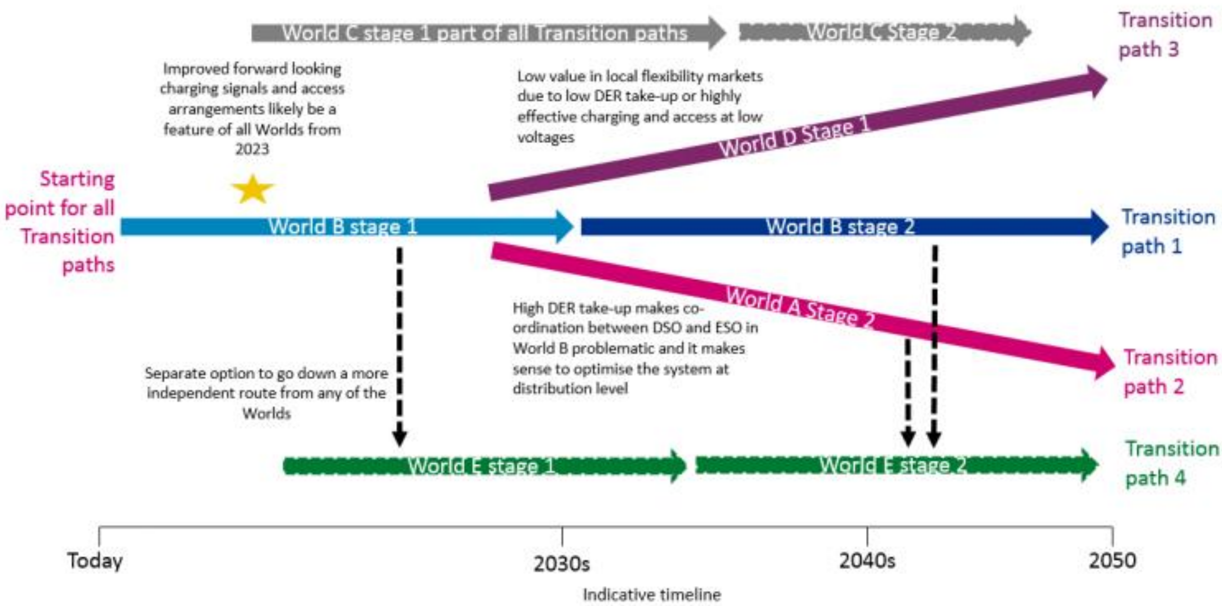

Figure 2-1: Future World Transition Pathways[1]

As a result, tor the remainder of the report, Future World B will be selected to illustrate the wider applications of learnings via this project. In addition, particular aspects of this world have been trialled and tested via real-world filed trials across network innovation projects in Great Britain (GB).This will in turn lead to some level of conflict which will require a higher degree of coordination between the ESO and DSOs to resolve as they arise. Figure 2.2 illustrates the flexibility market arrangements for World B and subsequent to this a summary is provided for the inherent characteristics and methods of working.

