National Grid ESO Stability Market Design: Final Outcomes

July 2023

PRESENTATION OF THE FINAL OUTCOMES

Webinar Agenda

ESO is undertaking an innovation project aimed at creating a new marketplace for services to resolve future system challenges with Stability

Context

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

Net-zero & stability require-ments
NG ESO has the ambition to operate a zero-carbon grid. Potential for RES 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 the recommendations for the design of future Stability markets and to enable ESO to commence implementation

Project focus

KEY QUESTION:
What is the ideal design for a stability market that allows ESO to meet its stability requirements whilst making optimal economic decisions and also enabling wide participation with minimal barriers to entry?

PROJECT OBJECTIVES:
- Analyse possible design options for a stability market, to address future growth of requirements for stability
- Evaluate different design models, supported by feedback received from Industry and ESO representatives

PROJECT OUTCOMES:
Provided a recommended market design model for Stability, nailing down eligibility, contract, pricing and product rules under different market timeframes[1]

1. i.e. Long-Term, Mid-Term, Short-Term | SQSS: Security and Quality of Supply Standard; RES: Renewable Energy Sources

Phases 1 and 2 of the project have provided final recommendations for the future Stability market model

Where we are today

Stability Market Design Phase 1 (2021-22)

- Project explored preliminary design options for a Stability market in GB
- High-level design arrangements presented, recommending a blend of ST/LT procurement

Stability Market Design Phase 2 (2022-23)

- Based on Phase 1 preliminary recommendations, Phase 2 has investigated some outstanding design questions (e.g. eligibility rules, contract structures, procurement strategies) providing final recommendation for the future Stability market design

Further developments (2023 and beyond)

- ESO are developing more detailed next steps towards implementation
- This process will include further process mapping activities and stakeholder engagement to fine-tune final market rules
- Mid-Term (Y-1) Stability market will be the first one to be launched, whilst Y-4 and D-1 are progressing in parallel

Stability Market initiation
(launch of Y-1 MT in 2023)

LT: Long-Term; ST: Short-Term; MT: Mid-Term

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Stability is defined by ESO through three products, which address different issues affecting the system

	What it is	Why it matters to National Grid
Inertia	– The system inertia is the kinetic energy stored in the rotors of the synchronous generators – In case of a sudden change in system frequency, these parts will carry on spinning and slow down the change in frequency	– Slows down the rate of change of frequency and allows frequency response to detect and respond to the failure – Allows generators to remain stable and connected to the network
Short Circuit Levels (SCL)	– Short circuit level (SCL) is the amount of current that flows on the system during a fault – SCL is important during such a fault as it helps NG to maintain system voltage	– Low amounts of SCL can lead to bigger disturbances which spreads further due to any voltage change (protections also take longer to operate at low SCL) – SCL is regional, and is expected to decline at different rates across the country
Dynamic Voltage Support (DVS)	– Faults on the system have a combined frequency and voltage effect (interaction between frequency drop/power flow and voltage) – In both cases, the result is an oscillation of power, voltage and frequency. To help reduce the impact of this unwanted effect dynamic voltage support can be used	– Synchronous generation provides more dynamic voltage support than non synchronous generation does – To continue integrating more non synchronous connection, additional dynamic voltage support will be needed

The increased need to manage stability manifests as a result of the decline in synchronous generation and growth of non-synchronous generation

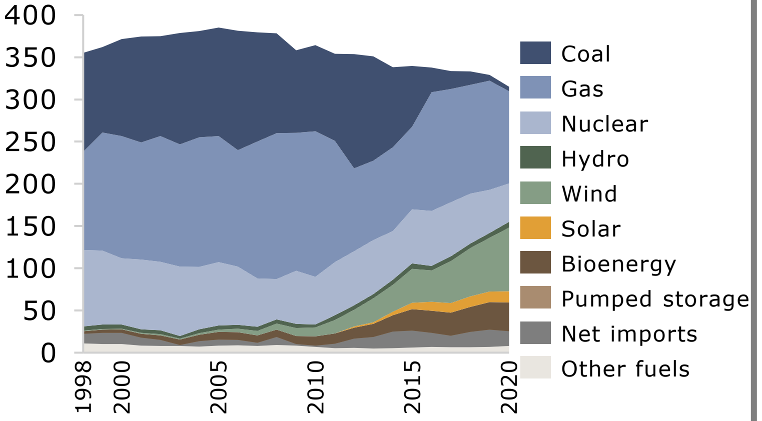
Historical

What happened in the past?

Historically, stability was provided as a by-product of synchronous 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



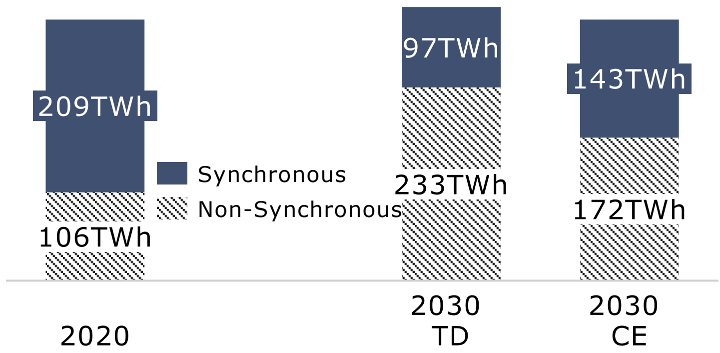
Today

What is happening now?

Rapid growth in renewables, retirement 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



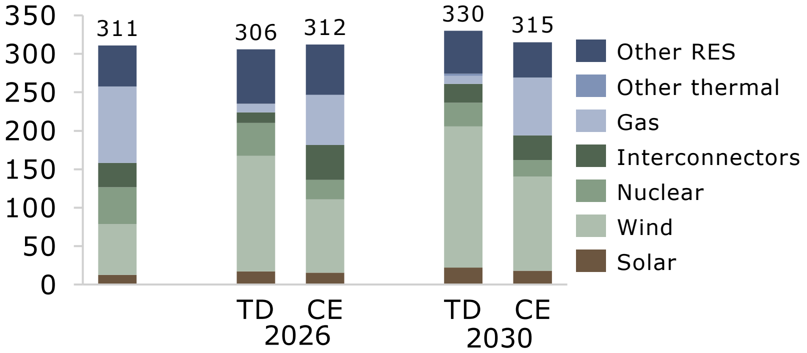
Future

Where is the system going?

Stability requirements will vary significantly under different operational situations within the power system.

When the system is dominated by technologies not inherently capable of providing system stability, ESO will need to procure additional services to meet this shortfall.

Projected generation (FES 2019), TWh



TD: Two Degrees; CE: Consumer Evolution

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Current arrangements procure Stability across several timeframes. However, there are challenges for cost-efficiency and investment signals

Pathfinder contracts

long-term targeted provision[1]

The ESO procures some stability services through 6-10 years Pathfinders contracts.

- The stability Pathfinders have been procuring a number of LT providers, offering a route to market for new & existing solutions in competition with the TO
- A targeted approach accounting for location
- A competitive, but ad-hoc, tender process 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

- Market schedule is determined exogenously to ESO's, being a result of traded positions in wholesale markets
- Some stability services materialise as by-product of generation due to the technical characteristics of certain technologies
- Historically, this was where the majority of stability services[1] would be delivered, but technology shift means that market schedule can no longer provide all/most stability needed

Balancing mechanism

short-term targeted provision[1]

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

- The BM is the primary tool to maintain compliance with physical system needs (e.g. thermal, voltage & stability constraints)[2]
- Procuring stability services through the BM often requires providers to deliver stability whilst generating energy

What is the desired solution for the future?

Legend Passive (+unpaid) | Targeted (+paid)

1. 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; 2. Other direct contracts such as SpinGen also exist but are not widespread | LT: Long-Term; BM: Balancing Mechanism; TO: Transmission Owner

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LT market is designed to underpin investments in Stability, while MT and ST will provide revenue streams for existing units

SKELETON OF STABILITY MARKET DESIGN

		Long Term (Y-4)		Mid Term (Y-1)		Short Term (D-1)
Purpose		– Procure capacity in advance (LT), to fulfil share of total requirements for Stability otherwise likely not to be met at delivery time – Allow financing of new build capacity (and enhanced capability[1]) through LT contracts		– Procure capacity in advance (MT), to adjust LT procurement in case necessary – Allow MT financing of any existing capability able to provide stability (e.g. expired PF contracts, enhanced capability[1])		– Procure capacity to fulfil residual of total requirements for Stability closer to real time (ST) – Allow remuneration of marginal costs for providing Stability at 0MW (proving a change in behaviour)
Eligibility		New build	Enhanced capability[1]	Existing capability		
Timeline	*Procurement lead time*	– Y-4		– Y-1		– D-1
	Contract duration	– 10y+ for new build; 3y for enhanced capability[1]		– 1 y		– Service windows
Product	*Contract type*	– Baseload availability		– Baseload availability		– 4 h (EFA blocks)
	Contract obligations	– e.g. 90% availability		– e.g. 90% availability		– 100% availability
Pricing		*Availability payment*	*Delivery payment*	*Availability payment*	*Delivery payment*	*Delivery payment (avail. paym. embedded)*
	Payment type	– £/MW.s/h	– £/MW.s/h	– £/MW.s/h	– £/MW.s/h	– £/MW.s/h
	Price mechanism	– Pay-as-bid	– Pay-as-bid	– Pay-as-bid	– Pay-as-bid	– Pay-as-clear

1. Existing assets with additional investments to provide incremental Stability | PF: Pathfinder; SP: Settlement Period; LT: Long-Term; MT: Mid-Term; ST: Short-Term

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Analysis and recommendations for selected topics of interest addressed during Phase 2 of the project will be presented today

QUESTIONS ADDRESSED ON SELECTED TOPICS OF INTEREST WITHIN PROJECT PHASE 2

ELIGIBILITY MODEL:

- *How do we define incremental investment, incremental capabilities and existing capabilities?*
- *Can existing capability enter the LT market?*
- *How do we enforce the selective eligibility for the ST market?*

PAYMENT MODEL:

- *What contract resolution should we choose for the ST market?*
- *Should we have a utilisation payment for the services in the LT, MT and/or ST markets?*

TO PARTICIPATION MODEL:

- *What are the key considerations for treatment of the TO assets?*
- *What is the role of the TO in the LT market?*
- *How is depreciation of TO assets assessed in a competitive market?*

ESO will publish the detailed analysis and recommendations for all the exam questions on its Stability Market Design webpage

TO: Transmission Owner; LT: Long-Term; MT: Mid-Term; ST: Short-Term

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ELIGIBILITY RULES: PROCUREMENT APPROACH

Net procurement through shortfall and opportunistic buying is the desired approach, meeting system needs while optimising costs

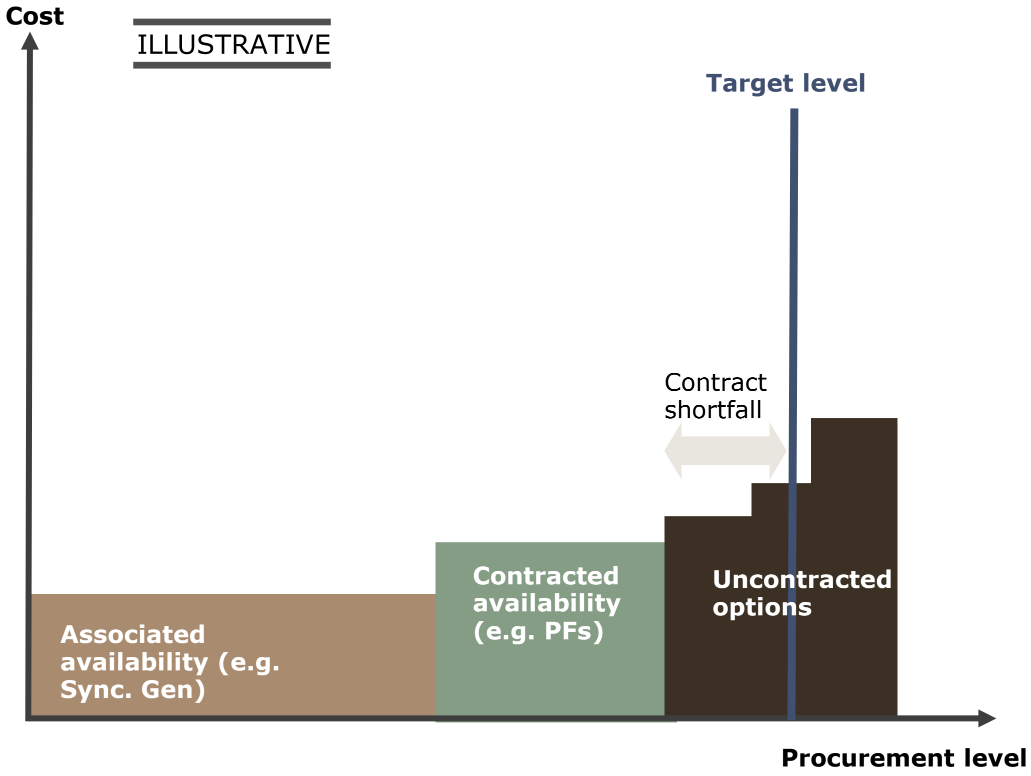
'PAY FOR ADDITIONALITIES' MODEL

- Treating the stability market as a substitute for BM activity, which will keep a minor role in the procurement
- Payment principle is to "*pay for action*", rewarding only those providers willing to change their behaviour ('**net procurement**') in order to:
  1. Maintain the incentive to provide stability services
  2. Minimise windfall gains
- Trading strategy can be undertaken under different (and complementary) approaches in all market timeframes:

Shortfall: procuring only the minimum capacity to meet target level
→ ***Principle:*** *buy now before it is too late*

Opportunistic: procuring to minimise costs compared to counterfactual (i.e. avoiding more expensive solutions at later timeframes)
→ ***Principle:*** *buy when it is cheapest*

ILLUSTRATIVE REPRESENTATION OF PROCUREMENT STRATEGY



BM: Balancing Market; PF: Pathfinder

GENERAL SELECTIVE CHARACTERISTICS RULES

The Long-Term market will allow ESO to fulfil Stability shortfalls over long periods through either new or incremental capability

LT Market	New build	Enhanced capability
Eligibility conditions	– New assets with capability to provide stability at 0MW – Must meet availability requirements	– Existing assets undertaking additional investments to provide incremental or enable 0MW stability – Must meet availability requirements
Expected participating solutions	New non-synch. gen. with GFC[1] New non-synch. storage with GFC New synchronous condenser[2]	Existing non-synch. gen. with new GFC[1] Existing non-synch. storage with new GFC Existing synch. condenser with new flywheel Existing synch. gen. with new clutch
Contract length	10+ years	3 years
Lead time	Y-4	Y-4 (units could have early start option with conditions)

Logic behind the market?

	New build	Enhanced capability
ESO	Procures necessary capacity (shortfall) in case of long requirements periods	Mitigates risk to lock capacity for too long periods when not necessary
Providers	Better matches investment profile of a completely new asset	Better matches investment profile of retrofitting existing plants[3]

1. And potentially equipped with additional storage as well; 2. Potentially equipped with a flywheel storage as well | GFC: Grid Forming Converter; LT: Long-Term

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GENERAL SELECTIVE CHARACTERISTICS RULES

The Mid-Term market allows ESO to adjust residual shortfalls on a yearly basis and providers to finance residual costs of existing assets

MT Market	**Existing capability**	
Eligibility conditions	– Any existing assets able to provide stability at 0MW (e.g. expired PF contracts) – Must meet availability requirements	
Expected participating solutions	Existing non-synch. gen. with GFC[1] Existing non-synch. storage with GFC	Existing synchronous condenser[2] Existing synch. gen. with clutch
Contract length	1 year	
Lead time	Y-1	

Logic behind the market?

ESO
– Mitigates risk to lock capacity for too long periods when not necessary
– Secures (potentially cheap) capacity otherwise closing[3]

Providers
– Allows financing of residual fixed costs of existing plants[4]

1. And potentially equipped with additional storage as well; 2. Potentially equipped with a flywheel storage as well; 3. e.g. Synchronous generation units otherwise closing; 4. Expired Pathfinders contract units | GFC: Grid Forming Converter; PF: Pathfinder; MT: Long-Term

GENERAL SELECTIVE CHARACTERISTICS RULES

The Short-Term market will allow ESO to refine its procurement on a D-1 basis, using the Balancing Mechanism as backstop at real-time

ST Market	Existing capability
Eligibility conditions	– Any existing assets able to provide stability at 0MW (e.g. expired PF contracts) – Must meet availability requirements
Expected participating solutions	Existing non-synch. gen. with GFC[1] Existing synchronous condenser[2] Existing non-synch. storage with GFC Existing synch. gen. with clutch
Contract length	4h - EFA blocks
Lead time	D-1

Logic behind the market?

ESO

– Mitigates risk to lock capacity for too long periods when not necessary
– Procures D-1 residual needs when necessary

Providers

– Most suitable way to market for existing plants characterised by relatively high variable costs
– Preferable way for those providers not be able to commit for long periods (i.e. years in LT/MT)

1. And potentially equipped with additional storage as well; 2. Potentially equipped with a flywheel storage as well | GFC: Grid Forming Converter; PF: Pathfinder; ST: Short-Term; LT: Long-Term; MT: Mid-Term

Eligibility model

CONTRACT RESOLUTION

Contract lengths have been designed in order to match both ESO procurement requirements and risk appetite of different providers

	Long-Term		Mid-Term	Short-Term
Expected market participants	New build	Enhanced capability	Existing capability	
Contract lengths	10+ years	3 years	1 year	4h - EFA blocks
Rationale behind contract length – ESO	– Secure capacity with high availability when Stability needs are forecasted for long periods	– Optimises procurement costs over limited periods of needs (3y)	– Optimise procurement costs over limited periods of needs (1y) – Secure (potentially cheap) capacity otherwise closing[2]	– Procure D-1 residual needs when necessary
Rationale behind contract length – *Providers*	– Better match investment profile and asset lifetime of a new asset	– Better match investment profile of retrofitting an existing plant[1]	– Allow financing of residual fixed costs of existing plants[3]	– Way to market for units not willing to commit for long periods[4]

1. One year contract is likely to be not sufficient to support investments such as e.g. grid forming converters or clutches; 2. e.g. Synchronous generation units otherwise closing; 3. Expired Pathfinders contract units; 4. e.g. non dedicated battery storage, willing to stack Stability with other sources of revenues

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TIMELINE ON EVALUATION OF UNITS WITHIN THE STABILITY MARKETS

We recommend a two-part payment structure to reflect provider costs, allowing ESO to use units in a cost-effective manner

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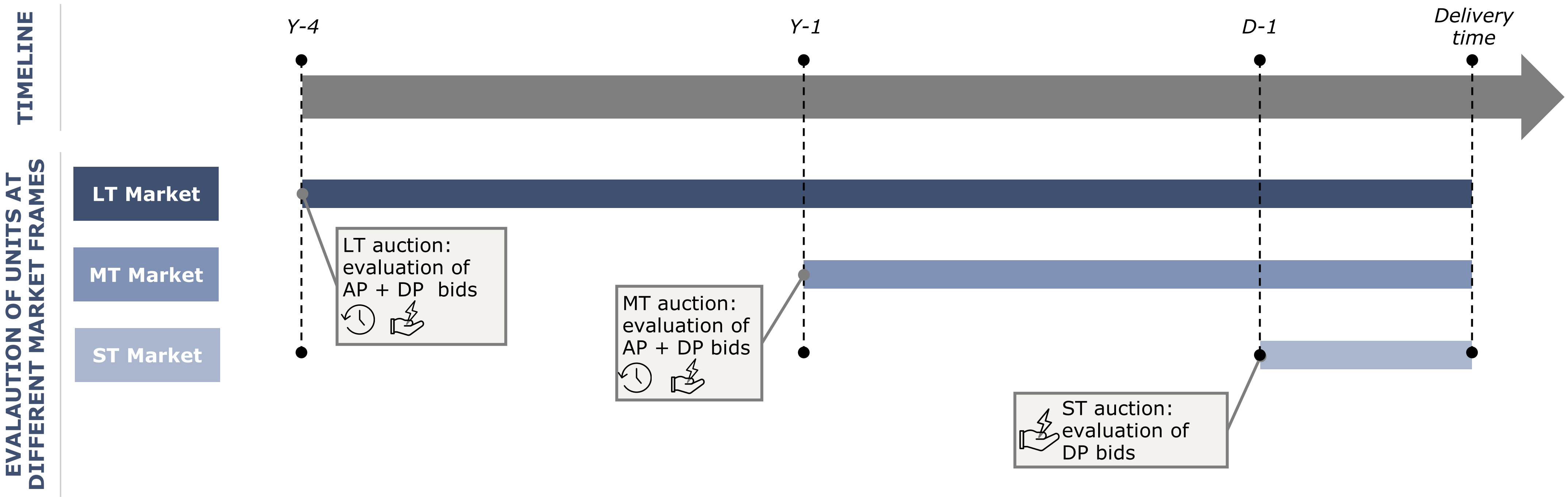
EVALUATION OF UNITS WITHIN STABILITY MARKETS



Definitions of payment components

Availability Payment (AP): offer for being 'active' and available to provide Stability at later timeframes. Embeds cost opportunity of not participating in other markets

Delivery Payment (DP): offer for delivering Stability as instructed by ESO. Embeds marginal costs (e.g. energy consumptions) to deliver the service and possibly opportunity costs in case of ST contract

DP: Delivery Payment; AP: Availability Payment LT: Long-Term; MT: Mid-Term; ST: Short-Term

Legend *Time period between procurement and actual delivery of stability – varies by market timeframe* *Availability payment* *Delivery payment*

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EVALUATION OF MODELS

Payments are a blend of pay-as-bid for LT and MT markets (two-part payments) and pay-as-clear for ST market (delivery payments only)

	LT Market	MT Market	ST Market
Availability payment	– £/MW.s/h – Pay-as-bid – Selection through LT auction (Y-4) – Adjusted yearly (e.g. indexed to CPI)	– £/MW.s/h – Pay-as-bid – Selection through MT auction (Y-1)	– *N.a. (effectively embedded in DP)*
Delivery payment	– £/MW.s/h – Pay-as-bid – DP is fixed at contract signature and adjusted (e.g. function of spot energy prices and/or indexed to annual CPI)	– £/MW.s/h – Pay-as-bid – DP is fixed at contract signature and adjusted	– £/MW.s/h – Pay-as-clear – Selection through ST auction (D-1)

LT, MT and ST offers for the DP are evaluated together to determine the units to select close to real time

LT: Long-Term; MT: Mid-Term; ST: Short-Term; AP: Availability Payment; DP: Delivery Payment; SBP: System Buy Price (Imbalance Price); CPI: Consumer Price Index

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FINAL MODEL TO PARTICIPATION IN LT

As in Pathfinders, TOs will provide a counterfactual for evaluation of LT market, but under a longer evaluation period (10+ years)

Initial situation

- During Stability Pathfinder, TOs participated indirectly in LT auctions, by providing a counterfactual
- A similar approach has been considered for the LT Stability market

Possible changes of the status quo

- In the PF methodology TOs are assumed to recover their full costs over the tender period, without considering a residual value afterwards. This could result in low competitive pressure applied on the commercial providers[1]
- For this reasons alternative models (based on the current Pathfinder one) have been appraised

Recommended model for TOs within Stability LT auction

- The recommended model confirmed PF methodology, but with a longer evaluation period where possible and so also longer contracts (10+ years)
- This would allow commercial providers to evaluate costs over a period closer to the actual technical (and useful) life of their assets

1. Who may assume some residual value | TO: Transmission Owner; LT: Long-Term; PF: Pathfinder

Agenda

Preliminary MT market for existing capability would provide the necessary price signals for the future Stability Market

EVOLUTION OF THE STABILITY MARKETS

Today
(Stability Pathfinder)

Stability Pathfinder

Stability Pathfinder contracts will gradually terminate

Short term horizon – ***late 2023***
(preliminary Stability Market)

MT MARKET (Y-1)

ESO MT procurement to fulfil Stability residual needs over 1y horizon

Way to market for units such as expired PF and other additional existing plants to secure fixed remuneration for 1y

Mid term horizon – ***TBC***
(fully operational Stability Markets)

LT MARKET (Y-4)

ESO Procure Stability over longer periods based on LT forecast of needs

Way to market for new investments, willing to commit for long periods

MT MARKET (Y-1)

ESO MT procurement continues to fulfil Stability in case needs will change

Way to market for existing assets willing to secure 1y contracts

ST MARKET (D-1)

ESO Fulfil Stability shortfall at D-1 stage when necessary

Way to market for those units not willing to commit for longer periods[1]

Note*: the BM will continue to the be the mechanism to procure Stability in case of shortfall close to real-time. This will be always optimised with alternative actions (e.g. ST procurement)*

1. e.g. non dedicated battery storage, willing to stack revenues from multiple sources | PF: Pathfinder; LT: Long-Term; MT: Mid-Term; ST: Short-Term; BM: Balancing Mechanism

Legend *Market evolving to* *Perspective:* ESO *NG ESO* *Providers*

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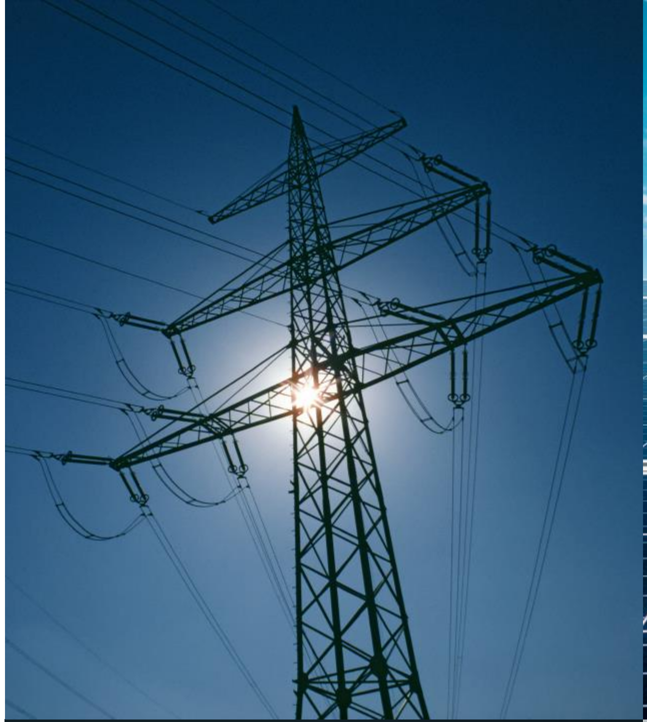
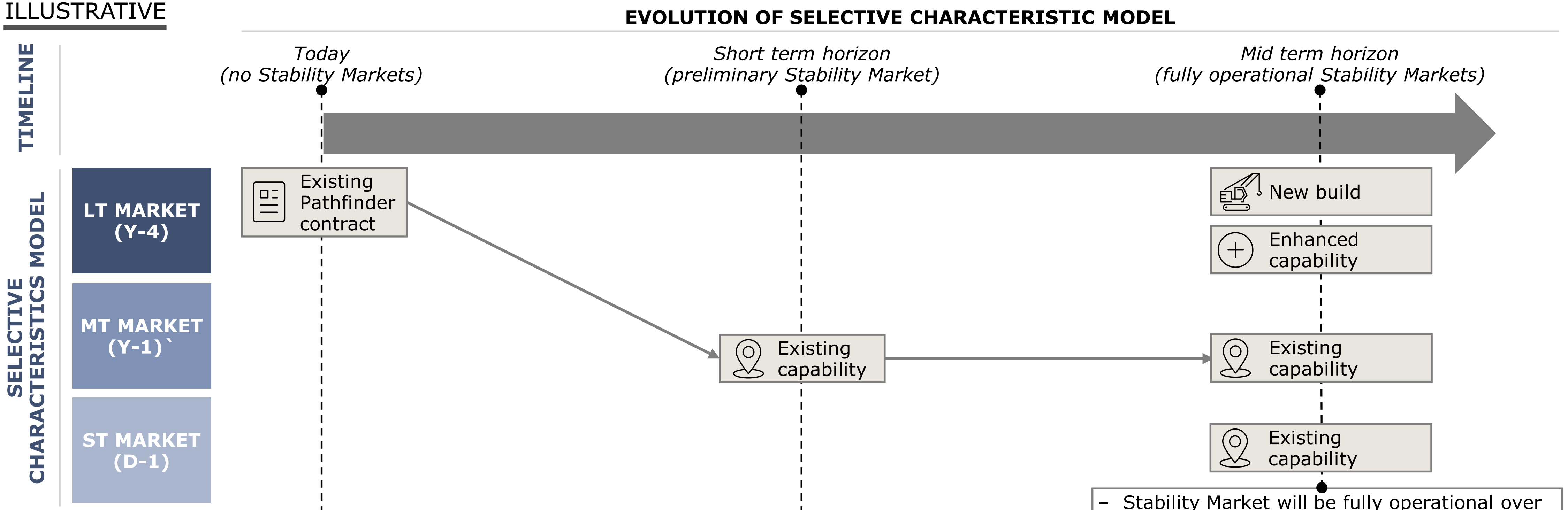



Agenda

Preliminary MT market for existing capability would provide the necessary price signals for the future Stability Market

ILLUSTRATIVE



- As of today, only Pathfinder contracts available for LT procurement of Stability

- Expired PF contracts as well as any existing asset able to provide stability can compete for a 1y contract (Y-1 procurement)
- Allows the necessary price signal formation for future providers to evaluate investments in Stability

- Stability Market will be fully operational over the LT/MT/ST timeframes
- Existing assets can participate to either MT or ST markets according to their risk appetite
- At that time, market rules for enhanced capability should be established (i.e. contract length, procurement period, session)

PF: Pathfinder; LT: Long-Term; MT: Mid-Term; ST: Short-Term

Legend → *Market evolving to*

Eligibility over the different timeframes is based on provider status, 0MW capability and change in behaviour

'PAY FOR ADDITIONALITIES': SELECTION CRITERIA FOR STABILITY

Selective characteristics

Selection criteria are defined by provider status:

Incremental investment:
- New build – in LT market

Incremental capability:
- Enhanced capability: significant investment in existing plants to enable or enhance 0MW stability provision – in LT market
- Existing assets undertaking additional (likely minor) investments and willing to receive a 1y contract or in alternative participate in ST – in MT or ST markets

Existing capability:
- Any existing capacity: e.g. expired Pathfinders, plants otherwise closing – in MT or ST markets

Selective characteristics take primacy over selective payment

Selective payment

Those units having a MT/LT contract and those participating to the ST can be selected at D-1 stage and paid for activation if they fulfil:

Technical conditions to deliver the service at the relevant time: operationally, unit needs to have necessary configuration/activation to provide the stability service

D-1 indication of intention to meet condition to deliver the service: eligibility model[1] for:
- Synch. gen. capable of providing 0MW[2] service
- Non synch. generation/storage units
- Synch. 0MW units (e.g. synchronous condenser)

ST market preferable procurement route compared to other intraday alternatives: e.g., evaluate possibility to procure through BM if cheaper

If compliant with the above criteria (and selective characteristics), units can be procured under complementary ***procurement strategies*** *in all market timeframes:*

Shortfall procurement AND *Opportunistic procurement*

1. Model 3.b '*Option to forego payment*'; 2. e.g. equipped with clutch, which intend to operate at 0MW unless otherwise instructed | BM: Balancing Market; ST: Short-Term; MT: Mid-Term; LT: Long-Term

GENERAL SELECTIVE CHARACTERISTICS RULES

Under 0MW and change in behaviour principles, synch. gen. would be eligible only if capable to provide 0MW service (dedicated clutch or switching mode)

PARTICIPATION MODEL

	Long Term		Mid Term	Short Term
Expected market participants	New build	Enhanced capability	Existing capability	
Conditions for eligibility	– New assets with capability to provide stability	– Existing assets undertaking additional investments to provide incremental/allow 0MW stability	– Existing assets with capability to provide stability	
	– Only synch. 0MW, storage and non-synch. gen. units eligible – Must meet availability requirements			
Contract lengths	10+ years	3 years	1 year	4h - EFA blocks
Lead time	Y-4	Y-4 (units could have early start option with conditions)	Y-1	D-1

SHORTFALL VS OPPORTUNISTIC PROCUREMENT

Opportunistic procurement would allow procurement at D-1 if expected to be cheaper than BM, while shortfall procurement will fulfil the residual need

ILLUSTRATIVE REPRESENTATION OF SHORTFALL AND OPPORTUNISTIC PROCUREMENTS AT D-1 STAGE

Flow of the procurement process

Market sizing illustrative only

Total requirement for stability at D-1 stage

Short term market supply

LT/MT market (already procured)

Gap between LT/MT and ST (D-1 need to be procured)

- Total shortfall of Stability to be procured at D-1/BM

Total unfulfilled shortfall in ST market

Scheduled synch. gen. with MW

- (Expected) scheduled synchronous generators determined to adjust total procurement volumes

Not scheduled – not avail. in BM (i.e. stability not bundled with MW)

Not scheduled – avail. in BM

Scheduled synch. gen. with MW

- Distinction by resources available/ not available in BM within remaining ST market supply

Exceeded volume & uneconomic (reject)

Must be bought due to shortfall — *Shortfall procurement*

More economic than at later timeframe — *Opportunistic procurement*

Scheduled synch. gen. with MW — ***Scheduled in BM***

Opportunistic procurement[1]

- Scheduling available resources in BM expected to be cheaper than in ST
- Buying volumes during ST rather than BM, if expected to be cheaper (*opportunistic proc.*)
- Buying volumes to meet residual shortfall (*shortfall proc.*)
- Remaining ST market supply is rejected as exceeding total requirements and uneconomic

Definitions of procurement strategies

Shortfall: procuring only the minimum volumes to meet SQSS (after having considered already scheduled synch. gen. units)
- ***Principle:*** *buy now before it is too late*

Opportunistic: procuring to minimise costs compared to counterfactual (i.e. avoiding more expensive solutions at later timeframes – e.g. BM vs ST market)
- ***Principle:*** *buy when it is cheapest*

1. Opportunistic based on delivery price – some short term providers may be accepted if/when cheaper than delivery from long term procured capacity | LT: Long-Term; MT: Mid-Term; ST: Short-Term; BM: Balancing Market; SQSS: Security and Quality of Supply Standard

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Legend Shortfall procurement Opportunistic procurement

