November 2023

Net Zero Market Reform: Investment Policy

Phase 4 Assessment and Conclusions

ESO

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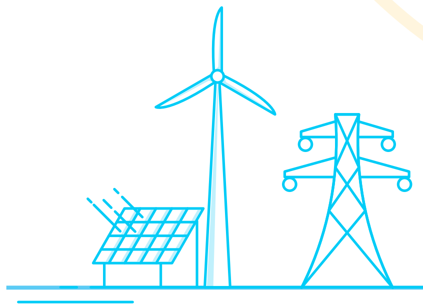

Foreword

I am delighted to publish the findings from the fourth phase of our Net Zero Market Reform (NZMR) programme. In this report, we focus on investment policy, and we aim to move the debate forward from individual market design elements, to holistic packages of market and policy reform, and pathways to getting there.

As the Electricity System Operator (ESO), we witness first-hand how the electricity system is performing as it rapidly transforms and decarbonises. Evidence of increasingly inefficient and expensive market outcomes is what drove us to launch the NZMR programme in 2021, and we fed this evidence directly into the case for change of the Department for Energy Security and Net Zero (DESNZ) Review of Electricity Market Arrangements (REMA), published in July 2022.

Cian McLeavey-Reville
Head of Market Development,
Electricity System Operator (ESO)

The reality is that the current package of market design and policy is no longer fit for purpose, and if left unchanged will result in significant unnecessary costs and will risk GB missing its carbon targets. Evidence of this has continued to mount over 2022 and 2023; for example on 1st July 2023 we incurred a cost of £20.3m[1] when we had to bid 88 GWh of wind down. These are but a sign of what is yet to come – we believe these trends will only accelerate as the system continues to decarbonise, unless markets and policy undergo fundamental reform.

Of course major reform brings with it uncertainty, as well as significant time to design and implement. This prolonged uncertainty is not conducive to investment, and GB needs an unprecedented scale and pace of investment in assets across the electricity system – across supply, demand and networks. It is therefore critical that through REMA we identify a long-term vision for net zero market arrangements as soon as possible, as well as a clear pathway to achieving it, including transitional arrangements. And it is this investment that forms a major focus of this phase of the NZMR work.

In this report, whilst we reinforce our principle that wholesale market signals remain the foundation for efficient operation and investment, we recognise that additional investment policy support remains critical to de-risk and accelerate the investment needed to achieve net zero.

As has been the case since the very beginning of the NZMR programme, we continue to engage with stakeholders by publishing our conclusions and latest insights. Our aim continues to be to work with stakeholders, informing from our unique position at the heart of the energy system, to design effective market reform for net zero. We look forward to continuing this engagement ahead of, and following, the second REMA consultation.

1 This cost includes the costs of bidding wind down and the costs of replacing this energy from different Balancing Mechanism Units (BMUs).

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The ESO Net Zero Market Reform (NZMR) programme to date

The objective of our NZMR programme, initiated in 2021, is to present ESO's view on holistic market design and complementary investment policy for net zero, and contribute to the Review of Electricity Market (REMA) debate from the perspective of the GB electricity system operator.

Phase 2 of the NZMR programme presented our case for change, identifying three key challenges: accelerating and scaling up investment; improving locational signals; and unlocking flexibility. We also established an options assessment framework. Phase 3 focused on wholesale market reform, addressing the challenge of how to incentivise assets to locate and dispatch where they can minimise whole system costs and manage energy imbalances. In Phase 4, our focus shifted to investment policy to facilitate investment at unprecedented scale and pace in low carbon, flexible and firm technologies across both supply and demand.

Current investment policy was designed nearly a decade ago based on a power system with very different characteristics

The New Electricity Trading Arrangements (NETA) were established in 2001 when the share of renewable generation in the power mix was low and when demand-side flexibility was very limited.

GB's current investment policy support mechanisms, the Contract for Difference (CfD) and Capacity Market (CM), were introduced in 2014 via Electricity Market Reform (EMR). The aim was to tackle several challenges and market failures including plant retirements, decarbonisation and lack of investor confidence. EMR policies were successful, driving down the cost of capital and ensuring the reliability standard has always been met.

However, the limitations of operating a high-renewables, highly flexible system under the current market design have already emerged given rising costs for consumers. Looking forward there are new challenges to address, such as rare stress events of long duration (several days or weeks) that will need to be met by low carbon technologies, some of which are not yet fully commercialised.

The challenge for REMA is to reform market design and complementary investment and innovation policies in a way that:

- drives sufficient investment at needed pace;
- ensures investment in an efficient mix of capacity with complementary attributes;
- addresses costly distortions;
- ensures efficient siting and dispatch.

NZMR programme to date

January 2021 – April 2021	November 2021	May 2022 – November 2023	
Phases 1-2	**Phase 3: Operation**	**Phase 4: Investment**	
High level scoping, case for change and options assessment framework	Detailed assessment of operational market design options	Detailed assessment of investment policy options	ESO approach to market reform packages that coherently combine market design and investment policy, with pathways

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Phase 4 Methodology

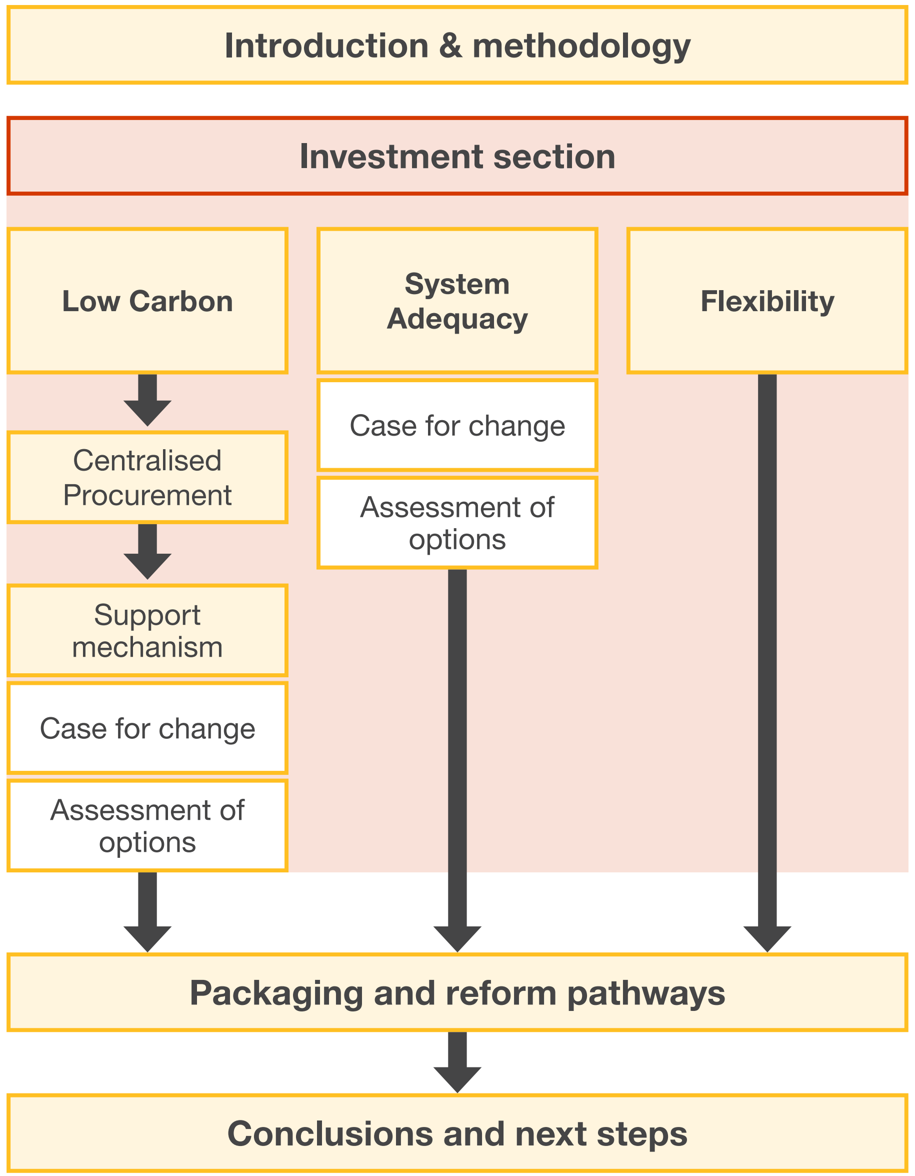
Phase 4 of the NZMR programme focuses on how investment policy can best complement wholesale market design, and sets out the pathway for a coherent package of reforms.

- Based on the ten market design options assessment criteria we established in Phase 2 of the programme, we commissioned Baringa to conduct an independent assessment of investment options, as well as of market design and policy packaging.
- We then combined Baringa's assessment with our own analysis and evidence, as well as stakeholder feedback, to form the conclusions in this report.
- In combining individual market design and investment policy options to form holistic packages, we have considered compatibility of components as well as coherency of sequencing.

Structure of this report

1. Introduction and methodology
2. A core section on investment policy, split into three sections:
   - **Mass Low Carbon;**
   - **System Adequacy; and**
   - **Flexibility**
3. We bring together the key conclusions from the investment options assessments, with consideration of how they are packaged with wholesale market reform, as well as pathways to achieving our preferred package.
4. Finally, we present our overall conclusions and outline the next steps for further ESO work on net zero market reform.

Structure of the report



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Our philosophy in Phase 4

We believe that wholesale energy prices that capture as fully as possible the true value of electricity, including major externalities (e.g. carbon, system constraints), are fundamental to efficient investment as well as efficient dispatch. It is the market's expectation of future wholesale prices that drives forward contracting, hedging and investment.

