Making Future

Stability market design – Preferred option

Annex report to National Grid ESO

MARCH 2022

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This annex focusses on Phase 3 of the overall project

1 Alignment, vision, objectives	2 Design elements, strengths, weaknesses	3 Industry views, refinement, finalisation
1a. Scene setting What are the realities? Establish 'givens' and make assumptions on all relevant topics	**2a. Market building blocks** Define the key design choices that can materially impact market outcomes	**3a. Refinement** Highlight the preferred option; make improvements to increase performance against our objectives
1b. Objectives What do we want to achieve? Establish the design principles for the market	**2b. Straw-man options** Define conceptual design options to assess – exploring alternative philosophies	**3b. NIA desirable option** Recommend a desirable design for stability market and way forward
	2c. Assessment Appraise design options qualitatively and (2d.) quantitatively against objectives	

Stakeholder engagement has fed into our assessment

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STABILITY MARKET DESIGN

Contents

STABILITY MARKET DESIGN

1. Preferred option

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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	

Timeframe	Long-term market	Year-ahead[1]	Short-term market	RATIONALE
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.

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. For T-1, due to the nature of these providers, preferred structure is a call option (availability + user defined utilisation fee).
	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.

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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 forecasted short term 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.

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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

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Option E

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 (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: Further work will need to be done to explore the advantages of implementing a T-1 procurement round

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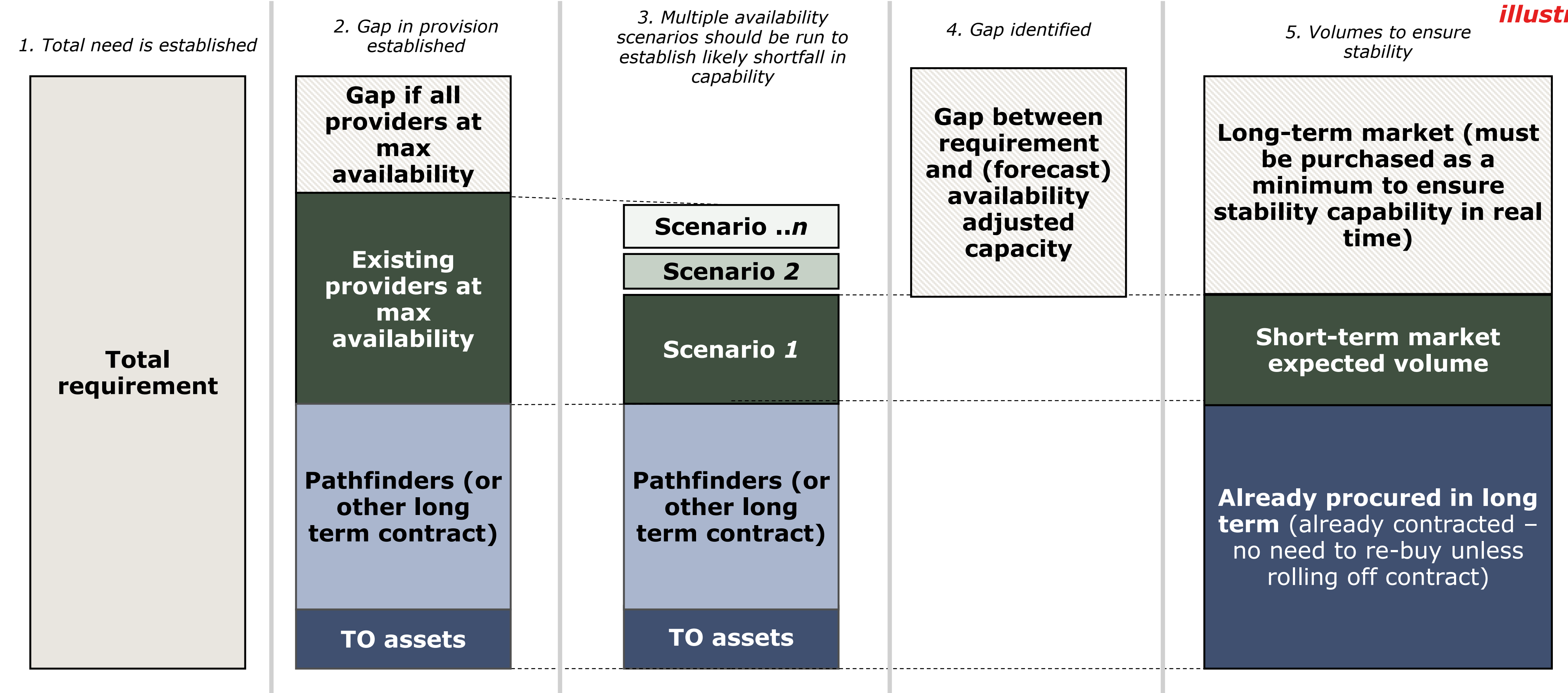
Option E

RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: LONG-TERM OPPORTUNISTIC BUYING (FOR INCREMENTAL ONLY)

Multiple scenarios can be run to understand the worst case plausible availability and secure sufficient providers to ensure SQSS compliance