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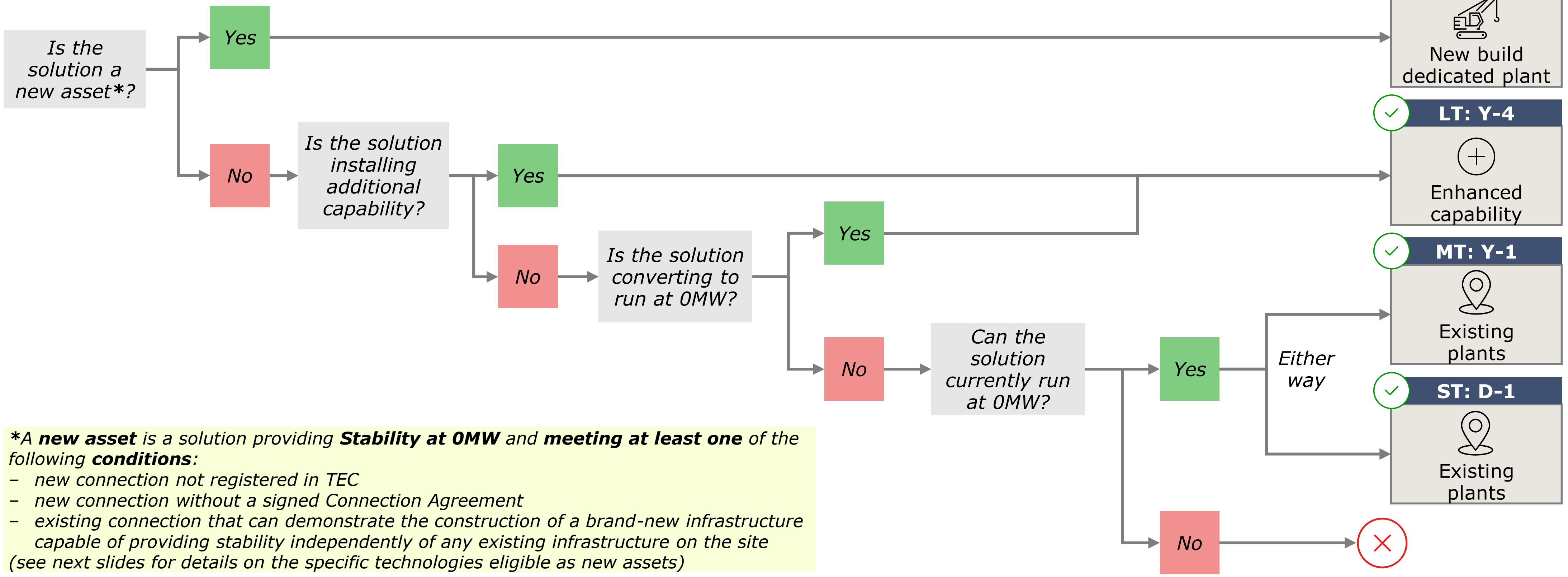
ELIGIBILITY RULES: NEW BUILD VS. ENHANCED CAPABILITY

New assets would be eligible for LT contracts as ‘new build’, while existing ones providing additional capability as ‘enhanced capability’

SELECTIVE CHARACTERISTICS ELIGIBILITY RULES FLOWCHART

Note: *the flowchart considers the eligibility rules as well as the expected preference of providers to participate to a certain market. In principle, all types of solutions (including e.g. new dedicated plants and enhanced capability) are always eligible for MT and ST markets.*



A new asset* is a solution providing ***Stability at 0MW* *and* ***meeting at least one*** *of the following* ***conditions****:*

- *new connection not registered in TEC*
- *new connection without a signed Connection Agreement*
- *existing connection that can demonstrate the construction of a brand-new infrastructure capable of providing stability independently of any existing infrastructure on the site*

(see next slides for details on the specific technologies eligible as new assets)

LT: Long-Term; MT: Mid-Term; ST: Short-Term; TEC: Transmission Entry Capacity

Legend *Eligible*

ELIGIBILITY CRITERIA FOR NEW BUILD

Only dedicated units, able to meet LT availability obligations and not bound by other regulated commitments would be eligible for 10+ year contracts

New build

- Assets need to be able to provide Stability through dedicated products (e.g. not as a by-product of MW generation)
- In case of providers capable to switch their MW contribution when providing Stability (e.g. CCGT with clutch), they should demonstrate the asset would have not otherwise been built without the support of a Stability LT contract (i.e. need to demonstrate a change in behaviour)

- Assets need to meet LT availability requirements for Stability (e.g. 90%)

- Assets shall not be committed to regulated (or semi-regulated) regimes (e.g. OFTO regimes) already covering assets' costs and imposing availability obligations incompatible with Stability ones

CCGT: Combined-Cycle Gas Turbine; LT: Long Term; OFTO: Offshore Transmission Owner

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ASSESSMENT OF TECHNOLOGIES FOR ELIGIBILITY AS NEW BUILD

According to the specified eligibility criteria, only non-synch. gen., storage, and synch. 0MW units would be eligible as new build (Y-4)

New build

ELIGIBILITY OF NEW BUILD PROVIDERS FOR LT CONTRACT

	ELIGIBLE PROVIDERS	NON-ELIGIBLE PROVIDERS
Technologies	**Sync. 0MW**: Sync. Cond.; Synch. gen. with 0MW capabilities **Storage**: Batteries/ supercapacitor **Non-sync. gen.**: Offshore wind; Onshore wind; Solar PV	**Sync. gen.**: CCGT/OCGT; Nuclear; Biomass; Hydro/ Pump. stor. **Non-sync. transm.**: HVDC (OFTO/IC)
Motivations for eligibility/ ineligibility	All above-mentioned providers: Able to provide product dedicated only for Stability (not a by-product of MW generation) Potentially able to meet LT availability requirements (e.g. 90%). *Question if technically feasible for non synch. gen. plants* Eligible when not committed to other regulated/semi-regulated regimes	<u>Synch. gen.</u>: assets not dedicated only to provide Stability (MW by-product). Even when equipped with clutch, complex to demonstrate a change in behaviour (i.e. that the synch. gen. plant would have not otherwise been built without the support of a Stability LT contract) <u>Non-synch. transmission</u>: commitment to regulated/semi-regulated regimes for most of OFTOs/ICs. Potential incompatibility with availability requirement s for stability

Legend *Eligibility criteria:* *Dedicated assets* *Meet availability requirements* *No other regulated commitments* *Criteria not met*

CCGT: Combined-Cycle Gas Turbine; OCGT: Open-Cycle Gas Turbine; LT: Long-Term: MT: Mid-Term; PV: Photovoltaics; HVDC: High-Voltage Direct Current; OFTO: Offshore Transmission Owner; IC: Interconnector

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Selective characteristics | Selective payment | **LT Market (Y-4)** | MT Market (Y-1) | ST Market (D-1)

DEDICATED ASSET CRITERIA

Even when equipped with clutch, sync. gen. is not eligible as a dedicated asset in LT market as not providing additional Stability.

New build – Technologies		Additional equipment	Criteria for dedicated assets: Provide additional Stability[1]	Criteria for dedicated assets: Provide Stability as dedicated product	Criteria for dedicated assets: Prove change in behaviour	Eligibility as dedicated assets
CCGT/OCGT; Nuclear; Biomass; Hydro/ Pump. stor.	Sync. gen.	Clutch (able to provide stability at 0MW)	✗ Can provide at least the same amount of Stability of the standard design	✓ Able to switch in declutched mode, providing stability without injection of active power	✓ Activate clutch to provide Stability, foregoing potential MW revenues	As not meeting additionality criteria
		N.a. - standard design (always provide stability as by-product of MW generation)	✗ Already providing Stability during traditional MW functioning	✗ Providing Stability as by-product when injecting active power	✗ No substantial proof that the plant would not otherwise generate	As not meeting any of the criteria
Offshore wind; Onshore wind; Solar PV	Non-sync. gen.	Grid-forming converter[2]	✓ Will provide additional Stability thanks to additional equipment (grid-forming converter)	✓ Stability as dedicated product, not served for other purposes	✓ Activate grid forming to provide Stability	As meeting all the criteria
Batteries/ supercapac.	Storage	Grid-forming converter[2]	✓ Same as non-synch gen.	✓ Same as non-synch. gen.	✓ Same as non-synch. gen.	As meeting all the criteria
Sync. Cond.	Sync. 0MW	Flywheel[3]	✓ Provide more stability than in standard design	✓ Same as non-synch. gen	✓ Synchronise to provide stability	As meeting all the criteria
		N.a. - standard design	✓ No other purposes out of Stability	✓ Same as non-synch. gen	✓ Synchronise to provide stability	As meeting all the criteria

Note: Transmission assets contemplated – potentially eligible as dedicated assets, but complicated to participate to Stability due to their regulated frameworks. Non-sync. gen. and storage without grid-forming converter not contemplated as not able to provide inertia by definition | 1. Compared to standard functioning (e.g. CCGT without clutch, Onshore Wind without grid-forming converter); 2. To allow providing Stability services; 3. To allow providing extra Stability

Legend — *Meeting criteria for dedicated assets:* ✓ *Criteria met* ✗ *Criteria not met* — *Overall eligibility as dedicated asset:* *Eligible* *Non-eligible*

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ELIGIBILITY RULES: NEW BUILD VS. ENHANCED CAPABILITY

Investment options eligible for LT, MT and ST contracts

Expected participating solutions	Selective characteristics		
	Long-Term		**Mid-Term/Short-Term**
	New build	*Enhanced capability*[1]	*Existing capability*
Technologies			
Sync. gen. – CCGT/OCGT – Biomass – Nuclear – Hydro/ Pump. Stor.	*Not eligible*	Clutch[2] Partial refurbishment[3]	*No additional investment required (assuming the solution is already capable of providing Stability at 0MW)*
Non-sync. gen. – Offshore w. – Solar PV – Onshore w.	Non-synch. gen. + Grid forming converter Non-synch. gen. + Grid forming converter + Storage	Grid forming converter[2] / Storage[2] Partial refurbishment[3]	
Storage – Batteries – Supercapacitors	Storage + Grid forming converter	Grid forming converter[2] Partial refurbishment[3]	
Sync. 0MW – Synchronous Condensers	Synch. cond. Synch. cond. & Flywheel	Flywheel[2] Partial refurbishment[3]	

1. For each of the technologies, the combination of the presented options is also eligible as 'enhanced capability'; 2. Installed on existing plant; 3. If refurbishment allows to increase capability of an existing plant (through e.g. increase of maximum capacity)

SELECTIVE PAYMENT: SELECTION PROCEDURE

Eligibility for the ST market under selective payment criteria requires a change in behaviour to provide stability services

Selective payment (at D-1 stage for LT/MT/ST units)

If units compliant with previous conditions

		Technical conditions to deliver the service at the relevant time	*D-1 indication of intention to meet condition to deliver the service*	*ST market preferable proc. route compared to other ID alternatives*	*Activation through change of behaviour*
Generation/storage units	Synchronous (e.g. CCGT, nuclear) with 0MW capabilities	– To be synchronised with clutch activated – For inertia provision, available to provide energy if required by ESO	– ESO **forecasts units intended to anyway generate** and withholds stability payments from those offering FPN>0 post-event	– Evaluate if procurement in SM is cheaper than BM	– Unit instructed to synchronise and activate clutch – For inertia provision, provide energy if required by ESO
Generation/storage units	Non-synchronous (e.g. Wind, PV, Battery) with grid-forming	– Grid forming activated – For inertia provision, available to provide energy (from RES plant or battery) if required by ESO	– No info on grid-forming status available to ESO – Assumed **always eligible** as they will not otherwise offer capability unless contracted[1]	– No routes other than Stability Market[2]	Unit instructed to: – Activate grid-forming – For inertia provision, provide energy (from RES plant or battery) if required by ESO
0MW units	Synchronous (e.g. condensers) 0MW units	– To be synchronised/grid forming activated – For inertia, rotating mass (e.g. flywheel) available to provide energy if required by ESO	– No info on synchronisation/grid forming status available to ESO – Assumed **always eligible** as they will not otherwise offer capability unless contracted[1]	– No routes other than Stability Market	Unit instructed to: – Synchronise/enable grid forming – For inertia provision, provide energy source through activation of rotating mass if required by ESO

Alternative investigated models shown in the next slides

1. Possible exception: if unit is already contracted under Reactive Power LT contract, remuneration for SCL and DVS provision under Stability Market would be denied; 2. Possible exception: in case unit is called in BM and grid-forming activated, it could deliver inertia service as a by-product of energy provision | CCGT: Combined Cycle Gas Turbine; PV: Photovoltaics; RES: Renewable Energy Sources; PN: Physical Notification; FPN: Final Physical Notification; SM: Stability Market; TO: Transmission Owner; SCL: Short Circuit Level; DVS: Dynamic Voltage Support; ID: Intra-Day

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SELECTIVE PAYMENT – WORKING MODELS

Several working models to select units eligible for stability payment have been investigated and few of them shortlisted based on their feasibility

Core models	Sub models	Approaches for indication of intention: Synch. generation units	Approaches for indication of intention: Synch. 0 MW, non-synch.[1] gen./stor. units
1. 'D-1 indication by ESO/units'	1.a 'ESO forecast'	Based on D-1 ESO forecasts, exclusion of units that would anyway generate and so provide stability as by-product	No indication needed - always eligible as assumed to not otherwise offer stability unless contracted
	1.b 'PN/self-declaration by unit'	Selection of only units providing PN=0 (or through self-declaration that unit does not intend to generate)	
2. 'Segmented eligibility'		Exclusion of 'baseload' units, defined by ESO as e.g. those with a historical pattern of synchronised operating hours higher than e.g. 80% in the relevant season	
3. 'Focus on 0MW synch. gen.'	3.a 'Commitment to submit FPN=0MW'	Eligibility restricted to units with capability to provide 0MW service (e.g. equipped with clutch) and committed to offer FPN=0MW[2]	
	3.b 'Option to forego payment'	Eligibility restricted to units with capability to provide 0MW service (e.g. equipped with clutch). In case units offer FPN>0MW, they are forced to forego stability revenues[2]	
	3.c 'No need to forego payment'	As per model 1.b (PN=0 or self-declaration), but units do not forego stability payment if they end up self-dispatching for energy (FPN>0MW)	
	3.d 'Gross procurement'	Gross procurement of resources, but payment for stability restricted only to those units offering FPN=0 (e.g. being equipped with clutch)[2]	
4. 'Allowing SEL'		Synch. gen. units receive Stability payment only if operating at or below their pre-declared Stable Export Limit (SEL). In case units offer FPN>SEL, they are forced to forego stability revenues[2]	

1. Equipped with grid-forming; 2. Exception if instructed by ESO to generate | PN: Physical Notification; FPN: Final Physical Notification; ID: Intraday; ST: Short-Term; SEL: Stable Export Limit

Legend Short-listed models

SELECTIVE PAYMENTS MODELS – COMPARISON AND OF FILTERED MODELS AND RECOMMENDATIONS

Short-listed models have been assessed under efficiency, competition and applicability criteria. Model promoting 0MW service has been recommended

COMPARISON OF SHORTLISTED OPTIONS

Criteria of comparison	3.b 'Option to forego payment' (Preferred model)	3.c 'No need to forego payment'	4 'Allowing SEL'
Efficiency - minimising costs for consumers	Level: Medium/High – Reduce the amount of units potentially making windfall gains (i.e. by not rewarding synch. units without clutches) – However, it might create distortions in ID market, as cost opportunity from stability ST market might reduce participation of units in ID	Level: Medium/Low – Increase the possibility for units to make windfall gains (i.e. receiving stability payment when anyway intended to generate) – Efficiency could raise if trading energy (as well as Stability) could be beneficial to the system (e.g. lower energy prices)	Level: Medium – Partly reduces the amount of units potentially making windfall gains when intending to run for energy (i.e. by not rewarding synch. units operating at >SEL) – However, as stability is provided as well as MW, other actions (bids) may be required on cheaper generation.
Competition level - opening to wide range of players	Level: Medium/High – Market excludes participation of traditional synch. units but allows them to invest in clutches (and so participate to the markets) through LT contracts	Level: Medium/High – Market excludes participation of traditional synch. units but allows them to invest in clutches (and so participate to the markets) through LT contracts	Level: High – Enhanced competition in stability markets by encouraging broader participation (i.e. market now open also to non-0MW synch. gen.)
Simplicity - ease of implementation	Level: Medium/High – Based on information provided by units (i.e. FPN) – However, FPN verification process[1] and settlement add an additional level of complexity for ESO	Level: High – Based on information provided by units (i.e. FPN) – Effectively no need for ESO to verify FPN=0	Level: Medium – Based on information provided by units (i.e. FPN) – However, FPN verification process[2] and settlement add an additional level of complexity for ESO – SEL parameter may be difficult to define as by nature it is 'dynamic'

1. i.e. Checking those units with FPN>0 and forcing them to forego the payment; 2. i.e. Checking those units with FPN>SEL and forcing them to forego the payment | PN: Physical notification; FPN: Final Physical Notification; LT: Long-Term; MT: Mid-Term; ST: Short-Term; ID: Intra-Day; CCGT: Combined-Cycle Gas Turbine; SEL: Stable Export Limit

Legend *Level:* *High* *Medium* *Low* Preferred model

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SELECTIVE PAYMENTS APPROACHES – APPRAISALS OF FILTERED MODELS

Each of the three filtered models for selective payment will bring pros and cons

APPRAISAL OF FILTERED MODELS

	3.b 'Option to forego payment'	3.c 'No need to forego payment'	4 'Allowing SEL'
Advantages	– Indications based on information (capability to provide 0MW and FPN=0) provided by the synch. units – Reduce the amount of units potentially making windfall gains (i.e. by not rewarding synch. units without clutches) – Synch. units still able to operate in the ID by providing FPN>0 (foregoing the stability payment) if perceived more convenient	– Indications based on information (only capability to provide 0MW) provided by synch. units – Allows total flexibility for synch. gen. to stack revenues from wholesale market if valuable for the system – Better incentives for bidding into wholesale market (however this could possibly increase costs if units do not bid transparently by discounting price based on stability payment) – Allow de-risking of clutch investment as there is no risk of payment clawback	– Opportunity to discover the value of inertia from non-zero MW synchronous plant, without ESO having to take account of the energy – Market providers would be obliged/encouraged to take account for their energy position (i.e. to be at SEL, they should sell capacity in wholesale market, with stability payment making up the difference between wholesale price and SRMC) – Enhanced competition in stability markets by encouraging broader participation
Disadvantages	– Opportunity cost of foregoing the stability payment might distort ID market – If during ID a (stability contracted) unit comes on in place of an another (uncontracted) one, then total stability provision gets reduced[1] – Synch. units would be excluded from stability payment when generating (FPN>0MW) even if they are providing more inertia compared to the 0MW configuration (i.e. with clutch activated)[1]	– Risk that synch. gen. get windfall gains when not intending to run at 0MW – Risk that synch. gen. units with clutches never intend to run at 0MW and use it as a mechanism to subsidise energy bids – Non-zero MW providers (e.g. CCGTs without clutch) could perceive the mechanism as not fair, as they would provide the same service as 0MW units (which may not activate the clutch very often), without being paid for Stability	– May slow down net zero targets by extending the life of out-of-merit sync. units (e.g. CCGTs), providing an additional inertia payment, instead of relying on low carbon units (e.g. 0MW). – SEL parameter may be difficult to define as by nature it is 'dynamic'. Likely to be arduous for settlement and monitoring behaviour – Unclear whether this model provide significant benefit over the status quo of accessing non-0MW synch. gen. capacity in the BM

1. Issue addressable if units can keep the stability payment if instructed by ESO to generate | PN: Physical Notification; FPN: Final Physical Notification; ST: Short-Term; ID: Intra-day; DA: Day-Ahead; CCGT: Combined-Cycle Gas Turbine; SEL: Stable Export Limit; SRMC: Short Run Marginal Cost; BM: Balancing Mechanism

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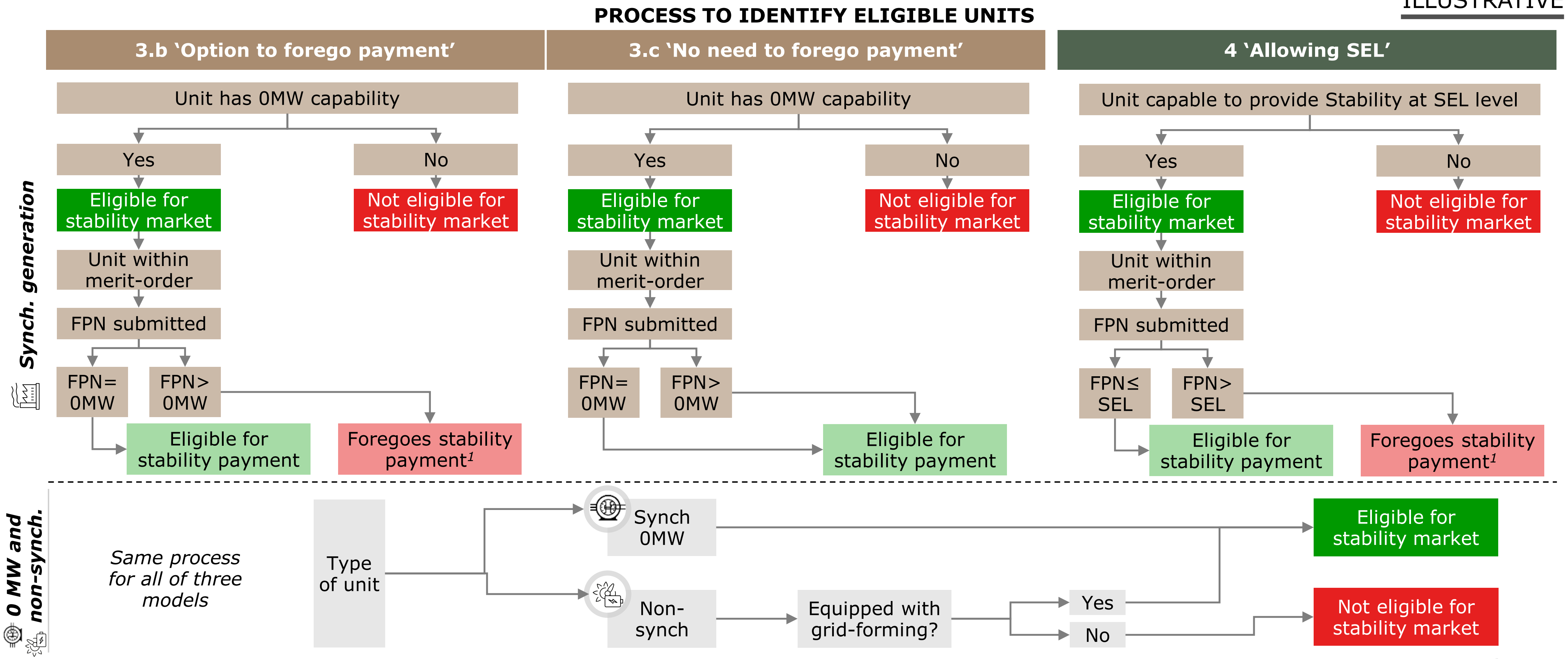
SELECTIVE PAYMENTS APPROACHES – REPRESENTATION OF PROCESSES TO IDENTIFY ELIGIBLE UNITS

Processes to identify eligible units of the filtered models

ILLUSTRATIVE



1. If not explicitly instructed by ESO to generate | PN: Physical Notification; FPN: Final Physical Notification; SEL: Stable Export Limit

ASSESSMENT OF TECHNOLOGIES FOR ELIGIBILITY AS NEW BUILD

New build non-synch. generation, storage and synch. 0MW units would be eligible during both opportunistic and shortfall procurement stages

New build – Technologies	Selective characteristics		Selective payment – Shortfall proc.		Selective payment – Opportunistic proc.	
Sync. gen. – CCGT/OCGT – Biomass – Nuclear – Hydro/ Pump. Stor.	Non-eligible	– Do not fulfil all general eligibility criteria for new build plants (not dedicated assets)	Non-eligible	– As not eligible under select. charact.	Non-eligible	– As not eligible under select. charact.
Non-sync. gen. – Offshore w. – Solar PV – Onshore w.	Eligible	– New build plants only – Capable to provide Stability – Must meet availability requirements	Eligible		Eligible	
Storage – Batteries – Supercapacitors	Eligible	– New build plants only – Capable to provide Stability – Must meet availability requirements	Eligible		Eligible	
Sync. 0MW – Synchronous Condensers – Synch. gen. converted to 0MW unit	Eligible	– New build plants only – Capable to provide Stability – Must meet availability requirements	Eligible		Eligible	
Transmission – HVDC (OFTO/IC)	Non-eligible	– Do not fulfil all general eligibility criteria for new build plants[1] (committed with regulated frameworks, not likely to meet availability requirements)	Non-eligible	– As not eligible under select. charact.	Non-eligible	– As not eligible under select. charact.

1. As per current regulatory frameworks | MT: Mid-Term; LT: Long Term; CCGT: Combined-Cycle Gas Turbine; OCGT: Open-Cycle Gas Turbine; PV: Photovoltaics; HVDC: High-Voltage Direct Current; OFTO: Offshore Transmission Owner; IC: Interconnector; TEC: Transmission Entry Capacity

Legend *Eligible* *Non-eligible*

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Selective characteristics | Selective payment | LT Market (Y-4) | MT Market (Y-1) | ST Market (D-1)

ASSESSMENT OF TECHNOLOGIES FOR ELIGIBILITY AS REST OF CATEGORIES

For the other categories, synch. gen. capable to provide 0MW can be selected only under opportunistic procurement if provided with TEC

Enhanced capability | Existing capability

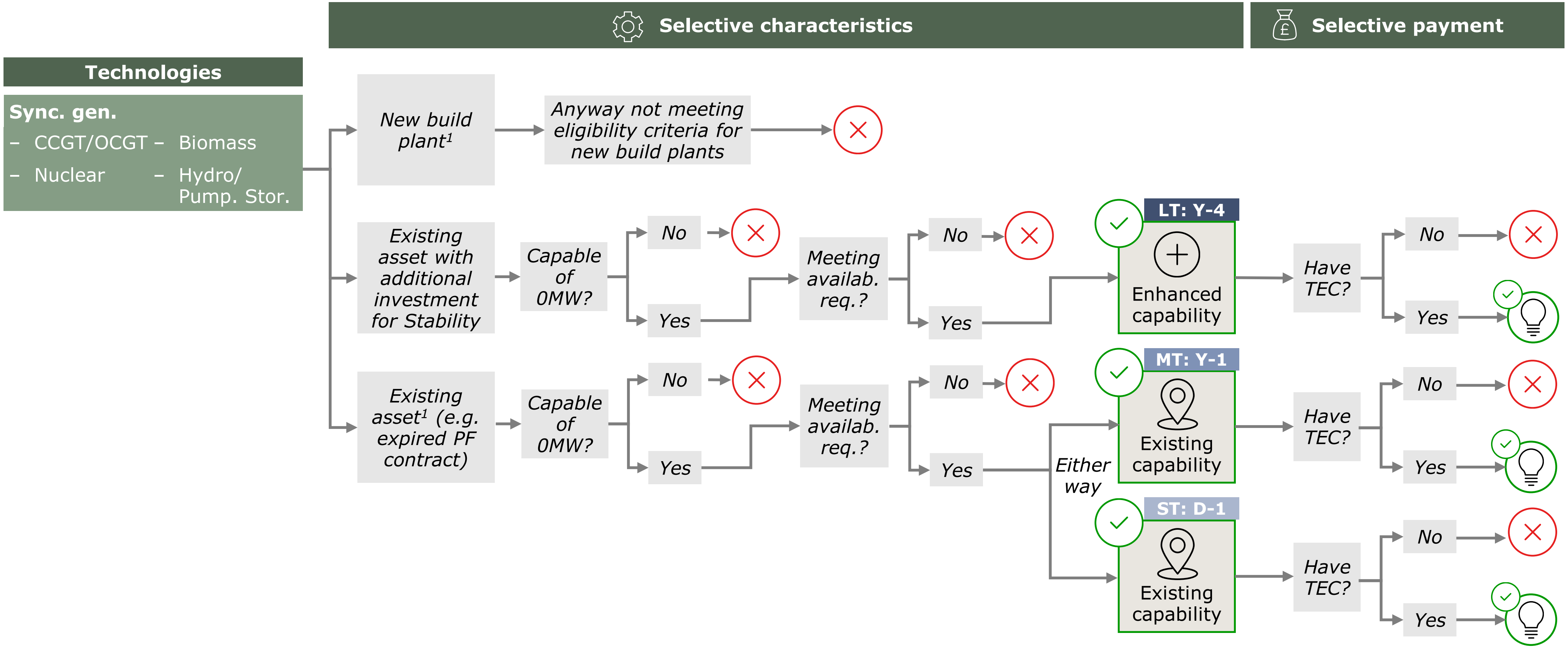
Technologies	Selective characteristics	Selective payment: Shortfall proc.	Selective payment: Opportunistic proc.
Sync. gen. – CCGT/OCGT – Nuclear – Biomass – Hydro/ Pump. Stor.	✓ – All categories: – Capable to provide Stability – Capable to provide 0MW – Must meet availability requirements – Enhanced capability: retrofit only	✗ – Potentially only for plants without TEC (effectively treated as synch. gen. converted to 0MW)	✓ – Only for plants with TEC *Plants with TEC under opp. only as they do not provide add. Stability than in standard functioning (when generating MW)*
Non-sync. gen. – Offshore w. – Onshore w. – Solar PV	✓ – All categories: – Capable to provide Stability – Must meet availability requirements – Enhanced capability: additional investments to provide incremental/allow 0MW stability	✓ – Access to all plants	✓ – Access to all plants
Storage – Batteries – Supercapacitors	✓ – All categories: – Capable to provide Stability – Must meet availability requirements – Enhanced capability: additional investments to provide incremental/allow 0MW stability	✓ – Access to all plants	✓ – Access to all plants
Sync. 0MW – Synchronous Condensers – Synch. gen. converted to 0MW unit	✓ – All categories: – Capable to provide Stability – Must meet availability requirements – Enhanced capability: additional investments to provide incremental/allow 0MW stability	✓ – Access to all plants	✓ – Access to all plants
Transmission – HVDC (OFTO/IC)	✗ – Participation limited by their current regulatory frameworks	✗ – As not eligible under select. charact.	✗ – As not eligible under select. charact.

MT: Mid-Term; LT: Long Term; CCGT: Combined-Cycle Gas Turbine; OCGT: Open-Cycle Gas Turbine; PV: Photovoltaics; HVDC: High-Voltage Direct Current; OFTO: Offshore Transmission Owner; IC: Interconnector; TEC: Transmission Entry Capacity

Legend ✓ *Eligible* ✗ *Non-eligible*

ELIGIBILITY FLOW DIAGRAM – SYNCH. GEN.

Flow diagrams for synchronous generation technologies

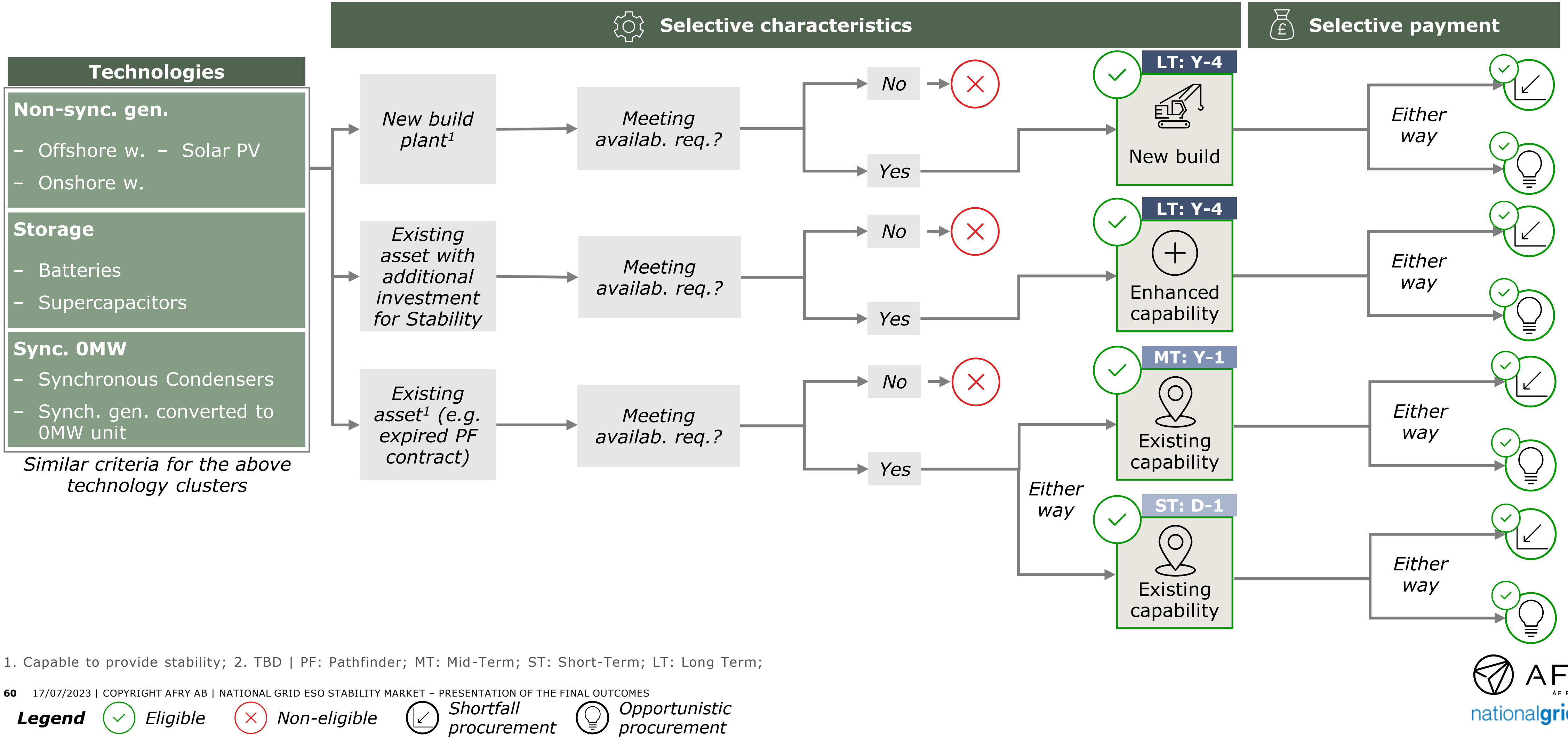


1. Capable to provide stability 2. TBD | PF: Pathfinder; CCGT: Combined-Cycle Gas Turbine; OCGT: Open-Cycle Gas Turbine; TEC: Transmission Entry Capacity; MT: Mid-Term; ST: Short-Term; LT: Long Term;

Legend *Eligible* *Non-eligible* *Shortfall procurement* *Opportunistic procurement*

ELIGIBILITY FLOW DIAGRAM – NON-SYNCH. GEN., STORAGE AND SYNCH. 0MW

Flow diagrams for non-synch. gen, storage and 0 MW synch. technologies



1. Capable to provide stability; 2. TBD | PF: Pathfinder; MT: Mid-Term; ST: Short-Term; LT: Long Term;

An appropriate signal is required to accelerate the uptake of grid-forming capability: this may be a mandatory obligation on non-synchronous plant to install capability for stability services, dispatched via a market mechanism

- Synchronous generators naturally have the inherent capability to offer and provide stability services to the grid.
- Traditionally, non-synchronous generators are grid-following and do not inherently provide stability.
- However, the development of Grid-Forming (GFM) convertors offers the potential for non-synchronous generators to provide stability services.
- There are few examples of stability-capable non-synchronous assets in operation currently, so there needs to be a stronger signal to encourage this equipment to be installed.
- This signal could be provided via a market mechanism (e.g. a long-term market), through code obligations to install the appropriate capability or other avenues.
- The direction on this will have an impact on the ST stability market.