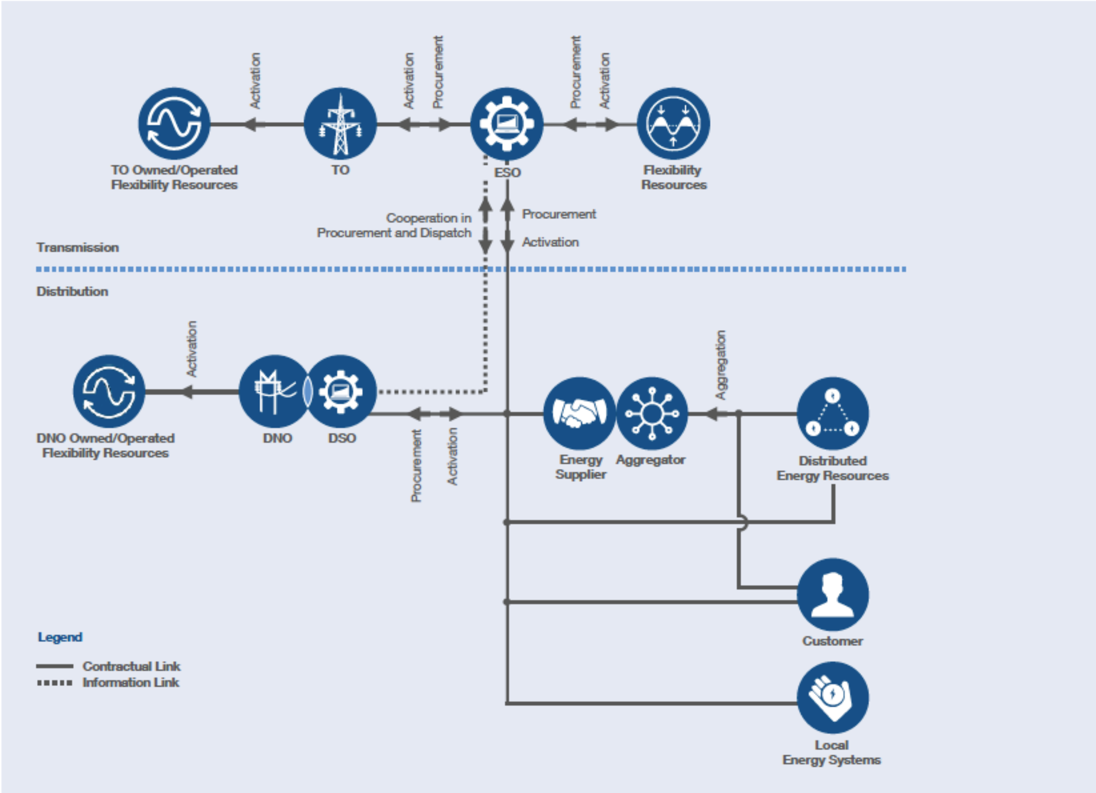

Figure 2-2: World B – Coordinated DSO -ESO procurement & Dispatch -Flexibility market arrangement[1]

Grid connections and commercial arrangements

All Customers wishing to connect to distribution networks will discuss their development with their local DSO (or IDSO). Where this causes potential issues across the transmission – distribution interface the DSO will discuss with NG ESO and submit a 'Transmission Impact Assessment' (or similar) request to ensure coordinated development of networks. Developers wishing to connect to transmission networks would speak to NG ESO who would develop a connection offer in collaboration with the host Transmission Operator (TO), and Developers wishing to connect to distribution networks would speak to DSO/IDSO who would develop a connection offer in collaboration with the host DNO/IDNO. World B has not seen significant change to charging and access arrangements.

Flexibility market arrangements

In this World, there could be a central ancillary services market for flexibility resources connected at the transmission and distribution networks providing services to NG ESO and some DSOs similar to the current Balancing Market. NG ESO will procure services for both national needs and also regional transmission requirements. Additionally, there could be coordinated regional and local markets for flexibility resources connected to the distribution networks facilitated by the host DSO. NG ESO and DSOs will work together to ensure efficient procurement and dispatch decisions are made across these markets to optimise procurement in a transparent manner and manage any conflict of service provision.

System coordination and operation

System coordination and operation interfaces will remain similar to today with DSO and NG ESO control rooms working together to ensure security of supply and asset safety. It is recognised that the future will have an increased number of active participants connected to distribution networks. This will increase the requirement for coordination between System Operators (SOs) whose processes will need to evolve to manage increased uncertainty in system flows and demands. Emergency restoration processes will also need to evolve recognising the increased number of options through the availability of Black Start DER.

Network design and development

Technical and commercial discussions between SOs will continue to be held similar to existing processes to ensure overall efficient network development. There will be an increased need for overall coordination of network and non-network solutions to meet future system needs. SOs would continue to have responsibility for the strategic design of their responsible networks. In the case of NG ESO, this would require discussions with the TO on detailed development requirements. A transparent process would exist to look at solutions to transmission needs from non-network and distribution options.

3 CONFLICTS WITHIN FUTURE WORLD B

This section highlights the most prominent conflicts that could emerge between NG ESO and DSOs in relation with the development of an operational framework similar to that of Future world B. As detailed in the ENA report[1], there are two main conflicts, however these are rather similar but applied to different commodities.

System coordination and operation

Conflicts of procuring and/or dispatch of generation by NG ESO and DSOs are likely. In World B, NG ESO procure and dispatch services to deliver requirements for national and regional needs while DSOs procure and dispatch services for regional requirements. This cross-over, especially in the regional sense has the potential to hamper each stakeholder and adds a layer of confusion both for bidding and dispatch, as well as in adding complexity to interpreting the loading of power network. The conflicts identified between ANM and Balancing Services are one example of such conflicts – the DNOs ANM schemes curtail generators to manage local constraints while NG ESO may also be procuring Balancing Services from those generators for national requirements.

