
AFRY
Making Future
AFRY
ÅF PÖYRY

Stability market design innovation project

Report to National Grid ESO

MARCH 2022

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ABOUT AFRY

AFRY at a glance

SECTOR EXPERTISE

Core sectors:
- Energy
- Bioindustry
- Process Industry
- Automotive
- Infrastructure

ENGINEERING

- Owners/Lenders engineering
- Detail engineering
- Operational services
- Project management & execution
- Technical studies

ADVISORY SERVICES

- Forward looking market analysis
- Strategic advice
- Operational excellence
- Transactions services

DESIGN

- Architecture
- Urban planning
- Digital/UX design
- Lighting & Sound design
- Product design

DIGITALISATION

- Software engineering / development
- AI / Robotics / Drones / 5G
- System integration and management

WE HAVE

16,000

Employees globally (as of 2021)

ANNUAL REVENUE

1.95 bn

euros in 2021

NUMBER OF COUNTRIES WITH OFFICES

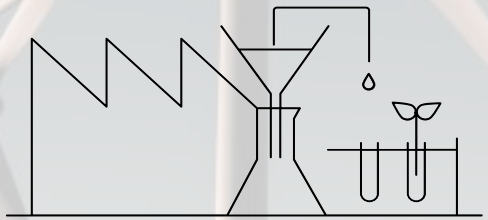
>50

NUMBER OF COUNTRIES WITH PROJECTS

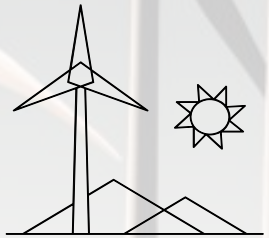
>100

4 Growth Drivers

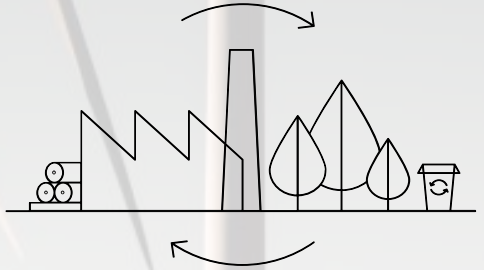
Infrastructure



Food & Life Science



Clean Energy



Bioindustry

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Key messages

Current arrangements are sufficient **to ensure security**, but are **narrow** in their facilitation of provider types.

There are **emerging technologies**, in particular grid-forming converter connected technologies, that can offer part of the solution to stability constraints – however no suitable *enduring* incentives exist for these provider types at present.

Long-term markets in the form of the **pathfinders** are making an impact already, offering **system security** and **reduced costs** to consumers.

Some providers are not able to make commitments under existing long-term market timeframes, particularly providers with **low availability certainty**, high & unpredictable **variable costs**, or high & unpredictable **opportunity costs**.

There is a **trade-off** between **complexity** of market arrangements, and expected **efficiency** of market outcomes. A pragmatic approach should be pursued, but complexity shouldn't be traded off 'at all costs' if benefits are sufficient.

Eligibility of different provider types must be carefully considered across timeframes to mitigate distortions and **avoid undesired lock-in** for both ESO and providers.

Key recommendations

Future arrangements should target and facilitate a **diverse mixture** of different technologies to provide stability solutions at **least cost** to consumers. Our high-level market design recommendation is to have a **combination of a long-term and short-term** (day-ahead) market dedicated for stability, while retaining BM actions as a backstop.

An **enduring solution** is required so that participants are able to optimise their asset stability characteristics in the design phase against expected stability revenues.

Long term procurement should **continue**, and be formalised into a systematic process so that providers are given the opportunity to **develop a pipeline** of solutions. Efficient signals for investment planning must be in place.

The addition of a **short-term market** would offer a route for providers that **aren't able to make long term commitments** and is expected to bring benefits in terms of dispatch efficiency and carbon reduction.

Contract types should (initially) be simple to promote **transparency**, and **reduce complexity** of solution value assessments. We are proposing a single duration & definition contract at each market timeframe to help manage complexity.

We are proposing **different eligibility** in **different timeframes**. Long term multi-year contracts to underpin investment, year-long (T-1) contracts to manage forecast error and influence closure decisions, and short term day-ahead contracts to fine tune positions and broaden the pool of potential providers – lowering barriers to entry and promoting competition.

Contents

STABILITY MARKET DESIGN

1. Introduction

ESO is exploring an enduring market solution to resolve stability challenges

Context

ESO role

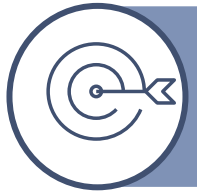
NG ESO is responsible for ensuring the operability of the electricity system (ultimately adhering to the SQSS[1]). This includes management of system frequency and voltage.

Net-zero & stability require-ments

NG ESO has stated an ambition to be able to operate a zero-carbon grid. The potential for renewables in GB is vast, but this has an impact on the requirements for system stability services due to the stability characteristics of these technologies

Stability arrange-ments

NG ESO uses a suite of tools called balancing arrangements, which include a complex set of nested marketplaces. NG ESO has regulatory freedom and incentives to contract with service providers over a range of timescales and products.



Potential solution

This project presents recommendations for high-level design of potential stability market arrangements. It is not a final decision, rather an enabler for ESO's next steps.

Project focus

PROJECT OBJECTIVE:
Explore design options for a potential GB stability market, to meet growing requirements for stability cost-effectively as the system transitions to net zero.

KEY QUESTION:
What are the possible designs for a stability market that would allow the ESO can meet its stability requirements whilst making optimal economic decisions and also enabling wide participation with minimal barriers to entry?

What next?

The project outcome is a preferred way forward – future steps will consider detailed market design & analysis. We outline key next steps in the recommendation including updated analysis. Further implementation planning will need to be done to assess practical challenges in more detail (systems, processes) and the refine design accordingly so that solution is workable for ESO and industry. There will be additional consultation with industry and opportunity to refine based on engagement.

Notes: [1]Security and Quality of Supply Standard

This document presents the current arrangements for stability management and the case for change, followed by strawman options, their assessment and then high level market design recommendations

1 **Alignment, vision, objectives**

1a. Scene setting

What are the realities? Establish 'givens' and make assumptions on all relevant topics

1b. Objectives

What do we want to achieve? Establish the design principles for the market

2 **Design elements, strengths, weaknesses**

2a. Market building blocks

Define the key design choices that can materially impact market outcomes

2b. Straw-man options

Define conceptual design options to assess – exploring alternative philosophies

2c. Assessment

Appraise design options qualitatively and (2d.) quantitatively against objectives

3 **Industry views, refinement, finalisation**

3a. Refinement

Highlight the preferred option; make improvements to increase performance against our objectives

3b. NIA desirable option

Recommend a desirable design for stability market and way forward

Stakeholder engagement has fed into our assessment

Project relied on a range of sources to support the market design process

Sessions with ESO experts

- Control room & Markets team: multiple expert sessions (power system management, market requirements management) probing the system operation planning, decision-making process and dispatch, and understand how a potential stability market would work.
- Pathfinder team: multiple engagements analysing the wider approach to current Pathfinders, distilling key challenges (long-term energy risk, eligibility), and deep-dives on specific issues like the treatment of retiring synchronous generators and the 'additionality criteria'.
- GC0137 team: this specification is expected to form the basis for the technical capability that can be procured in a potential stability market.

Industry workshops

- The project fed stakeholders' views directly in the design and assessment process. Two industry webinars were held to share initial findings and seek feedback.
- Webinar 1: sought views and feedback regarding the case for change and the building blocks of a potential market design.
- Webinar 2: shared initial findings on the design options and a preferred option, seeking feedback on both wider and specific design features.

Case studies & modelling

- Modelling of inertia and SCL requirements under the FES 2019 scenarios (Two Degrees, Community Renewables and Consumer Evolution). All scenarios were developed for two years (2026, 2030). Key enabler to understand nature of requirements and provider dependencies. We have not modelled Dynamic Voltage Control due to data limitations; this is a key consideration for next steps.
- Technology research: analysis of current & potential providers of services (incl. assumed capability for technology, typical size, and expected capex/opex).

Surveys

- Inputs from industry to design an effective market: information and evidence from industry surveys.
- The surveys sought evidence on a range of topics such as technology costs, the investment issues, the lead times, the interaction with other services like, cost structures, decision-making in dispatch timeframes.

Summary of industry engagement in key numbers

OF WEBINARS

- Webinar 1: situation, context & case for change
- Webinar 2: options, assessment, preference

OF PARTICIPANTS

- Webinar 1: ~40
- Webinar 2: ~70

OF VOTES CAST

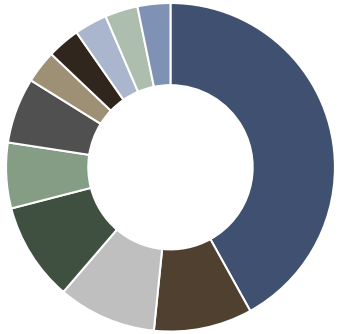
- Webinar 1: ~34
- Webinar 2: ~99

OF QUESTIONS ANSWERED

- Webinar 1 Q&A: 15
- Webinar 2 Q&A: 18

KEY ORGANISATION OF INDUSTRY PARTICIPANTS (#)

- **Energy company *(13)***
- **Engineering *(3)***
- **Energy advisory *(3)***
- **Network *(3)***
- **Investor *(2)***
- **Software *(2)***
- **Energy trading *(1)***
- **Government *(1)***
- **System operator *(1)***
- **Trade association *(1)***
- **Anon *(1)***



Definitions of key terminology used in market design process

	Characteristic	Definition
Timeframe	Long-term	Timescale enabling minimum lead time for investment
	Short-term	Timescale referring to day-ahead
	Real-time	Period from Gate Closure but prior to 'Settlement' (encompassing delivery)
Pricing	Capability	Provider of service is able to become 'available' within some defined time period
	Availability	Provider of service is 'active' and available to supply service as needed (by the SO)
	Utilisation	Service from the provider is used by the SO (distinction from availability may not be meaningful if an active service is 'always on')
Contract	Baseload	Provider commits to firm availability with a high expectation of reliability throughout the contract period (Product duration e.g. 10 year baseload)
	Shape	Provider commits to firm availability with a high expectation of reliability throughout the contract period (Product duration e.g. seasonal or daily-peak)
	Conditional	Committed under certain predefined conditions (e.g. when wind is blowing)
	Call option	Provider commits to availability on demand by NGESO throughout the product duration, at contracted quantity and price Provider paid only when ESO calls for availability
	Firm ST contract	Firm contracts with short procurement lead time (day-ahead) Product duration at low granularity (e.g. 30min)
Requirement & Procurement	Shortfall	The absolute difference in the gross market requirement and the provision from suppliers not available in subsequent timeframes
	Gross requirement	The absolute level of a given stability service needed by ESO
	Opportunistic buying	Opportunistic buying is a procurement strategy – once the shortfall has been met, ESO may wish to procure additional volumes if it expects a discount relative to the counterfactual procurement method – e.g. ST procurement (for the LT market) and BM actions (for the ST market)
	Effectiveness factor	Scalars accounting for the relative provision of different providers. Effectiveness factors can be applied as a percentage, an effectiveness factor of 50% means the provider must provide twice as much kA (in the case of SCL) as required to meet the requirement at the point of need
	Market dispatch	Simulates market conditions at day-ahead
	Market redispatch	Simulates SO actions to manage system operability

STABILITY MARKET DESIGN

2. Scene setting

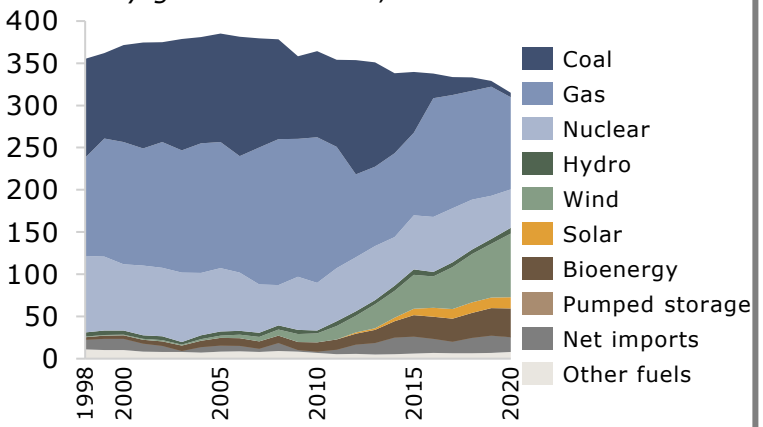
Challenges for managing stability manifest as a result of an evolving system

Historical
Where is the system coming from?

