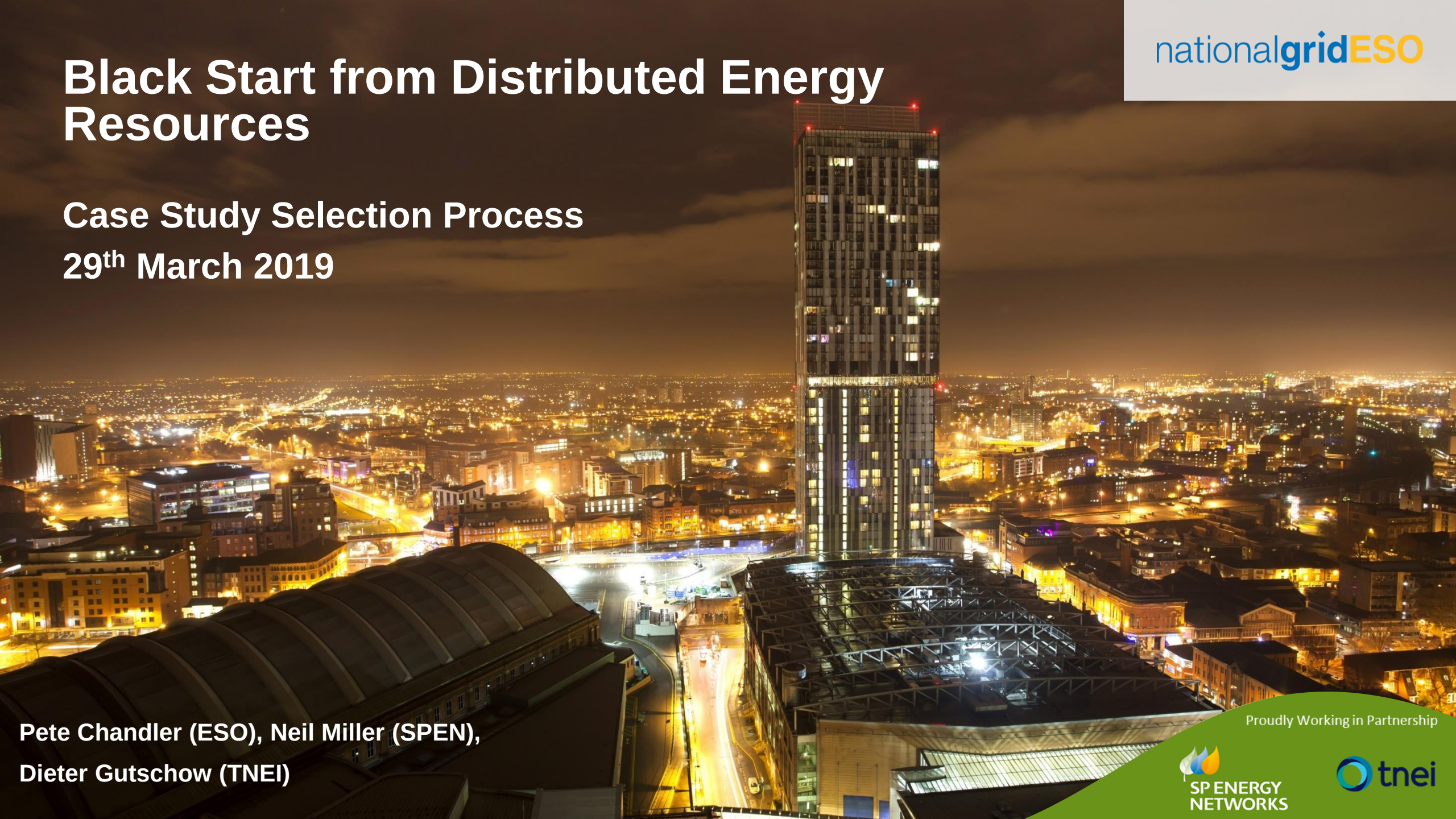
Black Start from Distributed Energy Resources

Case Study Selection Process

29th March 2019



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Dieter Gutschow (TNEI)

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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