If spot prices do not fully reflect the full value of electricity, then a revenue deficit ("missing money") exists. The more these sources of value can be incorporated into the wholesale price itself, the less need there is for investment policy intervention to top-up revenues. Figure 1 illustrates missing money in the context of unrewarded locational value with the right hand illustration restoring missing locational value through locational wholesale pricing.

Missing money is commonly thought of as a positive amount (e.g. when spot prices are not as high as they should be to reflect a period of scarcity). However, the opposite occurs whenever wholesale prices are higher than they should be because they do not fully reflect a negative externality (e.g. system constraints), as shown in Figure 1.1. In essence, inaccuracies mean that while some market actors may be under-compensated, faced with missing money, others are over-compensated to the detriment of affordable energy bills.

Missing money also exists in the GB market relating to resource scarcity value and carbon value. If wholesale market reform in isolation cannot fully address the carbon and scarcity externalities, then a market failure exists and policy intervention may be justified to restore the "missing money" in addition to other policy justifications. We conclude continued policy intervention will be required for carbon and scarcity respectively.

Figure 1. Total revenue for plant operating in alignment with system needs

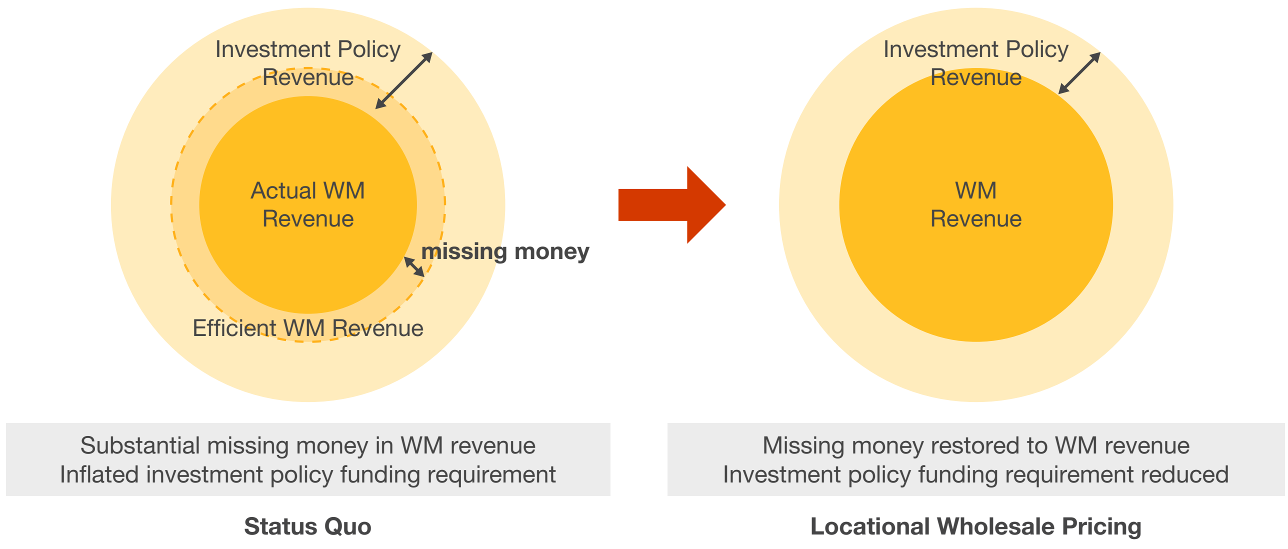
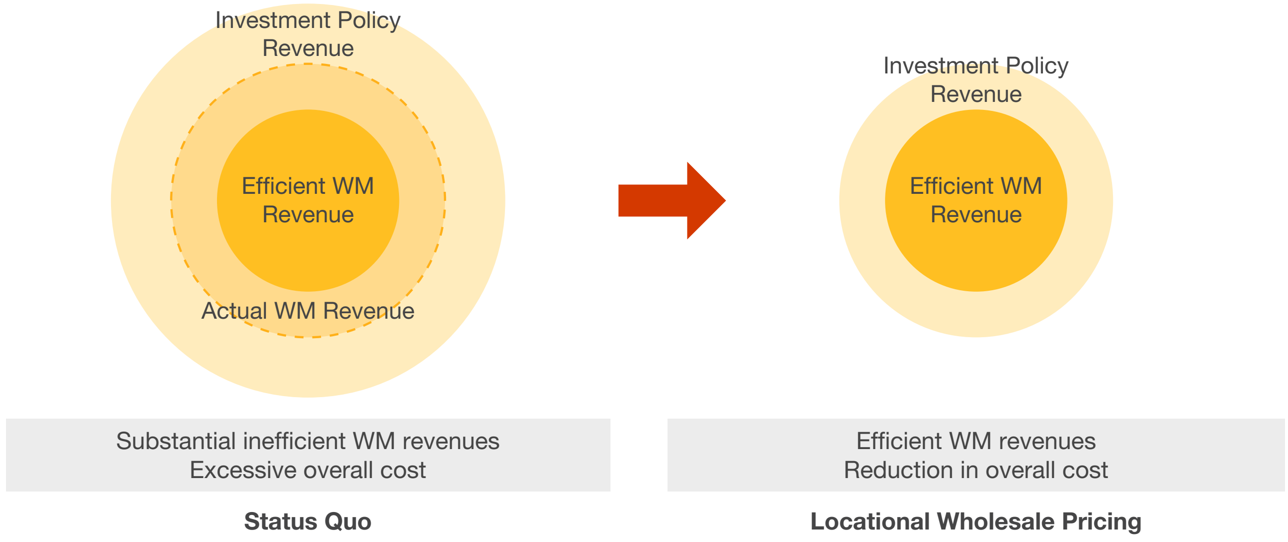


Figure 1.1 Total revenue for plant operating out of alignment with system needs



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Phase 4 conclusions: Wholesale market reform decisions should precede and determine investment policy choices. Policy reform should respect market signals and achieve appropriate allocation of risk.

Wholesale market reform: decision on market design should precede and determine investment policy choices

- **Temporally and locationally granular wholesale energy prices** are fundamental to achieving REMA's objectives as they: drive **efficient investment** by signalling assets to site efficiently; restore 'missing money'; and ensure efficient use of renewables and flexible resources e.g. interconnectors and storage.
- It is therefore crucial that investment policies are designed to **respect the integrity of accurate wholesale market signals**.
- Wholesale market reform will alter the **risk profile** for investors. Therefore, securing large volumes of low cost finance requires continued **de-risking support** along with **grandfathering** for existing investments and improved **wider investment conditions.**

Mass low carbon support: market reform decision and appropriate risk allocation should guide choices

- The design of the low carbon support mechanism should safeguard consumers' interests through **low cost of capital for investment, reduced distortions (to reduce costs) and appropriate allocation of risk**.
- **Today's CfD does not necessarily need to be overhauled** - both the existing and a deemed generation CfD could work in a locational market. **Whether and how to reform the CfD depends on decisions relating to:**

  1. Wholesale market design reform.
  2. How to allocate risk between producers and consumers.

- CfD auctions combined with **demand-led contracting**, must deliver adequate capacity volumes each year.

System security/adequacy policy: adapt to changing system stress and market failures

- System adequacy policy needs to be adapted to deliver: 1) **more effective response** to stress events in the 2020s; and 2) **sustained response** for rarer events of long duration as we move into the 2030s. Market reform decision, risk allocation and market failures should guide choices.
- More **ambitious bespoke innovation policy** for **emerging low carbon dispatchable technologies** that can sustain response for days/weeks.
- **More ambitious energy efficiency policy**, through traditional approaches rather than through power policies.

We see the market reform journey in 3 parallel phases:

1. **Flex mobilisation (today to 2028):** implement enablers of flexibility ASAP ahead of wholesale market reform.
2. **Wholesale market reform:** make decision as soon as possible, design market through 2020s, implement by early 2030s.
3. **Investment policy realignment (2025-2030):** once wholesale market design decision made, reform investment policy as appropriate.

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Low carbon support mechanism: reform package must address distortions while achieving a sufficiently attractive risk-reward balance and an appropriate allocation of risk between consumers and producers.

Our assessment[1] of low carbon support mechanisms concludes that the Deemed Generation CfD most efficiently tackles the distortions of the existing CfD, while retaining low cost of capital for generators. However, the distortions can also be tackled to some extent through other means, primarily wholesale market and dispatch design, so whether or not we need to reform the current CfD depends on these wider market design choices and consideration of cost/benefit payback efficiency.

Figure 2. Main distortions caused by CfD and possible options to address

Main distortions	Possible options to solve
1 **Balancing Mechanism –** bidding based on lost subsidies and perverse incentive to locate where congestion exists	• BSC Modification Proposal P462 to remove subsidies from BM bids (could be applied to either new or existing plant, and under central dispatch as well as self-dispatch). • Deemed Generation CfD
2 **Wholesale short-term markets –** bidding below marginal cost; herding behaviour	• Locational energy pricing reduces herding impact • Deemed Generation CfD • Central dispatch*
3 **Ancillary services –** no incentive for CfD generators to provide services as bidding based on lost subsidies	• Deemed Generation CfD • Co-optimisation of energy and ancillary services (central dispatch)

* Central dispatch markets use complex bid formats that may facilitate avoidance of distortions in short-term markets, including intraday markets, although this would significantly depend on the specific dispatch mechanism design implemented.