Market sizing illustrative only



Notes: simplified example

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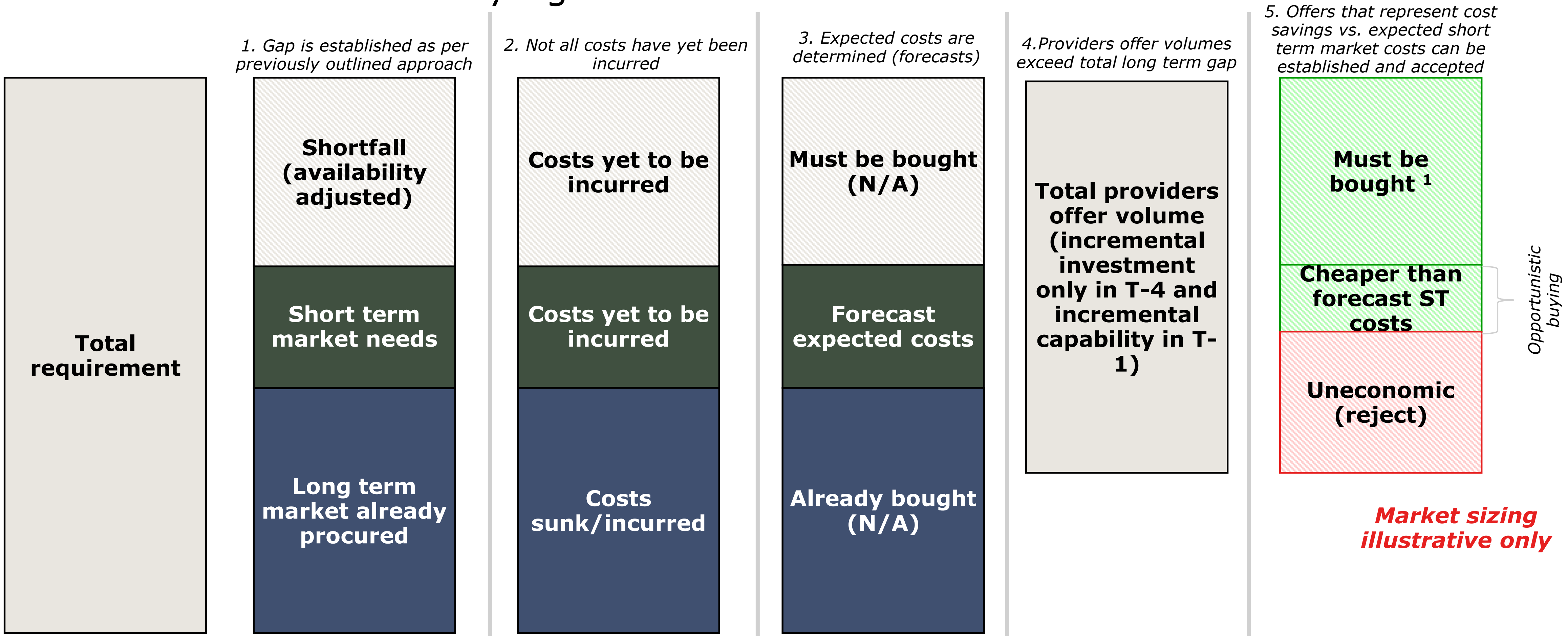
Long term | Short term

Option E

RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: LONG-TERM OPPORTUNISTIC BUYING - (FOR INCREMENTAL ONLY)

Opportunistic buying – Once the shortfall has been met, ESO may wish to procure additional volumes in the long-term market if it expects a discount relative to short-term buying



Market sizing illustrative only

Notes: [1]or TO counterfactual instructed to meet volumes if economically viable

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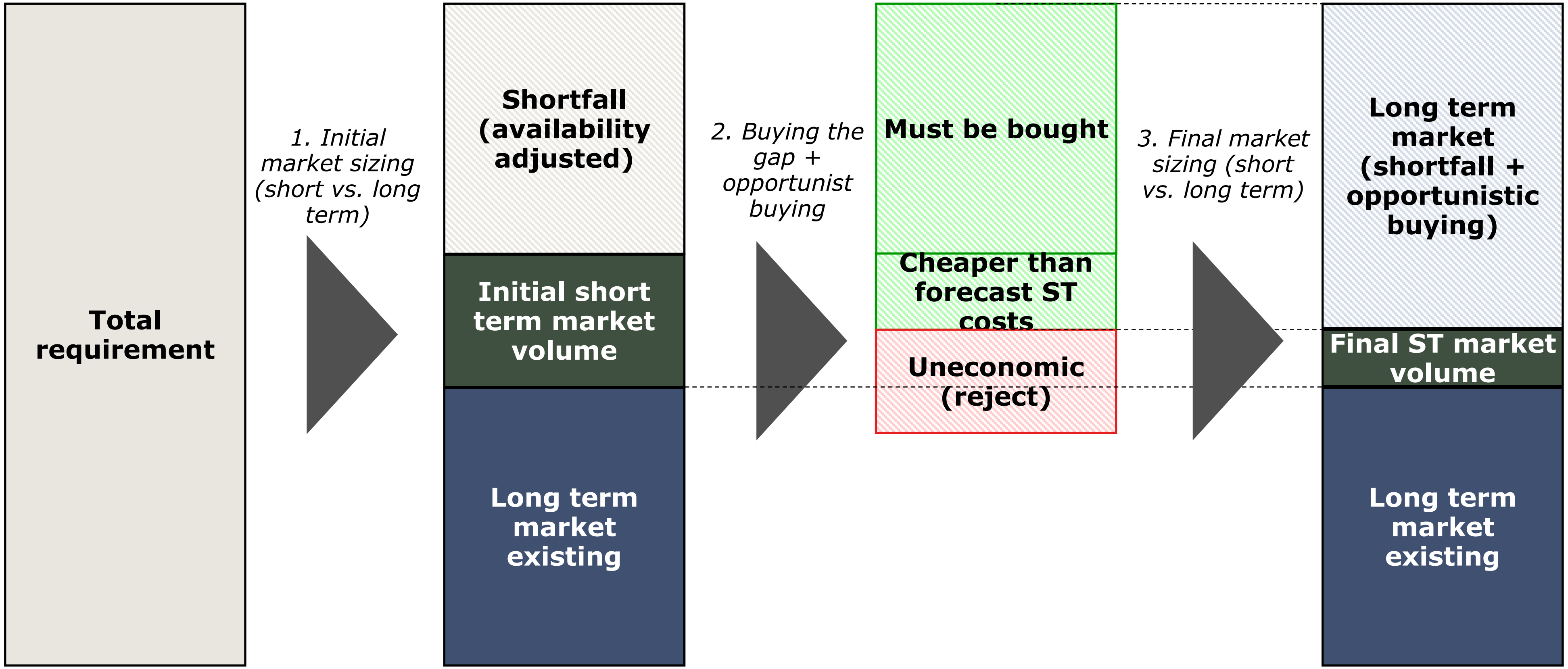
RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: LONG-TERM OPPORTUNISTIC BUYING - (FOR INCREMENTAL ONLY)