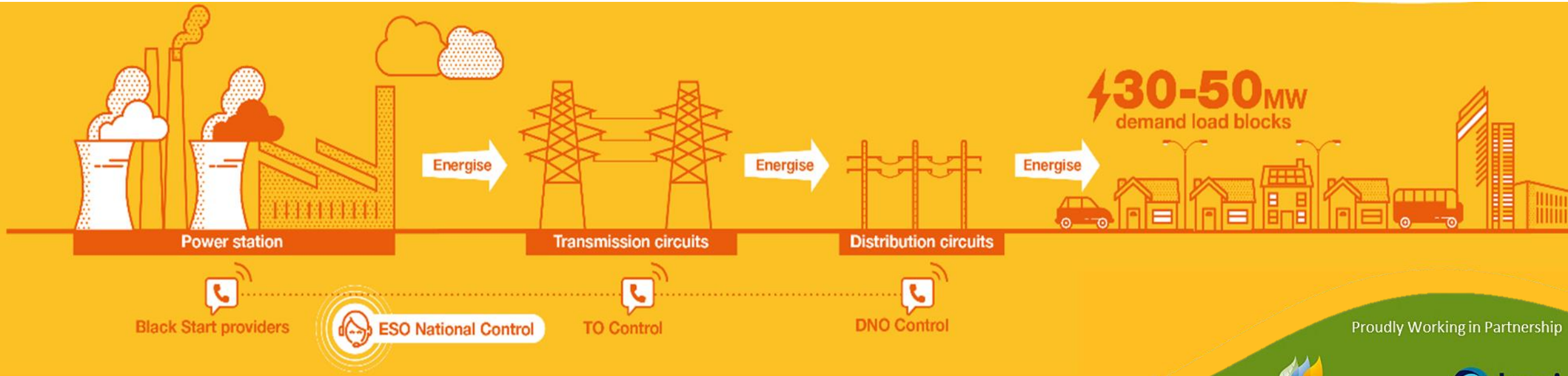
High Impact Low Probability

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



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What is Black Start?

Current Procurement

- Do not need to provide the full service from one unit
- Split into the 3 ‘key’ capabilities involved
- Different technologies can provide different services
- Bilateral contracts
- Tendered market rollout taking place
- New Black Start Strategy document published within April
- No discrimination on technology just capability

Conventional Black Start
Large provider

- ☑ Self starting
- ☑ Energise NETS
- ☑ Block load capability

Black Start Enhanced restoration
Large provider

- ☒ Self starting
- ☒ Energise NETS
- ☑ Block load capability

Black Start Embedded
Large Distribution Embedded provider

- ☑ Self starting
- ☑ Energise NETS
- ☑ Block load capability

(potentially lower MW block capability)

Trip to House Load (Readiness provision)
Large provider

- ☒ Self starting
- ☒ Energise NETS
- ☑ Block load capability

Interconnectors Full Service

- ☑ Self starting
- ☑ Energise NETS
- ☑ Block load capability

Interconnectors Fast Start

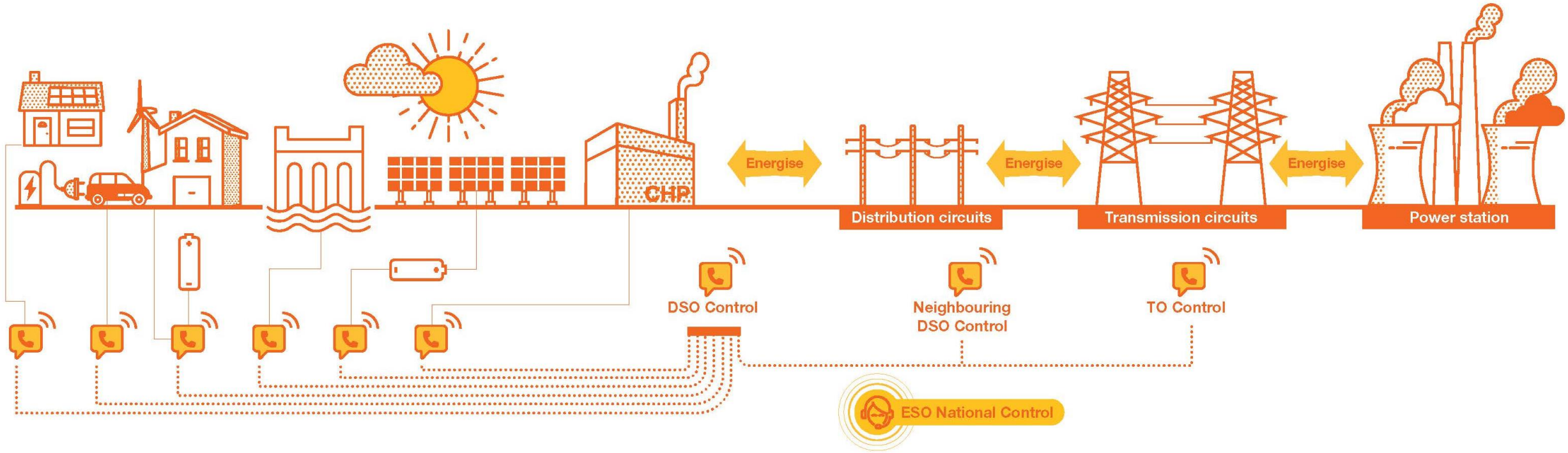
- ☑ Self starting
- ☑ Energise NETS
- ☒ Block load capability

