NG ESO and WPD

OPTIMAL COORDINATION OF ACTIVE NETWORK MANAGEMENT SCHEMES WITH BALANCING SERVICES MARKETS

Report on workstream six: project learnings dissemination

MAY 2021

WSP | CORNWALL INSIGHT | COMPLETE STRATEGY

OPTIMAL COORDINATION OF ACTIVE NETWORK MANAGEMENT SCHEMES WITH BALANCING SERVICES MARKETS – LEARNINGS DISSEMINATION

WSP | CORNWALL INSIGHT | COMPLETE STRATEGY

PROJECT NO. 70066637

DATE: MAY 2021

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QUALITY CONTROL

Issue/revision	First issue	Revision 1	Revision 2	Revision 3
Remarks	First issue	First revision		
Date	19/04/2021	07/05/2021		
Prepared by	Tom Goswell	Tom Goswell		
Signature				
Checked by	Andrew Enzor			
Signature				
Authorised by				
Signature				
Project number	70066637	70066637		
Report number	70066637 – D6.1	70066637 – D6.1		
File reference	70066637 – D6.1 First issue	70066637 – D6.1 First revision		

GLOSSARY

Abbreviation	Meaning
ANM	Active Network Management
BaU	Business as Usual
BOAs	Bid/Offer Acceptances
BM	Balancing Mechanism
CBA	Cost Benefit Analysis
CEP	Clean Energy Package
CLASS	Customer Load Active System Services
ENWL	Electricity North West Limited
DC	Dynamic Containment
DLH	Dynamic Low High
DNO	Distribution Network Operator
DPL	DIgSILENT Programming Language
EV	Electric Vehicle
FFR	Firm Frequency Response
GB	Great Britain
GEMS	Generation Export Management Systems
LIFO	Last In First Off
NG ESO	National Grid Electricity System Operator
NIA	Network Innovation Allowance
STOR	Short Term Operating Reserve
TRL	Technology Readiness Level
VDL	Voltage Dependent Load
WPD	Western Power Distribution

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EXECUTIVE SUMMARY

This project sought to set out and propose solutions to address the risks of Distribution Network Operator (DNO) Active Network Management (ANM) schemes which are uncoordinated with National Grid Electricity System Operator (NG ESO) Balancing Services. A range of learnings have been drawn from the research over several workstreams, coming from desktop research, quantitative analysis, bilateral stakeholder engagement and workshops an Advisory Group of ~20 stakeholders.

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 to date 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. ANM schemes benefit consumers by minimising the costs of connecting new, often low carbon, generation, which helps to decarbonise the network and reduce costs to consumers.

At the same time as ANM scheme use is increasing, NG ESO is increasingly using distributed assets for the provision of Balancing Services (including the Balancing Mechanism, response and reserve services). This benefits consumers by increasing market liquidity and ultimately reducing costs.

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.

This project aimed to determine approaches to optimal coordination of ANM with Balancing Services, to address the core problem statement:

ANM schemes which are not coordinated with wider Balancing Services markets will increase costs to consumers and may pose a risk to security of supply.

Two broad categories of coordination issues were identified. The first concerned ANM systems counteracting the effect of Balancing Services provided by distributed generators. The second concerned non-delivery or non-participation by distributed generators in Balancing Services due to the risks associated with ANM schemes.

Three key solutions to the coordination issues found have been shortlisted and put forward, with the barriers assessed and identified. These could be taken forward in further project work to trial their implementation. It is noted that while we have focused on distributed generators, these solutions could also be adapted and applied to similar issues for demand customers as ANM connections are more widely rolled out and demand-side response services grown in prominence. The shortlisted solutions broadly covered:

- Reconfiguration of ANM schemes, for example to hold headroom preventing a Balancing Service being counteracted.
- Improved information exchange between DNOs and generators, allowing generators to factor in the risk of curtailment to Balancing Services participation.
- Changes to Balancing Services procurement, allowing NG ESO to factor in the risk of curtailment when procuring Balancing Services.

There are a number of key learnings from the project:

- The increased growth in generation connecting at the distribution level is driving growth in use of ANM schemes across all DNO areas, and an increased need for Balancing Services to be procured from those assets means there are material and increasing risks if ANM schemes and Balancing Services are not coordinated.
    - These risks manifest themselves in increased concern over security of supply, and increased costs to consumers.
- While there are some examples of coordination between DNOs and NG ESO, no existing coordination is widespread enough to mitigate these risks.
- The solutions proposed under this project to better coordinate ANM schemes and Balancing Services present challenges to technology (ANM systems and DNO forecasting), operations (communication between organisations), and regulatory regimes. However, the solutions have been shown to be technically feasible.
- There are material benefits of improving coordination – conservative assumptions give benefits cases of between £40m and £110m per year, based on a subset of Balancing Services.
- While there are significant barriers to implementation of the selected solutions, there are clear actions that can be taken by various parties to overcome these. Examples include the establishment of secure communications links between DNOs and NG ESO (where these do not already exist) and more frequent and granular forecasting of curtailment risk by DNOs/DSOs.
- Solutions examined by this project may be utilised in a wider context, for example supporting the transition to procurement of flexibility by Distribution System Operators.

- Given the rising use of ANM systems and deployment of distributed generation, and the impending submission of business plans for the next DNO price controls (RIIO-ED2), action should be taken on the coordination issues identified at the earliest opportunity. Earlier action allows for the earlier realisation of security of supply benefits and cost savings.

1 PROJECT OVERVIEW

WSP[1], Cornwall Insight[2] and Complete Strategy[3] are undertaking a Network Innovation Allowance (NIA) funded project on behalf of National Grid Electricity System Operator[4] (NG ESO) and Western Power Distribution[5] (WPD). The project investigates the optimal coordination of Active Network Management (ANM) schemes on both the distribution and transmission networks with Balancing Services markets.

1.1 BACKGROUND

NG ESO's Future Energy Scenarios[6] (FES) and System Operability Framework[7] (SOF) show that the installed capacity of on the distribution networks increased to 31GW in 2019 and is set to rise to 45GW to 56GW by 2030 across all FES scenarios. This significant growth of distributed generation, 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.

Distributed generation 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 distributed generation and renewables to distribution networks quicker and at lower cost. ANM schemes are normally designed and operated to control the output of distributed generation 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[8]) connected within the networks managed by ANM schemes. This gives rise to an

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

increased risk of conflict between delivering Balancing Services and ANM schemes. ANM actions can counteract the effect of the Balancing Services procured by NG ESO from non-curtailable generators.