In the long term under an opportunistic buying approach, ESO is able to hedge costs as well as ensure security

Market sizing illustrative only



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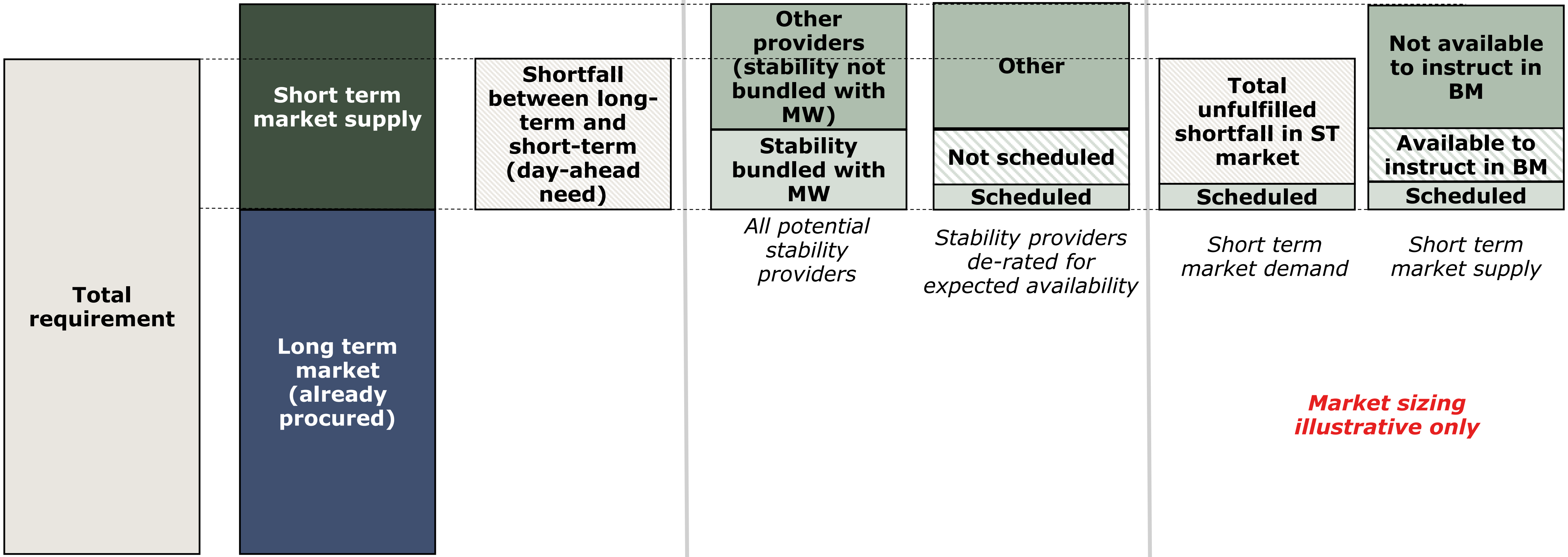
RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: SHORT-TERM OPPORTUNISTIC BUYING

The gap (if any) between long-term contracts and short-term needs must be identified

1. The gap between long-term contracts and residual short-term need is established based on day-ahead forecasts, employing the same methodology as the long term, but focussed on a single day (for each contract period)

2. Once total need is established, determine expected available capability[1] from providers

3. Establish categories for buying, there will be an expected volume of provision from the energy market plant schedule, providers that are not available, and potentially a gap between these providers and the total requirement



[1]At point of assessment this can be based on PNs, note that if this is a hard rule it may open opportunities for gaming as plants declare PN=0 when they actually intend to run to be considered for procurement at this stage. This needs consideration including whether regulatory protection might prevent such behaviour.

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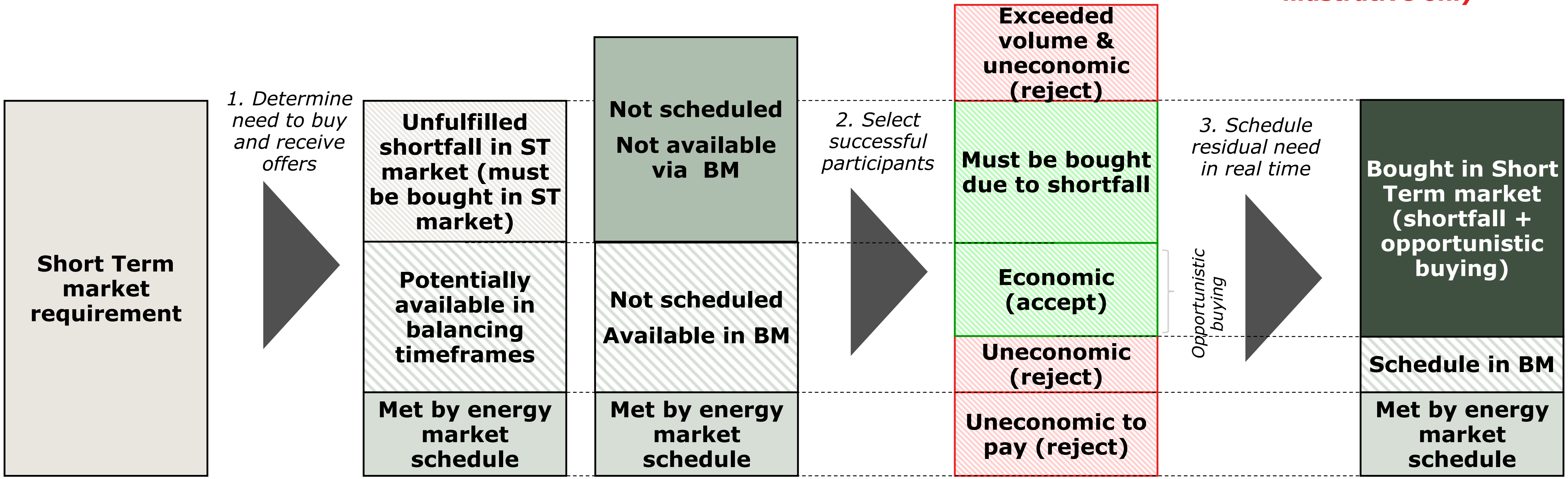
RECOMMENDATION – PROCUREMENT STRATEGY DEEP DIVE: SHORT-TERM OPPORTUNISTIC BUYING