https://www.nationalgrideso.com/balancing-services/system-security-services/black-start?technical-requirements

Introduction to the Projects

NIA: How can we incorporate non-conventional technologies in Black Start?

NIC: How can we incorporate DERs into Black Start strategy?



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How Could DERs Contribute?

NIA project has evaluated non-conventional generation types:

Wind

Large Wind ≥ 30 MW, Small Wind < 30 MW

Solar

Commercial PV ≤ 10 MW

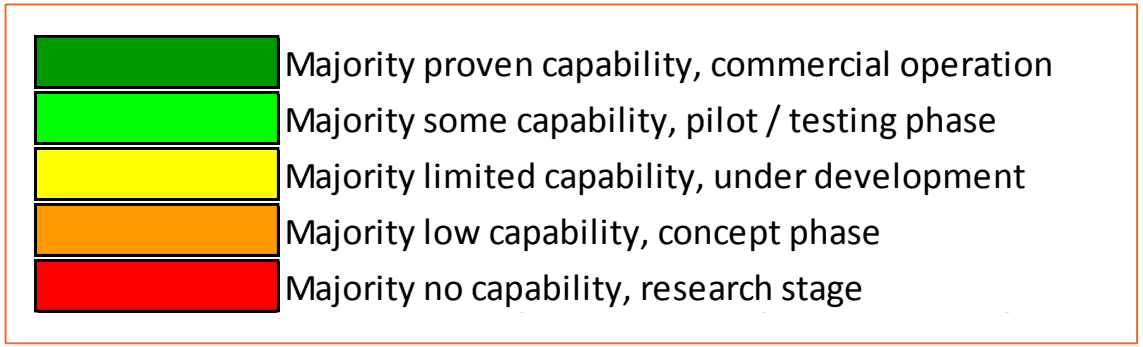
Battery Energy Storage Systems

Battery energy storage systems ≤ 50 MW

Demand Side Response (DSR)

Commercial and Industrial (C&I)

Relative scoring



Electric Vehicles (EV)

Electric Vehicles (EVs) as storage, and Vehicle-to-Grid (V2G) for generation

Synchronous DER

Energy-from-waste, Landfill gas, Coal mine methane, Liquid-air energy storage, Hydro

Note: Co-location / combination of technologies not considered at this stage

How Could DERs Contribute?

Resilience during power outage

DER Technology	1. Black-out resilience	
	Plant resilience (shut-down, standby)	Comms & Control resilience
Large Onshore Wind (>30MW)		
Small Onshore Wind (<30MW)		
Commercial Solar (PV)		
Battery Energy Storage		
Demand Side Response (I&C)		
Electric Vehicles/V2G		
Synchronous DER		

Larger facilities tend to have more resilience

Most communications and control systems are backed up by UPS with limited standby capacity for extended blackout

No common communications standard, reliant on public infrastructure

How Could DERs Contribute?

Capability to restore the network

Latest converters support grid-formation, but not yet demonstrated

DER Technology	2. Black Start - network restoration					
	Self-starting of plant	Grid-forming capability	Demand Block Loading Capability	Reactive Power Support	Frequency Control	Dispatch-ability
Large Onshore Wind (>30MW)						
Small Onshore Wind (<30MW)						
Commercial Solar (PV)						
Battery Energy Storage						
Demand Side Response (I&C)						
Electric Vehicles/V2G						
Synchronous DER						

BESS demonstration plants e.g. Germany

V2G can provide reactive power and frequency support, but volumes are still too low for Black Start

How Could DERs Contribute?

