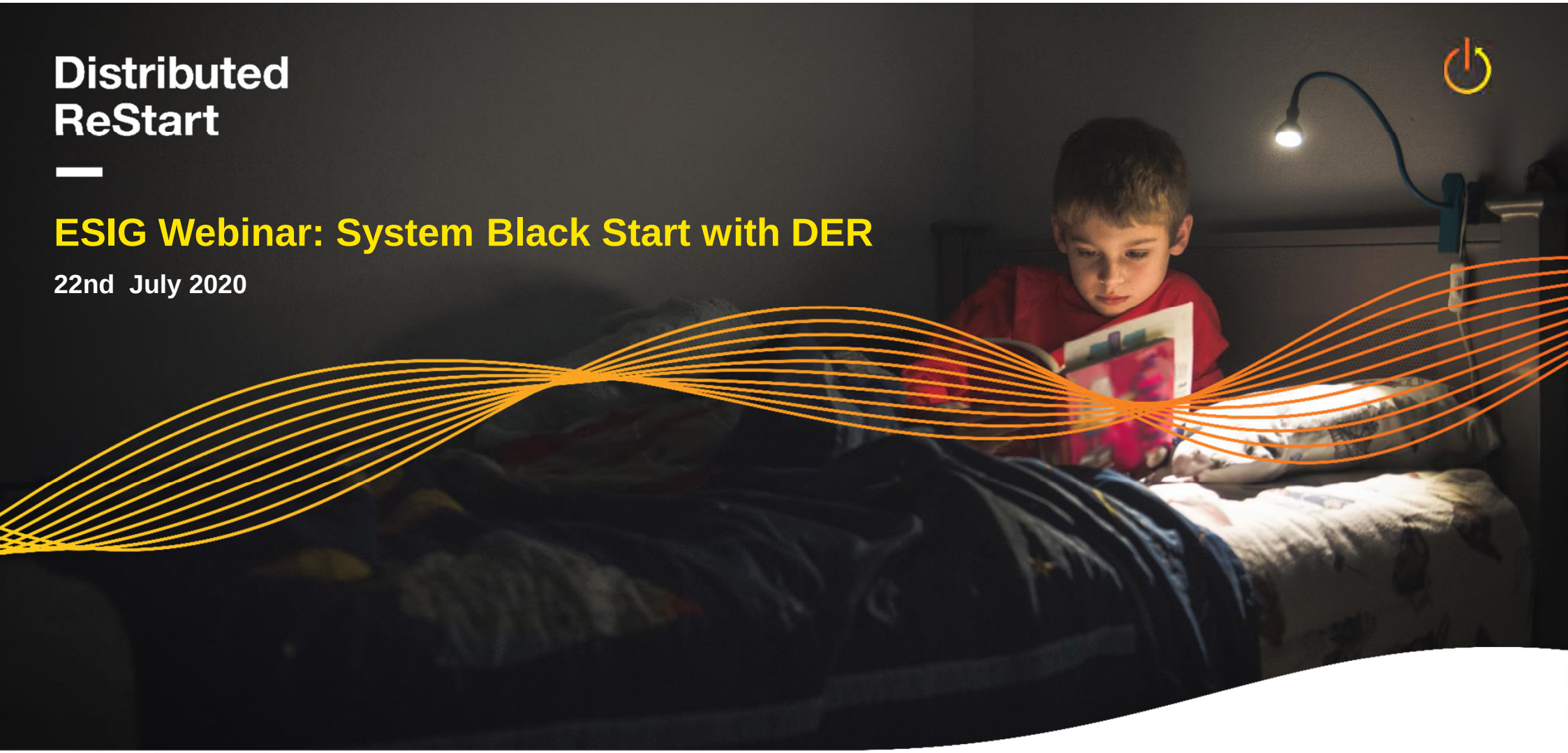
Distributed ReStart

ESIG Webinar: System Black Start with DER

22nd July 2020



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What is Black Start?

Technical Recovery Procedure

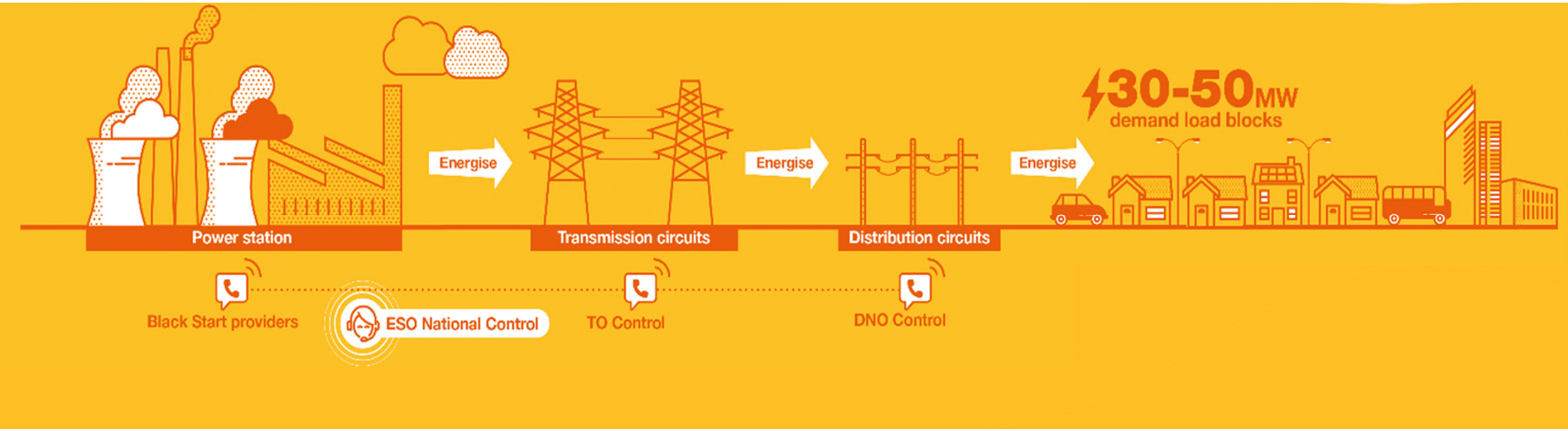
Plan to restore power in the event of a national failure of electricity supplies

High Impact Low Probability

It is a credible risk so must be planned for. It has never happened in the UK but has occurred internationally

Flexible Plans with Defined Partner Roles

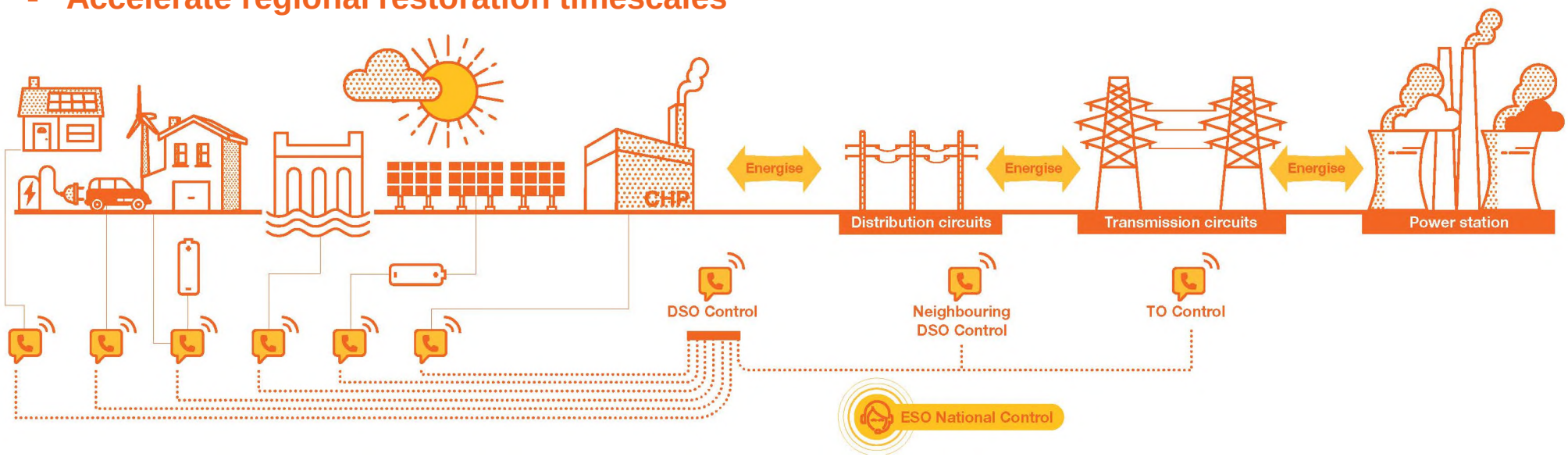
Multiple options within each local joint restoration plan (LJRP)
Partnership between Provider(s), TOs, NGESO & DNOs