Historically, stability was provided as a by-product of generation and was in abundance.

Reactive power production for voltage and inertia for frequency stability was co-produced when generating.

Electricity generation in GB, TWh

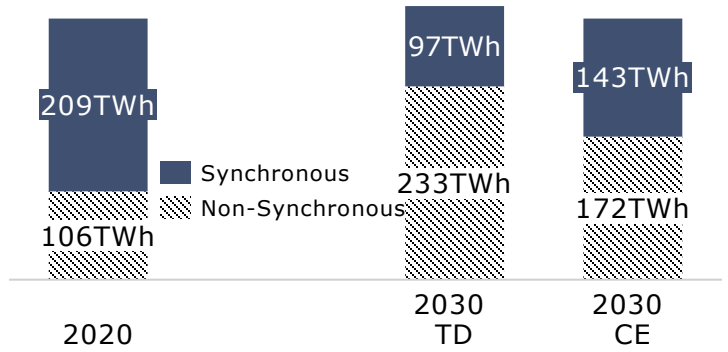


Today
What is happening now?

Rapid growth in renewables, retirals of synchronous generation and changes to the structure of demand. Systems get lighter and short circuit levels decrease at times with very high renewable penetration.

The management of grid stability has become increasingly expensive and we are exploring new commercial options for stability services including Pathfinders.

Projected generation (FES 2019), TWh

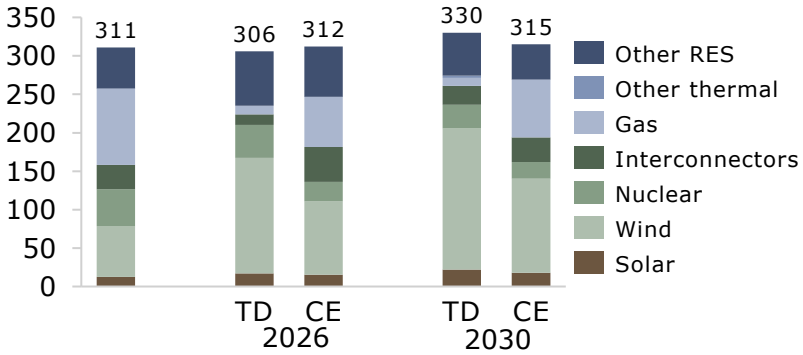


Future
Where is the system we going?

Stability requirements will likely be greater than today but also different from the current needs. These needs will vary significantly under different operational situations within the power system.

As the system evolves towards technologies not inherently capable of providing critical technical attributes to ensure system stability, how does ESO incentivise new providers and solutions to emerge, and respect existing providers?

Projected generation (FES 2019), TWh

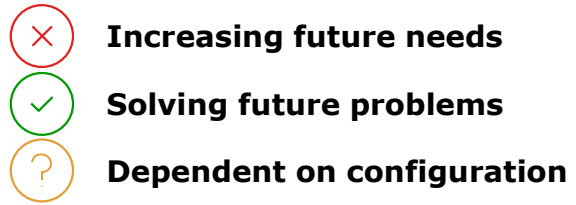


There are 3 core stability products which interact with other initiatives/arrangements

	Stability Product	*Management: BM*	*Management: PF*	*Wider interactions*	
Inertia	*Inertia governs the Rate of Change of Frequency (RoCoF) in the system – note practices for RoCoF management are set out in ESO FCRC report*	Balancing Mechanism actions can reduce the largest infeed or procure inertia to mange the RoCoF limit	Stability Pathfinders will result in the deployment of new solutions and increase inertia provision	Faster acting frequency response will contain inertia deviations more quickly allowing a higher RoCoF/inertia	The Accelerated Loss of Mains Change Program will allow a higher RoCoF limit and therefore reduced inertia
Short Circuit Levels (SCL)	*Short circuit levels improve voltage stability in the event of a fault, trigger protection equipment, and stabilise grid-following converters*	Balancing Mechanism actions can increase SCL but require curtailment of non-synch gen. In some regions there are no existing options to increase SCL	Stability Pathfinders are identifying regions where low SCL issues are prevalent and increasing provision	The constraints management Pathfinder is seeking to increase flows across the B6 boundary, low SCL contributes to these constraints[1]	
Dynamic Voltage Support (DVS)	*Dynamic reactive power stabilises the system voltage, responding to changes in the local system voltage*	Balancing Mechanism actions can synchronise providers capable of providing dynamic reactive power	Stability Pathfinders to date have procured dynamic voltage support through co-procurement with SCL/inertia	The Power Potential project has explored distributed dynamic reactive power to enable a whole system approach to RP	Grid assets and ORPS providers may also be able to meet these needs, however their inclusion in any market warrants consideration

[1]Due to limitations on the HVDC Western Link in low SCL conditions

Today's procurement & provision of stability interacts with other key initiatives, to drive future stability needs



	Retiring thermal plant	Increasing non-synch. gen & DC grid infra	Pathfinders	ALOMCP	Faster freq. response	Emerging technology (incl. Grid-forming)[1]
Inertia	✗ ✗	✗ ✗	✓	✓	✓	✓ ✓
Short Circuit Levels (SCL)	✗ ✗	✗ ✗	✓			✓ ✓
Dynamic Voltage Control (DVC)	✗ ✗	? [2]	✓			✓ ✓

Key question:

How can market structure help encourage and access new technologies?

[1]New technologies can only meet the shortfall if sufficient incentives are in place to do so
[2]Can potentially support today depending on configuration

Targeted (+paid)

Passive (+unpaid)

The relative importance of existing tools for managing stability is shifting

Procurement/provision mechanism		Volume today *(ESO reliance)*	Direction of travel
Pathfinder contracts *Long-term targeted provision*	**Investment timeframes** *(ESO secures long term capability)*	**Small**	**Growing** *(zero base)*
Electricity market schedule *short-term global passive provision*	**Commercial decision timeframes** *(ESO assesses whether needs will be met)*	**Large**	**Shrinking rapidly**
Balancing mechanism, trades, and other bi-laterals *short-term targeted provision*	**Operational timeframes** *(ESO intervention to ensure system stability)*	**Medium**	**Growing**

Key question

What is the desired solution?

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We have defined the objectives for a future set of arrangements – they articulate the framework for success

Primary objectives

Ensuring **cost-efficient provision** of services needed to **maintain system stability and security** in the interest of consumers and to **be able to operate a zero-carbon grid.**

Secondary objectives

- **Investable:** respecting existing and supporting efficient future investments.
- **Transparent:** visibility of service values and clear procurement decisions.
- **Technology neutrality:** being non-discriminatory between technologies with equivalent capabilities.
- **Practical:** ease of implementation, operation and transition.
- **Enduring (stable):** suitable and adaptable to future challenges.
- **Freedom of choice:** avoiding lock-in, giving ongoing choice in the market for providers and for ESO as buyer, ensuring liquidity and mitigating market power.

STABILITY MARKET DESIGN

3. Case for change

Targeted (+paid)

Passive (+unpaid)

CASE FOR CHANGE – STABILITY MANAGEMENT (STATUS QUO)

The current arrangements allow for procurement of stability services across different timeframes. There are, however, challenges for cost-efficiency and investment signals

Pathfinder contracts

Long-term targeted provision[1]

The ESO procures future expected stability requirements through 6-10 years Pathfinders contracts.

- The stability Pathfinders to date have been successful in procuring a number of long term providers, offering a route to market for zero-megawatt solutions.
- The stability Pathfinders take a targeted approach to defining system needs accounting for geographical dimensions.
- The process also selectively chooses to pay providers for service provision in exchange for an agreed level of availability – the process is competitive with lowest cost solutions selected for service delivery.

Electricity market schedule

short-term global passive provision[1]

Stability services are exogenously provided to the ESO by the wholesale market as a "by-product" of synchronous generation

- The market schedule is determined exogenously to ESO's business processes and is a result of traded positions in the wholesale electricity markets in Great Britain.
- The wholesale electricity markets in Great Britain work on an 'unconstrained' basis, i.e. the market solution does not have to meet the physical realities/constraints of the system.
- Despite not having to meet constraints, some stability services will materialise due to the types of technologies participating and their inherent technical characteristics.
- Historically, this was where the majority of stability services[2] would be delivered – however, shifting technology trends means the market schedule can no longer be relied upon to deliver all/most stability needs.

Balancing mechanism

short-term targeted provision[1]

ESO can procure stability services from providers in the Balancing Mechanism (bundled with active power)

- The Balancing Mechanism is the primary tool used by the ESO to ensure the system dispatch is compliant with the physical needs of the system (e.g. adhering to thermal transmission line constraints, managing voltage provider availability, ensuring sufficient head/footroom)[3].
- Procuring stability services through the BM requires providers to inherently deliver stability services whilst operating, specific dispatch instructions to e.g. 'increase inertia only' are not possible.

Notes: [1]For Dynamic Reactive Power, providers must be instructed to be operating in the correct mode. [2]stability services as a broader concept (inertia, SCL, DRP) have only recently come into existence as scarcity in the provision has manifested due to shifting technology trends. [3]Other direct contracts such as SpinGen also exist but are not widespread.

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A diverse range of technologies is capable of providing stability services and the technical capability of converter-connected equipment is evolving but requires commercial incentives

Technologies have been rated based on their performance against for each key performance indicator (KPI)

The Harvey Balls illustrate each technology's rating for each KPI based on the following scale:

○	Poor Performance
◔	Sufficient Performance
◑	Intermediate Performance
◕	Good Performance
●	Excellent Performance

Technologies	***Converter based*** / *Synchronous*	Refers to current market situation (base case)				
		Reactive Capability[1]	SCL Capability[2]	Inertia Provision[3]	CAPEX[4]	OPEX[4]
	Onshore Wind	◔	◔	○	◔	◔
	Offshore Wind	◔	◔	○	◔	○
	Solar PV	◔	◔	○	◑	◑
	Battery Energy Storage System	◔	◔	○	◑	◑
	HVDC	◔	◔	○	◕	●
	Pumped Hydro Energy Storage	◑	◕	◕	◔	●
	CCGT/OCGT	◑	◕	◕	◑	◕
	Nuclear	◑	◕	◕	○	○
	Biomass steam turbines	◑	◕	◕	◔	○
	Synchronous Condenser with Flywheel*	●	◕	●	●	◕

Note:[1]According to current NGESO grid codes. [2]Refers to desktop study values [3]Assumes grid-following converters in base case [4]Capex and Opex assessed on a per MVAr basis, we recognise that for most technologies this is a secondary consideration in terms of the business case. Excellence performance indicate low Capex and Opex.
Note: Grid-forming converters as defined by NGESO GC0137 Workgroup Consultation
*Base Case reflects today's capabilities of the technologies – SC relatively better performance reflects being a dedicated service provider for Reactive and Stability services

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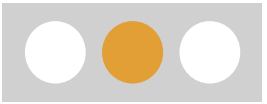
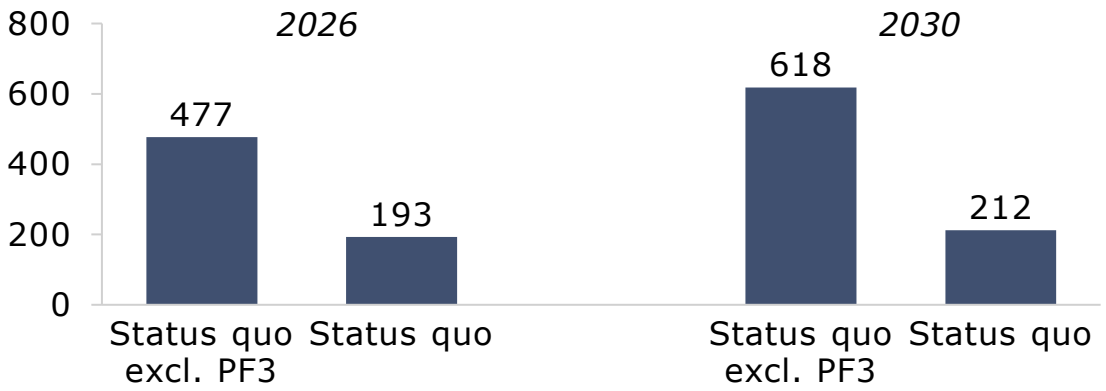
Current arrangements are sufficient for the coming years, but a number of weaknesses against our objectives can be identified further ahead