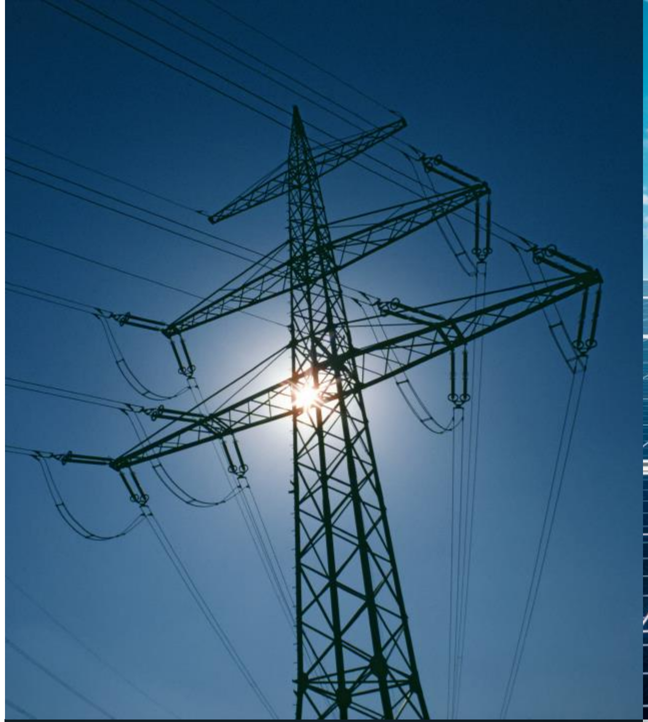
ENTSO-E has recently published their intentions to explore this topic via the Requirements for Generators 2.0 consultation. We expect they will strongly consider the case for mandatory service capability with dispatch via a market mechanism.

Other jurisdictions (e.g. Australian Energy Market) also have alternative approaches to delivering stability-capable assets from non-synchronous technologies which we are observing.

- ESO does not have a formal position on this at the moment but it is a key topic to explore alongside industry to understand the merits and drawbacks of utilising mandatory code obligations to accelerate the growth of stability-capable assets.
- This will be discussed further outside the scope of this phase of the Stability Market Design NIA project but we wanted to highlight it here as a point of note.

GFM: Grid-Forming; ST: Short-Term

Agenda




Outcomes from previous project Phase 1 and feedback from the industry suggested application of the utilisation payment just for LT/MT market units

Outcomes from Stability Phase 1

- Recommendations from Phase 1 have suggested application of availability and utilisation payment for the LT/MT market units, while only availability payment for ST
- Rationale was that LT market is likely to attract high-capex/low variable cost providers. Hence, there should be arrangements to manage their energy consumption costs. ST market is likely to attract high availability/variable cost or low availability/variable cost providers with high certainty over utilisation so no explicit UP needed
- On utilisation price for LT/MT, industry feedback was split over the application of imbalance or user defined utilisation prices

Possible design options

- Possible design options have been considered for the possible combinations of Availability and Utilisation Payments (*the latter called Delivery Payment from now on*) over the LT/MT and ST markets

AFRY assessment

- Feasibility of the proposed design options have been assessed under criteria of:
  1. Ease of evaluation
  2. Efficiency of dispatch
- A list of short-listed models have been proposed

UP: Utilisation Payment; LT: Long-Term; MT: Mid-Term; ST: Short-Term

Separation of DP and AP would mitigate risks for providers and consumers, considering increasing technology diversity and complexity of LT forecasting

ILLUSTRATIVE

		Pathfinder Phase 1	Pathfinder Phase 2-3	Future Stability Market
Situation	**Variety of technologies involved**	– Expected limited variety of technology types to participate (e.g. only synchronous condensers)	– Expected higher variety of technology types to participate	– LT/MT market open to even larger variety of technology types with different 'consumption behaviours'
Compli-cation	**Ease for ESO in forecasting LT utilisation**	– LT forecast of utilisation not particularly relevant, as 'consumption behaviours' linked to limited number of technologies	– Complex to forecast utilisation over LT period due to increased number of technologies to evaluate	– More complex to forecast utilisation over LT period due to still greater number of technologies to evaluate
Resolution	**Approach used for DP of LT[1] units**	– DP as passthrough – linked to imbalance price, evaluated ex-post of dispatching	– No DP – estimation left to comm. prov. which embed DP into AP (£/SP) offers	– Separation of AP (offered at Y-4 stage[2]) and DP (offered at D-1 stage)
	Ease of bidding for providers	– Bidding strategy over AP not affected by DP, as the latter already linked to imbalance price	– Risk of forecasting energy consumption borne entirely by comm. prov. (indication of expected %/y utilisation provided by ESO)	– Risk mitigated by separating DP from AP and moving its forecast closer to delivery time (from Y-4/Y-1 to D-1 stage)
	Protection of consumers	– DP linked close to real-time evaluation of actual energy consumptions	– High risk for comm. prov. is reflected in their estimation of energy consumption costs (leading to possibly high costs for consumers)	– Lower risks for comm. prov. should be reflected in more accurate forecast of consumption costs (possibly mitigating costs for consumers)

1. And MT units for Stability Market; | DP: Delivery Payment; LT: Long-Term; MT: Mid-Term; ST: Short-Term

Legend *Level:* *High* *Medium* *Low*

Different models for delivery and availability payments have been evaluated over the LT, MT and ST market timeframes

LT/ MT contract providers

Options	Availability Payment (eval. Y-4: LT; Y-1:MT)	Delivery Payment (eval. D-1: LT/MT)
a *Only AP (DP embedded)*	– Bid for LT/MT availability	– Effectively, DP embedded in availability bids during LT/MT auctions
b *AP and fixed DP*	– Bid for LT/MT availability	– Separate bid for ST delivery – DP fixed at the point of LT (MT) contract, at Y-4 (Y-1) stage
c *AP and indexed DP*	– Bid for LT/MT availability	– DP calculated through a formula linked to the actual costs of unit to provide services (e.g. real–time cost of electricity if unit consumes energy to provide stability)

ST contract providers

Options	Availability payment (eval. D-1: ST)	Delivery Payment (eval. D-1: ST)
a *Only DP (AP embedded)*	– Effectively, AP embedded in delivery bids during ST auctions	– Bid for ST delivery (ideally reflecting both cost opportunity and energy costs)
b *AP and bid DP*	– Bid for ST availability (ideally reflecting cost opportunity only)	– Separate bid at D-1 stage for ST delivery (ideally reflecting energy cost only)
c *AP and pass-through DP*	– Bid for ST availability (ideally reflecting cost opportunity only)	– DP calculated through a formula linked to the actual costs of unit to provide services (e.g. real-time cost of electricity if unit consumes energy to provide stability)

AP: Availability Payment; DP: Delivery Payment; ST: Short-Term; MT: Mid-Term; LT: Long-Term

Legend Shortlisted options

Application of criteria such as ease of evaluation and efficient dispatch have short-listed the feasible options, of which only few have been recommended

LT/ MT contract providers

Options	Evaluation criteria: Ease of evaluation	Evaluation criteria: Efficient dispatch	Feasibility
a Only AP (DP embedded)	Low: Treating DP=0 of LT/MT units leads to unequal D-1 evaluation with ST units	Low: LT/MT can be selected even when not effectively cheaper than ST units	Non-feasible: Complex comparison of offers and distortions in evaluating LT/MT vs ST at D-1 stage
b AP and fixed DP (shortlisted)	Medium: Complex for comm. prov. to estimate DP at a LT/MT horizon	Medium: Possibly not efficient as comm. prov. would assume conservative DP, but space for improvement (e.g. allowing bidding lower price)	Feasible: If measures to enhance efficient dispatch are applied
c AP and indexed DP (shortlisted)	Medium: Energy costs (if any) would differ for different techs. Need to evaluate multiple formulas	High: Most transparent model as it is closer to the actual delivery costs of the unit	Feasible: If manage to determine simple and effective formulas to evaluate DP

ST contract providers

Options	Evaluation criteria: Ease of evaluation	Evaluation criteria: Efficient dispatch	Feasibility
a Only DP (AP embedded) (shortlisted)	High: Single DP bids (embedding AP as well) to be evaluated with DP from LT/MT units	High: Cheapest solutions between LT/MT and ST will be selected at D-1 stage	Feasible: Relatively easy comparison of offers and providing high efficiency of dispatch
b AP and bid DP	Medium: Complex to evaluate separate bids (AP and DP) to be evaluated in ST along with DPs of LT/MT	High: Cheapest solutions between LT/MT and ST will be selected at D-1 stage	Feasible: Relatively complex comparison of offers, but providing high efficiency of dispatch
c AP and pass-through DP	Medium: Energy costs (if any) would differ for different techs. Need to evaluate multiple formulas	High: Most transparent model as it is closer to the actual delivery costs of the unit	Feasible: If manage to determine simple and effective formulas to evaluate DP

DP: Delivery Payment; AP: Availability Payment; LT: Long-Term; MT: Mid-Term; ST: Short-Term

Legend *Level:* *High* *Medium* *Low* *Feasible* *Non-feasible* *Shortlisted options*

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Moving forward from Pathfinder approaches, a two-part bid for AP/DP is recommended to allow efficient dispatch and reduce risks for providers

POSSIBLE SHORTLISTED MODELS FOR AP/DP OVER THE SHORT-TERM HORIZON (INITIAL STABILITY MARKET)

LT/ MT contract providers	A. Pathfinder Phase 1	B. Pathfinder Phase 2-3	C. Future Stability Market Alternative
Availability payment	– Single bid (£/SP) – reflecting AP only	– Single bid (£/SP) – reflecting both AP and DP	– Single bid (£/MW.s/h) – reflecting AP only
Delivery payment	– As pass-through – energy costs calculated by ESO ex-post as: $\sum_h [\text{En. Cons. (kWh)} * \text{SBP(£/kWh)}]_h$	– N.a. – energy costs assumed by comm. prov. (during contract duration) and embedded in AP bids	Possible options **i. Fixed DP**: DP (£/MW.s/h) set at the point of contract (e.g. Y-1), paid when the asset is utilised throughout the contract duration (e.g. 1 year) **ii. Indexed DP**: same as '*option i.*', but DP is then indexed (through a formula, e.g. day-ahead/intra-day) against variable(s) linked to energy consumptions (e.g. energy price, inflation) *VARIANTS OF OPTIONS i., ii.* **Variable DP (capped)**: either '*option i.*' or '*option ii.*', but comm. prov. are free to bid a lower price (e.g. at D-1 stage, monthly, quarterly) than the fixed DP set at the point of contract – effectively fixed DP works as a cap for the lower bids offered by comm. prov.

LT: Long-Term; MT: Mid-Term; ST: Short-Term; SP: Settlement Period: AP: Availability Payment; DP: Delivery Payment; SBP: System Buy Price (Imbalance Price)

Legend Preferred option

In future, when the ST Stability Market will be operational, efficient dispatch could be achieved by optimising bids across the LT/MT/ST markets

ILLUSTRATIVE

EVOLUTION OF AVAILABILITY AND DELIVERY PAYMENT MODEL

TIMELINE

	Today (no Stability Markets)	*Short term horizon (initial Stability Market)*		*Mid term horizon (fully operational Stability Markets)*
AVAILABILITY AND DELIVERY PAYMENT MODEL				
LT MARKET (Y-4)	Existing PF contracts AP: £/SP (pay-as-bid) DP: IP (PF 1); N.a. (PF 2-3)			**Model C:** opt. ii. (TBC) AP: £/MW.s/h (pay-as-bid) DP: £/MW.s/h (pay-as-bid)
MT MARKET (Y-1)		**Model C:** opt. ii. (TBC) AP: £/MW.s/h (pay-as-bid) DP: £/MW.s/h (pay-as-bid)		
ST MARKET (D-1)			*Option a.: 'Only DP (AP embedded)' recommended for ST units when ST will be established*	DP[1]: £/MW.s/h (*pay-as-clear*)
	– No bids for DP under Pathfinder – For PF 1 units, energy costs are remunerated by the hourly Imbalance Price, while for PF 2-3, these were estimated by the provider and embedded within the AP bid	– On a preliminary phase, we see the introduction of a MT market only, where commercial providers bid a DP at the point of contract (model C - final DP depends on chosen option between i.,ii.)		– Introducing LT and ST markets

1. Effectively embeds both opportunity cost and energy consumptions | DP: Delivery Payment; AP: Availability Payment; LT: Long-Term; MT: Mid-Term; ST: Short-Term; SP: Settlement Period; PF: Pathfinder; IP: Imbalance Price; SM: Stability Market6

Legend *Availability payment* *Delivery payment*

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Ofgem review of energy costs for ancillary service providers is still ongoing. Its outcomes would influence the treatment of DP in the Stability markets

CURRENTLY APPLICABLE TO ANCILLARY SERVICE PROVIDERS

Final Consumption Levies

Applied on the consumption of electricity to recover the costs of government schemes such as the Renewables Obligation, FIT, CfD and CM

System costs

Includes other cost and charges governed by regulatory frameworks

No licence

Without licence, providers are liable to pay FCLs for the electricity supplied to their premises and System costs

Based on voluntary request by the provider, licence could be granted for dedicated assets for AS

- Synch. Condenser
- Shunt Reactor

Licence

Licence holders are not liable to pay FCLs for the electricity supplied to their premises for the purpose of carrying on activities which they are authorised by their license to carry on

- Large Generator
- Trans. Networks

OFGEM REGULATORY REVIEW FOR AS PROVIDERS

Ofgem is currently reviewing long-term regulatory treatment of dedicated ancillary service assets to decide - 1. whether a licence is required; 2. If required, what kind of licence it will be and to which technologies it will be applicable to; 3. How licencing will impact costs and charges to providers.
As an outcome, one of three possible frameworks can be expected:

a. **Licence for all:** licence is granted to all ancillary service providers, exempting them to pay for their energy costs
   - ➢ DP would not be offered in LT/MT Stability markets and for, ST market, DP would be effectively equivalent to a AP, reflecting opportunity costs only

b. **No licence:** no ancillary service provider is granted a licence, making them liable to pay for their energy costs
   - ➢ DP would be offered in the LT/MT/ST Stability markets

c. **Licence for some:** based on techs' classification, some providers e.g. dedicated assets[1] would/would not be granted a licence
   - ➢ Unequal evaluation of DPs within Stability markets. Requires substantial mitigation measures to be applied either on Ofgem review or on Stability rules

Source: Ofgem | 1. e.g. Synchronous Condensers | AS: Ancillary Services; FIT: Feed-in Tariff; CfD: Contract for Difference; CM: Capacity Market; FCL: Final Consumption Levies; DP: Delivery Payment; AP: Availability Payment

Under Stability Pathfinder 2-3, Delivery Payment for units was estimated by providers at tender, embedded in their offers and used in the assessment

SELECTION PROCESS WITHIN PATHFINDER 2-3 AUCTIONS

TO counterfactuals

Provider's submission

Capital costs: m£ + *O&M costs:* m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Assessment ESO

ESO calculates the PV of capital costs over 40y period applying the regulated WACC and a discount rate[1]. O&M costs are discounted[1] over the contract length (e.g. 10)

Fixed DP estimated at tender stage and evaluated together with other costs[2] +

Other costs components added by ESO

Energy consumptions: m£ Estimate of losses

Penalty for late start: m£ Disadvantage for plants connected later

Final selection ESO

Assessed costs: £ m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Commercial offers

Provider's submission

Contract price: £/SP

Stability Contribution: e.g. MVA, MVAr, MVA*s

Fixed DP estimated at tender stage, embedded in LT contract price and evaluated together with other costs

Assessment ESO

Total contract present value: m£

ESO multiplies contract price by n. of SPs and discounts it[1] +

Other costs components added by ESO

Penalty for late start: m£ Disadvantage for plants connected later

Extra balancing: m£ For non 0MW plants

Infrastructure: m£ For connecting plant to the grid

Final selection ESO

Assessed costs: £ m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Algorithm optimises the selection of commercial offers and TO counterfactuals based on costs and contributions

Source: National Grid ESO | 1. As indicated by Treasury Green Book: i.e. 3.5% for the first 30 year, 3% afterwards; 2. Only for counterfactual purposes, energy consumptions for TO assets, if awarded, would be anyway treated under RAB | LT: Long-Term; TO: Transmission Owner; SP: Settlement Period; PV: Present Value; O&M: Operations and Maintenance; DP: Delivery Payment; RAB: Regulated Asset Base

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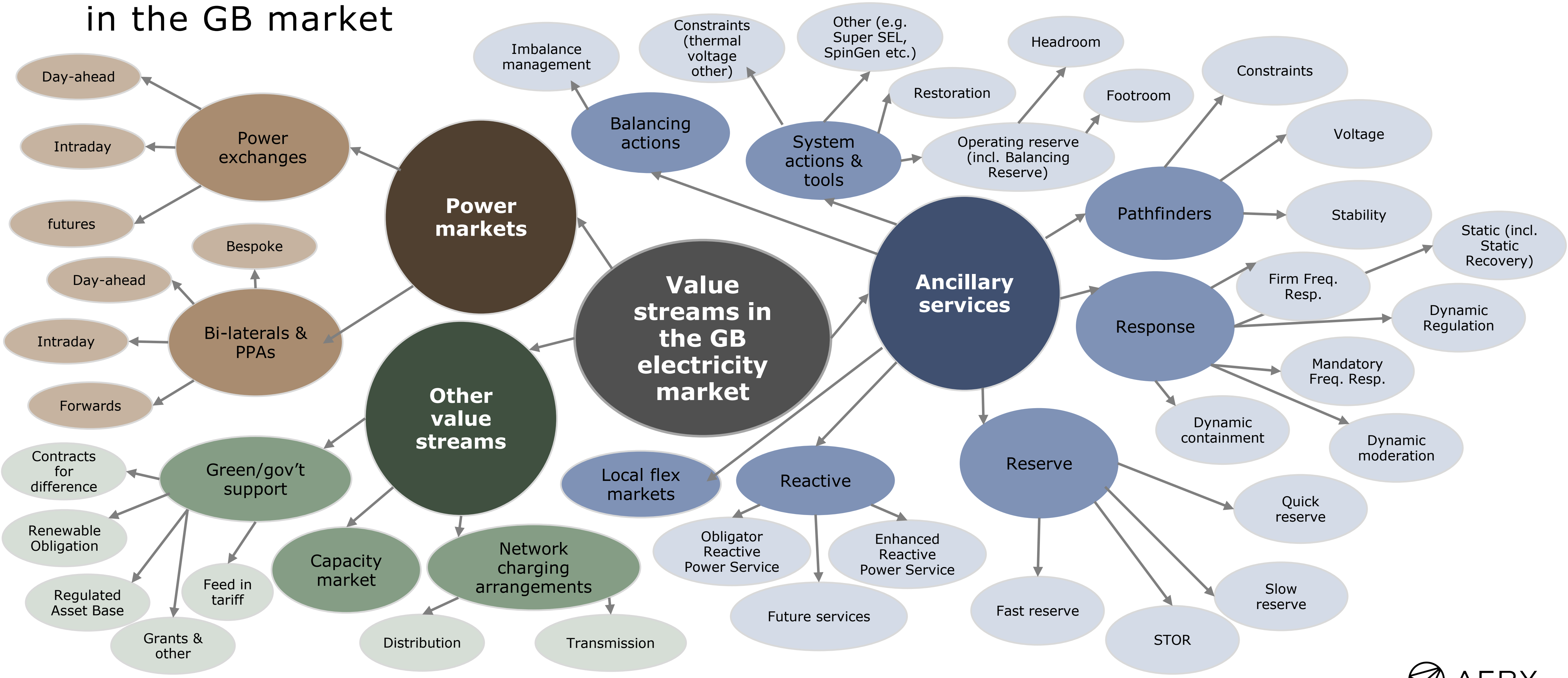
Agenda

There are a large number of value streams available to market participants in the GB market



Beside stability, there are four main categories of other ancillary services

RESPONSE

Mandatory frequency response
Automatic change in active power output in response to a frequency change

Firm Frequency Response
Frequency response services beyond mandatory arrangements

★ ***Dynamic Regulation***
Assists with keeping frequency near 50 HZ under normal conditions

★ ***Dynamic Moderation***
Rapid delivery to keep frequency within operational limits

★ ***Dynamic Containment***
Post-fault deployment after significant frequency deviation

RESERVE

Short Term Operating Reserve
Extra power to manage actual demand greater than forecast or unforeseen generation unavailability within a day

Balancing Reserve
Headroom and footroom to manage energy imbalance between generation and demand

Fast Reserve
Rapid delivery of active power by increasing generation or reducing demand

★ ***Quick Reserve***
Used to recover frequency post-fault back towards 50.0 Hz (expectation this supersedes Fast Reserve)

★ ***Slow Reserve***
Used to recover frequency to ± 0.2Hz within 15 mins (expectation this supersedes STOR)

REACTIVE

Obligatory Reactive Power Service (ORPS)
Obligatory requirement for all transmission connected generators to have capability to both absorb and inject reactive power

Enhanced Reactive Power Service
Provision of reactive power over and above the Grid Code and ORPS requirements

NOA Voltage Pathfinders
Firm capability (>90% availability, reactive power absorption only) procured through Pathfinder contracts to provide reactive power services in specific regions

OTHERS

Includes other Restoration, Thermal and Balancing Mechanism services such as:

Black Start/Restoration
Procedure to recover from a total or partial shutdown of transmission system which has caused an extensive loss of supplies

Balancing Mechanism
Allows market parties to submit offers to sell energy to the system and bids to buy energy from the system

Others
Other more niche or bespoke services including SpinGen/Pump (PS providing stability/arming for fast response), Super SEL (freeing up additional footroom), etc.

★ New Service

Source: National Grid | [1]Stability is procured through Pathfinders value stream

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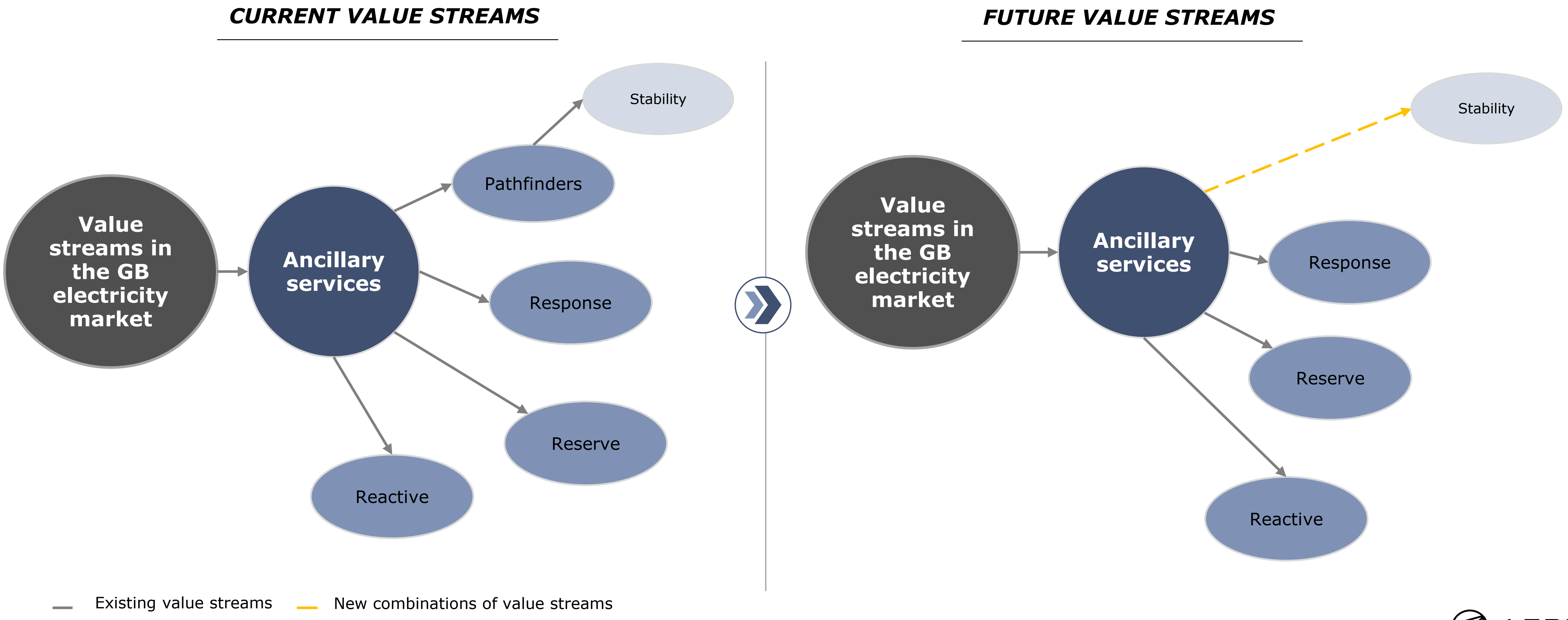
Stability products are currently procured through Pathfinders – however it will become a more direct value stream in future



Physical and design challenges must be considered to understand feasibility of stacking revenue streams

PHYSICAL CHALLENGES

Physical stackability	Technologies available which are capable of providing required stability and ancillary services within the same operating modes (power)
Complementary vs Contradictory services	For the same delivery period, services should provide greater economic value when procured together (A+B) than procurement of a single service (A or B)

DESIGN CHALLENGES

Similar commitment timing	Services can be committed for similar timeframes at the time of decision-making where if 1. *equal services* – same timeframes 2. *dominant-subservient services* – dominant starts earlier
Similar contract duration	Services are provided for similar contract durations where if 1. *equal services* – same duration 2. *dominant- subservient services* - dominant service is procured for a greater than or equal to duration to the subservient services
No unexpected double payment	Payment for same units (e.g. MW/MVAr) is not made twice during procurement of services except where this is intentional (and expected) within the design of the relevant markets

STACKING RULES: QUESTION 3A – WHO ARE THE ELIGIBLE PROVIDERS FOR CONTRACT STACKING?

Only a selection of providers who can operate at 0MW are deemed eligible in the recommended eligibility models for LT, MT and ST stability markets.

ELIGIBLE PROVIDERS

Non-synch. generation	Non-synch. storage	Synch. 0MW
Offshore wind + Grid forming	Batteries + Grid forming	Sync. Condenser
Onshore wind + Grid forming		Syn. Gen able to run at 0MW[1]
Solar PV + Grid forming		

Assets capable of providing dedicated stability services and can meet LT availability requirements

NON- ELIGIBLE PROVIDERS

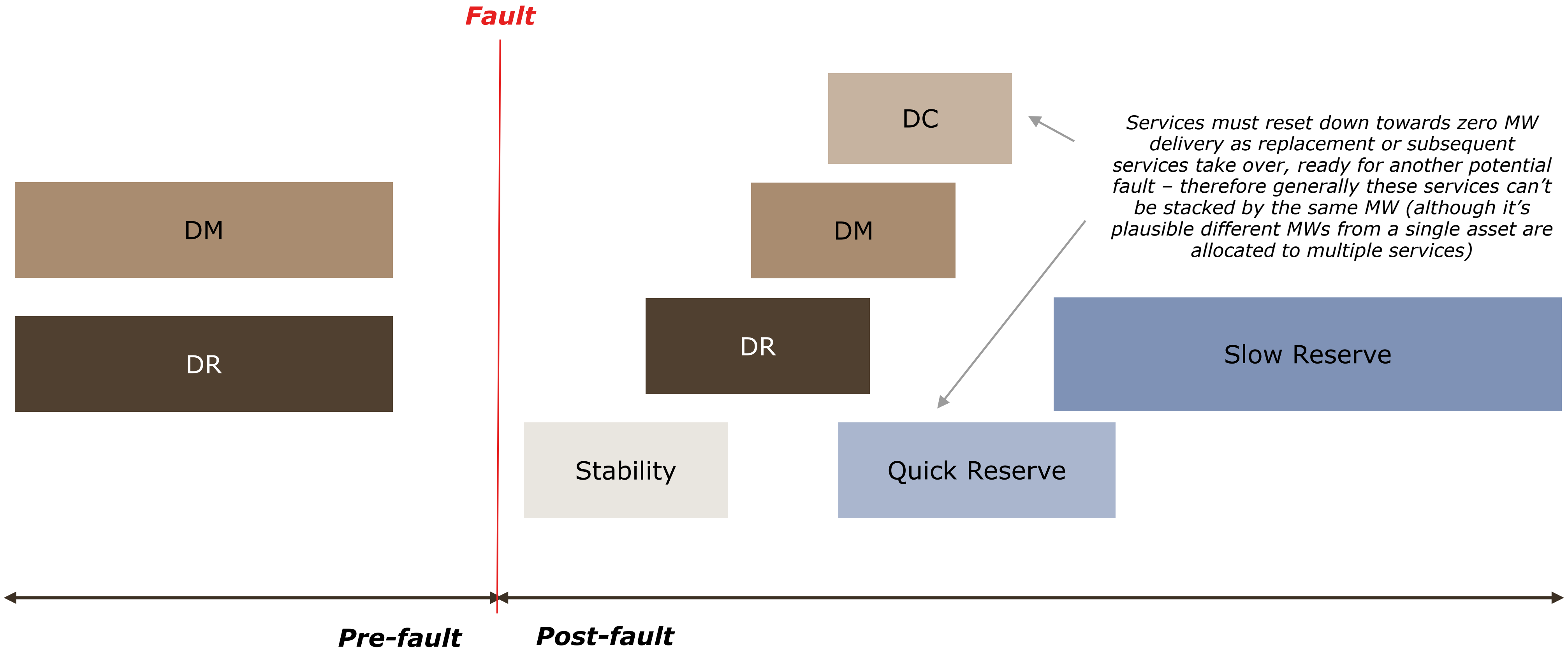
Synch. generation	Synch. storage	Non-synch. transm.
CCGT/OCGT	Hydro/Pump storage	HVDC (OFTO/IC)
Nuclear		
Biomass		

Sync. Generation assets cannot be dedicated to only stability services. Non-sync. transmission assets have potential incompatibility with availability requirement for stability.

Notes: [1]Includes Synchronous Technologies such as CCGT, Nuclear and Pumped Storage fitted permanently with a clutch

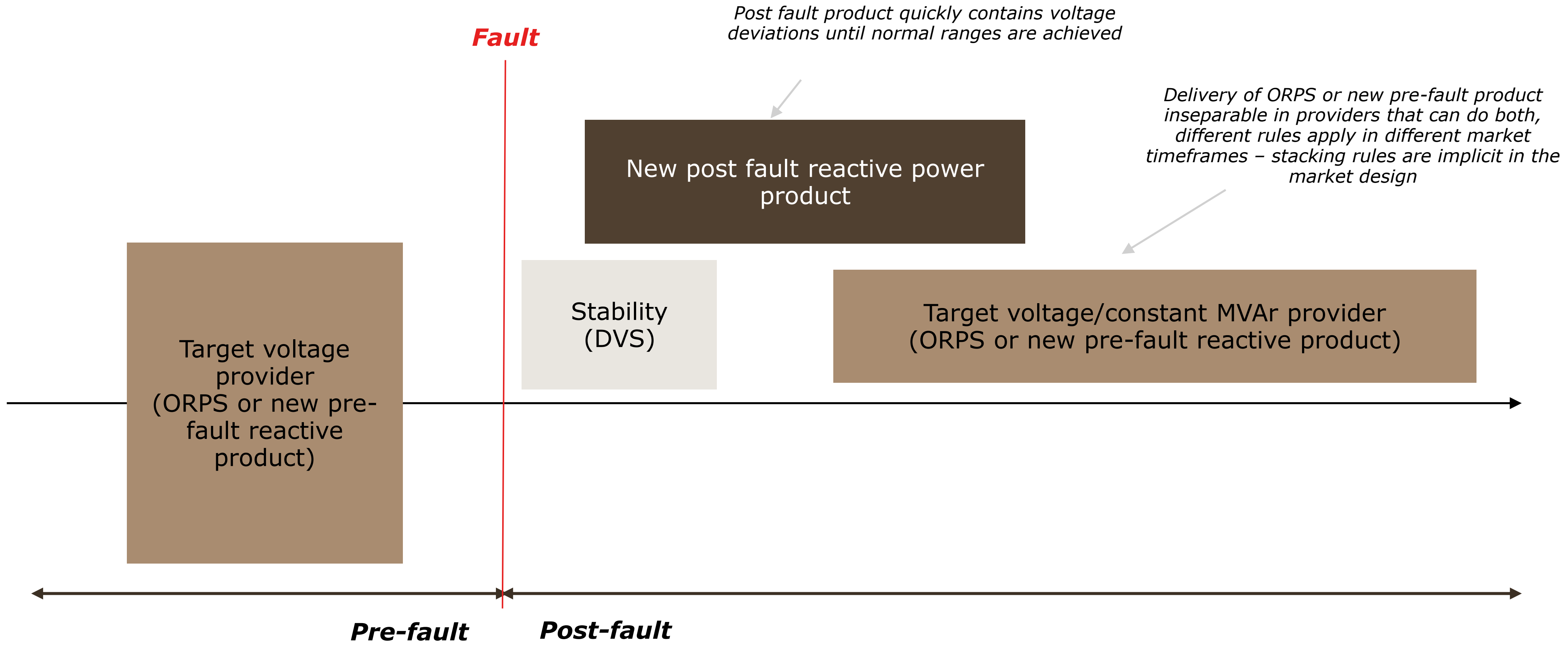
STACKING RULES: QUESTION 3A – WHERE ARE THERE CONTRADICTORY COMMITMENT TIMINGS?

Due to the potential overlapping delivery periods, response and reserve services are mutually exclusive by design when using the same MW



Notes: not all services shown pre-fault for simplicity | DM: Dynamic Moderation | DC: Dynamic Containment | DR: Dynamic Regulation

Similarly for reactive power, response varies by timeframe and product



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STACKING RULES: QUESTION 3A – WHICH TECHNOLOGIES CAN PROVIDE WHAT ANCILLARY SERVICES?

