Future of Reactive Power Webinar

14 October 2021

nationalgridESO

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Agenda

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Progress To Date

Yuting Dai

The Journey Of Work Done So Far And What Next

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Dec 2020

Problem analysis through internal and external industry engagement;

Share the output in **Industry webinar**

Jan - Mar 2021

Gap analysis to identify key focused area and **scope of work next** and share in **industry webinar**

Apr – May 2021

Develop and start **market survey** through emails and 121 meetings;

Initiate **RFI** for innovation project of reactive market design

Jun to Sep 2021

Analyse **market survey result;**

Assess Innovation RFI and finalise plan; Develop **project plan** incl detailed scope and deliverables

Establish **project team**

Sep – Jan 2022

Project kicked off to start delivering the output (Co-creation with industry)

Final report delivered from consultancy and NGESO

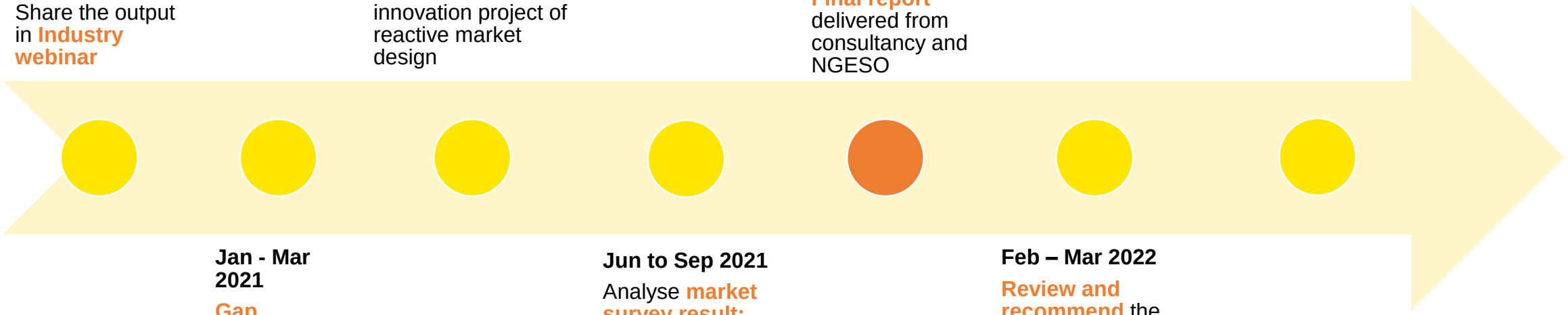
Feb – Mar 2022

Review and recommend the plan next for reactive market ;

Industry engagement to share the plan

April 2022 onwards

Start developing the plan for delivery based on recommendation



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Technical Need

David Gregory

Technical Need – Background

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- The Transmission System is to be designed and operated to the requirements of the Security and Quality of Supply Standard (SQSS) (a licence requirement)
- For voltage this requires:
  - Maintenance of pre and post-fault voltage levels against set criteria
  - The need to guard against the risk of voltage collapse

- These requirements are currently achieved by:
  - The control of mandatory reactive power capability provided by generation as per the Grid Code
  - The installation and control of reactive compensation equipment (both static and dynamic) by TOs
  - Operational measures (tap changing, circuit switching, etc.)
  - Provision of Reactive Capability by commercial providers who are not bound by the requirements of the Grid Code and subject to commercial contracts
- Note due to the reactive nature of the Power System it is not possible to transmit large volumes of Reactive Power across the System. It is therefore necessary to supply reactive power locally

Technical Need – Key Areas

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The key focus points for the technical analysis are:

Definition of requirements :

- **Size :** quantity of MVAr needed (absorption or injection) to maintain voltages at acceptable levels
- **Location :** by the nature of reactive power, its impacts are highly locational, and a key question is what do we capture in the requirement and how?
    - Should effectiveness be used, or is another metric more appropriate?
    - Should reactive power requirement zones be defined, with a requirement in a zone being quoted?
    - Should reactive power requirement be defined node-by-node?
    - Is there another way of capturing the locational requirement?

Service design :

- Current thoughts are that the service design will be to access sufficient reactive power to meet the SQSS voltage requirements, both steady state and step-change;
    - SQSS defines steady state as all operating quantities being considered as constant
    - SQSS step-change applies after the end of the *transient time phase*, typically 5 seconds after an initiating event
- Voltage stability is a different system need and service to be procured through the stability market, our reactive procurement work will be coordinated with stability procurement to ensure an efficient and optimised approach

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Project Delivery Plan

Rob Lee and Espen Døvle

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Reactive power for management of voltage is critical for a stable system

Historical

Where are we coming from?

- Historically, reactive power problems were with low, rather than high voltages.
- Large centralised thermal power stations were abundant under the ORPS and so the control room had more tools to mange the local system voltages.
- Rapid growth in renewables and changes in to the structure of demand has resulted in heavier reliance on proactive voltage management through the balancing mechanism and through NGET grid assets.

Today

Where are we today?