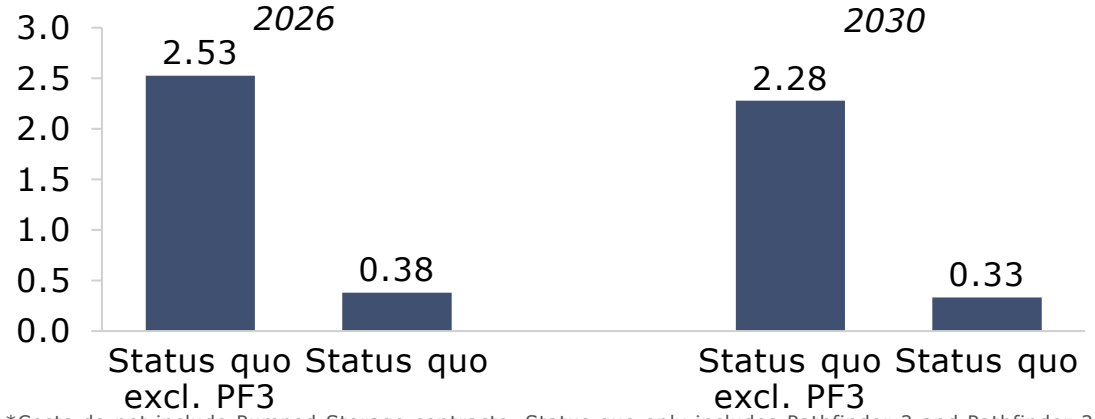
System stability & security	Meeting system security in the coming years (~5y horizon) due to **Pathfinders**. However, expectations of future needs **evolve rapidly** and there is no regular procurement exercise at present (ad-hoc Pathfinder process). This can exacerbate problems of over/under-procurement.	
Cost-efficient	Current routes to market **limit pool of participation and competition**. **No dedicated route-to-market** for providers with **low availability visibility** or **high opportunity/variable costs** of provision close to real time other than bi-lateral arrangements – not perceived as competitive.	
Zero-carbon compatible	Balancing Mechanism actions for stability are generally **carbon intensive**. Conversely, Pathfinders have enabled zero carbon stability solutions.	
Investable	Pathfinders require **high availability**, placing a **barrier to entry** for providers with high variable or opportunity costs or low availability certainty. **Single buyer risk** for participants is a perceived barrier.	
Transparent	Ad-hoc nature of Pathfinder does **not provide visibility** of future requirements. Balancing Mechanism is a single market where services are bundled and difficult to disaggregate accurately.	
Technology neutrality	Some providers are explicitly excluded from early Pathfinders while others face high barriers to entry (e.g. **high availability requirements**), limited routes to **participation in operational timeframes** (only Balancing Mechanism bundled with MW instructions or bi-lateral agreements).	
Practical	Current processes already in place, no major changes if sticking to status quo. Pathfinders could benefit from more **standardised process** for assessment.	
Enduring	**Restrictive eligibility**, **lack of long-term foresight** hinder market interest and R&D by OEMs, which can limit the scope of future innovation.	
Freedom of choice	Currently, only routes are to **lock-in long term** or rely on balancing actions. **Limited choice** for providers who can only participate in Pathfinders or be instructed through balancing actions.	

Long-term markets are already underway (with Pathfinders) and are expected to bring significant benefits

Total costs from stability management (Two Degrees, £m)



Emissions from stability management (Two Degrees, mtCO2)



*Costs do not include Pumped Storage contracts, Status quo only includes Pathfinder 2 and Pathfinder 3

- **LT procurement from Pathfinders provides evidence of tangible benefits from dedicated stability markets.** In our analysis, we have compared stability management under today's status quo against a counterfactual based on the current arrangements plus Pathfinder 3 contracts.
- Stability provision from Pathfinder 3 long-duration contracts is already expected to play a beneficial role in the management of stability, vastly reducing costs and emissions incurred in maintaining the system's stability needs.
- Critically, the Pathfinder 3 contracts result in fewer actions in the Balancing Mechanism to procure sufficient stability, which typically relies on turning down non-synchronous generation and turning up synchronous generation to increase stability. This is a much more expensive balancing action due to the difference in bid/offer prices between wind and replacement thermal generation, as well as being a sub-optimal carbon action.

There is no universal consensus in feedback received from participants to date, but some key themes have emerged and have been considered

The industry said…	…We considered
Participants expressed a preference in a **hybrid market timeframe** (long and short term).	A **hybrid** timeframe as being the most desirable option.
Pathfinder contracts have favoured **investment in new-build assets** over existing providers.	Short-term option to be more attractive for existing providers and allow **broader participation.**
Prospective providers highlight unpredictable opportunity costs, variable costs and maintenance costs leading to **long-term price risk**.	Short term option for those unable to **manage long term risk** + variable compensation mechanism for long term contracts.
Respondents share a view that **all providers** should be able to participate if they are bringing a **tangible benefit**.	**Global eligibility** for providers, with a **value-for-money** assessment.
Majority of responses were in agreement over the difficulties with locational aspects of the services, with respondents **favouring simplicity** and maintaining national procurement where possible.	**Single contract type** for long-term and **single contract type** for short-term.

Source: Webinar engagement & follow up survey

When transitioning from the status quo, the market design faces a number of key challenges with implications on final choice

ESO as single buyer

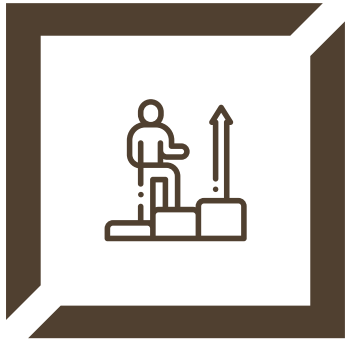
Challenge

Providers are exposed to volume risks as ESO is free to buy as much or as little as required. Volume requirements are subject to changes over time and in location, with providers facing the risk of stranded assets.

Implication

The market arrangement needs to ensure an appropriate allocation of risk.

If the perceived risk of uncertainty to investors is too great, reward offered by the market will be unattractive.



Energy complexities

There are complex interactions with energy, particularly for the provision of inertia.

LT contracts place a risk that is very difficult to manage for providers that face energy costs in order to be available.

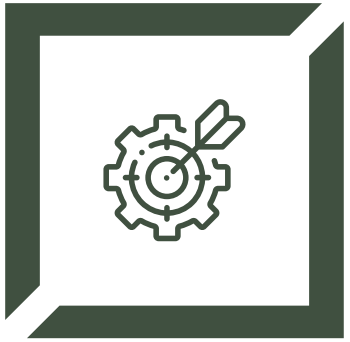
An idealised market may need a combination of LT and ST arrangements.

Ideally there are ST mechanisms for providers to manage this risk, such as enabling payback/buyback

Innovative technologies

Innovative technologies with grid-forming capability can simulate similar characteristics to a conventional synchronous generator in providing stability services. However, these technologies need to be promoted and facilitated.

There are technical characteristics to account for in enabling market participation. Grid-forming capability from asynchronous wind or solar generation may not be able to commit in advance (in LT timescales).



Overlapping solutions with TO

There are potential issues for a level-playing field between TO and non TO-assets. Fundamentally, there is an asymmetry in risks, obligations and information for non-TO assets vs. TO assets.

TO assets can promote competitive tension and lead to potential consumer benefit. However, TO participation can result in conflict of interest and subsequent market distortion given TOs role in network planning as well as assessing participants' bids.

Locational requirements

Stability requirements are characterised by a locational dimension, particularly for SCL and DVC. Inertia can also have a locational requirement if all provision is highly clustered.

Given the (current) national nature of inertia and regional nature of SCL & DVC, is it desirable to split the stability market in regional and national markets or bundle the procurement? How will the procurement of different stability products interact?

STABILITY MARKET DESIGN

4. Market design principles & models

In the market design process, the design is first broken down into the constituent parts ('building blocks')

Building blocks principles

The design is segmented into its constituent parts – referred to as the 'building blocks'. The building blocks serve as the basis around which a coherent/internally consistent design is constructed.

The building blocks give an insight into, and facilitate, the critical decisions about the market design, breaking down the design features in 'discrete' components (albeit there are limitations to this as there are interactions that cannot be isolated).

Crucially, building blocks are selected based on whether or not design choices will have a material impact on potential providers, the buyer of the services, and ultimately – market outcomes.

A 'perfect world'

The building blocks are an initial step in addressing the objectives and challenges of a potential market.

When framing the problem we can think about the challenge in terms of a 'perfect world' i.e. where a single omnipotent actor responsible for the energy system has perfect knowledge and perfect foresight. In this world, perfect decisions on investment, and perfect operational decisions are made.

The building block choices are defined to mimic these set of decisions, taking into account the realities of the energy system of today through offering discrete and reasonable choices.

Essentials building blocks

These are the critical dimensions of a potential market.

The essential building blocks are the constituent parts required to achieve the purpose of the market and represent the main philosophy of the market design.

They illustrate the key design choices in terms of delivering appropriate investment at the right times, delivering appropriate deployment of the resources in conjunction with other services such as energy.

- **Timeframe**
- **Eligibility**
- **Locational requirement**
- **Pricing**
- **Product definition**

SECONDARY & ADDITIONAL BUILDING BLOCKS: These are the 'mechanical' dimensions of the design and come as a natural extension of the essential building blocks. The additional building blocks are envisaged to be broadly uniform (across design options), facilitating the objectives of the market. The high-level market design has primarily focussed on the essential building blocks.

- **Performance standards**
- **Requirement determination**
- **Requirement signalling**
- **Measurement & verification**
- **Non-delivery consequences**
- **Stacking**
- **Price controls (caps and floors)**
- **Competition thresholds**
- **Results release**

Essential building blocks of the market design and choices under each building block

Key Choices

Timeframe

Time at which procurement decisions are taken

1 LT procurement

Long-term supply commitment – could be similar duration to asset lifetimes.

One-off or infrequent auctions.

Quantity supplied is defined (could be contingent, rather than just fixed) and can be predicted by suppliers.

2 ST procurement

Short time scale for supply commitment.

Repeated auctions, where quantity to be procured is known for each auction and price determined in each auction.

Suppliers face future quantity and price risk.

3 LT + ST procurement

Mix of short and long-term procurement.

Pricing

How participants are remunerated

1 Contractual utilisation price + availability price

Auction determines the availability price, and the utilisation price is set in the contract.

The supplier can anticipate this price when deciding to make themselves available or not. However, requires suppliers to take view on future requirements.

2 Activation price determined later (outside of contract)

Auction determines the availability price, but utilisation price is set outside of supply contract.

This is another benchmark to use and the process is broadly similar with the contractually set price (buyer must take view on future quantities to be provided) but suppliers also need to take view on utilisation price.

3 Availability only price

Seller must implicitly price in any potential utilisation costs into availability price

Eligibility

Which participants/ technologies are eligible for payment

1 Global

Where stability services where traditionally provided for free (as an inherent feature of synchronous generation) these services may in future need to be paid for as an additional service.

2 Selective

New providers ("additionality" approach): Only remunerating providers that are not existing.

3 Global with opportunistic buying

All providers are eligible, however only providers for whom incentives would alter behaviour (investment or operational) would be successful. Costs are weighed against benefits in long-term procurement.

Essential building blocks of the market design and choices under each building block

Key Choices

Bundling

Bundling of procurement

1 Individual stability services

Separate procurement for the relevant stability services.

Separate procurement (potentially at different times) for the 3 relevant stability services (inertia, SCL, dynamic voltage support).

2 Fixed ratios

Services are procured in a bundle, with a pre-defined ratio between the services that providers must adhere to. A single price is offered for the bundle.