1 Our assessment draws on Baringa's assessment and our own complementary analysis on distortion resolution.

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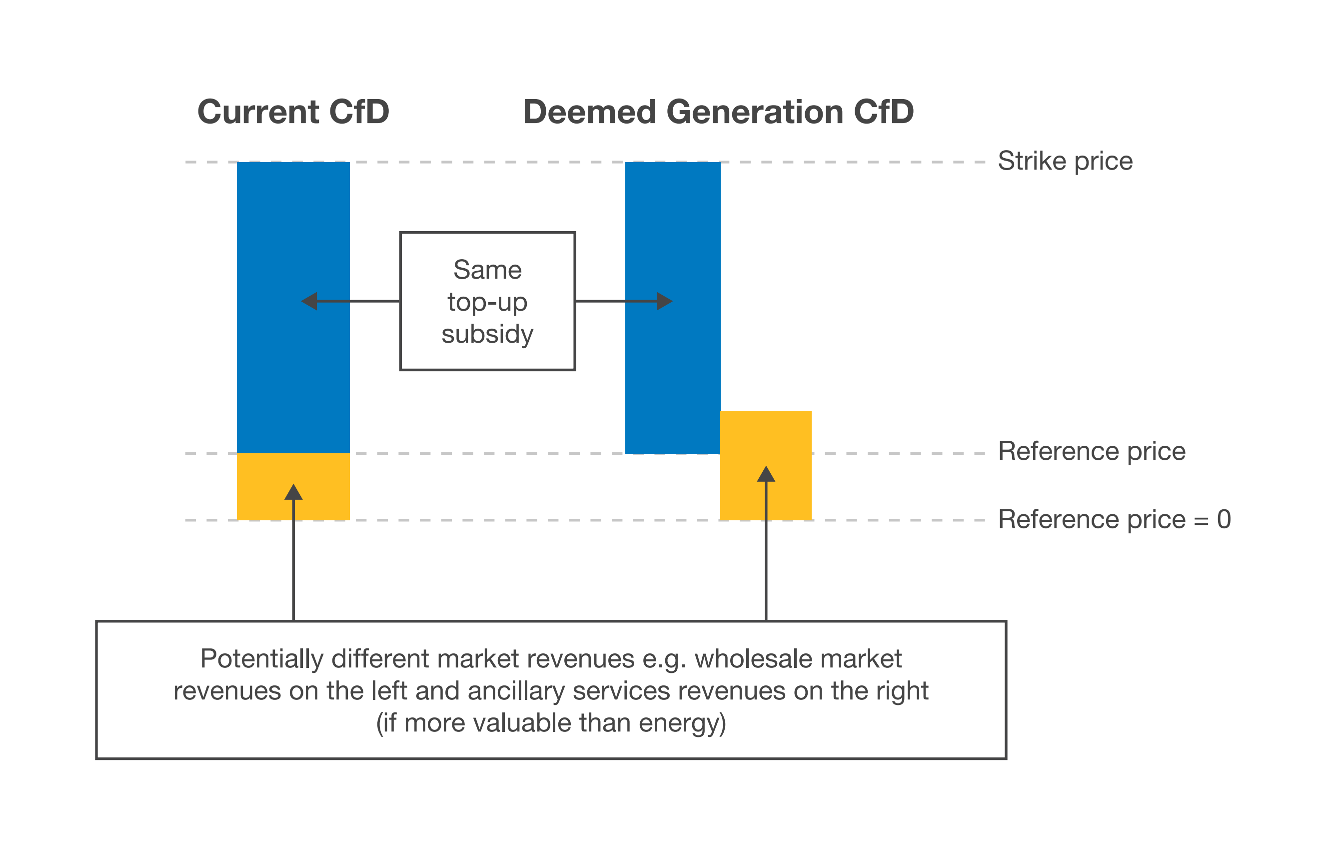
How does deemed CfD work vs existing CfD? Largely the same

Figure 3. Comparison of key features of Current CfD and Deemed Generation CfD

	Existing CfD	Deemed CfD
Strike price	Decided through auction, revenues topped up from reference price (e.g. day-ahead price) to strike price, in each settlement period	
Top-up (subsidy)	Based on product of metered output and price differential between reference price and strike price.	Based on product of maximum output generator could have theoretically delivered (i.e. deemed) and price differential between reference price and strike price.
Market revenues	Wholesale market revenues only	Revenues from different markets (though mainly wholesale energy)
Curtailment	No incentive to self-curtail as would lose top-up, so negative pricing rule introduced	Incentivised to self-curtail when wholesale energy price is below their short run marginal cost, and so the **negative price rule doesn't need to apply**

Figure 4. Comparison of revenues for Current CfD and Deemed Generation CfD



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The choice of CfD, whether to retain the existing CfD or adopt the Deemed Generation CfD, and the design features relating to the reference price and the negative pricing rule, depend on the desired allocation of risk between generators and consumers. However, more work needs to be done to determine the appropriate allocation of risk between generators and consumers, as well as understanding the interaction between locational pricing and the Strategic Spatial Energy Plan, before these design decisions are firmed up.

	More risk on generators	More risk on consumers
Negative price rule	**Current CfD with negative price rule** • A **negative price rule is needed** to stop generators producing when prices negative as generators must produce to receive subsidy. • If settling against national price, packaging the current CfD with locational energy pricing would require **applying the negative pricing rule to the local price in order to prevent dispatch distortions** (when national price positive but local price negative), increasing volume risk for some generators.	**Deemed Generation CfD without negative price rule** • No need for negative pricing rule as **generators self-curtail** when wholesale price below marginal cost, therefore significantly less volume risk for generators at low wholesale prices as they would always receive a top up (from zero), even when prices negative. • However, **double payments** (through BM) must be avoided.
Reference price	**Current CfD or Deemed Generation CfD settled against national price w/ locational energy pricing** • More locational price risk for generators in congested areas as top-up revenues will be lower, which may result in higher strike prices. In less constrained areas, assets may become more competitive. • Locational price risk can be mitigated with bespoke **Financial Transmission Rights (FTRs)**, which improves upon status quo (i.e. challenging for generators to manage risks associated with TNUoS).	**Current CfD or Deemed Generation CfD settled against local price w/ locational energy pricing** • No locational price risk for generators. • However, this design would need an **alternative locational signal** that would not be market-based (as locational energy pricing requires removal of locational signal from transmission charges to avoid double-charging), which would transfer more risk to consumers compared to status quo (i.e. TNUoS).

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System adequacy policy: In the short-term, improve reliability performance by adapting the CM; for the longer term, evaluate alternatives to the CM for implementation by early 2030s to adapt to changing system needs.

In the short term (2020s)

- Through the 2020s, stress events are expected to be short-duration and will be impacted by network constraints (alleviated with network build delivery, locational energy pricing implementation and flexibility mobilisation)
- Focus on:
  - Better utilisation of CM-awarded resources e.g.: penalties; improved secondary trading and notification process
  - Strategy for managing the transition for unabated gas
  - Strengthening ambition of innovation and de-risking support for low carbon, dispatchable, sustained-response resources
  - More ambitious and robust energy efficiency policy (traditional approach, not through power policies)
  - Developing new reliability metrics for changing nature of system stress

From the 2030s

- Stress events are expected to become less frequent but potentially much longer, so we need to consider more fundamental reform to the CM
- Policy choices will depend on:
  - the decision on wholesale market design; and
  - the status of market failures that underpin the CM given wider reforms and market development that could unlock demand-side elasticity.
- Interventions must be able to target procurement more accurately to system needs, treat resources fairly and provide accurate reward linking renumeration to wholesale prices. There are limits to the CM's capability to achieve this, even if reformed.
- Possible alternatives to the CM, which can be implemented as standalone options or packaged together, include:
  - Reliability Options – similar to the CM as they provide revenue stabilisation for capacity providers but different as they are financial contracts (i.e. call or put options) instead of physical contracts. They align closely with wholesale energy prices, provide strong incentives to deliver, enable market actors to trade out of position near real-time and provide optional hedge for consumers against extreme prices.
  - Strategic Reserves – these are availability contracts awarded through competitive procurement but resources cannot compete in the wholesale energy market. Could help cost-effectively manage the exit of high carbon assets (so long as design mitigates "slippery slope" risk).
  - A Scarcity Adder – administratively restores capacity value to wholesale energy prices, directly restoring missing money for flexibility.

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We see the market reform journey in three parallel phases:

