

Distributed ReStart



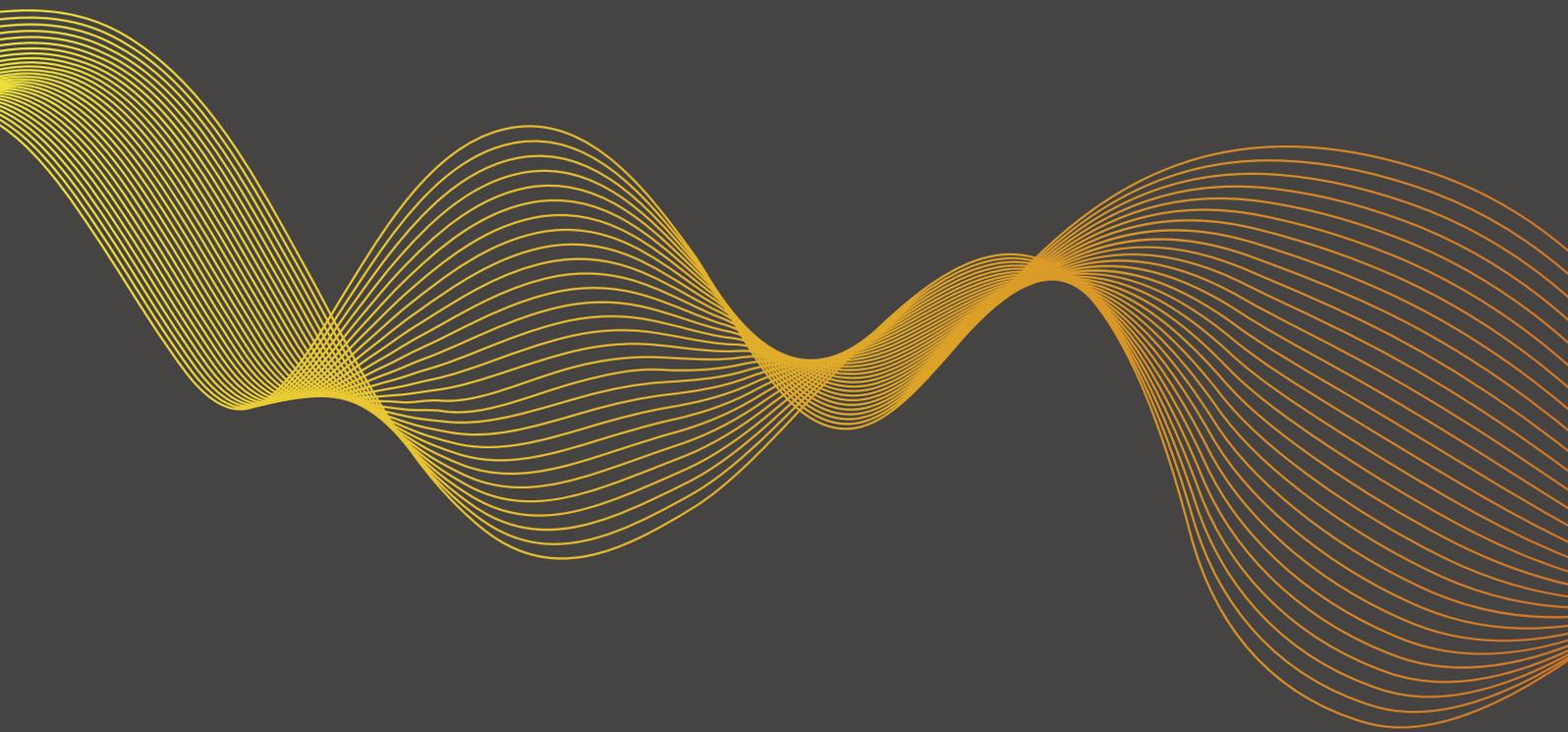
Energy restoration
for tomorrow

Project progress report
December 2021

In partnership with:



nationalgridESO



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The Distributed ReStart project is a partnership between National Grid Electricity System Operator (NGESO), SP Energy Networks (SPEN) and TNEI (a specialist energy consultancy) that has been awarded £10.3 million of Network Innovation Competition (NIC) funding.

The project is exploring how distributed energy resources (DERs) can be used to restore power in the highly unlikely event of a total or partial shutdown of the National Electricity Transmission System (NETS). Past and current approaches rely on large power stations, but as the UK moves to cleaner and more decentralised energy, new options must be developed. The enormous growth in DERs presents an opportunity to develop a radically different approach to system restoration. Greater diversity in Black Start provision will improve resilience and increase competition, leading to reductions in both cost and carbon emissions. However, there are significant technical, organisational and commercial challenges to address.

The project is tackling these challenges (Jan 2019–June 2022) and aims to develop and demonstrate new approaches, with initial procurement of Black Start service from DERs as part of the next tender round, which commences around April 2022 (with service commencement around 2025 onwards), if deemed feasible and cost-effective. Case studies on the SP Distribution (SPD) and SP Manweb (SPM) networks will be used to explore options then design and test solutions through a combination of detailed off-line analysis, stakeholder engagement and industry consultation, desktop exercises, and real-life trials of the re-energisation process.

Project Description

The project is made up of five workstreams. The Project Direction and Knowledge Dissemination workstreams cover the effective management of the project and ensure stakeholders are considered and communicated with throughout all project deliverables. The other three workstreams cover the wide range of issues to enable Black Start services from DERs:

- The Organisational, Systems and Telecoms (OST) workstream is considering the DER-based restoration process in terms of the different roles, responsibilities and relationships needed across the industry to implement at scale. It is developing requirements for information systems and telecommunications, recognising the need for resilience and the challenges of coordinating Black Start across a large number of parties. Proposed processes and working methods will be created and refined and consulted upon with various stakeholders.
- The Power Engineering and Trials (PET) workstream is concerned with assessing the capability of GB distribution networks and installed DERs to deliver an effective restoration service. It will identify the functional requirements that should apply on an enduring basis. This will be done through detailed analysis of the case studies and progression through multiple stages of review. It will be tested through demonstration of the Black Start from DERs concept in 'live trials' on SPEN networks.
- The Procurement and Compliance (P&C) workstream is addressing the best way to deliver the concept for customers. It explores the options and trade-offs between competitive procurement solutions and mandated elements. It uses a strategic process to develop fit-for-purpose commercial solutions that are open and transparent, stakeholder endorsed and designed end-to-end with the commercial objectives of the project and workstream in mind. It will feed into business as-usual activities to make changes as necessary in codes and regulations.

Keep up to date and find all other project reports here: nationalgrideso.com/future-energy/projects/distributed-restart/key-documents



This report provides an annual progress review for the Distributed ReStart Network Innovation Competition Project. Through this, it is demonstrated that Distributed ReStart is currently on schedule, on benefit and under budget.

Project Direction

The project has delivered its outcomes on time and under budget.

This has been achieved through an effective cycle of control processes with appropriate financial management and key quality controls in place.

Planning is ongoing for the live trials, and work will continue on these over the coming months.

Power Engineering & Trials

The Power Engineering & Trials workstream is currently in the latter stages of the Demonstration phase of the project, with the focus being on developing and implementing the live testing at three trial sites (Galloway, Chapelcross and Redhouse). In Q3 2021, four days' live testing was undertaken in the Galloway network with the key achievements from a 13 MVA 11 kV hydro generator being:

- simultaneous energisation of the Kendoon 11/132 kV 30 MVA transformer, ~60 km 132 kV overhead tower line, and a Glenluce GSP 132/33 kV 60 MVA transformer
- energisation of the 275 kV network and simultaneous energisation of two 240 MVA 275/132 kV super grid transformers at New Cumnock substation.

Testing at Chapelcross (using a 60 MVA biomass generator), and Redhouse (using a 11.6 MVA battery energy storage system [BESS]) will take place in 2022, with the latter being a GB first incorporating grid-forming technology.

In parallel with the live trial work, a prototype of the distribution restoration zone controller (DRZC) has been developed and a test plan finalised, with factory acceptance testing (FAT) planned for Q4 2021 within the vendor's own laboratory test environment. Further testing will be carried out on the Real Time Digital Simulator (RTDS) at the HVDC centre in Q1 2022.