Ultimately, once real-time is reached all residual needs must be fulfilled either through the short term market or in the balancing mechanism

Market sizing illustrative only



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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	ST contract resolution
[T-4]	[20 yrs]	[95% availability]	[Imbalance price]	[4 EFA blocks]
[T-3]	[15 yrs]	[90% availability]	[Bid-specific price]	[Day baseload]
[T-2]	[10 yrs]	[Other availability]	[No utilisation price]	[Settlement period]

Additional design features

Commercial issues	*Procedural issues*	*Compliance, monitoring, verification*
Treatment of TO solutions	Requirement determination	Completion milestones
Connection competition processes	Requirement signalling	Termination events and fees
Stacking	Effectiveness factors	Performance standards
Competition thresholds	Assessment determination	Measurement & verification
Price control determination	Results release	Penalty determination
	Operational review process	
	Rule change processes	

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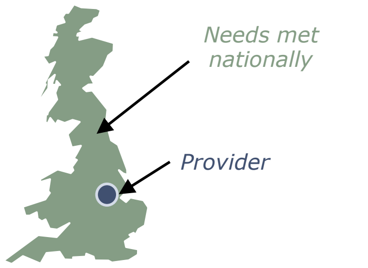
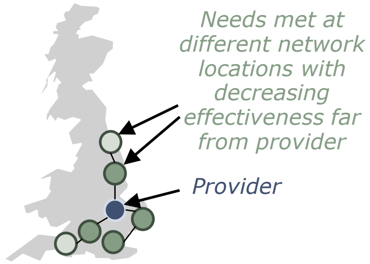
RECOMMENDATION – NEXT STEPS FOR PREFERRED SOLUTION

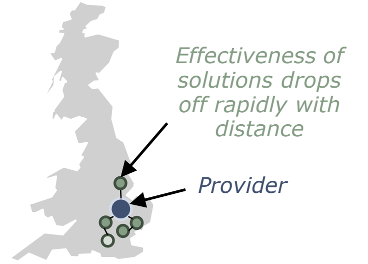
Locational aspects of the service design are similar to the pathfinders, but technical verification of solution is required

	Product	Description	Proposed solution
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 be to 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.

Illustrative diagram







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STABILITY MARKET DESIGN

2. Assessment of preferred option

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The preferred option builds on the flexibility from the hybrid market timeframe, opportunistic buying strategy and systematic processes

System stability & security	Hybrid timeframe provide flexibility in critical timeframes to ensure requirements are met, systematic nature of market mitigates exposure to forecast errors.	●
Cost-efficient	The hybrid timeframe and opportunistic buying strategy give the ESO choice to manage stability across critical timeframes, minimising exposure to expensive stop-gap solutions and extreme pricing. The LT and ST markets also give providers choice on when to commit (and for how long), helping to manage risks.	◕
Zero-carbon compatible	LT markets reduce reliance on carbon-intensive stop-gap solutions, and ST enables ESO to contract technologies (that may not be there in the LT). Both ultimately reduce reliance on carbon emitting balancing actions.	◕
Investable	LT markets provides signals for investment, also reduces price and volume risks improving revenue certainty for providers. ST markets signal price and volume for providers who cannot commit in advance.	●
Transparent	Recurring & systematic market arrangements convey transparent outcomes.	◕
Technology neutrality	Hybrid market timeframes aim to accommodate technologies with different characteristics, opportunistic buying.	◕
Practical	Hybrid market timeframe arrangements are a larger deviation from today, expected to require complex implementation and operation.	◔
Enduring	Choice in market timeframe, wide eligibility enable flexibility in the arrangements to be able to adapt to future challenges.	◕
Freedom of choice	LT & ST markets give choice for when to commit (for providers) and when to procure (for ESO).	◕

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Option E

Hybrid timeframe provide flexibility in critical timeframes to ensure requirements are met, systematic requirement determination and procurement mitigates exposure to forecast errors

Objective	Justification
System stability & security	– The hybrid timeframe gives ESO flexibility in managing risks and meeting stability requirements: – The ST market gives ESO close to real-time flexibility to access additional provision to maintain system security, particularly with highly variable, unpredictable requirements. – The LT and Year-ahead market ensure adequate capability is in place to meet forecasted stability requirements. The LT market procures for incremental investment and the year-ahead procures for incremental capability. The year-ahead market also allows for adjustments closer to the delivery time. – The markets enable a broader access to resources by giving a route for providers that cannot be instructed by traditional means (e.g. BM) potentially increasing the volume accessible close to real-time.
Score	– Systematic and recurring markets (across multiple timeframes) oblige SO to make forecasting and requirement determinations. This promotes a higher degree of certainty for market providers regarding requirements. Mitigates exposure to forecasting errors. – The market operates in critical investment and operational timeframes to ensure system security. The T-4 procures incremental investment, T-1 procures incremental capability and the ST market is open to all providers.