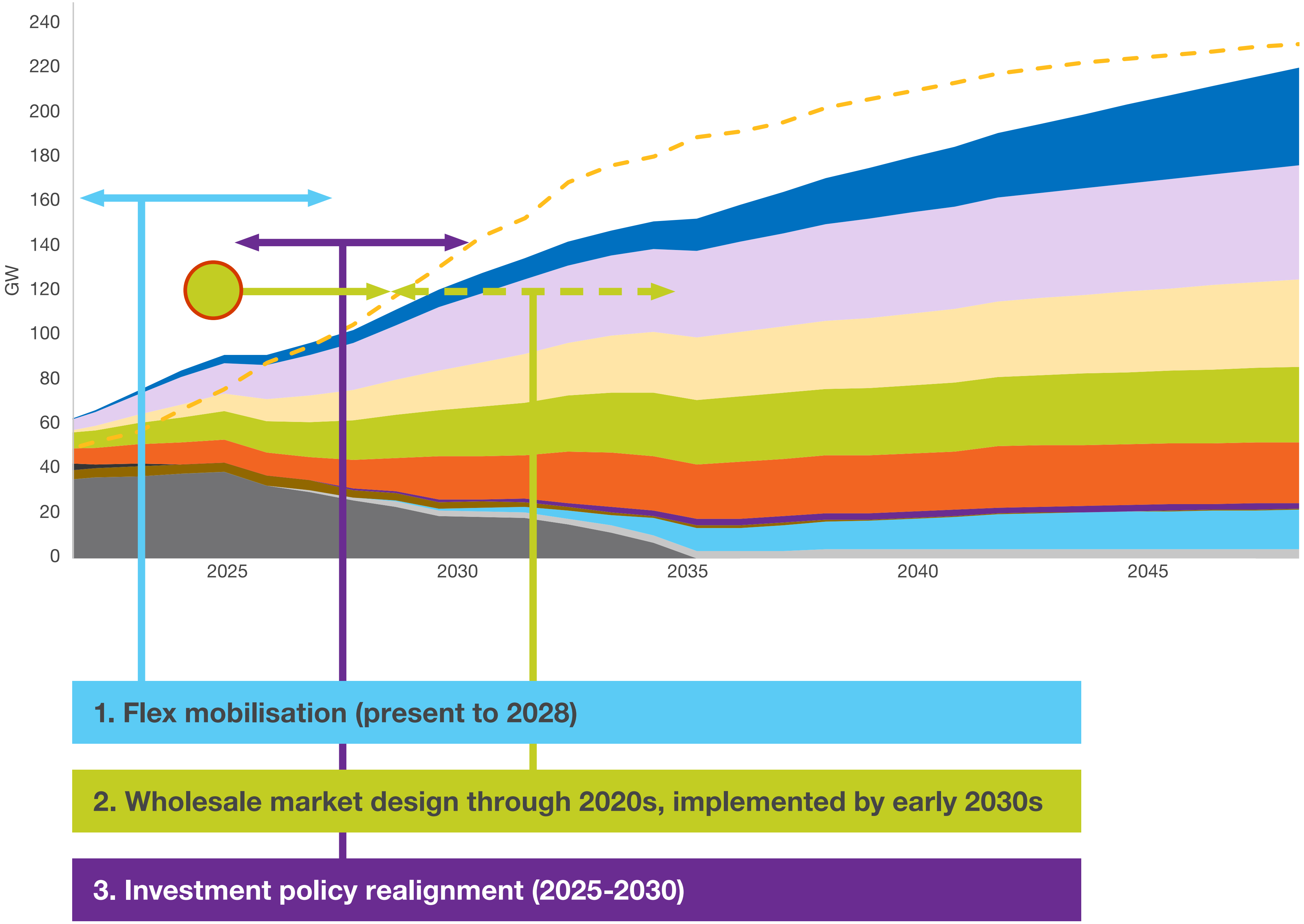
Massive expansion in both renewables and dispatchable resources are foreseen over the time period to 2050. Dispatchable capacity is likely to be dominated by two-way resources such as interconnectors, storage and demand-side response (DSR). Granular locational energy price signals are critical to the efficient investment and dispatch of these two-way resources, and complementary investment and innovation policies are also needed.

Key

- Renewables
- Electrolysis
- Storage
- V2G
- DSR
- Interconnectors
- Coal
- BECCS
- Biomass
- Hydrogen
- Gas CCUS
- Gas

- Wholesale market decision from 2024
- Wholesale market design and implementation
- Wholesale market implementation complete depending on design
- Flex foundation
- Investment policy realignment

Dispatchable supply & demand versus renewable capacity, 2020-2050



Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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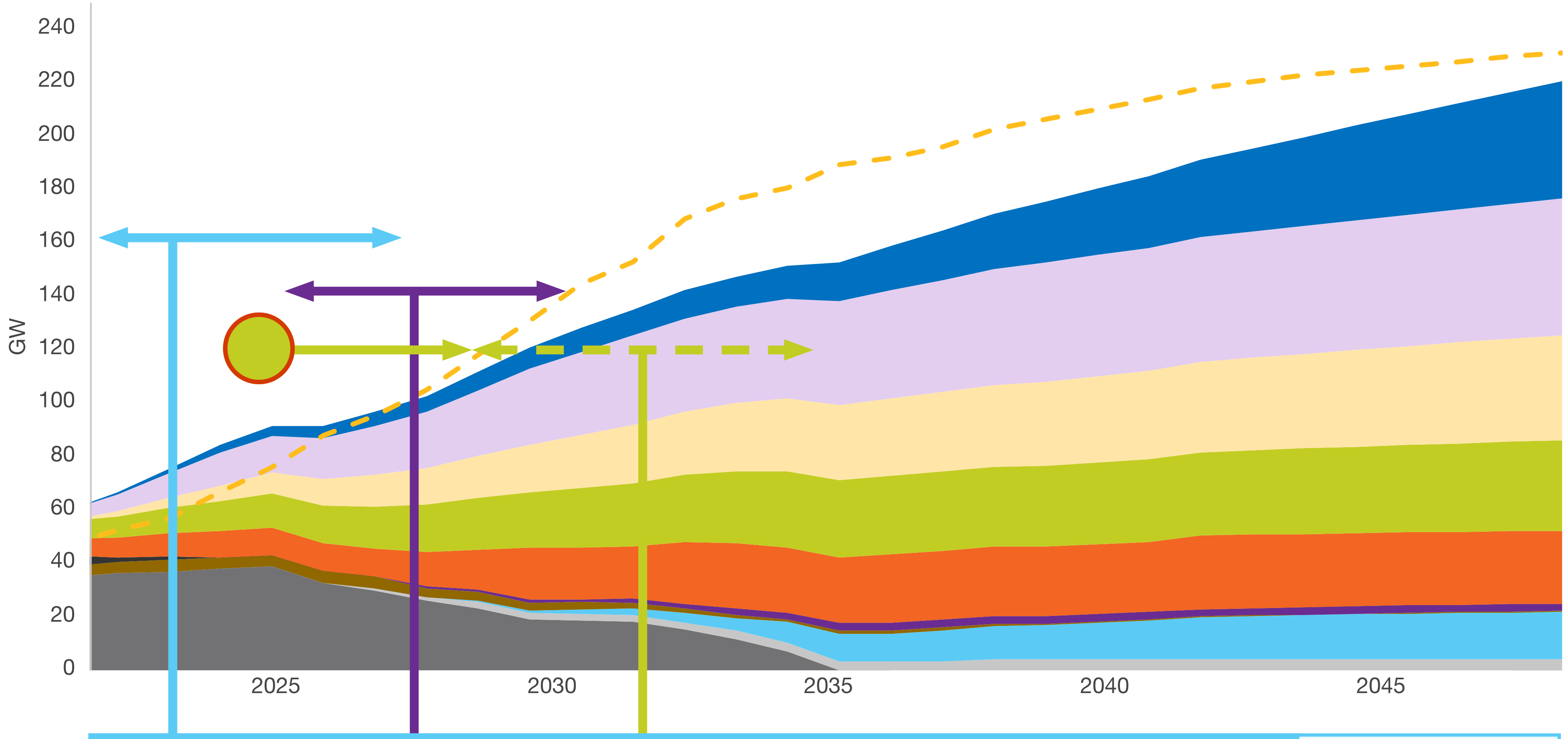

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1. Flex mobilisation (present to 2028)

Drivers for phase: rapid expansion in flexible capacity

Focus: expedite enabling processes including:

- Smart metering rollout
- Market-wide half-hourly settlement
- Retail market reforms
- Remove market barriers
- Connections and tariff reform
- Coordinate markets across whole system
- Standardise communication protocols across whole system markets
- Transform digital infrastructure

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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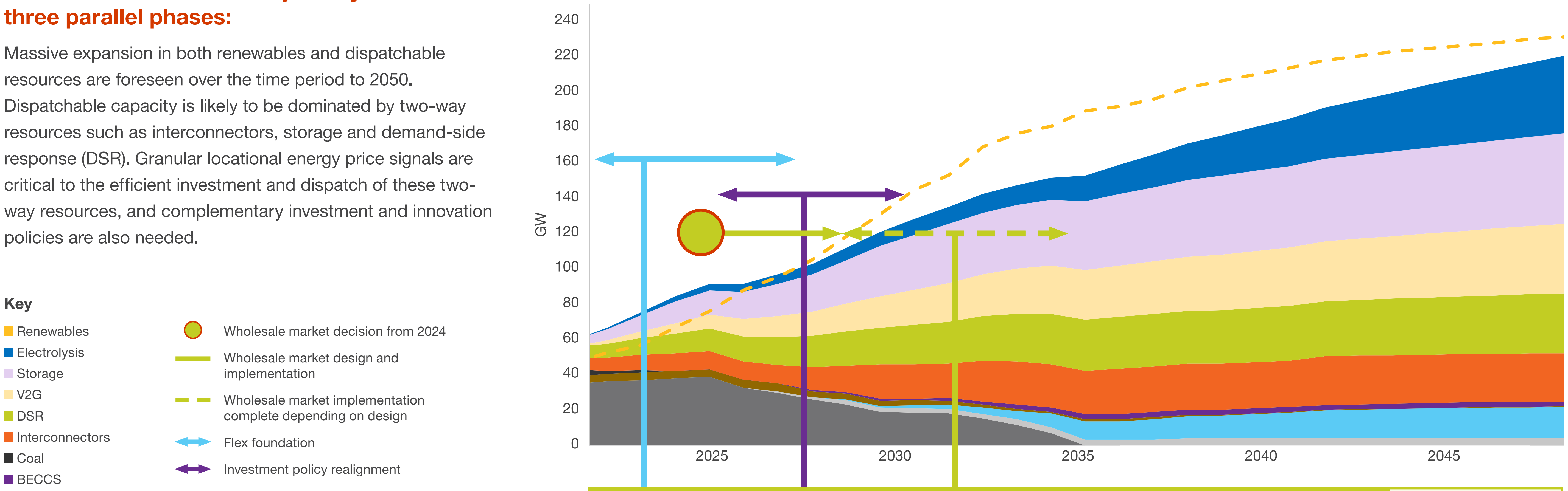
Dispatchable supply & demand versus renewable capacity, 2020-2050