Organisational Systems & Telecommunications

Across May, June and July, Organisational Systems & Telecommunications workstream (OST) successfully delivered three desktop exercises, which demonstrated the feasibility of Distributed ReStart processes, in terms of the

roles for each Black-Start participant, and the timing of the process through simulation of events. These exercises also allowed the project to increase stakeholder participation in to gain valuable feedback for process refinement, work through a range of scenarios and gain information for future development of high-level training plans. As a next step, OST will work closely with the PET workstream in assessing the cyber-security and communications (voice and data) elements of the proposed DRZ-C restoration system that will link DERs, DNO, TO and ESO, during hardware-in-the-loop testing in January 2022.

Procurement & Compliance

The Procurement and Compliance (P&C) workstream has delivered its final deliverable from the Refine stage of the project. This was published in December 2021. The deliverable included a set of final recommendations for the Procurement & Compliance designs.

Previously the P&C workstream developed a procurement approach based on open tenders for the essential 'anchor' generator and a flexible framework approach for the 'top-up' services to be taken forward for further development (please see the P&C report 'A high-level outline of commercial and regulatory arrangements', for more information). This has been further developed and a final recommended procurement process has been outlined in the latest P&C report named 'Distribution Restoration future commercial structure and industry codes recommendations'. Key decisions have also been made on the lead procurement party (NGESO), how costs are funded (via the Balancing Services Use of System charge (BSUoS) for DER costs and RIIO-ED2 for DNO costs) and a draft tripartite agreement between NGESO, the relevant DNO and the relevant DER.

Following a detailed Codes review, legal text drafting and proposals for solutions in the relevant industry Codes clauses and sections has been completed and will be progressed via the relevant Code modification processes.

Stakeholder engagement has been a pivotal part of the P&C workstream; part of this has been to run a Test Procurement Event, where the proposed procurement designs were tested and refined following feedback. The details of the event can be found on the website, and the outcomes and takeaways are discussed in the latest P&C report.

Knowledge Dissemination

The learnings from this project will be of immense value to the industry, both locally and internationally, as energy systems continue to decarbonise and decentralise. Knowledge and Dissemination plays a key role in disseminating these learnings. Effective stakeholder engagement is crucial not only for sharing key findings and challenges but also for incorporating valuable feedback into the project.

The format for this year's annual conference, was a 5-day series of Podcasts called 'The Live Trials Stage'.

This included interviews with industry experts and members from the Distributed ReStart Project Team. Each Podcast is currently available to download on Spotify.

Project Governance

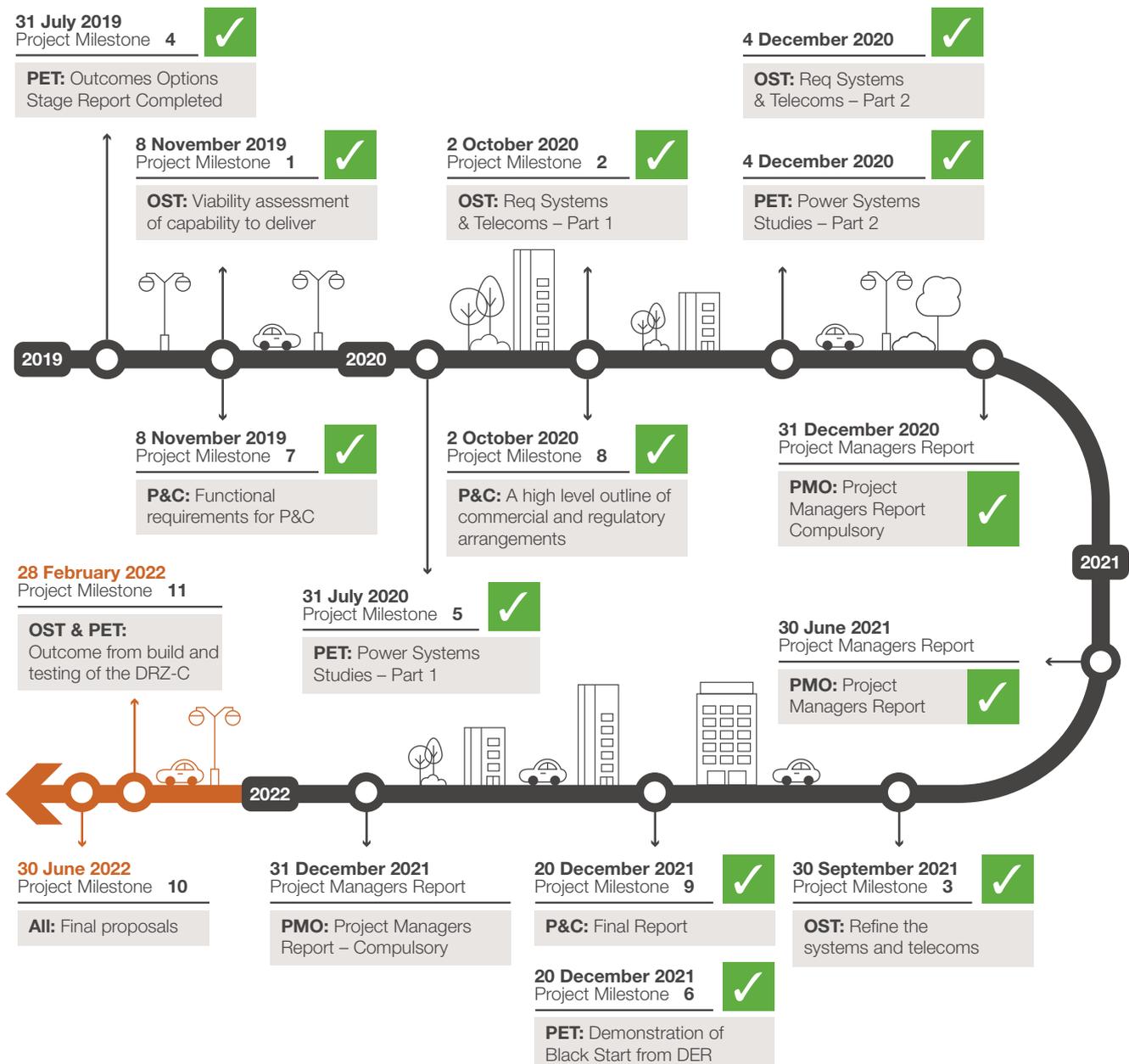
This project met all governance requirements in line with the 'Electricity NIC Governance document'.

The project confirms: no intellectual property has been generated to date which has not been publicly shared; all data is either publicly available on our webpage or available on request to our mailbox:

ReStart@nationalgrideso.com; and there are no material changes to project plans or outcomes from the bid submission stage. Every effort has been made to ensure the contents of this report are accurate.

Peter Candler

Figure 1:
Distributed Restart – Project milestones roadmap





Project delivery is highly dependent upon ensuring alignment between all workstreams, maintaining a clear direction and a project management office to hold the team to account. The Project Direction function delivers against these goals.

Key Controls

The Project Direction workstream has established and maintained a consistent approach to project management through a cycle of project controls, including:

- Monthly cost reporting from all partner companies contained in a centrally available system and detailed as far as possible against workstreams, cost categories and companies.
- Monthly finance surgeries to analyse costs incurred, verify their category allocation and review forecast costs.
- Monthly steering committee updates to senior leadership from all partner companies to scrutinise performance and action escalations.
- Weekly whole-project calls to address actions, update risks, update and mitigate any COVID-19 risks and promote awareness of whole-project outputs.
- Bi-weekly design architecture meetings to ensure alignment of all workstreams, supported by two senior engineers providing a design architect function.
- Weekly legal review of significant contracts to ensure value is being provided to the consumer through our significant works.
- Weekly PMO and Workstream lead meetings to monitor risks, actions, planned, leave and stakeholder engagement.

This is considered adequate control to enable delivery and manage spend, progress, risks and issues.

Key Challenges

Contracting for live trials has remained challenging. While contracts and non-disclosure agreements are in place, several participation agreements have remained in progress. The project has held a series of operator specific virtual meetings, calling many parties and their legal teams together. This has resulted in a richer discussion, improved understanding of requirements and ultimately a more efficient process. Participation agreements are now in place for the Galloway Trial, and the final agreements are in progress for Chapelcross and Redhouse Trials. The project aims to complete this work by end of January 2022.

