Future of Reactive Power Project
Commercial and Technical Conclusions Workshop

17 February 2022

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Agenda

Housekeeping, introduction and work so far	Yuting Dai
Market Analysis Recap	AFRY
DER Participation Conclusions	Vicci Page
Technical Analysis Conclusions	David Gregory & Energynautics
Commercial Conclusions	AFRY
Next steps	Yuting Dai

Housekeeping, introduction and work so far

Yuting Dai

Objective of today

- Update the progress and plan next for reactive market design NIA project
- Share the latest technical and commercial design proposed from project
- Discuss the specific design questions with participants for comments and feedback – Mural board

The journey of work done so far and what next

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 **innovation project support** and start RFI

Jun to Sep 2021

Analyse **market survey result;**

Assess innovation RFI options;

Develop **project plan** incl detailed scope and deliverables

Establish **project team**

Sep – Feb 2022

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

Industry webinars and workshops to share progress and discuss the feedback

Mar 2022

Share **the final project report** with industry

Develop **recommendation** for the next step of reactive market

April 2022 onwards

Industry webinar to discuss the Q&A for final report;

Develop the actions required from recommendation

Market Analysis Recap

AFRY – Stephen Woodhouse

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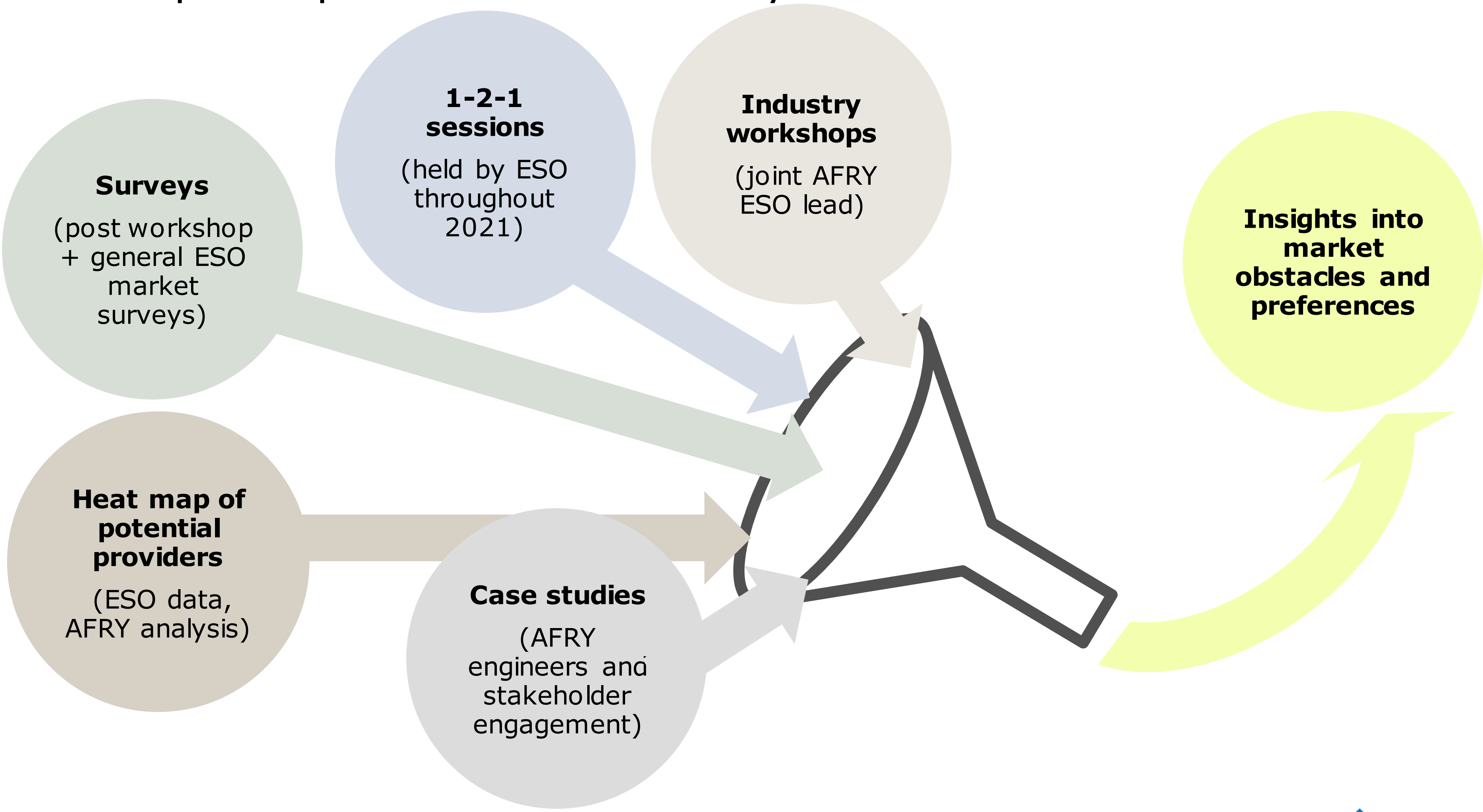
The market analysis workstream has been informed by a large range of inputs from participants and own analysis