2. Wholesale market design through 2020s, implemented by early 2030s

Drivers for phase: Demand flexibility, storage and interconnectors dominate GB's dispatchable capacity

Focus:

- Locational energy pricing required to unlock the full potential of flexible assets as well as renewables align assets with two-way flows with system needs
- Reform to dispatch/scheduling may be required to maximise participation of flexible resources

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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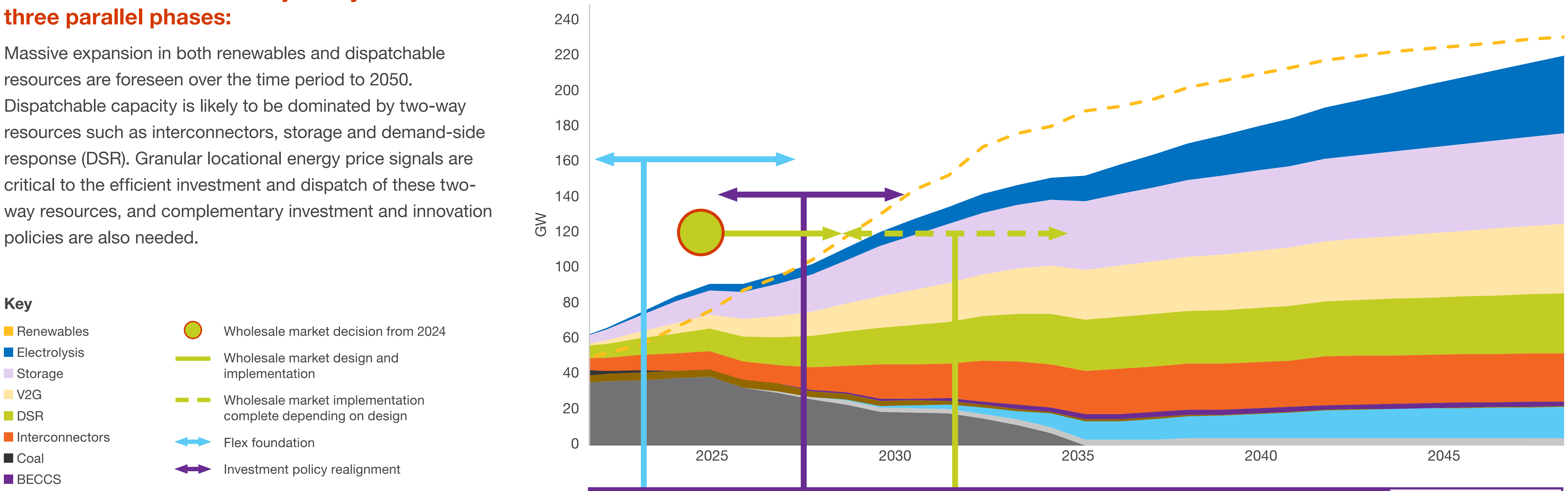

3. Investment policy realignment (2025-2030)

Drivers for phase: Total £bn CfD support triples between 2025-35* and costly distortions caused by the CfD could become unsustainable with scale up of investment using CfDs. Stress events become bidirectional with excess demand and excess generation and swings between the two while average length of tight periods triples between 2030-35 though frequency of tight periods reduces.

Focus:

- In the short term, implement improvements to the CfD and CM, ensuring coherence with chosen wholesale market design
- In second half of 2020s, decide on system security arrangements for post 2030, capable of cost-efficiently meeting radically different system needs

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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Next Steps

Figure 5 sets out the next steps for our NZMR programme following this report. We will continue to analyse wholesale market design, investment policy options and coherent market reform packages, working closely with other ESO teams to further develop our view on efficient market reform for net zero. We will draw on this, along with all stakeholder feedback, to respond to the next REMA consultation expected this autumn.

In parallel, from our unique position as electricity system operator, and as a trusted strategic partner in REMA, the ESO will continue to support the Government and Ofgem on the design and implementation of reform options as they are narrowed down in REMA, specifically advising on their impact on GB electricity system operation. This is a role we expect to continue beyond the consultation as we continue the transition to a Future System Operator (FSO).

Figure 5. Next steps for the NZMR programme

Wholesale Market Design

Engage with stakeholders on our assessments of:

- Centralised and decentralised scheduling
- Co-optimisation of energy and ancillary services

Investment Policy and Market Reform Package

Use stakeholder feedback to refine our conclusions and approach set out in this publication

Continue to engage with stakeholders on our conclusions set out in this publication – please reach out to .box.Market.Strategy@nationalgrideso.com to engage with the team

Work with internal ESO teams to further analyse options for reform, using available data and unique insight as system operator

Respond to the next REMA consultation

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Introduction to Phase 4

Introduction

As evidenced in our NZMR programme and the REMA case for change, the current market arrangements require reform to achieve net zero while ensuring a secure system at lowest cost to consumers. In Phase 4, we have focused on the challenges arising in investment timescales. To support government in designing holistic market reforms for net zero, we have also explored coherent wholesale market design and investment policy packages.

Context

Our current market arrangements in GB were designed for a very different electricity system

GB's current electricity market arrangements were established in 2001 at a time when the share of weather-dependent renewable generation in the power mix was low and when demand-side flexibility was limited to a relatively small number of energy intensive industries. The 'status quo' arrangements are called the New Electricity Trading Arrangements, or NETA. A few years later, the arrangements were extended to additionally cover Scotland under the British Electricity Trading and Transmission Arrangements (BETTA).

At this time, the need for real-time locational signals was not seen as a priority. BETTA is underpinned by generators and suppliers contracting bilaterally, or via spot markets, independently of ESO. This is under the fundamental premise that all generators, regardless of location, can serve load anywhere in the country. In the current market arrangements, generators inform ESO up to gate closure of their dispatch schedule. Originally, the role of ESO was 'residual balancer': responsible for fine-tuning the dispatch of generation to ensure continuous energy balance and for protecting the limits of the system, but not intervening in a major way. As we set out in our Phase 3 report, this is no longer the case, and as system operator we are having to redispatch an increasingly large share of the market to maintain reliability. This is reflected by the high balancing costs, which were £4.2bn in 2022.

Transmission network use of system charging (TNUoS), which provides a long-term locational investment signal, was extended to Scotland under BETTA. By splitting the country into a number of TNUoS zones (27 generation and 14 demand zones for 2023/24), there is an incentive for generators and demand users to locate in more optimal locations for the system. For instance, if a generator chooses to locate further from demand, they will have to pay greater annual TNUoS charges, reflecting the additional network build required to transfer the electricity for consumption.

Introduction

Our current investment policy schemes in GB were established a decade ago via the introduction of the Contracts for Difference scheme and Capacity Market

The main investment policy support mechanisms in the current GB electricity market were established via the Electricity Market Reform (EMR) policy as the cornerstone of the Energy Act 2013. This introduced two key investment policy mechanisms in the form of the Contracts for Difference (CfD) scheme (which replaced the Renewables Obligation as the principle low carbon subsidy), and the Capacity Market (CM). It also introduced a carbon price floor to underpin the carbon price in the EU Emissions Trading Scheme and an Emissions Performance Standard (EPS), a regulatory measure to provide a backstop to limit emissions from new fossil fuel power stations. This investment policy was established primarily to tackle two emerging challenges of the energy system at the time:

- Ensuring achievement of a legally binding EU target for 15% of the UK's energy to come from renewable sources by 2020, for which 30% renewable electricity generation was required to compensate for slower decarbonisation in other sectors
- Supporting security of supply during a period of extensive plant retirements (20% of 2013 capacity expected to retire by 2020) by providing "missing money" to firm capacity

The policies introduced by EMR were successful in driving investment in renewable generation, through the CfD, whilst also securing security of supply, through the CM:

- Nearly 30GW of low carbon capacity has been delivered by the CfD scheme and its predecessors since 2014, with the CfD lowering the cost of capital and sharing risk/reward with consumers via the return of revenues above the strike price to consumers
- Security of supply has been maintained whilst high-carbon coal power stations have been largely phased out, aided by around 15GW of new flexible capacity investments supported by the Capacity Market

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Case for Change

As evidenced in our NZMR programme, the Government's first REMA consultation, and other stakeholder studies, there is a need to reform the current arrangements (EMR overlayed on BETTA). In this section we have summarised the emerging issues and future challenges set out in previous phases of the NZMR programme.

We have identified three future challenges that need to be addressed via market reform

In Phase 2 of the programme, we concluded that three future challenges need to be addressed, as illustrated by the Venn diagram in Figure 6. These challenges were identified from the modelling completed by LCP, which explored the outcomes if the current market arrangements were to remain in place, alongside feedback from tailored stakeholder engagement across ESO and the energy sector.