3 Combinatorial auction

There are possible cost synergies in providing different stability services.

Approach is to express the synergies through packages of services. Each bid is made for packages of services (quantity for each service, with a single price offer for the package)

Multiple approaches in this setup that providers could take

Locational spec.

Static vs. dynamic effectiveness factor & regional vs. national market

1 National & regional procurement

SCL and dynamic voltage are considered to be regional with similar effectiveness for each provider across the region (and interaction between neighbouring regions). Inertia initially considered national. Procurement for all GB run in a single round.

2 Co-procurement by region

Procurement for each region independently (could be at different times), no interaction considered between regions (except for providers that have already been procured from previous rounds)

3 Procurement through individual effectiveness factors

Each provider is given a specific effectiveness factor (price/volumes scalar) for each of the services. Procurement for all GB run in a single round.

Product definition & contract type

Consideration of obligations, conditionality, delivery windows and other features tied to the service provision

1 Simple procurement

In simple procurement discrete products which do not overlap exist (except between short and long term where applicable). Commitments are firm and generally governed by baseload for long term or by more granular with-in day 'windows' for short term.

2 Complex procurement

Multiple conditional contract types exist with different structures *in addition to* simple products including: **shape** where long term commitments vary by time of day or year (firm); **ESO call options** where availability is guaranteed but utilisation is only delivered when option is exercised by ESO (firm); or **provider put options** where providers have the right to provide the service at a pre-agreed price but no obligation to be available/deliver (non-firm).

We have combined the building blocks in 4 potential solutions (straw-man options) to explore and assess the merits of potential design decisions

***All straw man options** include Pathfinders (1,2,3) and the BM*

All exclude direct TO participation

All envisage a national market for inertia and regional procurement for SCL & DVC

		A	B	C	D
		Short-term *(only)*	**Long-term *(only)***	***Our preferred option is a variation on option C*** **Evolution**	**Revolution**
		New ST market. No new Pathfinders.	A new LT market arrangement replaces the Pathfinder arrangements.	New ST market alongside continued Pathfinders, run at ESO discretion.	Introducing a new ST market + new LT market arrangement run at scheduled intervals
Timeframe	**Lead time**	Day-ahead*	T-1 Year T-4 Years	ST: Day-ahead* LT: ad-hoc	ST: Day-ahead* LT: T-4 + T-1
Timeframe	**Frequency** Baseload/firm	Daily	Annual	ST: Daily LT: ad-hoc	ST: Daily LT: Annual
Timeframe	**Contract duration**	Hourly / Half-hourly / EFA block	1-15 years	ST: Hourly / Half-hourly / EFA block LT: ad-hoc/10y	ST: Hourly / Half-hourly / EFA block LT: 1-15 Years
Product	**Contract type**	Simple	Complex	Simple	Complex
Product	**Complex contract**	No	Call option Put option Shape products	No	Call option Shape products
Pricing	**Pricing Mechanism**	Pay-as-clear	Pay-as-bid	ST: pay-as-bid Pathfinder: pay-as-bid	ST: pay-as-bid LT: pay-as-bid
Pricing	**Payment type**	Availability (£/SP)	Availability (£/SP) Utilisation (£/MWh)	ST: Availability (£/SP) LT: Availability (£/SP) + Implicit utilisation (£/MWh)	ST: Availability (£/SP) LT: Availability (£/SP) + Utilisation (£/MWh)
Eligibility	**New & Existing**	All	New	ST: all LT: "Additionality" (for new prov.)	All
Eligibility	**In-merit & Out-of-merit**	All	Not applicable in LT	ST: out-of-merit	ST: all
Eligibility	**Procurement strategy**	Gross	Opportunistic	ST: Shortfall LT: Opportunistic	ST: Gross LT: Opportunistic

Note: *daily procurement at day-ahead, after the DA energy markets and interconnection capacity allocation as interconnector position influences total stability requirement.

Strawman A: New ST market alongside BM, no new Pathfinders

A: ST-only

In the short-term only market, there'll be no continuation of the Pathfinders (after Pathfinder 3). Procurement of stability services will be done entirely within a short-term timeframe. The BM continues to be available as a solution of last-resort to meet operational needs.

Timeframe	**Lead time**	Day-ahead
	Frequency Baseload/firm	Daily
	Contract duration	Hourly / Half-hourly
Product	**Contract type**	Simple
	Complex contract	None
Pricing	**Pricing Mechanism**	Pay-as-clear
	Payment type	Availability (£/SP)
Eligibility	**New & Existing**	All
	In-merit & Out-of-merit	All
	Procurement strategy	Gross

- Market with daily procurement at day-ahead, after the DA energy markets and interconnection capacity allocation. Timing allows participants to trade out energy consequences in intraday market – to be in position (available) in real-time.
- The contract duration could be half-hourly, hourly, or EFA blocks.

- Firm contract type as the contract is being struck at day-ahead stage.

- A pay-as-clear pricing mechanism.
- Only availability is paid for (participants must price in any utilisation costs).

- All providers are eligible to participate
- All providers that are providing the service are paid the clearing price

Strawman B: New LT market replaces the Pathfinder arrangements

B: LT-only

Long-term only model where we don't have a dedicated stability short-term market, and Pathfinders are discontinued.

This model presents complex sets of contract types with built-in flexibility – this is because a long-term only arrangement would otherwise not facilitate the participation of certain technologies. It also introduces the idea of a 'utilisation' payment to manage LT price risks.

Timeframe	**Lead time**	T-1 Year T-4 Years
	Frequency Baseload/firm	Annual
	Contract duration	1-15 years
Product	**Contract type**	Complex
	Complex contract	Call option Put option Shape products
Pricing	**Pricing Mechanism**	Pay-as-bid
	Payment type	Availability (£/SP) Utilisation (£/MWh)
Eligibility	**New & Existing**	New
	In-merit & Out-of-merit	All if successful (unknown in LT)
	Procurement strategy	Opportunistic

- Operating in LT timeframes only
- A combination of shorter and longer term contracts (1 to 15 years) struck in advance with flexibility closer to real-time embedded within the contract.

- Simplistic contracting methods such as baseload contracts aren't suitable for all provider types.
- Complex contracting options offer routes to market for a broad range of technologies, however due to forecast error risk management this will always be imperfect for both providers and ESO.

- Providers submit an availability price in the LT market, on a pay-as-bid basis.
- We recognise LT contracts place a risk that's difficult to manage for providers with energy costs in order to be available. The utilisation payment is intended to provide a mechanism to manage this risk. Our thinking is to structure products that can help manage this risk such as a 'baseload LT contract with short-term buyback' or follow Pathfinder 1's approach in remunerating energy consumption with the imbalance price.

- This model follows an opportunistic buying strategy. This mandates the procurement of new capability (following the additionality criteria) to meet expected shortfalls (as a minimum), and retains the flexibility to procure additional services if it is economical to do so against the ST alternative (in this case the expected BM costs).
- The BM continues to be available as a solution of last-resort to meet operational needs.

Strawman C: New ST market alongside continued Pathfinders, run at the discretion of ESO

C: Evolution

Evolution is a model looking at a continuation of the existing Pathfinders for simple long-term contracts, complemented with a short-term market to meet a wider range of system needs.

Timeframe	**Lead time**	ST: Day-ahead LT: ad-hoc
	Frequency Baseload/firm	ST: Daily LT: ad-hoc
	Contract duration	ST: Hourly / Half-hourly / EFA block Pathfinder (LT): ad-hoc/10y
Product	**Contract type**	Simple
	Complex contract	None
Pricing	**Pricing Mechanism**	ST: pay-as-bid Pathfinder: pay-as-bid
	Payment type	ST: Availability (£/SP) Pathfinder (LT): Availability (£/SP) + Implicit utilisation (£/MWh)
Eligibility	**New & Existing**	ST: all Pathfinder (LT): "Additionality" (for new prov.)
	In-merit & Out-of-merit	ST: out-of-merit
	Procurement strategy	ST: Shortfall Pathfinder (LT): Opportunistic

- Pathfinders continue operating in LT timeframes with the aim of procuring capability from providers who can commit in advance and have high availability. Ad-hoc contracting follows the approach of existing Pathfinders. Pathfinder agreement lengths (capped at 10 years) vary depending on the provider's characteristics and ability to demonstrate clear value for money.
- A ST stability market is introduced. This can be expected to be procuring at DA and function in the same way as Strawman A.

- Pathfinder maintain current approach, procuring for a baseload high availability product.
- ST market procures for firm availability.

- Pay-as-bid is consistent with current PF arrangements.
- There is an availability and utilisation payment. We recognise LT contracts place a risk that's very difficult to manage for providers with energy costs in order to be available. The utilisation payment is intended to provide a mechanism closer to real-time to manage this risk - Our thinking is to structure products that can help manage this risk such as a 'baseload LT contract with short-term buyback' or follow Pathfinder 1's approach in remunerating energy consumption.

- This model follows an opportunistic buying strategy. This mandates the procurement of new capability (following the additionality criteria) to meet expected shortfalls (as a minimum), and retains the flexibility to procure additional services if it is economical to do so against the ST alternative.
- In the short-term the shortfall is always bought (not assessed against costs in BM timeframes which can be uncertain at the DA stage). Not all providers are paid as the market is procuring to meet the shortfall only (i.e. in-merit plants are not paid).
- The BM continues to be available as a solution of last-resort to meet operational needs.

Strawman D: a more radical alteration to the long-term model, complemented by a short-term market

D: Revolution

This model takes a step further from Strawman C: introducing a new ST market and a new LT market, running systematically at scheduled intervals (e.g. running an annual process for the LT market). It seeks to provide more certainty around the timing of the long-term contracts.

Timeframe	**Lead time**	ST: Day-ahead LT: T-4 + T-1
	Frequency Baseload/firm	ST: Daily LT: Annual
	Contract duration	ST: Hourly / Half-hourly / EFA block LT: 1-15 Years
Product	**Contract type**	Complex
	Complex contract	Call option Shape products
Pricing	**Pricing Mechanism**	ST: pay-as-bid LT: pay-as-bid
	Payment type	ST: Availability (£/SP) LT: Availability (£/SP) + Utilisation (£/MWh)
Eligibility	**New & Existing**	All
	In-merit & Out-of-merit	All
	Procurement strategy	ST: Gross LT: Opportunistic

- LT market procurement occurs on annual basis, promoting certainty around the timing of the LT contracts.
- LT contract length vary depending on the provider's characteristics and ability to demonstrate clear value for money.
- A ST stability market is introduced. This can be expected to be procuring at DA and function in the same as Strawman A.

- Long-term products include a mixture of Baseload, Shape & Call Options. Products explore the idea of meeting requirements with more "accurate" contracting structure (to prevent overprocurement). The extent to which this is desirable depends on the "predictability" of the specific requirements.

- Market arrangement procures for bundled services with a pay-as-bid mechanism.
- There is an availability and utilisation payment. We recognise LT contracts place a risk that are difficult to manage for providers with energy costs. The utilisation payment is intended to provide a mechanism partially to manage this risk.

- Global eligibility means all providers & technologies (new & existing, marginal & part of energy market plant schedule) can participate.
- The LT market remains opportunistic, ESO buying where they think it's a cheaper solution than the alternative costs faced in short-term markets.
- The ST market reverts to gross procurement, buying provision to cover the whole requirement stack, and paying for everything not already contracted in the long-term (whether they would have been providing stability regardless or not).

STABILITY MARKET DESIGN

5. Assessment of design options

There are no perfect solutions, a compromise between complexity and efficiency must be established to move forward

	Assessment	System stability & security	Cost-efficient	Zero-carbon	Investable	Transparent	Technology neutrality	Practical	Enduring	Freedom of Choice
A ST (only)	ST-only benefits from operating close to real-time but **fails to promote investment**. This is critical in ensuring cost-efficiency and system stability									
B LT (only)	LT-only performs poorly – the **lack of ST mechanisms** exposes ESO and providers alike to critical risks									
C Evolution	Evolution strikes a **balance** between desirable outcomes and the scale of change from required from the status quo									
D Revolution	Revolution scores the highest overall but lacks **practicality** – a crucial weakness, particularly if benefits are marginal									

Legend

- *Strong performance vs. objective*
- *Good performance vs objective. Few gaps remain*
- *Intermediate performance vs. objective. Some gaps identified*
- *Poor performance vs. objective. Many critical gaps*
- *Fails to meet objectives. Critical gaps identified*

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ASSESSMENT – SUMMARY ASSESSMENT OF OPTION A

Strawman A provides the most transparency but is poor on critical issues affecting investability and consequently system security

Strengths

Transparency. Close to real-time procurement enables better visibility for participants. Individual bids and individual prices provide high transparency.