- The management of reactive power has become increasingly expensive as old tools for voltage management (such as large thermal power stations) have begun to retire.
- New technologies are emerging which are potentially capable of resolving reactive power issues, but commercial barriers can be challenging.
- The ESO has recently been exploring new commercial options with the Voltage Pathfinder Initiative.

Future

Where are we going?

- The ESO has set an ambitious target to be capable of running the GB system on zero-carbon electricity by 2025.
- Generation will continue to shift to low-carbon sources, including intermittent renewables. In times of low output from these sources, the problem is expected to grow.
- Electricity demand will grow unevenly across the country with the inception of EV's and electrification of heat, resulting changing requirements.

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CURRENT ARRANGEMENTS

NGESO has a number of tools to manage the system, we are exploring how a market might encourage more efficient provision & new providers

MVAr capability available to NGESO

- Generation capacity over 50MW - covered by the Grid Code (ORPS)
- Voltage pathfinder contract holders or other bi-lats.
- Regulated network assets (e.g. shunt reactors)

Unutilised MVAr capability

- Potential providers with existing assets not covered by the above
- New providers

1. **How do we design an attractive framework for new providers?**
2. **How do we encourage sufficient participation for meaningful price signals to emerge?**

* No decisions have been made on the treatment of existing providers at this point in time

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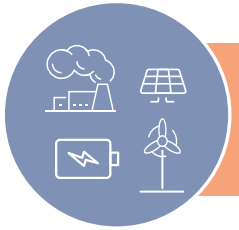
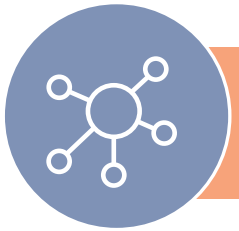
Overall project deliverables



Technology studies

Capabilities, characteristics, blockers and enablers



Methodology to define MVAr needs

considering volume, location and effectiveness

Map current and future MVAr capabilities

Market design

cost efficiency | voltage security | zero-carbon, consumer value |transparency |practical |investable

Feasibility study of market design

Economic modelling in BID3 based on FES scenarios

Recommendation

SCOPE OF WORK & APPROACH TO MARKET DESIGN

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Process to develop and select high level market design

Scene setting

1

Establish 'givens' and make **assumptions** on all relevant topics

Assumption	Implication
xxx	yyy
xxx	yyy
xxx	yyy

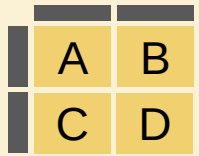
Scene setting

2

Identify **key uncertainties** in physical world and define **scenarios (FES)**

Uncertainties

- Presence of new RP providers
- Location of demand



Objectives and criteria

3

Establish **design principles** (objectives and priorities)

Primary principles	Cost	Sustainability	...
Sub principles	Stable	Investability	...
Constraints	100% RES	Carbon negative	...

Building blocks and options

4

Define **building blocks**, and the **options** for each building block. This defines the scope of the market design.

Building blocks	Options		
Approach to cap. adequacy	Scarcity pricing	Capacity mechanism	...
Approach to regulation	Prescriptive	Open	...
...	...	...	...

Strawmen design options

5

Create '**strawmen**' (high-level designs) that explore alternative **philosophies**; and have the **scenarios** in mind

Building blocks	Strawman 1	Strawman 2	Strawman ...
Approach to cap. adequacy	Scarcity pricing	Capacity mechanism	...
Approach to regulation	Prescriptive	Open	...
...	...	...	...

design options assessment

6

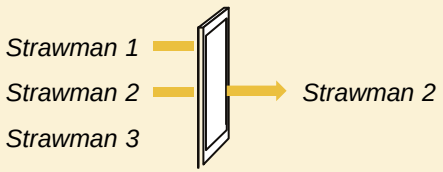
Assess each **strawman** against **design principles** in the context of all **scenarios**