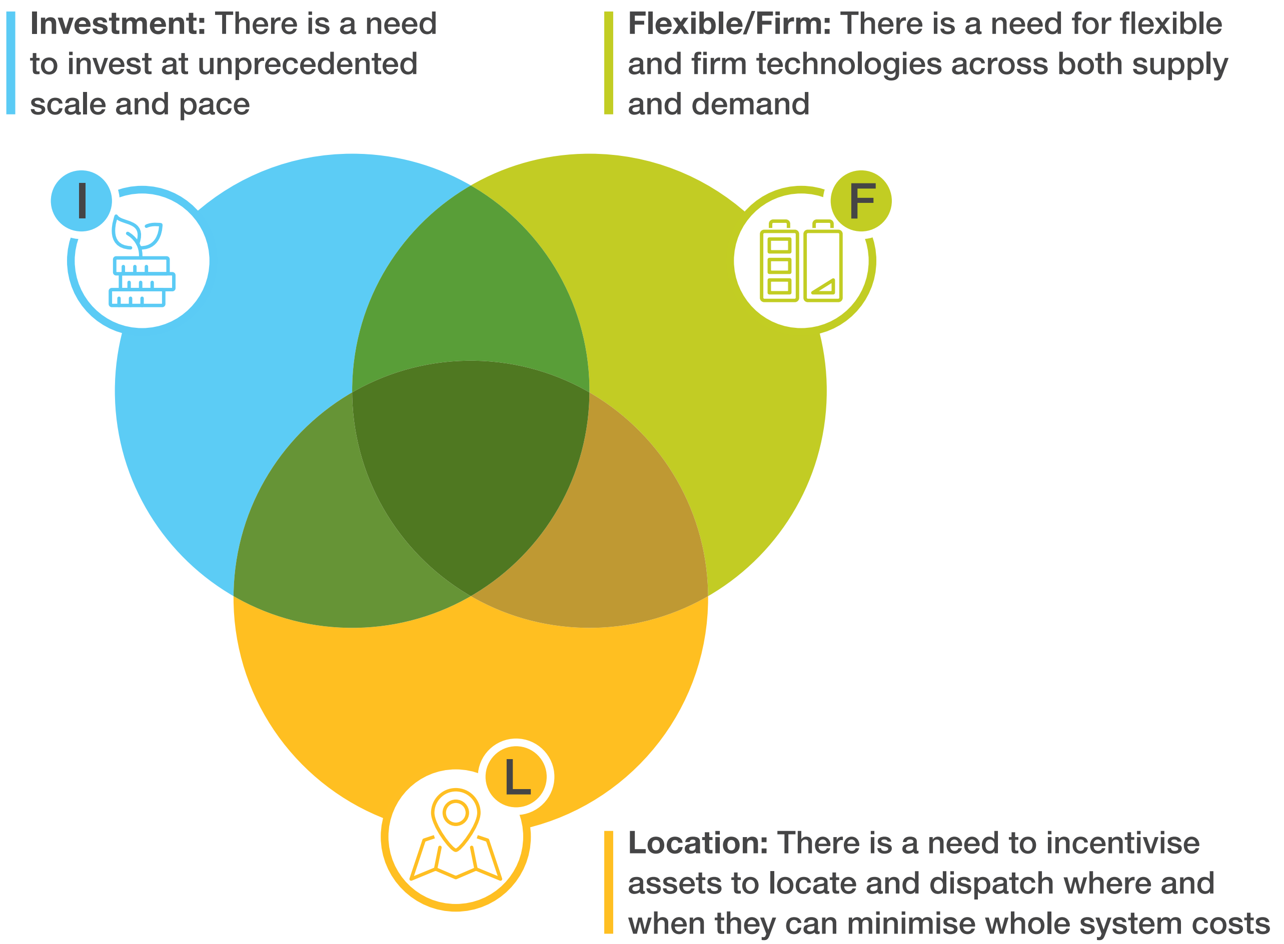
We have identified four key emerging issues to be addressed via market reform

Since the introduction of the status quo arrangements, the power system, markets, and technologies have developed considerably as we continue to transition to net zero. The limitations of operating a high-renewables, highly flexible system under the current arrangements have already emerged, leading to rising costs for consumers and operational issues.

In our phase 3 publication, we set out four key issues:

1. Constraint costs are rising at a dramatic rate
2. Balancing the network is becoming more challenging and requires increasing levels of inefficient redispatch
3. National pricing can sometimes send perverse incentives to flexible assets, that worsen constraints
4. Current market design does not unlock the full potential of flexibility from supply and demand

Figure 6. Future challenges that the GB electricity system will need to address, set out in our Phase 2 report



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Introduction

ESO's NZMR programme to date

We launched our NZMR programme in early 2021 to examine holistically the changes to GB electricity market design that would be required to achieve the power sector's 2035 decarbonisation targets cost-efficiently and securely, while laying the foundation for a net zero economy by 2050.

The launch of REMA in July 2022 confirmed the need to work together across the sector to map out the right net zero market reform in the best interests of current and future consumers. As the system operator, we have a unique perspective of the real-time performance of the system. In the NZMR programme, we focus on drawing upon ESO evidence to inform our analysis and conclusions.

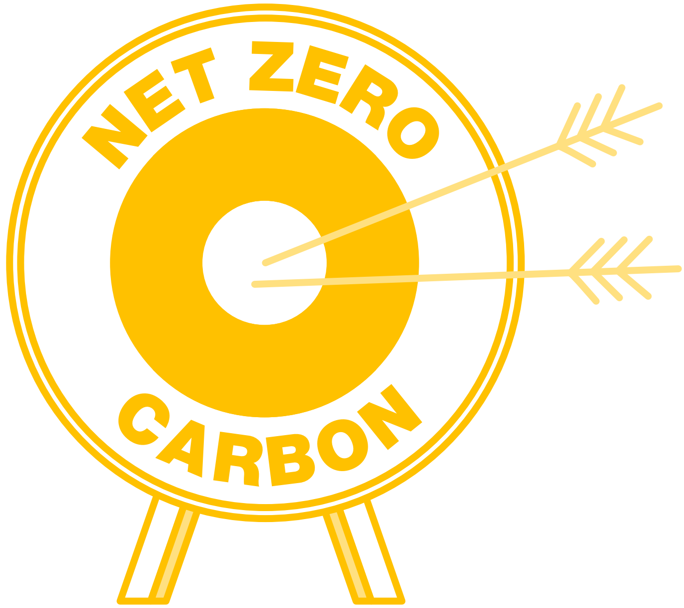
We also continue to engage with industry, academics, consumers, the government, and Ofgem, and this has been a focus since the start of the programme. Whilst it is crucial that we engage regularly to keep stakeholders up to date with our latest thinking, we also engage to gather feedback and adjust our analysis.

More recently, we held our phase 4 conclusions webinar to gather feedback; this can be found, along with all previous events and publications from the programme, on our NZMR website.

In Phase 3 we assessed operational elements of market design: location and dispatch

Phase 3 of the programme focused on the 'location' and 'flexibility/operation' future challenges, analysing how reform of the wholesale market can lead to more efficient operation of the GB electricity system in real-time. We built upon our Phase 2 case for change, drawing upon first-hand evidence relating to the system's performance. With FTI Consulting we then assessed market design options, focusing on location (national pricing/ locational pricing [including both zonal pricing/nodal pricing]) and dispatch (self-dispatch/centralised dispatch). We concluded that a combination of locational wholesale pricing with centralised scheduling, as a complement to significant strategic transmission network build, could deliver major efficiencies for a net zero system.

It is only after knowing which wholesale market design will be implemented, that the degree and nature of complementary investment policy can be determined; hence why the wholesale market design should be decided upon first and was analysed first in Phase 3. More information on this approach is set out in the introduction to the chapter on our 'investment policy assessment'.



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NZMR Programme to date

	Phases 1-2	Phase 3: Operation	Phase 4: Investment		
	January 2021 – April 2021	November 2021	May 2022		November 2023
Key Conclusion	We must reform markets to achieve net zero, starting with operational market design	Real-time, dynamic locational signals are needed to ensure efficient dispatch and investment	Robust investment policy still needed but currently not fit for purpose	Enduring policy must increase price exposure, avoid distortions, and treat demand-side fairer	Parallel phasing of short-term measures to address inefficiencies without undermining longer term foundational reforms
Programme Deliverable	High level scoping, case for change and options assessment framework	Detailed assessment of operational market design options	Case for change revisited with greater focus on investment	Detailed assessment of investment policy options	ESO approach to market reform packages that coherently combine market design and investment policy, with pathways

Methodology

Phases 1-2

- Define assessment criteria
- Define options assessment framework
- Identify design options for assessment
- Preliminary assessment; shortlist taken forward to Phase 3

Phase 3: Operation

- Refinement of operational market design policy options
- Assessment using Phase 2 criteria
- Draw insights from assessment and publish conclusions

Phase 4: Investment

- Analysing evidence from evolving energy landscape, including system operator data and stakeholder views (e.g. in summer 2022 REMA consultation)

- Develop sub-criteria to criteria from Phase 3
- Refinement of investment policy options
- Baringa conduct assessment using refined Phase 3 criteria
- Draw insights and publish conclusions

- Define approach to designing packages
- Baringa assess packages against refined Phase 3 criteria
- ESO conducts additional assessment with focus on interactions
- Draw insights from assessment and publish conclusions

Net Zero Market Reform / Phase 4 24

Net Zero Market Reform Bigger Picture

We see the market reform packages outlined in this document as an enduring foundation for long-term net zero market design; however, while market reform is crucial to achieve net zero cost-effectively, it is vital that we do not consider markets in isolation. Reforms of this scale must not preclude actions in the shorter term to improve the status quo design.

Net Zero Market Reform / Phase 4 25

1) Ensuring efficient and timely network development: pace and coordination of investment is critical

The scale of investment in transmission infrastructure required to facilitate net zero is unprecedented: last year's Holistic Network Design (HND) and Networks Options Assessment (NOA) recommended £54bn of investment in transmission network required to enable 50GW of offshore wind by 2030. Future growth in offshore wind and other technologies will require significant further investment in the transmission network.