1.2 PURPOSE OF THIS REPORT

This report is part of the sixth phase (WS6) of the project and covers the dissemination of project learnings, with a separate report covering the broader application of learnings. The overall project structure is shown in Figure 1-1 below:

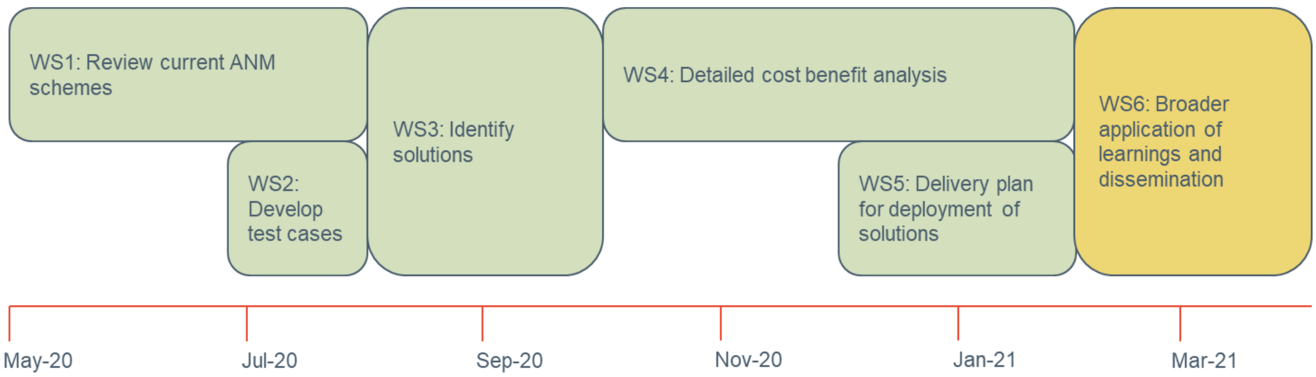

Figure 1-1: Focus of Report

This report focuses on:

- An overview of work carried out under all other project workstreams and deliverables.
- A summary of learnings that can be drawn from each of these deliverables.

1.3 REPORT STRUCTURE

The remainder of this report is structured as follows:

- Section 2: Overview of current ANM schemes and planed development of these, to provide the context for the remainder of the project work.
- Section 3: Overview of the test cases used to set out the issues of coordination between ANM and Balancing Services.
- Section 4: Overview of solutions identified to those test cases.
- Section 5: Outcome of the detailed benefit analysis of selected solutions.
- Section 6: Overview of the implementation plan.
- Section 7: Broader application of learnings from this project.
- Section 8: Summary and conclusions.

2 OVERVIEW OF CURRENT ANM SCHEMES AND CONFLICTS

2.1 SCOPE OF WS1

WS1[9] sought 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.

Research for this work stream combined desktop research with stakeholder engagement, including bilateral meetings with all GB DNOs and NG ESO. These conversations helped shape and define the issues addressed in later work streams, and also allowed for the establishment of an Advisory Group, made up of DNOs, NG ESO, TOs, ANM technology providers and generators. Discussions of our research with the Advisory Group helped further our thinking and draw out specific issues that were pertinent to particular parties.

2.2 DEFINITIONS

2.2.1 ANM SCHEMES OF INTEREST

Our definition of ANM schemes was adapted from a widely recognised definition from the Energy Networks Association[10] (ENA). The definition used for this project is:

Dynamic management of Distributed Energy Resources behind constraints to optimise utilisation of network assets without breaching operational limits, primarily to reduce the need for reinforcement driven by new connections, speed up associated connection times and reduce connection costs

For the purposes of this project, we have focused particularly on ANM schemes on the distribution networks. There are currently no ANM schemes that manage transmission connected generators, although NG ESO's Generation Export Management System (GEMS) is in development. These are similar in principle to distribution ANM systems, but will have some fundamental differences, including likely direct interaction with Balancing Services and compensation for generators that are curtailed. Some transmission constraints are managed by distribution ANM schemes. Additionally, NG ESO manages constraints through the Balancing Mechanism, and is seeking further solutions through its Constraint Management pathfinding project.

GEMS were considered throughout the project, but given the closer integration with Balancing Services, and that these schemes remain in development, the main focus of the project has been on distribution network schemes.

[9] Full WS1 and WS2 report available here: https://www.westernpower.co.uk/downloads-view/206443. Note, some figures in this WS6 report differ from those presented in the WS1 report, as a result of developments since the WS1 report and further research
[10] https://www.energynetworks.org/assets/files/news/publications/1500205_ENA_ANM_report_AW_online.pdf

We have also focused solely on those schemes which are implemented to reduce connection costs. That is, the reinforcement costs which are avoided through curtailment risk would otherwise have been borne largely by the connecting generator (through their connection charge). Compensation for curtailment is therefore realised upfront at the time of connection and not an ongoing basis when curtailment occurs.

Finally, we focus on permanent schemes, rather than temporary ANM schemes, which are only in place to enable quicker connections while network reinforcement is carried out.

Most schemes operate on a “last in first off” (LIFO) principle. Under this approach, constraints are managed by curtailing generators in the order they connected to the network, with the last to connect being the first to be curtailed when the constraint is reached. This prevents generators connected earlier being negatively affected by generators connecting later. While this is the most common design, some schemes have used a pro-rata curtailment system, whereby all generators on an ANM scheme are curtailed proportionally based on their contribution to the constraint. As such, generators connecting earlier and experiencing relatively little curtailment may see curtailment levels increase as more generators connect.

Curtailment of ANM generators is typically open ended. DNOs often informally share details of expected curtailment from power flow model runs with customers to inform customers’ investment decisions, but the level of curtailment is not typically included in connection agreements, although a clear exception to this is Electricity North West’s (ENWL’s) planned use of a curtailment index.

2.2.2 TYPES OF DER

Recognising that it is primarily generators which are affected by ANM schemes, we have focused on generators (as a subset of DER) rather than demand on ANM schemes.

In order to avoid any confusion on terminology, we consider the following types of generator:

- **Generator with standard connection.** This refers to generation connected in an area of the network where no ANM schemes are in place;
- **Non-curtailable generator in an ANM area**. This refers to generation which is behind a constraint being managed by an ANM scheme but is not itself controlled by that ANM system. This may be because the generation in question connected before that ANM scheme was put in place and so does not sit in the LIFO stack, or that the generator is below that DNO’s size threshold for inclusion on an ANM scheme; and
- **ANM generator.** Generator which is subject to curtailment by an ANM system.

Generators can move between these groups – for example, deployment of a new ANM scheme would likely result in a number of generators moving from standard connection to non-curtailable in an ANM area. It is important to note that this change is entirely out of a given generator’s control and they may not be aware that it has taken place, as it is driven by the action of other generators connecting in the area electing for an ANM connection rather than to fund network reinforcement through their connection charge.