Zero-carbon. Close to real-time procurement avoids lock in with sub-optimal carbon provision. Close to real-time procurement maximises opportunity of procuring the most modern, zero-carbon compatible technologies (of the future).

Technology neutrality. Expansive approach on eligibility and procuring for the gross market requirement mean all technologies can participate on paper. Close to real-time procurement accommodates weather-dependent providers.

Drawbacks

System security. Lack of LT hedging exposes ESO to shortages and risks being a 'distressed' buyer.

Cost-efficiency. ST-only procurement exposes ESO to under-procurement which can lead to scarcity and extreme pricing. There is no explicit arrangements to guarantee capability.

Investability. ST-only market fully exposes providers to changeable counterparty needs and face the risk of stranded assets if needs change, **fails to incentivise investment.**

ASSESSMENT – SUMMARY ASSESSMENT OF OPTION B

The lack of ST-mechanisms in option B raise challenges in accommodating all providers, limiting adaptability to future challenges

Strengths

Investability. Long contracts & lead time promote investment. Forward market for availability reduces price and volume risk. Longer contracts could significantly reduce risk for merchants

Freedom of choice. Freedom in form of long-term contract (firm, shape, options) provides some risk mitigation for participants

Drawbacks

System security. No explicit alternatives close to real-time expose ESO to system security risks as requirements can be variable & unpredictable.

Investability/Technology neutrality. LT-only contracts can expose providers to large risks over (long) contract duration.

Enduring. Key gaps in ensuring the arrangements can meet future challenges as it lacks flexibility to facilitate all new technologies. LT-only is inflexible, and risks locking ESO in with inefficient contracts.

Freedom of choice. LT-only is inflexible, the lack of ST mechanisms exposes ESO to greatest risk (among strawman options) of lock-in in with inefficient contracts.

Transparency. LT-only participation relies on decisions made with long lead times, with high uncertainty and little visibility for providers. Multiple, complex products can make assessment processes less transparent.

C: Evolution

D: Revolution

ASSESSMENT – SUMMARY ASSESSMENT OF OPTION C/D

Strawman C & D are desirable: provide the best characteristics in meeting the market objectives, but lacks practicality

Strengths

System security. Close to real-time flexibility for additional provision to maintain system security. Systematic & recurring nature of the market (particularly requirement determinations in LT timeframes)

Cost-efficiency. The flexibility to procure the desired volume across different timeframes lets ESO determine most cost-efficient procurement mix. Range of contract structures can mitigate and manage risks

Investability. LT (contracts & lead times) offers a route-to-market for investment. ST market promotes business case for providers who cannot commit in advance (by removing availability risk present in the forward procurement).

Cost-efficiency & Technology neutrality. Opportunistic buying strategy represents opportunity to save on costs and broadens eligibility pool. Together with the hybrid market timeframes, it provide a route-to-market for a wide pool of participants required to meet requirements, maximising resources available to ESO (e.g. the inclusion of a close to real-time market lowers barrier to entry for providers who cannot commit in advance).

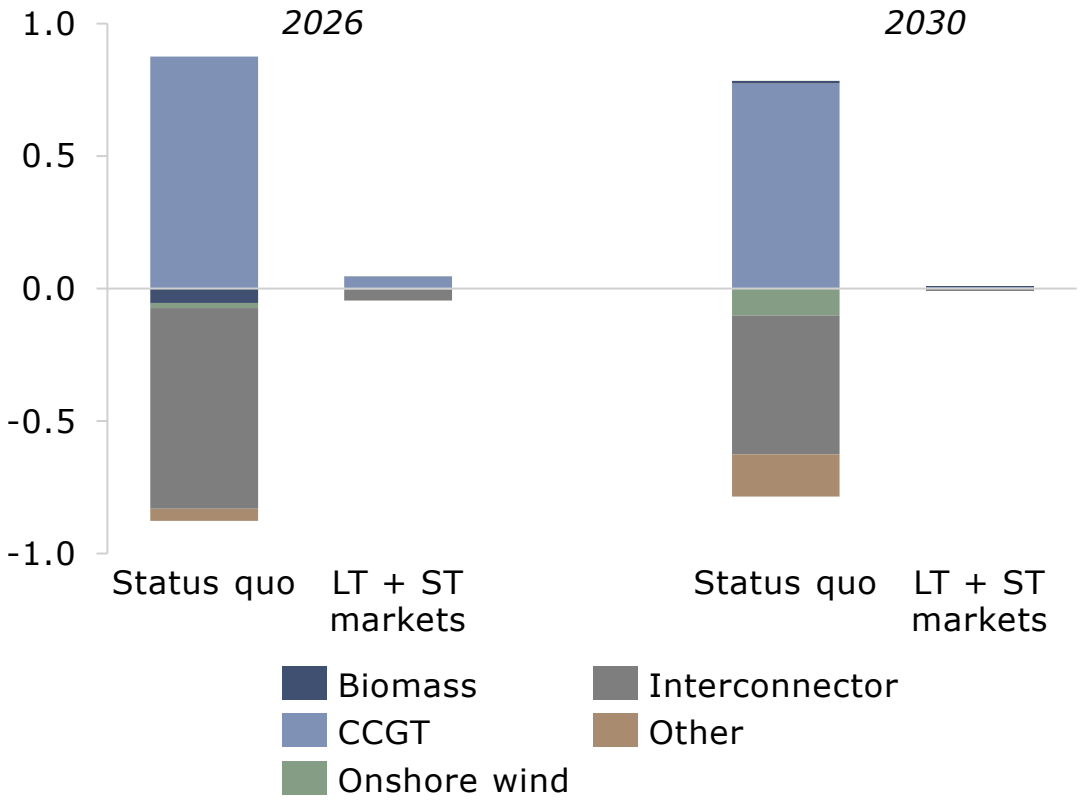
Drawbacks

Ease of implementation. New market arrangements in LT and ST timeframes are resource-intensive, time-consuming and complex to implement and operate

Ease of operation. Multiple products & contract types require a high & complex volume of work through all the main stages of the market (prequalification, tendering, assessing, operating/dispatching, monitoring & compliance)

Short-term markets can play a key role in facilitating participation and reduce reliance on costly BM actions

Redispatch volumes for stability provision[1] (Two degrees, TWh)

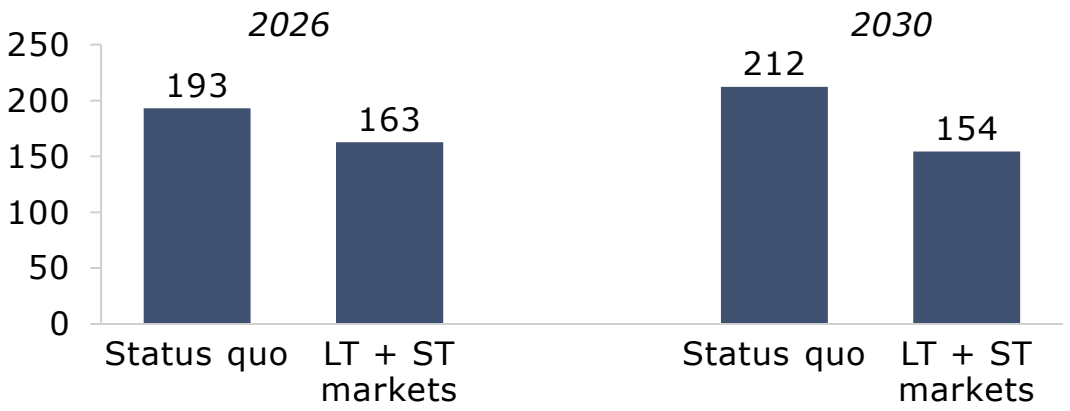


- **Markets – ST in particular – can enable grid-forming technologies to contribute to solving stability challenges.**
- Incentivising grid-forming based technologies to provide stability services, in particular SCL, can result in a significant increase of the SCL on the system ahead of any balancing mechanism actions.
- Furthermore, some grid-forming providers may be capable of providing inertia but require active energy to do so – availability of active energy is uncertain in long-term timeframes but much easier to predict (and in the case of dispatchable technologies, optimise) at the day-ahead stage.
- As the contribution from grid forming technologies increase the SCL available, fewer MW actions need to be taken in order to procure sufficient stability product availability. Fewer redispatch actions are primarily from CCGTs and interconnector, whose re-dispatch volume from stability management in 2030 decreases to close to zero with the addition of a ST market.
- Reducing reliance on redispatch can bring significant benefits in terms of cost-efficiency and carbon reduction. (and by extension brings additional system security benefits such as reduced volatility).

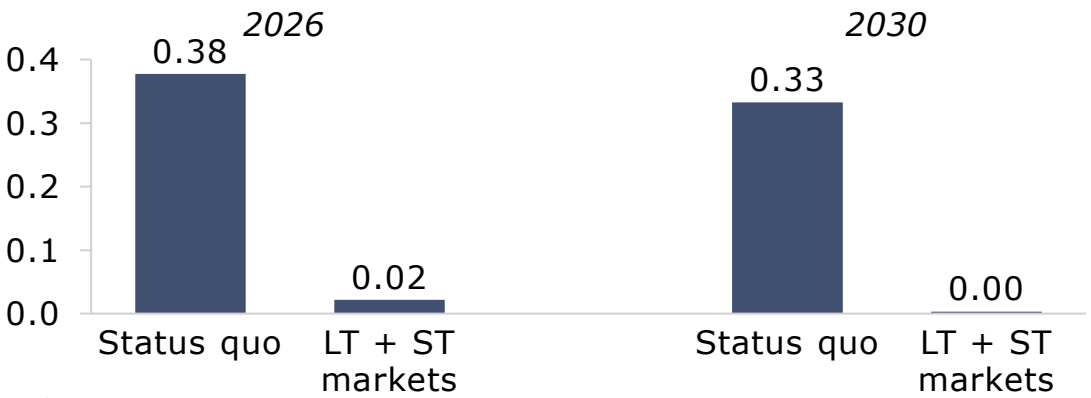
Notes: [1]Status quo includes pathfinders 1-3

The modelled scenarios[1] reinforce the case for multiple market timeframes as a desirable option

Total system costs from provision of stability[2,3] (Two degrees, £m)



Carbon emission from stability redispatch actions (Two degrees, Mt)