Capability to join / support a power island

DER Technology	3. Load Restoration: Power island joining & support	3. Load Restoration: Sustainability (reliability)
Large Onshore Wind (>30MW)		
Small Onshore Wind (<30MW)		
Commercial Solar (PV)		
Battery Energy Storage		
Demand Side Response (I&C)		
Electric Vehicles/V2G		
Synchronous DER		

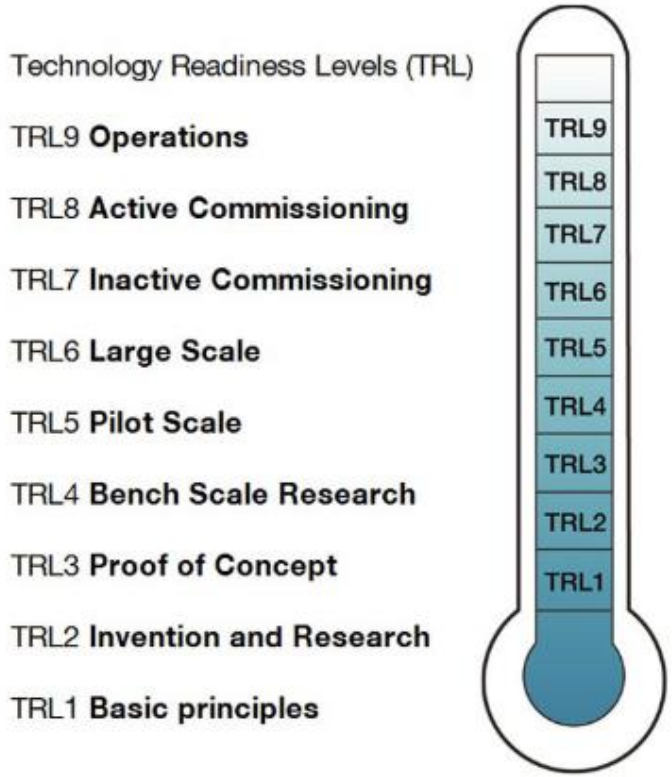
We are doing some analysis of the contribution that wind could produce to restoration. Emerging results show that this could be quite low on average, but during windy periods this could be quite reliable for short periods.

Large wind farms tend to have higher reliability over a set period compared to smaller wind farms or PV

Not enough deployment to provide meaningful capacity

Integration With The Network Innovation Competition

- Assessment of the Technology Readiness Level (TRL) of DER technologies for different Black Start phases and functions
- Identification of technology developments or barriers that need to be overcome to improve TRL
- Development of a roadmap indicating how and when DER technologies could play a role in Black Start
- Roadmap will consider co-location of different technologies and how combinations could increase black start services e.g. Wind and BESS



NIC Project - Power Engineering & Trials Work Stream

Aim

Provide credible technical solutions for the provisions of Black Start (BS) services from DER

- What is technically feasible and how do we do it?
- Recommendations for adaptations of DER and distribution networks to facilitate BS DER economically and safely.

Approach

Case Study Approach

- Assess DER and network capability, and the potential for BS for sample areas of the distribution network.
- Ten case studies selected (across SPD and SPM) based on a range of DER types, network topologies and potential BS restoration scenarios.

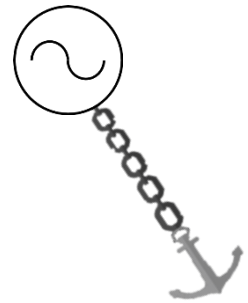
Assessment

Case Study Assessment

- Are the case studies on the right basis **(criteria)**
- Are the case studies suitably representative **(content)**.

Case Study Criteria

Essential Criteria:



- At least one grid forming ‘anchor’ generator
  - Capable of establishing an independent voltage source
  - Schedulable and sustainable
- Connected (or connecting in 2019) at 33kV, 132kV or 11kV (transforming directly to a higher voltage)

Conclusion A synchronous generator will be needed in each case study

N.B. Grid forming convertor connected resources are now available e.g batteries, and may be considered as an anchor generator if there is a suitable example within project timescales.