	Cost	Sustainability	...
Strawman 1	○	◔	●
Strawman 2	◔	●	●
Strawman 3	○	○	◔

Final end to end solution

7

Select the **end-state strawman** that performs best across the **scenarios**



Final recommendation

8

Develop a **roadmap** to transition to **end-state strawman** from today

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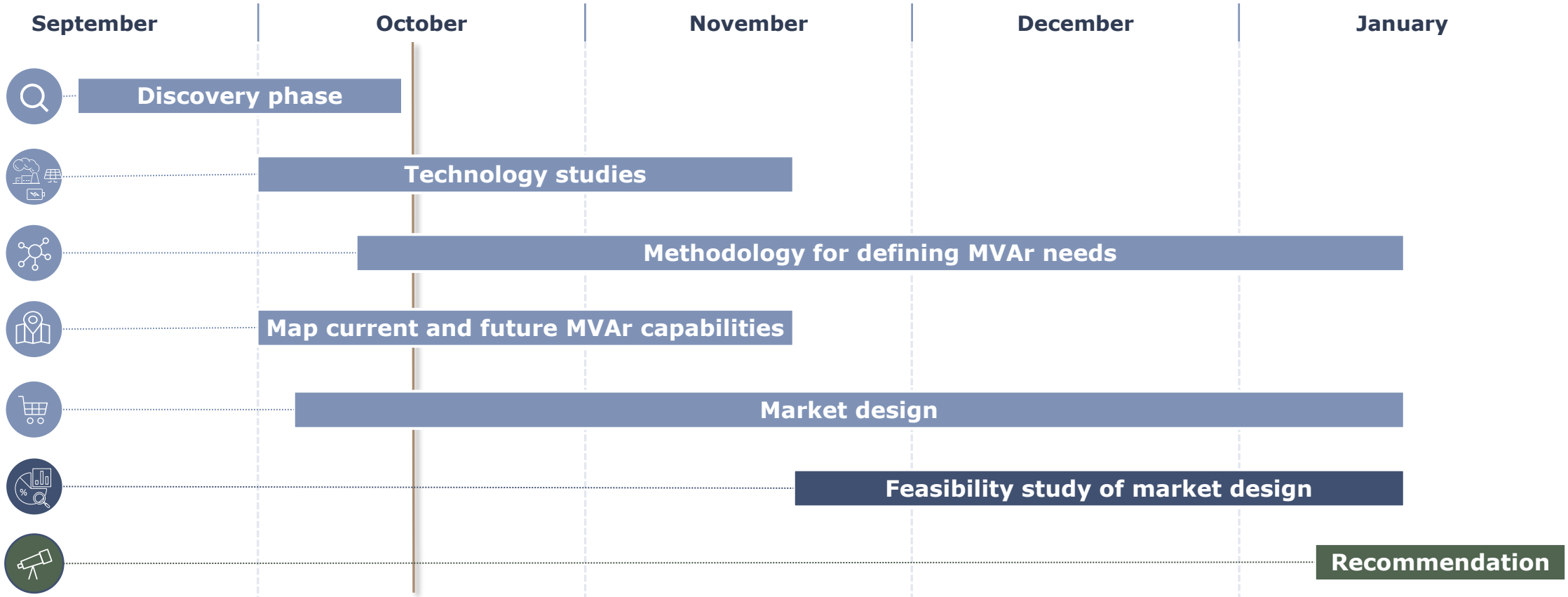
Project Timeline



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Summary of Survey Results

Yingyi Wang

Market Survey- Respondents Overview

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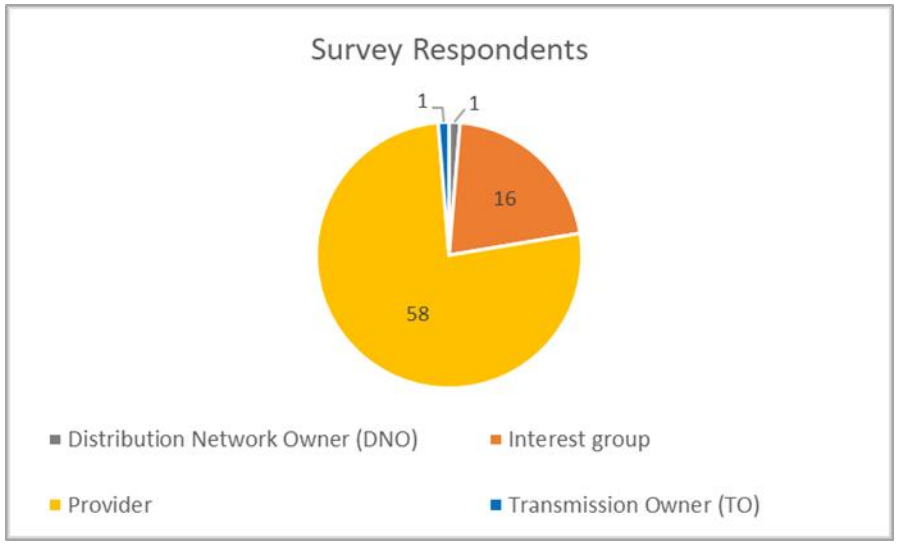