An overview of our legal work can be found in the table below:

Legal Document	Complete	In Progress
Non-disclosure agreement	19	0
Legal contract	5	0
Participation agreement	4	2

Plan & Progress

The project has successfully delivered against Design and Delivery milestones to date. These include OST, PET and P&C workstream reports, as well as PPR reports.

Financial Performance

The overall project remains under budget while meeting all stage gate requirements. Budget outperformance is currently met through a leaner resourcing structure and effective utilisation of external resources. This has offset telecoms review costs from the initial stage. Furthermore, extensive stakeholder engagement has created project opportunities for low- or no-cost delivery of some required inputs. Overall project costs are strongly linked to live trials. These costs have been forecast for both short- and long-term live trials at three locations compared with the bid document commitment to test at least two locations. Underspend to date has enabled the project to fund the third live trial and build and test a prototype control system (DRZC). This is because of the careful management of our project finances. These two additional activities were not in the original scope of the NIC bid document but are value-added activities which will enhance the learning output from this project.

Quality Assurance

The project continues to work with a stakeholder advisory panel consisting of independent experts from across the electricity industry. This panel scrutinises the outputs of the project, providing independent quality assurance raising points for investigation in later outputs. In addition, the project also includes a design architect forum where our technical solution experts can review and challenge new proposals and examine output from workstreams. Furthermore, webinars, email promotional campaigns, a virtual project conference and presentation at external industry events has enabled public commentary on outputs. A full record of this engagement is available on our webpage:

<https://www.nationalgrideso.com/innovation/projects/distributed-restart>



The technical capability to deliver Black Start using DERs is assessed through the Power Engineering & Trials workstream. The outcomes are detailed technical specifications supported by live trials in 2021/22.

Workstream Summary

The power engineering and trials workstream is currently in the Demonstration phase of the project, with the output at this stage being a report detailing the outcomes and learning from the live trials completed in 2021. This will be entitled 'Demonstration of Black Start from DERs' (due to be published by 20 December 2021).

The workstream is on track to deliver multiple live trials on three separate case-study networks.

Live Trials

Three case studies (sample areas of the SP Distribution and SP Transmission networks) have been selected to carry out live testing, with the goal of proving the principle of Black Start from DERs in practice. The key progress for each of the sites (Galloway, Chapelcross and Redhouse) is given below.

1. Galloway case study, south-west Scotland

Key Features – Two hydro generators, Glenlee (15 MVA) and Kendoon (13 MVA), used separately as the 'anchor' generator (to initially energise the network and control the voltage and frequency). The test network extends to Glenluce 132/33 kV Grid Supply Point (GSP) distribution network (including two wind farms connected at 33 kV), and to New Cumnock 275/132 kV substation (including two 240 MVA 275/132 kV super grid transformers [SGTs]).

2. Chapelcross case study, south-west Scotland

Key Features – This live trial utilises Steven's Croft Biomass (60 MVA) as the anchor generator, connected at 33 kV to Chapelcross 132/33 kV GSP substation. The test network includes the associated 132 kV transmission network, including a transmission connected wind farm, and the Gretna 400 kV/132 kV SGTs.

Key Progress – The National HVDC centre has built a RTDS model of the Chapelcross distribution and transmission test network. Hardware in the Loop (HiL) testing has been carried out, using replicas of the generator protection relays, showing that for the

proposed trial energisation scenarios, no tripping of the anchor generator occurs.

Future Live Testing – It is proposed to have one test phase, of five consecutive days, in May 2022 to carry out the Chapelcross live trials. At present, preparatory works are in progress to facilitate the testing including a feasibility study to identify the requirements for the Steven's Croft Biomass generator to operate in an islanded network.

3. Redhouse case study, Fife, Scotland

Key Features – This live trial site focuses on testing the grid-following and grid-forming ability of the Redhouse BESS (11.6 MVA). This is located adjacent to Redhouse GSP, at 33 kV, with the local 33 kV distribution network and 132 kV transmission network (including a 132/33 kV 60 MVA grid transformer) included in the test network.

Key Progress – Two phases of live testing with the Redhouse BESS are being developed, each up to five days in duration.

- Phase 1 – this will involve establishing a 'private' 33 kV test network at the Redhouse BESS site with the addition of temporary load banks and diesel generators (to act as the anchor generator when the BESS is in grid-following mode), with tests including load pick-ups, synchronising on a weak network and transformer energisations.
- Phase 2 – this will build upon the phase 1 tests to include the local distribution 33/11 kV and transmission 132 kV networks. Testing of the ability of the BESS on its own to energise these networks (in grid-forming mode) will be a GB first.

Future Live Testing

The phase 1 and 2 test weeks have been rescheduled to summer 2022. Preparatory system studies highlighted an issue where, with the 'weak' test network, multiple re-ignitions (leading to excessive high voltages) may occur within the test network 33 kV vacuum switchgear should a 33 kV fault occur. The delay is to allow surge arrestors to be procured and installed within the relevant 33 kV switchgear cable boxes to mitigate this issue.

Additional Work

- **Grid-Forming Technology**

To complement the BESS grid-forming live trial, testing is currently in progress, utilising the RTDS at the Power Networks Demonstration Centre (PNDC), to develop strategies for transformer energisations from grid-forming converters.

In addition, a report has been completed on the implications of protecting the distribution and transmission networks if the anchor generator was a grid-forming converter (the fault infeed is limited to the full load rating of the converter making it difficult for existing protections to distinguish between load and fault currents).

- **Automation**

In parallel with the live trial work, development of a distribution restoration zone controller (DRZC) prototype is in progress. This will automate the restoration process, including coordination of multiple DERs, with key innovative features being slow balancing and fast balancing (sub-second control) of the DERs to maintain control of the frequency within the DRZ.

A test plan has now been finalised, with factory acceptance testing (FAT) planned for Q4 2021 within the vendor's own laboratory test environment. Further testing will be carried out on the RTDS simulator at the HVDC centre in Q1 2022 (using the RTDS model of the Chapelcross trial network which has been built).

Galloway 2021 Live Trial Successes

At the end of the live testing, the Kendoon 13MVA (11kV connected) hydro generator had been successfully proven to:

1. Galloway case study, south-west Scotland

- Simultaneous energisation of the Kendoon 11/132kV 30MVA transformer, ~60km 132kV overhead tower line, and a Glenluce GSP 132/33kV 60MVA transformer by closing a 11kV circuit breaker at Kendoon.

- ### 2. Energise the New Cumnock 275kV busbars via simultaneous energisation of two 240MVA 275/132kV at New Cumnock (successful energisations of an individual 275/132kV 240MVA SGT was also carried out).

Key Workstream Findings

The key technical findings from the development and implementation of the live trials to date are:

- **Generator voltage** – When energising transformers, it may be required to reduce the generator terminal voltage (on synchronous generators by adjusting the Automatic Voltage Regulator [AVR] set point) to avoid transformer saturation, which leads to high inrush currents and potentially transient and temporary over-voltages that may result in generator over voltage protection operation.
- **Point of Wave (PoW)** – In some network energisation scenarios, reducing the generator terminal voltage is insufficient to stop the over voltage protection operating due to excessive transient over voltages. In these cases, a PoW relay can be installed to control the closing time of the energising circuit breaker (three phase), to minimise transformer inrush and consequently the over voltages.
- **Switchgear capability** – Studies are required to ensure the Transient Recovery Voltages (TRVs) associated with breaking low fault currents, or network charging currents, are within the switchgear capability. Moreover, multiple re-ignitions (which generate excessively high voltages) may occur in vacuum switchgear if the Rate of Rise of Recovery Voltage (RRRV) is too high. Surge arrestors may be installed to remove excessive peak TRVs, and RC snubbers installed to reduce the RRRV to within switchgear capability.
- **Modelling** – Simulations are carried out using an electro-magnetic transient (EMT) software programme. There is often a lack of equipment data for an EMT type of study, particularly data required to model transformer core saturation, so assumptions have to be made.