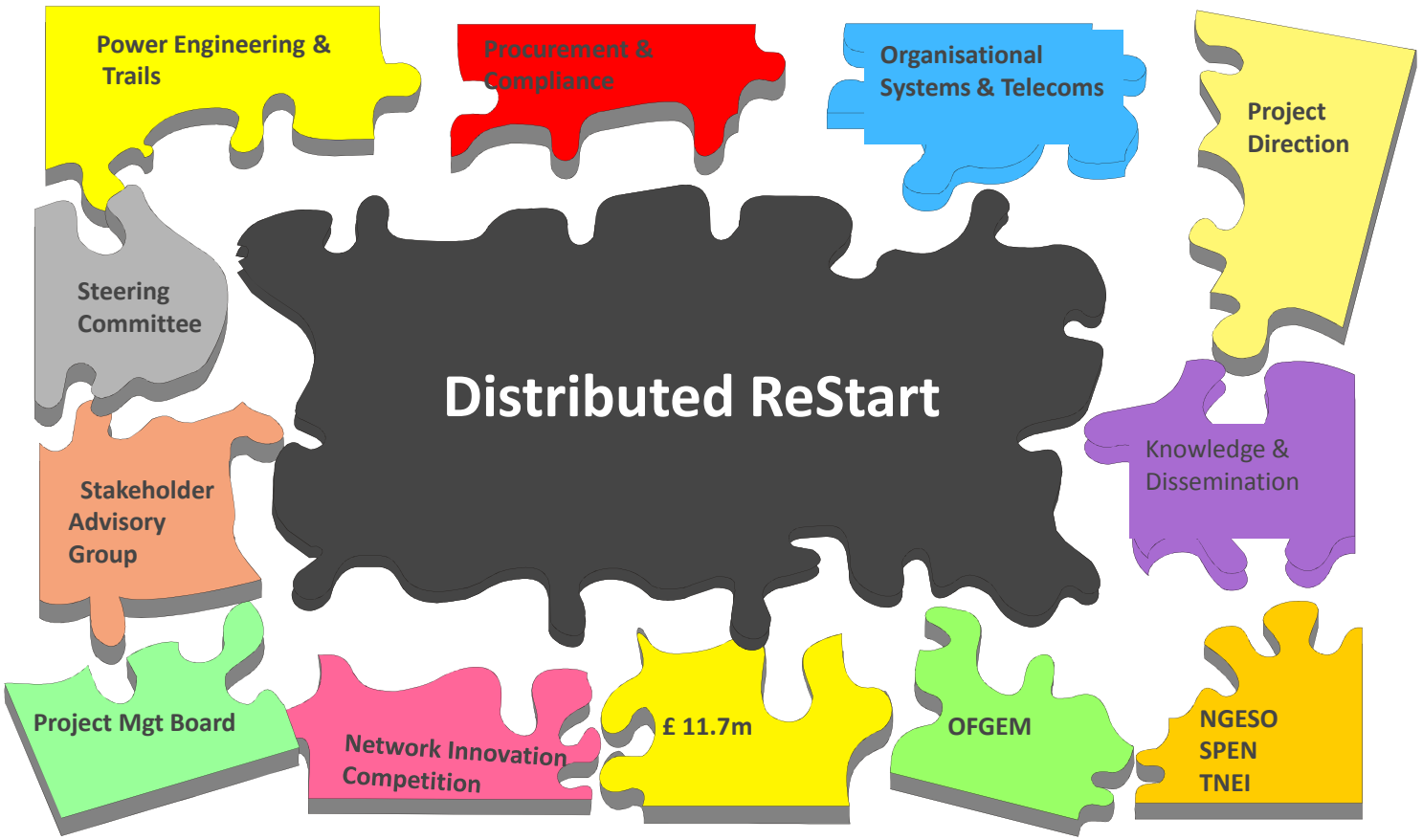
Why Distributed ReStart?

A ‘Bottom up’ approach for Black Start restoration from Distribution to Transmission using Distributed Energy Resources will:

- **Reduce cost to consumers by introducing competition**
- **Decrease carbon footprint**
- **Future proof our networks**
- **Accelerate regional restoration timescales**



What is Distributed ReStart ?



What We Delivered in 2019 - Options

Power Engineering & Trials

Delivery Criteria	Status	Action
Choice of case studies and options for network re-energisation in each case	Complete & Published	List of 10 case studies produced with load flow study outputs published for restoration options
Initial proposals for the functional testing requirements to apply for Black Start from DERs	Complete & Published	A holistic review of existing assurance test practice produced with initial change proposals made to make this applicable to a DER led restoration.
The potential for rollout across GB.	Complete & Published	A review of the long term development plans of all DNOs was used to demonstrate that initial proposals are suitable GB wide. In addition, case studies have been selected to ensure they are representative of the range of networks and DERs across GB.
Use a stakeholder led approach	Ongoing	Questionnaire issued to all DNOs, DNO/TO workshop and multiple stakeholder events held/attended.

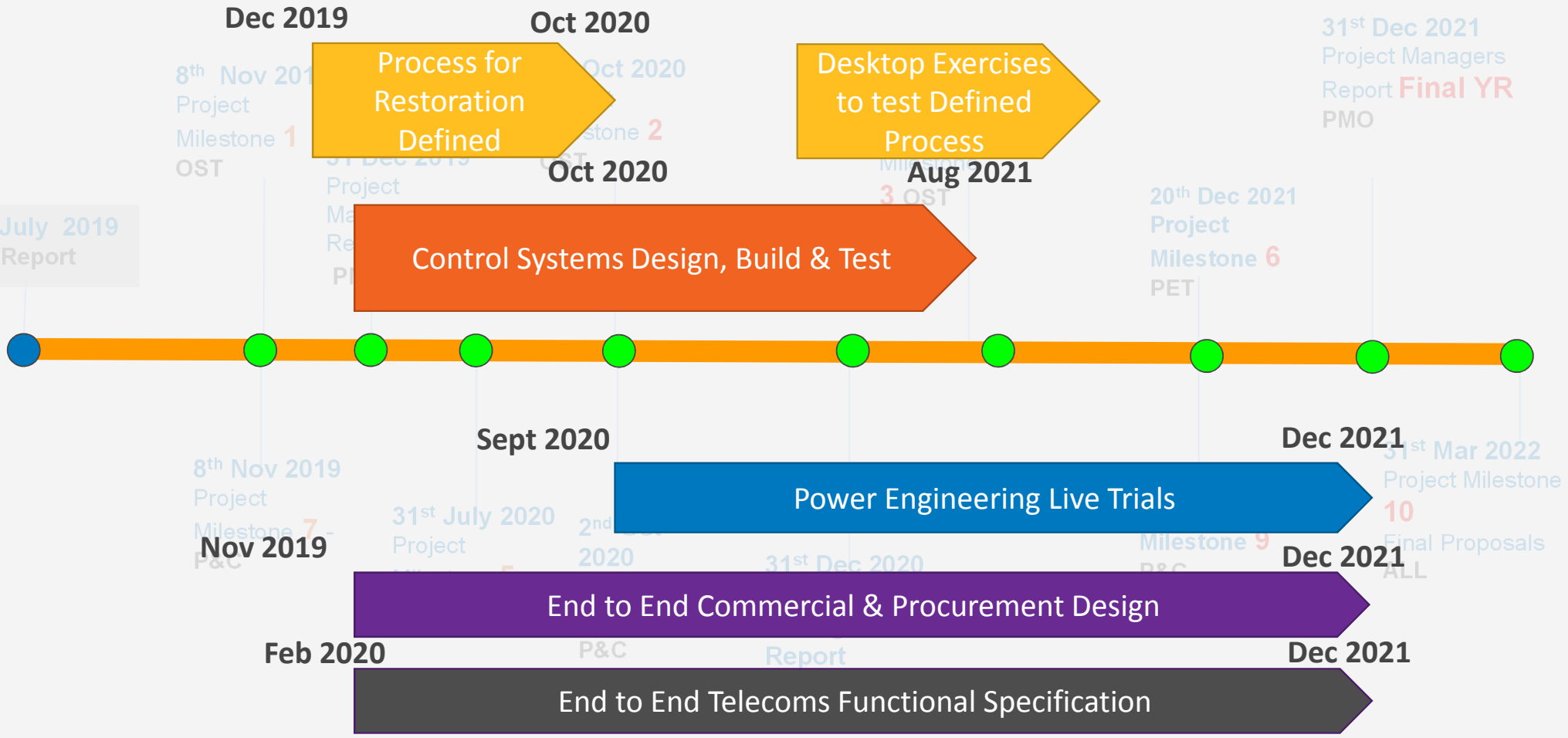
Organisational Systems & Telecommunications

Delivery Criteria	Status	Action
Resilience assessment of telecommunications	Complete & Published	High level assessment of telecommunication technologies completed. ENA Strategic Telecoms Group (STG) consulted. Detailed analysis commenced.
Resilience and capability assessment of systems	Complete & Published	A review of existing operational systems published, along side requirements for an automated controller (DRZC)
Capability assessment of Organisational structures and skills	Complete & Published	Existing organisational capabilities and skills reviewed and assessed against set of 4 organisational models
Identify key areas of focus for the design stage	Complete & Published	Assessments completed (see above) highlighted potential areas of change and focus. Key elements include: flexibility, familiarity and resilience.
Use a stakeholder led approach	Ongoing	Questionnaire issued to all DNOs, DNO/TO workshop and multiple stakeholder events held/attended. Ongoing engagement with STG and Open Networks.

Procurement & Compliance

Delivery Criteria	Status	Action
Procurement options and selection criteria	Complete & Published	A review of existing procurement practice has been produced. Along side potential procurement options to be adapted based on stakeholder review and wider project outcomes.
Commercial design	Complete & Published	Commercial considerations published. This outlines the anticipated changes from any commercial structure and will feed into the draft procurement and contractual design.
Gaps and blockers in codes & licences to enable the service	Complete & Published	A thorough review of existing codes has been produced outlining any gaps or blockers with proposed areas of focus. In addition a horizon scan exercise has been used to ensure the project is aware of risks and opportunities from future codified arrangements.
Use a stakeholder led approach	Complete & Published	A horizon scan of innovation projects with commercial implications has been produced and multiple stakeholder events held/attended.

What We Will Deliver in 2020 & 2021 – Design, Refine & Demonstrate



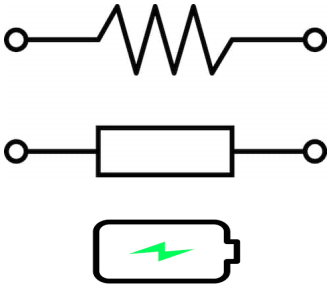
Technical Challenges Identified

DER

- How do we communicate?
- Who operates the unit?
- 'Anchor' unit synchronous or asynchronous?
- Must be located on a network which can be islanded
- Frequency response needs to be provided
- Voltage regulation needs to change
- Fuel must be resilient to loss of supply
- Must remain stable during block loading

Demand

- What is the Block Load Pickup capability?
- Is flexible demand needed to mitigate Cold Load Pickup risks?
- How will customer demand be restored?
- Instantaneous switching?