Flexibility market arrangements

Similar to that aforementioned for system coordination and operation, there is the potential for conflicts in the procurement and/or dispatch of Ancillary services e.g., assume a large generator on the system is lost resulting in a frequency dip, thus more real power generation is required to offset the dip, however, if a large battery system is contracted by the DSO to draw reactive power to suppress voltage, then this has the potential to lead to operational challenges and challenges for the battery system owner to know how to respond without being penalised.

4 SOLUTIONS TO CONFLICTS VIA LEARNINGS

This section outlines how learnings through the project, whilst developing solutions, could be applied to that of future world scenarios and/or demonstrate its wider potential to contribute to developing future market models.

During the Project, several solutions were developed, and the solutions were narrowed down to three as reported in the project workstream 5[10]. Each is discussed below as well as how each may be harnessed to assist in wider application in the future.

4.1 SOLUTION W1 - RECONFIGURATION OF ANM SCHEMES

This solution focused on modifying the design, where necessary, of existing and new ANM schemes to allow for NG ESO instructions to the DNO's Distribution Management System (DMS), which would in turn be converted by the DNO into instructions to the ANM scheme. Those instructions would require the ANM to hold headroom in the specific instance when that headroom is created by NG ESO instructing a generator connected downstream of an ANM constraint to reduce output. Figure 4-1 below presents the sequences and required interaction between different parties to enable this solution.

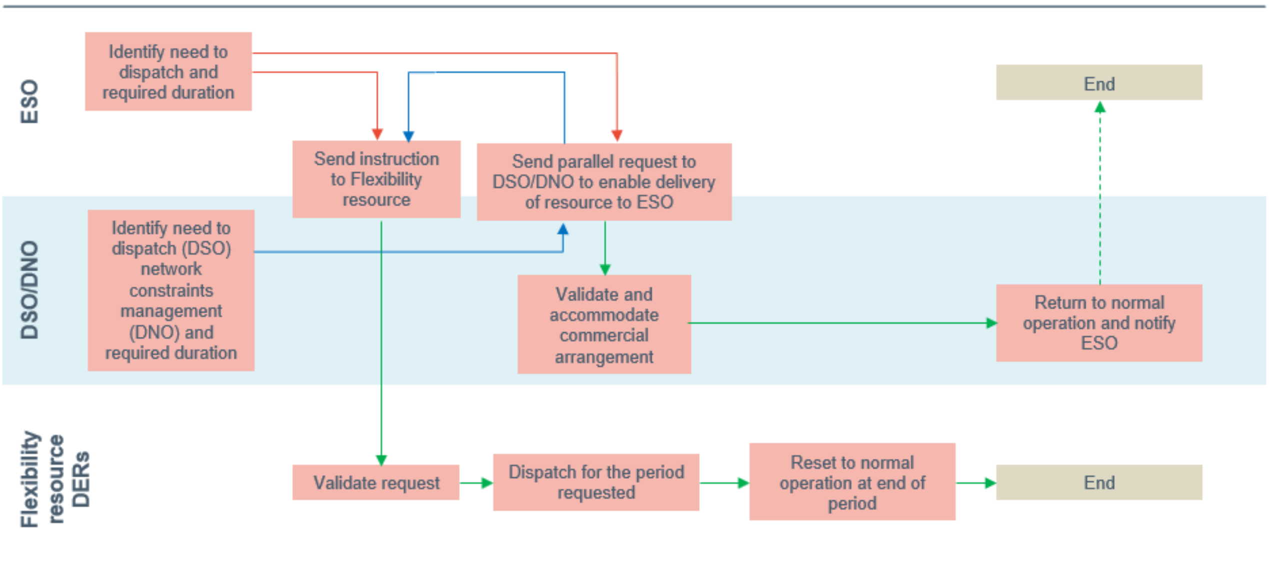

Figure 4-1: Overview of process associated with solution W1

This methodology has the potential to reduce conflicts between NG ESO and DSOs when dispatching generation either in the form of System coordination and operation and/or Flexibility market arrangements. The capability to hold headroom aids to alleviate automatic response of generators and assist in keeping all stakeholders informed. It could be thought of as the generation dispatch

[10] Workstream 5 deliverable WS5: Delivery plan for deployment of solutions," 2021.

equivalent of interlocking for protection systems, that holds headroom and stops overloading of the network. It must be noted that this report does not state if NG ESO or DSO should be given priority of dispatch. A framework would need to be agreed between relevant parties.