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The insight revealed by market participants has informed our thinking throughout the project

Participants expressed an interest in a **hybrid** approach with long term contracts available and short term options with short term only and long term only being the least preferred options

Some providers have **additional capability** able to provide reactive power outside of ORPS ranges

Several providers quoted TO/DNO **connection agreement terms** as a barrier to utilising their full capability

Most participants either provide **ORPS**, were participating in **pathfinders**, or were DNO connected with **no route to market**

Providers felt that as the issue of reactive becomes **more salient**, **transparency** and **focus** on it should increase

Some providers felt **ORPS** didn't cover **total cost** of service provision when **heavily utilised**

Some existing ORPS providers can't understand why they are **not instructed** for their MVAr capability (transparency issues)

There was **disagreement** between providers on whether **availability payments** or **utilisation payments** were appropriate for remuneration

Providers identified **opportunity cost** outside ORPS ranges as a **key consideration** (lost subsidy payments, active energy sales, etc.)

Surveys | **1-2-1 feedback** | **Industry workshops**

Notes: Some views were expressed across multiple engagement activities

Most commercial barriers are related to uncertainty and variability

Technology affected	Key blocker	Key enabler	Preferred solution
Batteries/converter connected storage	High opportunity costs in valuable/high demand periods	Need to allow plant to participate when service is most valuable	**Short term market**
Variable converter connected technologies (e.g. wind)	Low availability certainty	Need to allow plant to participate at point where availability becomes more visible/certain	**Short term market**
Traditional thermal providers	High and uncertain fuel cost + uncertain requirement (difficult to hedge)	Need to allow plant to participate when costs are known and when requirements are highest	**Short term market**
All capacity	Additional Capex and Opex associated with higher MVA rating of equipment (if relevant)	If there is a low incremental cost, but long term commitment is inappropriate need to allow some short-term revenue to encourage deployment	**Short term market**
	Complex relationship between power factor, MW output, and heat losses (additional costs)	Need to give the opportunity for participants to bid portions of capacity to reflect non-linear cost	**ST market, availability and utilisation fee (or volume visibility)**
	Poor visibility over dispatch commitments	Dispatch risk should sit with ESO (to the extent possible), availability only fee requires participant to forecast dispatch and price in	**Both availability and utilisation fee (or volume visibility/cap)**