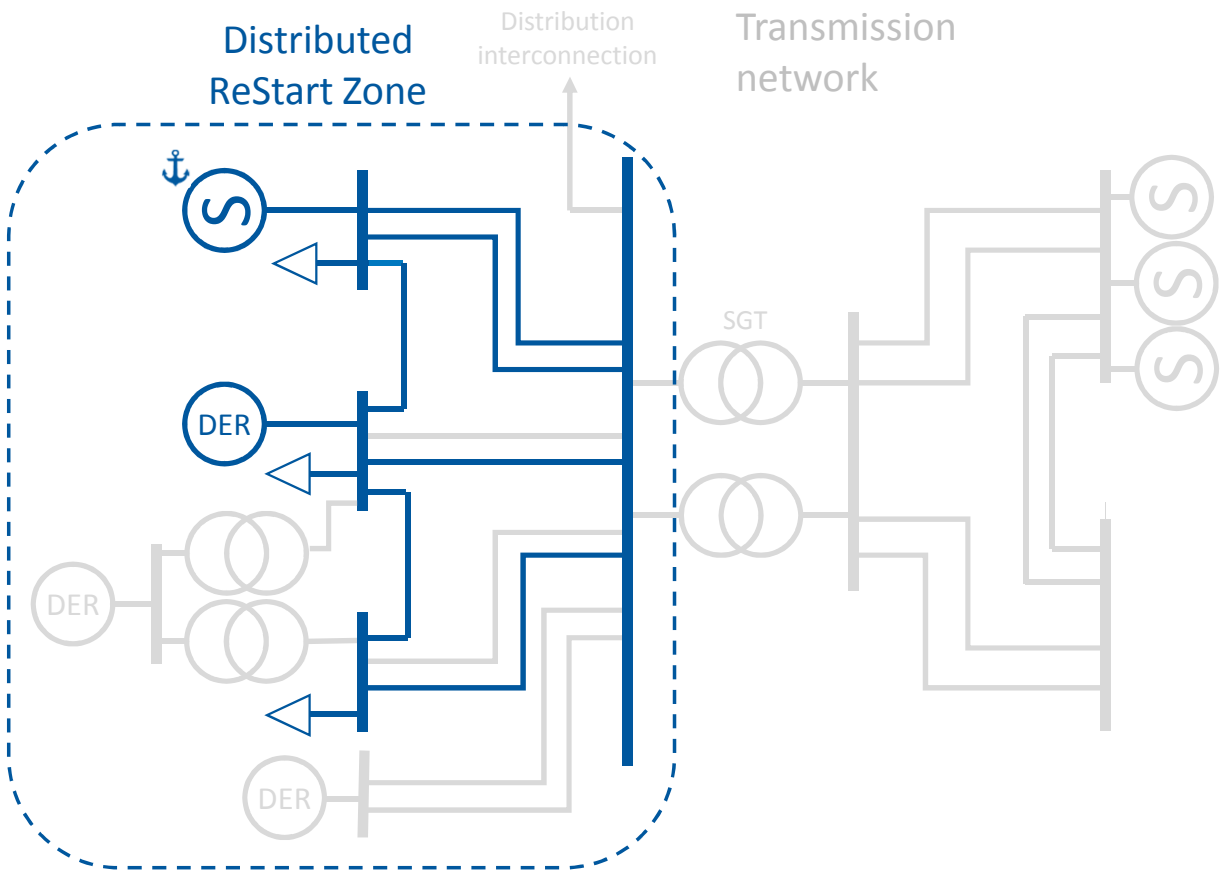


Networks

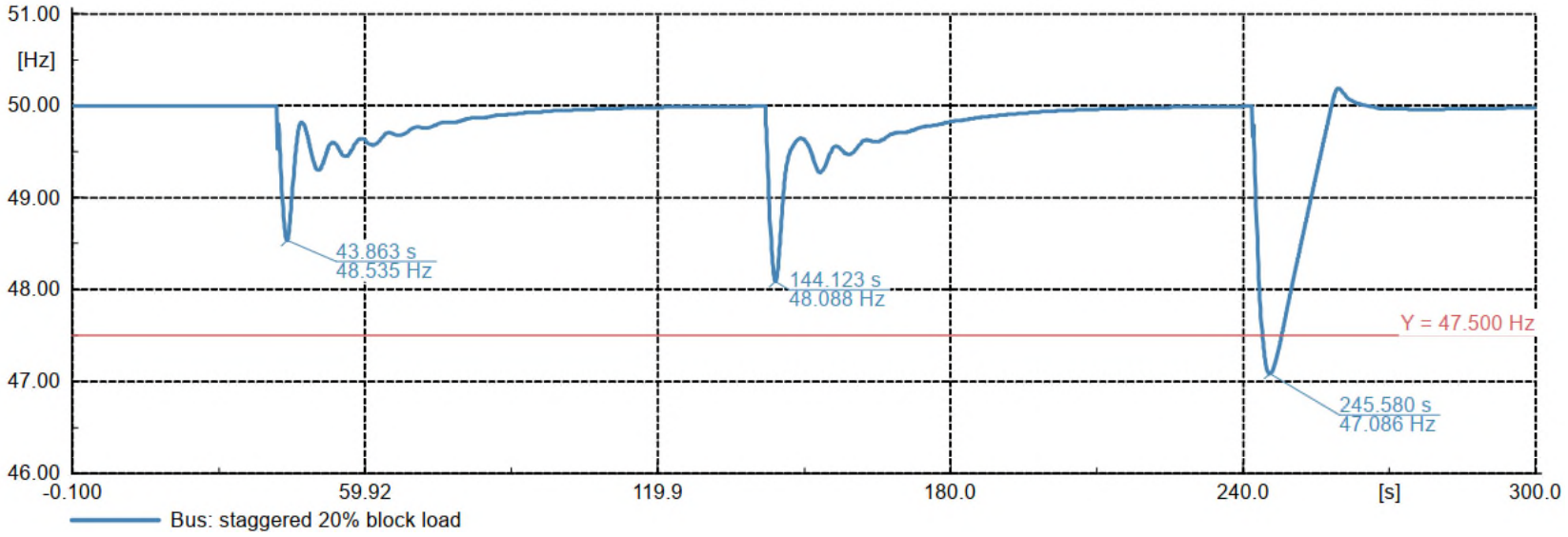
- Can we back-energise the network?
- What are the implications on protection systems?
- Where should we install a new earth & who should own it?
- What level of automation is appropriate?
- How can we effectively segregate networks?
- How can we synchronise power islands?

Distributed ReStart Zone (DRZ)

- Distributed ReStart Zone (DRZ) = network & contracted DERs contained within a distribution restoration plan. This will act as a virtual Black Start provider with pre-defined synchronisation point(s)
- Each DRZ consists of at least 1 ‘anchor’ generator to establish voltage & frequency source and provide an earth reference
- DRZ design will be technology agnostic, may consist of multiple DERs & (where needed) a source of flexible demand to increase block load capability & ensure a stabling demand
- Not all DRZs may be suitable for providing outward transmission energisation. Options for distribution network interconnection are under review
- We have commissioned DRZ controller functional designs to demonstrate options for automation, reduce organisational burden & meet key technical requirements where sub second control is beneficial



Block Load Pickup Capability

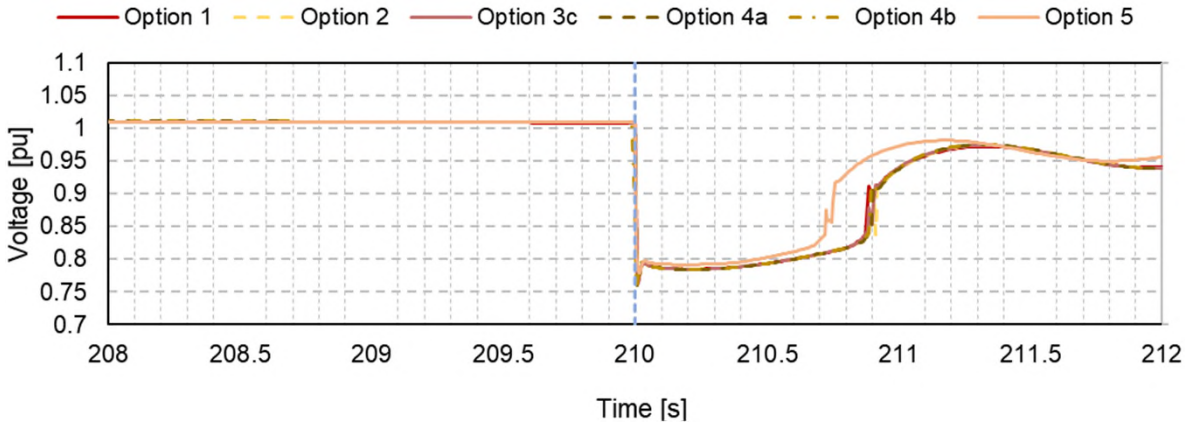


- Block Load Pickup (BLPU) capability of an anchor generator will vary during the restoration process
- As more substation demands are picked up, the capability will reduce
- BLPU capability will be unacceptable well before the max MW operational limit is reached
- Energising a typical Grid Supply Point, therefore, might require support from other sources

Voltage Regulation

- Anchor generator will impose the voltage & frequency during the restoration process
- AVR will take action in the event of a voltage excursion
- Other DERs such as wind farms will be asked to operate in voltage control mode & provide dynamic voltage support

Outside Security & Quality of Supply Standards limit of -12%



However, there could still be cases during BLPU when the voltage goes beyond acceptable limits

Reason

- Weak system, low short circuit levels
- DER response is not fast enough
- Local reactive support unavailable, far from the location of the problem
- DERs operating at maximum MVAr capability

Solution

- Delay the BLPU of successive substations >30mins
- Divide the block load into smaller chunks
- Change the tap position of the transformer before energisation
- Dynamic voltage support from additional sources