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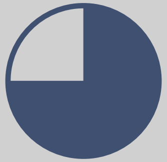
ASSESSMENT OF PREFERRED OPTION – COST-EFFICIENT

Hybrid timeframe is optimal to ensure cost-efficient provision of services

Objective

Cost-efficient

Score



Justification

- The hybrid timeframe approach is beneficial for cost-efficiency – from ESO's view it provides flexibility in managing risks and meeting stability requirements:
  - The ST market allows ESO to access stability provision close to real-time, mitigating against risk of variable requirements (over/under procurement) and against expensive stop-gap solutions in the BM.
  - The LT and Year-ahead market ensures "new" capability is procured if needed to meet requirements. Mitigates shortages and extreme prices close to real-time. Also reduces reliance on stop-gap BM solutions.
- From the providers' perspective, the hybrid timeframe lowers barriers to entry and promotes lowest cost-solutions. The close to real-time market lowers barriers to entry for providers who cannot commit in advance.
- The LT market provides a route for investment in new build assets by reducing price and volume risks via long-duration contracts. This is particularly beneficial to providers who can commit in advance and require some forward revenue certainty to lower the risk profile of the investment.
- The recurring nature of requirement determination and procurement promotes a LT vision for the stability market, thereby benefitting providers who can build a pipeline of projects over time and take of advantage of technology learnings.
- Choice and flexibility are key characteristics sought in this design to lead to cost-efficient outcomes. This is supported by the opportunistic buying strategy – under this arrangement ESO has a minimum requirement to meet but has the choice to procure more if it is cost-optimal. This strategy promotes cost-efficiency.
- The opportunistic buying strategy also promotes competitive forces by broadening the eligibility pool.

- LT contracts can still lock ESO in to inefficient outcomes in certain circumstances, exposing it to variability in requirements, resulting in over-procurement and/or scarcity with resultant extreme pricing.
- Providers have ways to mitigate LT price risks, such as exposure to energy and operational risks in LT timeframes, but these are not perfect and a risk premium to participate may still feed through.

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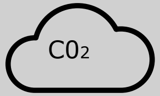
ASSESSMENT OF PREFERRED OPTION – ZERO-CARBON COMPATIBLE

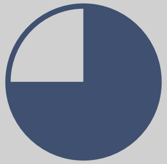
LT markets reduce reliance on carbon-intensive stop-gap solutions, and ST enables ESO to contract zero-carbon technologies (that may not be there in the LT)

Objective

Zero-carbon compatible



Score



Justification

- Hybrid timeframe enables choice, limiting potential lock-in of suboptimal carbon emitting providers in LT timeframes and mitigating ST shortage/reliance on sub-optimal carbon alternatives in real-time (e.g. through the BM).
- Dedicated stability markets provide route-to-market for 0MW providers (non-carbon emitting).
- Lowers barriers to entry for clean technologies. The short lead time of the procurement offsets most of the availability risk for weather-dependent (RES) providers.
- The hybrid market timeframes provide flexibility but is not a perfect solution as there is no perfect foresight:
  - ESO may still need to take sub-optimal stop-gap actions close to real-time (e.g. through the BM or what is available on the day, which may be carbon intensive).
  - ESO may still find itself locked-in a to sub-optimal LT contract (with hindsight) versus the ST alternative.

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LT markets reduce price and volume risks, ST markets signal price and volume for providers who cannot commit in advance

Objective	Justification
Investable	– Long contract & lead time provide investment signals for providers who can commit in advance and require revenue certainty (e.g. high capex) from LT firm procurement, also mitigates single buyer risk faced by participants. Lead time gives sufficient opportunity for investment decisions to be made and assets realised. The Year-ahead market (procuring for incremental capability) enables existing assets the opportunity to make decisions about closure.
	– ST market incentivises investment for providers who cannot commit in advance by removing the availability risks present in forward procurement but are crucially only investible if incremental investment is relatively small.
	– Wide eligibility via opportunistic buying strategy (e.g. new and existing providers both eligible) promotes a degree of revenue certainty beyond initial contract. For example, a new-build asset with a long-term contract benefits from the certainty of a route-to-market for stability services beyond its initial contract.
Score	– Requirement volume uncertainty **-** Under opportunistic buying ESO retains discretion over the procurement volumes of the markets. This means procurement volumes can be variable, inhibiting market visibility for providers looking to participate (forming a view on future market volumes, prices becomes more difficult).
	– No track-record **-** investors face difficult choices as to whether participation in a market will yield returns sufficient to cover investment costs and provide an adequate rate of return to meet cost of capital thresholds (hurdle rates).

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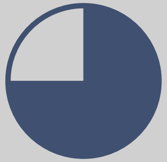
ASSESSMENT OF PREFERRED OPTION – TRANSPARENT

Recurring & systematic market arrangements support transparent outcomes

Objective	Justification
Transparent	– Procurement across multiple timeframes enables market visibility (from LT to ST). – Close to real-time partial requirement allows providers to recognise prevailing value based on underlying system conditions. – Frequency of requirement determination and procurement can inherently make the arrangement more transparent (requirement determinations, results sharing).
Score	– Under opportunistic buying, ESO retains discretion over the procurement volumes. This means procurement volumes can be variable, inhibiting visibility for providers looking to participate (forming a view on future market volumes, prices becomes more difficult). Furthermore, uncertainty around cost forecasts for opportunistic procurement of services. – LT timeframe procurement process can be complex with significant lead times and high duration pre-qualification stages exposing participants to uncertainty throughout the contracting period/process. – Bundled bids in combination with pay-as-bid pricing make it a complex arrangement, assessment relies on complex winner determination algorithm selecting feasible outcome with lowest costs.



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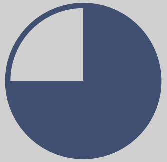
Option E

Hybrid market timeframes aim to accommodate technologies with different characteristics, opportunistic buying

Objective	Justification
Technology neutrality	– Opportunistic buying strategy means all providers that are technically able to provide stability services can participate (though not in all timeframes) and be contracted under the principles of ensuring system security at least-cost. – All capacity (new & existing) providing stability can participate depending on timeframe. – ST timeframes provide an accessible route-to-market for providers with uncertain availability, lowering barriers to entry. – Stability market provides a route-to-market for dedicated stability providers (e.g. at 0MW, that cannot currently be instructed through the BM).
Score	– Variable procurement volumes (particularly under opportunistic buying) between LT and ST can influence market outcomes, making it difficult to achieve neutrality.