All eligible technologies are technically capable of delivering stability & reactive power services, batteries have additional response and reserve capabilities

	Intermittent RES + Grid forming	Non-synch. Storage + Grid forming	Synchronous 0 MW
Inertia	✓ Able to provide service at partial load. At max load, no upwards headroom for service provision. Unless curtailed down to zero, no provision at zero load	✓ Able to provide service at partial and zero load. At max load, no upwards headroom for service provision, but can provide if charging	✓ Able to provide service unless at zero load (considered to be switched off)
DVS	✓ Able to provide service by addition of grid forming capability at all operating modes	✓ Able to provide limited service at all operating modes	✓ Able to provide service unless at zero load (considered to be switched off)
SCL	✓ Able to provide service by addition of grid forming capability at all operating modes	✓ Able to provide limited service at all operating modes	✓ Able to provide service unless at zero load (considered to be switched off)
Reactive Power	✓ Able to provide service by addition of grid forming capability at all operating modes	✓ Able to provide limited service at all operating modes	✓ Able to provide service unless at zero load (considered to be switched off)
DC/DM/DR	? At max load, no upwards headroom for service provision – only downward possible. Unless curtailed down to zero, no provision at zero load	✓ At max load, no upwards headroom for service provision – only downward possible. Able to provide service at partial and zero load.	? May be able to provide response or reserve services alongside stability if technically capable
FFR/MFR	? At max load, no upwards headroom for service provision – only downward possible. Unless curtailed down to zero, no provision at zero load	✓ At max load, no upwards headroom for service provision – only downward possible. Able to provide service at partial and zero load.	? May be able to provide response or reserve services alongside stability if technically capable
Quick Reserve	✗ At max load - no upwards headroom for service provision - can provide downwards services only. At partial load, unclear if response can be sustained for long enough	✓ Able to provide service at all operating modes, given sufficient storage duration	? May be able to provide response or reserve services alongside stability if technically capable
Slow Reserve	✗ For slow reserve specifically, must be able to sustain for 120 mins – difficult w/o storage	✓ Able to provide service at all operating modes, given sufficient storage duration	? May be able to provide response or reserve services alongside stability if technically capable

Source: AFRY analysis

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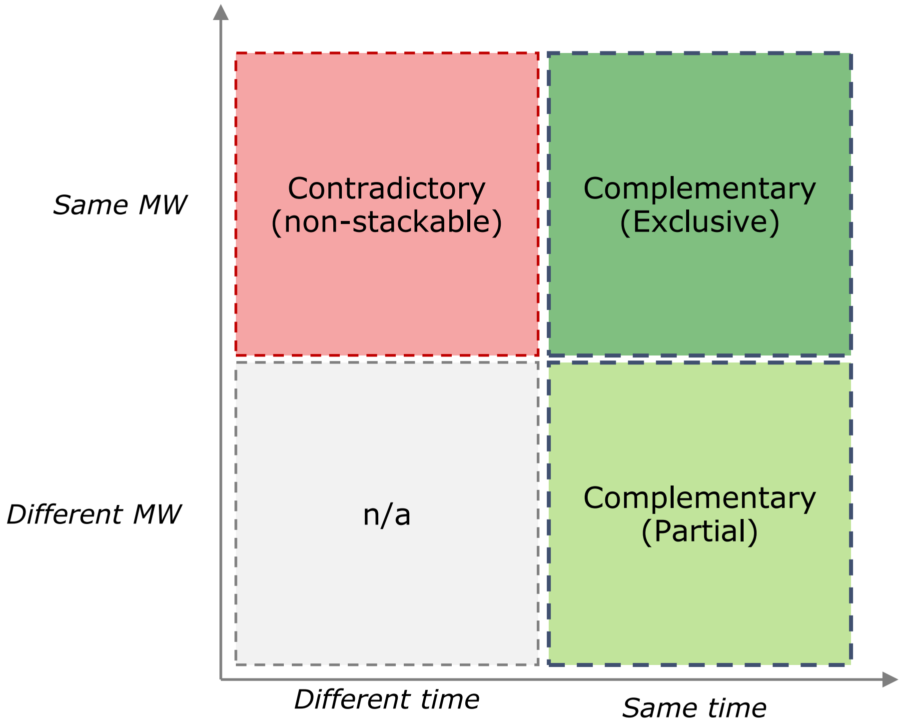
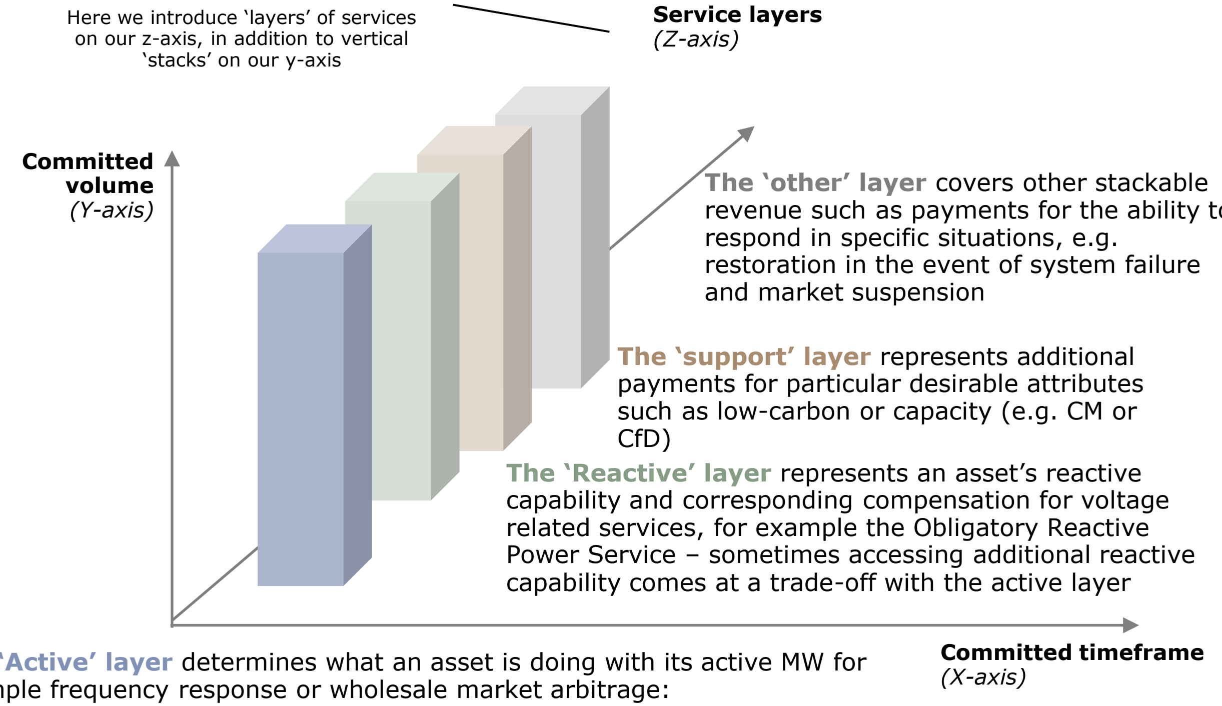
STACKING RULES: QUESTION 3A – WHAT ARE PHYSICAL CHALLENGES OF STACKING CONTRACTS?

'Stacking' is where participants combine these various different value streams and activities into a business model

Complementary vs contradictory services



Service class and associated 'layers'



The 'other' layer covers other stackable revenue such as payments for the ability to respond in specific situations, e.g. restoration in the event of system failure and market suspension

The 'support' layer represents additional payments for particular desirable attributes such as low-carbon or capacity (e.g. CM or CfD)

The 'Reactive' layer represents an asset's reactive capability and corresponding compensation for voltage related services, for example the Obligatory Reactive Power Service – sometimes accessing additional reactive capability comes at a trade-off with the active layer

The 'Active' layer determines what an asset is doing with its active MW for example frequency response or wholesale market arbitrage:

- Some Active layer activities can be done with different MW at the same time (e.g. frequency response and wholesale markets, which are stackable by a single asset at the same time with different MW)
- Some must currently be done at different times (e.g. dynamic moderation and dynamic regulation, which are not stackable)

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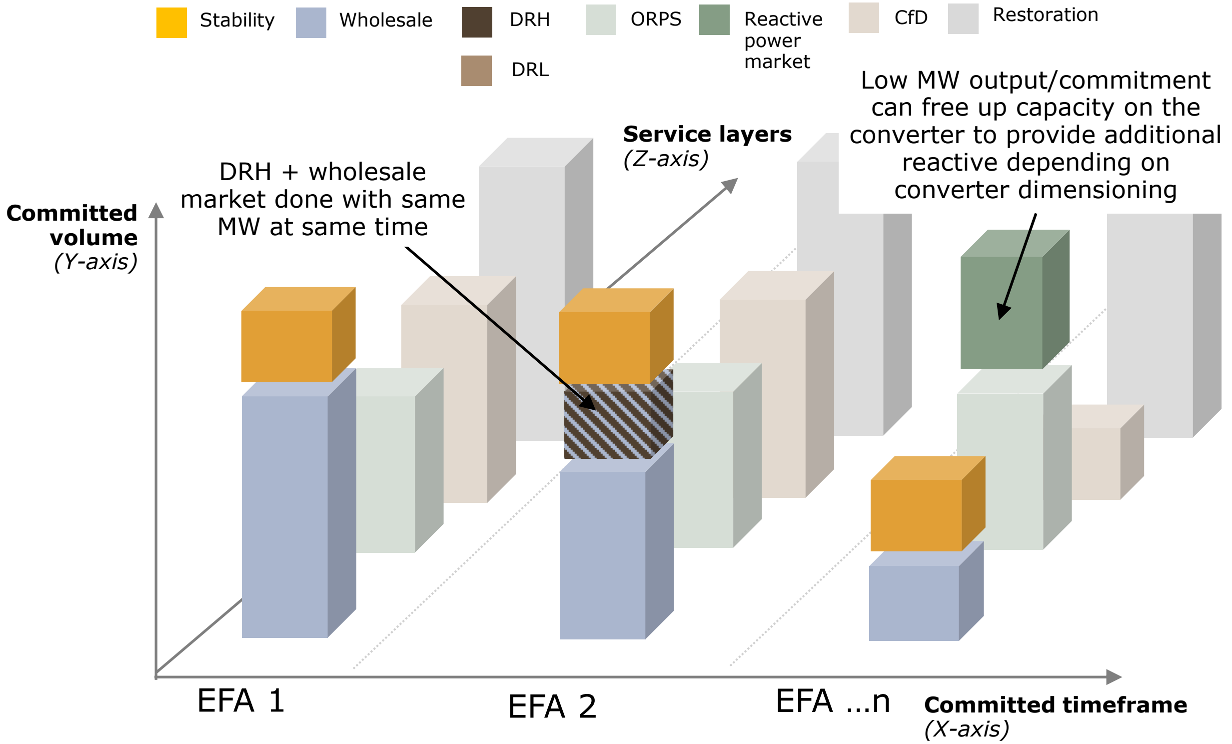
STACKING RULES: QUESTION 3A – WHAT DO THE STACKING OPTIONS LOOK LIKE ACROSS THE TECHNOLOGIES?

Intermittent GF is limited by energy resource as well as capability

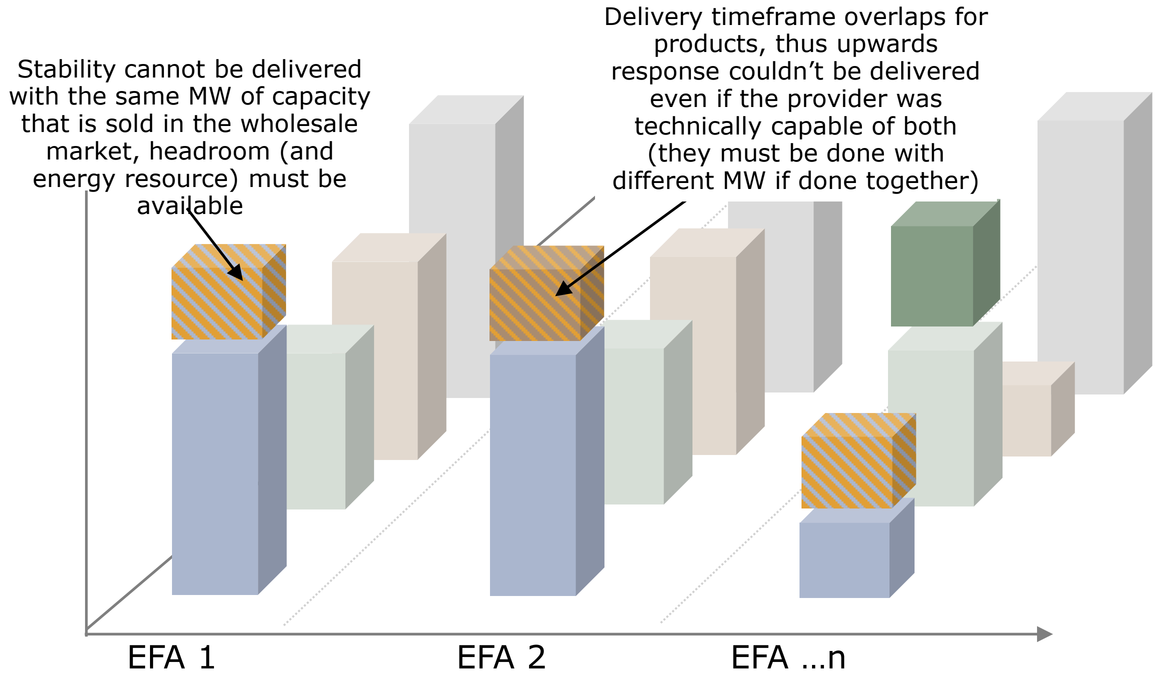
STACKABLE



Complementary (exclusive):
- Restoration and CfD (with CfD still based on metered volumes)
- Reactive power services

Contradictory (partial))
- Stability can be delivered with downwards frequency response services or wholesale markets with different MW
- Different Reactive Power services can be stacked together provided the same MVAr is not committed twice and MWs are unaffected

NON-STACKABLE



Contradictory (non-stackable)
- If wholesale power is sold, the same MW of both capacity and energy cannot be used for stability, as without headroom (both capacity and energy), inertia cannot be delivered.
- Due to overlapping delivery, Low frequency response services cannot be delivered at the same time as stability services with the same MW – however these can be delivered simultaneously with different MW

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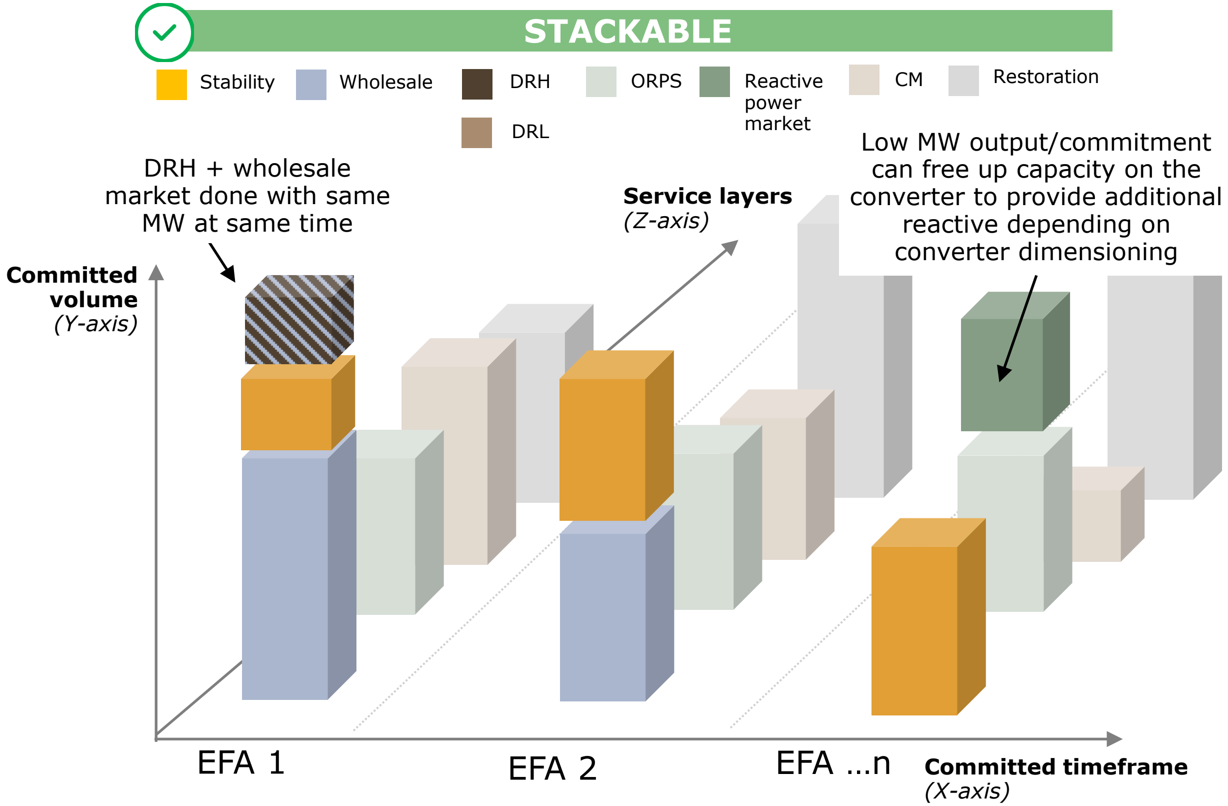
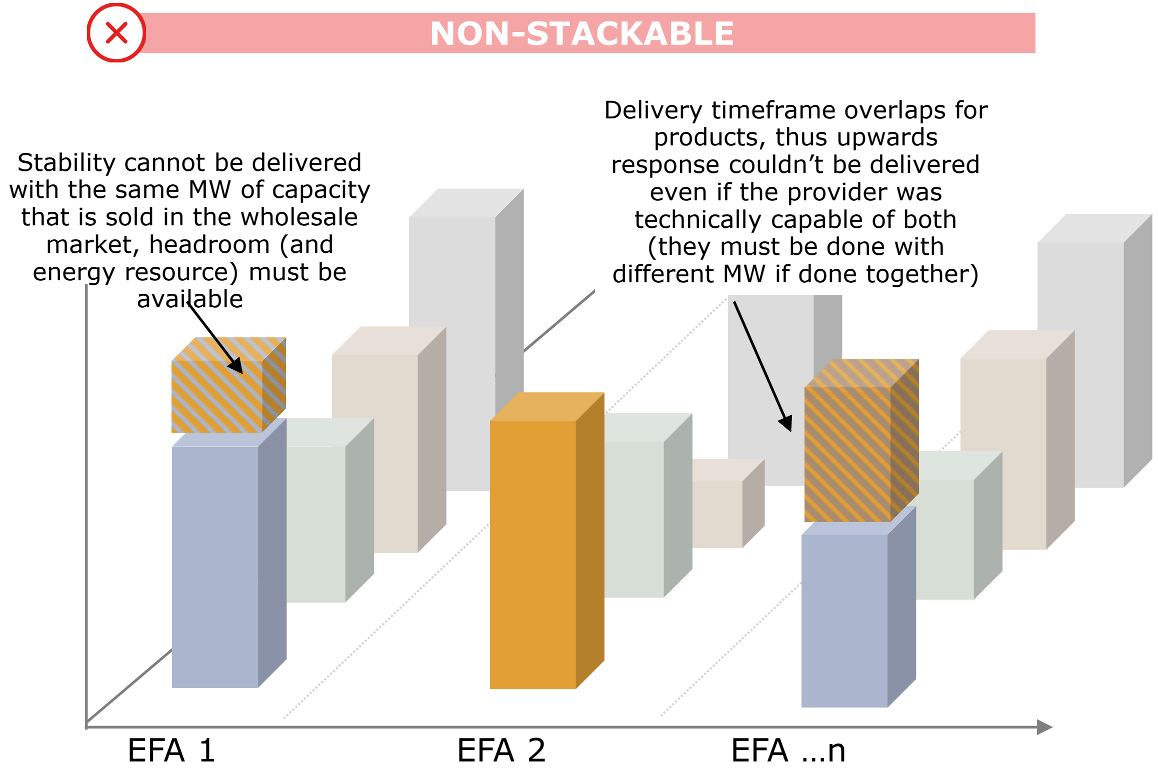
Non-synchronous storage GF is limited more by energy resource than capability





Complementary (exclusive):
- Restoration and Capacity Market
- Reactive power services

Complementary (partial)
- Stability can be delivered with downwards frequency response services or wholesale markets with different MW
- Different Reactive Power services can be stacked together provided the same MVAr is not committed twice and MWs are unaffected

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- If wholesale power is sold, the same MW of both capacity and energy cannot be used for stability, as without headroom (both capacity and energy), inertia cannot be delivered.
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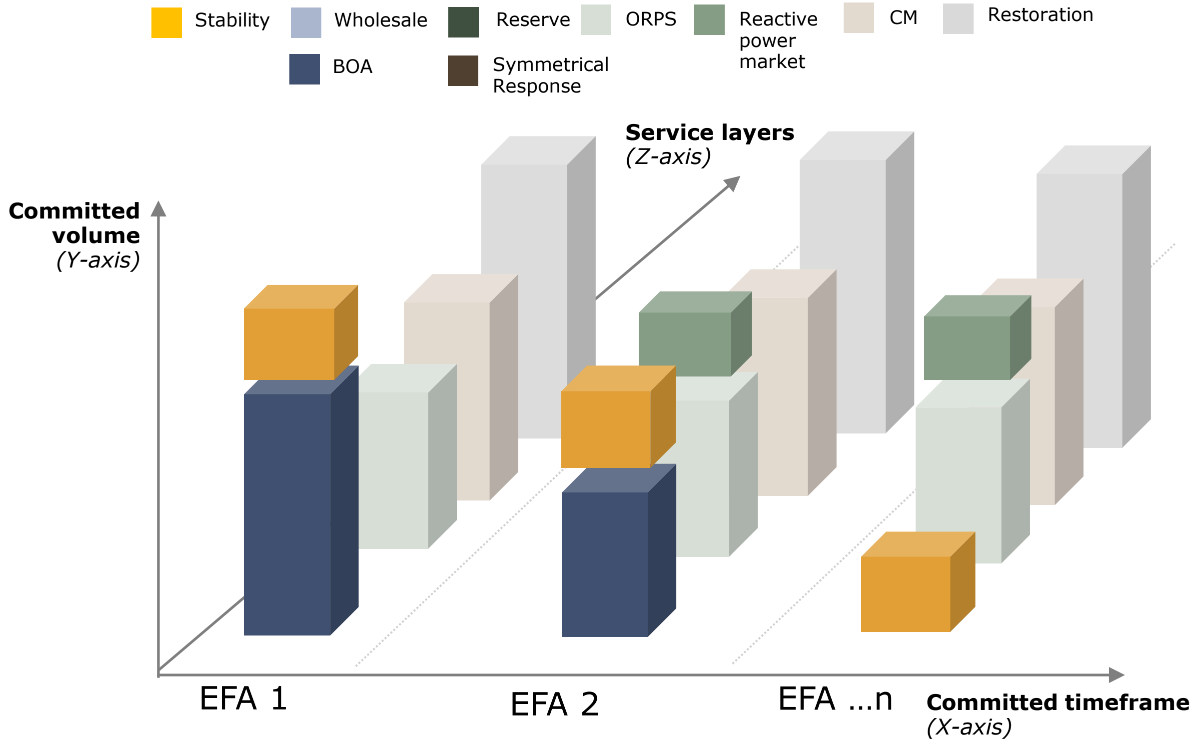
STACKING RULES: QUESTION 3A – WHAT DO THE STACKING OPTIONS LOOK LIKE ACROSS THE TECHNOLOGIES?

Synchronous zero MW providers can't deliver stability with wholesale markets

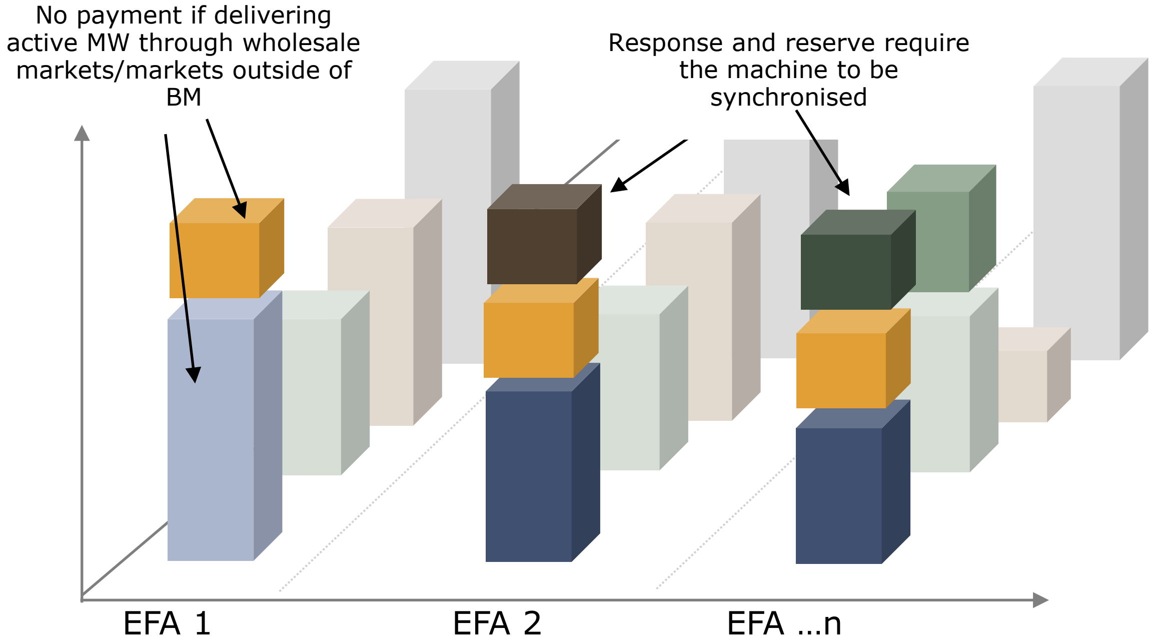
STACKABLE



Complementary (exclusive):
- BOA and Restoration and CM and Reactive Power Services
- Reactive power services

Complementary (partial):
- n/a

NON-STACKABLE



Contradictory (non-stackable) – for non-dedicated providers
- Providers not eligible for payment when participating in wholesale markets as operational consequences (e.g. locational issues, system room) of energy are not borne by the provider (only wholesale value consequences are borne by provider)
- Frequency response and reserve products typically require synchronous machines to be synchronised and provide energy which is incompatible with the design arrangements (exception may be MFR if the machine was specifically synchronised through the balancing mechanism to provide the service or fast responding units)

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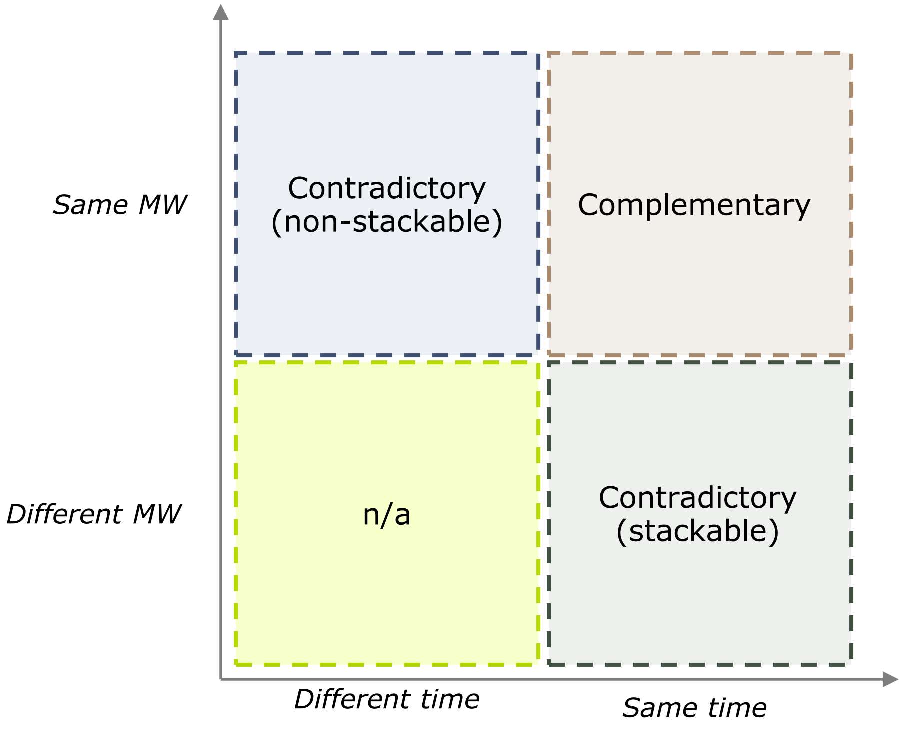
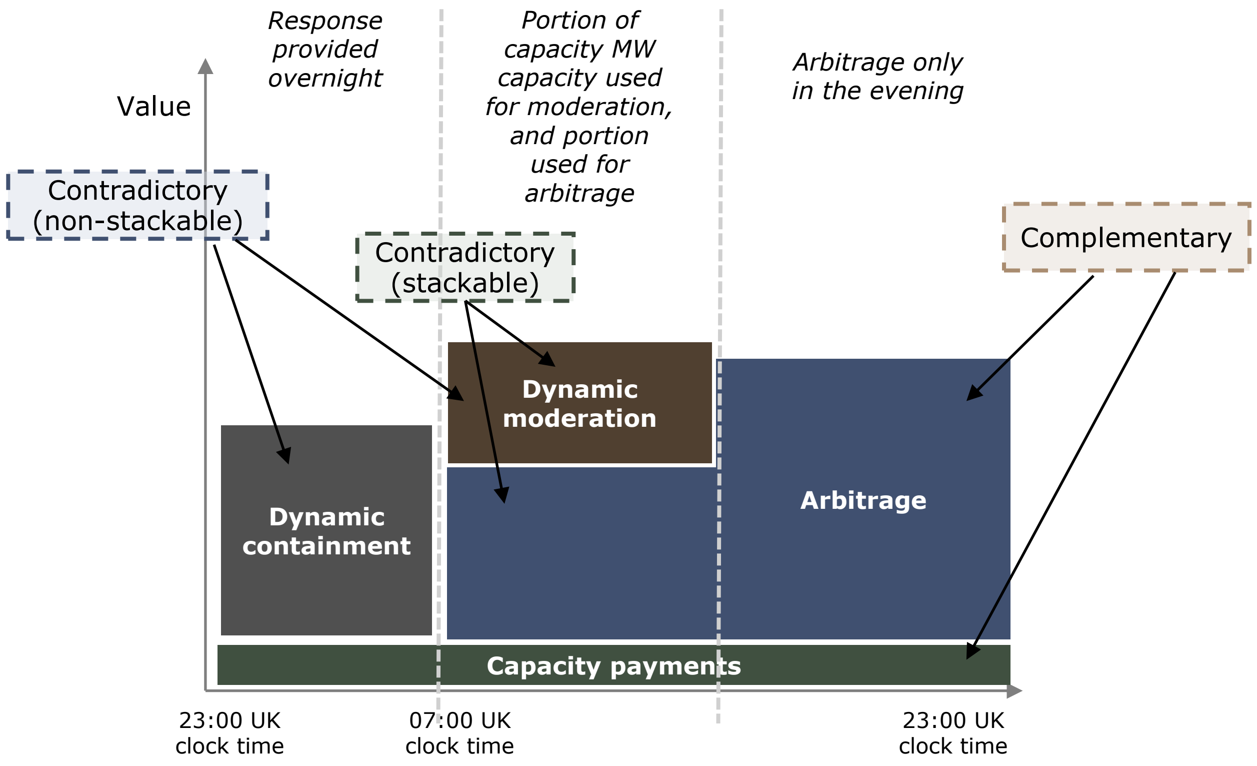
STACKING RULES: QUESTION 3A – WHAT ARE PHYSICAL CHALLENGES OF STACKING CONTRACTS?

‘Stacking’ is where participants combine these various different value streams and activities into a business model

COMPLEMENTARY VS CONTRADICTORY SERVICES



ILLUSTRATIVE MODEL FOR SERVICES PROVIDED BY BATTERY



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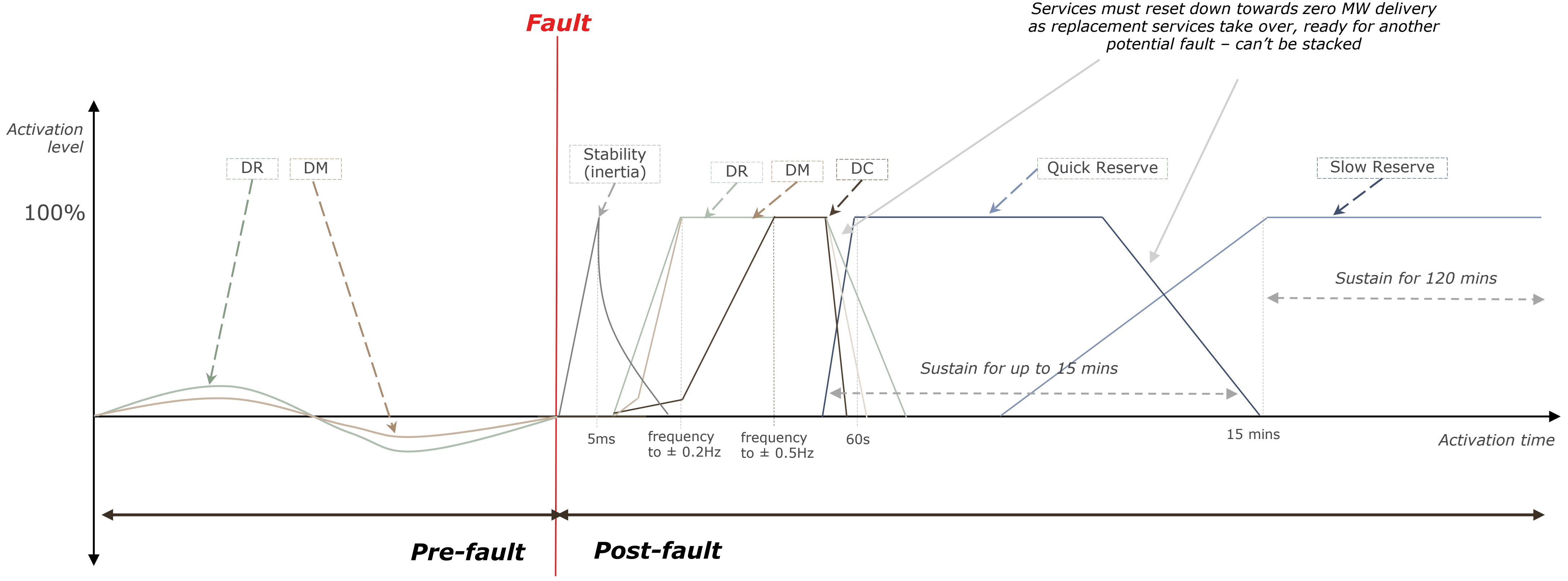
STACKING RULES: QUESTION 3A – WHERE ARE THERE CONTRADICTORY COMMITMENT TIMINGS?