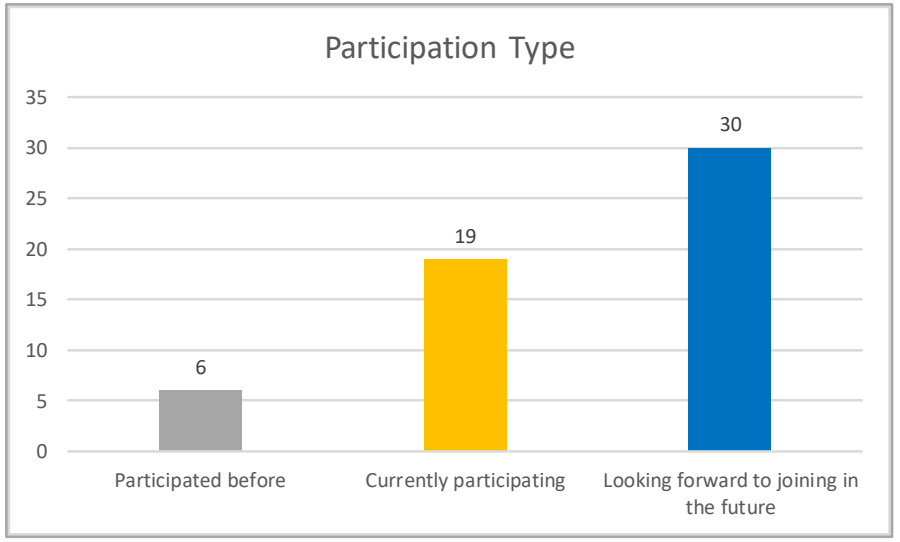

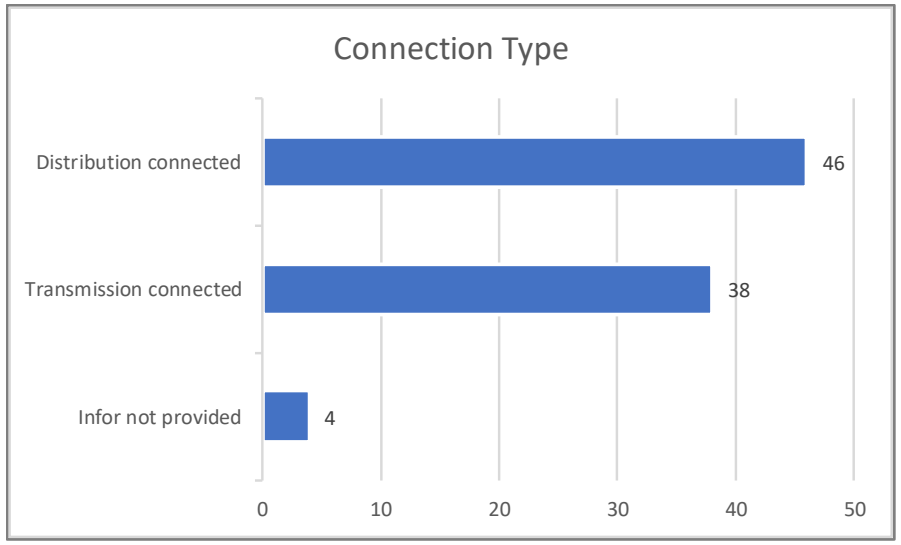

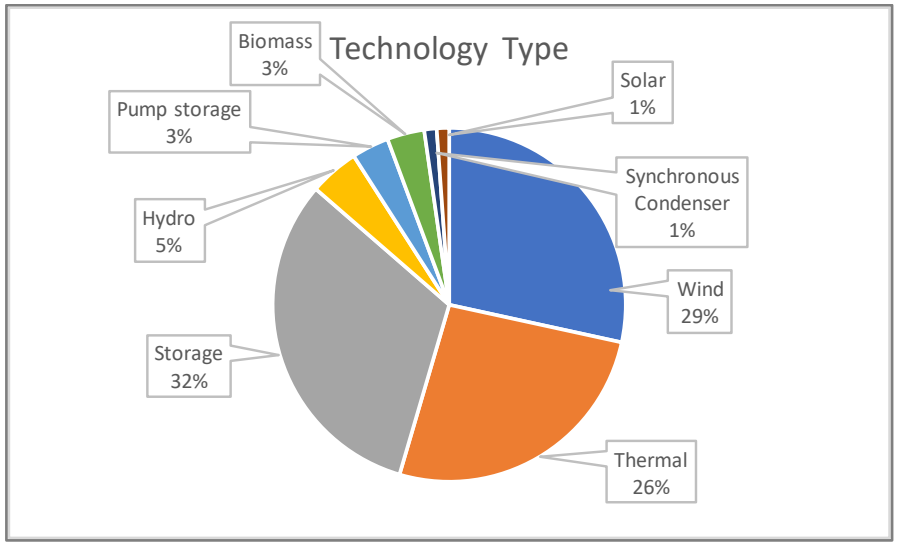

- FoRP market survey closed with105 opens and 76 responses from 1 TO, 1 DNO, 58 providers, and 16 interest groups.
- More than half of the providers are potential providers who look forward to taking part in the future.
- Regards to the connection type of responded units, the survey result shows a well balance between transmission connected and distribution connected.
- Wind, Storage, Thermal are the top 3 technology types responded the market survey (based on the number of units).