Conclusions

Significant learning has been obtained from the live trial preparatory studies, which have highlighted key technical issues that require to be considered before live testing, for example:

- When energising transformers, inrush currents can be of high magnitude and rich in harmonics, which can cause over voltage tripping of the anchor generator.
- The capability of distribution switchgear has to be considered for non-standard operation (i.e. breaking very low fault currents and network charging currents).

Invaluable experience has been gained from the Galloway live testing, which has developed and proven network energisation strategies in practice. Significant success has been achieved in energising large sections for example the transmission network (~60 km 132 kV overhead line and grid transformers simultaneously), and up to the 275 kV network (including 480 MVA of SGT capacity simultaneously), from a relatively small hydro generator (13 MVA) connected at 11 kV.

Workstream Delivery

The Power Engineering & Trials workstream is on track to deliver the December report to meet the criteria outlined in Table 1:

Table 1:
Power Engineering & Trials Demonstration Stage successful delivery criteria

Delivery Criteria	Status	Action
Report 'Demonstration of Black Start from DER'	Ongoing	This report will be issued in two parts with part 1 (in December 2021), detailing the development of the three live trial sites to date (including the live testing at Galloway), and part 2 on completion of all the trials.
Detail the outcomes and learning from the trials	Ongoing	The results and learning from the individual trials will be recorded and collated in the part 1 or part 2 reports as appropriate.
Assess against the testing objectives specified for the trials	Ongoing	For each live trial a step-by-step test plan is created detailing the objectives for the individual test. The results will then be assessed accordingly.
Use a stakeholder-led approach	Ongoing	By the nature of the critical involvement of DERs in the live testing, significant stakeholder engagement is undertaken to carry out all the necessary preparatory works and the live trials themselves.

Workstream Technical Challenges

A summary of the biggest challenges expected to be resolved through the demonstration stage of the PET workstream is given in Table 2.

Table 2:
Key PET workstream challenges and mitigating actions

Challenge	Current supporting activities
Ensure that the live trials result in no damage to the DNO, TO or DER equipment.	System studies undertaken for all trials as appropriate to identify any potential issues (e.g. switchgear capability).
For the live trials, the low fault levels may inhibit the connection of converter connected DERs (e.g. wind farms).	Early engagement has been carried out with wind turbine owners, studies undertaken and test plans agreed to connect turbines incrementally to determine limits.
De-risk the live trials such that the maximum testing and learning is obtained.	Where practical, the trials will be carried out in a staged approach (e.g. live testing in the Galloway region was carried out over several weeks, with each subsequent test building on the previous learning.)
Ensure that future restoration solutions do not always require a synchronous generator as the anchor generator in a DRZ.	In the Redhouse trial, a grid-forming converter connected BESS has been commissioned to test its ability to energise the distribution and transmission networks (as per a synchronous generator). A GB first.

Workstream Plan

Table 3:
Workstream delivery plan for PET

Activities	Target Date
Report – Demonstration of Black Start from DERs – Part 1	December 2021
Factory Acceptance Testing (FAT) of DRZC	November 2021
DRZC Report: Findings to be published on the web with an Executive Summary	February 2022
Galloway Final Live Trial (including distribution connected wind farms)	April 2022
Chapelcross Live Trials	May 2022
Redhouse Phase 1 & 2 Live Trials	July 2022
Report – Demonstration of Black Start from DERs – Part 2	To be confirmed



Delivering the restoration process will be dependent upon the capabilities of the organisations involved, their teams, and teams' processes, systems and secure operational telecommunications. These areas are being developed through the Organisational Systems & Telecommunications workstream.

Workstream Summary

Having completed the three desktop exercises over the summer and published all the findings in our September report deliverable, the Organisational, Systems & Telecommunications workstream (OST) is now working with the PET workstream on the further development of the automated platform, including an integration plan and consultation on the functional requirements for operational telecommunications.

Successfully delivered the desktop exercises outcomes and system design and recommendations in September report.

This will allow the project to demonstrate capability to conduct a Black Start using DERs with tested processes and system integration proposals, alongside costed options for delivery of the required secure communications infrastructure and security.

In planning and delivering the Desktop Exercises, we engaged extensively with stakeholder communities, ensuring that all the existing restoration processes & procedures across organisations, communications, processes and command were captured. This involved representative teams and many representatives of Distributed Energy Resources (DERs) to build a clear picture of where restoration is today and where it needs to be tomorrow. We also worked closely with our partners, both SPEN & TNEI. With these partners, we established a restoration scenario, based on SPEN's Chapelcross distribution zone and, with TNEI, built this as a model that could be represented in an on-line simulation tool, as well as producing a restoration script that participants could follow. The release of the September report was supported by a new Podcast, featuring all the OST workstream team.

For the design and build of a prototype Distribution Restoration Zone Controller (DRZ-C). This would be capable of automating many of actions needed to create and establish an initial power-island as well as build and test the necessary communication (voice & data) infrastructure needed has produced several communication related

reports, which will be vital as Factory Acceptance and Hardware-in-the-Loop testing at the National HVDC facility in Scotland, early in 2022.

The key findings and recommendations will be further tested in follow-on projects, such as SPEN's 'Project Synergy', which is a Green Recovery/Ofgem funded Innovation project that will run from 2022 to late 2023, implementing a staked service in the SPD network a key input or additional tool to support the implementation of the Electricity System Restoration Standard (ESRS).

Key Workstream Findings

Organisations

Across the three desktop exercises and Engineering Advisory Council review, key learning themes have been established which have fed directly into the new process design presented in Chapter 5 of OST September Report. A key requirement for the desktop exercises was to test the efficacy of the proposed Organisational Model in four main areas:

1. Communications between the parties involved
2. Sequence of actions for restoring the target network
3. Command and control
4. Timing

Communications: It was clear from desktop exercises that communication was a key area of focus for further improvements both in clarity of communications, more specific requirements for data to be exchanged and a streamlining of some communications to reduce the operational burden. Across both the desktop exercises and the Engineering Advisory Council, it has been raised that it was possible that control engineers from different organisations could come away with a different understanding of what was agreed under highly pressurised scenarios. The use of automation will significantly mitigate this risk, as this reduces the number of human instructions and manual tasks which can lead to misunderstanding. This enables standardised training across the participants where human instruction is required. It has been identified that after instruction of the start of a plan, NGENSO does not need to be directly involved in operational approvals. This has been adopted in the new process map, which seeks to

remove any non-essential communications steps. There is no need for a notification after the anchor DER is stabilised, and there is complete DNO autonomy to continue growth of the restoration plan within the pre-defined distribution restoration zone (DRZ) area even after transmission energisation.

Sequence of actions: The project was challenged on the preference of loading only a single point of demand while proceeding to connect more DERs. It was thought that this introduces a single point of failure to the procedure so may be a high-risk strategy. This proposal has been assessed and does not substantially reduce the level of risk as the anchor DER already represents a single point of failure. However, re-sequencing demand connection ahead of top-up service provider connection is more likely to lead to unacceptable voltage or frequency deviations being passed on to consumers. Therefore, the guidance for distribution restoration zone (DRZ) plan creation that energisation of DER should be prioritised before demand but do note that this specific risk should be considered when conducting feasibility studies on distribution network operator (DNO) switching options.

Command and control: In desktop exercises, the concept of a transmission connected wind farm forming part of the restoration zone to understand the command and control issues. In a scenario where the transmission connected energy resource will become part of the DRZ, the instruction to join should come from the transmission network owner (TO) rather than the DNO. The DNO/DRZ-C will manage the voltage and frequency of the resource. The TO engineers did not see this as an issue. This case is only likely to occur in Scotland, where 132 kV connected generation is transmission scale and there may be a requirement for 132 kV connected fault infeed.

Timing

In addition to confirming the 8 hour lead-time for anchor generators to be ready to initiate a DRZ plan, top-up service providers may have a lead time after connection of auxiliaries before the service could be provided. This will be variable by technology type, but typical values raised in desktop exercises were up to 20 minutes. This has been considered within the process design, and the estimated time to connect a top-up service provider has been adjusted.

Operational Telecommunications

The functional specification for operational telecommunications which was delivered as part of the Design Stage II report will be reviewed. The specifications include general, technical and bandwidth requirements; others include supported protocols and cyber security considerations. The output from the DRZ-C design will compare the requirements from the DRZ-C against the initial published specifications, and this will be refined where changes have been identified or additional requirements identified. The DRZ-C design work is expected to be completed by end of February 2022.

