Distributed ReStart

Project Brief

March 2020

In partnership with:

tnei

SP ENERGY NETWORKS

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Executive Summary

Introduction

All workstreams of the Distributed ReStart project are now in the design stage of the project after delivery of the feasibility analysis reports in July and November 2019. This briefing report is intended to give a high-level technical update on project outputs at this interim stage prior to delivery of detailed technical reports at the conclusion of the design stage. In addition, this report highlights some key challenges for the project and poses questions for input across wider industry.

Power Engineering

Power engineering functional requirements will be built off the basis of ongoing power systems analysis across various case studies, consultation and finally refinement through live network demonstration.

Across all four case studies progressed, restoration strategies have been developed and work towards developing live trial plans and contracting DERs has begun. In addition, electromagnetic transient models have been developed for each case study and testing will outline the capability of generators to deliver against these restoration plans. For each case study, analysis which will propose specific protection solutions are also in progress.

Functional requirements for an automated restoration zone controller are also being developed by several technology companies to inform both power engineering requirements, organisational design and operational system specifications.

Many work packages are in progress, centred around delivery of functional technical parameters which will be tested through live trials.

Organisational systems and operational telecommunications

Organisational process structures, inclusive of system consideration and potential automation options are being developed alongside an operational telecommunications functional specification which will enable their delivery. These will be refined through ongoing cross industry engagement.

All organisational models developed through the feasibility analysis stage indicate some level of organisational change and do not currently lead to a specific model which is most appropriate.

For this reason, both ESO and DNO control models are being consulted on through manual process refinement.

This will identify bottlenecks and demonstrate relative model merits for enabling targeted use of automation, systems or staff resources.

Consultation is also ongoing against the telecommunications functional specification to refine technical requirements for:

- Minimum or/and maximum speed
- Minimum or/and maximum accepted network latency
- Network Bandwidth /Circuit number
- Independent Power resilience
- Separation
- Telecommunication devices requirements on electrical sites
- Cyber requirements
- Redundancy

Procurement and compliance

Effective procurement of the service is required to drive value for consumers, suppliers and wider industry. As a result of this, the feasibility stage has produced multiple commercial models to be progressed and consulted on across the design stage.

In addition, work to develop code change proposals which build on the initial code change requirement analysis is ongoing.

Delivery timeline

The project will deliver detailed analysis of the outputs discussed in this report through technical reports:

- Power Engineering: 31st Jul 2020
- Organisations and operational systems: 2nd Oct 2020
- Procurement and regulation outline: 2nd Oct 2020

Summary progress reports will also be delivered on:

- Project Progress Report 30th Jun 2020
- Project Progress Report 31st Dec 2020

We have also outlined possible service delivery timelines and posed some of our key project challenges at the end of this document to better enable wider industry participation. In addition, organisational, telecommunications and procurement consultations are ongoing prior to delivery of technical reports.

Email us at Restart@nationalgrideso.com with any thoughts, queries or requests to be involved in ongoing consultations.

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Introduction

Distributed ReStart aims to incorporate the views of wider industry at every opportunity, bringing diverse expertise across the electricity market to help deliver a world first solution to the challenge of Black Start using Distributed Energy Resources. *The project has conducted a feasibility study and begun development of end to end service design for Black Start from DERs. This gives consideration of power engineering challenges; organisations, systems and operational telecommunications which will enable the process; procurement methods that will lead to greatest consumer benefit; and compliance issues which will allow for integration into business processes. This technical brief will consider the main outcomes for the project until March 2020 based upon ongoing design stage work and the outputs of the feasibility reports (Power Engineering, Operations and Telecommunications; Procurement and Codes).*

Detailed reports, live Q&A logs and detailed of how to get involved can be found on our webpage: https://www.nationalgrideso.com/innovation/projects/distributed-restart
If you have any queries or comments stemming from this report, don't hesitate to contact us at ReStart@nationalgrideso.com, we look forward to hearing from you

1. Power Engineering

Following on from a report on the 'Viability of restoration from DERs' in July 2019 the project is in the Design Stage (August 2019 till July 2020).

The outcome of this stage (due to complete on 31/07/2020) will be a report entitled "The Technical and Financial Proposals for Demonstration." This report will be based on detailed analysis of networks and DER, and will produce initial proposals on the technical aspects of Black Start from DER.

The project case studies will be used as the basis to support this assessment, with the works including; identifying the potential restoration strategies, the DER functional requirements, network changes required, indicative cost to make the DER and networks Black Start 'ready', and the scope of the live trials to prove the theory in practice.