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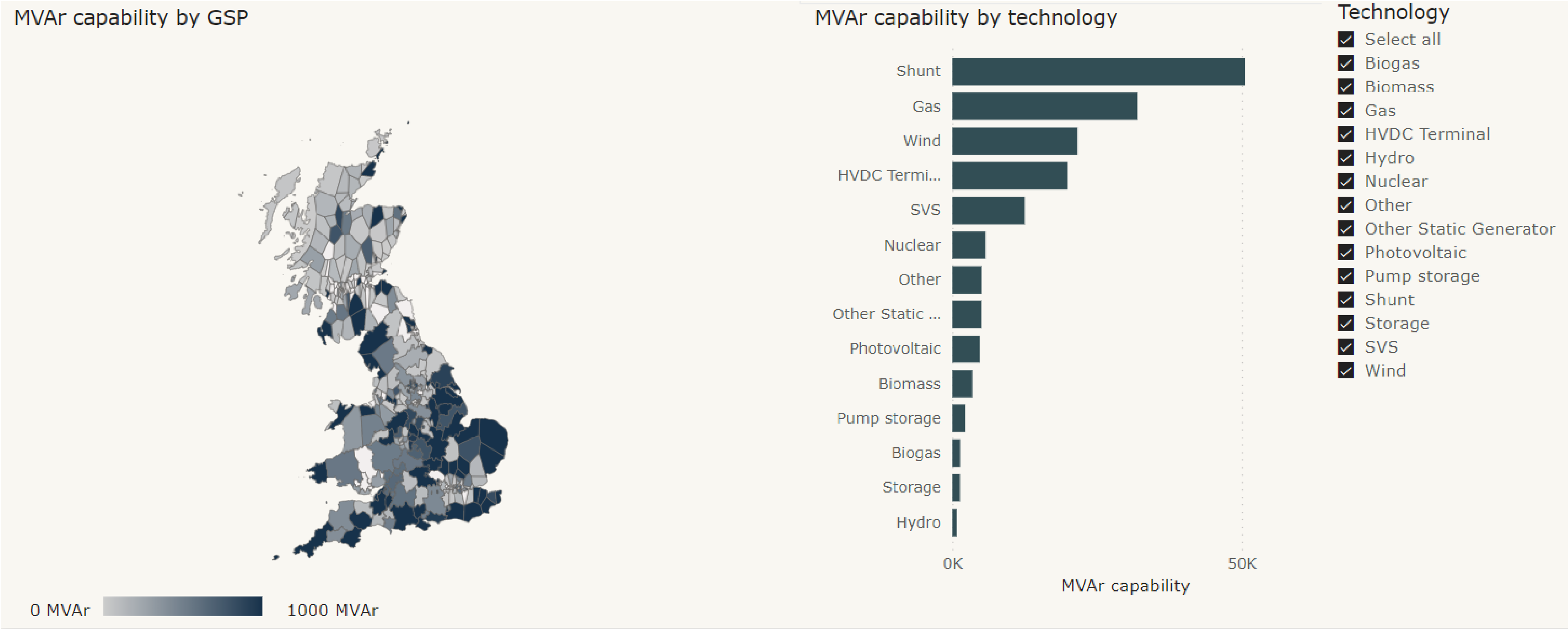
We have created a heat-map of providers to understand the potential for these resources in a reactive power market

Example – 2025, all providers MVAr injection capability (accessible today + additional capability from known assets)



Notes: Under ETYS scenario for 2025

DER Participation Conclusions

Vicci Page

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Reactive Power Provision from Distribution Connected Assets

- Enabling distribution connected assets to deliver reactive power to the ESO is complicated – I'll go on to share the detail around this complexity
- Actions taken at a Transmission level can significantly impact the stability of the Distribution network and operational limits and vice versa
- The DER workstream has identified a number of key areas where further work is required to enable DER to participate in a reactive power market
- Keen to understand:
  - Are the areas well defined
  - Are the enabling initiatives reasonably characterised
  - Are there other options

Possible ways forward to allow routes for overcoming DER participation barriers

#	Barrier	Possible way forward	*Relative ease (provisional)*
1	**Distribution system stability**	– Technical review of standards specified in ESQCR and Distribution Code to identify scope for amendment. Possible small adjustments if necessary to remove red tape - potential enabling activity.	Red (left)
2	**Distribution system losses**	– Issue may diminish under RIIO-ED2 (proposed removal of financial incentive around losses). As part of losses strategy, DNOs can make case for the value of trading-off increased losses and provision of reactive services, but this may be complex. Should be tested to understand if there is benefit for providers in the distribution network to be delivering these services as a whole.	Green (right)
3	**Distribution charging**	– Review of charging methodologies to identify potential alternative approaches or parameters to apply in respect of treatment of power factor to support efficient provision of reactive power services within cost-reflective charges. Could be effort intensive and complex, with scope for distributional impacts on users.	Red (left)
4	**Connection agreement power factors**	– Technical review of standards specified in connection terms to identify scope for amendment to support efficiency while maintaining stability/security. If potential benefits available, need cost-benefit analysis to assess merits of rollout.	Amber (middle)
5	**Non-firm connection limitations**	– Non-firm connections provide valuable flexibility for system management and so are expected to remain. Inclusion of a non-firm reactive power product in ESO design may allow for provision by parties with non-firm connections.	Green (right)
6	**System studies**	– Scope for specific provisions to cover system study costs/resources under RIIO-ED2 (although final business plans now submitted, so if not covered already, it will be difficult to achieve for RIIO-ED2).	Amber (middle)
7	**ESO / DSO conflict potential**	– Requires ongoing consideration of appropriate frameworks for coordination. This is a long-standing issue and difficult to resolve. Models such as Power Potential offer a possible solution, but it requires broad consensus and effort to rollout.	Amber (middle)