Distribution System Earthing

Existing

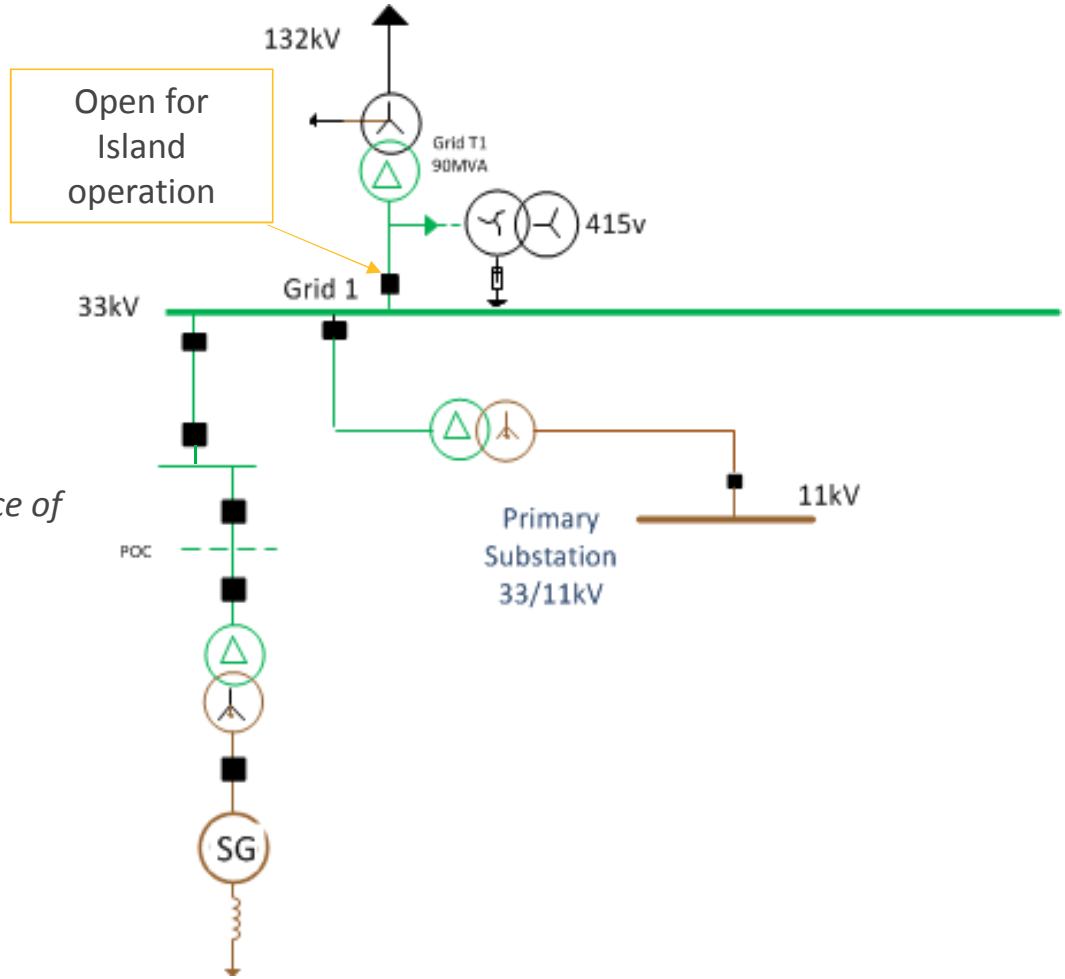
- Typical DNO 33kV network earthed at Grid transformers only
- Earthing transformer

Issues

- If operating as 33kV island (Grid 1 Open) no 33kV earth!
- Electricity Safety, Quality & Continuity Regulations – *'network connected with earth ..as near as reasonably practical to the source of voltage'*

Solution

- Install switchable earthing transformer at anchor generator 33kV site



Short Circuit Levels & Protection

Voltage Level	CT Ratio (feeder)	MAIN Unit/Distance pick up (10% In)		BACK-UP O/C (E/F) IDMT min plug setting 10%In assume min If = 1.5xplug setting If at least 2x plug setting		Min Fault Level Req (+15%) MVA
		A	MVA	A	MVA	
132kV	1200/1	120	27.4	180	41.2	**47.3**
275kV	1200/1	120	57.2	180	85.7	**98.6**
400kV	2000/1	200	138.6	300	207.8	**239.0**

33kV – 50MVA

(At primary transformer 33kV bushings. Also ensures 11kV & LV protections okay.)

132kV – 50MVA

275kV – 100MVA

400kV – 250MVA

		Chap 33kV		Chap 132kV		Gretna 275kV [3]		Gretna 400kV	
		3 Phase Fault (1s)		3 Phase Fault (1s)		3 Phase Fault (1s)		3 Phase Fault (1s)	
Anchor Gen 33kV	MVA	kA	MVA	kA	MVA	kA	MVA	kA	MVA
0.5	30	0.9	49 [1]	0.2	44	0.09	41	0.06	40
1 x	60	1.6	94	0.3	78	0.15	71	0.09	65
2 x	120	3.15	180	0.6	129	0.24	112	0.16	109
3 x	180	5.1	292	0.7	165	0.29	139	0.20	136
4 x [2]	240	6.9	395	1.1	258	0.42	200	0.28	192

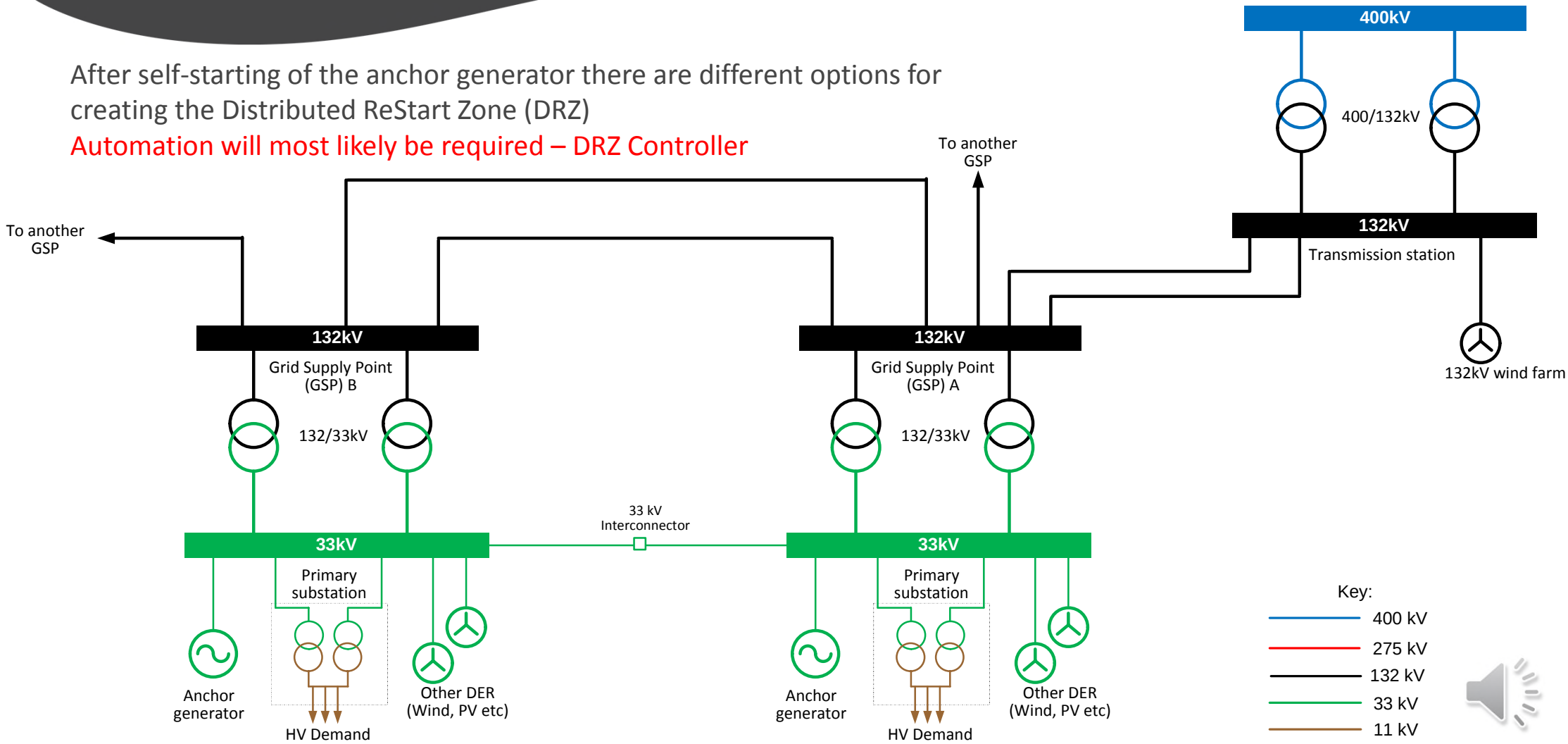
Conclusions:

- If 33kV protection is OK, likely can protect associated 132kV
- Possible to protect 275kV if sufficient fault infeed from 33kV
- Not possible to protect 400kV from 33kV island directly (need additional fault infeed at higher voltages)

Network Restoration Options

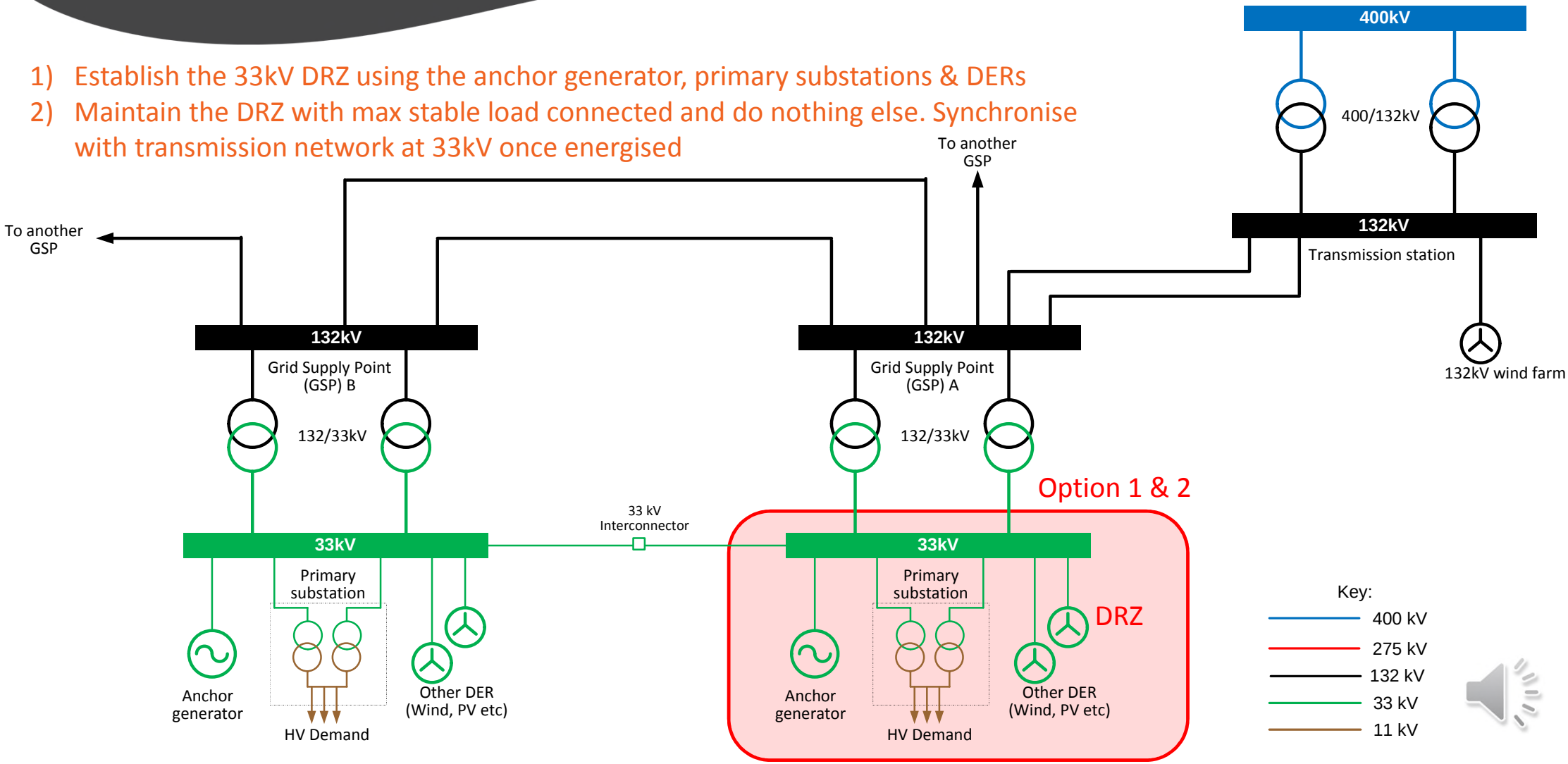
After self-starting of the anchor generator there are different options for creating the Distributed ReStart Zone (DRZ)