1.1. Case Studies

In order to 'flesh out' the exact requirements to enable Black Start from DER, at this stage three of the ten case studies have been selected for further detailed analysis. These have been chosen as they provide a variety of types of anchor generation (the synchronous generator which will initially energise the network), in order that any critical differing technical characteristics can be identified and modelled. Two of the networks are in the SPD area, Chapelcross and Galloway Region, and the third in the SPM area, Legacy. Additional case studies will be utilised as required to provide learning applicable on a GB wide basis.

The project is currently developing test programmes and contracting with generation to prove capability of DERs to Black Start. To reduce the overall project risk these will be split into two phases with the first intended to prove to the ability of an anchor generator to operate in island mode and power system model validity, and the second stage to prove the ability to establish and maintain a stable power island and energise up to the transmission network. There may also be options to test automation during later stages.

The case studies cover a broad range of generation technologies including: biomass and wind, hydro and natural gas as voltage source providers. In addition, a case study incorporating batteries and solar panels may be used to demonstrate co-location of technologies and utilising existing network assets to provide stabilising demand for a synchronous generator.

1.2. Restoration Strategies

For the selected case studies, stage by stage restoration plans have been developed. The purpose of these is to identify the extent of network energisation that can be achieved from the anchor and additional DER (e.g. wind, solar and batteries), and the optimal strategies for achieving this. The options include the sequential switching of circuits, simultaneous energisation of multiple circuits, establishing 33kV power islands, and energising up to higher voltages (132kV, 275kV or 400kV).

1.3. Power system studies

Based on the case study restoration strategies, power system studies are currently being undertaken to assess what options are technically viable and identify the associated technical capability of the DER and the challenges. The studies include steady state load flow, dynamic, and electromagnetic transient (EMT) studies.

1.4. Network Protection

One of the major network issues is the ability of the existing protection systems to detect and clear a fault given the relatively low fault level when the network is supplied from DER only. As such, protection assessment studies are in progress, on the three selected case study networks, to identify the extent of the protection changes which may be required, and possible solutions (e.g. new relays may be required with additional settings to be implemented during a Black Start).

1.5. Functional and testing requirements

It is expected that technical requirements will be analogous to existing Black Start service requirements with reduced requirements suitable for lower voltage level and lower MVA machines. However, identification that network load may not provide a reliable stable minimum demand, means functional requirements may be extended to include demand specification. Live network demonstrations and further power systems studies will allow for further refinement of system operability figures and development of technical functional requirements.

1.6. Conclusions

Many work packages are currently in progress with a view to informing the next PET report in July 2020. This will include a detailed analysis of networks and DER, to provide proposals on the relevant technical aspects of providing a Black Start service from DER

Ongoing, the project will use a learn by demonstration approach to produce and refine technical parameters into a functional specification.

2. Organisations and Operational Systems

Appropriate organisational structures, allocation of roles and responsibilities, systems and resilient operational telecommunications are essential for delivery of a Black Start service.

In the initial stage of Distributed ReStart, the project conducted a high-level analysis of the Black Start participants, focusing on the capabilities of Distribution Network Operators (DNO), Transmission Owners (TO) and the Electricity System Operator (NGESO). Distributed Energy Resources (DER) were also considered but less DER stakeholder engagement was conducted in this early stage.

Development of Black Start processes, functional specifications for resilient Operational Telecommunications, and requirements for automation and systems, are current focus areas. The project will ensure that we meet our design criteria of familiarity, flexibility and end to end resilience.

2.1. Organisations

Four organisational models were developed in the feasibility stage, considering the Black Start control entity as either the ESO or DNOs and the automation extremes of fully automatic and fully manual. The key finding is each model will require some degree of organisational change. To better understand the impact of these changes, both ESO led and DNO processes have been developed for industry consultation. This will enable bottlenecks to be

identified and measures, such as automation to be targeted at the most appropriate points.

Table 1: Key focus areas identified through the organisational analysis)

Category	Organisation	Automated ESO control	Manual ESO control	Automated DNO control	Manual DNO control
Control Staff	NGESO	A	R	G	G
	DNOs	A	A	A	R
Organisational impact analysis showed that without automation significant additional resource would be needed for both control party options. Therefore, automation options for DMS and EMS are undergoing assessment in parallel to development of an automated controller for restoration zones.					
Training Processes	DNOs	A	A	A	R
The key issue from the viability stage for training requirements is that under all scenarios DNOs would need additional training regarding power island control, particularly with regards to balancing and frequency. Consultation against processes which have been developed will refine the training requirements.					
Supplementary Criteria	Meets Black Start Needs	A	R	G	A
	Ease of roll out	R	A	R	A
	Alignment with wider industry change	R	A	A	A
No single model exists for the Distribution System Operator. Therefore, the project has progressed both ESO and DNO control models through to the design stage to align with wider network changes. The project continually engages with the strategic telecommunications group and the Open Networks project to remain aware of these wider changes.					