Technical Analysis Conclusions

David Gregory, Energynautics

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Technical Analysis - Recap

- Current NGESO processes to define reactive power requirements:
  - Are focused on management of high voltages (low voltages/voltage stability are considered as transmission constraints)
  - Are based on locations of BMUs which can be accessed through the BM for their reactive power range
  - Don't specify actual MVAr requirement, just a "number of units" or regions with high voltage issues based on high level criteria

    (See Week Ahead Overnight Voltage Requirement on Data Portal and the Voltage Screening Report)
  - Are manual and time consuming
- For a reactive power market, participants need to know
  - A numerical reactive power requirement
  - Locational information (location of requirement, effectiveness, etc.)
- Current process don't provide that information, so the technical workstream has investigated:
  - A suitable methodology for defining requirements in a transparent way
  - Zoning (or otherwise) of the requirement
  - Effectiveness (or otherwise)

Technical Analysis - Products

- Four products are being considered:
  - Steady state/pre-fault absorption
  - Steady state/pre-fault injection
  - Response/post-fault absorption
  - Response/post-fault injection
- Aim is to meet SQSS voltage requirements
  - Assumption that system is stable following an event
  - Steady state/pre-fault product allows pre-fault steady-state voltages to be maintained
    - Instructed to deliver following receipt of the instruction (by tapping step up transformer, changing set point voltage, switching reactor/capacitor, etc.)
  - Response/post-fault product allows voltage steps and steady-state voltages to be maintained following an event or operational switching
    - Delivered within 5 seconds following an initiating event (in line with SQSS definition of *Transient Time Phase*)
    - Instructed to be available (delivered as needed by automatic control system action, automatic switching of reactors/capacitors, etc.)
- Intention is that this will not exclude technologies and lines up with current Grid Code requirements

Defining the Demand – Top-down Zoning Issues

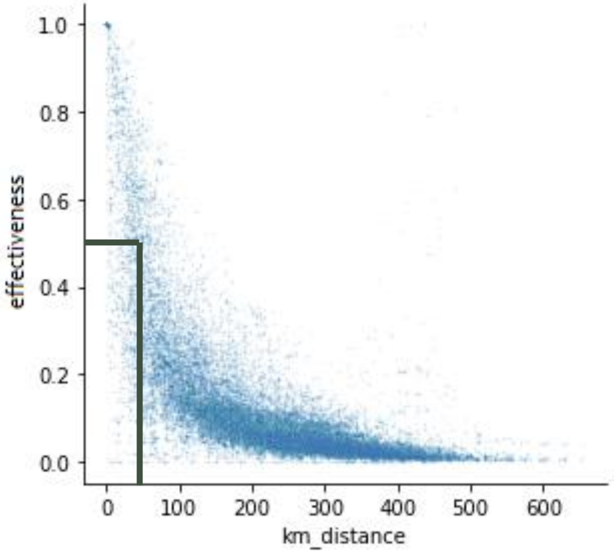
ZONING

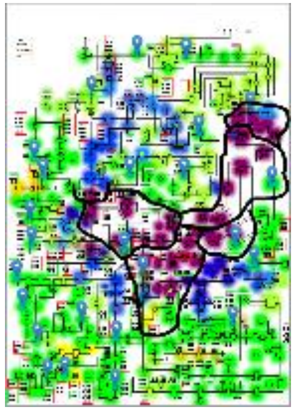
- Assumptions
  - Reactive power providers can be grouped according to where they are technically able to contribute to supplying the reactive power demand.
  - Conversely, for a given provider location, transmission nodes can be grouped according to where the provider can effectively contribute.
  - If we can pre-determine these grouping structures, we can use them to aggregate, communicate, and optimize the reactive power allocation between the providers. Can we?