2.2.3 BALANCING SERVICES

This project considers the interaction between ANM and Balancing Services. NG ESO procures a range of Balancing Services from users connected to the transmission and distribution network, including DERs. These include:

- Balancing Mechanism (BM);
- Firm Frequency Response (FFR) and Dynamic Containment (DC);
- Reserve services (including Short Term Operating Reserve (STOR) and Fast Reserve);
- Reactive power, including NG ESO's high voltage pathfinding project;
- Optional Downward Flexibility Management (ODFM); and
- NG ESO pathfinding projects, including stability and constraint management.

These services vary considerably in their design and how they are procured, and a full overview is provided in the full WS1 report. Quantitative analysis throughout the project was primarily focused on a subset of these Balancing Services: the BM, STOR and FFR. Those services provide a range of suitable services to assess. The BM is the most widely used Balancing Service, and provides a good example of both an incrementing service (under which NG ESO instructs a generator to increase output – BM Offers) and a decrementing service (under which NG ESO instructs a generator to decrease output– BM Bids). FFR is an example of a service that requires a very fast response with a relatively short delivery period. STOR, in contrast to FFR, requires a relatively slow response with a longer delivery period.

2.2.3.1 CLASS

The Customer Load Active System Services (CLASS)[11] project trialled voltage management technologies on distribution networks, and used this to provide Balancing Services to NG ESO, specifically FFR services.

This system has, to date, only been used by ENWL. However, it is considered further by this project, as the same risks of uncoordinated schemes apply to both CLASS schemes and Balancing Services and ANM.

2.3 RANGE AND SCALE OF ANM SCHEMES

Our 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. ANM

[11] https://www.enwl.co.uk/zero-carbon/innovation/key-projects/class/

schemes benefit consumers by minimising the costs of connecting new, often low carbon, generation, which helps to decarbonise the network and reduce costs to consumers.

ANM schemes can range from simple systems controlling the output of a small number of generators to manage a single network constraint; through to systems controlling many generators across a wider area to manage multiple interdependent constraints. Data was provided by DNOs and also obtained from published Embedded Capacity Registers to give a view of ANM schemes in each area. A full breakdown by DNO is provided in the full WS1 report, but a summary is provided below.

As of January 2021, 6.7GW of generation was connected, or had accepted an offer to connect, to distribution ANM schemes (summarised in Table 2-1). 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.

Table 2-1: Summary of ANM connected generation and planned development by DNO

DNO	Volume of ANM Generation (MW)	Planned Development
Scottish Power Energy Networks	150	Dumfries and Galloway wide area scheme managing interacting transmission and distribution constraints. Transmission ANM being developed which will manage transmission constraints
Scottish and Southern Energy Networks	175	South West Operational Tripping Scheme will result in ~60% of the Southern region being managed by ANM
Electricity North West	770	Licence area wide scheme planned
Northern Powergrid	950	Further schemes as needed. Latest system is fully scalable
UK Power Networks	1,725	Further schemes in development

Western Power Distribution	2,945	High volume of accepted connection offers in ANM-managed areas likely to increase curtailment
Total	**6,715**	

The amount of ANM connected generation is expected to grow substantially in the future, with many DNOs planning schemes that will cover several GSPs or, in some cases, entire licence areas. For most DNOs, plans are in place to expand or introduce new schemes through the early 2020s.

A notable difference between different DNOs is the speed of response of ANM schemes. Some can instigate a sub-second response from generators, while others seek a response within around five minutes.

2.4 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.

In summary, 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.

2.5 EXISITNG COORDINATION

While the remainder of the project focused on a plan to mitigate the risks outlined in Section 2.4, existing examples of coordination were identified as part of WS1. 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. However, it was not always clear to what extent these affected distribution-connected generators, due to a lack of clear and consistent definitions in the industry on ANM schemes and generators behind ANM-managed constraints. A key example was frequency response services. In a previous (2016) invitation to tender for Enhanced Frequency Response[12] (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). Our findings on existing and planned interactions between DNOs and NG ESO is shown in Table 2-2.

[12] EFR was the predecessor to the suite of frequency response services now procured by NG ESO.

Table 2-2: Existing coordination between network companies

DNO	Coordination with NG ESO
SPEN	**Current schemes:** digital alarms indicating current ANM operation **Future schemes:** integration with GEMS and NG ESO on Dumfries and Galloway project, some ESO requests can be rejected by SPEN
SSEN	**Current schemes:** information on planning timescales only, not operational **Future schemes:** SSEN is engaged in the South West Operational Tripping Scheme (SWOTS) which involves ESO, TO and DNO coordination
ENWL	**Current schemes:** not applicable (no ANM schemes in operation) **Future schemes:** coordination not currently built into design, but early discussions on ICCP link
NPg	**Current schemes:** limited coordination on one scheme **Future schemes:** no planned coordination
UKPN	**Current schemes:** limited operational data on transmission constraint scheme **Future schemes:** enterprise-wide system now in place across network with the timeline for roll-out now driven by constraints materialising
WPD	**Current schemes:** limited coordination on existing schemes **Future schemes:** ICCP link is in build phase, allowing for NG ESO visibility at GSP level

3 OVERVIEW OF TEST CASES

3.1 SCOPE OF WS2

The second workstream ran in parallel with WS1, seeking 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. The findings of WS1 and WS2 were presented in a consolidated report.[13]

3.2 TEST CASE DESCRIPTION

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.

These main test cases were split further into sub examples, to provide specific cases that could be tested. A summary of these is shown in Table 3-1.

Table 3-1: Summary of Test Cases

Test Case	Type of Test Case	Description
1A	ANM system counteracts Balancing Services provided by DER or transmission connected resources	Incrementing service action from a non-curtailable generator in an ANM area is counteracted by an ANM generator
1B		Decrementing service action from a non-curtailable generator in an ANM area is counteracted by an ANM generator
1C		Service action from a non-curtailable generator in a GEMS area is counteracted by a GEMS generator
2A	ANM system counteracts Balancing Services provided by DNO using CLASS system	Demand reduction through a lowering of tap position (through CLASS) is counteracted by downstream ANM scheme
2B		Demand boost through a raising of tap position (through CLASS) is counteracted by downstream ANM scheme

[13] https://www.westernpower.co.uk/downloads-view/206443

2C		Reactive power absorption through tap stagger (through CLASS) is counteracted by downstream ANM scheme
2D		Reactive power absorption through tap stagger (through CLASS) is counteracted by downstream ANM scheme
3A	Non-delivery or non-participation by DER in Balancing Services due to ANM risks	ANM generator curtailed and defaults on Balancing Service
3B		ANM generator unable to access Balancing Services markets

A full description of each Test Case, and the benefits of investigating them further, is set out in the full WS1 and WS2 report. A sample schematic diagram is shown for Test Case 1A in Figure 3-1, showing an example of the parties involved and the interactions that take place.