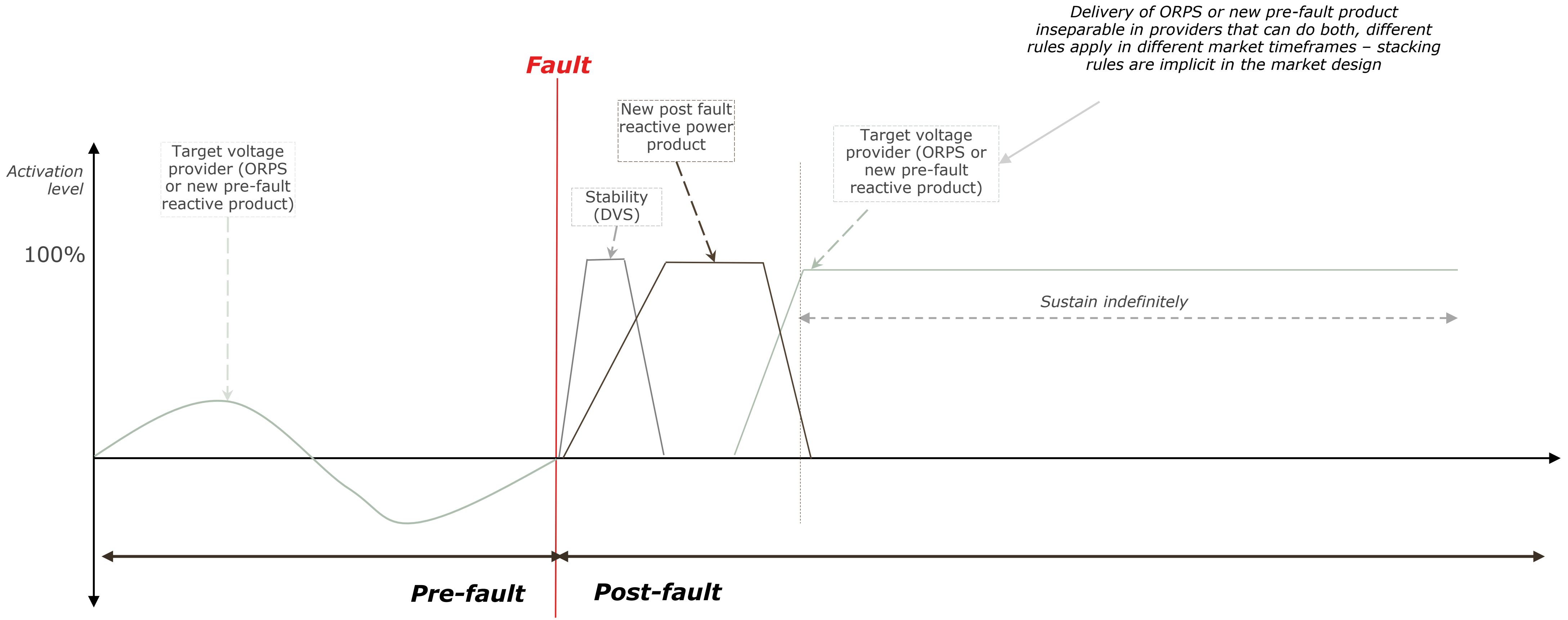
Due to the overlapping activation periods, response and reserve services are mutually exclusive by design when using the same MW



Notes: not all services shown pre-fault for simplicity | DM: Dynamic Moderation | DC: Dynamic Containment | DR: Dynamic Regulation

STACKING RULES: QUESTION 3A - WHERE ARE THERE CONTRADICTORY COMMITMENT TIMINGS?

Similarly for reactive power, response varies by timeframe and product



Notes: not all services shown for simplicity (excl. constant MVAr providers), new reactive products not yet fully defined | DVS: Dynamic Voltage Support

Ultimately the stacking options for stability will vary with technology, commitment volumes and timings – however it may evolve in future

	Intermittent RES + Grid forming	Non-synch Storage + Grid forming	Synchronous 0 MW
STACKABLE *Complementary (Exclusive)*	Reactive Power services **and** Capacity market **and** Restoration		*If the unit is a dedicated provider:* (non-ORPS) Reactive Power Services *If the unit is a generator or storage capable of providing stability at 0MW:* Reactive Power Services (incl. ORPS) **and** Capacity Market **and** Restoration
STACKABLE *Complementary (Partial)*	Wholesale markets (+CfD if applicable) **or** frequency response services **or** reserve services (*or a combination of these services provided with different MW and allowable by ESO policy*) **and** BOA		BOA, reserve, response
NON-STACKABLE	Active MW services with same MW e.g. DCL **and** Stability with same committed MW		Wholesale markets

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Agenda

TOs would theoretically be able to play different (and multiple) roles, as network planning facilitator, competitive and/or last resort provider

POSSIBLE ROLES FOR TOs WITHIN LONG TERM MARKET

NETWORK PLANNING FACILITATOR

- Assess the feasible connection points to be reserved for the awarded providers, providing a view of the site location, available connection dates and infrastructure costs[1]
- Support technical feasibility assessments of proposed solutions

COMPETITIVE PROVIDER

- Offer solutions within the new Stability Market through the two alternative regimes with two very different participation options:
  - *Indirect participation (counterfactual regime)*: as for the Stability Pathfinders
  - *Direct participation (fully competitive regime)*: as for the Early Competition Plan

LAST RESORT PROVIDER

- ESO may request the commissioning of the required capability for stability directly from TOs, in the case that commercial provisions are insufficient to meet stability needs
- Design and assessment of the solutions would be carried out by ESO in co-operation with TOs
- Availability programs for the designated solutions would be indicated by the ESO
- Solutions built by TOs will follow a regulated RAB based payment approach

1. Similarly to what already envisaged by Pathfinders - Phase 3 | LT: Long-Term; TO: Transmission Owner; RAB: Regulated Asset Base

Under Stability Pathfinder, TOs compete with commercial providers through a separated counterfactual scheme, with bids subject to regulated assessment

OVERVIEW OF THE NOA STABILITY PATHFINDER INITIATIVE

Principles

- Procurement of cost-effective solutions to address stability issues in the electricity system due to the continuing closure of synchronous generation plants
- Open to all technologies able to offer the required services and complying with technical requirements

Project phases

- Phase 1 (completed): procurement of resources for inertia regulation in GB
- Phase 2 (completed): procurement of resources for SCL and inertia regulation in Scotland
- Phase 3 (completed): procurement of resources for SCL and inertia regulation in selected locations in England and Wales

Competi-tion

- Comparison of commercial and regulated TO solutions, but separated methodologies for TO and commercial assets to assess their offers

Remunera-tion system[3]

- Availability payment: £/SP
- Active energy payment: £/MWh[1] for SPF1

Contract duration

- Phase 1: 6 years
- Phase 2: 10 years
- Phase 3: 10 years

TO ASSETS PARTICIPATION WITHIN STABILITY PATHFINDER

- Commercial assets present their offers under a competitive assessment, based on their estimation on costs per settlement period (£/SP), inclusive of all the costs faced to provide the services
- TO assets, since they recover their costs under regulated regimes, are subject to a regulated counterfactual assessment. TOs need to provide ESO with evidences of their total costs and ESO calculate the Present Value of the TO solution[2].
- Total costs are assumed to be recovered over the contract length and so the assessment does not envisage any residual value for TO assets
- The costs underneath the calculation of the Present Value for the TO solutions are represented by:
  - Capital costs
  - O&M costs
  - Estimate of losses
  - Penalties for late start

Source: National Grid ESO | 1. Active power consumed by the provider, reimbursed at imbalance rates; 2. According to Spackman methodology (applying discount rate at total costs, already inclusive of WACC), where using TO’s WACC and discount rate of 3.5% for the first 30 years and 3% afterwards; 3. Payments eligible for incremental capability only | TO: Transmission Owner; NOA: Network Option Assessment; GB: Great Britain; SCL: Short-Circuit Level; SP: Settlement Period; O&M: Operation and Maintenance; WACC: Weighted Average Cost of Capital; SP: Settlement Period

Under Early Competition, ESO supports direct participation of TOs with the rest of commercial bidders, envisaging measures to limit conflict of interest

ESO POSITION ON KEY ISSUES FOR TRANSMISSION OWNER PARTICIPATION WITHIN EARLY COMPETITION PROGRAMME

PARTICIPATION

TO bidding can benefit consumers since TOs:

- are well placed to deliver competitive bids due to their capabilities and experience in the sector
- are able to increase competitive pressure to other participants

COMPETITIVE REGIME

- TOs should participate through the same bidding process as other participants. ESO believes this is the most fair, transparent and efficient way to compare bids and maximise competition

CONFLICT OF INTEREST

- Participation of incumbent TOs can result in potential conflict of interests[1] due to their involvement in network planning
- ESO identified three actions to mitigate conflicts:
  - Ringfencing TO bidding team from rest of organisation
  - Challenging TO initial reference solution by ESO[2]
  - Transferring relevant planning responsibilities from TOs to the ESO[3]

Source: National Grid ESO | 1. e.g. Access to information not available to other bidders such as tender specifications; TOs will be the one assessing proposed solutions, including their own; since TOs have access to RIIO funds, they do not have same bidding risks as commercial providers; TOs have influence on the design of reference solutions; 2. To ensure tender specifications do not favour TOs; 3. e.g. Design of reference solution, assessment of connection feasibility for each bid | TO: Transmission Owner; EC: Early Competition

The possible participation models for TOs involves a range of potential categories

What roles do we want the TO to play?	In case eligible, how do we want TO to play the Competitive Provider role?	Given the desired role and participation method, what structure do we want the TO to take?

Possible roles

Network Planning Facilitator
- Assess the feasible connection points to be reserved for the awarded providers
- Support technical feasibility assessments of proposed solutions

Competitive provider
- Offer solutions within the Stability Market through either indirect or direct participation

Last resort provider
- Commissioning of the required capability for stability in case of commercial provision being insufficient to meet stability needs

Participation options

Competitive provider

Indirect participation (**counterfactual** regime)
- TO’s cost submission assessed under regulated counterfactual approach
- Assessment will determine final TO offers to be compared at a later stage with offers by commercial providers

Direct participation (**fully competitive** regime)
- TOs participate in the same competitive bidding process along with other commercial participants

TO structures

I) ‘Fully regulated body’: TO keep the role envisaged as today, owning and managing regulated assets

II) ‘Blended risk taker’: bidding assets are owned and managed (under non-regulated basis), still under TO’s control

III) ‘Risk silo’: bidding assets are owned and managed (under non-regulated basis) by a third entity, separated from TO’s company structure (e.g. as already used for NGV and NGET)

TO: Transmission Owner; NGET: National Grid Electricity Transmission; NGV: National Grid Ventures

Legend *Alternative options*

The choice behind TOs' involvement in Pathfinders and ECP was mainly driven by the duration of the need and complexity of procurement scheme

PROCUREMENT MECHANISMS

	NOA Stability Pathfinder	**Early Competition Plan** (ESO’s view)
Roles adopted by the TO	Network Planning Facilitator; Competitive Provider	*Planning to separate from commercial team* (Network Planning Facilitator ?); Competitive Provider
How TO assets compete with commercial solutions	**Indirect participation** (counterfactual regime) – TOs’ cost submission is assessed under a regulated counterfactual approach – The assessment will determine the final TO offers to be compared at a later stage with offers presented by commercial providers under the competitive regime	**Direct participation** (fully competitive regime) – Incumbent TOs participate in the same competitive bidding process along with other commercial participants
Main drivers behind the approach adopted	– One purpose of the Pathfinders was to discover whether commercial providers could offer economic solutions (learning by doing) – To ensure a competitive process for new and innovative products whilst protecting the interest of consumers, ESO wanted to ensure a solution would be delivered by the process to meet the identified needs (by ensuring TO participation) *ESO had no visibility of stability requirements beyond the 10 years assessed and therefore deemed it inappropriate for grid assets to be assessed over their full lifetime (instead focusing on the duration of need for which they had visibility)*	– Direct competition would provide the same timescale and evaluation principles to allow transparency in the comparison between the network solutions – It would be challenging to compare competitive and counterfactual solutions separately during the ITT, design of the solutions, and later stages, before knowing the final costs of the solutions

TO: Transmission Owner; ITT: Invitation to Tender; ECP: Early Competition Plan

Legend *Network Planning Facilitator* *Competitive Provider* *Las Resort Provider*

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The Counterfactual route (similar to Pathfinder’s) would be beneficial in terms of simplicity, competitive pressure and achievement of SQSS

Recommended model

A. Counterfactual route

Roles combination	Participation	Structure
The ‘Competitor’	*Indirect Participation*	*‘Fully regulated body’*

Advantages

- Add competitive pressure on commercial providers by leveraging regulated WACC for TO
- Easier to ensure a sufficient number of solutions offered by TOs, encouraged by their licence obligations to meet SQSS
- Simple route as it fits within current TO price control regime

Disadvantages

- Complex to ensure a fair comparison with commercial assets (particularly in terms of duration of their obligations)
- Excess competitive pressure could reduce attractiveness of participation of commercial providers in the LT market[1]
- COI (perceived or otherwise) difficult to monitor/enforce
- Does not work very well if there is material cost uncertainty between tendering and construction phase (no credible counterfactual)
- May require compensation/compulsion to ensure TO participation

B. Fully competitive route

Roles combination	Participation	Structure
The ‘Competitor’	*Direct Participation*	*‘Risk silo’* **OR** *‘Blended risk taker’*

Advantages

- Application of the same terms makes easy to compare solutions by incumbent TOs and other competitive providers
- Approach in line (for ‘*Blended risk taker*’) or *broadly* in line (for ‘*Risk silo*’) with other early competition eligible projects (reducing administration burden)
- Add competitive pressure on commercial providers by potentially leveraging low regulated WACC for TO (for ‘*Blended risk taker*’)
- Easier to manage COI through a separate entity, with mitigation measurements (e.g. ringfencing) in place (for ‘*Risk silo*’)

Disadvantages

- Competitive risk component could lead to higher WACC and so lower competitive pressure compared to indirect participation approach
- COI (perceived or otherwise) difficult to monitor/enforce
- Complex organisational restructuring required for ‘*Risk Silo*’ case
- Under ‘*Blended risk taker*’, complex adjustments to licence conditions (already ongoing). Under ‘*Risk silo*’, not bound by licence obligations[2]
- Potential long term implications for TO risk profile under the ‘*Blended risk taker*’ case

1. While in ST high competitive pressure would benefit consumers by reducing costs, under LT this could drop the appetite of commercial participants, resulting in lower level of competition during auctions and so higher bidding prices; 2. Potentially requiring last resort solutions in case of market failure, raising further COI issues | TO: Transmission Owner; WACC: Weighted Average Cost of Capital; SQSS: Security and Quality of Supply Standard; COI: Conflicts of Interest

Legend *Network Planning Facilitator* · *Competitive Provider* · *Indirect participation* · *Direct participation* · *Fully regulated body* · *Blended risk taker* · *Risk silo*

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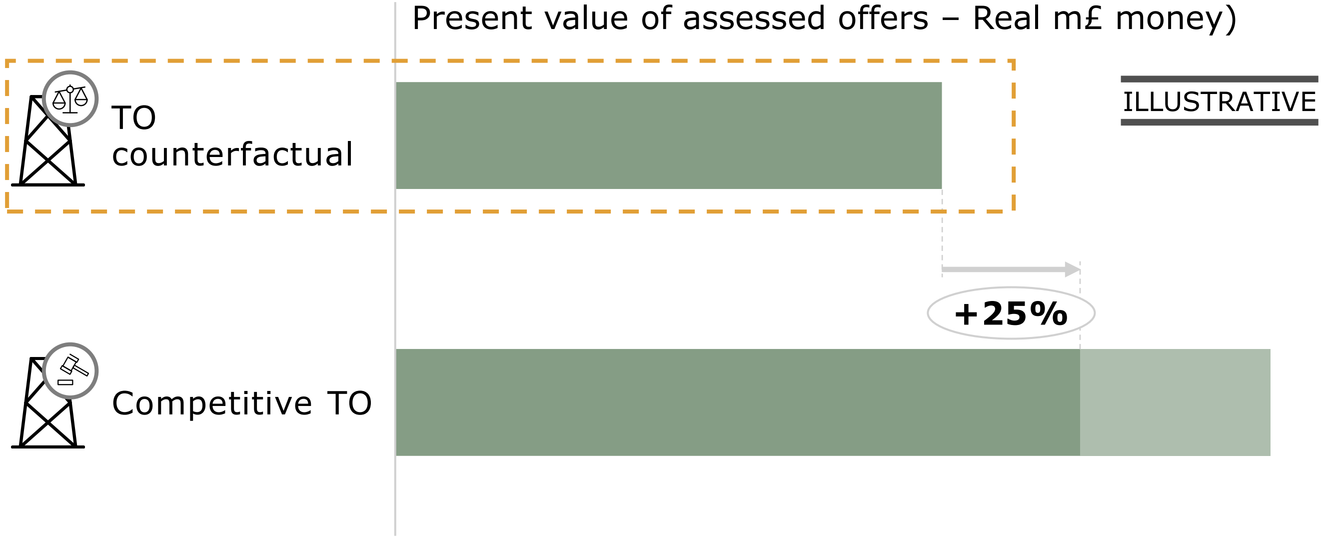
Under a fully competitive regime, TOs would not be able to leverage regulated WACC, resulting in higher offers

SELECTION APPROACH CONSIDERING TOS PARTICIPATING AS COMMERCIAL PROVIDERS WITHIN COUNTERFACTUAL AND FULLY COMPETITIVE MODELS



- If participating as competitive providers, TOs will be remunerated according to commercial terms and so not under RAB
- The higher risks borne by TOs (compared with the regulated route) will imply the assumption of higher cost of capital (likely higher than the regulated WACC) which will be reflected in their offers

MODERATE ASSUMPTIONS

	TO counter-factuals	Competitive TOs
Techno-logy	– Synchronous condenser	
Costs	– Capex, Opex, Losses: as from example provided by ESO[1] – Reference date to calculate delay costs: 31/03/2024[2]	
WACC	– 3%	– 10%
Residual value	– No residual value	– 30% of Capital Costs
COD	– 2026 (as from example provided by ESO[1])	
Tender period	– 10 years	

1. Through spreadsheet "*Stability Phase 2 CBA Cost Model for afry*", used "*Hunterston Synchronous Compensator*" plant. Minor changes applied to costs assumptions to make the simulation consistent; 2. As indicated in Pathfinder Assessment Methodology | TO: transmission Owner; WACC: Weighted Average Cost of Capital; RAB: Regulated Asset Base; COD: Commercial Operation Date

Legend *Offer/counterfactual for:* *Stability service* *Residual value (not part of offer)* *Selected solution* *Indirect participation* *Direct participation*

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Since direct participation of TOs in LT might undermine competition, indirect route could be suggested to correctly treat the regulated nature of TO assets

PROCUREMENT MECHANISMS

	Indirect participation	Direct participation
Key advantages	– Structurally simple – successful TO assets treated similarly to the rest of TO business – Puts competitive pressure on providers to deliver solutions in the interest of consumers	– Allows a more transparent and fair comparison between solutions, applying the same timescale and evaluation principles
Key challenges	Key challenges are mainly in comparing regulated with commercial solutions: – *Asset lifetime*: under RAB, a 45-year assumed asset life is used, which far exceeds that of envisaged commercial contracts, inflating the actual costs to provide the service (mitigation measure could be to allow a residual value after contract termination) – *Cost of capital and risk*: lower cost of capital for regulated assets due to the allocation of risk compared to commercial asset – how can this risk allocation be appropriately managed? – *Obligations & non-delivery*: obligations on availability/ consequences of non-availability not uniform between TO and commercial assets – *Energy cost exposure*: treatment of energy costs linked with delivery of the service are different between TO[1] and commercial assets – *Access to information*: preferential access to information by TOs – *Access to sites*: preferential access to sites/connections by TOs	– Cost of capital for TOs is generally low due to stable returns and low risk – if TOs were to increase their risk exposure significantly this could impact regulated parts of the business increasing consumer costs (depending on the structure of the TO and financing arrangements) – TOs rely on models of their own networks, allowing them to identify and target solutions potentially before ESO is able to signal needs to all potential participants. This is particularly an issue with locational requirements where solutions must be located close to demand for services as with SCL and DVS. In "worst case" outcomes, TOs could lock out commercial providers in advance[2] as if competing competitively, no obligation to use 'reserved bays' only (depending on structure) – Potential market participants are reliant on the TOs to secure their connections – the facilitation of such requests is not always in the interest of TOs if competing directly – Difficult to see how direct participation would lead to more competitive prices than indirect approach as increased risk should be priced within TO bids

1. Some of the energy costs related to TO assets are socialised in the form of losses; 2. e.g. Land grabbing, connection request gaming | SCL: Short-Circuit Level; TO: Transmission Owner; RAB: Regulated Asset Based; DVS: Dynamic Voltage Support; LT: Long-Term

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Key challenges deriving from indirect competition of TO assets have already been raised during Project Phase 1

PROJECT PHASE 1 - KEY CHALLENGES DERIVING FROM INDIRECT COMPETITION OF TO ASSETS

Asset lifetime

Under the RAB, a 45-year assumed asset life is used which far exceeds that of envisaged commercial contracts

The latest Pathfinder evaluations assumed 10 years as the counterfactual duration for regulated TO assets

Cost of capital and risk

There exists a comparatively low cost of capital for regulated assets due to the allocation of risk (ultimately, consumers bear risk for regulated TO assets)

Obligations & non-delivery uniformity

Obligations on availability/consequences of non-availability are not uniform between TO RAB assets and commercial solutions (again, consumers ultimately bear risk for TO assets)

Energy cost exposure

*Treatment of energy costs associated with delivery of the service is different between TO RAB and commercial solutions**
**NB licence-lite consultation is under way for commercial assets*

Preferential access to information

Potential for preferential access to information by TO(s)

Preferential access to sites

Preferential access to sites/connections by TO

TO: Transmission Owner; RAB: Regulated Asset Base

Each roles combination would raise issues, linked mainly to the regulated nature of TOs and their involvement in additional commercial activities

Role's name	Roles combination	Role's description	Key considerations
1. *The 'Planner'*	Network Planning Facilitator	– TOs will be involved only in the activities as part of the Network Planning Facilitator	– To cover market need, there must be a sufficient number of commercial participants – Potential unlimited willingness to pay since bids are left to commercial providers only
2. *The 'Backstop'*	Network Planning Facilitator, Las Resort Provider	– TOs will be part of the Network Planning Facilitator and provide last resort solutions in case of market failure (Y-4 only)	– Ensures needs are met – Similar to the *Competitor*, with indirect participation – However, does not add competitive pressure to commercial providers (unless last resort option is priced)
3. *The 'Too Big to Fail'*	Network Planning Facilitator, Competitive Provider, Las Resort Provider	– TOs will cover all the three roles, as part of Network Planning Facilitator, participating also as Competitive Provider and, only in case of Y-4 market failure, as Last Resort Provider	– Presence of a "last resort" option may dissuade commercial participation by incumbent TO (benefitting if commercial providers fail to deliver from lower market risk & tender participation costs)
4. *The 'Competitor'*	Network Planning Facilitator, Competitive Provider	– TOs will be part of the Network Planning Facilitator and participate as a Competitive Provider – Most similar to Pathfinder	– To cover market need, there must be a sufficient number of participants guaranteed – Benefits from TOs' expertise in NP, adds competitive pressure to commercial providers and eliminate the risk of TOs preferring to pursue last resort options[1]

1. It may be that incumbent TOs would need to be required to offer enough solutions to ensure the total tender needs are met | TO: Transmission Owner; NP: Network Planning; mkt: market; NGET: National Grid Electricity Transmission; NGV: National Grid Ventures

Legend *Network Planning Facilitator* *Competitive Provider* *Las Resort Provider*

Some considerations have been raised under the desired solution (Counterfactual) during the discussions within ESO

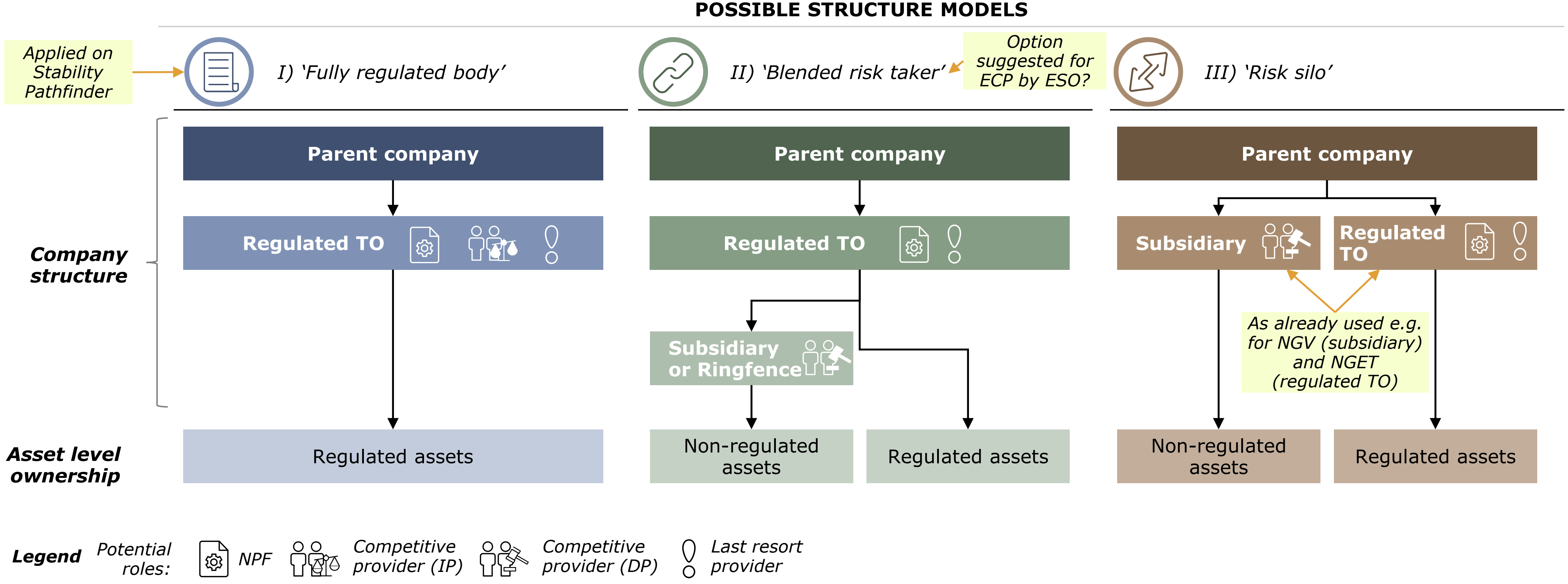
Key considerations on Counterfactual Route emerged during discussions within ESO

- "The idea that the out-of-area TOs are able to compete, meaning that the advantages of TOs bidding competitively are likely to be realised even with the counterfactual model"
- "If an independent subsidiary (controlled by same parent company of TO) already exists, should that participate as solution provider instead of the TO (similar to 'risk silo' approach)?" e.g. NGV/NGET, SP-RE/SPT, SSE-G/SHET
- "The idea that to use the counterfactual route it would be wise to require the TO to submit a counterfactual in certain circumstances (and to allow the cost of so doing)" - this fundamentally avoids 'last-resort' role
- "The idea that the counterfactual could be used for "shortfall"[1] but not for opportunistic[2] purchases (thereby minimising administrative burden)"
- "Overall, it seems premature to discourage TO regulated participation until we know that the competitive process is working. We can then seek feedback from participants on the TO counterfactual as a disincentive or otherwise"
- "Current asset assessments for counterfactual include accelerated depreciation of assets with zero assumed residual value as an artificial tilt of the playing field against the regulated option: can we improve on this to save consumers money?"

1. Procuring only the minimum capacity to meet SQSS; 2. Procuring to minimise costs compared to counterfactual (i.e. avoiding more expensive solutions at later timeframes) | TO: Transmission Owner; NGET: National Grid Electricity Transmission; NGV: National Grid Ventures; SP-RE: Scottish Power Renewables; SPT Scottish Power Transmission; SSE-G: SSE Generation; SHET: Scottish Hydro Electric Transmission; SQSS: Security and Quality of Supply Standard

Several ways to allocate the regulated and commercial risks exist, having different effects on TO WACC and so on final costs for consumers

SIMPLIFIED, ILLUSTRATIVE



TO: Transmission Owner; SPV: Special-Purpose Vehicle; ECP: Early Competition Programme; WACC: Weighted Average Cost of Capital; NGET: National Grid Electricity Transmission; NGV: National Grid Ventures; NBF: Network Planning Facilitator; IP: Indirect Participation; DP: Direct Participation

The separation of non-regulated activities may be the way to isolate TOs' WACCs (and so risks), without affecting the rest of regulated business

FINANCING MECHANISM EXAMPLES

	Non recourse project (Project Finance)	Balance sheet (Corporate Finance)
Principles	– Financing of a project, of which cashflows and risks are managed separately from the rest of company portfolio – Main scope is to address fund sources to specific projects which have a different risk (usually higher) compared to the rest of company activities	– Financing of a project, of which cashflows and risks are managed under the same company umbrella (corporate balance sheet) – The main scope is to optimise the fund sources by distribute them through projects with similar risk profile
Risk management	– Risks are ringfenced to the specific project, not affecting the overall corporate balance sheet – In case of project failure, collaterals are limited only to the asset/cashflows of the specific project – Risk of the single project is typically high	– Risks from projects are aggregated and shared, each affecting the overall corporate balance sheet – In case of project failure, collaterals are linked to the overall assets/cashflows of the company's portfolio – Risk of the single project may be either high or low, but the aggregation of risk reduces the overall volatility of returns

In case of a TO, under a non recourse project financing, projects characterised by high risk[1] (e.g. assets participating in competitive tenders) could be financed separately from the TO core regulated business. Their related risks can be then separated from the underlying total WACC of the regulated business, and may therefore not impact the WACC allowances

1. Compared to what the usual risk associated to the TO regulated core business | WACC: Weighted Average Cost of Capital; TO: Transmission Owner

Most compatible solution for TOs would be to operate as Network Planning Facilitator and Competitive Provider, through indirect/ direct regimes

	Structure model		
Roles combination	*I) 'Fully regulated body'*	*II) 'Blended risk taker'*	*III) 'Risk silo'*
1. The 'Planner'	✓ – No involvement in competitive activities	✘ – No reason to split function if no commercial activities are envisaged	✘ – No reason to split function if no commercial activities are envisaged
2. The 'Backstop'	✓ – No involvement in competitive activities	✘ – No reason to split function if no commercial activities are envisaged	✘ – No reason to split function if no commercial activities are envisaged
3. The 'Too Big to Fail'	✘ – Only works with 'counterfactual' as no structure to support de-regulated assets – However, same solutions offered in competitive/backstop roles renders this combination inappropriate	~ – COI[1] more difficult to monitor/manage than 'Risk Silo model' – Potentially effects on WACC for regulated activities (problem today)	~ – COI difficult to manage as subsidiary effectively competing with regulated assets (last resort providers)
4. The 'Competitor'	✓ – Assuming TOs offering solutions under indirect participation only	~ – COI[1] more difficult to monitor/manage than 'Risk Silo model' – Potentially effects on WACC for regulated activities (problem today)	✓ – Greatest degree of separation to avoid COI[1] – Potentially effects on WACC for regulated activities (problem today)

1. e.g. TO has access to information not available to other bidders such as tender specifications | SPV: Special-Purpose Vehicle; TO: Transmission Owner; NPF: Network Planning Facilitator; COI: Conflicts of interest

Legend *Network Planning Facilitator* *Competitive Provider* *Las Resort Provider* | *Compatibility:* ✓ *Compatible with minor issues* ~ *Compatible with major issues* ✘ *Not compatible*

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Some key questions remain for each of the potential approaches

	Roles combination	Participation	Structure	***Key questions***
A. Counterfactual route	*The 'Competitor'*	*Indirect Participation*	*'Fully regulated body'*	Can we build a credible counterfactual?
B. Fully competitive route	*The 'Competitor'*	*Direct Participation*	*'Risk silo'* ***OR*** *'Blended risk taker'*	– Is the solution demonstrably better than doing nothing/allowing the TO to build the asset under traditional route? – What (if any) additional benefit is brought relative to the administrative burden?

TO: Transmission Owner

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Legend *Network Planning Facilitator* · *Competitive Provider* · *Indirect participation* · *Direct participation* · *'Fully regulated body'* · *'Blended risk taker'* · *'Risk silo'*

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The entry of TOs in competitive businesses might have an incremental effect on their regulated WACC and so on costs for consumers

HOW COST OF CAPITAL IS TREATED WITHIN TO BUSINESS?

- Under the RIIO framework, the regulated WACC sets the 'allowed returns' for TOs, which is correlated to the level of risk in their business

What are the consequences for consumers from TOs entering more competitive businesses with uncertain returns?