4.2 SOLUTION X1 - IMPROVED INFORMATION EXCHANGES AND COORDINATION

This solution focuses on improving communication between ANM schemes and ANM generators (see Figure 4-2), allowing generators to take more informed commercial decisions based on the likelihood of ANM curtailment. DNOs would likely issue forecasts to generators over a range of timeframes (from broad forecasts a month ahead through to week ahead, day ahead and hour ahead timescales), enabling generators to commit assets to different services based on their varying procurement timeframes.

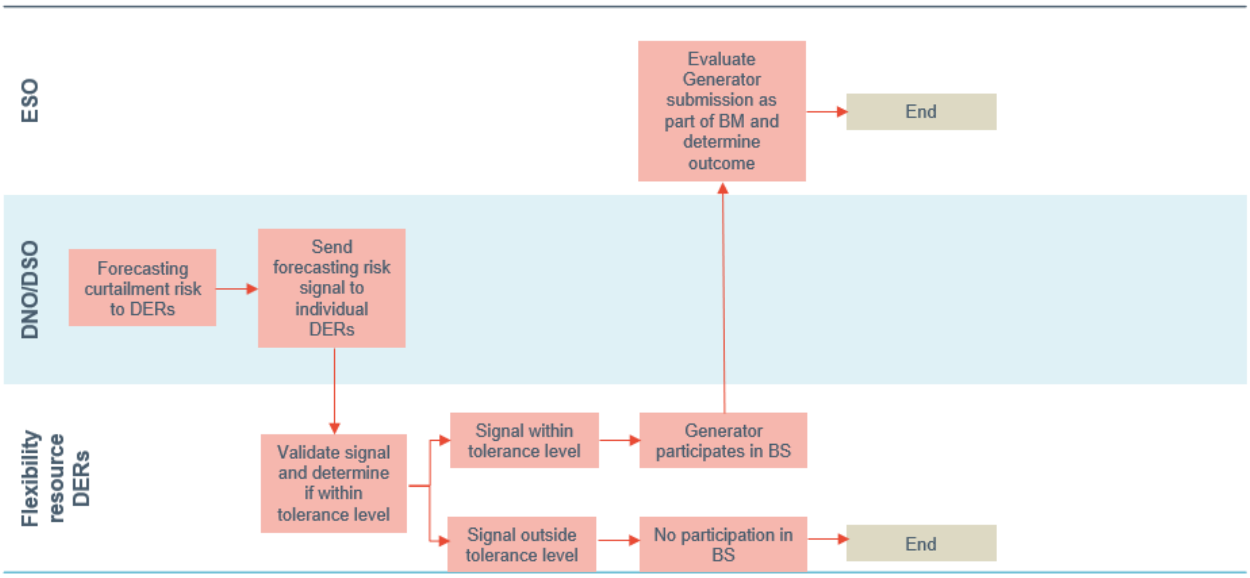

Figure 4-2: Overview of process associated with solution X1

Whilst this report mainly focuses on the DSO and NG ESO related conflicts, the learnings from this solution have potential in other areas. Information is essential to all stakeholders to make informed decisions i.e., generation companies that have invested and/or are potentially thinking of investing in a part of the network as things become more congested, the level of information granularity will increase to assist in quantifying financial return. The learnings of this solutions show potential promise to feed into the developments of streams of work that enhance prognostic forecasting to give more granularity to generators and system operators.

4.3 SOLUTION Y1 CHANGES TO MARKET RULES

This solution looks to market-based remedies by accounting for non-delivery risk due to ANM in the processes used for procurement of Balancing Services.

For NG ESO, a risk-based framework would be established to evaluate information provided by DNOs on curtailment risk for each ANM scheme. This framework would be used for selecting Balancing Service offers based on both price and curtailment risk where generators are connected downstream of ANM constraints. This view of risk would be used to evaluate generator submissions as part of Balancing Services. Solution Y1 looks at ways of 'splitting' risk between stakeholder's dependent on who is responsible for ANM not being able to provide required output i.e., if a generator is requested to provide increased output and there are no issues with the power network and no ANM curtailment, non-delivery penalties will apply. However, if non-delivery is because of a fault on the network or the generator is curtailed by the ANM scheme; a waiver on penalties will be imposed and the generator will be paid as if the service was delivered. To determine whether penalties are required, DNOs would be required to undertake an ex-post assessment where non-delivery is identified, and to communicate their findings to NG ESO. This assessment would be used to ensure that appropriate payments are made as part of the settlement process.