Market Survey - Technical Capabilities Summary

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	Storage	Wind	Thermal/ Gas	Hydro	Pump Storage/ Long Duration Storage	Solar	Biomass	Synchronous Condenser
Static/ Dynamic	Dynamic/ Some units can do both	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic
Need produce MW to provider MVAr?	No	Depends	Depends	Yes	No	No	Yes	No
Reactive power is provided with inertia or SCL	Some units can provide inertia and SCL	No	Yes, both	Yes, both	Yes, both	No	Yes, some units can provide with inertia, some both	Yes
Have extra capacity above Grid Code	N/A	Some units have excess capacity	Some units have excess capacity	No (based on survey feedback)	No (based on survey feedback)	N/A	Some units have excess capacity	N/A

Market Survey - Commercial Preference

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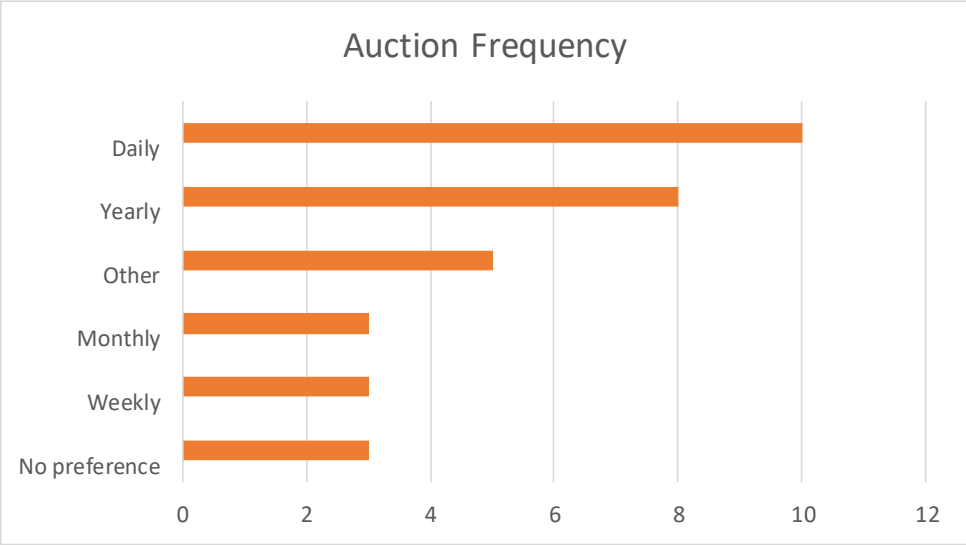
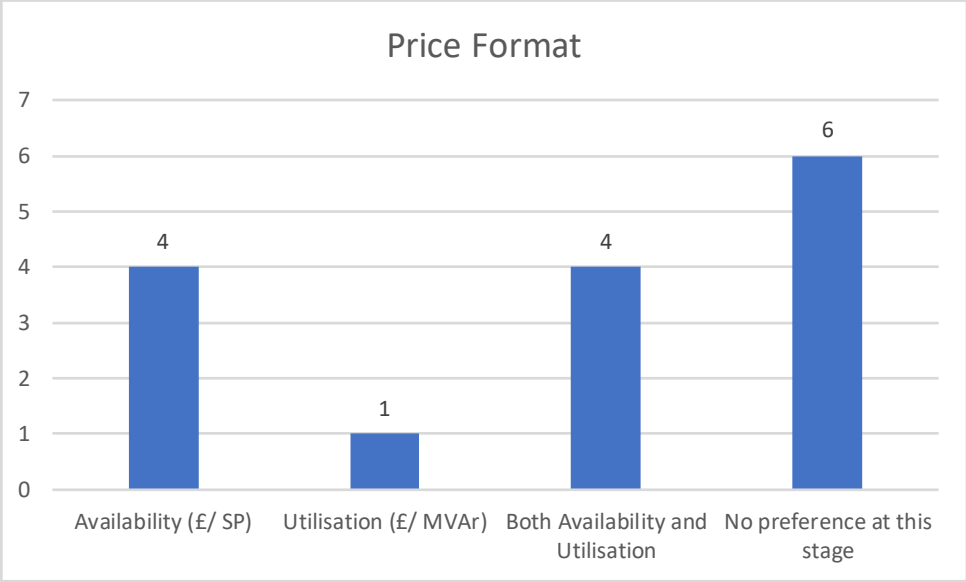


In order to send signals to existing providers while incentivising new investment for either new equipment or retrofits, there should be a right balance between short term and long-term procurement process.

For the short-term market, daily auction is the most popular option.



As to the price format, most providers felt they were not ready to answer this question or had no preference at this stage (especially the new players or future providers). This indicates that more information needs to be provided.