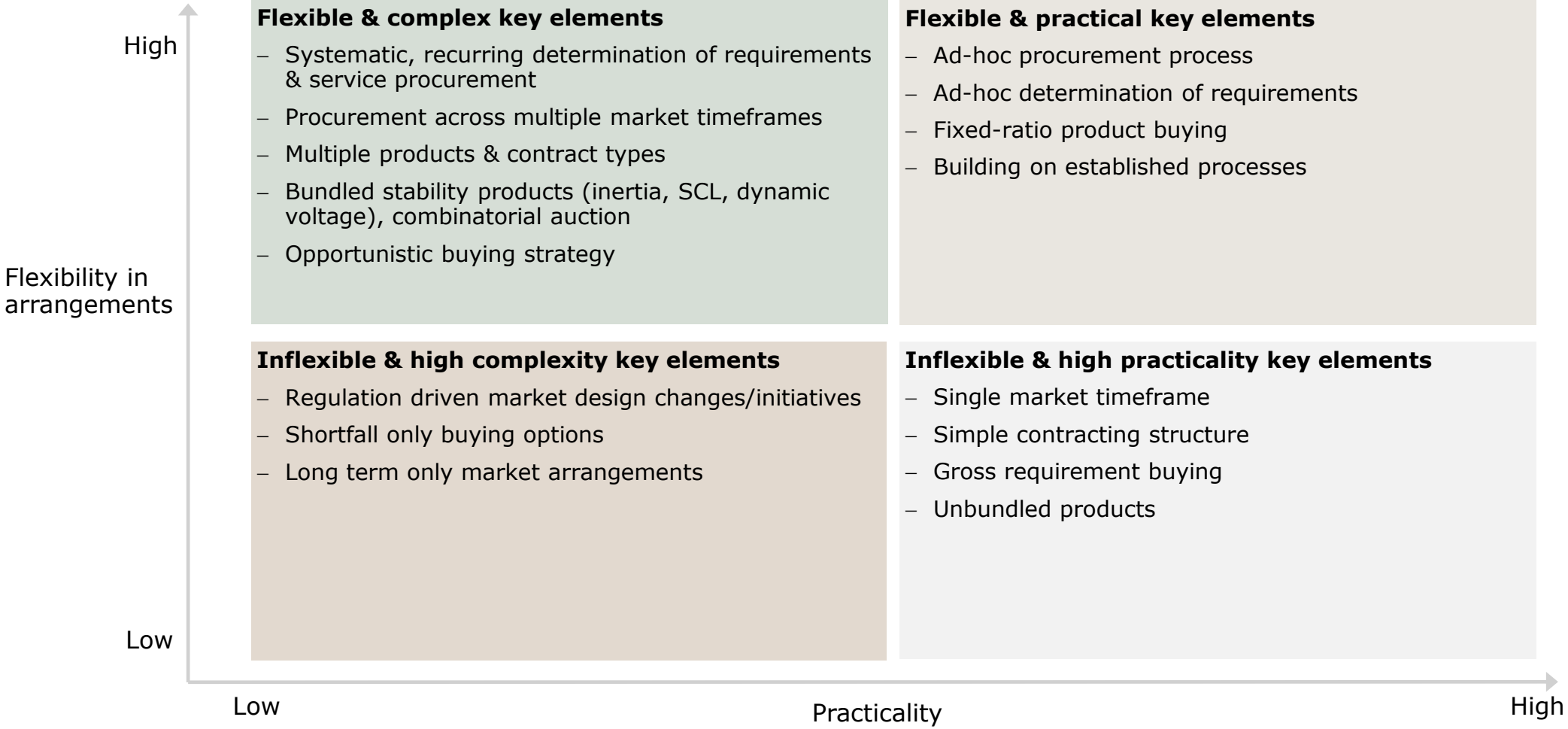


- **A combination of LT & ST market procurement has potential to reduce costs.**
- Continuing with long-term procurement to ensure security can also bring significant benefits in terms of reducing reliance on costly balancing actions. Albeit, the scope to drive significant (economic) benefits in near term is expected to be limited under the current scenarios – as Pathfinder contracts already make a vast contribution with respect to the forecasted requirements.
- Ultimately, accommodating a broader range of technologies and providers should lead to more efficient outcomes.
- Reducing reliance on redispatch where there are a limited pool of providers (mostly carbon intensive) can bring significant benefits in terms of carbon reduction. The majority of redispatch reductions are due to grid-forming providers.
- The analysis indicates the introduction of markets reduces costs (by ~£58m in 2030) and emissions (~0.3mtCO2 in 2030), the majority of which are realised through the short-term market.

Notes: [1]This modelling exercise was undertaken potential benefits with FES19 in line with pathfinder analysis and does not represent a full cost-benefit assessment which is recommended as a next step, including updated analysis [2]Status quo includes pathfinder 1-3, [3]Costs do not include Pumped Storage contracts

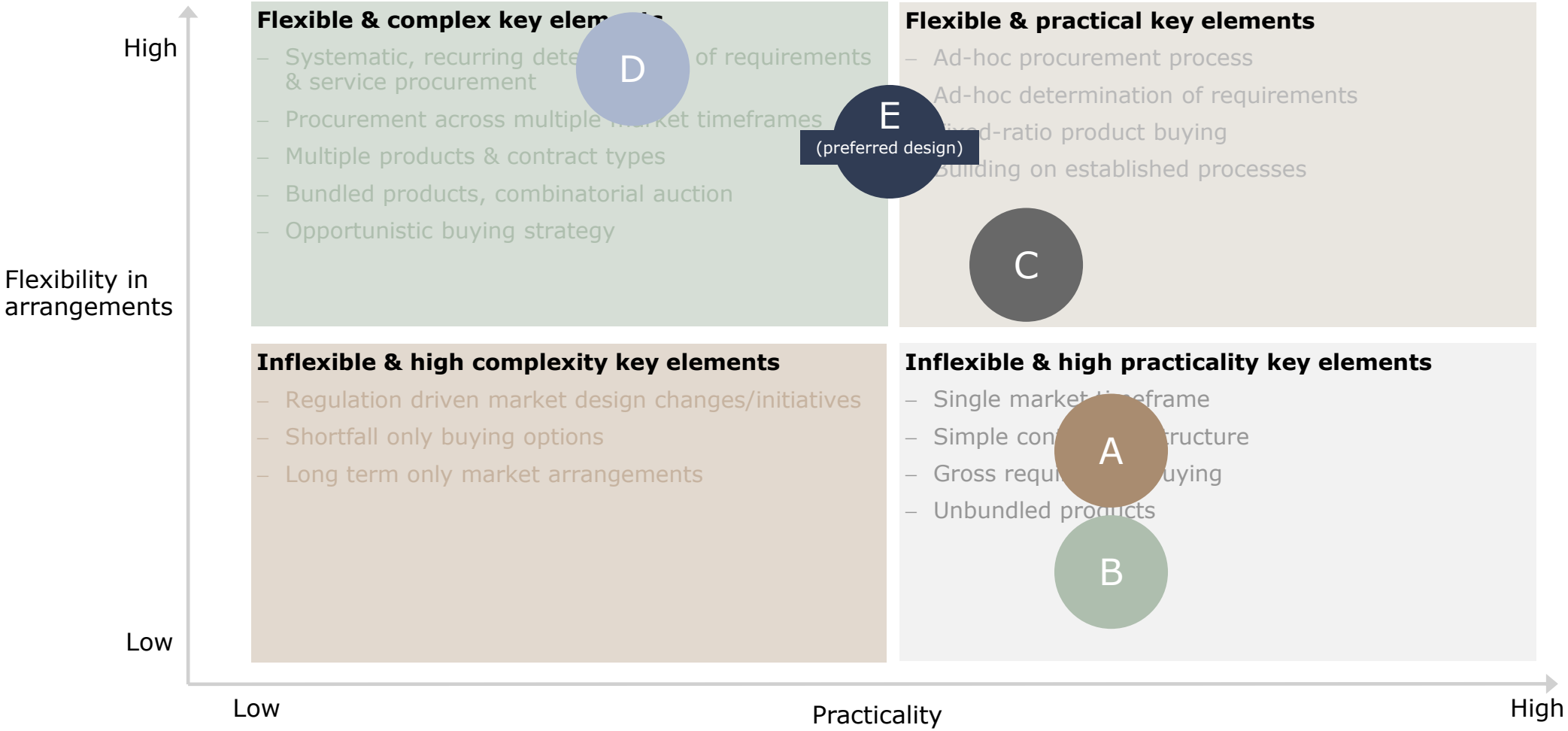
ASSESSMENT – TRADE-OFFS

There is a key trade-off between flexibility of arrangements and practicality



Flexibility drivers key outcomes such as cost-efficiency, system security and investability. Practicality is a key consideration in the feasibility and desirability of the potential solution

Our preferred design sits somewhere between options C and D



Flexibility drivers key outcomes such as cost-efficiency, system security and investability. Practicality is a key consideration in the feasibility and desirability of the potential solution

STABILITY MARKET DESIGN

6. Recommendation/preferred option

RECOMMENDATION – SUMMARY OF PREFERRED SOLUTION

Summary - The preferred solution builds on the strengths of strawman C, opportunistic procurement strategy is a key design feature

		Long-term market	Year-ahead	Short-term market
Timeframe	Requirement determination	Annual	Same as LT	Daily
	Frequency of procurement	Annual[1]	Same as LT	Daily
	Procurement lead time	T-4 (pre-qualification to start earlier) & T-1	T-1	Day-ahead
	Contract duration	10 years	1 year	Daily 23:00 D to 23:00 D+1
Product	Contract type	Baseload	Call option	Settlement Period[3] or EFA blocks
	Product ratio	User-defined	User-defined	User-defined
	Product bidding	Bundled bid	Bundled bid	Bundled bid
	Contract obligation	Completion milestones 90% availability	Availability: same as LT	100% availability
Pricing	Payment type	Availability (£/SP) Utilisation (£/TBC) ('implicit utilisation': imbalance price for energy consumption[2] & guidance on utilisation volumes)	Same as LT	Availability (£/SP)
	Pricing mechanism	Pay-as-bid	Pay-as-bid	Pay-as-bid
	Price regulation	TO alternative costs	ST market alternative costs	Real-time alternative costs
Eligibility	Procurement strategy	Shortfall + opportunistic	Shortfall + Opportunistic	Shortfall + Opportunistic
	New & Existing	Incremental investment only *(additional investment required to increase stability capability such as new synch comps)*	Incremental capability only *(capability otherwise not accessible to ESO such as plants intending to close, or not accessible in the BM)*	All providers
	TO & Commercial assets	Direct participation: Commercial Indirect participation: TO	Commercial only	Commercial only

Notes: [1]Annual procurement with the possibility of not running the auction in the remote possibility the whole requirement is already met. [2]Provisional, dependent on Ofgem review of AS assets & further engagement [3]Provisional, dependent on complexity that can be practically implemented.

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RECOMMENDATION – SUMMARY OF PREFERRED SOLUTION

The preferred design option has two (potentially three) timeframes with different objectives and characteristics

Further consideration	
Preferred option	

		Long-term market	Year-ahead[1]	Short-term market	RATIONALE
Timeframe	Requirement determination	Annual	Annual	Daily	NG ESO will carry out periodic offline studies and forecasting to determine requirements – on an annual basis (deviates from C which had an ad-hoc approach).
	Frequency of procurement	Annual	Annual	Daily	Given the opportunistic buying procurement strategy of the market – the market is run every year, even if there is no explicit shortfall identified. The Short Term market is run daily.
	Procurement lead time	T-[5]: Prequalification T-[4] : Procurement ***Industry preference for T-4 based on initial feedback***	T-1: Procurement (if needed to correct forecast error/closures, preferred to structure as a call option)	Day-ahead *TBC exact timing based on ESO internal processes*	Multiple procurement across critical timeframes. The LT market operates with prescribed lead times to accommodate investment decisions. A 'prequalification' stage may be necessary, recognising network connection lead times. The year-ahead market operates with the prescribed lead time to enable existing plants to make decisions about closure. The ST market operates in operational timeframes, better meeting the needs of providers that face uncertain/high opportunity and variable costs or have low availability certainty.
	Contract duration	10y/15y/longer ***Industry preference for 10yrs based on initial feedback***	1 year	Daily 23:00 D to 23:00 D+1	New providers in the LT procurement are able to strike long-term contracts to support investment. Existing providers in the T-1 eligible for 1-year contract, this is intended to influence closure decisions in the event of a capability shortfall due to closure forecast errors. Due to the nature of these providers preferred structure is a call option (availability + user defined utilisation fee).

Notes: [1]Year-ahead market provisional.

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RECOMMENDATION – SUMMARY OF PREFERRED SOLUTION

The preferred design aims to provide flexibility in the product and contract type

Further consideration	
Preferred option	

		Long-term market	Year-ahead	Short-term market	RATIONALE
Product	Contract type	Baseload	Call option with year-round availability requirement	Settlement period or EFA blocks ***Industry split preference for Settlement period or EFA block***	The contract types are designed around the nature of the requirements and the characteristics of the providers.
	Product ratio	User-defined	User-defined	User-defined	In both time-frames, market providers offer user-defined product ratios (lending itself more to pay-as-bid). Users can offer volumes in ratios that reflect their specific technology choice.
	Product bidding	Bundled bid	Bundled bid	Bundled bid	Each bid is made for packages of services (with a single price offer for the package), providers can offer synergies where they exist to increase chance of successful bids.
	Contract obligation	Completion milestones 90%/95% availability ***Industry preference for 90%***	Availability: same as LT	100% availability	Failing to deliver availability results in facing non-performance process. Must have strong disincentives for non-delivery as stability is crucial to transmission network operation.