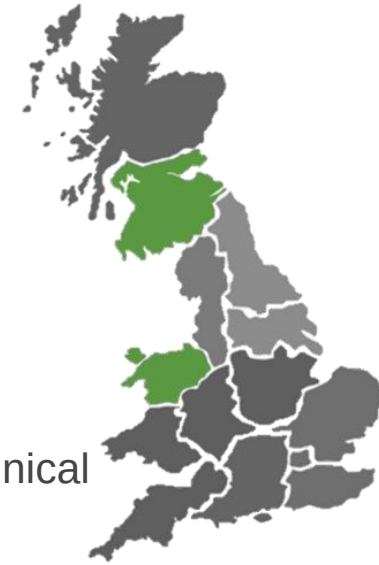
Supplementary Criteria:

- Variety and capacity of additional DER (e.g wind, solar and batteries) that could be used to grow the power island
- Range of network types and characteristics
- Live trial suitability (outages available without disconnecting customers)

What amendments to the case study selection criteria may be appropriate?

Selection and Proposals

Case Study Selection:



- Analysis of SPD & SPM networks to identify all areas with DER that meet the case study essential criteria
  - SPD – Radial 33kV network with 65 Grid Supply Points (GSPs) - 132/33kV or 275/33kV substations (Distribution 33kV and below.)
  - SPM - Meshed 33kV networks. Fifteen supergrid groups (400/132kV or 275/132kV infeeds) with each 132kV network supplying several 33kV groups. (Distribution 132kV and below.)
- Identify ten case studies with a variety of DER, network topologies, restoration options and degrees of technical challenge to make the selection as applicable of a GB wide basis as possible.

Case Study Proposals:

- Six case studies selected in SPD and four in SPM predominantly based on the largest capacity of 'anchor' DER but also to provide:
  - a variety of anchor types (including: hydro, gas and diesel) and additional DER types (solar, wind and batteries)
  - varying network topologies (radial and meshed) and network types (rural and urban)
  - Various restoration options (including :establish 33kV power island, synchronise two 33kV islands and energising from 33kV to 132kV or 275kV)

What else should be included in the proposed case studies?