Operational Systems

A report on technical and resilience capabilities of existing DERs to provide Black Start services has been delivered. This report summarises the capabilities and limitations of control and communications systems used for wind, solar, BESS and synchronous thermal generation. The information relates to the current and future control systems and communication interface with the DNO. Gathered through interfaces with subject-matter experts and DER owners/operators. This report will be available on the Project website February 2022. The report includes typical communication and resilience capabilities based on their connection topology, intrinsic capabilities and associated plant installed alongside each technology. Two case study types for thermal installations which included a steam-based and engine-based generation were reviewed. The report has provided the project with existing and future capabilities of power supply resilience, and control and monitoring facilities.

DRZC Design and Cyber Security Assessment:

The OST and PET workstreams are currently working in collaboration to deliver two strands of the project deliverables – the DRZ-C design and the refinement of the cyber security and resilient power and telecoms design to deliver the automated distributed restoration. As detailed in our December 2020 stage II report and highlighted in the June 2021 Project progress report, the proposed work has commenced, and this is intended to be completed by end of February 2022. The findings of this detailed work will be published as part of the project deliverables.

The DRZ-C design work includes detailed design of a DRZ-C solution, followed by its implementation and Hardware in the Loop (HiL) testing at the National HVDC centre. The intended outcome will be to investigate the resilience of the proposed design and its reliance on other systems, particularly power supplies and telecoms.

Cyber security assessment is being carried out alongside the DRZ-C design. This will investigate the communication resiliency, security strategy and design for potential participants' operational telecommunications (OT) networks and systems interfacing with power infrastructure and hardware. The intention will be to incorporate the cyber design as part of the DRZ-C design build.

This will be delivered in two phases published in February 2022 to align with the DRZ-C report:

Phase 1 – The Requirement phase has now completed and has delivered a series of reports, highlighting best practice for communications strategies and cyber-resilience for multi-party power systems and industrial control systems, along with communication, network and high-level data and end-to-end system requirements. In addition, it will set out options for disaster recovery systems.

Phase 2 – The Design phase intends to deliver costed designs for the communication, network and data systems, as well as setting out the communications strategies that will complement the designed systems. In addition, expect to receive detailed designs of selected disaster recovery options and estimated implementation and running costs of the designed systems.

Workstream Delivery

The Organisational, Systems & Telecommunications workstream has delivered against all Design stage and organisational requirements and is now in the Refine stage, next deliverables are shown in Table 4.

Table 4:
OST Refine stage successful delivery criteria

Delivery Criteria	Status	Action
3 Desktop Exercises, simulate a restoration of a DRZ (manual process)	All Desktop exercises completed	Findings documented, reviewed extensively with stakeholders (with the Engineering Advisory Council-EAC) and published in our September report
Capture learnings from the exercise within an update to the Key Deliverable 2 report.	Published 30/09/2021	Supported by an OST Podcast, released on Spotify simultaneously with the September report
Working with manufacturers to complete designs of systems and telecommunications required.	In Progress	OST team members are working closely with colleagues in the PET and P&C workstreams to finalise the functional specifications required.
Where appropriate, undertake offline tests to prove capability of systems via Hardware in the Loop testing.	In Progress	In 'Build' phase with partners.
Write-up of the final Systems & Telecoms requirements in the February Report.	Planned	

Workstream Technical Challenges

Table 5:
Challenges for the OST workstream

Challenge	Current supporting activities
There is not a consistent operational communications or system interface with DERs.	OST are working closely with Industry (ENA) and the DNOs to establish the best approach to standardising communications & system interfaces.
Wider industry changes could impact on systems and Black Start participants' responsibilities.	This is already a reality, with the requirement for NGENSO to establish a new Electricity System Restoration Service, as well as the ongoing progression towards a DSO future.
DERs do not currently participate in Black Start, so new processes and training will be required.	This is fully addressed on our OST September Report, and will be detailed in the future.
Provision of cyber secure end-to-end operational telecommunications.	A key objective of this workstream is to ensure that this vital (to the Critical National Infrastructure) requirement is not overlooked and is given full visibility in the February Report.

Workstream Plan

The high-level delivery plan for the refine stage of OST is provided in the table below.

Table 6:
Organisational Systems & Telecommunications refine stage plan

Activities	Target Date
Desktop exercises	Completed
September OST report on desktop exercises	30 September (delivered)
DRZ-C design and build	December 2021
DRZ-C cyber-security analysis	December 2021
Hardware-in-the-Loop testing of the DRZ-C	January 2022
Post-September Report telecoms refinement (DRZ-C related)	February 2022

Anticipated Change Requirements

Organisational change requirements are limited to the roles, responsibilities and training requirements with introduction of the DRZ-C system limiting the need for additional control engineers on site. Resilient and cyber-secure communications between DER and DNO are required to facilitate. These must be upgraded or replaced to meet the functional specification and include power resilience. Table 7 below summarises all anticipated changes, listed by organisation impacted:

Table 7:
Changes resulting from the Distributed ReStart Process Design

Organisation	Area Impacted	Changes Required
Transmission Owner	Interfaces	No expected changes in England and Wales. For Scotland, where there is a need for interface with transmission connected energy resources within a DRZ.
	Systems	No expected changes in England and Wales. For Scotland, elements of the control system may be installed at transmission level (132 kV).
	Telecommunications requirements	There may be a requirement for transmission phasor measurement unit data to be exchanged with the DNO to enable synchronisation functionality.
	Training requirements	At least biennial training adapted for specific DRZ options.
	Staff requirements	No change required.
NGESO	Interfaces	New interface with DNO.
	Systems	New Inter-Control Centre Communication Protocol for situational awareness of DRZ-C.
	Telecommunications requirements	Existing OPTTEL is suitable.
	Training requirements	Training frequency is suitable, but content needs to include distribution options. Joint training with DNO, TO and providers is recommended biennially.
	Staff requirements	No change required.

Table 7: Contd.

Changes resulting from the Distributed ReStart Process Design

Organisation	Area Impacted	Changes Required
DNO	Interfaces	The DNO now interfaces with NGESO. The DNO now interfaces with DER (via DRZC and voice communication).
	Systems	New group telecontrol sequences added to Advanced Distribution Management System. DRZ-C which meets the functional specification. New Inter-Control Centre Communication Protocol link with ESO
	Telecommunications requirements	Upgraded, power-resilient communications network which meets the functional specification.
	Training requirements	At least yearly training. Active participation in cross-industry training at least biennially. Desktop exercises conducted with DER participants. Internal specific DNO training on use of the DRZ-C system. Frequency control capability for redundancy to automation.
	Staff requirements	No specific change to minimum staffing but an enhanced reliance on called- in resources in the control room due to involvement earlier in the process. At least two control engineers should be involved in DRZP management. For this reason, where a DNO has multiple DRZP and LJRP options in their there may be a need for increased minimum resourcing or prioritisation based on staff constraints while further control engineers are called to site.
Distributed Energy Resources	Interfaces	A new interface providing redundant voiceover IP DNO communications will be introduced.
	Systems	It is anticipated that delivery of a contracted anchor or top-up service will require the DER to install new equipment to deliver the service. This will include direct response to DRZ-C instructions. However, this upgrade would be funded as part of service provision.
	Telecommunications requirements	The telecommunications requirements must meet the functional specification.
	Training requirements	The DER must demonstrate a robust training process for restoration capability or a resilient automated response to DRZ-C input signals. This will form part of assurance requirements.
	Staff requirements	A minimum staffing requirement should be maintained so that availability information can always be provided and that the contracted service can be delivered within 8 hours of instruction. For service delivery any contractor, called-in resource or self-starting organisational structures used must ensure that staff are dedicated to the specific provider in the event of restoration and that it does not compromise the overall ability of the energy resource to deliver the contracted service within 8 hours.



A key aspect of this project is to develop a viable route to market that ensures value for end consumers through transparency, competition and increased participation. The aim of the workstream is to develop a fit-for-purpose, stakeholder endorsed, end-to-end procurement process that meets the commercial objectives of the project.

Workstream Summary

The Procurement and Compliance (P&C) workstream has completed the Refine stage and has finalised its recommendations within the final report deliverable of the P&C workstream.