RECOMMENDATION – SUMMARY OF PREFERRED SOLUTION

Pricing mechanisms should mitigate risk for providers, and offer them an opportunity to offer synergies where they exist

Further consideration	
Preferred option	

		Long-term market	Year-ahead	Short-term market	RATIONALE
Pricing	Payment type	Availability (£/SP) Utilisation (£/*TBC*) ***Industry preference split over Imbalance price / user defined utilisation price***	Same as LT	Availability (£/SP)	LT market likely to attract providers with high-capex low variable cost. There should be arrangements for providers to manage their LT energy consumption costs, currently we envisage this to be in line with Pathfinder 1 where providers receive the imbalance price for power draw from the grid. We would assume these volumes are not exposed to final consumption levies/costs (FCL). These costs would however be considered in an economic assessment (pre-FCL). ST market likely to attract high availability & variable cost or low availability & variable cost providers with high certainty over utilisation so no explicit utilisation price needed.
	Pricing mechanism	Pay-as-bid	Pay-as-bid	Pay-as-bid	Due to the bundled nature of the products and the locational nature of the services, pay-as-bid is preferred. This reduces the complexity of the clearing determination and promotes transparency (assuming ESO publishes information on the assessment). It also allows providers to offer synergies where they are possible without partial acceptance risk.
	Price regulation	TO alternative costs and forecast short term cost for opportunistic procurement	Forecasted short term cost for opportunistic procurement	Forecasted real-time alternative costs	Partially manages potential manifestation of market power. In the LT this cap is implicit at the level of the TO owned asset solution depreciated on a like-for-like basis, similar to today's Pathfinders (residual value requires further investigation). In the ST this is a dynamic cap, at the level of the real-time alternative cost of meeting the stability requirement.

RECOMMENDATION – SUMMARY OF PREFERRED SOLUTION

Our desired design broadens participation whilst protecting consumers

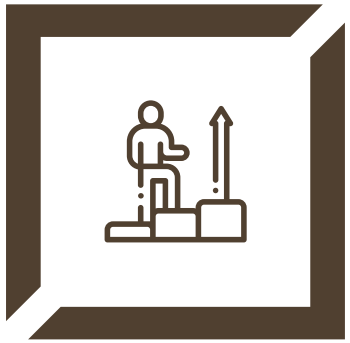
Further consideration	
Preferred option	

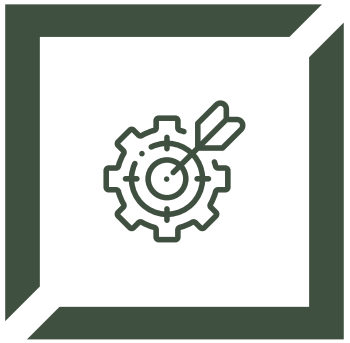
		Long-term market	Year-ahead	Short-term market	RATIONALE
Eligibility*	Procurement strategy	Shortfall + Opportunistic	Shortfall + Opportunistic	Shortfall + Opportunistic	Procurement strategy based on opportunistic buying – under the principles of ensuring system security at least-cost to consumers. Under opportunistic buying – once the shortfall has been met, ESO may wish to procure additional volumes if it expects a discount relative to ST procurement (for the LT market) and BM actions (for the ST market).
	New & Existing	Incremental investment only	Incremental capability only	All providers	The LT market procures only from new (or incremental) capability. ESO will buy services if they are needed to maintain system security and/or are economically advantageous: *Note: the opportunistic buying in the ST market does not guarantee all participants will be paid for the service*.
	TO & Commercial assets	Direct participation: Commercial Indirect participation: TO	Commercial only	Commercial only	Indirect participation (alternative costs) for regulated TO assets is assumed in this competitive stability market, similar to current Pathfinder processes. TO submits cost of solutions to ESO. It is expected that competition for connections based on TO offered solution location will be accounted for in the procurement process (similar to Pathfinder 3).

*GC0137 is expected to form the technical basis of grid-forming capability, defining the types of power and fault current responses required

RECOMMENDATION – ISSUES ADDRESSED

The market design choices under the preferred solution have been made with consideration to key challenges identified at project inception





	ESO as single buyer	Energy complexities	Innovative technologies	Overlapping solutions with TO	Locational requirements
Design Choice	Long-duration contracts provide price and volume certainty for providers to underwrite investment/build business case. The recurring ST-market promotes price and volume visibility, consolidating a LT-vision for the market. The ST-market also provides an additional route-to-market for providers that cannot commit in advance.	Contracts struck in the LT will have a ST-mechanism to manage LT price risk. This is an area that requires further consideration but it is envisaged to take the form of a utilisation payment or imbalance price for energy consumption.	The potential stability market provides a route-to-market and dispatch/instruction mechanism for dedicated stability providers and those with grid-forming capability. In particular, the ST-market enabling a route-to-market for intermittent grid-forming capability, providing commercial incentive for deployment of grid-forming technology.	No direct commercial participation of TOs envisaged in this high-level market design (indirect participation allowed). This is intended to minimise the risk of conflicts of interest and market distortion. Further work is needed on residual value for TO assets & synergies with other services (i.e. multi-purpose TO assets providing services beyond stability), this should also be considered for commercial providers in the context of stacking/co-procurement.	Procurement of highly locational stability services with effectiveness factors. National procurement rounds preferable to optimise procurement and realise benefits across whole-system.

RECOMMENDATION – ELIGIBILITY ACROSS TIMEFRAMES

Our proposed solution has selective eligibility across timeframes due to issues with forecast error, transparency, and practicality

Eligible | Ineligible

	Long term (T-4)	Long term[1] (T-1)	Short term (day-ahead)
Incremental investment	Can be easily identified as providing additionality to ensure security. Buy curve can be established for opportunistic approach based on marginal unit cost displacement	Assets that can deploy quickly should not be excluded from the arrangement	Unlikely to pursue this approach, but providers should be allowed to access short-term market if they don't wish to make long term commitments
Incremental capability	Unclear how to define closing plants with a high level of accuracy, opportunities for other incremental providers in later timeframes	Offers an opportunity for closing providers, or providers who not be available in subsequent timeframes. Buy curve can be established for opportunistic approach based on marginal unit cost displacement	Providers with a high opportunity cost, variable cost, or low availability certainty for access to additional capability given a route to market when MW positions and costs are more certain
All	Appetite to pay on individual unit basis in pay-as-bid, multi-timeframe market. Impossible to establish universal buy curve for existing providers. High level of forecast uncertainty for units available in subsequent timeframes	Appetite to pay on individual unit basis in pay-as-bid, multi-timeframe market. Impossible to establish universal buy curve for existing providers. High level of forecast uncertainty for units available in subsequent timeframes	Higher degree of certainty on individual unit level costs, precedent exists for procuring existing providers if discount to real time solution in the interest of consumers

Notes: [1]T-1 still provisional and may not be included in final market design depending on outcome of a thorough CBA.

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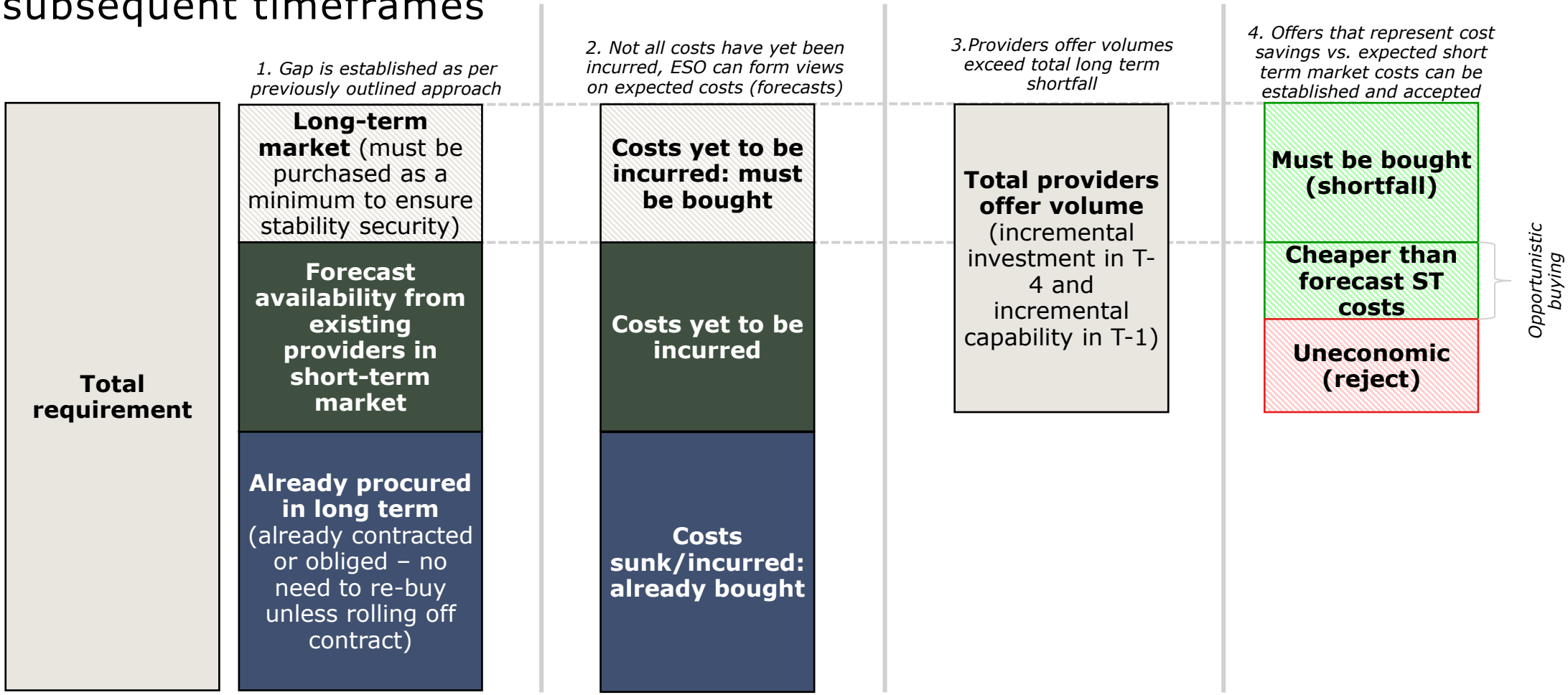
RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: LONG-TERM OPPORTUNISTIC BUYING

Opportunistic buying – Once the shortfall has been met, ESO may wish to procure additional volumes if it expects a discount relative to buying in subsequent timeframes



Note: the same principle applies in all timeframes, long-term vs. short term shown here as an example

RECOMMENDATION – NEXT STEPS FOR PREFERRED SOLUTION

There are a number of building blocks that require further consideration

Features under option E

LT procurement lead time	LT contract duration	Contract obligation	Utilisation payment (LT)	ST contract resolution
[T-4]	[20 yrs]	[95% availability]	[Imbalance price]	[Settlement period]
[T-3]	[15 yrs]	[90% availability]	[Bid-specific price]	[4 EFA blocks]
[T-2]	[10 yrs]	[Other availability]	[No utilisation price]	[Day baseload]

Additional design features

Commercial issues

- Treatment of TO solutions
- Connection competition processes
- Stacking
- Competition thresholds & price control
- Outcome of Ofgem AS asset review[1]

Procedural issues

- Requirement determination
- Requirement signalling
- Assessment determination
- Results release
- Operational review process
- Rule change processes

Compliance, monitoring, verification

- Completion milestones
- Termination events and fees
- Performance standards
- Measurement & verification
- Penalty determination

Notes: [1]Ongoing review by Ofgem to consider the treatment of dedicated ancillary service assets in a competitive market context needs further investigation to ensure compatibility with proposed market design

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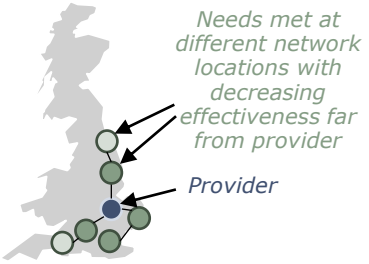
RECOMMENDATION – NEXT STEPS FOR PREFERRED SOLUTION