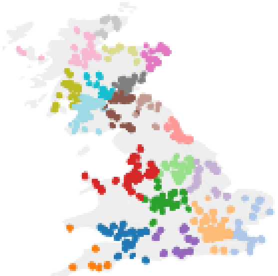
- Investigation
  - Locational effectiveness determines what grouping structure sizes are reasonable and, thereby, how many are needed. How precisely does the effectiveness relate to transmission distance?
  - How to cluster the transmission system nodes according to (electrical) proximity?

INVESTIGATION RESULTS

- Effectiveness can be estimated to 50% at 50 kilometres transmission distance.
- Top-down zoning approach would require 100+ grouping structures.
- 100+ grouping structures would hardly be transparent to providers.
  ⇒ not recommended
  ⇒ look into nodal approach instead







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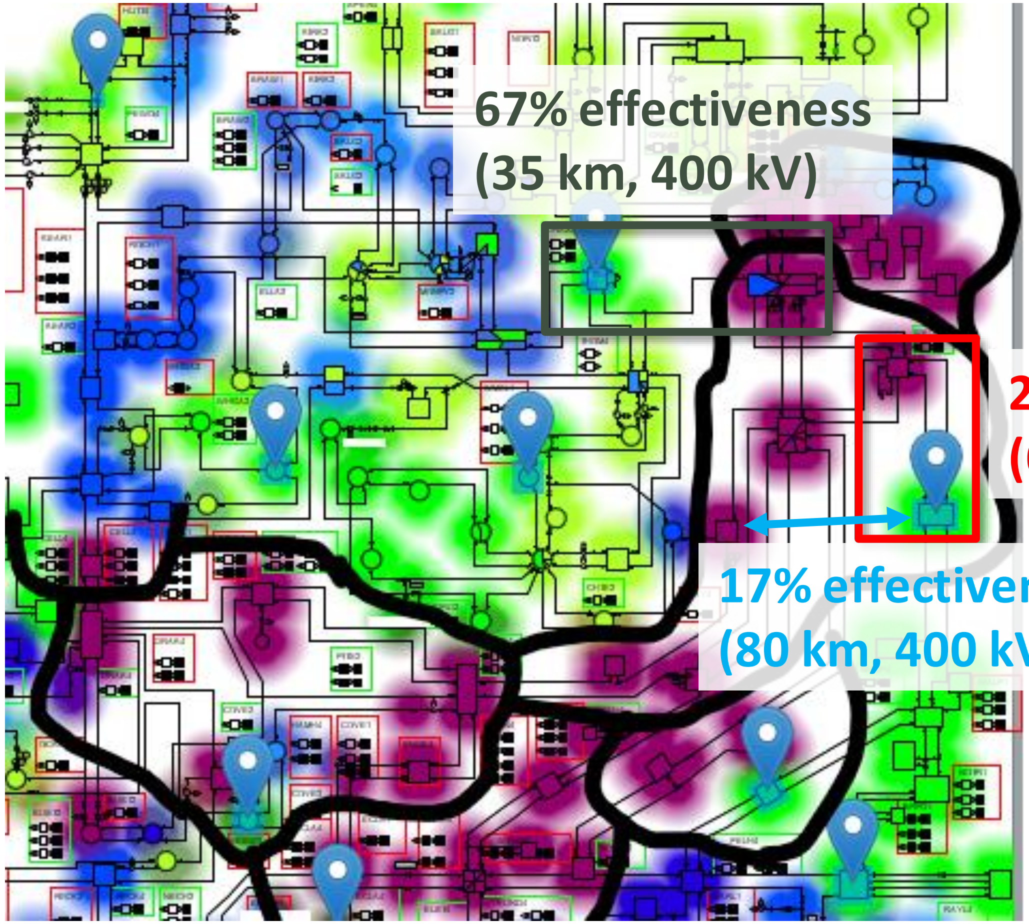
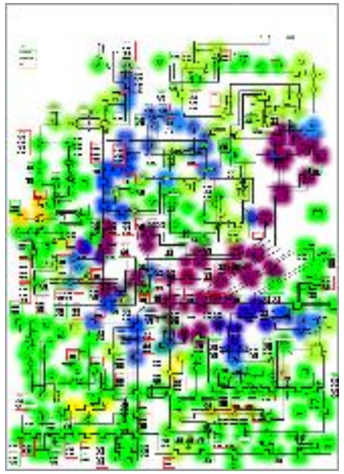
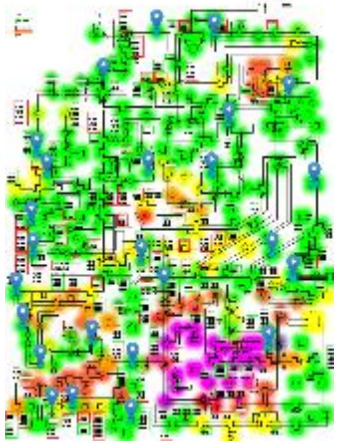
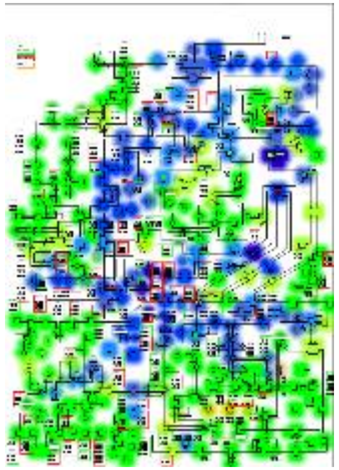
Defining the Demand – Top-down Zoning Issues