Proposals for the procurement process and commercial structures that create a route to market for a future Distribution Restoration service from DERs, which will be enabled through the proposed Code changes. The proposals and approaches developed by the workstream, have been refined through engagement with industry stakeholders.

Workstream Outputs

The output from the Refine stage is a final set of recommendations for the procurement and commercial designs, which is stakeholder endorsed and fit-for-purpose for a roll-out to business as usual.

A final set of proposed changes to the industry Codes and proposed legal text drafting to the Grid Code and Distribution Code has been developed.

Table 8:
Stages of the proposed procurement process for Distribution Restoration

Stage	Description
National strategy	This stage will be conducted by NGENSO, considering the whole of GB and the required level of restoration services to meet the Electricity System Restoration Standard (ESRS).
Regional strategy	This stage will be undertaken by each of the DNOs and will consider their areas and whether support from DERs can be provided to meet the regional elements of the ESRS.
Pre-event	Assessment and design of a tender for restoration services, considering the potential participants, timelines, technical requirements, etc.
Procurement event	The procurement event, involving submissions, feasibility studies, assessments, and contract award.
Construction	The period for any enabling works to parties awarded contracts, plus development of the Distribution Restoration Zone Plan (DRZP).
Commercial operations	The period of contract delivery; this will involve providers ensuring they meet their availability targets, alongside completing any required tests to prove restoration capability.

Procurement

The strategy development process involves five stages:

- objectives
- inputs and analysis
- initiatives
- refine
- implement.

The Design stage focused on refining the objectives and inputs and analysis, through stakeholder engagement, and developing initiatives. The Refine stage of the project has focused on the refinement of the developed initiatives, as well as developing the route for implementation.

The approach taken forward from the Design stage provided the most flexibility for the procuring entity around the specific design of the service, and it also offered the lowest barriers to entry for potential providers.

A process map was designed to understand the end-to-end process for the proposed procurement approach. This was tested with stakeholders to gather their views and ensure the procurement process is stakeholder endorsed. The final process is outlined in the Distribution Restoration future commercial structure and industry codes recommendations report. It has six high-level stages which are outlined, along with a description, in the below table 8.

Stakeholder engagement has been a pivotal part of the P&C workstream. Many engagements were undertaken with DERs, DNOs and other industry forums and workgroups. A key element of the challenge and review from industry was the Test Procurement Event, which was used as a 'live trial' to test the procurement and commercial designs. The feedback was used to shape the final decisions and recommendations of the P&C workstream. Further detail of the stakeholder engagements undertaken can be found in the latest P&C report.

Following the extensive stakeholder engagement, the P&C workstream produced a set of final recommendations and service designs, which were approved by the Project's Steering Committee.

1. The end-to-end procurement process is the main new deliverable for the P&C workstream, and following stakeholder input, the procurement processes for the anchor generator and top-up services were aligned as part of the service designs.
2. As part of the discussions around the proposed procurement process, the lead procurement agent has been agreed to be NGENSO until a point in time (probably around 2026) when a review of the process should be held. At this stage, depending on the outcomes of other industry-wide initiatives and following direction from Ofgem, the process can be evolved accordingly.
3. For the settlement and funding aspect of the process, NGENSO will cover DER contract costs through its normal price control, and the DNOs should recuperate their network upgrade and automation system costs through their own price control. Ofgem has stated that provisions in RIIO-2 and ED2 can be made as required, especially for any initiatives supporting our net zero ambitions.
4. To supplement the changes in Codes and to capture roles and obligations effectively, a tripartite contract is recommended which will use the Standard Agreement produced by the Open Network's WS1A, as the boiler plate detail that underpins the contract. The draft contract that has been developed fulfils the final requirement from the P&C workstream.

Codes

Following the detailed review of the industry Codes completed in the second report from the P&C workstream - A high level outline of commercial and regulatory arrangements report, the Codes work has progressed forwards to developing legal text draft changes and solutions to enable Distribution Restoration.

Draft legal text has been developed for the Grid Code, Distribution Code and the System Operator Transmission Owner Code (STC). The proposed legal text changes for the Grid Code and Distribution Code will be progressed via the Code modification GC0148 Implementation of EU Emergency and Restoration Code Phase II, while Distribution Restoration continues to be in scope of the terms of reference for GC0148. The STC legal text changes will be progressed via a Code modification for Distribution Restoration, which will be raised late 2021/early 2022.

A more detailed review of the commercial Codes has also been undertaken and solutions proposed to enable Distribution Restoration; the key Codes considered are the Connection and Use of System Code (CUSC), Balancing and Settlement Code (BSC) and Distribution Connection and Use of System Agreement (DCUSA). These changes as required will be progressed via Code modifications and issues groups during late 2021/early 2022.

A summary list of the key discussions that have been had during 2021 to agree the required changes to the Codes are as below:

- how to deal with non-CUSC parties participating in restoration services
- how to capture Distribution Restoration service providers and their obligations in the Grid Code and Distribution Code via the definitions and legal text drafting
- how to deal with DER providers and fuel compensation payments within the BSC
- impacts on DCUSA with potential increased DNO spending due to Distributed ReStart.

Conclusions, next steps and dependencies

Following the submission of the P&C final report, the next steps for the designs developed by the P&C workstream are intended to support the next round of the Electricity System Restoration (ESR) tenders, the first of which is in the South East (SE) region, commencing in April 2022 with contract delivery from 2025 onwards. It is intended that the two processes – the traditional process and the Distribution Restoration process – will be run in tandem.

The process designs, draft contract and the mock tender documents that were developed in this project will require

further consultation by NGESO’s BAU Restoration teams in order to align with their tender plans. Further collaboration with the DNO for the SE, which is UK Power Networks (UKPN), will also be required.

To fully embed the recommendations into the mainstream ESR process, the next outcomes/successes/challenges from the SE Tender will be needed to evolve this process to suit the industry needs for Distribution Restoration.

Workstream Delivery

Table 9 outlines the 2021 Procurement & Compliance workstream report’s criteria.

Table 9: Successful Delivery Criteria for the P&C workstream

Delivery Criteria	Status	Action
Generic standard terms of contract by which a service for Distribution Restoration could be procured reflecting industry engagement.	Developed	Draft standard contract terms for anchor generator and top-up service contained within the P&C final report published December 2021.
Outline the contractual obligations on each party required in the delivery of the service & the necessary commercial arrangements	Developed	Recommendations for these obligations and the ways they are captured explained within the P&C final report.
Regulatory and funding arrangements.	Developed	Recommendations for these obligations and the ways they are captured explained within the P&C final report.
Required changes to Codes and licence requirements.	Developed	The final proposed changes and legal text drafts have been developed and shared within the final P&C report.
Use a stakeholder-led approach.	Developed	The proposals are stakeholder endorsed, and this has been a pivotal part of the P&C workstream.

Delivery Challenges

The P&C workstream has now delivered on its requirements by developing a final set of recommendations for the Procurement and Compliance designs. However, there still a couple of key challenges for the workstream:

- The PET and OST workstreams still have deliverables outstanding, such as the completion of the PET live trials and the final designs of the DRZ Controller.
- How to manage the knowledge share and transition of the recommendations into business-as-usual processes.

Workstream Plan

Table 10: Procurement & Compliance workstream plan

Activities	Target Date
Industry stakeholder engagement	Ongoing
Engagement with PET and OST to address ongoing dependencies	Ongoing
Refinement of the recommended procurement approach	Completed
Design and delivery of a test procurement event subject to dependencies	Completed
Development of contract principles to support contract drafting	Completed
Development of Code change proposals and input to relevant Code modification workgroups	Completed

Anticipated Change Requirements

The transition of the project into business as usual will need careful considerations and enhanced stakeholder engagement to ensure a smooth transition.