Market Survey - Market's Expectation on new market design

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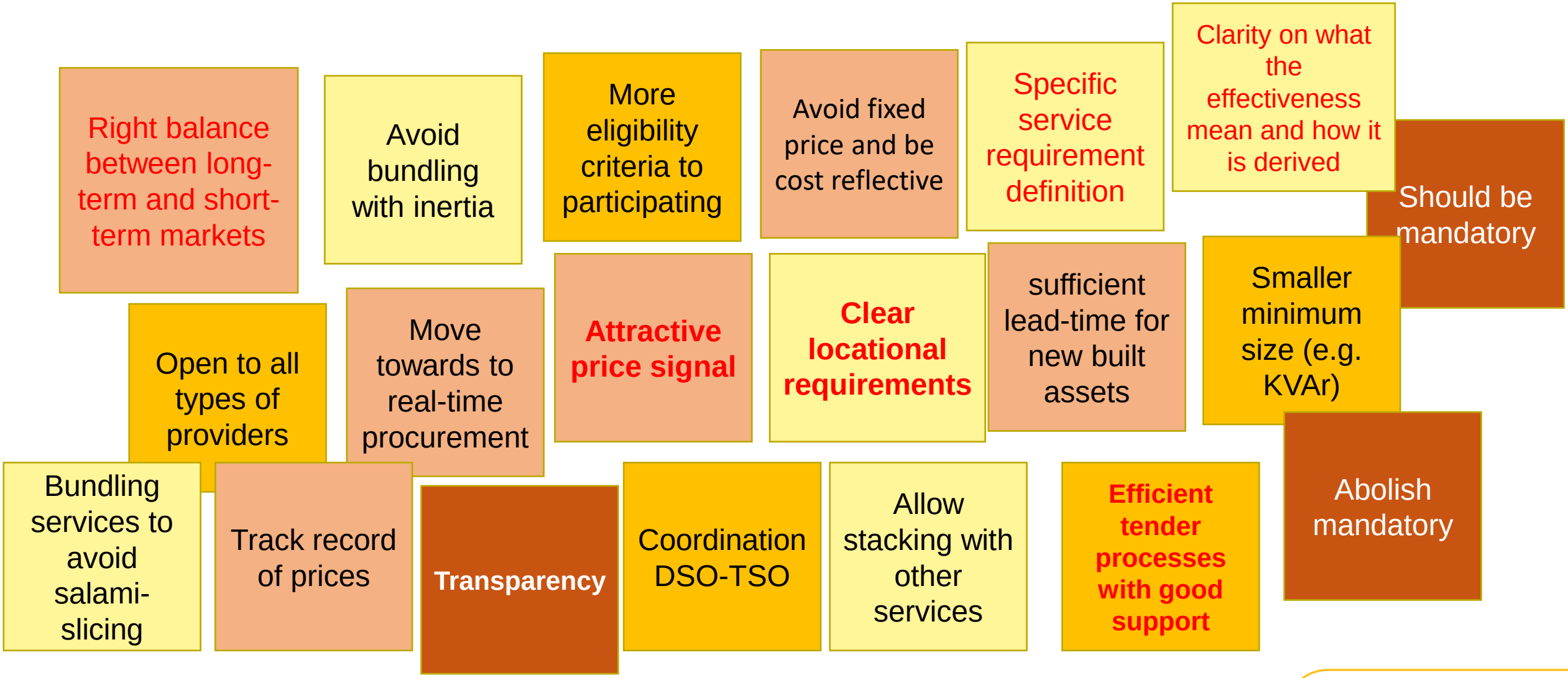

Market Survey - Blockers & Insights for next step

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	Blocker	Insights for our next step
General	• Not a defined product, commercial opportunity and requirements are unclear • Large minimum unit size • Poor tender process support • High cost of provision	• Specific product/ service design • More transparent locational requirements • Further exploration on the minimum unit size setting • Correctly valuing the reactive power service to send a value signal
Storage	• High opportunity cost	• Correctly valuing the reactive power service to send a value signal
Wind	• Who has control of the power factor is unclear (offshore wind)	• Clarify participation rules for offshore wind generators and OFTOs in a reactive market
Thermal	• Unbundled product design is not ideal	• Explore if procurement strategy and stacking rules can lower the barrier for them
Hydro	• Hard to provide sync-comp services without upgrading	• No data available for transmission connected hydro- need further exploration
Pump storage/ Long duration storage	• High opportunity cost • Undeliverable if the services are contracted separately	• Correctly valuing the reactive power service to send a value signal
Solar	• Not designed to produce reactive power, need extra investment to upgrade	• Further investigation on this type of technology
DER	• DNO connection agreements/ DUoS Charge • Minimum unit size	• Engage with DNO and implement impact analysis • Understand effectiveness of DER
Fill the gap		• Further investigation on Nuclear, HVDC • Explore network assets participation rules

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Overview of Market Analysis Work

Eleanor Horn

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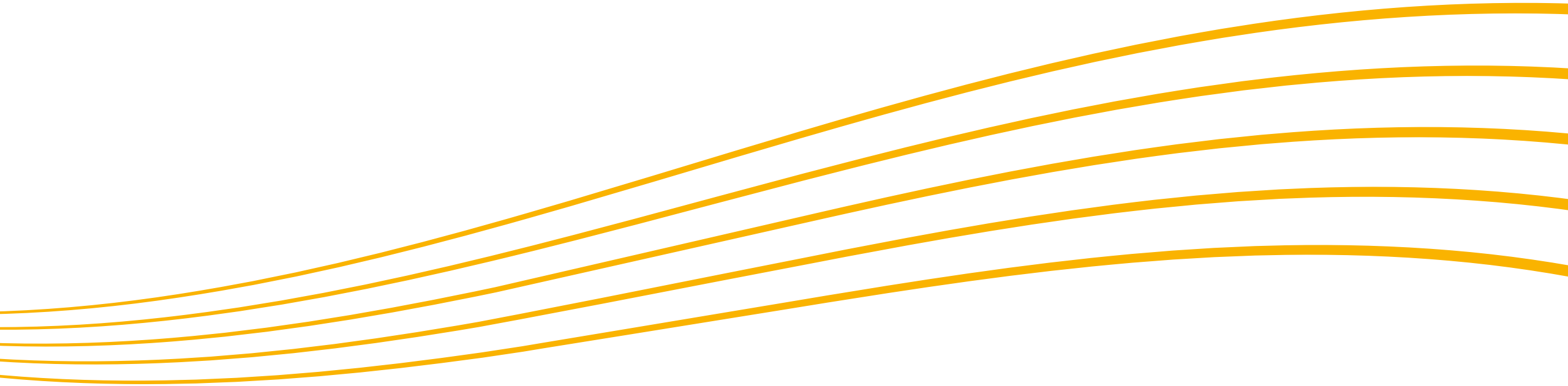