Notes: Technology neutrality can never be perfect as different contracting structures suit different provider types – we have endeavoured to enable contracting across different timeframes that can suit the broadest range of participants possible.

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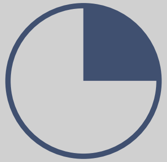
Hybrid market timeframe arrangements are a larger deviation from today, expected to require complex implementation and operation

Objective	Justification
Practical	– Recurring markets can benefit from standardised processes (such as requirement determination and assessment). For example, the short-term market running daily is suitable for automation. It needs to cover shorter timeframes and can act to offset the complex nature of processes such as requirement determinations of SCL.
	– Simple contract types - baseload only contract in LT simplifies management of provision for both ESO and the provider. – A baseload contract is most practical with the nature of the requirements observed in our analysis which has demonstrated no clear timetabled pattern that could be contracted in advance via complex contracts such as a shape contract (hence no discernible benefit).
Score	– High set-up and transaction cost for this new arrangement. This is time-consuming, resource-intensive and costly to ESO – in particular for short-term markets where no pre-existing arrangements can be exploited (such as pathfinder with long-term markets).
	– High management cost - facilitating and managing multiple market timeframes is more resource-intensive than ST-only and LT-only.
	– LT forecasting complex - **c**omplexity of requirement determinations is more resource-intensive for procurement to cover multiple years, more uncertainties (for the LT market timeframe).



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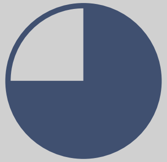
Option E

Choice in market timeframe and products enable flexibility in the arrangements to be able to adapt to future challenges

Objective

Enduring

Score



Justification

- Hybrid market procurement timeframes accommodate technologies and their characteristics. For example, the ST market is an arrangement more compatible with the ever-greater levels of renewables expected in the future.

- Recurring requirement determination and procurement in LT + ST market provide a LT vision for market participants.
- LT vision promotes a degree of price and volume certainty for potential participants.

- In a scenario where stability provision becomes standardised and is abundant (e.g. grid-forming capability becomes standard, large synchronous generation plants become common), these market arrangements could become irrelevant or require large reform.

- Unintended consequences of global eligibility via opportunistic buying**:** limited incentives for existing participants to innovate / improve their assets through additional investment.

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Option E

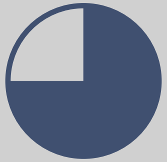
ASSESSMENT OF PREFERRED OPTION – FREEDOM OF CHOICE

LT & ST markets give choice for when to commit (for providers) and when to procure (for ESO)

Objective

Freedom of choice

Score



Justification

- Choice for ESO: Hybrid market procurement timeframes accommodate different technologies and their characteristics, in particular accommodating for the ever-greater levels of renewables expected in the future. Enables wider participation and pool of choice for ESO.
- Choice for providers: Hybrid market timeframe widens choice for participants in terms of how and when to participate.

- Short-duration contracts in ST market avoid lock-in of inefficient contracts.

- Opportunistic buying strategy provides choice for ESO: ESO will buy services if they are needed to maintain system security and/or are economically advantageous. 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).
- Opportunistic buying strategy for providers provides a route-to-market for a wide pool of participants.

- Gap between the ST market (at day-ahead) and real-time results in reliance on BM if conditions change during this timeframe.

- Annual (and multi-year) contracts can lock ESO into inefficient contracts.

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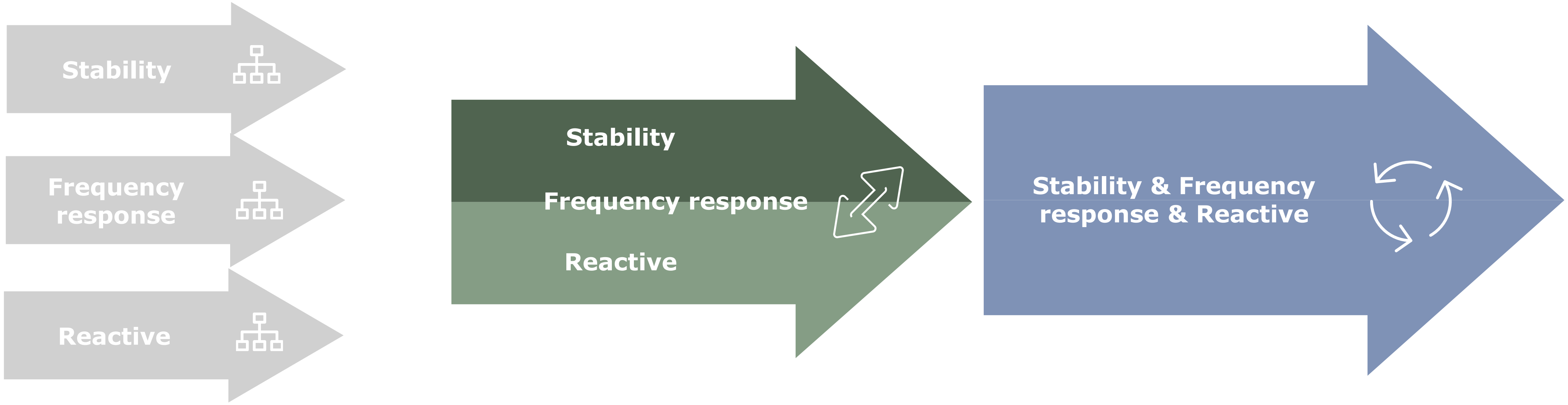
STABILITY MARKET DESIGN

3 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.