Example Case Study

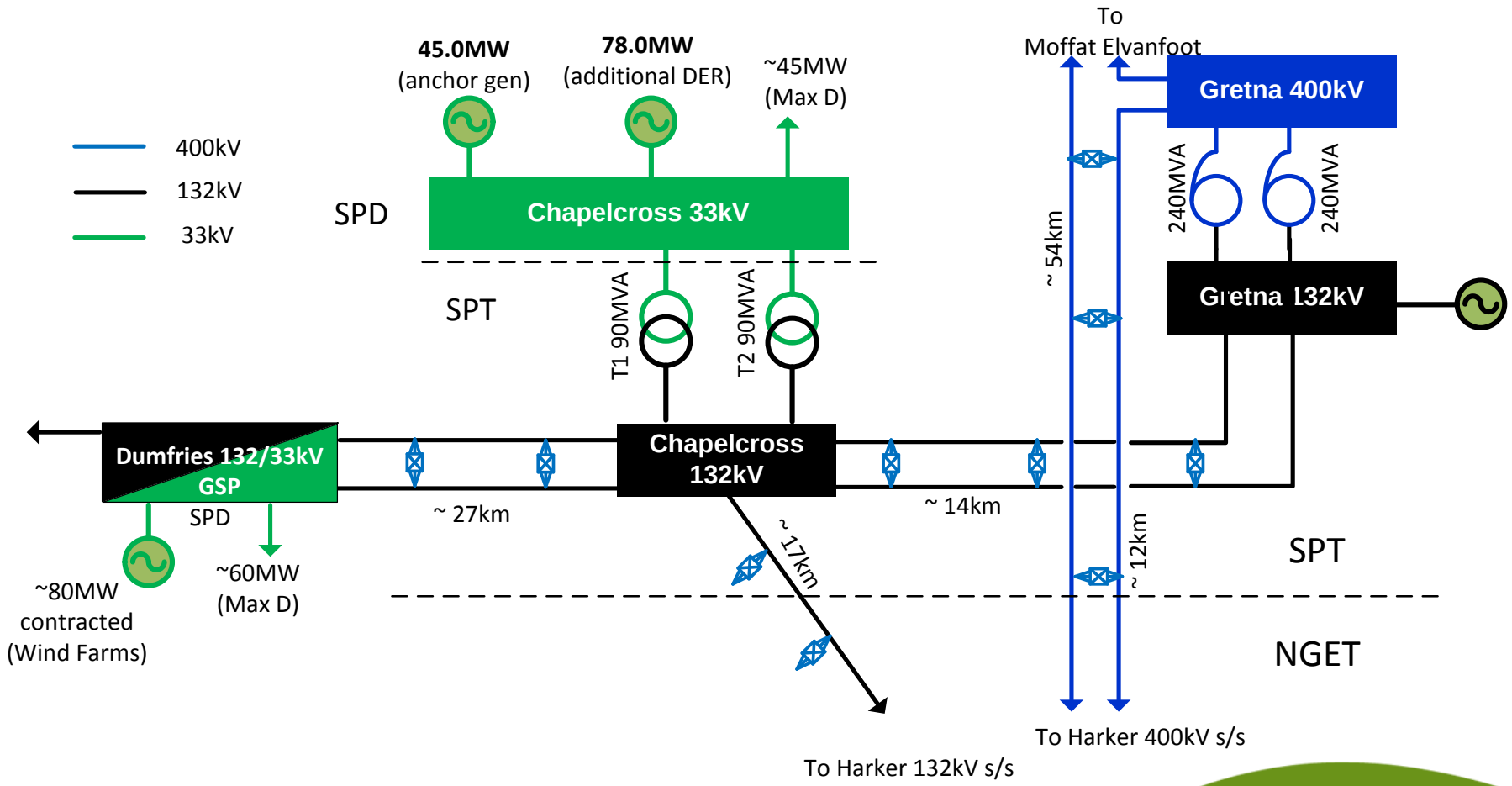
Chapelcross GSP

- 45MW anchor gen
- 78MW additional DER (wind)

Restoration options:

- Establish 33kV power island
- Energise Chapelcross 132kV
- Energise to Dumfries GSP
- Energise to Harker 132kV
  (synchronise with NGET)
- Energise to Gretna 132kV
  (additional DER and T connected wind)

Is it that easy?



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Case Study – Technical Challenges

- **Earthing –** When a 33kV network is isolated from the transformer infeeds at a GSP, the 33kV earthing point is typically disconnected (e.g. earthing transformers) leaving an unearthed 33kV network.
- **Low Fault Levels –** Will existing protection at all voltage levels be able to detect faults (on the network and DER)? Minimum fault level required to ensure wind turbine stability (typically 2-3x wind farm rating)
- **Temporal nature of demand –** Difficult to predict what demand (or generation) may 'appear' when a feeder is closed, e.g. Cold Load Pick Up (CLPU).
- **Frequency Stability –** How can the generation/load balance best be maintained (most DER does not have f control)?
- **P (MW), Q (MVAr) Pickup –** In a low inertia system, how to enable a viable PQ pick up capability to grow a power island while staying within frequency limits.
- **Reactive Power Capability –** The ability for DER to absorb, or the network to be compensated for, the reactive gain when energising the network.
- **Voltage Control –** Where best to monitor, and how to control the voltage (33kV normally controlled by GSP transformers).
- **Automation –** A certain level of automation will be required to initiate, maintain and re-synchronising a power island. Limited human resources available (e.g control engineers).
- **Others –** Transformer inrush currents, resynchronising with the wider network, oscillations, harmonics, zero inertia …

What other technical challenges should be considered?