2.2. Operational Telecommunications

The existing Black Start processes rely heavily on TO-owned highly resilient dedicated operational telecommunications, which enable Black Start communications between the ESO, TOs, DNOs and service providers (mainly transmission connected generators). Introducing DER into the Black Start process, requires the involvement of many more stakeholders, both in terms of number and type. These new Black Start participants use a large variety of Operational Telecommunication technologies, with varying levels of resilience.

A high level review of the current options for Operational Telecommunications (satellite, fibre optic cable, microwave radio, private LTE, mobile network (4G/5G), private radio, Openreach Ethernet services, Open reach fibre to the premise and Openreach fibre to the cabinet options) has been conducted and the relative merits of each approach outlined in the OST viability report.

The project is now focussing on understanding the requirements for Operational Telecommunications and the development of a functional specification. The criteria considered critical for design include:

- Minimum or/and maximum speed
- Minimum or/and maximum accepted network latency
- Network Bandwidth /Circuit number
- Independent Power resilience
- Separation
- Telecommunication devices requirements on electrical sites
- Cyber requirements
- Redundancy

Consultation has commenced to refine the functional specification and ensure alignment with other existing and developing communications standards across the industry.

2.3. Operational Systems

During the feasibility stage, the project reviewed the existing systems key to Black Start. For example, the energy management systems currently provided to DNOs, TOs and ESO. Visibility, familiarity and interoperability are key criteria for developing the Distributed ReStart system requirements. System needs will also depend on the organisational models and processes brought forwards and will, in turn, influence the technical requirements for Operational telecommunications.

Ongoing consideration will be given to the elements of processes most suitable for Energy Management System automation and the controller functions being investigated through the power engineering analysis.

2.4. Conclusions

The key findings to date are that familiarity, flexibility and resilience are essential requirements for all proposals.

3. Distributed Restoration Zone Controller

The organisational and power engineering analysis demonstrates that, growing, maintaining and restoring a distribution power island at distribution level is likely to require some level of automation for the process to be technically and operationally viable. The project has introduced the concept of a Distributed Restoration Zone Controller (DRZ Controller or DRZC) to describe the system(s) that will enable monitoring, control and coordination of a range of DER, and network resources to provide Black Start services.

Our approach has been to engage four companies with expertise in Active Network Management and DER Management Systems (DERMS) to develop a DRZC front end design specification and associated reports on communications and interface requirements. These will have the potential for progression to prototyping and testing. In addition, through engaging multiple vendors and including additional project findings, this will provide information that can be used to produce a vendor neutral set of requirements for rollout across GB.

Each specification is expected to consider: Power island growth, compatibility with multiple DER technologies, coordination of multiple DERs in a power island, controllable demand requirements, measurement parameters and signal types required, wider network restoration compatibility, utilisation/integration of existing DMS and EMS systems, and options for control engineer intervention.

The outcomes of this process will be released in a project publication that will inform future decisions across GB on the specification of DERMS.

4. Procurement and Codes

The overall objectives of the code change and procurement methodology are to provide:

- Increased competition
- Reduced barriers to entry
- Increased transparency
- Financial value for the end consumer
- Accelerated restoration times
- A functional route to market for new service

In order to achieve this, commercial options which may enable service delivery, have been identified and will be refined through industry consultation and further technical findings. This will inform the contract and procurement design to ensure greatest value is provided to the consumer, providers and network operators.