This Test Case involves the situation in which a non-curtailable generator in an ANM area provides Balancing Services to NG ESO. Test Case 1A involves the generator performing an incrementing service. Similarly, this case also applies to a demand customer reducing demand through DSR.

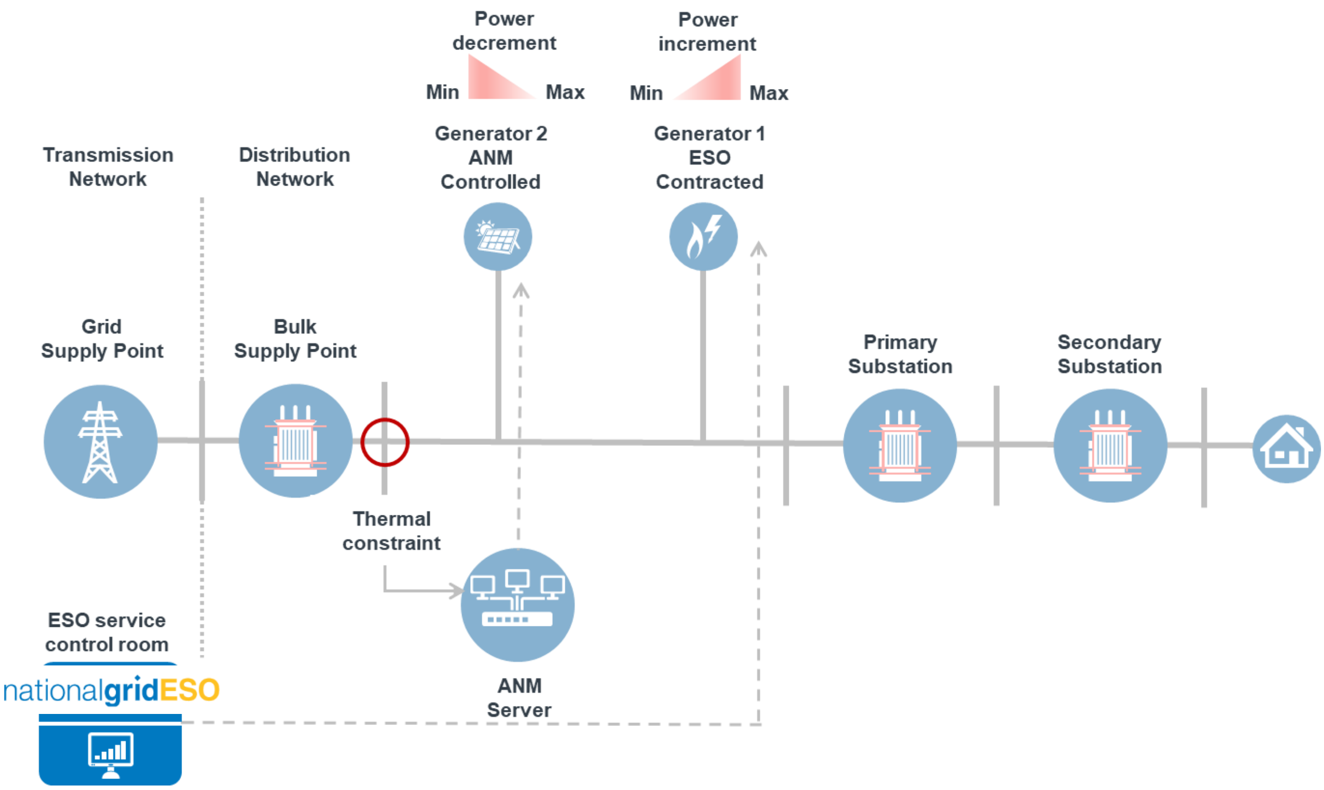

Figure 3-1: Example schematic of the parties and interactions involved in Test Case 1A

WS1 also included a high-level assessment of the benefits, focusing on the benefits found by addressing the issues in these Test Cases as realised in the BM. This focused on Test Cases 1A and 1B (counteraction of incrementing and decrementing services) and 3B (ANM generators unable to access Balancing Services). This is not set out in detail in this report, as a further workstream (WS4) fully assessed the benefits of well-defined solutions to these Test Cases.

However, this was an important early exercise as it confirmed that the Test Cases identified warranted further research through the remaining workstreams.

4 OVERVIEW OF SOLUTIONS

4.1 SCOPE OF WS3

The aim of WS3[14] was to set out solutions that would be assessed further, based on the Test Cases set out in WS2.

It was noted throughout this workstream that specific solutions may address some Test Cases and not others, and the optimal solution to the problem of coordination may be a combination of the specific solutions set out. However, for the purposes of analysing specific solutions they are kept separate.

4.2 SOLUTIONS OVERVIEW

Solutions were developed through bilateral discussions and a workshop with the project Advisory Group, with the aim of identifying a broad range of options to address the issues defined by the Test Cases, which were then refined and shortlisted. The full set of solutions considered (prior to shortlisting) is summarised in this section.

The solutions worked up 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.

A detailed description of each solution is provided in the full WS3 report, but a summary of each solution is provided here.

[14] https://www.westernpower.co.uk/downloads-view/206446

4.2.1 SOLUTION W1: PARALLEL DECREMENTING INSTRUCTION TO DER AND ANM

Solution W1 addresses Test Case 1B (counteraction of decrementing service by ANM). The solution would see a signal sent simultaneously to the generator and to the ANM scheme, requiring that the ANM scheme either:

- Holds headroom equivalent to the level of the decrementing service for the duration that the NG ESO service is required; or
- Does not release any existing curtailment for the duration that the NG ESO service is required.

This could be done through NG ESO having knowledge of which generators are subject to curtailment by ANM schemes, and issuing parallel instructions accordingly, or by NG ESO issuing instructions to the generator and DNO simultaneously, and allowing the DNO to manage the instruction to the ANM scheme.

4.2.2 SOLUTION W2: PREPARATORY INCREMENTING INSTRUCTION TO ANM

Solution W2 addresses Test Case 1A (counteraction of incrementing service by ANM). The solution proposes that, prior to each settlement period, NG ESO sends a signal to each relevant ANM scheme to provide the volume of potential incrementing services behind the constraint in that period (e.g. the volume of BM Offers). The ANM would then hold that level of headroom to enable those increments to be delivered without counteraction if called.

4.2.3 SOLUTION W3: BRING FORWARD ANM CURTAILMENT AHEAD OF GATE CLOSURE

Solution W3 addresses issues relating to the BM, specifically those raised in Test Cases 1A (counteraction of incrementing service by ANM), 1B (counteraction of decrementing service by ANM), 3A (generator defaults on Balancing Service due to constraints) and 3B (generators with ANM connection prevented from accessing Balancing Services markets).