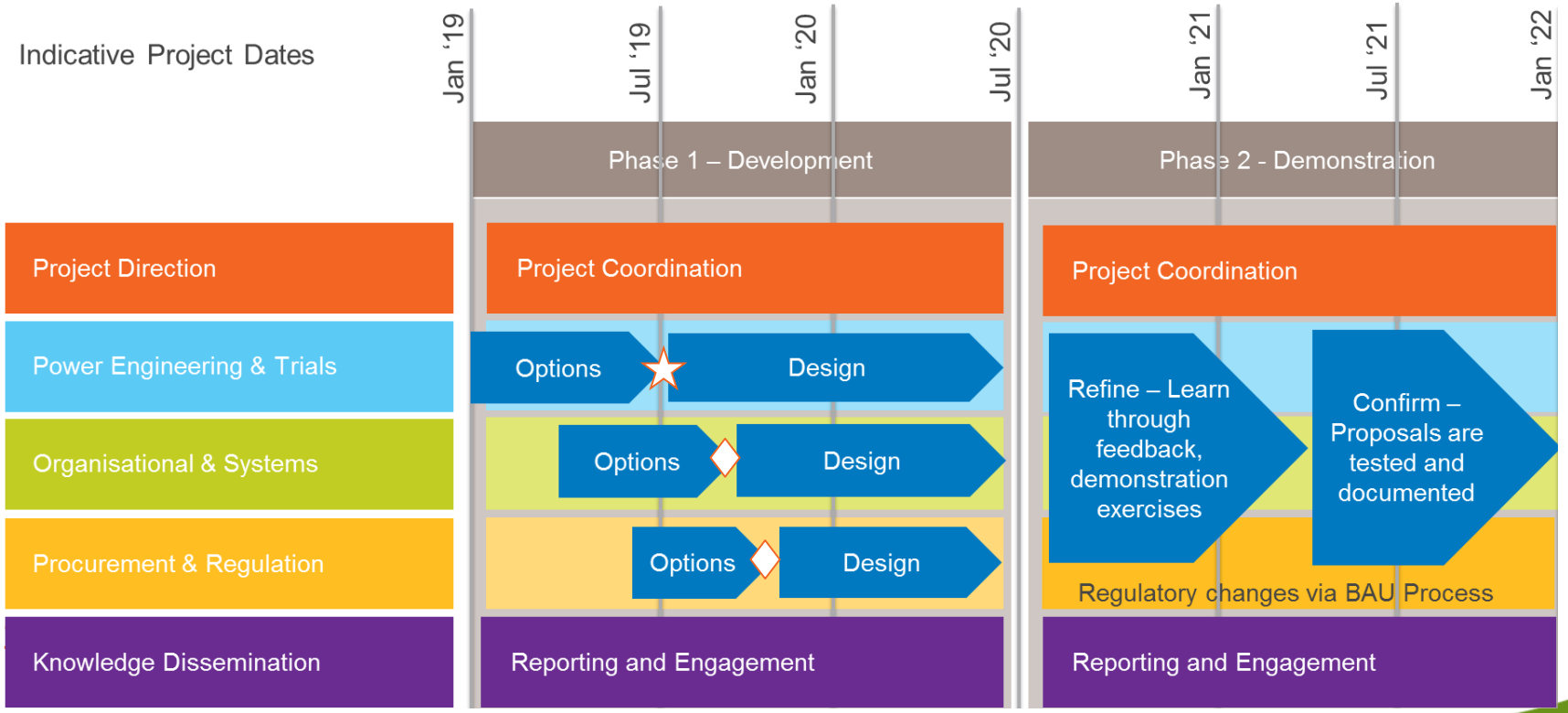
Our Next Steps

Deliverables:

- ☆ Report published incorporating case study viability of BS DER based on case studies, proposals for technical requirements on a future service, potential across the UK
- ◊ Reports covering possible solutions to the Organisational and Procurement challenges

Engagement:

- Follow up email to all participants with details to register for our workshop in early May (Cross Work Stream)
- Provide guidance on how we have acted on your feedback



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How can you get involved?

NIA & NIC Project Contacts

Join our mailing list for updates and invitations: https://mailchi.mp/db16788e123e/distributedrestoration

(We will send a recording of this webinar and an invitation to join our workshop in May through this list)

Black Start from DER queries box.BlackStartNIC@nationalgrid.com

We will get the appropriate expert to answer you query from the technical, commercial or organisational work streams

Web page due to go live end of today: https://www.nationalgrideso.com/innovation/projects/restored

(We will publish all documentation and event details on this site (Go-Live Imminent)

Existing Black Start Services Contacts

Talk to your account manager if you have an existing contract

For general enquiries please contact: Commercial.operation@nationalgrid.com

Any Questions?

nationalgridESO

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SP ENERGY NETWORKS

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