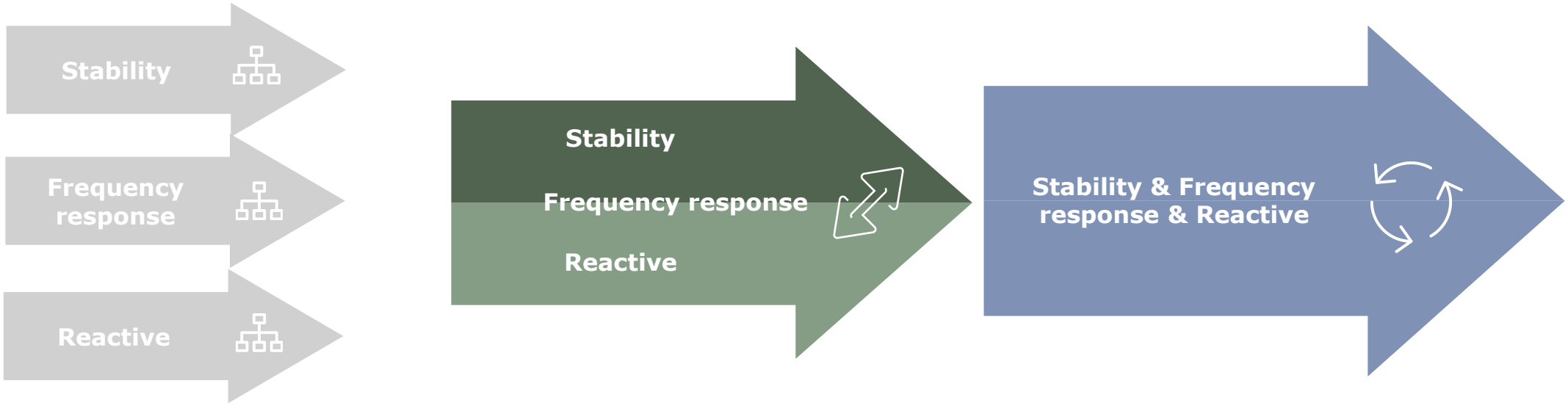
Locational aspects of the service design are similar to the pathfinders, but technical verification of solution is required

	Product	Description	Proposed solution	Illustrative diagram
Least locational	**Inertia**	Inertia is the least locational of the services considered. In our initial design we believe that inertia could be a national product (provision is uniform independent of location). However, in the future regional problems with inertia may emerge and if this becomes a manifest issue, regional inertia requirements may need to be adopted.	**National market** (initially)	
	Short circuit levels	Short circuit levels are locational, with a provider at one node able to affect multiple adjacent (and further afield) nodes. Whilst short circuit level contribution can travel a reasonable distance, effectiveness drops off.	**Effectiveness factors** single provider can contribute to multiple needs. Factors essentially scale the cost of the solution.	
Most locational	**Dynamic voltage support**	Dynamic voltage support requirements are highly locational as response to voltage disturbances does not travel far. This aspect of the service is the most locational and as such, sharp locational signals should be in place to ensure voltage security.	**Effectiveness factors** single provider can contribute to multiple needs. Factors essentially scale the cost of the solution.	

STABILITY MARKET DESIGN

7. Future considerations

There are multiple options for ancillary service markets with interactions, from separate procurement to full co-optimisation



Separate, fixed requirements

- Stability requirements are fixed and procured separately from other services that interact with it such as inertia and frequency response.

Separate, dynamic requirements

- Stability requirements are set dynamically, meaning the requirement is optimised as interaction between services is accounted for
- For example, possible to procure more inertia and less (or slower) frequency response.

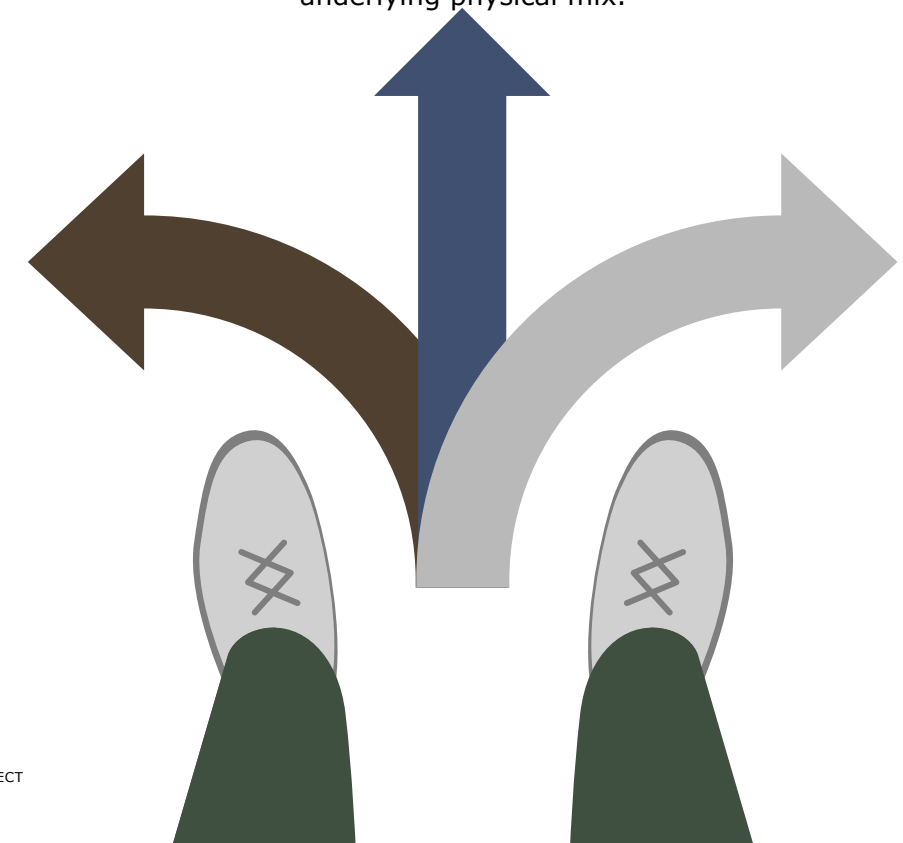
Full co-optimisation

- Full co-optimisation to maintain and limit frequency deviation.
- Co-optimisation across all services that interact with each other could realise additional benefits through increased efficiency.

There are a near infinite number of potential futures, we have considered three development pathways where recommendations might materially differ

Nodal pricing market design

Where the system transitions to a locational marginal pricing form of market design. Key considerations affecting the topology of the system, the timeframe of the market and changes in the operation of demand and generation, the underlying physical mix.



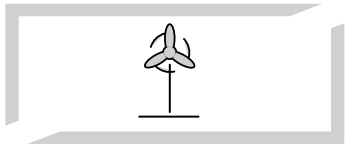
‘Recentralisation’

Where trends shift from todays deployment of decentralised intermittent (or small dispatchable) plant and large dispatchable plants such as nuclear, CCS, hydrogen drive the future mix. Key considerations must be around the topology of the system, and the nature of the requirements.

‘Grid-forming revolution’

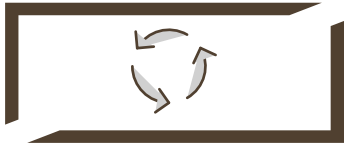
Manufactures offerings in grid forming capability begin to mature, and eventually become standard offering – replacing old ‘grid following’ kit. A rapid deployment of grid-forming technologies takes place.

Depending on the direction of travel and magnitude of deviation from our expected evolution, recommendations might change



Grid-forming revolution

Nodal pricing market design



Recentralisation

Potential solution

- Standardisation of grid-forming capability (mandating a technical standard as a requirement in the Grid Code) for new connections. This could be take the form of mandating GC0137 as a requirement for new connections.

- Co-optimisation of services with energy in plant scheduling algorithm.

- Stability management may or may not require full blown market solution (but could still be a workable solution).
- Opens up the possibility of network charging reform as a signal for generators with grid-forming capability to connect as a simple solution (due to low uncertainty about provider capability and availability).

Considerations

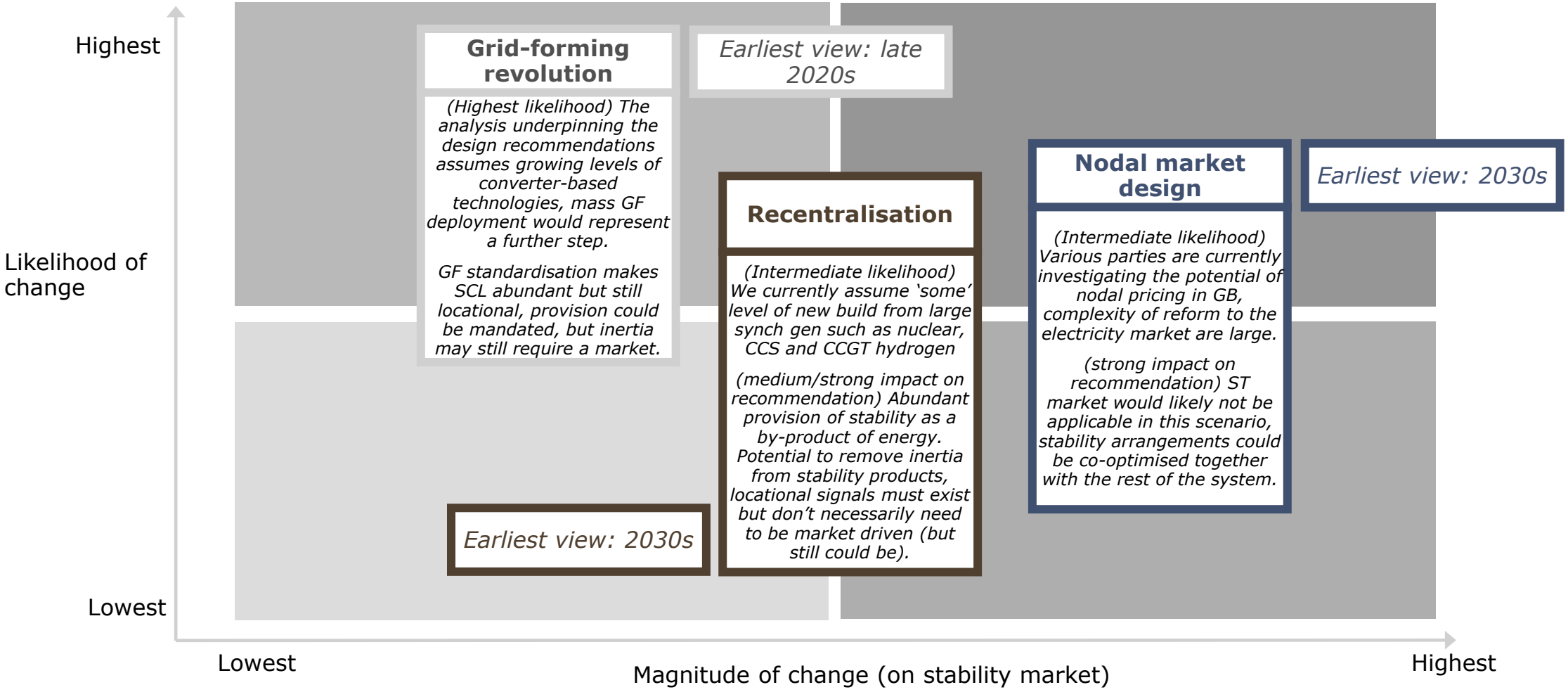
- Would require determination of a min. threshold (e.g. min level of capacity, connection voltage).
- Existing investment must be respected so as not to (a) undermine confidence of investors; or (b) exposure consumers to costs of retrofitting.
- Market may still be required, particularly for inertia (locational SCL and dynamic voltage to be monitored).

- Nodal markets can bring redistributive effects between providers in different locations.
- Value can be very volatile – may still need long term 'out of the market' solutions.
- Can be difficult to accurately understand the value of an isolated service in a large co-optimisation problem.

- Inertia may become significantly less relevant unless regional issues emerge.
- Locational signals will likely need to remain and could be delivered either through a market or via other means.
- Depending on degree of recentralisation, market for stability may no longer be relevant.

AGIC = Avoided GSP Infrastructure Credit

Some futures are more likely than others…

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