Automation will most likely be required – DRZ Controller



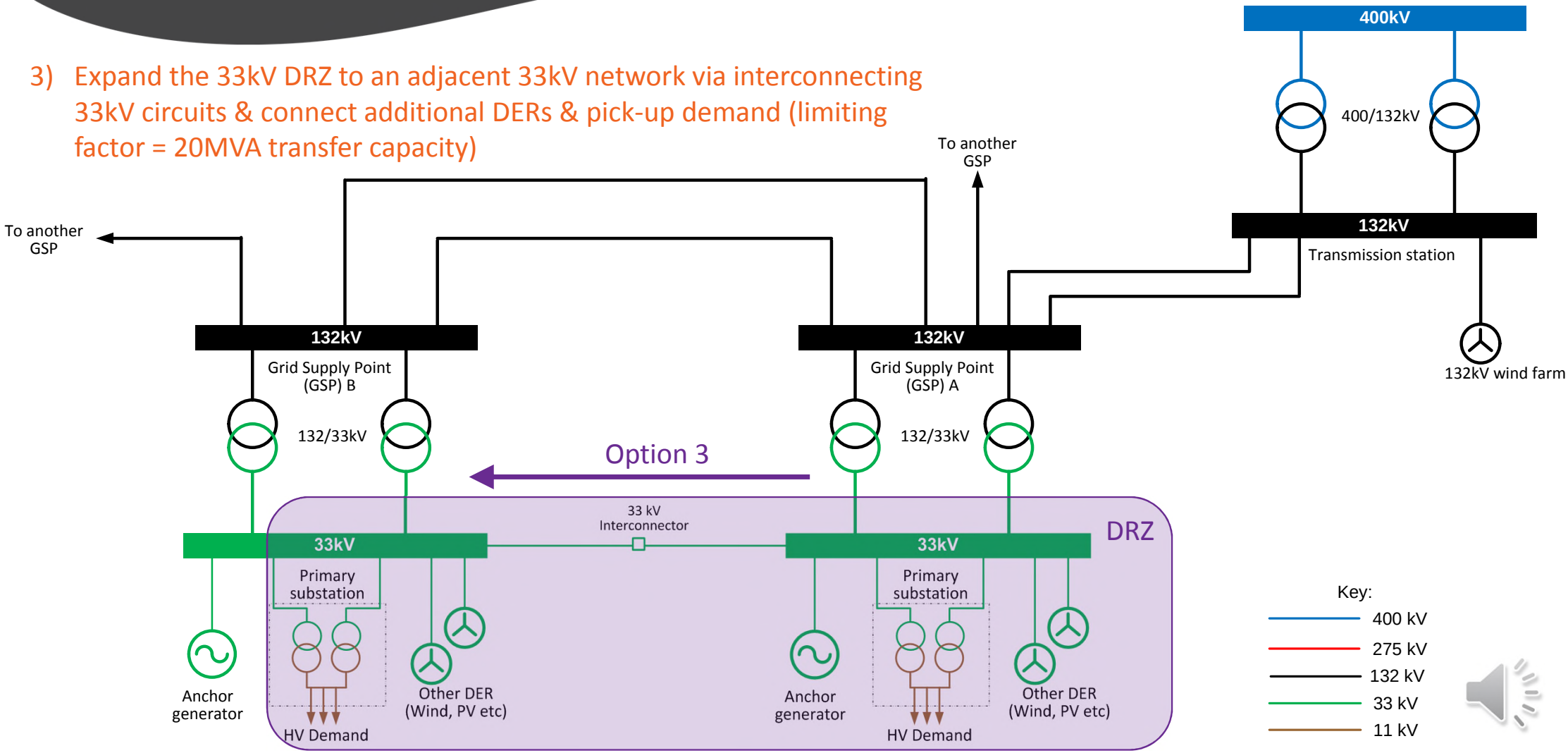
Network Restoration Options

1) Establish the 33kV DRZ using the anchor generator, primary substations & DERs
2) Maintain the DRZ with max stable load connected and do nothing else. Synchronise with transmission network at 33kV once energised



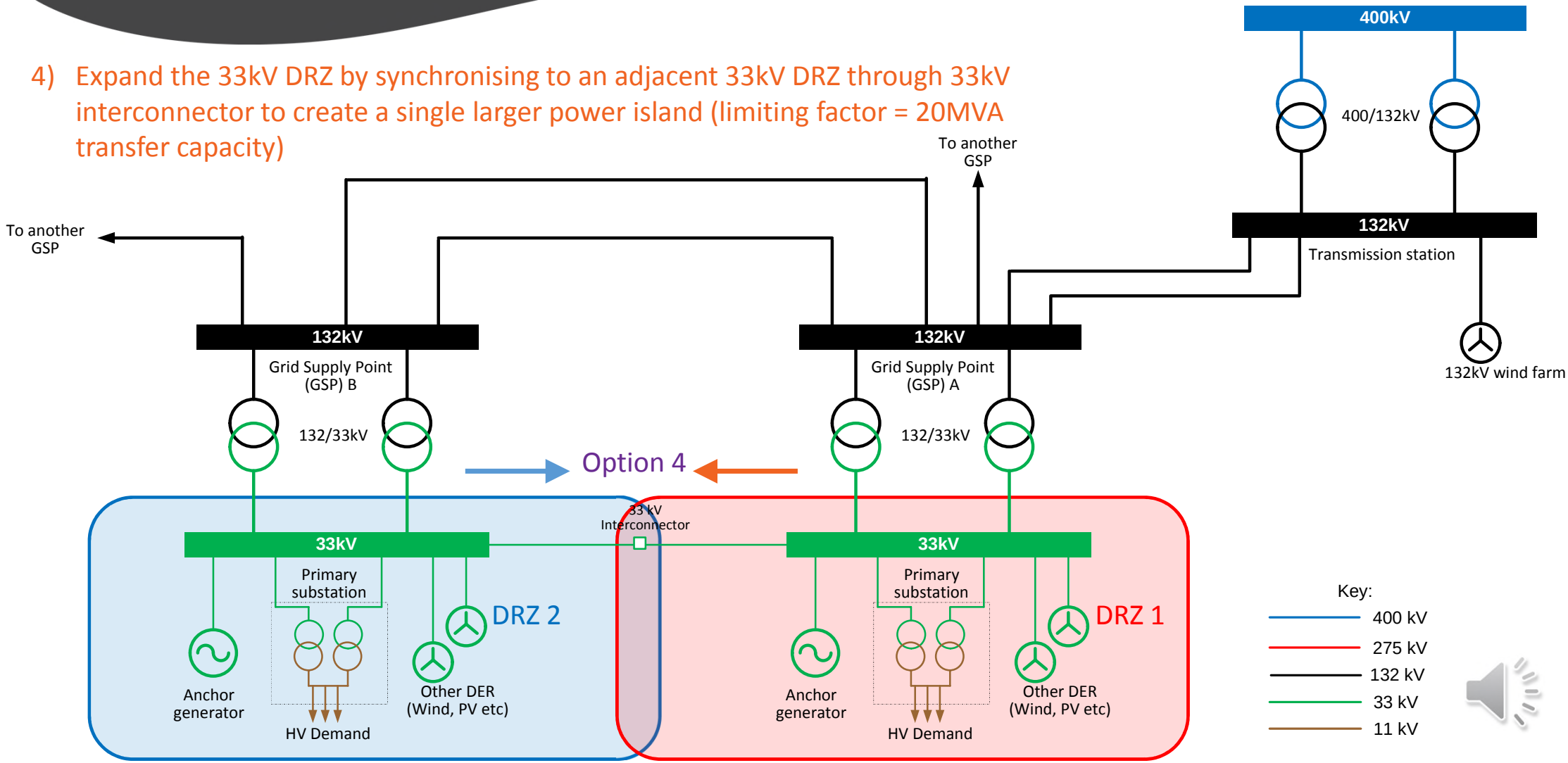
Network Restoration Options

3) Expand the 33kV DRZ to an adjacent 33kV network via interconnecting 33kV circuits & connect additional DERs & pick-up demand (limiting factor = 20MVA transfer capacity)