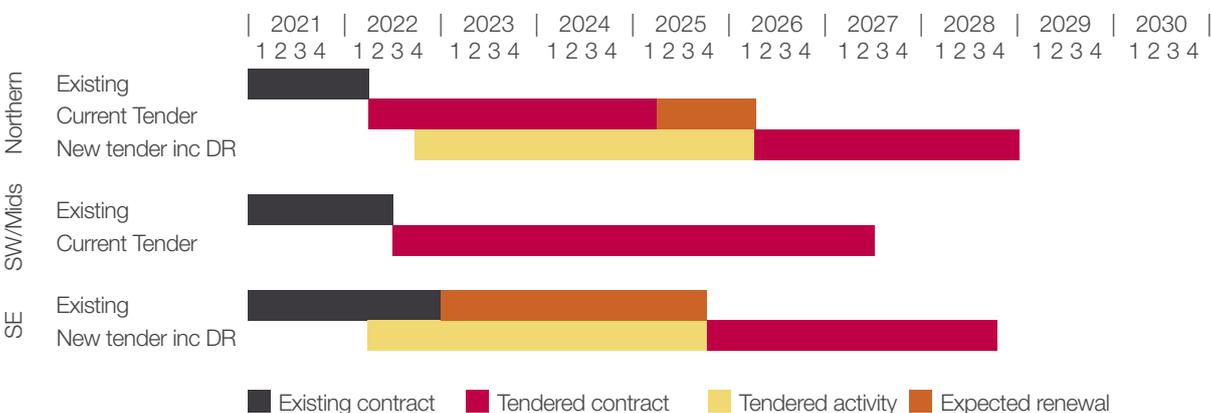
The below image, which was shared within NGENSO's Black Start Strategy and Procurement Methodology for industry consultation in March with subsequent submission to Ofgem at the beginning of April, outlines how NGENSO

expects the Distribution Restoration service procurement could align with the current Electricity System Restoration (ESR) tenders.

To ensure these timelines align, there will need to be increased engagement with industry stakeholders, including DERs and the relevant DNO for the South East region.

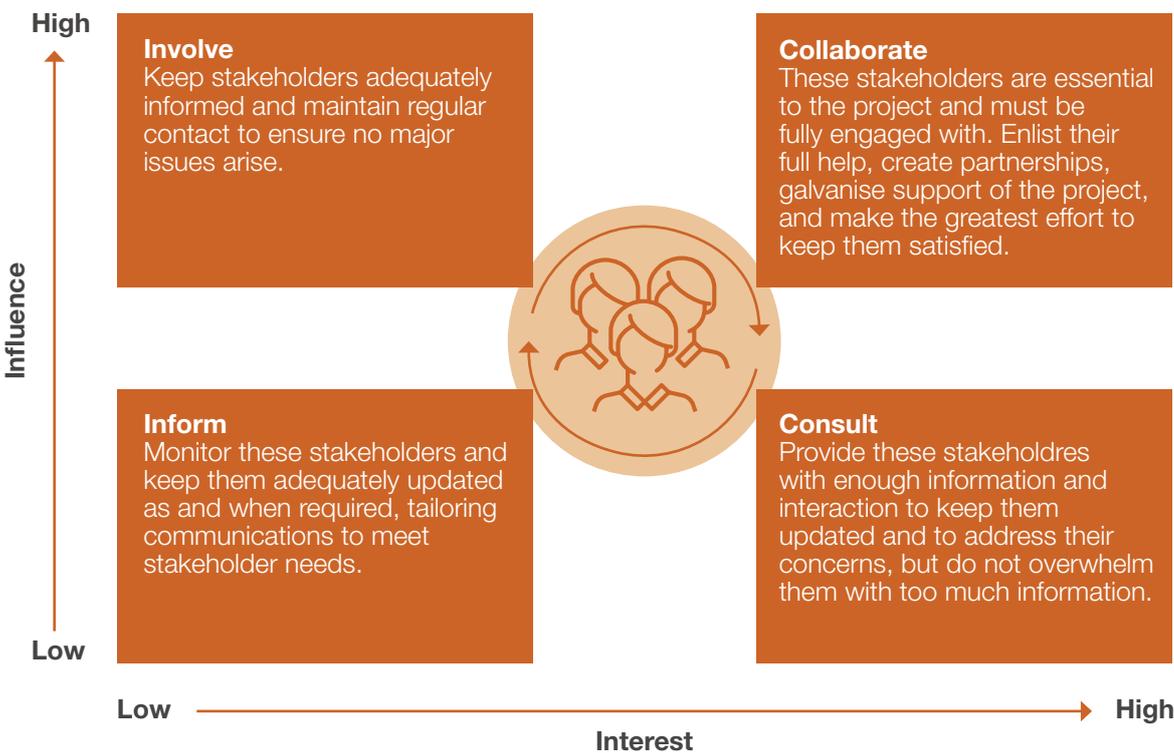
Figure 2:

Indicative timelines for the regional Electricity Restoration Services (ESR) tenders based on the **Black Start Strategy and Procurement Methodology 2021/22** report.





All workstreams have relied on a stakeholder-led approach to uncovering challenges, establishing existing capabilities and developing future options. This approach has been facilitated through the Knowledge Dissemination workstream.



Co-creation

The principles of co-creation and its complex interactions can be defined into four clear pots, as shown above. Co-creation, in the context of Knowledge and Dissemination, refers to our product and service design process in which input from stakeholders plays a vital role in implementation being realised. The four main principles defined above demonstrate the keys areas in which we now ensure our messages are reaching our various stakeholders. Through this, we demonstrate that all information is readily available and that we track and monitor feedback effectively. Stakeholder growth is changing, and to ensure that delivery is met our messaging is becoming more defined, enabling us to set the path for delivery. In the early stage, our engagement focused on building awareness, developing interest and getting people involved. We did this through:

- accessible content, industry-wide events, webpage and social media updates
- webpage and social media analytics targeted industry events
- targeted email campaigns and regular updates
- annual conferencing and engagement via LCNI
- 1:1 meetings, targeted workshops, conference papers.

As we move to the later stages of the project, our focus becomes more defined by keeping our audiences informed and delivering outputs. This is being achieved through:

- our stakeholder advisory panel
- invitation to tender for the delivery of small works
- delivery of larger works
- involvement in the trials and procurement contracts.

Stakeholder Analysis

As we move to the releasing our closing reports, we continue to monitor and track via statistical analysis the following:

Email registration campaign – open rate vs global average, email click rate vs global average and email unique clicks by global average. All figures reviewed showed an above average pick-up indicating that the messaging landed as intended.

Number of registrants – number of attendees that directly register to participate in our workshops.

Segmentation – we understand from the analysis carried out to date that our smaller, more specialised audiences are pivotal in the delivery of continued roll-out. This is a current consideration in all work that we undertake going forward. Audience participation – over 120 technical questions were raised by the audience and answered, with follow-up being published in the post event email campaign.

Post event/On demand – By utilising our social media channels we can see that multi-faceted media is required to ensure delivery giving people options to participate at a time that is most convenient to them.

Feedback – To date, engagement feedback has either been excellent or incredibly good or good.

Engagement Activities

The format for this year's annual conference, was a 5-day series of Podcasts called 'The Live Trials Stage.' This included interviews with industry experts and members from the Distributed ReStart Project Team. Each Podcast is currently available to download on Spotify. The Distributed ReStart project is now entering its most challenging and exciting phase – The Live Trials Stage. This stage involves testing the proposed designs at live network trials and with desktop exercises.

This years Distributed ReStart annual event was delivered via a series of podcasts. 'The Live Trials Stage', followed on from last year's conference, 'The Design Stage'.

The podcasts were designed to incorporate all the workstream leads and to present our journey through a series of challenging questions. Giving the audience the opportunity to download and listen at a time that was convenient for them.

The podcasts remain hosted on Spotify and the main webpage, for people to download.

The hosting and interviewing were carried out by people independent of the core project and externally employed. Hosting was Trisha Lewis an actor, facilitator, business coach and podcast host with experience as a professional performer and speaker.

Interviewing was Simon Harrison, a member of the project's Stakeholder Advisory Panel and is Group Strategic Development Director at Mott MacDonald.

The podcast dashboard details the whole campaign including email campaign, podcast statistics, webpage analytics and customer feedback.

The agenda consisted of the following:

MONDAY 12/04/2021

Podcast 1: High level summary on the progress of the project. Why is it such an important project and why is so much at stake?

[Click here](#)

Podcast 2: To explore the role of design architects in the project. How design architecture works, the assumptions, trade-offs and choices made.