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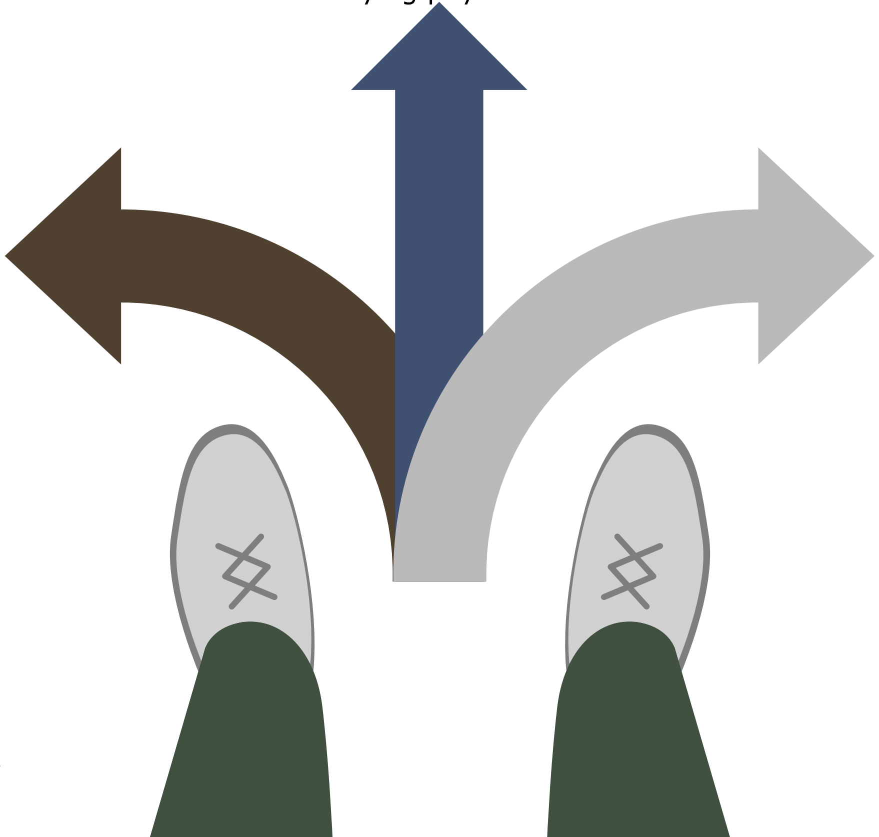
There are a near infinite number of potential futures, we have considered three development pathways where recommendations might materially differ

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.

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Under each of the potential future pathways, structural changes to stability provider types or fundamental changes to market design occur

Grid-forming revolution

Spectrum of change: Continuous

A **rapid deployment of technologies with grid-forming capability** takes place, and the share of synchronous generation in the mix continuous to reduce.

This is a scenario where providers capable of providing stability are in abundance. This may be driven by widespread standardisation between manufacturers, maturing of grid forming technologies, and consequently the replacement of 'grid following' with 'grid forming' as a standard offering from technology providers.

Changes to the deployment and provision of grid-forming capability means there will be an abundance of providers able to offer dynamic reactive for voltage stability and SCL, however inertia may still be more limited/difficult to access (as most technologies will still require some form of storage to offer reliable inertia services).

Nodal pricing market design

Spectrum of change: Discrete (Binary)

System transitions to **a locational marginal pricing form of market design**.

Nodal markets are expected to operate close to delivery, whereby prices are determined for each 'node' on the network accounting for network capacity constraints, and network losses (there are a range of different nodal market designs operating across the world with higher/lower degrees of sophistication).

Changes towards a nodal market (co-optimising constraints and energy at a point in time) are expected to provide enhanced spatial dispatch efficiency, at the expense of the temporal value of flexibility.

The transition towards a nodal market is likely to affect issues of market power, transparency and investment risk. All are important considerations for the potential stability market.

Recentralisation

Spectrum of change: Continuous

Large, synchronous plants – such as hydrogen CCGT, CCS, Nuclear - drive the future mix.

These reduce the role of small, distributed generators from the system, including asynchronous technologies such as renewables and batteries.

This is a scenario where the growing footprint of large thermal, synchronous plants transforms the system *back* towards one structured around large plants.

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Due to fundamental changes, opportunities emerge that can be exploited to ensure system stability issues are adequately addressed

	Grid-forming revolution	Nodal pricing market design	Recentralisation
Reality	– Grid-forming capability becomes default equipment built-in with deployment of new converter connected generators. Provision of SCL and dynamic voltage support becomes abundant. – Inertia will still require providers to have some form of storage, or curtail output depending on the configuration so that energy can be delivered at (very short notice).	– Nodal market is implemented and nodal price signals emerge. – Role of the ESO fundamentally transforms from balancing and service. procurement/administration to market scheduling and operation.	– Stability is provided as a by-product of energy generation to a much greater extent – bundling of stability with energy.
Opportunity	– Obligations could potentially be changed (respecting existing assets/investment) to require providers to offer the service as a condition of connection (or similar). – Only applicable if there isn't a significant incremental investment or marginal costs for service provision (which may be the case for inertia vs. other stability services).	– Opportunity to co-optimise stability with energy and other services which overlap and interact with stability services, such as frequency response, reactive, etc. – Potential for greater visibility of requirements with enhanced spatial dispatch.	– Significant stability provided by market schedule, reduces the value of service provision as overprovision is a common occurrence. – Reliance on a stability market may be reduced, as stability services become valueless in most (or all) periods for one or more services. – Possibility to avoid implementation, or reduce complexity in procurement of stability.

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Each of the future pathways present unique challenges

Grid-forming revolution

Cost-efficiency. There are risks around the level of 'standardisation' and maturity of the technology. If technology is not a default offering from majority of manufacturers, a mandatory obligation to have grid-forming capability could result in a more expensive solution for the end consumer.

Legacy issues: Fair treatment of converter connected technologies that don't have grid-forming capability must be considered (potential to only mandate grid requirement for new providers).

Location: Plants with grid-forming capability are likely to locate where RES resource is best and space is available. As many high resource locations are already saturated[1] with legacy converter connected intermittent technologies, there is a risk insufficient volumes of new GF providers emerge in the right locations to resolve needs.

Volumes: In a scenario where all providers are equipped with grid-forming capability, any market may become systematically oversupplied and reduce the value of stability, liquidity could become thin, and prices extremely volatile.

Nodal pricing market design

Spatial vs temporal flexibility: A nodal market operating at a specific point in time presents a key issue: whether enhanced spatial dispatch efficiency arising from a nodal market at a single moment can substitute for the loss of temporal flexibility of a continuous market.