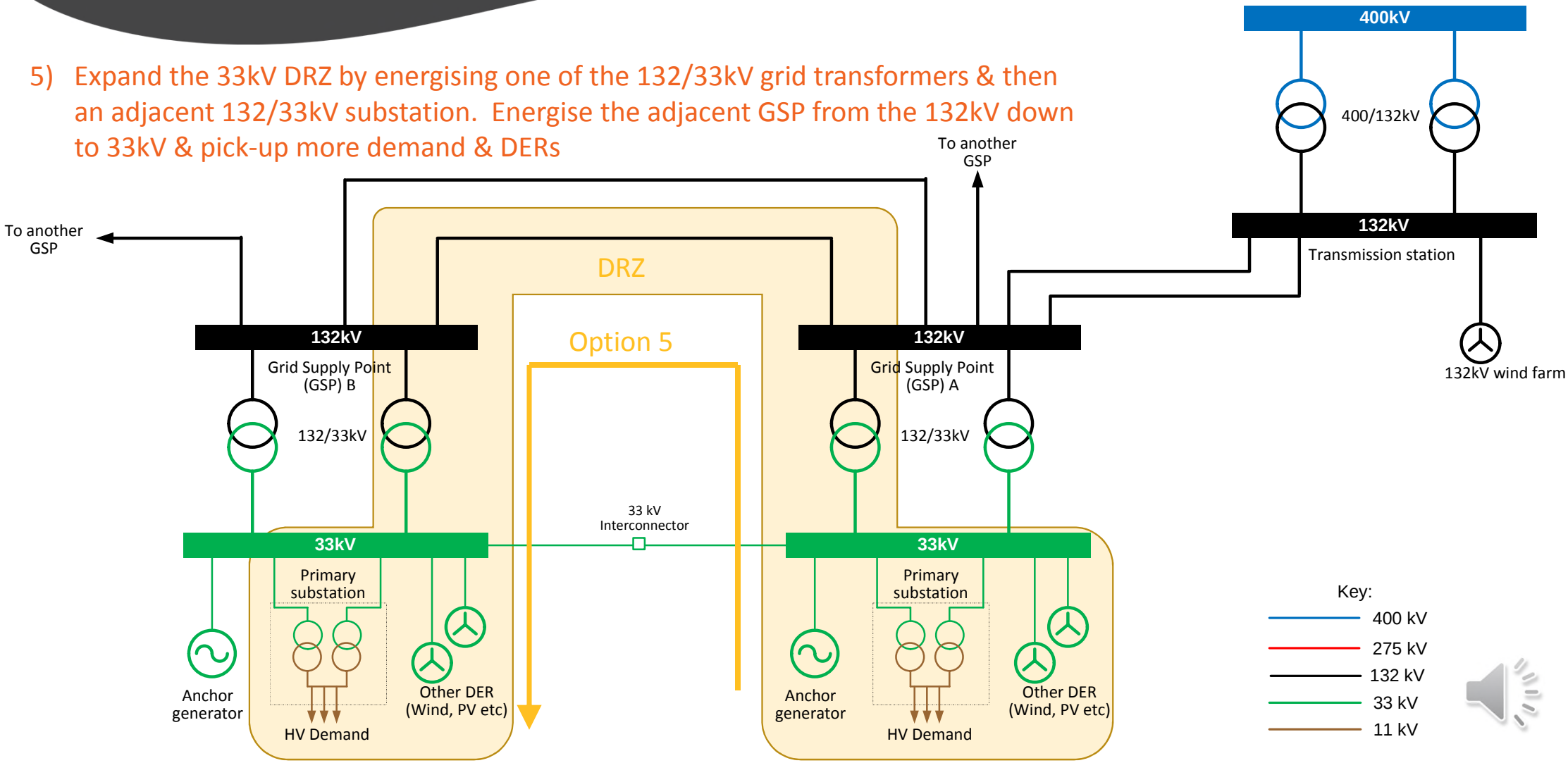
Network Restoration Options

4) Expand the 33kV DRZ by synchronising to an adjacent 33kV DRZ through 33kV interconnector to create a single larger power island (limiting factor = 20MVA transfer capacity)



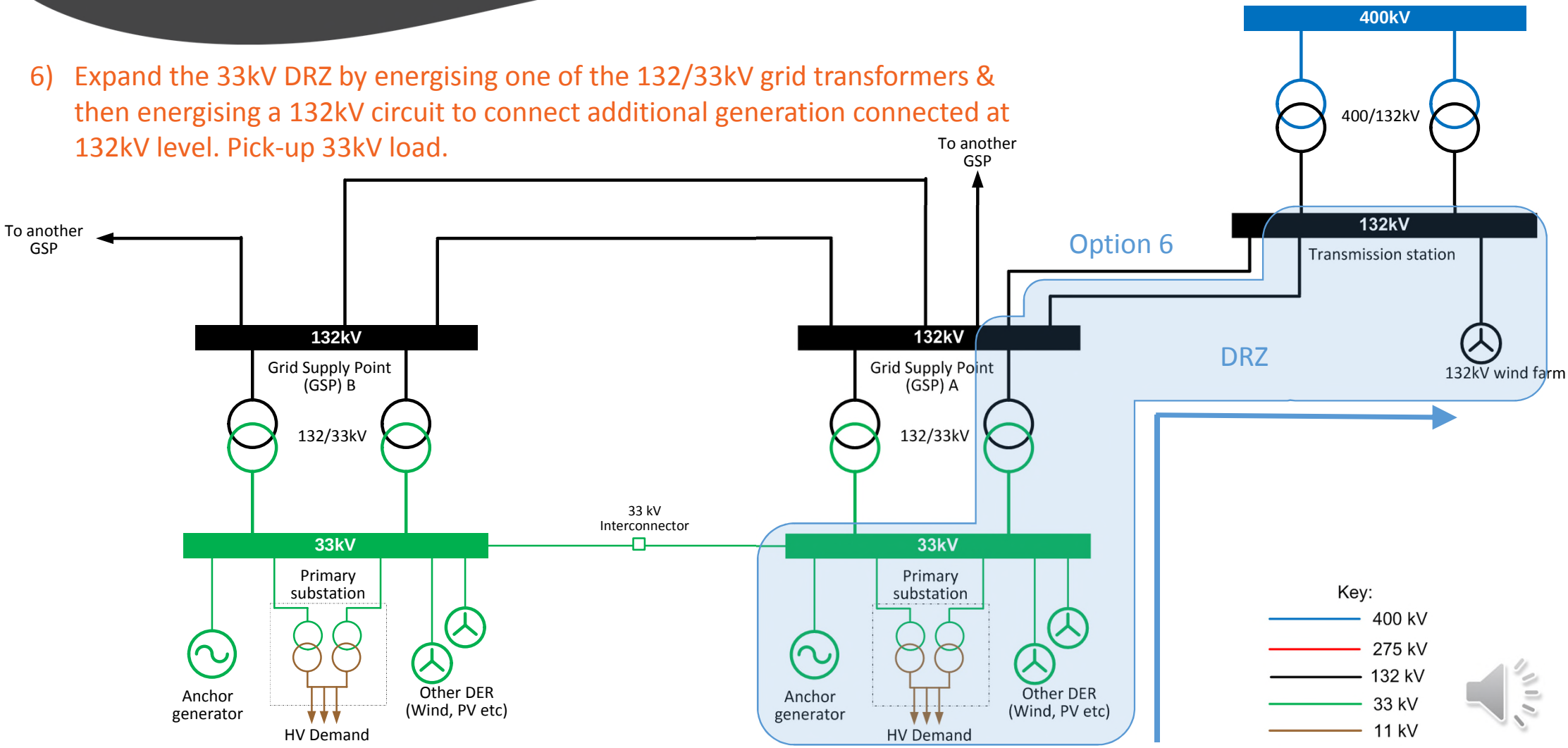
Network Restoration Options

5) Expand the 33kV DRZ by energising one of the 132/33kV grid transformers & then an adjacent 132/33kV substation. Energise the adjacent GSP from the 132kV down to 33kV & pick-up more demand & DERs



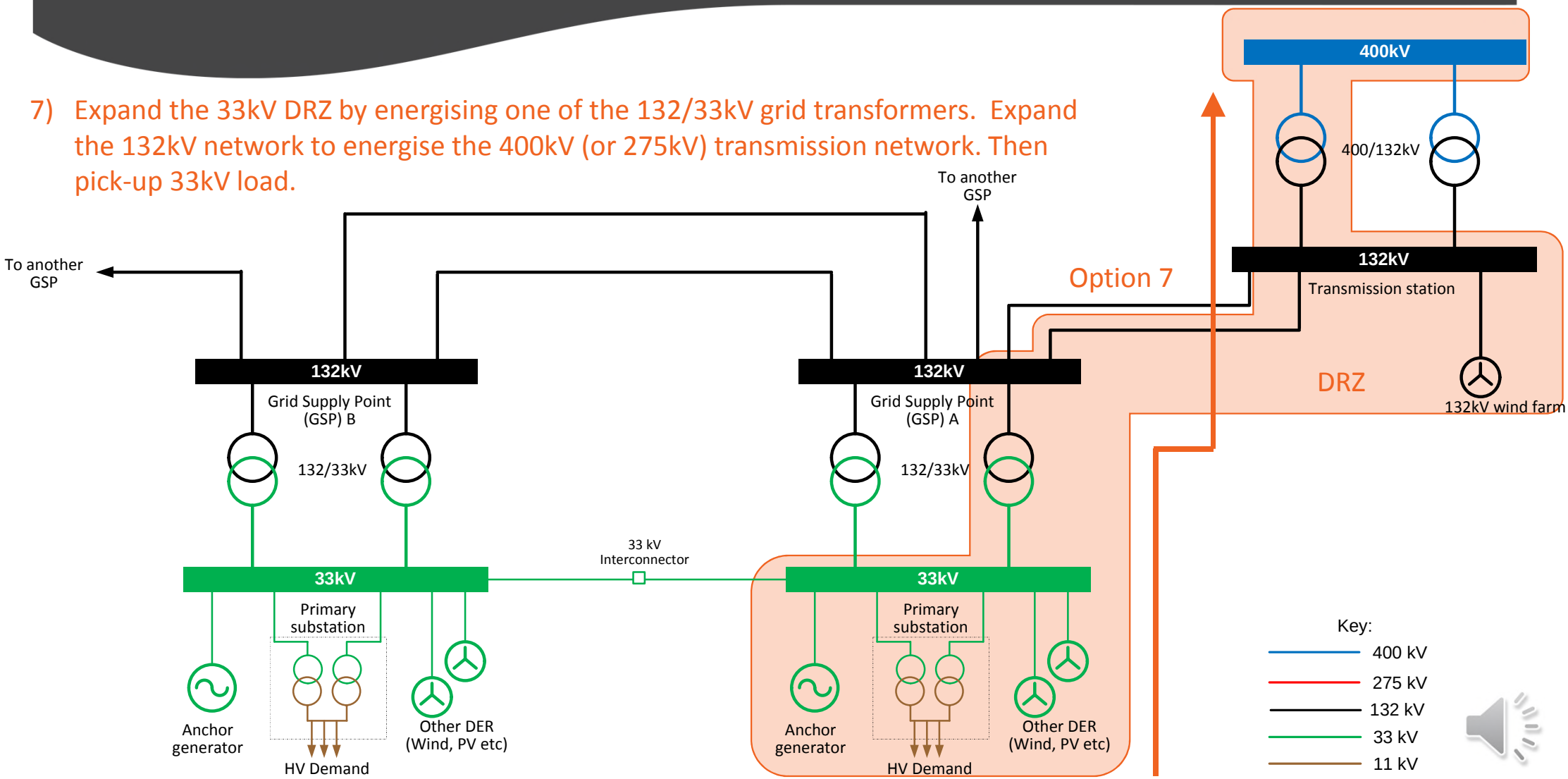
Network Restoration Options

6) Expand the 33kV DRZ by energising one of the 132/33kV grid transformers & then energising a 132kV circuit to connect additional generation connected at 132kV level. Pick-up 33kV load.