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Understanding The Supply Side Of A Reactive Power Market

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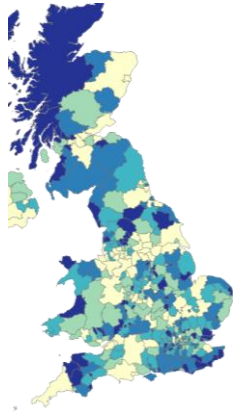
To support the market design of a reactive power market and recommendations on next steps for a reactive power market in GB we need to assess the **potential capability of providers to participate in a market and to access new MVAr capability that we don't currently access**.

What is the potential size of the market?

MVAr Heatmap of GB



Provider Case Studies

Asynchronous Machines

- Wind
- Solar PV
- Battery Storage

Synchronous Machines

- Gas
- Biofuel
- Hydro/ Pumped Storage
- Nuclear

MVAr specific tech

- 3rd party solutions
- HVDC
- Network assets

What are the technical routes to participation?

What are the commercial routes to participation?

Case Studies

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- Aimed at helping to support new and existing providers in their understanding of Reactive Power provision, including issues/blockers, associated costs and maturity levels
- Drafts will be shared for feedback / input from providers (example below)
- Once finalised we will publish them on the Reactive pages of the website

CASE STUDIES

Synchronous condenser with flywheel

Characteristics

Spider diagram

- A synchronous condenser (SC) is an AC-driven synchronous motor able to spin freely without load. It can provide system-critical services such as reactive power, inertia and additional short circuit levels to the electrical grid.
  - A flywheel can be added to the SC to provide additional inertia provision
- Advantages and enablers
  - Good provision of system stability services, especially inertia with flywheel
  - Fast enough to meet dynamic response requirements
  - Mature technology
- Barriers and disadvantages
  - Relatively high level of losses and mechanical wear

	Base case	High range	Low range
Typical unit size (MVAr)	125	200	50
Capex (£/kVAr)	248	324	172
Opex (£/kVAr/year)	14	21	8
Availability dependencies	Must be running to provide MVAr		
Reactive capability (Typical MVAr range per MW)	See unit size	See unit size	See unit size
Static only or dynamic? (Reactive Power)	Dynamic		
Additional range available outside ORPS range			
Short circuit levels (MVA fault current at 100ms/MW)	4	5	3
Typical inertia provision (MWs)[1]	500-2000	2000	250
Maturity		● ○ ○	