Connecting 50GW of offshore wind by 2030 will have an enormous cost impact as well as broader societal impacts on coastal communities and the environment that need to be carefully managed. We are delivering work as part of the DESNZ-led Offshore Transmission Network Review (OTNR) to design a more coordinated network to support the delivery of offshore wind targets that balances the impact to the environment and communities whilst ensuring the network remains economic, efficient, deliverable and operable.

The ability to connect new generation currently exceeds the pace at which the industry can approve, consent and deliver major transmission projects. This means that, unless we develop ways of accelerating the delivery of transmission infrastructure, the constraint costs that would most efficiently be mitigated by network reinforcement will continue to rise beyond their optimal level. The ESO is collaborating closely with Ofgem on their Electricity Transmission Network Planning Review (ETNPR). One of our main objectives is to identify key investments which will allow the transmission network capability to be there ahead of need and also to identify potential whole energy system optimisations that deliver value.

Identifying and delivering greater levels of anticipatory investment in the transmission system, however, does not change the fundamental goal to optimise the aggregate cost of generation, constraints and networks in order to achieve net zero at lowest overall cost to consumers.

The recent Electricity Network Commissioner report recommended the creation of a Strategic Spatial Energy Plan (SSEP), and enhancements to the Centralised Strategic Network Plan, to accelerate transmission investment and the Prime Minister confirmed its introduction earlier this year in September. Further thought and discussion is required to understand how the spatial recommendations of the SSEP interact with locational market and network charging signals to provide longer-term investment signals for supply, demand and networks. We are working closely with DESNZ and Ofgem to agree the scope, status, governance and timelines of the SSEP, and its interaction with the CSNP. We will engage with key stakeholders as proposals develop.

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2) Ensuring timely connections to the transmission network

We recognise the challenges currently facing our connections customers and the need to update the connections process. As a result, we launched the Connections Reform project to address these challenges and put our customers and stakeholders at the heart of this change.

For the longer-term we are developing a reformed connections process. In June 2023, we published a consultation on our initial recommendations for a reformed connections process and we are now currently in the process of reviewing consultation responses and plan to publish our final recommendations shortly.

In parallel to the longer-term reforms, in the shorter-term we have introduced our 5-Point Plan of tactical initiatives to manage some of the immediate challenges.

Our 5-Point Plan Category	Category Overview
Transmission Entry Capacity (TEC) Amnesty	This was the first TEC Amnesty since 2013. We received a total of 8.1GW of applications and are currently working with Ofgem to allow the termination/reduction of TEC process from connection agreements.
Construction Planning Assumption (CPA) Review	Review the CPAs to reflect current connection rates and reducing the assumption that most projects in the queue will connect. This will allow connection dates to be brought forward and reduce works in existing agreements. We are currently working with the TO's on this and will update contracts as soon as possible for those customers.
Treatment of storage	Revising the way storage connections are modelled as the current process takes a conservative view of what the assumed behaviours of storage could be. These changes will allow storage to unlock more capacity to connect others.
Queue Management	There is currently no mechanism in the Connection and Use of System Code (CUSC) to terminate projects that are not progressing. If changes are approved, it would allow the ESO to terminate projects that are not progressing against their contracted milestones and agreed timescales, in order to free up capacity for other projects that can progress. CMP 376 CUSC modification is now with Ofgem for a decision.
Non-Firm Offer Development	The policy aims to accelerate the connection of energy storage projects by removing the non-critical enabling works to be complete before they connect under a non-firm connection agreement. We are currently developing new clauses for the connection agreements that this applies to as well as working with the TO’s to understand which customers can benefit from this policy first.

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Net Zero Market Reform Bigger Picture

3) Ensuring an efficient resource mix: capacity adequacy will become a different challenge

A fully decarbonised electricity generation mix in 2035, combined with the significant increase in demand, will present new challenges in ensuring system adequacy. There will be much higher volumes of weather-dependent generation (e.g. wind and solar), which will drive the need for greater system flexibility. Many of the flexible technologies that we will depend on to balance the system may also be impacted by weather (e.g. storage, interconnectors, demand).

In collaboration with AFRY, we published our first long-term resource adequacy assessment in December 2022. The key findings were:

- There is no trade-off between adequacy and meeting net zero but we need to bring forward investment in clean, reliable technologies.
- Understanding risks due to weather patterns will become increasingly important to ensure adequacy in a fully decarbonised system with high levels of weather dependent generation.
- New modelling approaches and metrics will be required to assess risks to adequacy in a fully decarbonised power system.
- It will become more important to consider adequacy in the context of developing the right markets, the right networks and future operability challenges to be confident that adequacy is ensured in a cost-effective way.

In July 2023, we published how we intend to develop our resource adequacy studies, reflecting stakeholder feedback, as we build towards our next full study in summer 2024. Further information is available on our website.

4) Ensuring operability: the system will face increased challenges

As the GB power system decarbonises, there will be a number of engineering challenges that need to be solved, such as low inertia and short circuit levels. The ESO ambition to operate a zero-carbon electricity system by 2025 will solve these challenges for short periods. As the system further decarbonises there will be a need for more of these services. Co-ordinated system operator activities and flexibility markets will be used as standard to manage distribution issues as well as transmission issues.

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5) Ensuring consumers are at the heart of a just transition

Empowering consumers to participate in net zero is fundamental and the removal of barriers to participation enables consumers to become an active partner. ESO's Demand Flexibility Service (DFS) that operated over winter 2022/23 demonstrated the opportunities for consumers to be incentivised to actively engage with the energy system. Consumer engagement with the energy system through smart home devices enabling automation and shifting of energy demand offers an opportunity to meet net zero in the most cost effective way. The Crowdflex innovation project with a range of industry partners, is investigating how much reliable residential consumer flexibility could potentially be unlocked, which will feed into our Net Zero Market Reform analysis on how to unlock it in a fair and efficient manner.
Our Virtual Energy System programme will also help to model the impact of consumer behaviour within the wider system.

Unlocking the value of small scale domestic and non-domestic demand side flexibility by ensuring it can compete on a level playing field with supply side resources, with access to fair reward, will be a cornerstone of achieving net zero and is integral to our assessment of net zero market design. In parallel through workgroups and trials, we are working to investigate the removal of barriers to entry in the current market that prevent domestic and non-domestic demand side response from being aggregated and bid into the balancing mechanism.

6) Ensuring a smart, flexible system through digitalisation and data

The sheer complexity of the whole net zero energy system, with smart appliances in homes responding to price signals, millions of EVs and heat pumps, and thousands of decentralised assets taking part in wholesale and balancing markets, means that the digitalisation of processes and systems is vital. Increased data sharing will be needed to provide digital systems with the information needed to optimise markets and control room decision making. A major digital transformation is required, not just for ESO but for the industry as a whole, and it must be coordinated across different voltage levels, energy vectors and economic sectors. Increased visibility of distributed generation and demand will be crucial.

We published our updated ESO Digitalisation Strategy & Action Plan in June 2021, aligned with the recommendations of the Energy Data Taskforce. Transforming our data capabilities is foundational to delivering on our digital objectives, and to the wider digital transformation of the UK's energy sector.

An example of one of many such programmes running across ESO is the Balancing Programme. This programme was established with the aim to develop the balancing capabilities that the Electricity National Control Centre needs to deliver reliable and secure system operation, facilitate competition everywhere and meet our ambition for net-zero carbon operability. To date, the programme has done extensive work to modify our existing capabilities to meet changing market conditions and customer requirements. In addition, the Open Balancing Platform (OBP) is planned to launch in December and is a new real-time balancing capability which will progressively replace the legacy ESO balancing systems (EBS, BM and ASDP). New functionality will be incrementally delivered, this will ensure that we have the vital flexibility to facilitate future changes, both expected and emerging, across the industry.

Net Zero Market Reform / Phase 4 29

Introduction

Purpose of Phase 4 and this Report

In Phase 4 we have focused on long-term investment timescales, and how investment policy facilitates investment 'at unprecedented scale and pace'. This involves analysing how current investment policy, set out in EMR, can evolve such that both emerging issues and future challenges are addressed.

We have also addressed how investment policies can best complement the different wholesale market designs set out in REMA. Working with Baringa, we have developed an approach to exploring coherent wholesale market design and investment policy packages. As we enter a period of considerable regulatory change through REMA, a clear, holistic long-term vision and roadmap for market and policy reform, is critical to ensure that the GB electricity market remains attractive to investors.

With a clear direction for net zero market and policy reform, it is then possible to design coherent transitional arrangements. This pathway must be communicated to stakeholders as early as possible in order to minimise any periods of uncertainty, maintain investor confidence and ensure investment at needed pace.

In Phase 4, we have articulated the short-term, medium-term, and long-term arrangements required in the pathway to our best view end state.

In parallel to our work on 'investment policy', we also continue to examine in greater detail potential reforms to wholesale and balancing markets, specifically by:

a) Further assessing zonal pricing based on self-dispatch versus nodal pricing based on centralised scheduling with self-commitment

b) Disaggregating the benefits of locational pricing and centralised scheduling (including co-optimisation)

c) Assessing options for shorter-term improvements to dispatch efficiency (including Balancing Mechanism Review analysis and outcomes) and locational siting

In the next steps section, we set out how we will continue to share this additional analysis with stakeholders in the future.