This solution would require DNOs to determine the level of ANM curtailment required for each Settlement Period at a pre-determined point in time ahead of that Settlement Period. Generators would then be able to submit Bids and Offers, and NG ESO would be able to dispatch with certainty on ANM curtailment, avoiding non-delivery and counteraction risk.

4.2.4 SOLUTION X1: IMPROVED COMMUNICATION WITH GENERATORS

Solution X1 addresses Test Cases 3A (generator defaults on Balancing Service due to constraints) and 3B (generators with ANM connection prevented from accessing Balancing Services markets), where generators with ANM connections may default or be excluded from participating in Balancing Services markets.

This solution would require DNOs to develop new operational communication links with generators, so that at defined points ahead of each time period, ANM systems could issue a signal on the likelihood of curtailment based on demand and generation forecasts. For services where participation is contractually blocked, terms would be updated under this solution to allow participation up to a pre-determined likelihood of curtailment, i.e. to allow participation when the likelihood of curtailment is low.

Forecasting of curtailment likelihood would have to be on a half-hourly basis and available at least at the day-ahead stage, to allow for aggregation of those half-hourly periods where services are required over a longer delivery window. This could be refined closer to time, for a more accurate view for shorter-term services. The specific risk tolerances for each service would be determined by NG ESO.

4.2.5 SOLUTION Y1: RISK-BASED BALANCING SERVICES VALUATION

Solution Y1 addresses Test Cases 1A (counteraction of incrementing service by ANM), 1B (counteraction of decrementing service by ANM), 3A (generator defaults on Balancing Service due to constraints) and 3B (generators with ANM connection prevented from accessing Balancing Services markets). This solution would see a change to the way in which NG ESO values Balancing Services to reflect the risk of non-delivery due to network issues, including faults (for example where there is a higher risk of faults driving non-delivery for generators with a single circuit connection) and ANM schemes.

NG ESO would create a risk-based framework, taking into account information from the DNOs on curtailment risk for each ANM scheme, and factoring in this risk for each Balancing Service. This would require knowledge of generators in ANM areas (or highly granular information from DNOs on a generator level), as well as forecasting of curtailment risk on an ongoing basis, similar to that in solution X1.

The risk would need to be priced into Balancing Services, as NG ESO itself manages the risk of service counteraction by ANM schemes on behalf of Balancing Services Use of System (BSUoS) payers. In doing this, NG ESO would pay for the service as if it had been delivered and waive any non-delivery penalties where non-delivery is caused by network faults (both for transmission and distribution connected users) or ANM curtailment.

4.2.6 SOLUTION Y2: MARKET-BASED FRAMEWORK FOR ALLOCATING NETWORK CAPACITY

As with solution Y1, solution Y2 addresses Test Cases 1A (counteraction of incrementing service by ANM), 1B (counteraction of decrementing service by ANM), 3A (generator defaults on Balancing Service due to constraints) and 3B (generators with ANM connection prevented from accessing Balancing Services markets). This solution would see the development of a framework that makes network capacity a tradeable commodity. This would allow the market to find the most effective dispatch solution if there was sufficient liquidity in the market for tradeable capacity. Those with capacity could then choose whether to use that capacity for the provision of energy only or for Balancing Services. This would resolve conflicts by making explicit which generators have capacity (i.e. will not be subject to curtailment) and those which do not (i.e. will be subject to curtailment). Only those with capacity would contractually be able to provide Balancing Services.

Capacity could either be tradeable across all generators (with ANM generators de-rated to reflect the likelihood of curtailment during the period under consideration), or just between ANM generators within a given ANM zone, although it is unlikely to be desirable to restrict the market in this way.

As with other solutions (namely X1 and Y1), DNOs would have to forecast the likelihood of curtailment. It would be particularly important in this case that the forecasting is carried out on a consistent basis to allow for a common approach to setting market parameters.

4.2.7 SOLUTION Z1: CLASS TO ANM COORDINATION

Solutions Z1 and Z2 address Test Cases 2A-D, which look at the issues of coordination between CLASS systems providing services to NG ESO and ANM systems.

Typically, CLASS will be implemented in areas that are dominated by demand rather than generation. This means there will be limited numbers of ANM generators, and the likelihood of conflicts with ANM operation will be relatively low. However, if the number of distributed generators in an ANM area was to increase, the probability of conflicts would increase.

Based on this assumption, this solution would see the CLASS system harmonised and coordinated with each ANM system. In this case, the CLASS system would monitor the ANM system and provide an updated export limit to the ANM (or deactivation of the ANM), reflecting CLASS actions taken and avoiding ANM counteraction of these.

If CLASS was implemented in an ANM area dominated by generation, the CLASS system would be deactivated or limited if there is a conflict with the ANM export capacity.

4.2.8 SOLUTION Z2: CLASS VISIBILITY OF ANM

Solution Z2 would see a similar monitoring scheme to Z1, with real-time monitoring between the CLASS and ANM systems. In this case, rather than the operation of the ANM system being modified due to CLASS actions, the CLASS system will modify its own operation to take account of ANM actions. This would ultimately ensure the level of service provided to NG ESO is as expected.

4.3 SOLUTIONS TAKEN FORWARD

For each solution, the pros and cons were assessed and a recommendation made on whether the solution would be taken forward for further examination. The outcome of this was to take forward five solutions:

- Solution W1: Parallel decrementing instruction to DER and ANM;
- Solution W2: Preparatory incrementing instruction to ANM, but only in the context of Frequency Response;
- Solution X1: Improved communication with generators;
- Solution Y1: Risk-based Balancing Services valuation; and
- Solution Z2: CLASS visibility of ANM.

Further details are shown in Table 4-1.

Table 4-1: Summary of Solutions to Test Cases

Solution Category	Solution	Recommendation from WS3
W – Reconfiguration of ANM schemes	W1 – Parallel decrementing instruction to DER and ANM	We proposed to carry out a CBA on this solution to fully understand its merits and any implementation challenges.
	W2 – Preparatory incrementing instruction to ANM	We proposed to carry out a CBA on this solution for frequency response only, where it may also be coupled with changes to market rules.
	W3 – Bring ANM curtailment ahead of Gate Closure	We anticipated that this solution was unlikely to deliver benefits, but proposed to carry out a high-level CBA to confirm that this is the case.
X – Improved information exchange	X1 – Improved communication with generators	This solution requires generators to use DNO forecast information to make their operational and trading decisions, compared to solution Y1 which requires NG ESO to use that information. It is not immediately clear which of these would deliver more benefit, so we proposed to subject both to a detailed CBA.
Y – Changes to market rules	Y1 – Risk-based Balancing Services valuation	It was not immediately clear whether this solution or solution X1 would deliver more benefit, so we intend to subject both to a detailed CBA.
	Y2 – Framework for allocating network capacity	To avoid duplication with the UKPN Energy Exchange project[15], we proposed to not consider it further under this project.
Z – CLASS solutions	Z1 – CLASS to ANM coordination	Based on consultation with ENWL we understood that ANM conflicts were likely to be minimal, and CLASS would have dominance (as implemented by ENWL). As such, we proposed to use Z1 as a reference case when assessing the merits of Z2.
	Z2 – CLASS visibility of ANM	It was recognised that this solution may be difficult to implement, but it may have material benefits allowing for the parallel operation of CLASS and ANM systems. Therefore, we proposed to carry out a detailed CBA on this solution.