Network Restoration Options

7) Expand the 33kV DRZ by energising one of the 132/33kV grid transformers. Expand the 132kV network to energise the 400kV (or 275kV) transmission network. Then pick-up 33kV load.

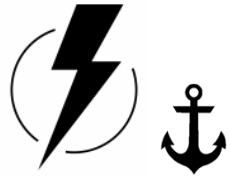


Organisational Roles & Responsibilities

National Grid Electricity System Operator

Transmission Owners

Distribution Network Operators



Anchor DER

Distributed Energy Resources

Transmission Connected Energy Resources

Action	Responsible under current Black Start	Responsible in DNO led	Responsible in ESO led
Declare Black Start	ESO	ESO	ESO
Responsible for national strategy	ESO	ESO	ESO
Responsible for regional strategy	ESO	**DNO**	ESO
Instruct start of plan	ESO	**DNO or ESO***	ESO
Instruct transmission switching actions	ESO	ESO	ESO
Physical transmission network actions	TO	TO	TO
Instruct distribution switching actions (33kV control party)	DNO	DNO	**ESO**
Physical distribution network actions	DNO	DNO	DNO
Instruct DERs	N/A	**DNO**	**ESO**
Physical actions of contracted generation	Provider	DER	DER
Instruct non-contracted generation (Emergency Instruction)	ESO via DNO instruction	We are currently assessing if there is a requirement to use Emergency instruction to grow a DRZ beyond the contracted zone*	
Manage overall distribution power island voltage and frequency	N/A	**DNO**	**ESO**

Operational Telecoms Resilience

Resilient End to End Operational Telecoms are required to ensure a viable Black Start from DER service

Technologies considered:

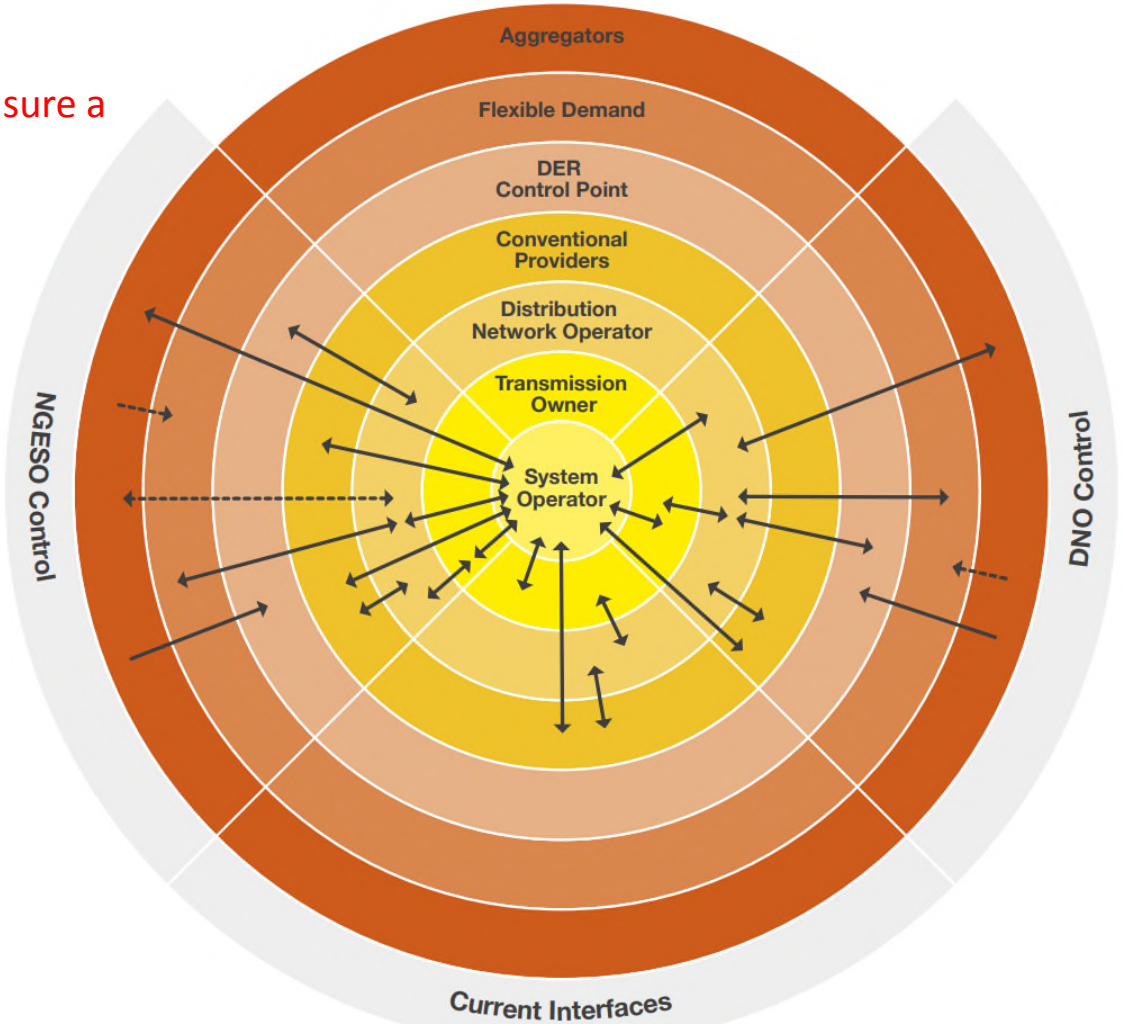
- Fibre
- Satellite
- Microwave
- BT Openreach fibre and ethernet services
- 4G LTE, 5G
- Public mobile services, Airwave
- Private Mobile

Assessment

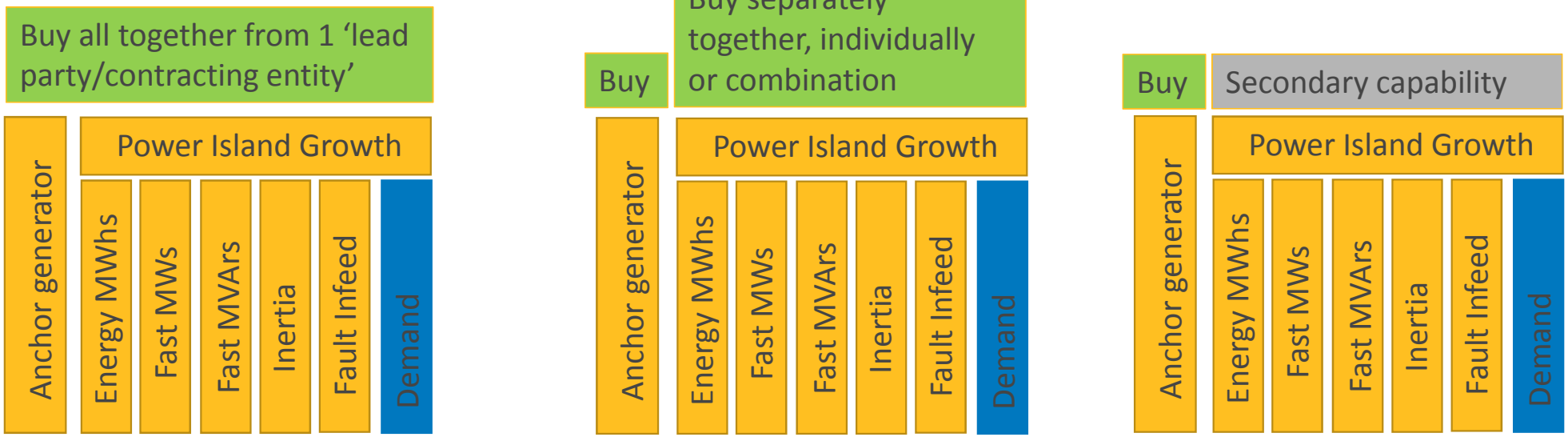
- Reliability & availability
- Ease of deployment
- Cost of deployment and ongoing operational cost
- Cyber security of technology types

Initial findings

- No 1 size fits all
- All viable options being considered
- Cost of deployment will vary
- Automation is likely to be required