[1]Only includes capacity able to respond within 5ms of a fault

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Long Term Strategy

Jon McDonald

Operability Strategy

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Voltage management

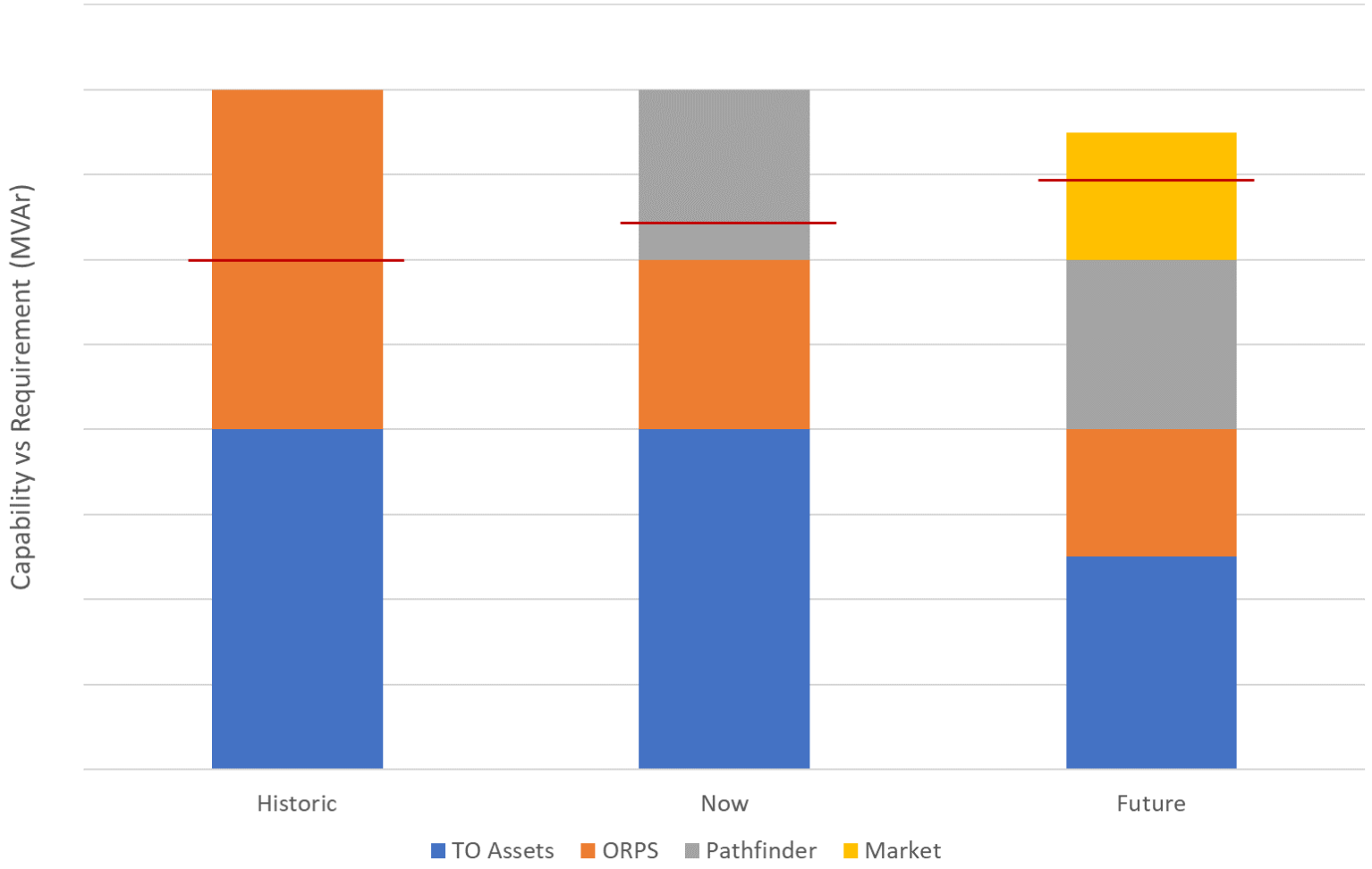
- Increasing requirement
- Decreasing capability from traditional providers

Pathfinders

- Delivering long term solutions
- Ensures compliance

Potential Reactive Market

- Additional capability to meet residual need



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Questions and Answers

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Next Steps and Close

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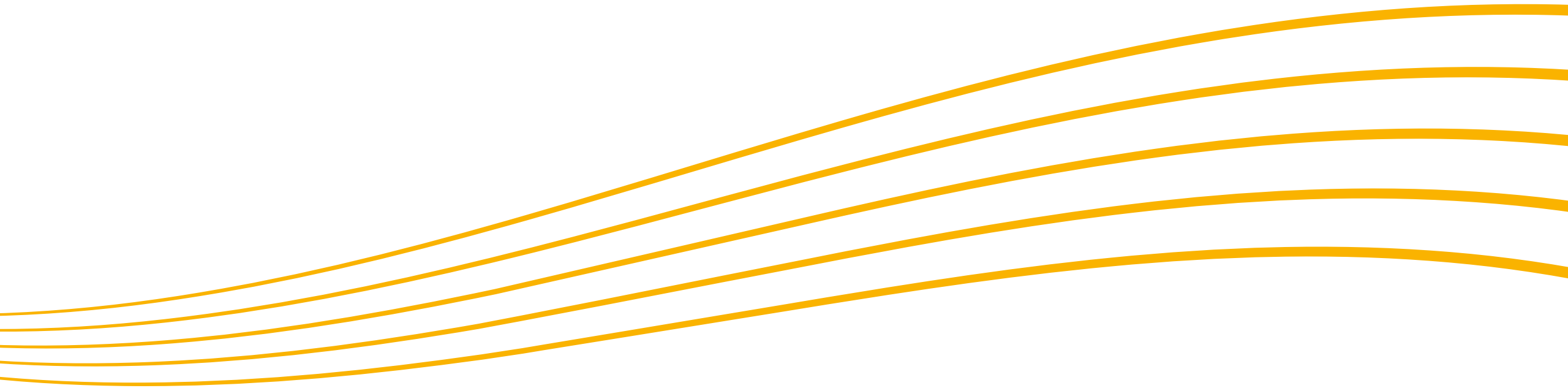

Next Steps and Close

- Slides and the recording will be published next week
- FAQ documents will be published after the webinar and updated on the future of balancing services webpage

https://www.nationalgrideso.com/industry-information/balancing-services/reactive-power-services/reactive-reform-market-design

- We want your input to our work and will reach out to you directly but do please contact us to get involved and provide your input
- Please give us your feedback on the webinar, please use this form
- Contact us via our Future of Balancing Services email address: box.futureofbalancingservices@nationalgrideso.com

Thank you all for joining the call.

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