Stability market design – Scene setting and objectives

Annex report to National Grid ESO

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This annex focusses on Phase 1 of the overall project

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

Contents

STABILITY MARKET DESIGN

1. Scene setting

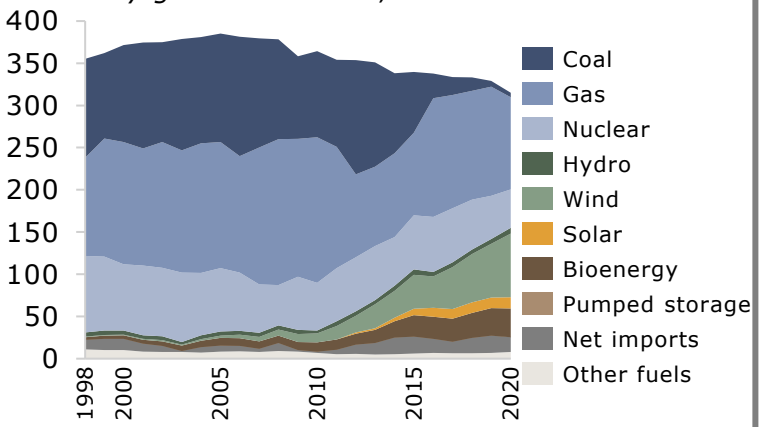
Challenges for managing stability manifest as a result of an evolving system

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

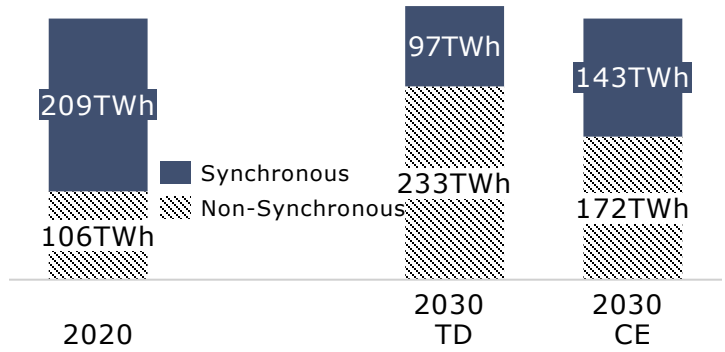


Today
What is happening now?

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

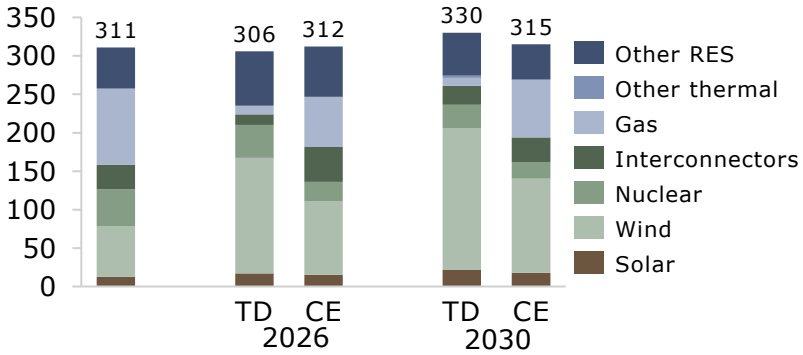


Future
Where is the system we going?

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



Ultimately NGESO must adhere to the SQSS[1], and new stability services will contribute to ensuring frequency and voltage limits are met

	Frequency limits (Inertia)	Voltage limits (SCL, DVS)
Current limit	**49.2Hz** (for up to one minute) **to 50.5Hz**	**~±10% of nominal voltage[2]**
Limit breach implication	– At regular frequency intervals load will be disconnected to restore system frequency back to within operational limits (drop to 48.8Hz=5% of demand, 47.8Hz=60%).	– Voltage disturbances on the system are relatively local and may need to be contained by disconnection of certain assets/customers. – Insufficient fault current may result in relevant protections during a fault failing to trigger (highly unlikely).
Other considerations	– The system must have sufficient inertia such that active power compensation from frequency response providers has time to ramp up/down and prevent outages. – There must also be sufficient inertia to prevent frequency from deviating too quickly, triggering cut-off of equipment (such as embedded generator protection), exacerbating the problem.	– Insufficient SCL may result in limitations on HVDC equipment, effectively reducing their capacity and increasing the cost of managing the system as a whole (curtailment of other generation).