Complexity of solution. Nodal markets are difficult to optimise (growing in complexity with a larger time horizon) – it is challenging to fit market solution within market scheduling timescales. There is a trade-off in terms of the optimisation horizon, granularity and solution complexity - the longer the optimization horizon, the more complex the solution will be (more "granular" timeline and providers add complexity). It is also uncertain if centralised algorithms could effectively deal with the diverse resources which will characterise the future energy system within a centralised optimisation.

Recentralisation

Location: Given current network charging cost signals (TNUoS), it is expected that providers will connect where connection costs[2] are cheaper, which is not necessarily where locational services are most required.

Limited providers: There is potential for market power and issues of competition in locational services in the event that there are few, very large providers on the system able to offer stability services (assuming these are still competitively procured and not redundant).

Regional inertia. In a scenario where the location of synchronous and asynchronous plants becomes increasingly polarized, regional inertia issues could manifest.

Volumes: In a scenario where more providers are inherently providing stability as a by-product of generation, any market may become systematically oversupplied and reduce the value of stability, liquidity could become thin, and prices extremely volatile.

Notes: [1]It could be possible to expose repowering sites to new requirements to mitigate these issues. [2]Trade-off with land costs will also be considered by developers.

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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

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Some futures are more likely than others…

Highest

Likelihood of change

Lowest

Grid-forming revolution

Earliest view: late 2020s

(Highest likelihood) The analysis underpinning the design recommendations assumes growing levels of converter-based technologies, mass GF deployment would represent a further step.

GF standardisation makes SCL abundant but still locational, provision could be mandated, but inertia may still require a market.

Recentralisation

Earliest view: 2030s

(Intermediate likelihood) We currently assume 'some' level of new build from large synch gen such as nuclear, CCS and CCGT hydrogen

(medium/strong impact on recommendation) Abundant provision of stability as a by-product of energy. Potential to remove inertia from stability products, locational signals must exist but don't necessarily need to be market driven (but still could be).

Nodal market design

Earliest view: 2030s

(Intermediate likelihood) Various parties are currently investigating the potential of nodal pricing in GB, complexity of reform to the electricity market are large.

(strong impact on recommendation) ST market would likely not be applicable in this scenario, stability arrangements could be co-optimised together with the rest of the system.

Lowest — Magnitude of change (on stability market) — Highest

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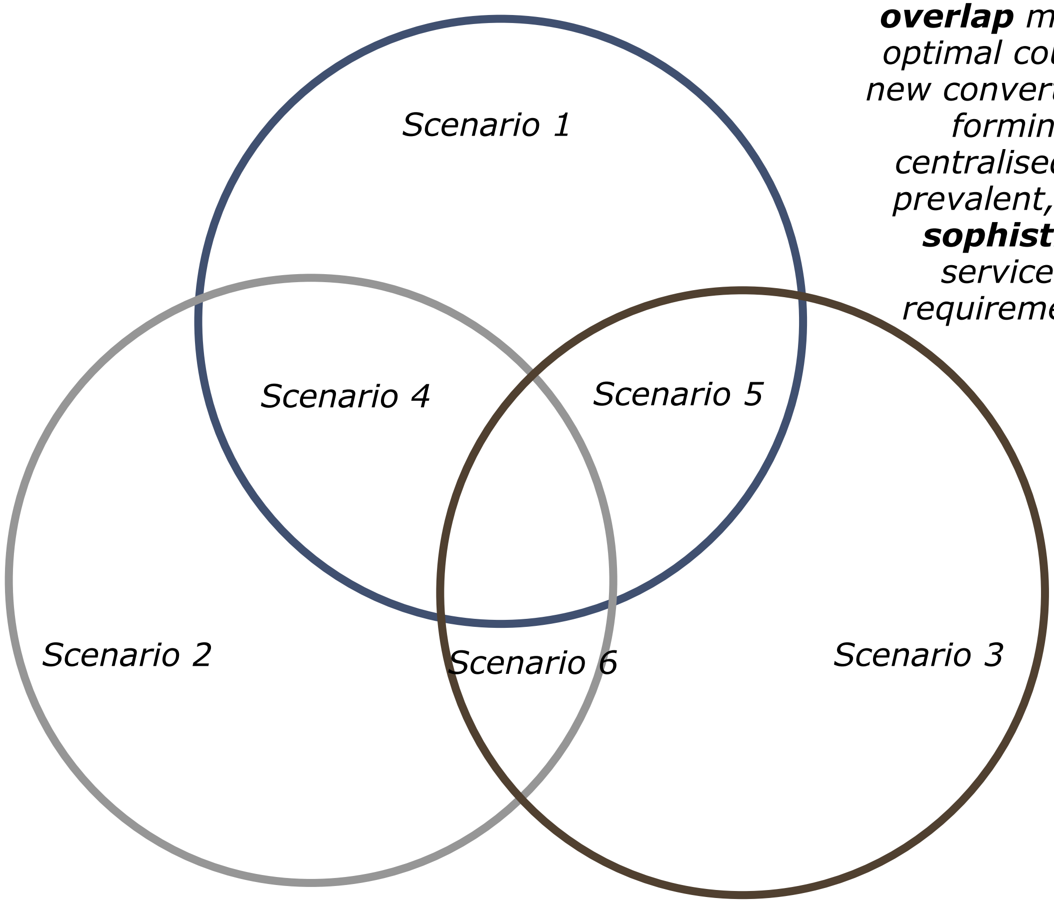
…but these scenarios are not mutually exclusive

Nodal pricing market design

Grid-forming revolution



Recentralisation

The degree to which these scenarios ***overlap*** *may* ***influence decisions*** *on the optimal course of action, for instance if all new converter connected providers had grid forming capability, and new large centralised power stations became more prevalent, there may be* ***less value in a sophisticated approach*** *to stability service procurement and grid code requirements may be sufficient to meet most needs.*

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