[Click here](#)

TUESDAY 13/04/2021

Podcast 3: Panel discussion with external industry experts Distinguished external experts holding the project to account in all areas

[Click here](#)

WEDNESDAY 14/04/2021

Podcast 4: The Live Trials – latest developments and progress. An exploration of the latest findings and possibilities for a future roll-out

[Click here](#)

THURSDAY 15/04/2021

Podcast 5: Technical and cyber challenges for systems and telecoms. Unpacking the cyber-challenge and how to ensure system resilience

[Click here](#)

FRIDAY 16/04/2021

Podcast 6: A new procurement approach for DER-based black start. Why do we need a new approach and how will codes work?

[Click here](#)

Figure 3:
Live trials stage –
Five day podcast dashboard

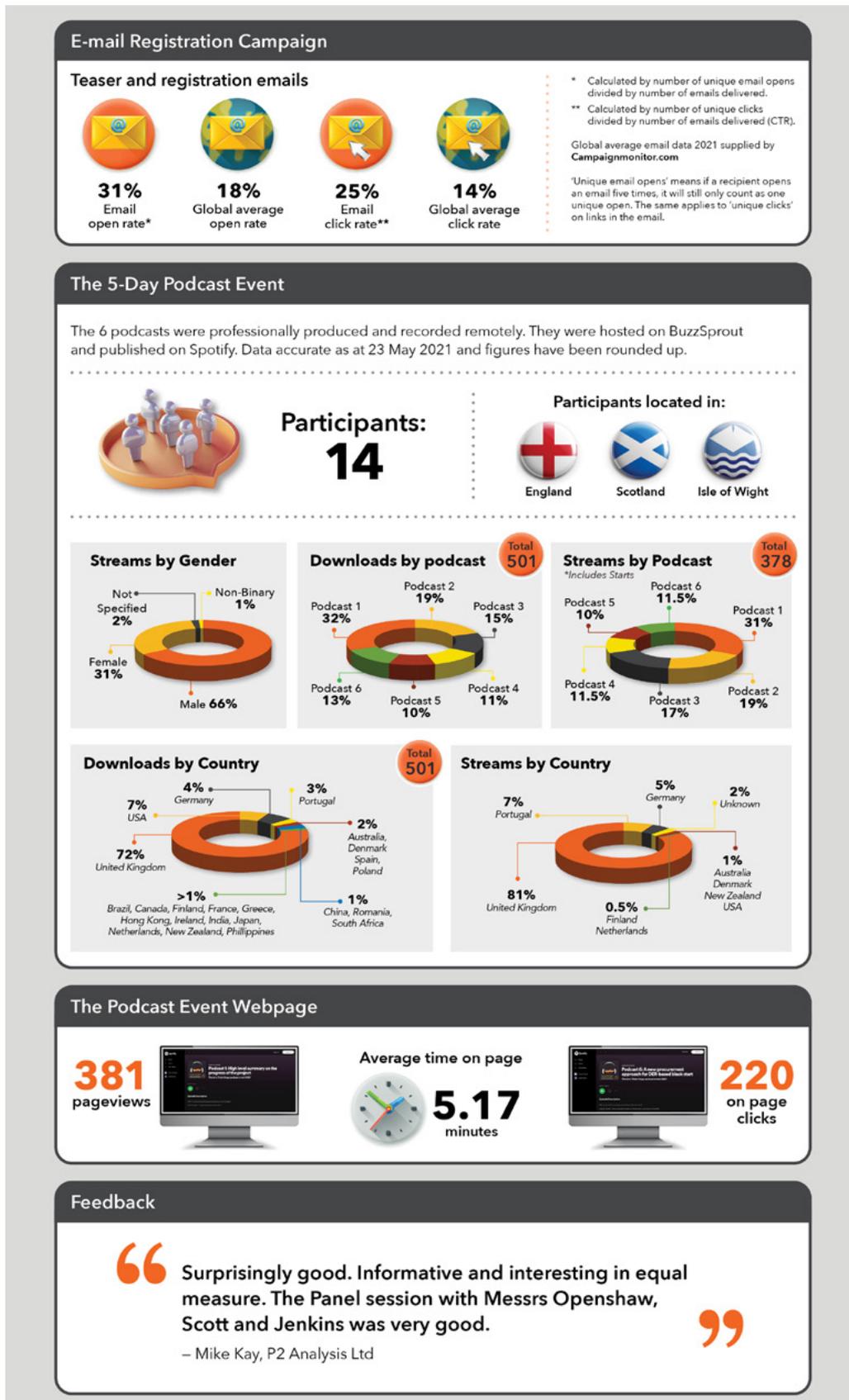


Figure 3 Stakeholder Campaigns, demonstrates the reach and success of the campaign.

We have an active distribution list of over 793 registered interested parties and use this as a channel to engage with

people globally through email updates sharing pertinent project information and news, for webinars discussing specific project deliverables and challenges, and to promote attendance at specific industry events.

Table 11: Engagement activities

Event	Description
<p>27 May - 06 Jul 2021 Desktop exercises</p>	<p>Three opportunities to experience a simulated black start from DERs and help co-create the restoration process.</p> <p>For anyone involved in Distributed Energy Resources (DERs), who could potentially offer a future Black Start service.</p> <p>The desktop exercises gave you hands-on experience of the proposed operational processes. And an opportunity to feed back into the processes and comms structures to help shape the future service.</p>
<p>2 Aug - 06 Sep 2021 Procurement & Codes Test Procurement Event</p>	<p>Test Procurement Event for providers of Distributed Energy Resources (DERs) who are interested in offering a future Black Start service.</p> <p>The event is the equivalent of a 'live trial' for the Procurement and Compliance workstream. An opportunity to get first-hand experience of the potential procurement process for DERs to deliver a Black Start and give feedback to ensure the process works across various DER types.</p>
<p>12-15 Oct 2021 ENIC 2021</p>	<p>ENIC 21 (formerly LCNI) brings together the learning from over 60 UK innovation projects. ENIC 21 is a conference for people who manage, develop, and implement innovation initiatives in the Energy sector.</p>
<p>30 Sep 2021 OST Close-down and podcast report launch</p>	<p>The final report on the conclusion of the desktop exercises is for the organisational component of the OST workstream. Highlights of the report include:</p> <ul style="list-style-type: none"> • how Distributed ReStart will meet the requirements of the new Electricity System Restoration Standard (ESRS) for restoration timelines • how the process design has been shaped by stakeholder views at every stage, enabling optimisation and end-user consideration in its development • the restoration simulation, which was conducted with distribution network operators, transmission operators, the electricity system operator and more than 20 representatives from distributed energy resources (DERs) • the process design for the role played by automation, which incorporated feedback from refining the manual proposal in the Design Stage • how this process design involves an element of change for all organisations • a change impact assessment with recommended approaches to change management.

Email Campaigns

Table 12: Summary of stakeholder engagement activity

Summary December 2019–November 2021	Statistics
Campaigns	73
Emails	46,092
Delivery Rate	99.35%
Bounce Rate	0.645%
Open Rate	31%
Click Rate	38%
Engagement	
Active	34%
Inactive	66%
Segmentation	
DNO/TO	7%
Industry Experts	27%
Stakeholders	66%

Planned Future Engagement

Table 13: Planned stakeholder events

Event	Date
Stakeholder Advisory Panel	Ongoing via teleconferencing
Strategic Telecommunications Group	Ongoing via teleconferencing
CIGRE Black Start working group	Ongoing via teleconferencing

Knowledge Sharing

As a project team it is important to us that all stakeholders are listened to and the knowledge gained from an interaction is passed on to everyone. If this report has prompted any questions of your own, email us at ReStart@nationalgrideso.com



Data Access

Every effort is made to disseminate all project learnings through [our webpage](#):

Should any further information be required, such as access to raw data, this may be requested subject to conditions on background IP. This request should be sent to:

ReStart@nationalgrideso.com

Intellectual Property

No specific intellectual property has been developed which has not been shared openly in reports at this time.

Contracts with third parties are structured so that their background intellectual property is protected but the project can share findings on designs and solutions proposed for Black Start from DER.

Material Changes

No material changes have been made to deliverables or budgets within the reporting period.

Accuracy Statement

The contents of this document are accurate and representative of our current project progress as of 20/12/2021.

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