4.1. Procurement

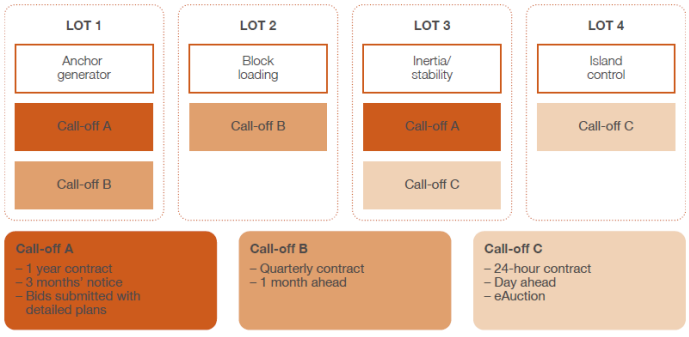
The existing principles of Black Start procurement remain relevant to the DER restoration approach and will guide the design stage consultations:

- A clear and transparent service requirement;
- Enablement of competition and;
- A reduction or removal of barriers to entry

To enable this, overall project deliverables across power engineering, systems and telecommunications design are aiming to develop functional technical requirements. Commercial analysis shows that allowing providers to develop their own method for meeting a requirement drives transparency and enables competition.

It is possible that there may be a requirement for more than one solution, to access a wider range of participants or to access different types of services. If the technical requirements could be split into component parts of a 'full' Black Start service, it could reduce overall costs and reduce barriers to entry.

An example of how this structure could work is provided below (Lots are illustrative only).



Procurement design will investigate, through industry consultation, the appropriateness of specific timescales for purchase and the overall impact this will have on supplier participation. In addition, opportunities for streamlining the existing contractual process will be considered to reduce complexity which is a current barrier to entry.

4.2. Codes

An initial review of the codes has established which changes may be required to facilitate a bottom up restoration strategy. Table 2 shows a summary of the code change requirements identified. Ongoing work will create code change proposals based on this analysis which will be developed through the standard change mechanisms.

Table 2:Anticipated impact of the Distributed ReStart project on network codes (R – Some change requirements, A- Minor change requirements, G – No change requirements)

Code	Change requirement
BSC	Changes made to reflect greater involvement of DERs and DNOs during restoration
CUSC	Potential changes dependent upon the procurement mechanisms used.
DCUSA	Potential changes dependent upon the procurement mechanisms used.
Distribution Code	Additional detail could be added to DOC9 or adequate signposting to Grid code may be appropriate.
ESQCR	The earthing policy from this documentation could lead to an un-earthed power island below 132kV without review.
G5	Minor alteration or relaxation under restoration scenarios may be appropriate.
G91	This could include clearer requirements for telecommunications resilience of DERs in the event of power outages.
G99	Clauses relating to island operation, protection, frequency response and fault ride through may be subject to change or derogations for a Black Start restoration scenario.
Grid Code	Principally inclusion of new parties in specific roles and responsibilities across OC5, OC9 and BC2.9
P2	No changes required
P28	Minor alteration or relaxation under restoration scenarios may be appropriate.
P29	Minor alteration or relaxation under restoration scenarios may be appropriate.
SQSS	No changes required
STC	An adaption could include all relevant participants, or an equivalent distribution equivalent document could be created

4.3. Conclusions

Since the publication in November 2019, the project has been developing material and a plan for industry consultation on commercial and codified options for service delivery. This will be used to refine the procurement strategy and methodology options identified in the initial report.

In addition, code change work is being progressed through ESO and DNO code change teams to ensure compliance of the service and enable procurement processes to start after the project is completed.

5. How to get involved

On our webpage you will find an animation, high level description of project outputs and the project infographic explaining current and potential future Black Start Processes.

If you would like to be invited to our ongoing events and project consultations, ensure you are registered to our mailing list where we will announce participation at industry events or issue invitations for workshops. If you have specific contributions for any workstream don't hesitate to contact us at ReSart@nationalgrideso.com .