- If regulated companies such as TOs were to undertake higher risk activities[1] than is typical for their core business, their WACC may rise to reflect the new risk profile of the company
  - this could have knock on implications for WACC allowances under the RIIO framework which would need to be adjusted to reflect the reality facing the TOs (or risk difficulty in TO financing of regulated investments)
- Based on current RAV values across the three main TOs in GB, a **1 percentage point increase in WACC** allowances could increase cost to consumers by approximately ~**£200m/pa**[2], or £1bn for a 5 year regulatory period

It is important to note that WACC has a number of drivers, and is not only influenced by risk – in particular the wider macroeconomic environment in which the company is operating

Key takeaways

1. WACC is related to perceived risk amongst other factors (*albeit macroeconomic factors not easily controlled*)
2. Setting WACC allowances is already a challenge for Ofgem, consequences can inhibit investment in network development or lead to excess costs through RIIO
3. Depending on how widespread we expect competition for traditional TO assets to be, the risk of WACC inflation could be negligible or high

1. Authorised by Ofgem; 2. Estimation calculated as the 1% of total RAV in 2022 from National Grid Electricity Transmission, Scottish Power Transmission and Scottish and Southern Electricity Networks | TO: Transmission Owner; WACC: Weighted Average Cost of Capital

There are no easy choices when deciding which structure to pursue

Competition and consumer outcomes

- ESO acts as an agent between consumers and producers
- When comparing potential solutions, this must always be with the status quo in mind (are we improving on existing arrangements?)
- The risk that outcomes are worse than the status quo should be mitigated wherever possible, particularly for a service/market in its infancy

Fairness

- Competing regulated assets against commercial solutions assets is a challenge, there are no simple comparison methods (without also aligning obligation durations and terms)
- If there is a perceived advantage by one party over another, this may limit participation interest

COI management

- A single entity responsible for maximising shareholder value and facilitating competition between it's *own entity* and *rivals* presents a conflict of interest – this is true in all instances
- Perception of COI can be damaging even if risk mitigation in place
- Careful calibration of incentives and licence obligations required
- Monitoring & enforcement can be burdensome, minimising the number of points at which COI can arise could be beneficial

Administrative burden

- The administrative burden of potential solutions should be proportional to the problem we are looking to solve
- if tender processes are too long and complex this can reduce the overall benefit

TO: Transmission Owner; COI: Conflicts of Interest

The Pathfinder 2-3 assessment comprises two parallel methods of calculating Present Value for commercial (competitive) and TO assets (counterfactual)

SELECTION PROCESS WITHIN PATHFINDER 2-3

TO counterfactuals

Provider's submission

Capital costs: m£ + *O&M costs:* m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Assessment ESO

ESO calculates the PV of capital costs over 40y period applying the regulated WACC and a discount rate[1]. O&M costs are discounted[1] over the contract length (e.g. 10)

\+

Other costs components added by ESO

Energy consumptions: m£ Estimate of losses

Penalty for late start: m£ Disadvantage for plants connected later

Final selection ESO

Assessed costs: £ m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Commercial offers

Provider's submission

Contract price: £/SP

Stability Contribution: e.g. MVA, MVAr, MVA*s

Assessment ESO

Total contract present value: m£ ESO multiplies contract price by n. of SPs and discounts it[1]

\+

Other costs components added by ESO

Penalty for late start: m£ Disadvantage for plants connected later

Extra balancing: m£ For non 0MW plants

Infrastructure: m£ For connecting plant to the grid

Final selection ESO

Assessed costs: £ m£

Stability Contribution: e.g. MVA, MVAr, MVA*s

Algorithm optimises the selection of commercial offers and TO counterfactuals based on costs and contributions

Source: National Grid ESO | 1. As indicated by Treasury Green Book: i.e. 3.5% for the first 30 year, 3% afterwards | TO: Transmission Owner; SP: Settlement Period; PV: Present Value; O&M: Operations and Maintenance

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However, the Pathfinder methodology risks overpricing the TO counterfactual by assuming the full cost of the TO asset over the tender period

TO's submission

TO counterfactuals

Capital costs: m£, Nominal money

Assessment ESO

1. **Annuities calculation:** constant amount of nominal revenues to recover costs in 40y at interest rate equal to TO WACC
2. **Depreciation:** annuities are depreciated following Treasury Green Book guidelines – DF=3.5% for the first years 0-30, DF=3.0% afterwards

Illustrative example

Capital costs: 10m£, WACC: 2.93%, Asset life: 40y → Annuity: 428k£/y

Year	DF	DR	Annuity	Present value (PV)
0	3.5%	100.0%	428k£	428k£
…	…	…	…	…
10	3.5%	70.9%	428k£	303k£
…	…	…	…	…
31	3.0%	34.6%	428k£	148k£
…	…	…	…	…
39	3.0%	27.3%	428k£	117k£

Hp: TO asset connected at Year 0 → Total PV = $\sum_{y=0}^{39} PV_y$ = 9.5 m£

RECAP POINTS

- In WP1 and EG1 we recommended that the counterfactual regime should be the enduring approach
- We want to ensure a level playing field between commercial providers and TO assets to account for the fact that commercial providers could bid in some residual value as part of their submission

CONSIDERATIONS ON CURRENT COUNTERFACTUAL METHODOLOGY

- Total costs are fully depreciated over the tender period, far shorter than the economic/technical lifetime of the TO asset
- This approach does not account for future capabilities of TO assets and the need for grid services beyond the tender period
- As commercial providers likely consider a residual value within their offers, TO assets are disadvantaged, at a cost to the consumer
- The discounted annuities after the tender period make up approximately 60% of the total Present Value (assuming 10y tender period)

Source: National Grid ESO | 1. Likely applying a DF higher than the one indicated by the Treasury Green Book (i.e. 3.5%) | TO: Transmission Owner; WACC: Weighted Average Cost of Capital; DF: Discount Factor; DR: Discount Rate; RV: Residual Value; PV: Present Value Hp: Hypothesis; RAB: Regulated Asset Base

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Different models to compare the TO counterfactual against commercial offers have been examined and shortlisted

	Depreciation Models	Description: TO counterfactual	Description: Commercial providers
The Pathfinder assessment methodology can be improved…	**1. '*The Pathfinder evaluation*'**	– The total cost of TO counterfactual is depreciated over the tender period, without accounting for any RV after that	– Commercial providers may (implicitly) consider a residual value within their contract price
…ESO could assume a RV for the TO counterfactual…	**2. 'Asset lifetime'**	– TO assets assumed to be useful (i.e. in service, and needed by ESO) over the entire economic lifetime. The residual value is proportional to the residual lifetime after the tender period1	– Commercial providers may (implicitly) consider a residual value within their contract price
	3. '*Fixed residual value for TOs*'	– ESO assumes a residual value, based on expected need/capability of TO assets to provide services[2] after the tender period, which is used to markdown the TO counterfactual	– Commercial providers may (implicitly) consider a residual value within their contract price
…or adjust the commercial offer so depreciation is assessed over a more equal period of time.	**4. 'Offered residual value'**	– The total cost of TO counterfactual is depreciated over the tender period, without accounting for any RV after that	– Alongside contract price, comm. prov. offer and compete for a residual value as well. ESO has option/obligation (TBC) to trigger asset auction or extend the contract by the RV
	5. 'Forced zero residual value'	– The total cost of TO counterfactual is depreciated over the tender period, without accounting for any RV after that	– ESO has option/obligation (TBC) to trigger asset auction or extend the contract to cover marginal cost only - commercial providers forced to assume zero residual value within their offers
	6. '*Pathfinder, but longer contracts*'	– Same as '*The Pathfinder approach*', but assessment considers longer tender period (e.g. 20 years vs. current 10 years of Pathfinder)	– Same as '*The Pathfinder approach*', but assessment and contracts consider longer tender period (e.g. 20 years vs. current 10 years of Pathfinder)

1. e.g. considering a lifetime of 40y and a tender period of 10y (LT contract length), 25% of costs will be included in the counterfactual, while remaining 75% in the residual value; 2. Stability and other ancillary services | TO: Transmission Owner; RV: Residual Value

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Each of the explored models envisages different approaches for treatment of RV and ownership of TO/commercial assets after contract expiry

Models	RV calculation		Treatment of assets after tender period	
	TO counterfactual	Commercial providers	TO counterfactual	Commercial providers
1. 'The *Pathfinder approach*'	Not calculated	Calculated	Under RAB	Ownership maintained
2. '*Asset lifetime*'	Calculated	Calculated	Under RAB	Ownership maintained
3. '*Fixed residual value for TOs*'	Calculated	Calculated	Under RAB	Ownership maintained
4. '*Offered residual value*'	Not calculated	Calculated	Under RAB	Option/obligation for ESO to auction the asset or to extend contract / Ownership maintained
5. '*No residual value*'	Not calculated	Not calculated	Under RAB	Option/obligation for ESO to auction the asset or to extend contract / Ownership maintained
6. '*Pathfinder, but longer contracts*'	Not calculated	Calculated	Under RAB	Ownership maintained

TO: Transmission Owner; RV: Residual Value; RAB: Regulated Asset Base

Legend *Calculated* *Not calculated* *Under RAB* *Option/obligation for ESO to auction the asset or to extend contract* *Ownership maintained*

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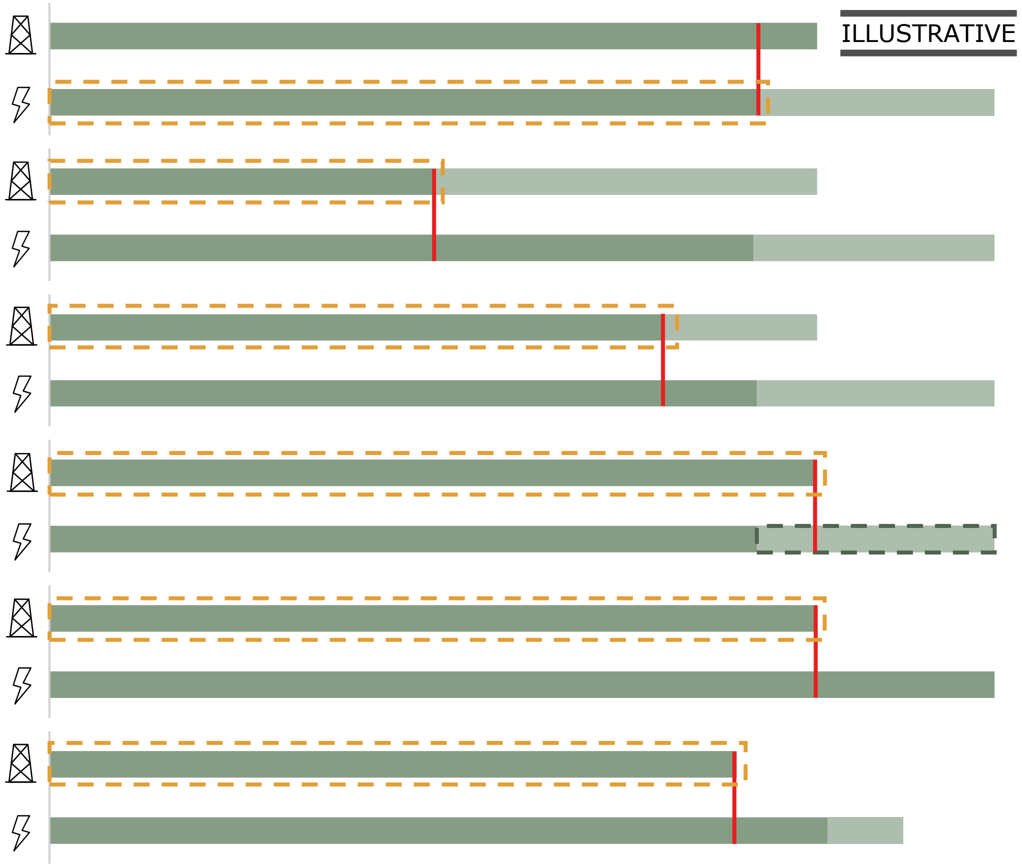
The assessment model will significantly affect the chosen offers as well as the distribution of costs for consumers

ASSUMPTIONS USED FOR THE SUMULATIONS, PROVIDED IN ANNEX[4]

Selection approach (Present Value of assessed offers – Real m£ money)



Models	Considerations
1. 'The Pathfinder approach'	– Under Pathfinder model, TO counterfactual is unfairly expensive due to full depreciation over the tender period. This gives the commercial offer an advantage in the assessment process
2. 'Asset lifetime'	– Assuming the TO's RV is a function of the asset's economic lifetime[1] will result in a cheap counterfactual. This will drive excessive competitive pressure on commercial providers
3. 'Fixed residual value for TOs'	– The TO counterfactual is reduced based on an ESO derived RV, which reflects the need/capability of assets to provide services after tender period. This provides a fairer assessment and drives increased competition from commercial providers
4. 'Offered residual value'	– The contract price and RV offered by the commercial solution is assessed to calculate a present value (fully depreciating the commercial offer over the tender period). The total offer is then compared to the TO counterfactual
5. 'No residual value'	– Option/obligation for ESO to auction/extend contract of commercial assets will incentive providers to assume zero RV – However, this front loads cost to the consumer
6. 'Pathfinder, but longer contracts'	– Longer tender period will reduce counterfactual[2], mainly due to lower Late Penalties, only slightly compensated by higher OPEX – Competitive offers will reduce/increase, depending on the assumption used for interest rate and RV[3]

1. Applied only to the TOs' capital costs; 2. Compared to Model 1; 3. In principle both lower than the ones assumed in Model 1, as Competitive Provider would assume lower market risk and asset value after the tender period, relying on a longer contract; 4. See slide 124| TO: Transmission Owner; RV: Residual Value; RAV: Regulated Asset Value

Legend *Offer/counterfactual for:* *Stability service* | *Residual value (not part of offer)* | *Residual value (part of offer)* | *Lowest price threshold* | *TO counterfactual* | *Commercial provider* | *Selected solution*

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Each of the models has pros and cons. Ultimately a measure to provide an equal assessment of commercial and TO assets should be identified

Models	ADVANTAGES	DISADVANTAGES
1. 'The *Pathfinder approach*'	– No need for ESO to calculate RV on TO counterfactual – Reduced administration burden as it is in line with existing Stability Pathfinder's	– Counterfactual does not reflect needs/capability of assets to provide services after tender period. This results in low competitive pressure from counterf. and comm. offers potentially being selected inefficiently considering the time frame beyond the tender period
2. '*Asset lifetime*'	– Increases competitive pressure on the commercial providers. This model could result to be more accurate than the Pathfinder model if TO assets are useful/capable to provide stability services over the entire assumed lifetime of the asset	– Counterfactual assumes TO assets to be useful/capable to provide services after tender period proportionally to its assumed lifetime, not necessarily reflecting the actual situation after tender period[1] – Such depreciation likely underestimates cost of TO counterfactual
3. '*Fixed residual value for TOs*'	– Depreciating TO counterfactual by an assumed RV will increase competitive pressure on commercial providers – Though complex to calculate, any reasonable estimate of RV[2] is likely more robust than zero RV currently assumed	– Complex to estimate RV (e.g. estimate future needs for services, quantify a 'discount' on counterfactual, treat different costs components, consider additional costs for the reuse of asset) – Discounting counterfactual may inhibit participation of comm. prov.
4. '*Offered residual value*'	– No need for ESO to calculate RV on TO counterfactual – ESO has view of commercial RVs and possibility to opportunistically extract it (through contract extensions or auctions) after the tender period	– More complex and onerous tender process for commercial providers – Potentially high administrative burden for ESO to extract RV – Comm. prov. (particularly those stacking revenues) might not accept forced auction
5. '*No residual value*'	– No need for ESO to calculate RV on TO counterfactual – ESO can (opportunistically) extract value from assets after contract expiry	– Potentially high administrative burden for ESO to extract RV – Consumers bear costs for stability within tender period timeframe – Comm. prov. (particularly those stacking revenues) might not accept forced auction
6. '*Pathfinder, but longer contracts*'	– Reduce the time misalignment in the assessment of TO and competitive assets (proportionally to the length of contract). This increases competitive pressure on comm. providers, ideally assuming lower residual value in their offers	– Increase risk for consumers to contract stranded sources, as complex to forecast need for services in the medium-long term (>10 years)

1. Forecasts are affected by errors related to e.g. asset breaking before the assumed lifetime or getting stranded during the lifetime period; 2. Reflecting future need/capability of the asset | TO: Transmission Owner; RV: Residual Value

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ESO desired to investigate Model 3, which would ideally increase competition (benefitting the consumers), but requires to calculate a RV for TO assets

Models	Consumers	NG ESO	Transmission Operators	Commercial providers
1. 'The Pathfinder evaluation'	– Comm. solutions might be awarded even when not the cheapest (as compared with lifetime cost of TO solution)	– No RV to be calculated – No view on costs for services after tender period	– Full depreciation of TO assets in the counterfactual represent a disadvantage for TOs	– Low competitive pressure form TO counterfactual gives commercial providers a competitive advantage
2. 'Asset lifetime'	– Counterfactual likely too low as assumes TO assets valuable for entire life[2] – consumers bear the cost/risk of this assumption	– Simple approach to calculate RV – No view on costs for services after tender period	– Constant depreciation makes TO assets more competitive	– Extremely high competitive pressure from the TO counterfactual
3. 'Fixed residual value for TOs' (Option further investigated)	– Competitive pressure set by RV would reduce costs – Consumers bear risk of RV to reflect situation after tender period	– Complex to calculate RV based on expectation of grid services in the future	– RV makes TO assets more competitive	– Higher competitive pressure from TO counterfactual – No change of pricing strategy compared to Pathfinder
4. 'Offered residual value'	– Possibility to hedge costs through ESO option/obligation – Cap of gains of comm. prov. – No severe front payments within tender period	– No RV to be calculated – Administrative burden to extract RV at contract expiry	– Commercial offer assessed on the same timeline of the counterfactual	– Higher competitive pressure from TO counterfactual – More complex tendering process
5. 'Forced zero residual value'	– Avoids windfall gains – Consumers bear whole contract costs in tender period	– No RV to be calculated – Administrative burden to extract RV at contract expiry	– Commercial offer assessed on the same timeline of the counterfactual	– Higher competitive pressure from TO counterfactual – Free from risks after contract expiry, but no chances to extract extra value from asset[3]
6. 'Pathfinder, but longer contracts'	– Lower risk of windfall gains in case of contract renewal, but at the same time higher risk to pay for stranded assets in future	– Lower administrative burden as resources are contracted for longer time[4] – Complex to forecast need for services for longer periods	– Commercial offer assessed on timeline closer to the counterfactual's compared to model 1	– Lower commercial risks with longer contract – Higher competitive pressure from the TO count. Compared to model 1

1. Effectively loosing the regulated WACC advantage; 2. Which realistically may not be the case; 3. As ESO would likely auction the asset in case perceives any value left; 4. Less need to extend contracts after tender period | TO: Transmission Owner; RV: Residual Value; mgmt.: management

Legend *Overall impact:* *Positive* *Balanced pros/cons* *Negative* *Shortlisted models*

3. *'Fixed residual value for TOs'*

Due to the timeframe misalignment between the RAB and tender period, the counterfactual calculation may consider a RV for the TO capital costs

TO counterfactuals

Cost components	Assessment timeframe	Compatibility with tender period timeframe
Capital costs	RAB period	✗ RAB likely longer than tender period
O&M costs	Tender period	✓
Energy consumption	Tender period	✓

Legend ✓ *Compatible* ✗ *Not compatible*

POSSIBLE PARAMETERS TO CALCUALATE THE RESIDUAL VALUE

Asset technical life

Representing the expected **residual capability** of the asset to provide services after the tender period, based on:

- *Technology type* – average lifetime of the single technologies (e.g. synchronous condensers, HVDC cables)
- *Utilisation rate* – reflecting how the use for stability services impact asset total lifetime

Asset usefulness

Representing the expected **residual need** for the asset to provide services after the tender period, based on:

- *Service requirement* – based on ESO forecasts on local need for services (taking into account possible differences in required assets' availability compared to stability[1])
- *Portability of the asset* – possibility to reinstall the asset in different site in case services are needed elsewhere

1. In case need for services after tender period requires plants to be available more/less hours compared to Stability market, RV calculation will take into account the n. of years and the rate of usage (availability) required to the asset after the tender period| RV: Residual Value; TO: Transmission Owner; O&M: Operations and Maintenance; RAB: Regulated Asset Base

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The depreciation model needs to ensure target objectives such as fairness of the appraisal, matching expense with use of service and payment efficiency

TARGET OBJECTIVES OF THE DEPRECIATION MODEL

FAIR APPRAISAL BETWEEN TO AND COMMERCIAL ASSETS

- TO counterfactual and commercial bids have to reflect costs related to the same timeframe (i.e. the tender period)
- Assuming assets to be needed even after the tender period, TOs and commercial providers would have to consider a RV, reflecting the period of time between the end of tender and usefulness periods

CUSTOMERS PAYING WHEN RECEIVING THE SERVICE

- Costs for stability, and other services after the tender period, should be paid by consumers over the periods when such services are actually required by the system (and provided by assets)
- This would apply only on commercial assets (which recover their costs during the contract period), as TO asset will anyway have to recover their costs over the RAB period (45 years), regardless of length of tender period

COMMERCIAL ASSETS NOT OVERPAID/UNDERPAID

- Tender and usefulness periods have to be assumed by ESO so that commercial assets do not get paid multiple times or underpaid
- Wrong forecasts of usefulness might occur in:
  - Real usefulness period longer than forecasted – contract extensions pay windfall gains to the previously contracted commercial providers
  - Real usefulness period shorter than forecasted – results in missing money for commercial providers

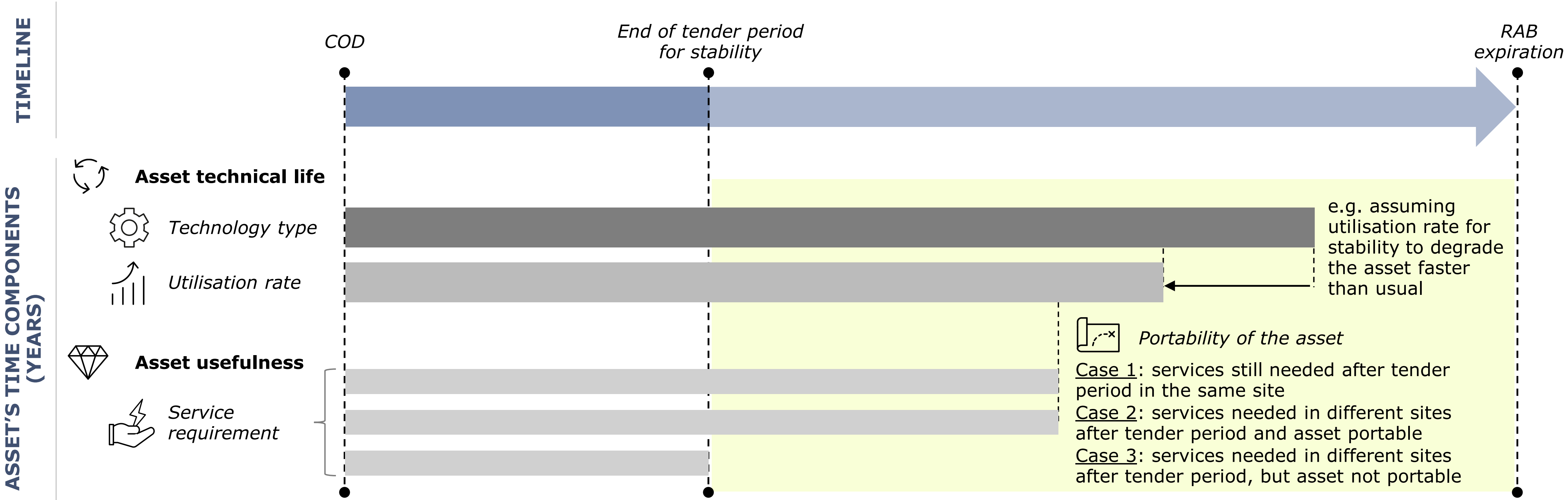
TO: Transmission Owner; RV: Residual Value; RAB: Regulated Asset Base

3. ‘Fixed residual value for TOs’

The residual value will be based on the asset residual lifetime, which takes into account both technical life and usefulness time parameters

ILLUSTRATIVE

CALCULATION THE RESIDUAL LIFETIME



Residual lifetime = shortest between time components

- Cases 1 and 2: Residual Lifetime = residual service requirements after tender period
- Case 3: Residual Lifetime = 0

Note: example assuming residual asset technical lifetime higher than asset usefulness | COD: Commercial Operation Date; RV: Residual Value; TO: Transmission Owner; RAB: Regulated Asset Base

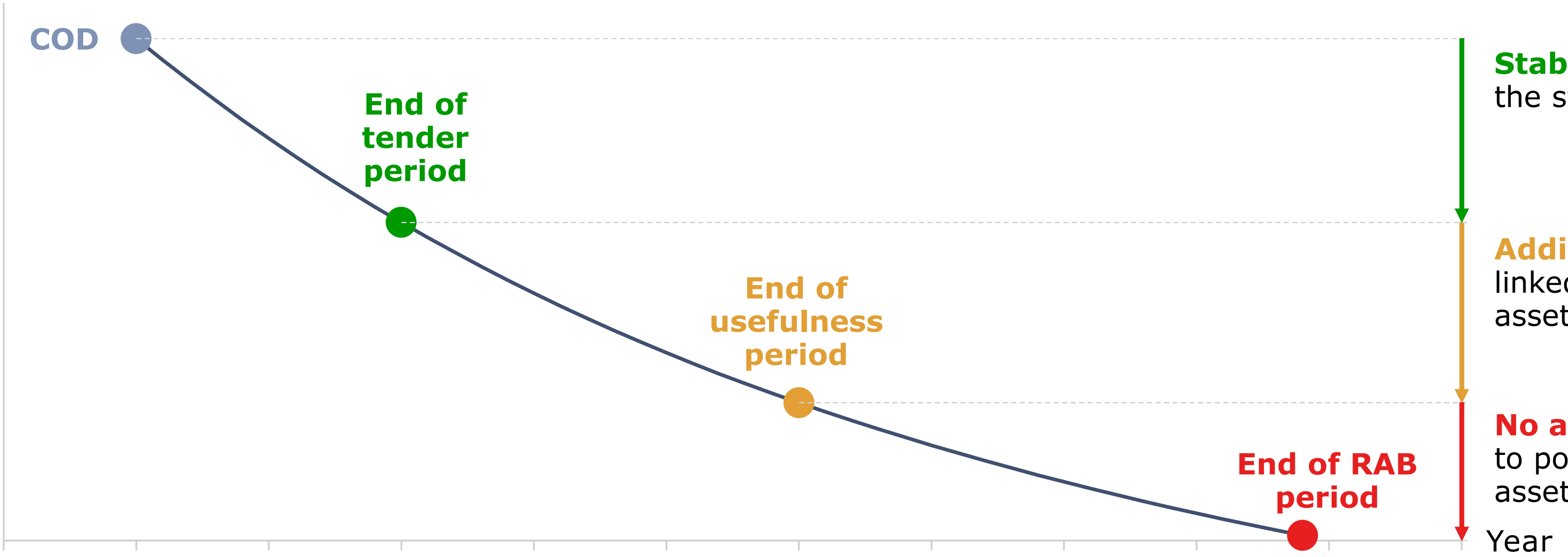
3. 'Fixed residual value for TOs'

The proposed methodology for Model 3 calculates the RV on the basis of the forecast of future asset usefulness and the choice of contract length

ILLUSTRATIVE

POSSIBLE ASSESSMENT OF ASSET'S COSTS TO DETERMINE COUNTERFACTUAL AND RESIDUAL VALUE

NPC – Asset costs (m£)



Stability value = costs linked to the stability tender period

Additional useful value = costs linked to post tender period when asset is still useful for services

No actual value = costs linked to post-usefulness period when asset has no value for services

Counterfactual = '**Stability value**' + '**No actual value**' → Sum of asset's value during stability provision and when the asset is not needed by the system anymore

Residual value = '**Additional useful value**' → Residual value of the asset, reflecting its usefulness for services after the tender period

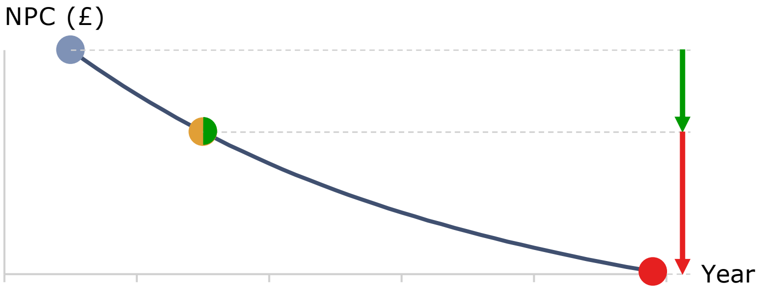
HYP: assuming asset technical life longer than asset usefulness, WACC=2.93% and discount factor equal to 3.5% for the first 30 years and 3.0% afterwards | COD: Commissioning Operation Date; RAB: Regulated Asset Base; NPC: Net Present Costs

Assuming a usefulness period between the end of tender and RAB period would mitigate the risk of over/under-estimating the counterfactual cost

ILLUSTRATIVE

Scenarios	Visual representations	Counterfactual – RV calculation

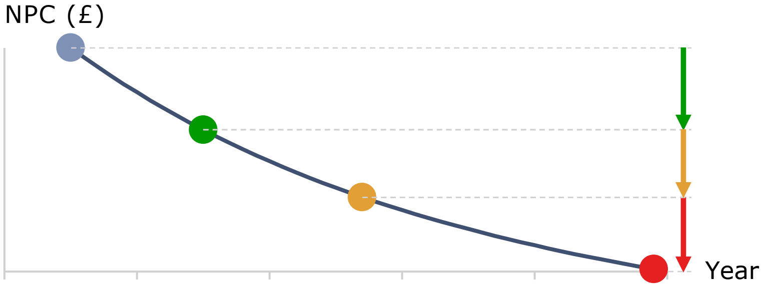
3.a 'No value after tender period'



- Effectively, same as Model 1. '*The Pathfinder approach*' and Model 5. '*No residual value*'
- Variation of tender period does not affect Counterfactual/RV

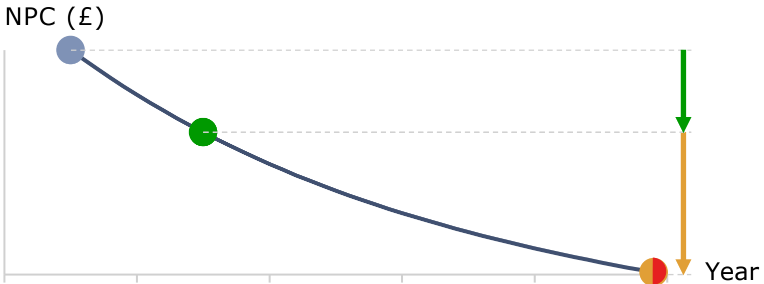
Preferable option

3.b 'Usefulness window after tender period'



- Both variation of tender and usefulness period affect Counterfactual and RV

3.c 'Services needed for entire RAB'



- Effectively, similar to Model 2. '*Asset lifetime*'[1]
- Counterfactual (RV) is proportional (inversely proportional) to the tender period

HYP: assuming asset technical life longer than asset usefulness, WACC=2.93% and discount factor equal to 3.5% for the first 30 years and 3.0% afterwards | 1. Slightly different: in Model 2, RV is proportional to remaining RAB period after contract expiry, while Model 3.b considers the portion of NPC after contract expiry | TO: Transmission Owner; COD: Commissioning Operation Date; RAB: Regulated Asset Base; NPC: Net Present Costs; RV: Residual Value, WACC: Weighted Average Cost of Capital

Legend COD · End of tender period · End of usefulness period · End of RAB period · Stability value · Additional useful value · No actual value

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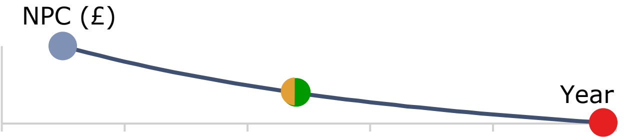
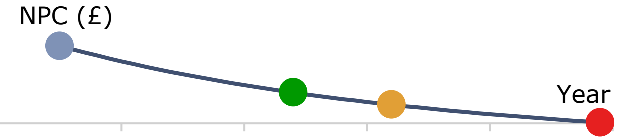
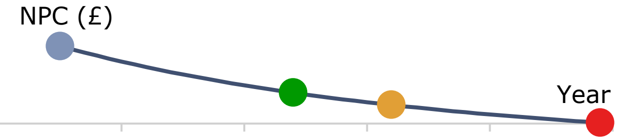
3. 'Fixed residual value for TOs'

POSSIBLE DEPRECIATION MODELS: DEEP DIVE OF MODEL 3

In the likely event of longer need for assets, scenario 3.b would require ESO to establish a methodology to determine the usefulness period (UP)

ILLUSTRATIVE

	Assets useful in the short period	**Assets useful in the long period**	
	I. RV of TO assets assumed to be zero	***II. RV of TO assets set by ESO***	***III. RV set by commercial providers***
			
Determination of usefulness and tender periods	Usefulness calculated by ESO through current methodology used in Pathfinder with zero residual value assumed for TO assets ESO needs to ensure contracts which are long enough to guarantee bankability of commercial projects	ESO calculates UP through either: a) 'Simple approach': e.g. usefulness end set between tender and RAB ends; or b) 'Refined approach': e.g. usefulness end positioned based on a detailed estimate of the usefulness decay curve Contract length enough to guarantee bankability and keep a reasonable window for contract extension after TP	Usefulness, calculated by ESO through current methodology used in Pathfinder Contract length enough to guarantee bankability and keep a reasonable window for contract extension after TP
RV calculation	No need to calculate a RV – entire cost reflected within counterfactual/commercial offers Commercial providers may assume some RV	– TO assets: by ESO[1], based on its decision on tender and usefulness periods – Comm. assets: by providers, based on indications on TP and UP provided by ESO	– TO assets: by ESO, based on the RVs explicitly provided by comm. providers – Comm. assets: by providers, based on their expectations on future assets' value
Treatment of assets after tender period	– TO assets: under RAB – Comm. assets: providers maintain ownership & eligibility for future contracts	– TO assets: under RAB – Comm. assets: eligible for contract extension (e.g. based on submitted RV?)	– TO assets: under RAB – Comm. assets: eligible for contract extension at tariff based on RV or auctioned
Equivalence with proposed models	***3.a 'No value after tender period'*** ***1. 'The Pathfinder evaluation'***	***3.b 'Usefulness window after tender period'***	***4. 'Offered residual value'***

1. Through the methodology explained in previous slides | NPC: Net Present Costs; RV: Residual Value; UP: Usefulness Period; TP: Tender Period; RAB: Regulated Asset Base; TO: Transmission Owner

Legend COD End of tender period End of usefulness period End of RAB period Preferable option

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Further analysis of future needs would provide higher degree of certainty on usefulness period. This would however imply complex methodologies to apply

ILLUSTRATIVE

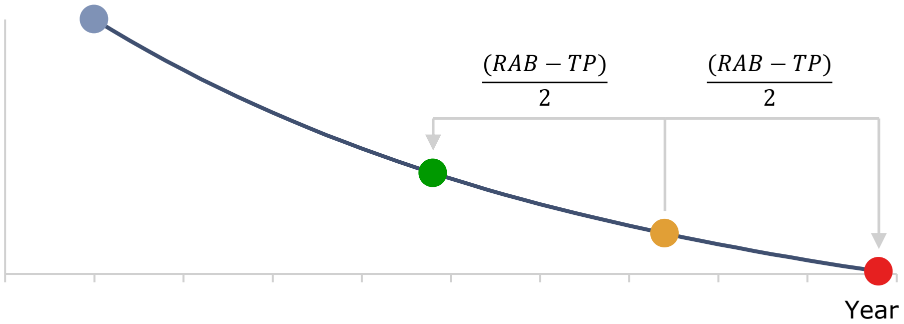
Determination of usefulness and tender periods