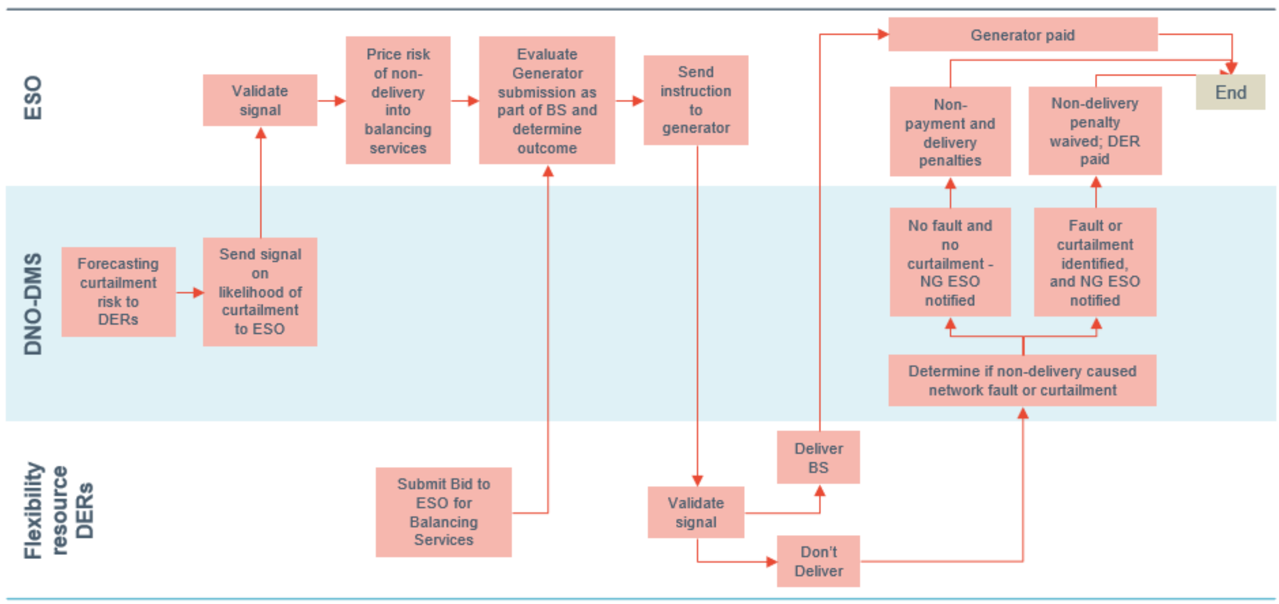

Figure 4-3: Overview of process associated with solution Y1

This solution whilst applied to ANM and balancing services in this instance could potentially be used as a framework for other services in order to minimise risk when procuring generation and thus increasing the likelihood of avoidance of conflict and more efficient procuring of service.

5 CONCLUSION

The report has provided example applications of how the learnings gained over different workstreams of the optimisation of coordination between ANM systems and balancing service (BS) project can be applied beyond this project, and how these learnings may aid to mitigate challenges associated with the integration of flexible services and NG ESO/DSO generation procurement/dispatch, to create a workable framework.

In this report ENA future world B was used as a case to demonstrate broad application of learnings. The main conflicts related with attaining a framework similar to that of future world B were highlighted, and how the learnings developed over the span of the project could be applied to develop solutions for each of these conflicts was demonstrated. These can be summarised as follows:

- The methodology employed in Solution W1 could be harnessed to reduce conflicts between NG ESO and DSOs when dispatching generation either in the form of System coordination and operation and/or Flexibility market arrangements as it helps alleviate automatic response of generators.

- Solution X1 mainly concentrates on the communication between DNOs and ANM generators for curtailment forecasting. Whilst this report mainly focuses on ESO and DSO related conflicts/solutions, information is essential to all stakeholders to make informed decisions i.e., generation companies that have invested and/or are potentially thinking of investing in a part of the network as things become more congested, the level of information granularity will increase to assist in quantifying financial return. The learnings of this solutions show potential promise to feed into the developments of streams of work that enhance prognostic forecasting to give more granularity to generators and system operators.

- Finally, solution Y1 entails the development by NG ESO of a risk-based framework for the dispatch of BS based on granular forecasts from the DNO on the risk of ANM curtailment. If a risk model could be used to assist in the procurement of BS and ANM to avoid conflict, a similar approach could be applied to other services too i.e. this solution, whilst applied to ANM and balancing services, in this instance, could potentially be used as a framework for other services in order to minimise risk of procuring generation and thus increasing the likelihood of conflict avoidance and economical generation dispatches.