Effectiveness decreases quickly even between neighbouring nodes.







Areas with reactive power needs vary significantly between scenarios.

Commercial Conclusions

AFRY – Simon Bradbury, Stephen Woodhouse

Market objectives create a framework for evaluation of market design performance based on desired outcomes

Primary objectives

Ensuring **cost efficient provision** of reactive power to **maintain system voltage security** in the context of a **zero-carbon system**

Secondary objectives

Practical
- Ease of implementation
- Ease of ongoing operation

Investable
- Respecting existing investments
- Supporting efficient future investments

Transparent
- Visibility of service values
- Clear procurement decisions

Enduring (stable)
- Suitable/adaptable to future challenges
- Well understood governance for changes

Consumer value
- Promoting competition between providers
- Minimising cost burden on customer

Freedom of choice
- Technology agnostic
- Avoiding lock-ins

4 broad design (strawman) options created based on combination of long and short timeframe; existing arrangements; different contract types; and other market feature variations

A

Long term (LT) only

Multiple new LT market arrangements, replacing the Pathfinder (PF) arrangements.

B

Short term (ST) only

New ST market. No *new* Pathfinders.

C

ST + LT

New ST market alongside LT baseload market run ad-hoc (PF)

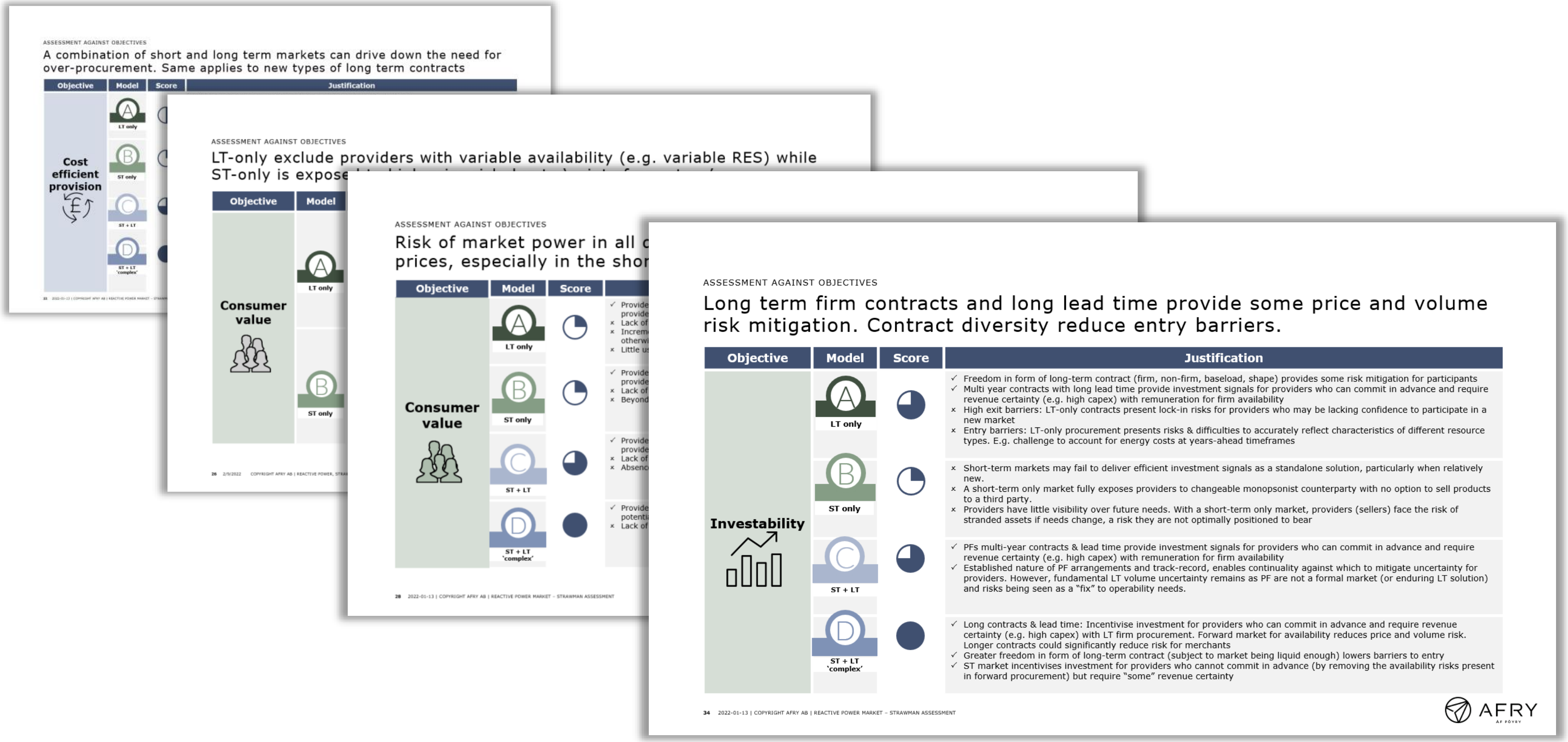
D

ST + LT 'complex'

New ST market alongside multiple new LT contracts, run at scheduled intervals

Note: Adjustment to arrangements such as ORPS are not considered within the scope of this project

A thorough appraisal of the merits and drawbacks of each model has been undertaken and will be shared