15 https://innovation.ukpowernetworks.co.uk/projects/energy-exchange/

5 BENEFITS ANALYSIS OF SELECTED SOLUTIONS

5.1 SCOPE OF WS4

WS4[16] took forward selected solutions from WS3 and further assessed them through three stages:

- Assessment matrix analysis to further shortlist solutions.
- Modelling work to assess the technical merit of the nominated solutions.
- Quantitative analysis to determine the benefits case for the nominated solutions.

5.2 ASSESSMENT MATRIX

The assessment matrix was used to assess solutions, checking they were practical, affordable and reliable. The outcome of this was a narrowing down of solutions to take forward to a fuller assessment.

Solutions were assessed against five criteria:

- Technology Readiness Level (TRL)
  - The Technology Readiness Level (TRL) delivers a consistent approach for assessing the readiness of technologies for use as Business as Usual (BaU).
- Regulatory readiness
  - The need for significant regulatory changes could pose delays to the implementation of solutions. As such a gap analysis was carried out to identify the compliance of each option with the current Code and Licence requirements and the modifications that would be required before they could be implemented.
- Commercial readiness
  - Commercial readiness assesses whether the commercial mechanism is in place, if alterations to current mechanisms are required, or new mechanisms are needed in order to implement the solution. This includes assessment of aspects financial/balancing mechanisms e.g. BM, STOR and FFR.
- Complexity and scale of changes
  - The criterion focuses on infrastructure and communication infrastructure. Solutions which vary in design radically from current equipment/infrastructure and communications, that require the procurement and installation of new state of the art technology or the use of complex controllers and algorithms, will be deemed as more complex.

16 https://www.westernpower.co.uk/downloads-view-reciteme/302791

- Impact of curtailment
  - This considers the extent to which the solution will impact the frequency, magnitude and duration of curtailment on the networks.

For each of these criteria, each solution was scored between 1 (low impact) and 5 (high impact), to determine an overall score out of 25 and to compare the solutions. The outcome of this is shown in Table 5-1, with the reasoning behind each score set out in the full WS4 report.

Table 5-1: Assessment matrix for shortlisted solutions

Rank	Solution type	Impact Criteria					Total Score
		TRL	Regulatory Readiness	Commercial Readiness	Complexity	Impact of levels of curtailment	
1	Z2: CLASS visibility of ANM	3	3	1	4	1	12 ✓
2	W1 Parallel decrementing ESO-ANM interface	3	3	2	3	2	13 ✓
3	X1: Improved Comms with generators	3	3	3	4	1	14 ✓
4	W2: Preparatory ESO-ANM interface	3	3	3	3	4	16 ✗
5	Y1: Risk-based procurement	3	5	3	4	1	16 ✓
6	W3: Bring forward ANM curtailment	4	4	3	4	4	19 ✗

From the impact scorings for each solution type and a technical workshop with the project team, the following conclusions were drawn:

- Solutions that would lead to significant increases in ANM curtailment (W3 and W2) were eliminated as any benefits will likely be eroded by higher curtailment.
- Y1 scored poorly due to regulatory challenges, however, it has the potential to be an efficient long-term solution, so it remained under consideration.
- The low impact scoring of Z2, W1 and X1 merit further investigation and these solutions were taken forward for detailed assessment.

5.3 TECHNICAL ASSESSMENT OF NOMINATED SOLUTIONS

The Test Cases and solutions were modelled based on a real network case study (North Tawton BSP), using DIgSILENT.

Balancing Services and ANM operation were overlaid on this case study network to provide a view of each relevant Test Case and solution, and were not based on real examples. A full set of assumptions is provided in the full WS4 report. A schematic layout of the test network model is shown in **Figure 5-1**.