Notes: [1]Security and Quality of Supply Standard, [2]In operational timescales for up to 15 minutes following a pre-defined secured event, chosen here as DRP is expected to be a post-fault service, may be greater in exceptional circumstances

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

Increasing future needs

Solving future problems

Dependent on configuration

	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

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

ESO as single buyer

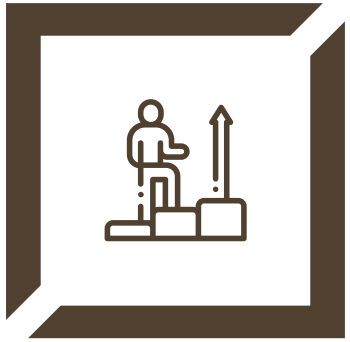
Challenge

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.

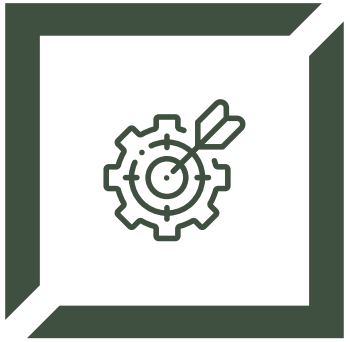
An idealised market may need a combination of LT and ST arrangements.

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

2. Objectives

OBJECTIVES - OVERVIEW

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

OBJECTIVES - OVERVIEW

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**
Cost-efficient	– Cost-efficiency refers to the overall economic efficiency of the system in this context, reducing the spend required to meet stability constraints on the system relative to the baseline in the interest of consumers. – In recent years costs for managing system stability have increased substantially and is one of the key drivers to exploring reform options today. – Any future arrangements need to establish the framework to deliver a benefit with respect to current stability management practices. – Cost-efficiency is already well embedded in NG ESO's wider objectives.
System stability & security	– The ESO is intending to procure services to comply with licence obligations to ensure a safe and reliable supply of electricity throughout the network. – This is the ultimate purpose that ESO is aiming to achieve with the market, and will be delivered through procuring a suite of stability products which will give the ESO the tools needed to manage the system stability. – System security factors-in the need to ensure adequate capability is in the system to meet requirements. – Whilst this is the ultimate goal, failing to meet other key objectives does not constitute 'success', as the solution identified must account for the needs of consumers and whilst being compatible with the future electricity mix.
Zero-carbon compatible	– National Grid ESO has committed to be able to run the system with net-zero carbon emissions in any given period should the market deliver that solution. – With the evolving system, it would be a fallacy to design market arrangements which cannot accommodate technologies capable of delivering against this commitment. – This means ensuring arrangements are able to cater for zero-carbon solutions for provision of stability services.

OBJECTIVES - SECONDARY

Primary objectives	Motivation
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	– The market should give investors sufficient clarity for them to recognise and manage their risks. – Risks should be borne by the party most suitably equipped to bear them; undue unknowns should not be placed on providers unless there is sufficient reward to justify these risks. – Incentives should not just target investment as a whole but focus on rewarding the right investments to improve overall system efficiency.

Secondary objectives	
Investable	Respecting existing investments – Ensuring existing investors commitments are respected under any new arrangements. – This means paying consideration to mitigating disadvantages a new market could bring, rather than a commitment for all existing investors to receive additional payments. Supporting efficient future investments – If there is foresight on the impact from this market design, need to think about linking it to wider investment plans. I.e. signals to be in place with sufficient lead time for participants. – Provide adequate lead time for investment market signals.
Transparent	
Technology neutrality	
Practical	
Enduring (stable)	Adequate sustainable solution, providing the right capability – Ensure sufficient capability to meet requirements is procured in the right locations. Either incentivising new build or ensuring existing provision stays in place. – Ensure capability is in place & available in real-time.
Freedom of choice	

OBJECTIVES - SECONDARY

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
Transparent
Technology neutrality
Practical
Enduring (stable)
Freedom of choice

Motivation

- Transparency is needed for a market to function effectively, the absence of sufficient information on which to make commercial decisions could lead to inefficient outcomes.
- In the context of a stability market with a single buyer, there is a need to communicate needs in a way that allows market participants to understand their costs of service provision, market volumes and prices.
- Without sufficient transparency additional risk can manifest on the providers which will feed through into their bidding behaviour.