POSSIBLE OPTIONS

Assets useful in the long period

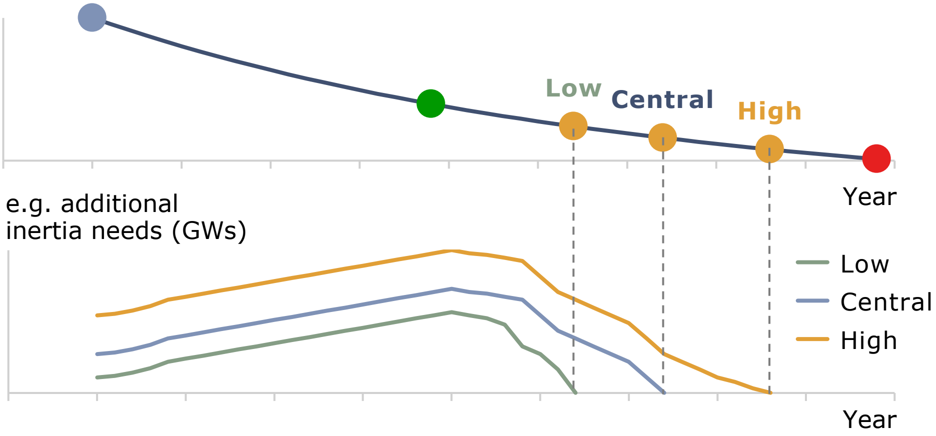
II. RV of TO assets set by ESO

a) <u>‘Simple approach’</u>



- Usefulness period is estimated to be in between the end of tender (estimation of reasonable need for stability, enough to support bankability of the commercial projects) and RAB periods (rough estimation of technical lifetime of the TO assets)
- This simple methodology assumes that setting the end of usefulness period right in between the end of tender and RAB periods statistically provides highest accuracy

b) <u>‘Refined approach’</u>



- Usefulness periods are determined through estimation of stability needs (inertia in this example) based on different scenario assumptions (e.g. High, Central, Low views)
- This more complex methodology would require additional analysis by ESO and would also provide strong signals to the market. This exposes ESO and commercial providers to high risks if ESO assumptions and, as a result bidding strategies, end up to be incorrect

NPC: Net Present Costs; RV: Residual Value; UP: Usefulness Period; TP: Tender Period; RAB: Regulated Asset Base; TO: Transmission Owner

Legend: COD; *End of tender period*; *End of usefulness period*; *End of RAB period*

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Alignment of information between TO and commercial providers over future needs would guarantee the achievement of the proposed objectives

ILLUSTRATIVE

Target objectives

3.b 'Usefulness window after tender period'	Fair appraisal between TO and commercial assets	Customers paying when receiving the service	Commercial assets not overpaid/underpaid
I. Comm. prov. assume (correct) RV≠0 *Counterf.* *RV* *Offer* *RV*	Positive: Assuming comm. prov. being aware of usefulness period forecasted by ESO. TO counterfactual and commercial offers assessed over the same period, which assumes the assets to be still useful for a certain timeframe after the tender period	Negative: If TO asset wins: customers pay stability service over the entire RAB period (likely longer than tender and usefulness period) – unavoidable[1] Positive: If comm. asset wins: customers pay costs associated to stability and, potentially, additional costs associated to residual usefulness of the asset at a later stage (e.g. through contract extensions)	Positive: Assuming RV correctly reflecting the residual usefulness of the commercial asset, possible contract extension after the tender period would not provide windfall gains to commercial providers
II. Comm. prov. assume (wrong) RV=0 *Counterf.* *RV* *Offer*	Negative: Assuming comm. prov. NOT being aware of usefulness period forecasted by ESO. TO counterfactual and commercial offers assessed over different periods (equal to the UP for TO assets and to the TP for commercial providers)	Negative: If TO asset wins: customers pay stability service over the entire RAB period (likely longer than tender and usefulness period) – unavoidable[1] Negative: If comm. asset wins: customers pay the entire costs of the solution within the TP, while the asset would be useful even after it	Negative: Comm. prov. would be able to make windfall gains if awarded for contract extension after the tender period as their previous stability contract already covered the entire cost of the solution

Cases

1. Unavoidable negative effect: change of RAB remuneration system is not up for discussion | TO: Transmission Owner: RV: Residual Value; TP: Tender Period; RAB: Regulated Asset Base; UP: Usefulness Period

Legend Stability value | *Additional useful value* | *No actual value* | *TO counterfactual* | *Commercial providers* | *Positive effect on target objective* | *Negative effect on target objective*

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SUMMARY OF FINAL CONSIDERATION FOR DEPRECIATION OF TO ASSETS

The (potential) adoption of Model 3 would require the ESO to determine the usefulness period, which would bring high uncertainties and risks

SUMMARY OF FINAL CONSIDERATIONS ON MODEL 3

Reasons for further investigating Model 3

- There is reasonable certainty that the period of need is longer than 10 years
- ESO is better placed than commercial providers to estimate future need and value
- This has driven the choice of Model 3 (where ESO calculates a RV for TO assets) expected to ensure the achievement of target objectives[1] of the Stability market

Elements affecting the calculation of the RV

- The methodology for calculating the counterfactual needs to consider only the portion of capital costs linked to the tender period
- The RV, to be deducted from the counterfactual, determined by both the expected technical lifetime and period of time when the asset is expected to be useful

Possible approach to calculate the RV

- Approach requires scenario analysis to determine future system needs and value
- Potential future mandating of services (e.g. grid forming) will influence future value
- To determine the RV, apply a depreciation model[2] which is based on the timeframe between the end of tender and usefulness periods, or (directly) the future values

Possible methodologies to determine the usefulness period

- The major complexities in the proposed approach relate to the methodology (and transparency) of the estimation by ESO of the usefulness period
- The usefulness period could be determined through a simple[3] or a more detailed[4] approach. The latter potentially provides more accurate indications, but it is affected by high uncertainty and exposes ESO and comm. prov. to higher risks

1. Fair appraisal between to and commercial assets, customers paying when receiving the service, commercial assets not overpaid/underpaid; 2.Assuming asset tech. life longer than asset usefulness, TO WACC and a discount factor equal to 3.5% for the first 30 years and 3.0% afterwards; 3. Usefulness period estimated to be in between the end of tender and RAB periods; 4. Usefulness periods determined through estimation of stability needs, based on different scenario assumptions |TO: Transmission Owner; RV: Residual value

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Model 6 has been recommended as it reduces risk of paying assets multiple times and complexity of calculating a residual value after the tender period

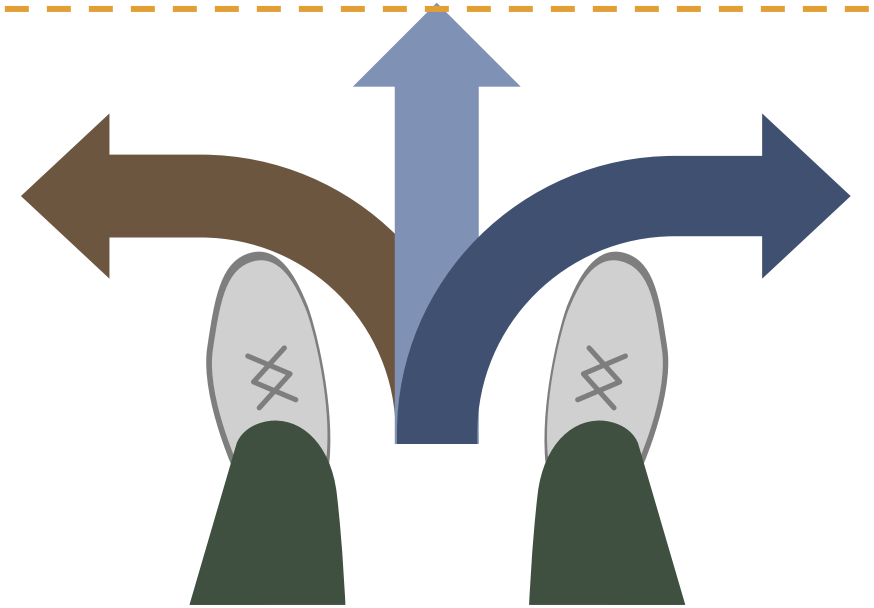
Recommended model

6. *'Pathfinder, but longer contracts'*

- Applies Pathfinder model but envisages longer contract duration
- This to be more aligned with the usefulness period, expected to be longer than 10 years, but complex to estimate
- Requires a compromise between granting possibly too short contracts, risking to pay for assets multiple times if asset remains useful after tender period, and the risk of over-burdening future customers by offering contracts longer than then actual usefulness period

3. *'Fixed residual value for TOs'*

- Require the ESO to determine the usefulness period, which would bring high uncertainties and risks



1. *'The Pathfinder evaluation'*

- Model currently in use for Pathfinder, with 10 years contract duration
- Counterfactual might be overpriced (as does not consider the residual value of TO asset after tender period)
- However, a competitive ST market after the tender period could provide fair remuneration to commercial providers, in alternative to contracts extensions, avoiding paying for them multiple times

TO: Transmission Owner; ST: Short-Term; RV: Residual Value; RAB: Regulated Asset Base

Assumptions used for simulation of depreciation model – slide 111

	TO counterfactuals	Competitive provides
Technology	– Synchronous condenser	– Synchronous condenser
Costs	– Capex, Opex, Losses: as from example provided by ESO[1] – Interest rate: 2.93% – Reference date to calculate delay costs: 31/03/2024 (as indicated in Pathfinder Assessment Methodology)	– Capex, Opex, Losses: assumed by AFRY to results in a price offered (£/SP) equal to the average of prices offered by commercial providers for synchronous condensers during Pathfinder Stability 2 auctions (i.e. 645 £/SP) – Infrastructure: as from example provided by ESO[2] – Interest rate: 10% - models 1-5; 6% - model 6 – Reference date to calculate delay costs: 31/03/2024 (as indicated in Pathfinder Assessment Methodology)
Residual value	– Model 1: 0% (all costs) – Model 2: 75% (Capex), 0% (rest of costs) – Model 3: 30% (Capex), 0% (rest of costs) – Model 4: 0% (all costs) – Model 5: 0% (all costs) – Model 6: 0% (all costs)	– Model 1: 30% (£/SP offer), 0% (rest of costs) – Model 2: 75% (infra.), 0% (rest of costs) – Model 3: 30% (£/SP offer and infra.), 0% (rest of costs) – Model 4: 30% (£/SP offer and infra.), 0% (rest of costs) – Model 5: 0% (all costs) – Model 6: 5% (£/SP offer), 0% (rest of costs)
COD	– 2026 (as from example provided by ESO[1])	– 2025 (as from example provided by ESO[2])
Tender period	– 10 years – models 1-5; 20 years – models 6	– 10 years – models 1-5; 20 years – models 6

1. Through spreadsheet "*Stability Phase 2 CBA Cost Model for afry*", used "*Hunterston Synchronous Compensator*" plant. Minor changes have been applied to costs assumptions to make the simulation consistent.; 2. Through spreadsheet "*Ph3 CBA Cost Model-for AFRY options removed*" Assumed infrastructure costs equal to 1m£ at the plant's COD | TO: Transmission Owner; COD: Commercial Operation Date

Agenda

APPROACH

Recommendation of EFA block (4h) resolution for ST has been based on criteria of low level of overholding and consistency with other ST products

Outcomes from Stability Phase 1

- Recommendations from Phase 1 have suggested the application of either Settlement period or EFA blocks for ST product resolution, based on the (split) feedback from Industry, the nature of the requirements and the characteristics of the providers

Possible design options

- Possible design options have been considered for ST product resolution:
  a) ½h
  b) 1h
  c) 4h
  d) 12h (day/night)
  e) 24h (baseload)

AFRY assessment

- The following criteria have been considered to evaluate the most suitable design option:
  1. Acceptable degree of overholding[1]
  2. Consistency with other existing ST products
- The analysis have been performed based on 2017-2022 historical data (SP granularity) on inertia requirements and procurements
- EFA blocks (4h) is the recommended resolution for ST, having evaluated an acceptable level of overholding, practicality and the consistency with other existing ST products
- Cost assessment of the different procurements could not be performed, due to lack of historical inertia price data at SP granularity

1. Difference between profile requirements and actual profile supply | ST: Short-Term; SP: Settlement Period

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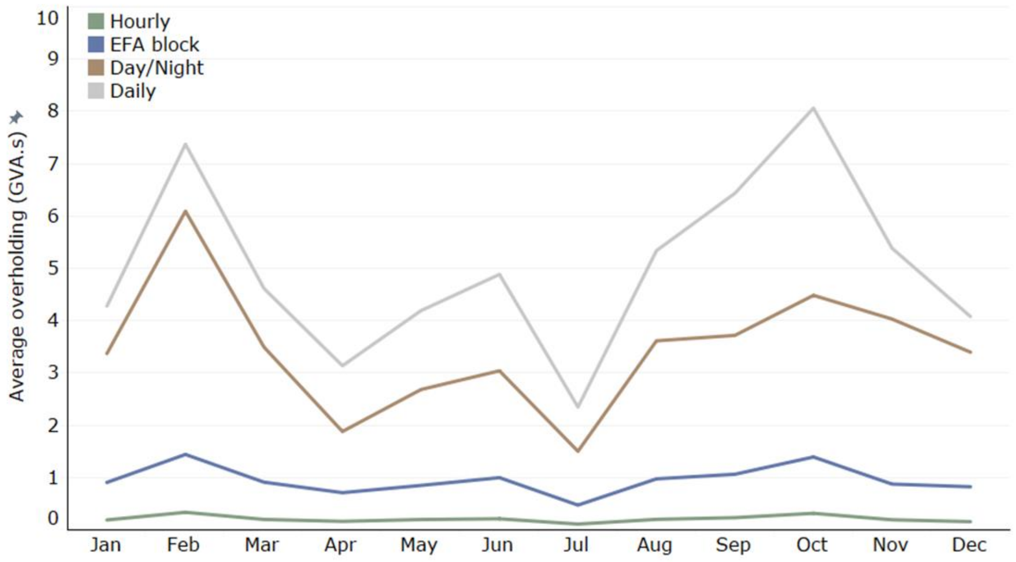
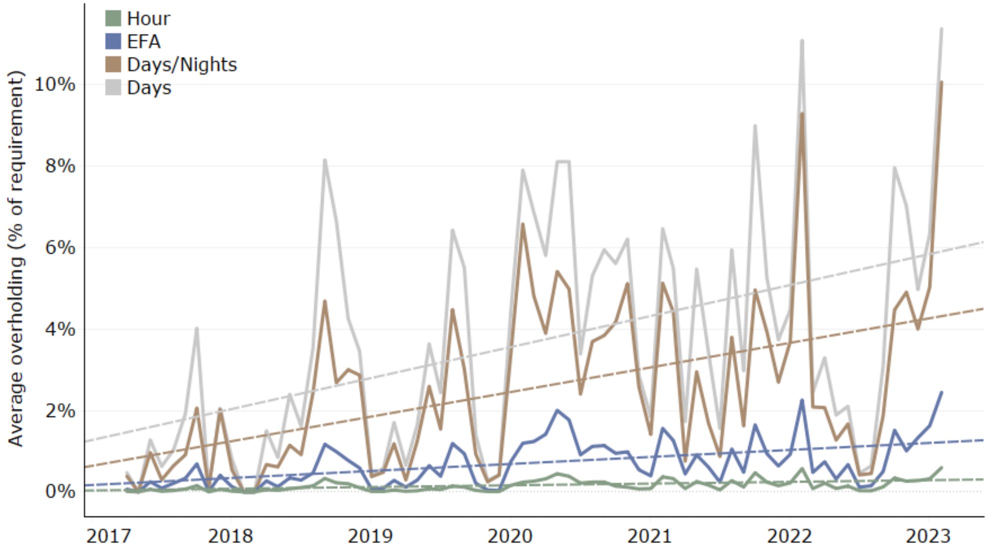
ST Market (D-1)

ANALYSIS RESULTS

1h and 4h blocks would provide relatively low overholding compared to higher resolutions, considering also their historical trends

Comparison of overholding for different ether blocks





Volume

- Large difference in avg. overholding between Day&Night/ Daily and Hourly/EFA block
- Low overholding in EFA and Hourly blocks, with EFA overholding only slightly higher than that of hourly

Volatility and rate of change

- Greater overholding volatility in Day/Night and Daily blocks
- Accelerating overholding requirement in Day&Night/Daily blocks over time, while slower increase in EFA and Hourly. This indicates a lower future requirement for overholding for EFA/Hourly

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FINAL CONSIDERATIONS

EFA blocks (4h) would be the recommended ST resolution for Stability, considering practicality and the coherency with other existing ST products

ST PRODUCTS PROCURED BY NATIONAL GRID

Dynamic Containment	Following large volume of eligible capacity taking part in auctions, National Grid moved auctions from daily to EFA block resolution
Dynamic Moderation	Dynamic Moderation takes place in similar auctions to Dynamic Containment, with non-symmetrical procurement and EFA block resolution
Dynamic Regulation	Dynamic Regulation takes place in similar auctions to Dynamic Containment, with non-symmetrical procurement and EFA block resolution
Firm Frequency Response	Firm frequency response is already purchased in EFA blocks

- For flexibility, **4 market products** are already procured in EFA blocks resolution in ST market
- ESO control room **further approves** the choice of EFA blocks contracts in ST market

ST: Short-Term

FINAL RECCOMMENDATIONS FOR EXPIRED CONTRACTS

Expired PF and Stability contracts could be renewed within the MT market, with prices set through a competitive assessment

ILLUSTRATIVE

EVOLUTION OF SELECTIVE CHARACTERISTIC MODEL

TIMELINE

Today (no Stability Markets)

Short term horizon (initial Stability Market)

Mid term horizon (fully operational Stability Market)

SELECTIVE CHARACTERISTICS MODEL

LT MARKET (Y-4)

MT MARKET (Y-1)

ST MARKET (D-1)

Existing Pathfinder contract

Existing capability

New build

Enhanced capability

Existing capability

- MT market will open to expired Stability contracts providers as well, at 1y contract duration and Y-1 procurement period

- A competitive MT market (which will include expired PF also) will be introduced in a short while with the following purposes:
  a. Enable ESO to **fulfil** Stability **requirements** before initiating SM
  b. Develop necessary **price signals** for future providers to evaluate investments in Stability
  c. Ensure **efficient procurement** through a competitive assessment
- Recommended contract duration of 1y, with Y-1 procurement period

LT: Long-Term; MT: Mid-Term; ST: Short-Term; PF: Pathfinder; SM: Stability Market

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POSSIBLE OTHER DESIGN OPTIONS

There is a wide range of possible design options for contract extension …

LIST OF OTHER POSSIBLE DESIGN OPTIONS FOR CONTRACT EXTENSION

1. CAPPED PRICE AND BILATERAL NEGOTIATION	2. SAME COMM. TERMS AS PREVIOUS CONTRACT	3. REGULATED COMPENSATION OF RV	4. PRE-BID PRICE FOR EXTENDED CONTRACT	5. NO CONTRACT EXTENSION
– As currently envisaged for Pathfinder units – Price of the extended contract is capped at the price of the expired contract – Final price and contract duration will be agreed by ESO and the commercial provider through bilateral negotiation	– Extended contract will be priced at the same price of the expired LT contract – Duration of the extended contract will be decided by ESO according to the residual need for services	– During stability auctions, based on the RV calculated for the TO counterfactual, RV of commercial assets are assessed by ESO, which provides a regulated price and duration for possible contract extension after the tender period	– Along with bid for Stability contracts, commercial providers bid a RV, which is assessed by ESO at contract expiry to determine contract extensions – Technically similar to TO depreciation Model 4[3]	– Commercial providers do not receive contract extension after stability contract terminates – Expired contract providers become eligible for ST market (and possibly for MT)

1. e.g. Model 3 'Fixed residual value for TOs' does not envisage any pre-terms on contract extension for commercial providers; 2. e.g. in case of 20y contracts, there might be no need to extend commercial contracts; 3. 'Offered residual value' | LT: Long-Term; TO: Transmission Owner; RV: Residual Value; ST: Short-Term; MT: Mid-Term

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Expired PF and Stability contracts

EVALUATION OF DESIGN OPTIONS

… of which a first high-level assessment shows different (and diverging) compatibilities for Pathfinders and Stability expired assets

COMPATIBILITY OF OTHER DESIGN OPTIONS WITH PROCUREMENT SCHEMES FOR STABILITY

Type of expired contracts	Design options for contract extension				
	1. CAPPED PRICE AND BILATERAL NEGOTIATION	**2. SAME COMM. TERMS AS PREVIOUS CONTRACT**	**3. REGULATED COMPENSATION OF RV**	**4. PRE-BID PRICE FOR EXTENDED CONTRACT**	**5. NO CONTRACT EXTENSION**
Pathfinder	✓ – Current approach used for future expired Pathfinder contracts	~ – Effectively represents the upper limit of design option 1 – May lead to windfall gains if price are higher than actual RV	✗ – Pathfinder contracts do not envisage regulated ways for contract extension as well as any methodology to calculate a RV for commercial providers	✗ – Awarded units were not asked to bid RV during Pathfinder bids – Model anyway inconsistent with approach currently in use[1]	✓ – ESO may decide not to apply contract extension if there is no actual usefulness of Pathfinder assets after the tender period
Stability	✓ – No relevant barriers perceived	~ – May lead to windfall gains if price are higher than actual RV	✓ – No relevant barriers perceived	~ – Might required to revise the chosen TO depreciation model (give the possibility to comm. prov. to bid a RV as well ESO to design a methodology to assess these RVs)	✓ – No relevant barriers perceived

1. As the TO counterfactual currently does not consider a RV, there will be inconsistency with the methodology used for commercial providers (required to provide a RV) | TO: Transmission Owner; RV: Residual Value

Legend *Compatibility:* ✓ *Compatible with no/minor issues* ~ *Compatible with major issues* ✗ *Not compatible*

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Agenda

KEY ISSUES OF OFTOS AND INTERCONNECTORS

Involvement of OFTOs and ICs depends on their technical capability to provide stability and the resolution of possible regulatory/economic barriers

KEY QUESTIONS ON THE PARTICIPATION OF OFTOs AND ICs WITHIN THE STABILITY MARKET

TECHNICAL ENABLERS

- *Are current OFTO/IC technical configurations able to provide stability services?*
- *In case not, what are the possible add-on components to allow service provision?*

REGULATORY/ECONOMIC ENABLERS

- *Are there any regulatory and economic barriers affecting the participation of OFTOs and ICs in the stability market?*
- *What are possible regulatory and economic measures that could facilitate their participation?*

OFTO: Offshore Transmission Owner; IC: Interconnector

EQUIPMENT ENABLING STABILITIES FOR OFTOS/IC

OFTOs and ICs are able to provide stability when equipped with specific kits, such as a VSC, Synchronous Condenser, Flywheel Storage

Voltage Source Converters (VSC) with algorithm for stability provision	VSCs are a type of converter made with transistors (usually IGBTs) that can be turned on/off by a control action, allowing converter-based technologies such as HVDC cables to deliver electricity and provide grid services. A VSC equipped with a Grid Forming control algorithm can allow a HVDC cable to provide inertia, short circuit levels and dynamic control to the grid. For inertia provision, a flywheel can be added to deliver additional energy required for the inertia service.
Synchronous Condensers (SC)	A synchronous condenser (SC) is an AC-driven synchronous motor able to spin freely without load, providing stability services such as inertia, short circuit levels and dynamic voltage control to the electrical grid. A flywheel can be added to the SC to provide additional inertia provision.
Storage (flywheels)	Flywheels are solid cylinders with large mass, spun at very high speed through a motor which converts electricity into kinetic energy. Kinetic energy can be released back to the system through the motor acting as a generator, converting flywheel spinning motion back into electricity. Flywheels can be used to release energy into the system, supporting inertia provision when coupled with VSCs or SCs.

OFTO: Offshore Transmission Owner; IC: Interconnector; HVDC: High-Voltage Direct Current; SCL: Short Circuit Levels; DVC: Dynamic Voltage Control; VSC: Voltage Source Converter; IGBT: Insulated-Gate Bipolar Transistor; SC: Synchronous Condenser

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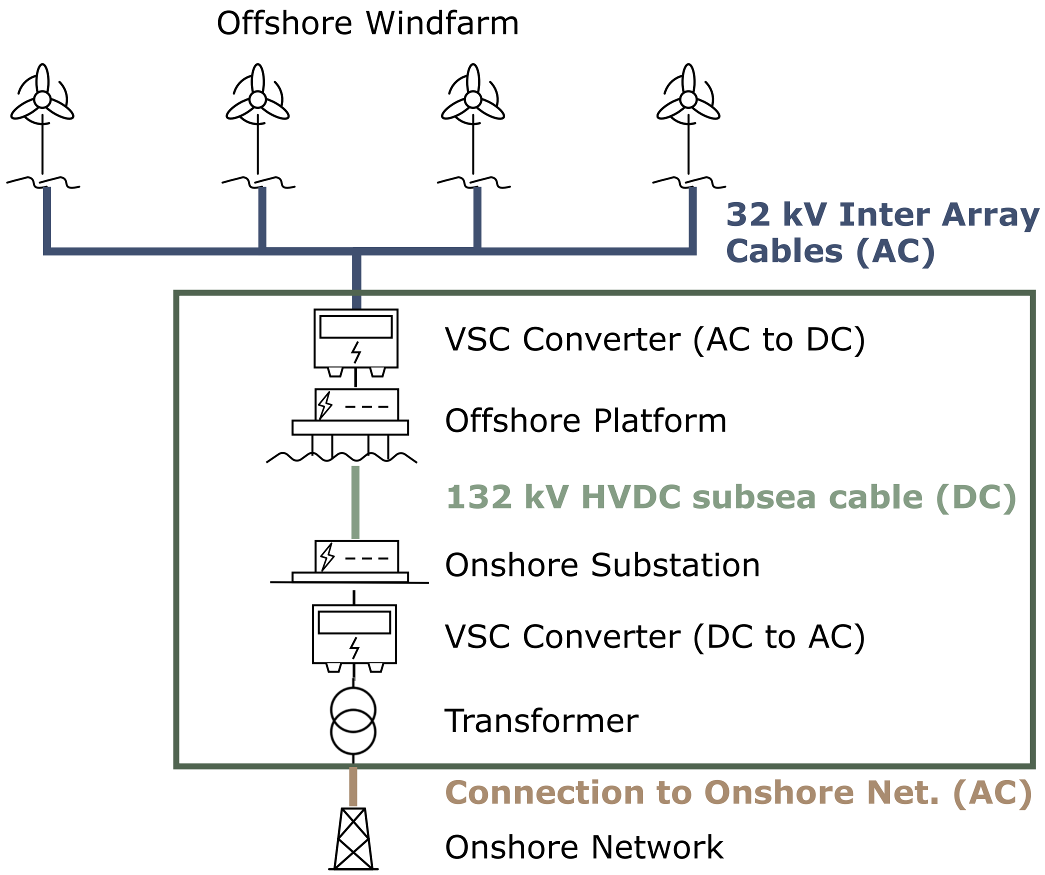
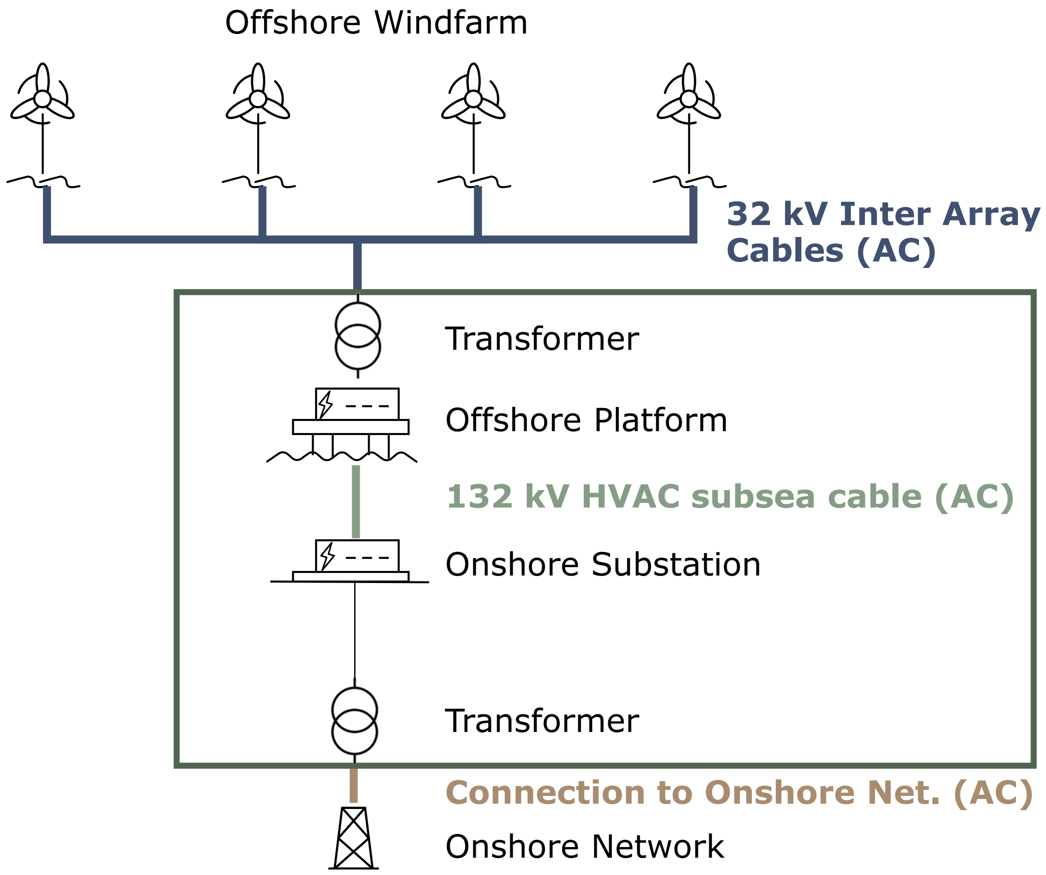
TYPICAL CONFIGURATIONS OF OFTOS

Typical OFTOs utilise either AC or DC connections, depending mainly on length of subsea cable (DC typically for long distance applications)

HVDC OFTO - SIMPLIFIED CONFIGURATION



HVAC OFTO - SIMPLIFIED CONFIGURATION



OFTO: Offshore Transmission Owner; HVDC: High-Voltage Direct Current; HVAC: High-Voltage Alternating Current; DC: Direct Current; AC: Alternating Current; VSC: Voltage Source Converter

Legend Perimeter of OFTO’s ownership

POSSIBLE CONFIGURATIONS AND STABILITY PROVISION FOR HVAC OFTOS

HVAC OFTOs would require to install a VSC (with dedicated algorithm for stability) or a synchronous condenser to provide stability

HVAC OFTOs – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION

	Additional components[1]	**Model description**	**Entities providing stability services: Inertia** – *Frequency reg.*	**Inertia** – *Energy*	**SCL**	**DVC**
	None (as-is model)	OFTO not equipped with VSC. Windfarm can provide stability if equipped with grid-forming converters				
VSC/VSC+Storage		OFTO equipped with a VSC converter and algorithm to provide stability. Also windfarm able to provide stability[2]				
VSC/VSC+Storage		As per previous model, with the addition of a storage (flywheel) and related converter to enable the OFTO to provide energy for inertia				
SC/SC+Storage		OFTO equipped with a Synchronous Condenser, enabling it to provide stability. Also windfarm able to provide stability[2]		SC can provide inertia even without injecting energy		
SC/SC+Storage		As per previous model, with the addition of a storage (flywheel) to enable the SC to provide extra inertia				

1. Compared to as-is configuration described in previous slide; 2. If equipped with grid-forming converters | OFTO: Offshore Transmission Owner; HVAC: High-Voltage Alternating Current; SCL: Short Circuit Levels; DVC: Dynamic Voltage Control; VSC: Voltage Source Converter; SC: Synchronous Condenser

Legend *OFTO* *Offshore Windfarm* *None* */ Potentially provided by both* *VSC with algorithm for stability* *Synchronous Condenser* *Storage (flywheel) and related converter*

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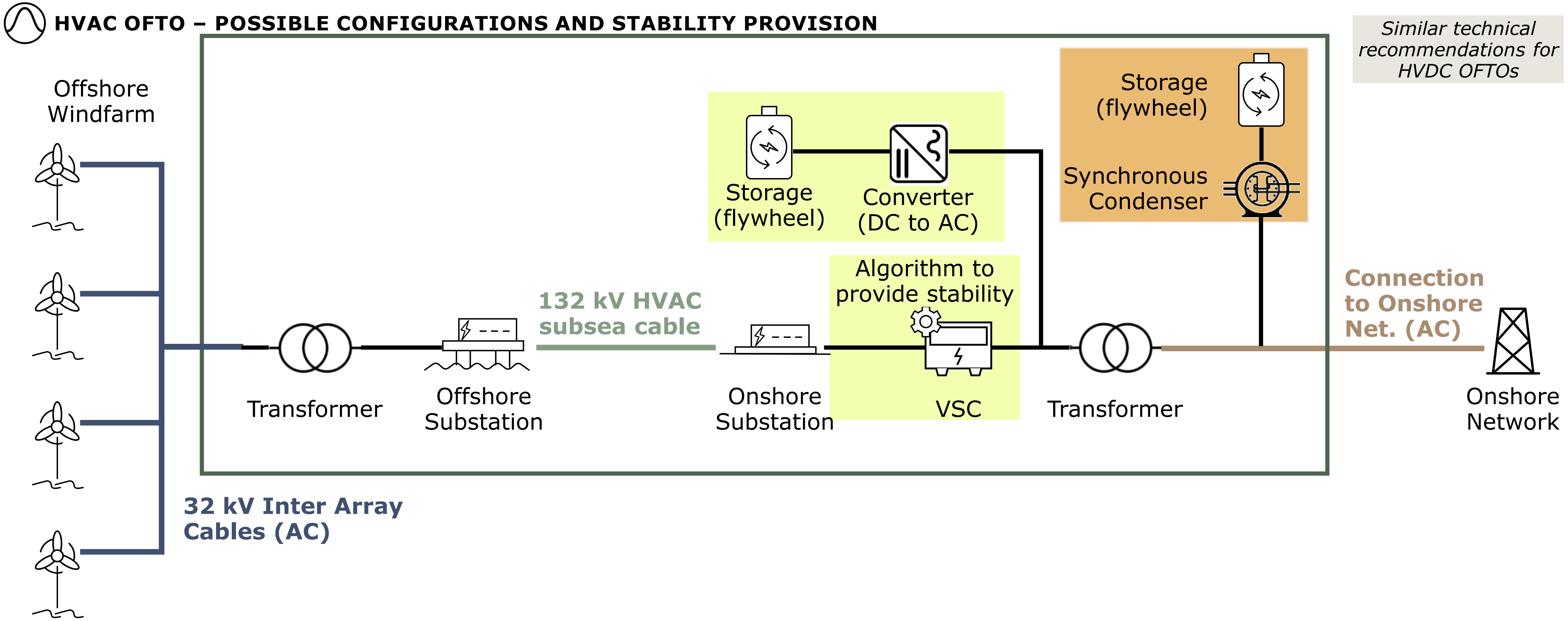
CONFIGURATION FOR HVDC OFTOS FOR STABILITY PROVISION