Commercial Design Options – Black Start from DER

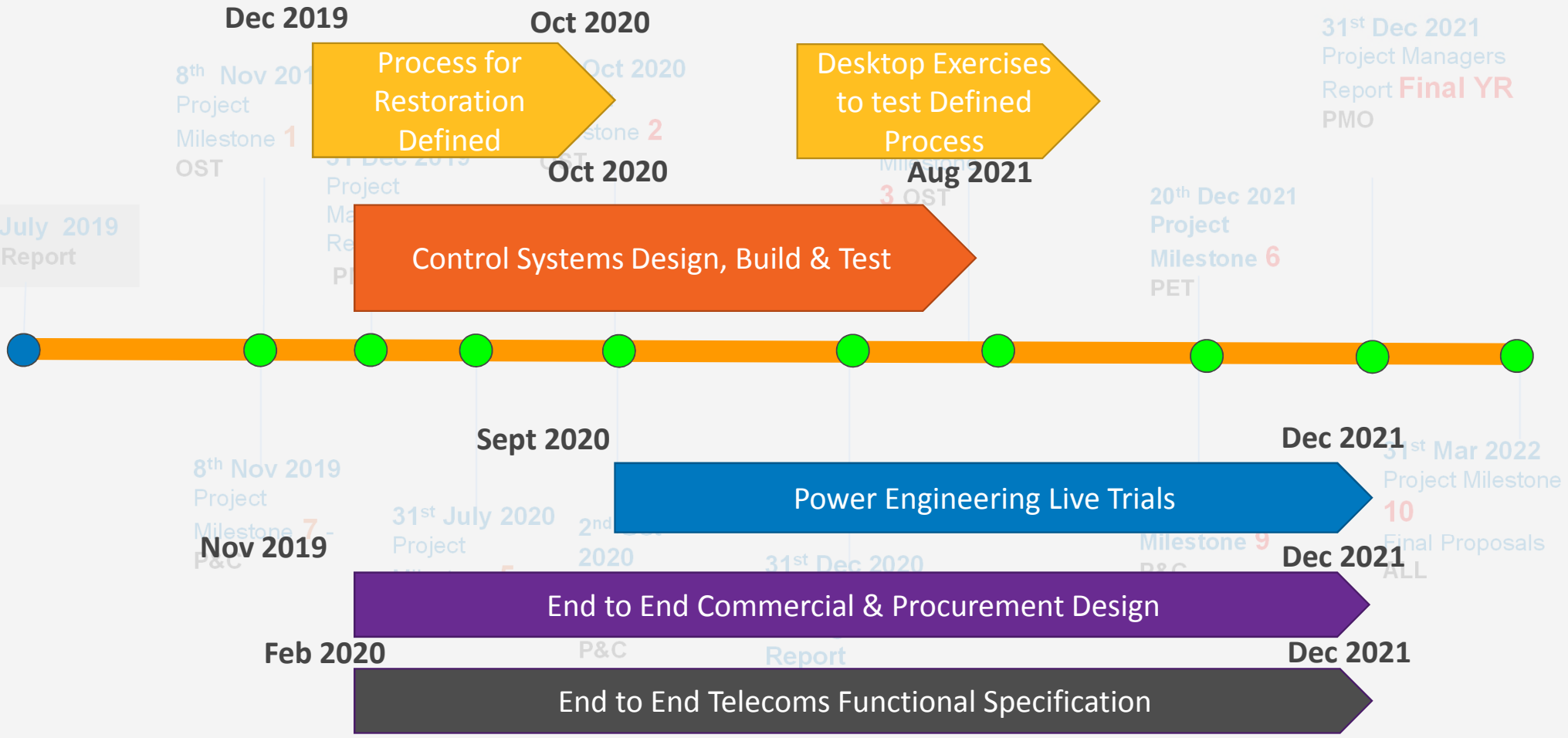


Procurement Options – Black Start from DER

eAuction	Frameworks	Open tender/Request for proposal (RFP)	Bilateral/Single source	Mandated
May also require a framework agreement. Requires an online platform where providers can bid against a requirement. Generally allows greater flexibility and suits shorter-term requirements/closer to real time procurement.	High level requirements are set and 'zero-value' contracts are agreed with more parties than are required. Closer to real time, mini-tenders can be used to 'call off' these contracts based on pre-agreed terms bound by the frameworks.	Requirements are set and published, providers submit a tender against an agreed timeline. New contracts are awarded each time. Generally useful for more complex requirements with solutions that take longer to develop.	Agreeing contracts independently with providers to access specific partnership/portfolio benefits. Typically useful in situations where liquidity is low, or where significant innovation is required to solve a challenge.	A solution where certain capabilities are required as a condition of connecting to the network.

RAG Status	eAuction	Frameworks	Open Tender/Request for Proposal (RFP)	Bilateral/Single Source	Mandated
Meet objectives					
Benefits					
Challenges					
Enablers					

What We Will Deliver in 2020 & 2021 – Design, Refine & Demonstrate



On Demand – Stay Connected

The Design Stage virtual event was a huge success, with high levels of interaction and participation from delegates.

Our presentations and documents on the virtual event are available online until 31/07/2020

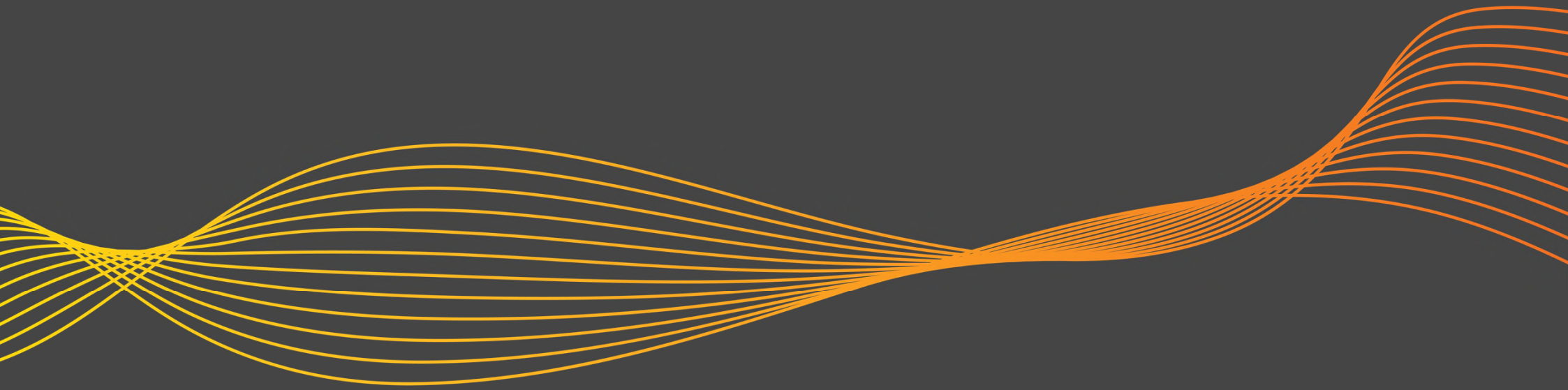
https://distributedrestart.com

Our replies to questions (120) posted during the presentations have also been published

Keep in touch: Restart@nationalgriedeso.com

Distributed ReStart

Any Questions?



Distributed ReStart

Appendices

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Evidence

Workstream Papers delivered last year

- Power Engineering & Trials - Viability Report - July 2019
- Procurement & Compliance - Functional Requirements - Nov 2019
- Organisational Systems & Telecommunications - Viability Report - Nov 2019
- Year 1 - Project Progress Report - Dec 2019
- Project Brief - March 2020

Option Stage Deliverables

- Distributed ReStart - Animation Video
- Distributed ReStart Webpage

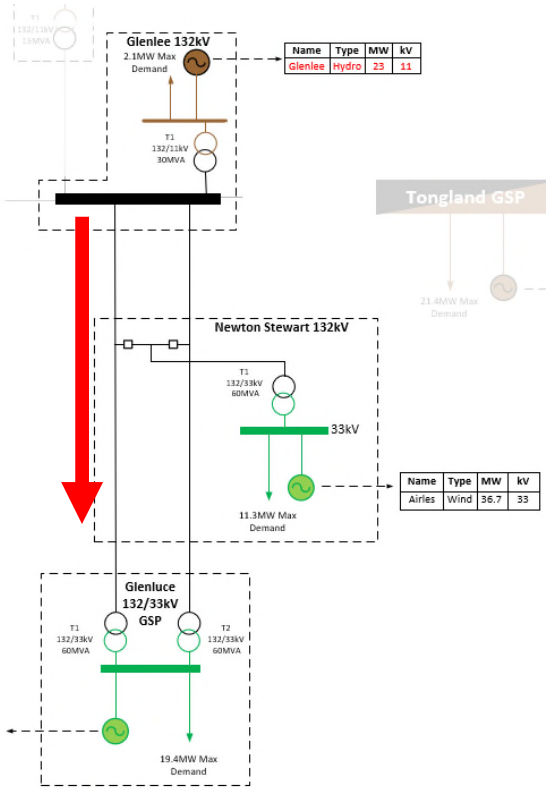
Live Trials Update

Project Progressing with Live Trial Plans

- Technical development of potential live trials currently in planning at all 3 case studies
- Live trials to be developed in multiple stages:
  - Spread over remaining duration of the project
  - Maximise learning whilst de-risking project

Galloway Trial Plan (2020 – COVID-19 allowing!)

- Stage 1 of Galloway Live Trials
- Glenlee Hydro
  - Auxiliary power supplies fed from interconnecting 11 kV network
- Glenlee and Glenluce GSPs
  - Energisation of Glenlee 11/132 kV 30 MVA transformer and Glenluce 132/33 kV 60 MVA transformer
  - Glenluce GSP 33 kV incomer open
  - Stop there!



Distributed ReStart – how the service might look

Service	Description	Options
Anchor generator	Self-start and provide a controlled voltage source, able to energise the network to reach the next resource.	Grid forming converters are now being installed but in the near term, this will require a synchronous generator.
Flexible MW control	Fast control of power output (or import) in response to control signals or frequency deviations. Provide minimum stable demand, allow adjustment of position on other resources, and prepare for next steps.	Export and import services required with fast, accurate, reliable MW control. Services will be split depending on the speed of response and ramp rate. Generators, controllable demand and batteries may all play a role.
Energy	Power supplied on a sustained and reliable basis to support restoration of demand and DRZ expansion.	Some resources may have excellent MW flexibility but limited energy, and vice versa.
Flexible MVAr control	Control of reactive power, either in voltage control mode or a MVAr setpoint from a separate control system. Needed to maintain steady state and to meet the reactive gain of unloaded circuits.	Most generators have a reactive capability although this may require modifications to existing control systems. STATCOMs or other reactive compensation might also be used.

Distributed ReStart – how the service might look

Service	Description	Options
Inertia	Complements power control by slowing the rate of change of frequency.	Recognises the value provided by synchronous or induction machines. Virtual Synchronous Machines may be used once the technology matures.
Short circuit current	Fast fault current delivery to ensure protection detects faults. Closely related to voltage control but may be defined as a separate service.	Recognises different capabilities, e.g. conventional machines compared with power electronic converters.
Demand	Control of power import in response to control signals. Provide known fixed levels of MW and MVArs.	Recognises the potential value for demand side services to be provided individually or aggregated.