Visibility of service values

- Provide transparency generally, and specifically in the operation of the pricing mechanism.

Visibility of service requirements

Transparent, clear signalling of requirements enable efficient decisions from providers wishing to participate in the market.

Clear procurement decisions

Transparent procurement decisions attract competitive bids, secure better value and deliver better final outcomes.

OBJECTIVES - SECONDARY

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
Transparent
Technology neutrality
Practical
Enduring (stable)
Freedom of choice

Motivation
– The market should ensure all potential providers have aligned incentives.

Technology neutrality

- Being non-discriminatory between technologies with equivalent capabilities.
- Design should not discriminate between low-carbon and fossil fuel at the moment.
- Neutral contract terms and risks (e.g. TO vs Commercial providers' exposure).
- Neutral requirements (e.g. limits that can reduce the competitiveness of certain providers).
- Treatment of existing vs new capability will depend on nature of requirements and consistency with the primary objectives of the market (e.g. cost-efficient provision).

OBJECTIVES - SECONDARY

Primary objectives	Motivation
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	– The solution itself must be deliverable from the ESO perspective - unnecessary complexity can lead to additional administrative cost burdens which can offset some benefits of implementation.

Secondary objectives	
Investable	
Transparent	
Technology neutrality	
Practical	Ease of implementation – Costs and barriers related to the introduction of the market for both ESO and participants. Ease of ongoing operation – Costs and barriers related to the management, running and monitoring of the market for ESO. – Additional burden of participation for potential providers.
Enduring (stable)	
Freedom of choice	Ease of transition – There will be a transition with a period of overlap with existing pathfinders contracts to go through as the market is being implemented.

OBJECTIVES - SECONDARY

Primary objectives	Motivation
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	– The market design should be sufficiently stable for market participants to avoid unnecessary administrative burden and associated costs. – In particular, if arrangements must be scrapped due to changing energy landscape – this represents significant additional burden on ESO and ultimately costs to consumers. – Give providers confidence in the new market arrangements that participation is meaningful and sufficiently valuable to incentivise ongoing participation (ultimately helping to promote liquidity).

Secondary objectives	
Investable	
Transparent	
Technology neutrality	
Practical	
Enduring (stable)	**Suitable and adaptable to future challenges** – Providing adequate capability under evolving requirements. – Promoting competition and low barriers to entry: enabling a level-playing field among different providers and technologies. – Ensuring appropriate risk allocation between buyer and seller, and access to mitigation tools.
Freedom of choice	**Well understood governance for changes** – Rules and governance for changes should be well understood for providers to understand the initial launch of the market (and participation) but also in the long-term beyond the market launch (e.g. rule change processes). – Minimise regulatory risk, including careful consideration of the process for amending market arrangements.

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
- Transparent
- Technology neutrality
- Practical
- Enduring (stable)
- **Freedom of choice**

Motivation

- Freedom of choice for providers in terms of the technologies they wish to employ to participate in the market.
- Freedom of choice for providers to make commercial decisions.
- Freedom for the ESO to change arrangements should the market fail to deliver in line with other objectives and needs (e.g. tightening rules to prevent anti-competitive behaviour).

Avoiding lock-in and ongoing choice

- Freedom of choice aims to present options
  - Giving ongoing choice acts as a stabilising factor in the market (rather than locking participants in with fixed 'things').
  - Avoiding lock-in, ongoing choice can mitigate issues around over/under-procurement.
- Ensure liquidity
  - The market should aim to enable as many providers as possible to participate, and for provision to be as flexible as possible. For example enabling the participation of intermittent providers.

Mitigate market power

- The market for stability is a great ambition, but there may be issues of market power, especially for locational services.
- There may not be a plethora of providers in some areas and there will be times of shortage of providers.
- Choice for providers widens participation, which in turn promotes choice for ESO which can mitigate issues of market power.