Storage and synchronous condensers can be connected in parallel with AC OFTOs, with the VSC (with algorithm for stability) in series

HVAC OFTO – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION



OFTO: Offshore Transmission Owner; HVDC: High-Voltage Direct Current; HVAC: High-Voltage Alternating Current; VSC: Voltage Source Converter; SC: Synchronous Converter

Legend *Perimeter of OFTO's ownership* *Additional components for stability:* *Option VSC/VSC+Storage* *Option SC/SC+Storage*

POSSIBLE CONFIGURATIONS AND STABILITY PROVISION FOR HVDC OFTOS

For HVDC OFTOs, stability can be provided by equipping VSC with a dedicated algorithm for stability or through a synchronous condenser

HVDC OFTOs – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION

	Additional capabilities[1]	Model description	Entities providing stability services: Inertia – Frequency reg.	Inertia – Energy	SCL	DVC
	None (as-is model)	OFTO equipped with VSC but no algorithm to provide stability. Windfarm can provide stability if equipped with grid-forming converters				
VSC/VSC+Storage		VSC provided with an algorithm to deliver stability services. Also windfarm able to provide stability[2]				
VSC/VSC+Storage	+	As per previous model, with the addition of a storage (flywheel) and related converter to enable the OFTO to provide energy for inertia				
SC/SC+Storage		OFTO equipped with a Synchronous Condenser, enabling it to provide stability. Also windfarm able to provide stability[2]		/ SC can provide inertia even without injecting energy		
SC/SC+Storage	+	As per previous model, with the addition of a storage (flywheel) to enable the SC to provide extra inertia				

1. Compared to as-is configuration described in previous slide; 2. If equipped with grid-forming converters | OFTO: Offshore Transmission Owner; HVDC: High-Voltage Direct Current; SCL: Short Circuit Levels; DVC: Dynamic Voltage Control; VSC: Voltage Source Converter; SC: Synchronous Condenser

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Legend OFTO | Offshore Windfarm | None | Potentially provided by both | VSC algorithm to provide stability | Synchronous Condenser | Storage (flywheel) and related converter

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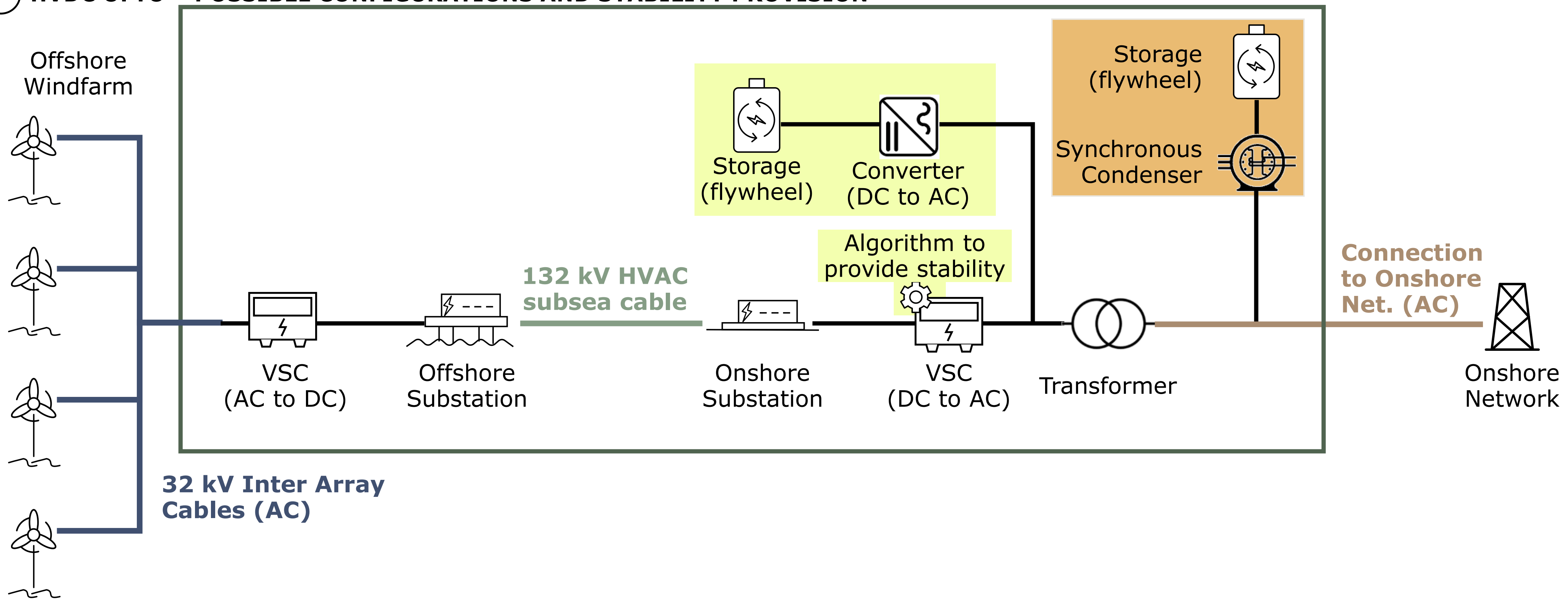
CONFIGURATION FOR HVDC OFTOS FOR STABILITY PROVISION

Storage and synchronous condenser components can be connected in parallel with OFTO, while algorithm for stability is upgraded on existing VSC

HVDC OFTO – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION



OFTO: Offshore Transmission Owner; HVDC: High-Voltage Direct Current; HVAC: High-Voltage Alternating Current; VSC: Voltage Source Converter; SC: Synchronous Converter

Legend *Perimeter of OFTO's ownership* *Additional components for stability:* *Option VSC/VSC+Storage* *Option SC/SC+Storage*

EXISTING REGULATORY REGIMES FOR OFTOS

OFTOs can be developed under either ‘generator-led’ or ‘OFTO-led’ approach, where the ‘generator-led’ is the only route followed to date

Adopted by all OFTOs so far

EXISTING REGIME MODELS FOR OFTOs

	Generator-led	OFTO-led
Responsibilities	– The wind developer is responsible for constructing the offshore transmission system – The OFTO is responsible for operating and maintaining the asset	– The OFTO is responsible for the construction, operation and maintenance of the asset
Awarding process	– Wind developer designs and constructs the offshore transmission system – Ofgem initiates the competitive tender process, where offshore transmission assets are transferred from the wind developer to the OFTO and a licence is granted to the OFTO entities	– Two options: – *Early OFTO Build*: once wind dev. obtains the connection offer, Ofgem initiates the competitive tender where OFTO bids its approach to aspects of preliminary works, consenting, design, procurement, financing, construction, operation, maintenance and decommissioning of transmission assets and costs associated with these activities – *Late OFTO Build*: wind dev. undertakes preliminary works, consenting, and high-level design of the transmission assets. Ofgem then initiates the competitive tender where OFTO bids its approach to procurement, financing, construction, operation, maintenance and decommissioning of transmission assets and the costs associated with these activities
Remuneration	– Provided by NETSO and based on the Tender Revenue Stream (TRS), which is fixed (regulated) and guaranteed over a period of 25 years – In case the wind developer requests the OFTO for an incremental investments (up to 20% of original investment costs) to install additional transmission capacity, the NETSO can increase the TRS to recover such incremental investment	
Availability conditions	– OFTOs are incentivized to maintain availability above 98% (upper revenue effect – up to +5% of annual revenues), while penalties are applied, in case availability reaches lower levels (lower revenue effect – up to -10% of annual revenues)	

Source: Ofgem | OFTO: Offshore Transmission Owner; NETSO: National Electricity Transmission System Operator; TRS: Tender Revenue Stream

REGULATORY/ECONOMIC CONSIDERATIONS FOR OFTOS

Potential participation of OFTOs in stability provision raises several open points

Topics	Areas	Considerations
1. Overlap of OFTO and wind dev.'s operations	*Technical aspects*	– Both windfarms and OFTOs would be able to provide stability: which entity has priority to provide the service? Does the provision of stability by wind farm/OFTO have negative implications on the quality of their services (i.e. generating and injecting energy to the grid)?
2. Recovery of investment for stability retrofit	*Regulatory framework*	– Current regulation allows OFTOs to invest up to 20% of original investment costs (when asked by wind developer) to increase transmission capacity in return for a revised (increased) TRS. Existing OFTOs not able to recover costs of investing in additional equipment (e.g. VSCs, SCs, flywheels) for stability service provision. – Also, as the TRS is regulated, there is an open question on how stability revenues (e.g. ST) would be treated
3. Incentives for wind farm to invest in stability	*Costs-benefits*	– Under the generator-led regime, there are no incentives for the wind developer (who builds and then sells the assets) to invest in equipment for stability to be installed in the OFTO. – Adding stability service capabilities will increase project costs, which will initially be financed by the windfarm developer. Additional capital and financing costs will need to be appropriately reflected in the transfer value.
4. Impact on OFTO's risk profile	*Costs-benefits*	– Main goal of OFTOs is to maintain the availability target in order to capture the contracted TRS. – As per its business model, OFTO is considered a low risk business. The addition of stability service provision within OFTO's activities could increase its risks profile, potentially impacting TRS requirements.
5. Impact of stability provision on wind developers	*Regulatory framework*	– In case the provision of stability services by the OFTO has impacts on the windfarm business model (e.g. alters generation to support inertia provision), this would require complementary commercial arrangements to define compensation for the wind developer.
6. OFTOs owning storage	*Regulatory framework*	– As per the current regulatory framework, it is not clear if OFTOs are allowed to own storage assets to provide grid services.
7. Applicability on MPI	*Technical aspects/ Reg. framework/ Costs-benefits*	– Specific case of Multi-Purposes Interconnectors (MPIs) have not been considered. Some of the considerations relevant for the stand-alone OFTOs and ICs[1] will be relevant.

1. Illustrated in the IC's section \| OFTO: Offshore Transmission Owner; HVAC: High-Voltage Alternating Current; TRS: Tender Revenue Stream; VSC: Voltage Source Converter; SC: Synchronous Condenser; NETSO: National Electricity Transmission System Operator; ST: Short-Term

POSSIBLE MEASURES TO FACILITATE OFTOS' CAPABILITIES FOR STABILITY

Possible measures can be applied to allow OFTOs to provide stability, but required amendments may be considerable for existing/new OFTOs

POSSIBLE MEASURES TO FACILITATE OFTOs' CAPABILITIES FOR STABILITY

New OFTOs

Design:

- Generator-led – wind developers mandated by Ofgem[1] to include stability equipment in the design of transmission assets. Alternatively, OFTOs should be allowed to install stability equipment once they have their licence.
- OFTO-led – OFTO allowed[2] by Ofgem to install stability equipment in the design of transmission assets

Remuneration: in case of incremental investment with LT contract in place, TRS should not cover the stability equipment expenditure already financed through LT market

Permission to operate storage: possible revision of role specification to allow OFTOs to operate storage only in case of provision of grid services

Existing OFTOs

Design:

- Generator-led – wind developers and OFTOs would need to discuss the design of the additional stability equipment and how this will impacts the windfarm's daily operations
- OFTO-led – no existing OFTOs so far under this route

Additional investment: regulation will need to be revised to allow existing OFTOs to bear additional investment (for stability purposes) compared to the original plan

Remuneration: TRS might be revised in order to reflect the investment made by the OFTO for stability equipment (only in case existing TRS does not guarantee return of investment/operational costs related to stability provision)

Permission to operate storage: as for new OFTOs

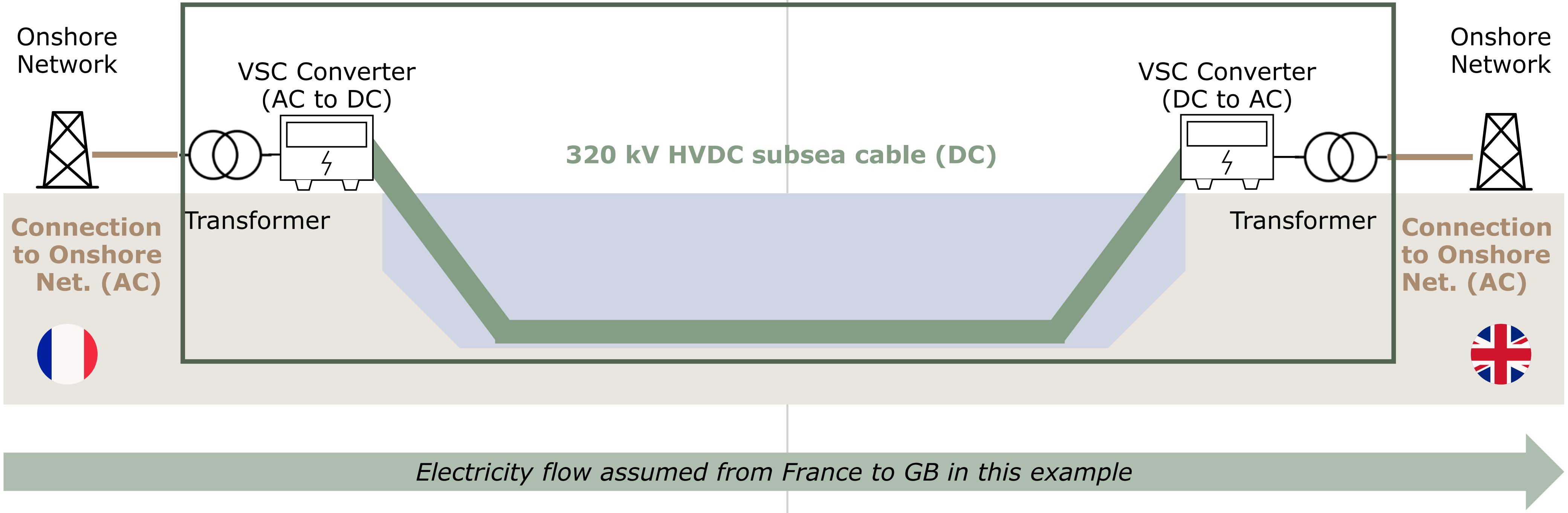
Third-party provision (alternative to provision of stability by OFTOs): allows third-party providers to connect assets for stability (e.g. SC, storage) to the same connection bay of the OFTO, effectively operating as a separate commercial provider for stability[3]

1. In case Ofgem consider necessary the provision of stability in specific areas; 2. But not forced; 3. Condition that stability operations must not interfere with the normal operation of the windfarm | OFTO: Offshore Transmission Owner; TO: Transmission Owner; TRS: Tender Revenue Stream; VSC: Voltage Source Converter

TYPICAL CONFIGURATIONS OF INTERCONNECTORS

Typical Interconnectors rely on DC cables, allowing flows of electricity between GB and other overseas countries

HVDC INTERCONNECTORS - SIMPLIFIED CONFIGURATION



Legend *Perimeter of IC's ownership*

HVDC: High-Voltage Direct Current; IC: Interconnector; AC: Alternating Current; DC: Direct Current

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POSSIBLE CONFIGURATIONS AND STABILITY PROVISION FOR HVDC IC

IC would be able to provide stability by equipping VSC with a dedicated algorithm or through a synchronous condenser

HVDC INTERCONNECTORS – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION

Entities providing stability services

	Additional components[1]	Model description	Inertia – Frequency reg.	Inertia – Energy	SCL	DVC
	None (as-is model)	Interconnector equipped with VSC but no algorithm to provide stability. Overseas generator might be able to provide stability				
VSC/VSC+Storage		VSC provided with an algorithm to deliver stability services. Also overseas generator could able to provide stability				
VSC/VSC+Storage	+	As per previous model, with the addition of a storage (flywheel), and related converter, to enable the IC to provide energy for inertia				
SC/SC+Storage		IC equipped with a Synchronous Condenser, enabling it to provide stability. Also overseas generator could able to provide stability		SC can provide inertia even without injecting energy		
SC/SC+Storage	+	As per previous model, with the addition of a storage (flywheel) to enable the SC to provide extra inertia				

1. Compared to as-is configuration described in previous slide | IC: Interconnector; HVDC: High-Voltage Direct Current; SCL: Short Circuit Levels; DVC: Dynamic Voltage Control; VSC: Voltage Source Converter; SC: Synchronous Condenser

Legend Interconnector · Overseas generator · None · Potentially provided by both · VSC algorithm to provide stability · Synchronous Condenser · Storage (flywheel) and related converter

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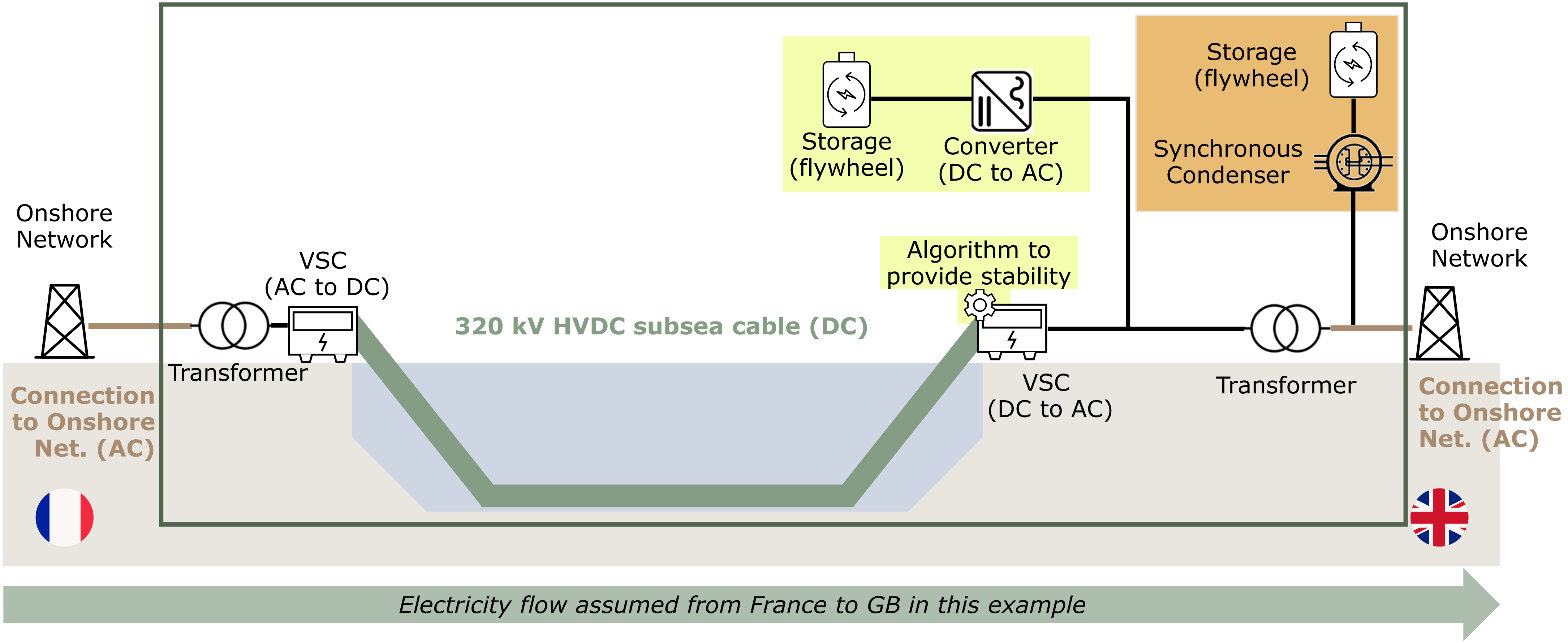
CONFIGURATION FOR HVDC IC FOR STABILITY PROVISION

Storage and synchronous condenser components can be connected in parallel with IC, while algorithm for stability is upgraded on existing VSC

HVDC INTERCONNECTOR – POSSIBLE CONFIGURATIONS AND STABILITY PROVISION



OFTO: Offshore Transmission Owner; HVDC: High-Voltage Direct Current; HVAC: High-Voltage Alternating Current; VSC: Voltage Source Converter; SC: Synchronous Converter

Legend | *Perimeter of IC's ownership* | *Additional components for stability:* | *Option VSC/VSC+Storage* | *Option SC/SC+Storage*

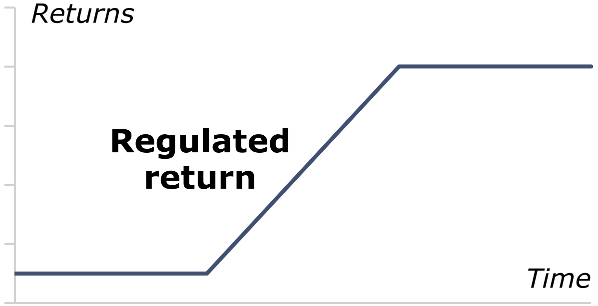
CURRENT REGULATORY FRAMEWORK FOR INTERCONNECTORS

Regulatory framework in GB allows interconnectors to operate as regulated, semi-regulated (Cap&Floor) or fully merchant assets

EXISTING REGIME MODELS FOR INTERCONNECTORS

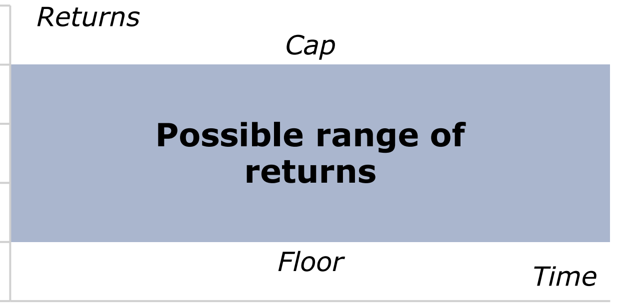
Revenue model

Regulated



- Interconnector asset is included in the Regulated Asset Based (regulated revenues)
- The revenue risks are socialized (on consumers)

Cap&Floor



- Cap&Floor regime assures a minimum threshold of revenues to the IC (floor), under which the missing revenues to reach the floor will be paid by consumers
- If revenues go above an upped threshold (cap), the exceeding revenues beyond the cap will be returned to the consumers
- The revenue risks are partly socialized (on consumers) and partly borne by the IC owner

Merchant

- Merchant regime does not provide regulatory underpin (no floor) and does not limit the operator’s revenue capture (no cap)
- The operator has greater commercial freedom compared to the other regimes, but it will bear all the revenue risk

IC: Interconnector

INTERCONNECTORS' REVENUE STREAMS

ICs can access a range of revenue streams, depending on the market arrangements, where congestion rents revenues represent the main source

INTERCONNECTOR TOTAL VALUE

CONGESTION RENTS

- Main revenue source for ICs
- Revenue streams from arbitrages on wholesale price differentials between zones
- Either embedded in implicit auctions or indirectly received through selling interconnector capacity explicitly (where price of capacity is based on expected arbitrage opportunities)

+

CAPACITY MARKET

- Revenue streams from capacity auctions or capacity obligations
- Compete with assets such as power plants
- Subject to national regulatory regimes

+

ADDITIONAL SERVICES

- Participate directly in existing balancing markets where possible
- Bespoke interconnector arrangements
- Capacity reserved for cross-border balancing
- Subject to national regulatory regimes

IC: Interconnector

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REGULATORY/ECONOMIC CONSIDERATIONS FOR ICS

Potential participation of ICs in stability provision raises several open points

Topics	Areas	Considerations
1. Limited incentives to capture additional value	*Costs-benefits*	– Within overseas markets, ICs are generally treated as part of the onshore TSOs' regulated assets[1]. – As the revenue accruing to the connected country is likely to be regulated/fixed, there might be limited incentives for an IC to provide stability services as well.
2. Implications on connected countries	*Regulatory framework*	– Project costs/revenues are typically allocated between the two connected markets (often 50:50, but this is not necessarily the case). In case of additional costs to provide stability to GB, how will the counterparty regulator view this (in case of no/limited benefits to its market)? Should the counterparty regulator also be involved for regulatory approvals? – Also, where service provision affects the connected market as well, there is need to consider energy/imbalance implications of service provision on either market. This implies the potential need for trilateral agreements between IC and foreign markets.
3. Recovery of investment for stability retrofit	*Regulatory framework*	– For existing ICs under regulated and cap & floor, in case of financing and installation of equipment for stability, the cap & floor thresholds would need to be revised to reflect extra costs for such equipment. At the moment, regulation does not specify how additional costs (e.g. for retrofitting) may be treated under regulated/cap & floor regimes.
4. Impact of ICs on stability service requirement	*Technical aspects*	– While ICs may be helpful as sources of stability provision, there is also the need to consider implications of installing additional ICs and of geographic clustering of ICs (e.g. south-east, east coast) on service requirements – do excess of ICs connected to a region of the grid increase needs for stability (e.g. local voltage issues). – Consideration could be given to making stability capability mandatory for ICs, but the implications would need to be evaluated[2]
5. Applicability on MPI	*Technical aspects/ Reg. framework/ Costs-benefits*	– Specific case of Multi-Purposes Interconnectors (MPIs) have not been considered. Some of the considerations relevant for the stand-alone OFTOs[3] and ICs will be relevant.

1. With the exception of Ireland, where a Cap&Floor regime is also in place; 2. Germany mandate GFM capability on NeuConnect whilst GB don't; 3. Illustrated in the OFTO's section | TSO: Transmission System Operator; IC: Interconnector; MPI: Multi-Purpose Interconnectors

POSSIBLE MEASURES TO FACILITATE IC CAPABILITIES FOR STABILITY

Possible measures can be applied to enable IC provision, but required amendments may be considerable for existing/new cables

POSSIBLE MEASURES TO FACILITATE ICs' CAPABILITIES FOR STABILITY

New ICs

New agreement terms: agreements between IC and the connected markets' entities need to include terms to enable the IC to provide stability in GB (e.g. split of revenues, management of imbalances)

→ Regulated, Cap&Floor, Merchant

Treatment of additional components in costs assessments: costs related to the additional stability-aimed equipment[1], need to be considered within the regulated costs assessment and covered within the e.g. cap-floor levels

→ Regulated, Cap&Floor

Risk profile adjustments: revenue potential of new ICs has to consider risks of provision of stability service and potential for lost revenues from other routes to market

→ Regulated, Cap&Floor, Merchant

Existing ICs

Revision of agreement terms: existing agreements between IC and the connected markets' entities need to be revised to include additional/changes of terms to enable the IC to provide stability in GB (e.g. split of revenues, management of imbalances)

→ Regulated, Cap&Floor, Merchant

Treatment of additional components in costs assessments: not clear how additional CAPEX/OPEX (stability equipment in this case) are treated within cap & floor regime. In case not allowed, need to revise regulation to include these costs within the costs assessment

→ Regulated, Cap&Floor

Risk profile adjustments: revenue potential of ICs need to be revised considering risks of provision of stability service and lost revenues from other routes to market

→ Regulated, Cap&Floor, Merchant

Third-party provision (alternative to provision of stability by ICs): allows third-party providers, similarly to what suggested for OFTOs

1. e.g. VSC algorithm, Synchronous Condenser, Storage (flywheel) | IC: Interconnector; VSC: Voltage Source Converters; OFTO: Offshore Transmission Owner

Legend *Application of measure according to regimes:* *Regulated* *Cap&Floor* *Merchant*

SUMMARY

OFTOs and ICs can potentially provide Stability, but there are many technical, regulatory and economical challenges to consider

CONSIDERATIONS

Technical Enablers

- Voltage source converters
- Synchronous condensers
- Storage

Regulatory & Economic Enablers

OFTOs:

- Overlap of OFTO and wind developer operations
- Recovery of investment for stability retrofit
- Incentives for wind farm to invest in stability
- Impact on OFTO’s risk profile
- Impact of stability provision on wind developers
- OFTOs owning storage
- Applicability on MPI

ICs:

- Limited incentives to capture additional value
- Implications on connected countries
- Recovery of investment for stability retrofit
- Impact of ICs on stability service requirement
- Applicability on MPI

Possible Measures

OFTOs:

- Consideration of requirements for stability equipment to be included in OFTO design
- Additional investment for existing OFTOs
- Ensuring consistency between the transfer / TRS revenue values and stability investment costs
- Consideration of permission to operate storage

ICs:

- New / revised agreement terms to enable the IC to provide stability in GB
- Costs of additional stability-aimed equipment considered within the regulated costs assessment
- Revenue potential considers the risks of providing a stability service and the potential for lost revenues from other routes to market

KEY ISSUES OF EXPIRED RAB ASSETS

The possible involvement of expired RAB assets within the stability market raises several open points

KEY QUESTIONS ON THE PARTICIPATION OF EXPIRED RAB ASSETS WITHIN THE STABILITY MARKET

Treatment of TO assets after RAB period	– How are TO assets treated once RAB is expired? Will they be decommissioned or will they be free to keep running?
Technical life of RAB assets	– Does the economic lifetime (i.e. RAB period of 45 years) of the TO assets differ from their actual technical life?
TO obligations before/after RAB period	– Are there any obligations for TOs to keep assets running within/after the RAB period? Are there any penalties if the asset stops functioning before the end of RAB?
Cost recovery of expired RAB assets	– How is cost recovery managed for expired RAB assets?

TO: Transmission Owner; RAB: Regulated Asset Base

EMPLOYMENT OF EXPIRED RAB ASSETS

‘Expired RAB assets’ are not expected to be eligible for contractual payment via stability markets

CONSIDERATION ON EXPIRED RAB ASSETS

Treatment of TO assets after RAB period

- If TO assets are still functioning after the RAB period, and they are considered still useful for the system (e.g. to provide stability) and beneficial for consumers (cheaper than other alternatives), they are likely to continue to be employed until the end of their technical life

Technical life of RAB assets

- Technical lifetime of TO assets depends on technology (e.g. substation, synchronous condenser, cable etc.) and more in general on type of asset (e.g. software technical life expected to be way shorter than an overhead line)
- Technical life of each TO asset can differ from the 45 year depreciation period applied to the RAB

TO obligations before/after RAB period

- No obligations for TOs to keep specific assets running or penalties if they stop functioning after the RAB period. TOs’ activities are driven by specific performance targets[1] rather than by e.g. building new assets or keeping them functioning
- However, in case it is efficient and useful for the system, TOs might be requested to refurbish their assets if they stop functioning before the RAB period

Cost recovery of expired RAB assets

- Expired RAB asset should be able to cover only future OPEX, as CAPEX should already be covered during the RAB period[2]
- *Remaining open question: in case of additional CAPEX expenditures after the RAB period, how these will be approved? By ESO/Ofgem or the TOs themselves?*

1. e.g. flowing electricity through transmission lines, maintaining security of the system; 2. In case no additional CAPEX needed after the RAB period | TO: Transmission Owner; RAB: Regulated Asset Base

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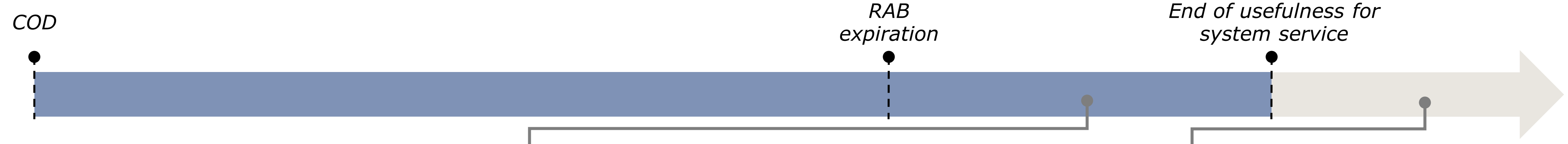
EMPLOYMENT OF EXPIRED RAB ASSETS

Expired RAB assets can potentially remain operation if still useful for system services or other system related purposes

SCENARIO 1: NEED FOR SYSTEM SERVICES LONGER THAN RAB PERIOD

Timeline



Treatment of expired RAB assets

Cases

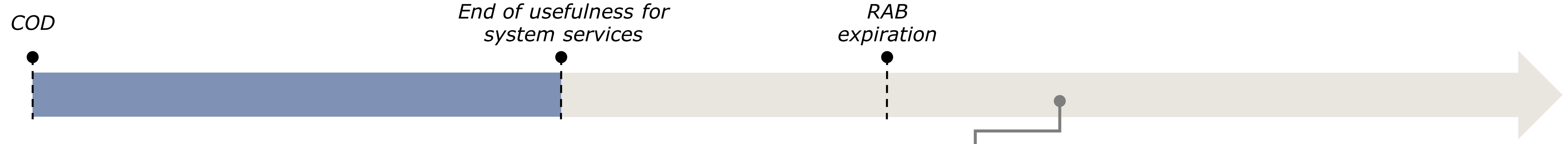
- ✗ *Asset stop functioning:* need for refurbishment (if efficient) as asset still required for system services
- ✓ *Asset still functioning:* keeps operating for system services

Cases

- ✗ *Asset stop functioning:* no need for refurbishment as asset not anymore necessary for system services
- ✓ *Asset still functioning:* might remain operational if believed useful for other purposes

SCENARIO 2: NEED FOR SYSTEM SERVICES SHORTER THAN RAB PERIOD

Timeline



Treatment of expired RAB assets

Cases

- ✗ *Asset stop functioning:* no need for refurbishment as asset not anymore necessary for system services
- ✓ *Asset still functioning:* might remain operational if believed useful for other purposes

TO: Transmission Owner; RAB: Regulated Asset Base

POSSIBLE REMUNERATION OF STABILITY SERVICE FOR EXPIRED RAB ASSETS

Regulation does not clearly state whether TO stability revenues should be included within General System Charges or Directly Remunerated Services

POSSIBLE TREATMENTS OF STABILITY REVENUES FOR TO ASSETS

GENERAL SERVICE CHARGES

- They recover all costs for providing, replacing and/or refurbishing TO's transmission infrastructure assets
- The mentioned activities fulfil the requirements set by the TO's Licence: to provide electricity flows between connection sites and guarantee transmission system security

DIRECTLY REMUNERATED SERVICES

- Dedicated remuneration for activities not covered by the other charges categories[1] and requested by NG ESO[2]
- "DRS15 – Miscellaneous" category could be compatible with the provision of stability
- DRSs should only cover CAPEX/OPEX related to the stability service. Any extra benefit should be shared with consumers

1. i.e. General Service Charges, Site Specific Charges and One-Off connection related charges; 2. Or any other counterparty; 3. i.e. Provision of any other services that is for the specific benefit of any third party who requested and not made available by the licensee as part the Transmission Business Activities | Transmission Owner; DSR: Directly Remunerated Service; NG: National Grid

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