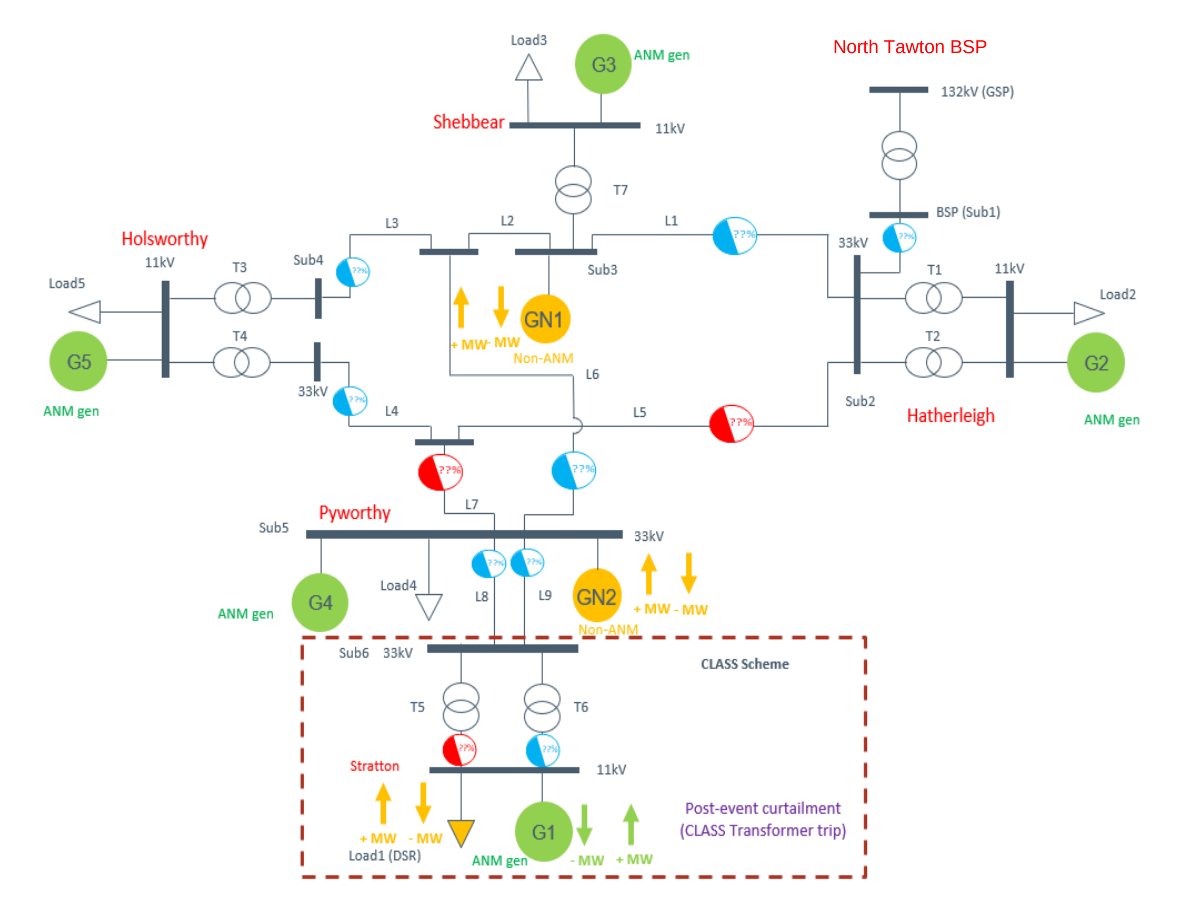

Figure 5-1: Schematic layout of the test network model

The modelled solutions were W1 and Z2 (relating to CLASS), as solutions X1 and Y1, which had also been taken forward, focused on regulatory changes rather than technical changes to operations. The solutions were modelled under a variety of network conditions.

The full results of the modelling exercise are not repeated here. In summary, for solution W1, the exercise found that the solution was feasible and would reduce conflicts between Balancing Services and ANM operation.

Similarly, the CLASS solutions were found to be feasible and respond as expected, with effective coordination between CLASS and ANM by operating the schemes within different voltage bands.

5.4 BENEFITS ANALYSIS

5.4.1 QUANTITATIVE BENEFITS

The analysis of the benefits associated with each solution focused on two benefits of better coordination:

- The benefit of reduced counteraction, avoiding additional procurement from NG ESO and increased cost; and

- The benefit of increased liquidity in Balancing Services markets, potentially reducing costs paid by NG ESO and ultimately reducing consumer costs.

The assessment of these benefits was made by:

- Analysis of historical pricing data for each of the services considered while considering how procurement of those services may evolve in the future to derive a £/MW cost of procuring Balancing Services from different technologies.
  - The Balancing Services under consideration were the BM, STOR and FFR, to give a range of different services.
- Making assumptions on the likelihood of ANM curtailment in each time period.
  - It was assumed that curtailment risk is higher at times of higher embedded renewable output and low demand. The proportion of demand met by embedded renewables was used to characterise each settlement period over 2019 and 2020 into one of three bands (red, amber, green), based on assumed likelihood of ANM curtailment.
- Using information on the capacity of different technologies behind ANM schemes.
  - This was obtained from the published Embedded Capacity Registers, and additional information provided by the DNOs.

A full range of assumptions and data sources used is set out in the WS4 report.

For the BM, the behaviour of embedded generators was simulated based on assumptions on the marginal cost of generation and margins required by generators to act. Once this behaviour had been determined, the cost of counteraction and benefit of increased liquidity could be calculated.

For STOR, only the cost of counteraction was considered because of the dominance of gas and diesel plant in the market meant an increase in liquidity was unlikely to provide a meaningful benefit.

A similar approach was taken for FFR with the precedence of battery capacity in the market.

Table 5-2 shows a summary of the results of the quantitative analysis. This demonstrates that the highest benefits accrue from solution Y1 (£100m - £130m/year), followed by X1 (£80m - £110m/year) then W1 (£30m - £45m/year).

Although a full assessment of costs was not carried out in this package of work, at face value, the highest benefits arose from the most complex solutions.

The CLASS solutions (Z1 and Z2) were found to have the lowest benefits, due to the limited roll-out of CLASS systems (only ENWL use CLASS) and corresponding limited Balancing Services provision from these systems. There is uncertainty over the level of adoption in future of CLASS systems, and the extent to which these solutions would be 'business as usual' arrangements. It is unlikely a DNO would implement CLASS without coordinating the system with any ANM systems.

Table 5-2: Summary of solution benefits

Solution	Reference Year	Total benefit (£m)	BM benefit (£m)		STOR benefit (£m)	FFR benefit (£m)
			Avoided counteraction	Increased liquidity	Avoided counteraction	Avoided counteraction
W1	2019	**30.7**	10.6	20.1	-	-
	2020	**44.4**	18.5	25.9	-	-
X1	2019	**79.0**	21.6	47.1	10.3	-
	2020	**109.5**	47.3	59.4	-	2.7
Y1	2019	**103.6**	35.1	50.7	17.8	-
	2020	**137.5**	64.3	68.9	-	4.3
Z2	2019	**0.3**	-	-	-	0.3

5.4.2 QUALITATIVE BENEFITS

A number of qualitative benefits, beyond the benefits that were quantified, were also identified. These were:

- An increase in the need for Balancing Services from distributed generation, as the electricity system becomes more dominated by intermittent renewables, can be accommodated.
- Increased liquidity in frequency response markets with the expected roll-out of battery capacity.
- Increased benefits of greater coordination as more ANM schemes are rolled out.
- Increased benefits associated with CLASS solutions if CLASS is adopted more widely.

6 IMPLEMENTATION PLAN OVERVIEW

6.1 SCOPE OF WS5

WS5[17] sought to:

- Assess the barriers to implementation of the shortlisted solutions.
- Assess actions required to overcome these barriers to implementation.
- Set out a proposed implementation plan for shortlisted solutions.

WS5 considered three solutions: W1, X1 and Y1. The solutions related to CLASS (Z1 and Z2) were not considered further, due to the limited benefits case from WS4 and the limited relevance of CLASS to wider industry, with only one DNO adopting the technology to date.

6.2 ASSESSMENT OF BARRIERS AND REQUIRED ACTIONS

Barriers to each solution were assessed in six broad areas:

- Technological
  - Including technology maturity, whether there are conflicts to be resolved and/or modifications required.
- Regulatory
  - Alignment of the change to relevant regulations, including the distribution licences, the Grid Code and the Balancing and Settlement Code; and an assessment of the level of regulatory change required.
- Commercial
  - Interaction with the existing arrangements for procuring Balancing Services, and whether changes are needed to connection agreements.
- Financial
  - Investment required to deliver the solution and financial impacts for other parties.
- Organisational
  - Impacts on the existing roles of organisations involved in Balancing Services and ANM schemes, any new responsibilities and the ability of organisations to respond to the required change.

[17] https://www.westernpower.co.uk/downloads-view-reciteme/326608

- Process related
  - The complexity of changes to existing processes, the stakeholders impacted and any interactions with processes outside of ANM and Balancing Services.

The three selected solutions were scrutinised against this framework, and findings were developed further through engagement with NG ESO and WPD, and a workshop with the project Advisory Group.