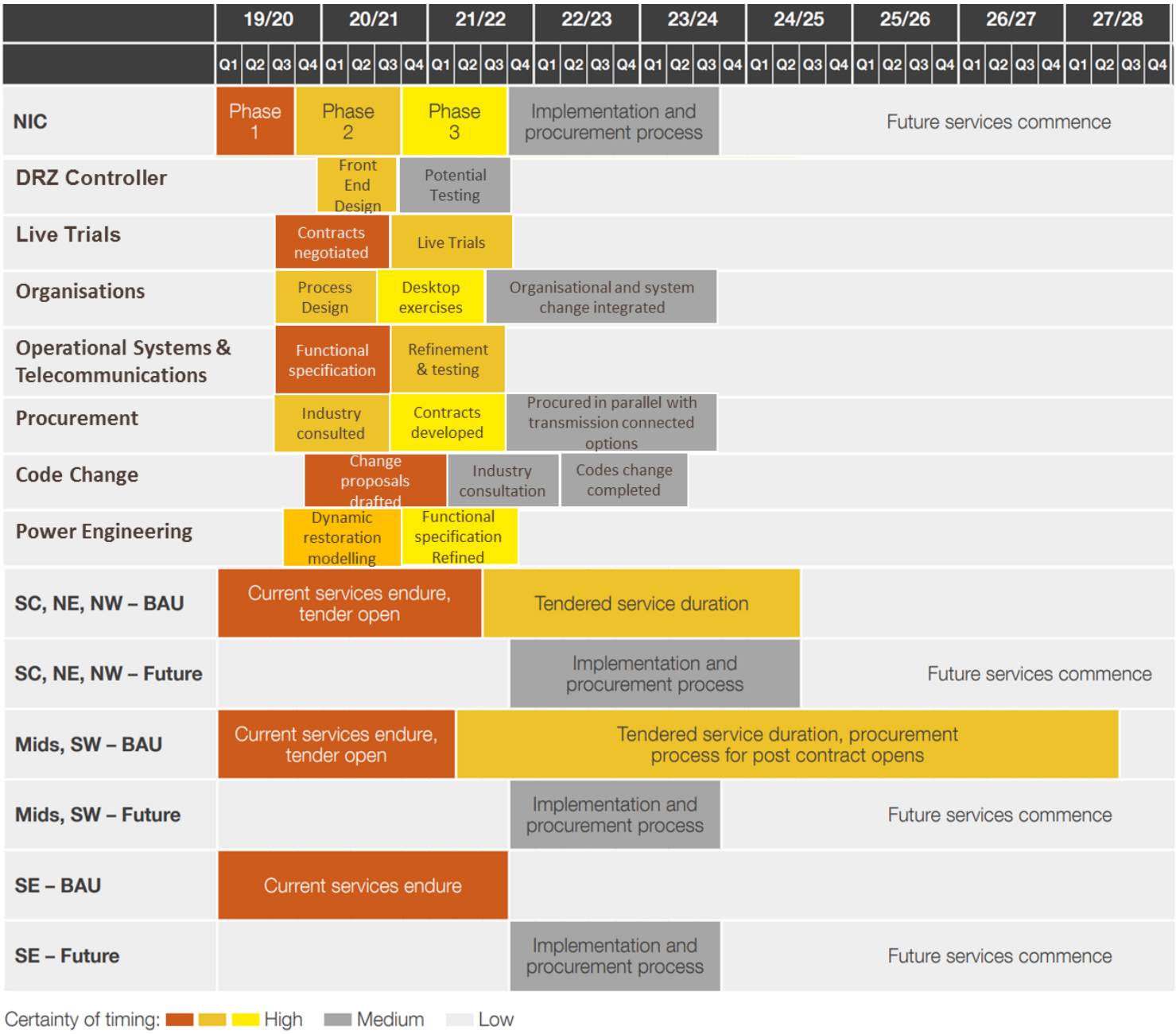
6. Next Steps

The project will deliver the outputs and findings through three reports scheduled for delivery on:

- Project Progress Report 30th Jun 2020
- Power Engineering: 31st Jul 2020
- Organisations and operational systems: 2nd Oct 2020
- Procurement and regulation outline: 2nd Oct 2020

In addition, there will be opportunities to engage in consultations on: telecommunications specification, process design and procurement design from April to August 2020.

Table 3: Timeline of Black Start procurement including the Distributed ReStart outputs (NIC), please note that these are subject to change based on project findings.



7. Key Project Challenges

As a project we know that you are keen to help, and we are keen to listen. Below is a list of the key challenges we expect to face over the design stage. If you have answers or ideas let us know at ReStart@nationalgrideso.com

1. **There is significant change across the electricity industry as the DSO model develops and decentralisation of generation continues. How can the project effectively future-proof solutions?**

2. **Most DER were never intended to provide Black Start capabilities. Is it practical to retrofit the capability or will this service have to be "built in" to new DER?**

3. **Will commercial incentives alone be enough to ensure sufficient volume of DER with Black Start capability, or should Codes be revised to make some capability mandatory for new connections?**

4. **DER-based Black Start places new responsibilities on multiple organisations. Will training and organisation preparation take longer than technical changes to DER and networks?**

5. **DNO flexibility markets are starting to emerge but have so far demonstrated low liquidity. How can the project promote liquidity and competition for this more complex service?**

6. **Co-located services and procurement over different timescales potentially enable more technologies to participate but also increase service search costs. How should the project balance these different cost drivers?**

7. **Based off this report are there any additional methods or approaches we should consider to maximise consumer benefit?**