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Overall, strawman D scores highest, reducing some of the complexity (trending towards option C) will make it more practical

	Maintain voltage security	Cost efficient provision	Zero carbon compatible	Consumer value	Transparent	Investability	Practical	Enduring (stable)	Freedom of choice
A LT only	◐	◐	◐	◔	◐	◕	◕	◔	◔
B ST only	◔	◔	◕	◔	●	◔	◕	◔	◐
C ST + LT	◕	◕	◕	◕	◐	◕	◐	◐	◕
D ST + LT 'complex'	●	●	◕	●	◕	●	◔	◕	●

Option D scores the highest but lacks practicality for both ESO and providers – conclusion is to go with a simplified version of D/more complex version of C

The assessment concludes that a hybrid of C and D is the most pragmatic way forward whilst maximising benefits against the objectives

A — LT only

Not preferred option because of unpredictability of demand.
- × Leads to over-procurement to maintain adequate system security, raising cost
- × All risks needs to be mitigated by NGESO in the long term when degree of predictability is low
- × High barriers of entry for some technologies

B — ST only

Not a viable option because:
- × Exposing ESO to system security risk (beyond point of no return)
- × Limited incentives for new investment, limited suppliers and competition

C — ST + LT

- ✓ Combination of long term and short term market gives the best balance between system security and cost efficiency, while increasing consumer value by promoting competition from a wider range of technologies

D — ST + LT 'complex'

- ✓ Adding peak contracts allows reducing over-procurement compared to baseload only, thus can save cost while also increasing freedom of choice.
- × Introducing overly-complex contracts makes market less practical and value less transparent