A full description of the barriers identified is provided in the WS5 report. A brief description of the main barriers identified for the three solutions is outlined below.

6.2.1 BARRIERS TO SOLUTION W1

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.

6.2.2 BARRIERS TO SOLUTION X1

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 of forecasting 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.

6.2.3 BARRIERS TO SOLUTION Y1

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.
- Changes may be required to Balancing Services to reflect changing procurement.

6.2.4 LINKS TO THE OPEN NETWORKS PROJECT

Many of the actions set out to overcome the barriers have links to the ENA's DSO Roadmap, prepared under Workstream 3 of the ENA Open Networks Project[18]. These are set out in Table 6-1.

Table 6-1: Links between identified actions and the ENA DSO roadmap

DSO Function	Activity	Link to implementation of solutions
System Coordination	A9: Real time Data Exchange and Forecasting. Developing mature processes and IT infrastructure to facilitate operational data exchange in alignment with Open Networks WS1B P3 2020 Paper[19] on real time exchange and forecasting.	**Solutions W1 and Y1:** Whilst the data requirements referred to in this report are specific to Operational Tripping Scheme (OTS) arrangements being implemented on DNO networks to enable the tripping of distributed generators for faults on the GB transmission network, there are overlaps with the potential instructions associated with solution W1 (for example, requesting DNOs to stop curtailing after a trip event).
	A21: Enable DNO-ESO control centre data exchange. Build and Implement appropriate	**Solutions W1 and Y1:** This action is directly aligned to the technological solution identified to

[18] https://public.tableau.com/profile/open.networks#!/vizhome/RM-97_16116703134880/Roadmap
[19] https://www.energynetworks.org/industry-hub/resource-library/open-networks-2020-ws1b-p3-operational-tripping-scheme-arrangements.pdf

DSO Function	Activity	Link to implementation of solutions
	communication link between DNO-ESO control centres e.g., ICCP link	enable NG ESO to issue hold headroom instructions to DNOs.
Connections and Connection Rights	Various steps in relation to Activity A: Connection agreements, covering curtailment assessments, flexible connection agreements and the connections process. Many of these steps relate to actions identified in the Open Networks WS1 P7 2018 paper on curtailment process and ANM reliability[20]	**Solutions W1, X1 and Y1:** These actions represent the existing progress that has been identified on the type of information DNOs provide in relation to curtailment. The additional impact of the hold headroom instruction would be an additional change compared to this ongoing work.

6.3 TIMESCALES

WS5 found that most changes could be made within five years (and many within two years), but some, notably communication links, may take longer than five years. As such, solution X1, which does not require as sophisticated communication links, may be able to be implemented faster than the other solutions. Solutions W1 and Y1 may also be suitable for consideration across a shorter time frame where existing communication links are already in place, or currently being implemented.

[20] https://www.energynetworks.org/industry-hub/resource-library/open-networks-2018-ws1-p7-good-practice-guide.pdf

7 BROADER APPLICATION OF PROJECT LEARNINGS

7.1 SCOPE OF WS6

WS6 focuses on learnings and dissemination of project findings. The present report (6.1) represents one part of this objective, while a separate deliverable (6.2) focuses on wider learnings. A summary of that report is given here.

In deliverable 6.2, focus is given to identifying if learnings developed throughout the project have wider reaching application for DNO, DSO and NG ESO operations. In order to demonstrate the potential wider benefits of solutions, as well as the impacts on the development of the electricity networks and their operation, the ENA 'Future Worlds' model[21] is employed as a benchmark.

Of the ENA Future Worlds, World B was selected to illustrate the wider applications of learnings. World B sees coordinated DSO-ESO procurement and dispatch.

7.2 SUMMARY OF FINDINGS

The main conflicts related with attaining a framework similar to that of Future World B, and findings on how learnings could be applied to develop solutions for these conflicts, is 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, or flexibility market arrangements. The solution helps to alleviate automatic response of generators as well as assist in keeping NG ESO and DSO informed of system operational conditions.

- Solution X1 mainly concentrates on the communication between DNOs and ANM generators for curtailment forecasting. This focus here is mainly on ESO and DSO related conflicts/solutions. However, information is essential to all stakeholders to make informed decisions, for example, generation companies making investment decisions. In this example, information on ANM curtailment becomes more important as networks become more congested, to assist with financial modelling. The learnings of this solution show potential 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 Balancing Services based on granular forecasts from the DNO on the risk of ANM curtailment. If a risk model could be used to assist in this procurement to avoid conflict with ANM schemes, a similar approach could be applied to other services. For example it could be used as a framework for other services in order to minimise risk of under-procuring generation and thus increasing the likelihood of conflict avoidance and economical generation dispatches.

[21] https://www.energynetworks.org/industry-hub/resource-library/open-networks-2018-ws3-14969-ena-futureworlds-aw06-int.pdf

8 SUMMARY AND CONCLUSIONS

This project sought to set out and propose solutions to address the risks of uncoordinated ANM schemes and Balancing Services. A number of learnings have been drawn from the research over several workstreams, coming from desktop research, quantitative analysis, bilateral stakeholder engagement and workshops with the wider Advisory Group.

Three key solutions to the coordination issues found have been put forward, with the barriers assessed and identified. These could be taken forward in further project work to trail their implementation.

There are a number of key learnings from the project:

- The increased growth in generation connecting at the distribution level is driving growth in use of ANM schemes across all DNO areas, and an increased need for Balancing Services to be procured from those assets means there are material and increasing risks if ANM schemes and Balancing Services are not coordinated.
    - These risks manifest themselves in increased concern over security of supply, and increased costs to consumers.
- While there are some examples of coordination between DNOs and NG ESO, no existing coordination is widespread enough to mitigate these risks.
- The solutions proposed under this project to better coordinate ANM schemes and Balancing Services present challenges to technology (ANM systems and DNO forecasting), operations (communication between organisations), and regulatory regimes. However, the solutions have been shown to be technically feasible.
- There are material benefits of improving coordination – conservative assumptions give benefits cases of between £40m and £110m per year, based on a subset of Balancing Services.
- While there are significant barriers to implementation of the selected solutions, there are clear actions that can be taken by various parties to overcome these. Examples include the establishment of secure communications links between DNOs and NG ESO (where these do not already exist) and more frequent and granular forecasting of curtailment risk by DNOs.
- Solutions examined by this project may be utilised in a wider context, for example supporting the transition to procurement of flexibility by Distribution System Operators.
- Given the rising use of ANM systems and deployment of distributed generation, and the impending submission of business plans for the next DNO price controls (RIIO-ED2), action should be taken on the coordination issues identified at the earliest opportunity. Earlier action allows for the earlier realisation of security of supply benefits and cost savings.