C/D — ST + LT

Long Term market with simple product(s)
+
Short Term day-ahead market ✓

Open questions
Preferred solutions

		Long-term market	Short-term market	Description / rationale
Type of products	**Products**	– Pre-fault injection – Pre-fault absorption – Post-fault injection – Post-fault absorption	– Pre-fault injection – Pre-fault absorption – Post-fault injection – Post-fault absorption	4 products in both markets : – Pre and post fault – Absorption and injection
	Product linking	– Possible to submit mutually exclusive bids or bundled bids for a combination of products	– Possible to submit mutually exclusive bids or bundled bids for a combination of products	– Participants can link products and make their offers mutually exclusive. Applicable for technologies capable of providing both injection and absorption, pre and post fault.
	Contract type	Baseload availability [+ Potential for Fixed shape/peak window products TBC]	4 hour EFA blocks	The different contract types are targeted at different needs and provider segments. ESO and some providers' preference for short term is EFA blocks initially.
Requirements and provider eligibility	**Locational Requirement**	Nodal		Requirements are assessed and communicated per node.
	Procurement strategy	Shortfall + Opportunistic		ESO buys (expected) shortfall plus the economically desirable (opportunistic) – incl. ORPS if it is cheaper than alternatives.
	Provider Eligibility	– For shortfall: Additionality criteria – For opportunistic: All providers. However, NGESO discretion for awarding contracts	– For shortfall: Additionality criteria – For opportunistic: All providers. However, NGESO discretion for awarding contracts	**Shortfall:** Additional capability required to meet the demand for reactive services **Opportunistic:** NGESO procure if economically efficient to do so. All providers are eligible, including existing capacity.

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Open questions
Preferred solutions

		Long-term market	Short-term market	Description / rationale
Timeframe	Frequency of procurement	National annual procurement	National daily procurement for next day (D-1)	For the long-term market, the assessment of the forecast demand for additional reactive power will be run annual, potentially leading to no new need, and therefore no new long-term procurement.
Timeframe	Lead Time	[T-3] & [T-1]	D-1	Sufficient lead time for asset deployment, closure decisions, and operational decisions across the three time frames.
Timeframe	Product duration	[15 year]	[4 hour EFA blocks]	Aligns with other long-term contracts (CM, CfD) for the long-term market, control room preference for short-term arrangements
Pricing mechanism	Payment structure	**Availability [+ utilisation]** – £/MVAr/h availability payment – [£/MVAr/h utilisation via ORPS payment mechanism]	**Availability + utilisation** – £/MVAr/h availability payment – £/MVAr/h utilisation via ORPS payment mechanism	**Long term** market mainly targeting high-capex & low variable cost – utilisation TBC. **Short term** market targeting high availability & variable cost or low availability & variable cost providers.
Pricing mechanism	Clearing principles	Pay-as-bid	Pay-as-bid	Due to nodal nature of requirement and bundled products (multi-clearing price impractical)
Pricing mechanism	Price cap	– TO owned asset solution depreciated over [15y] horizon for new build. – Forecasted short term cost for opportunistic procurement	Real-time alternative cost forecast (cost of meeting demand in balancing timeframes)	One tool to mitigate potential manifestation of market power given nature of reactive needs
Pricing mechanism	Settlement schedule	Monthly payments with annual availability reconciliation payment	Monthly payments	– Long term payment schedule in line with current pathfinders. – Short term payment schedule in line with STOR market.

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Open questions	(green)
Preferred solutions	(blue)

		Long-term market	Short-term market	Description / rationale
Availability Requirement	**Availability requirement**	High [95%]	Self-declared availability (firm) per market time unit	Failing to deliver (declared) availability/utilisation results in facing non-performance process
	Non-performance process	Penalties: Non-payment, becoming more 'penal' below availability requirement (similar to current pathfinder approach)	Firm 'penalty' for non-delivery of declared availability (beyond non-payment [strong fixed penalty agreed price * X or agreed price + X])	Strong incentives to 'show up' due to criticality of need. Simple to start with – desirable end state may be to expose participants to alternative costs depending on time frame.
Provider location	**Effectiveness factor**	– Effectiveness factor defined individually per node. – Fixed at point of contracting for the whole contract duration	– Effectiveness factor defined individually per node. – Dynamic, i.e. changing frequently, to reflect changes towards reference node	Provider effectiveness same as the node it connects to. Effectiveness factor for one period adjusted to minimum effectiveness of the contingency scenarios.

Q&A
See link in the chat

Next steps

Yuting Dai

Next steps

- Final project report will be shared by the end of March
- Industry Webinar in April to discuss any points of clarification or questions on final report through Q&A
- All project information, recordings and outputs from previous work:

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

- Contact us via our Future of Balancing Services email address: box.futureofbalancingservices@nationalgrideso.com

Thank you all for listening to this recording.

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