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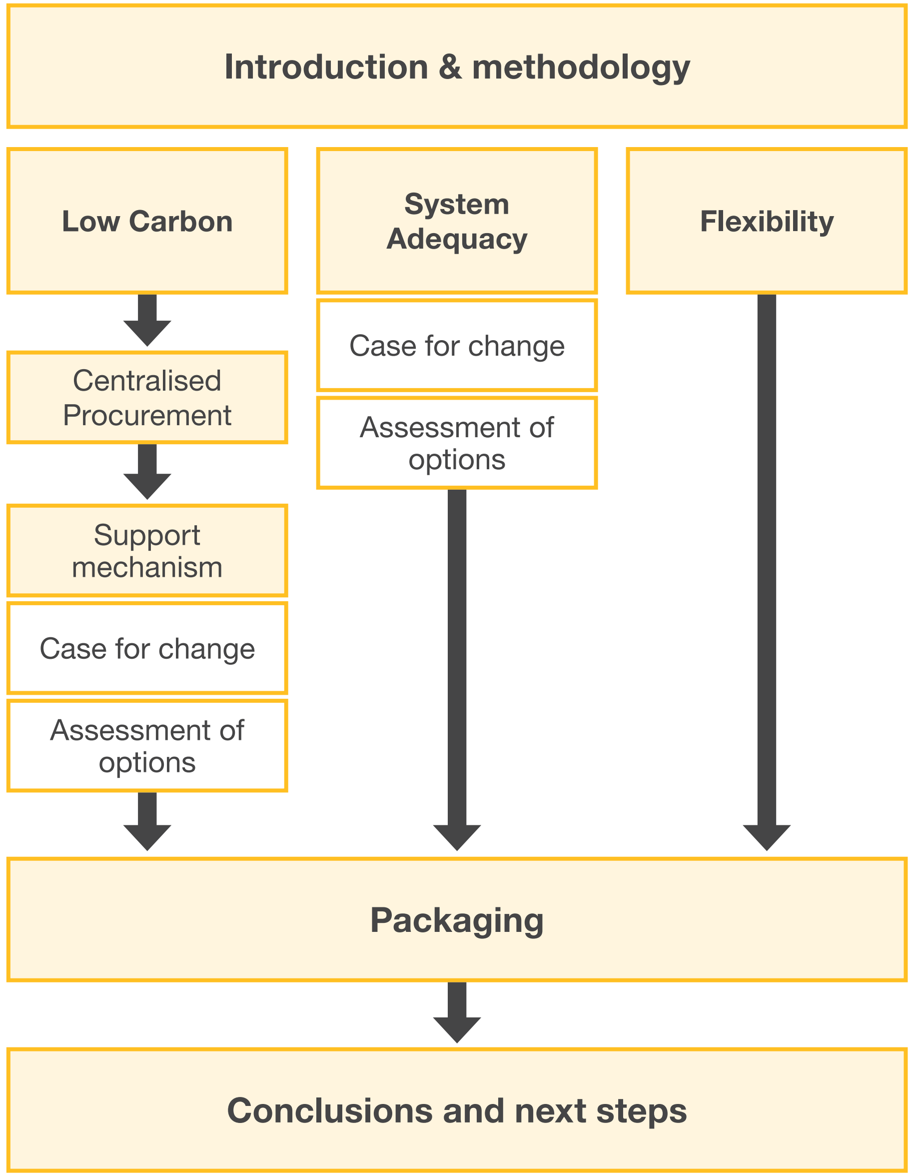
Introduction

This report brings together this body of Phase 4 work and stakeholder feedback to form our best view on holistic market reform for net zero. We have also set out our proposal for phasing of short-term, medium-term, and long-term measures towards a clear, long-term vision that meets the REMA objectives.

The purpose of this document is therefore to share our analysis and conclusions on investment policy and to set out an approach to effectively combine investment policy with wholesale market design, at such a critical time in the REMA debate.

Structure of this Report



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In the fourth phase of the Net Zero Market Reform programme:

1 **We further developed our case for change, specifically focusing on investment policy**

2 **We commissioned Baringa to conduct an independent assessment of investment policy options and potential holistic market reform packages**

3 **We developed ESO's best view market reform package with a proposed implementation pathway**

1 We further developed our case for change, specifically focusing on investment policy

Since publishing our initial case for change in Phase 2 of the programme at the end of 2021, the GB energy system, and the landscape within which it operates, has continued to evolve. It was therefore necessary to revisit and update our case for change, with a specific focus on investment. The case for change is critical as it informs a robust assessment approach. We:

- Refreshed our operational case for change through research, feedback and ESO data
- Deepened our case for change relating to investment policy based on stakeholder feedback

Stakeholder input in Baringa's assessment

We facilitated stakeholder engagement throughout the Baringa assessment, both to keep stakeholders updated and to inform improvements to the assessment, drawing on stakeholder feedback. In September 2022, at ESO's Autumn Markets Forum, we first introduced the rationale and methodology underpinning Baringa's assessment, and incorporated the stakeholder feedback. In November 2022, we then hosted online workshops to gather views on preliminary results with the stakeholder feedback incorporated in the final version of their assessment, published by ESO in February 2023.

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Methodology

2 **We commissioned Baringa to conduct an independent assessment of investment policy options and potential market reform packages**

2a) Updated assessment criteria to include sub criteria

Stakeholder feedback suggested the need for greater transparency in the qualitative assessments. For this reason, we asked Baringa to expand the ten assessment criteria by defining comprehensive sub-criteria. These can be found by expanding each of the assessment criteria in Table 1.

The same ten primary assessment criteria used in Phase 3 have been used for Phase 4, although two have been renamed. 'Deliverability' was relabelled as 'challenge to implement', and 'security of supply' has been relabelled as 'energy security and system operability'.

REMA assessment criteria:

We agree that the trilemma (decarbonisation, security of supply and cost-effectiveness) should be objectives of REMA, although we disagree with their omission as assessment criteria. In the NZMR programme we embed the trilemma objectives and principles into our assessment criteria. Omitting the trilemma as criteria risks de-prioritising the most important outcomes and introduces greater subjectivity in the decision making process.

We also believe it is important to separate the 'whole system flexibility' assessment criteria into 'whole system' and 'full-chain flexibility' to ensure distinction between two materially different considerations is fully represented in the REMA assessment.

Q5 in our 2022 REMA consultation response (p.11) sets out our position on this in greater detail.

Table 1 - NZMR assessment criteria with their associated sub-criteria developed in Phase 4

Assessment Criteria	Description
Decarbonisation	Provides confidence that carbon targets will be met
Energy security and system operability	Ensures that adequacy and operability challenges can be met
Value for money	Ensures that the electricity system (network build, short-run dispatch and long-run investment) is being delivered efficiently
Investor confidence	Investors are exposed to appropriate risks (e.g. risks they can manage) and finance costs are minimised subject to appropriate risk allocation
Challenge to implement	Transition from current market design to target design is deliverable in an appropriate timeframe
Whole system	Facilitates decarbonisation across other energy vectors
Consumer fairness	The costs of the system are fairly shared across all consumers
Competition	Facilitates competition within and across technologies, between generation and demand and across connection voltages
Adaptability	A market design that can adapt to changes in technology or circumstances with limited disruption within a reasonable time frame
Full chain flexibility	Market design enables the flexibility from all assets at all levels of the electricity system to contribute

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Methodology

Table 1 - NZMR assessment criteria with their associated sub-criteria developed in Phase 4

Assessment Criteria	Description	Sub criteria
Decarbonisation	Provides confidence that carbon targets will be met	Increase probability of achieving decarbonisation objective
Energy security and system operability	Ensures that adequacy and operability challenges can be met	Ensure sufficient capacity to meet peak system needs
		Ensure sufficient available capacity and demand response to manage extended low renewable output
		Ensure sufficient responsive capacity to maintain system operability
		Manage external shocks and unintended consequences
Value for money	Ensures that the electricity system (network build, short-run dispatch and long-run investment) is being delivered efficiently	Reduce relative proportion of redispatch
		Improve operational efficiency of interconnectors
		Ensure appropriate risk allocation and efficient cost of capital
		Increase system flexibility
		Reduce inefficient inframarginal rent
Investor confidence	Investors are exposed to appropriate risks (e.g. risks they can manage) and finance costs are minimised subject to appropriate risk allocation	Respect existing legal framework and rights
		Provide assurance for debt holders
		Provide suitable incentives for equity
		Promote market liquidity
		Minimise ongoing regulatory risk

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Methodology

Table 1 - NZMR assessment criteria with their associated sub-criteria developed in Phase 4

Assessment Criteria	Description	Sub criteria
Challenge to implement	Transition from current market design to target design is deliverable in an appropriate timeframe	Minimise policy complexity/interdependencies
		Minimise market disruption
		Reduce implementation cost
		Reduce risk of unproven solutions
		Expedite implementation
Whole system	Facilitates decarbonisation across other energy vectors	Align investment incentives for cross-vector assets
		Align dispatch incentives for cross-vector assets
Consumer fairness	The costs of the system are fairly shared across all consumers	Limit adverse distributional impacts for consumers
		Allow greater consumer choice
		Ensure fair allocation of costs, based on cost-reflectivity
Competition	Facilitates competition within and across technologies, between generation and demand and across connection voltages	Align markets/avoid distortions
		Ensure sufficient available capacity and demand response to manage extended low renewable output
		Promote greater inter-technology competition
		Promote greater market transparency
		Reduce barriers to entry
		Reduce risk of gaming or exploitation of market power

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Methodology

Table 1 - NZMR assessment criteria with their associated sub-criteria developed in Phase 4

Assessment Criteria	Description	Sub criteria
Adaptability	A market design that can adapt to changes in technology or circumstances with limited disruption within a reasonable time frame	Facilitate new and evolving business models
		Reduce risk of lock-in or asset stranding
		Adapt to changing technology trends
Full chain flexibility	Market design enables the flexibility from all assets at all levels of the electricity system to contribute	Optimise investment in flexibility
		Optimise dispatch of flexibility
		Manage large and extended mismatches between supply and demand
		Promote demand side participation

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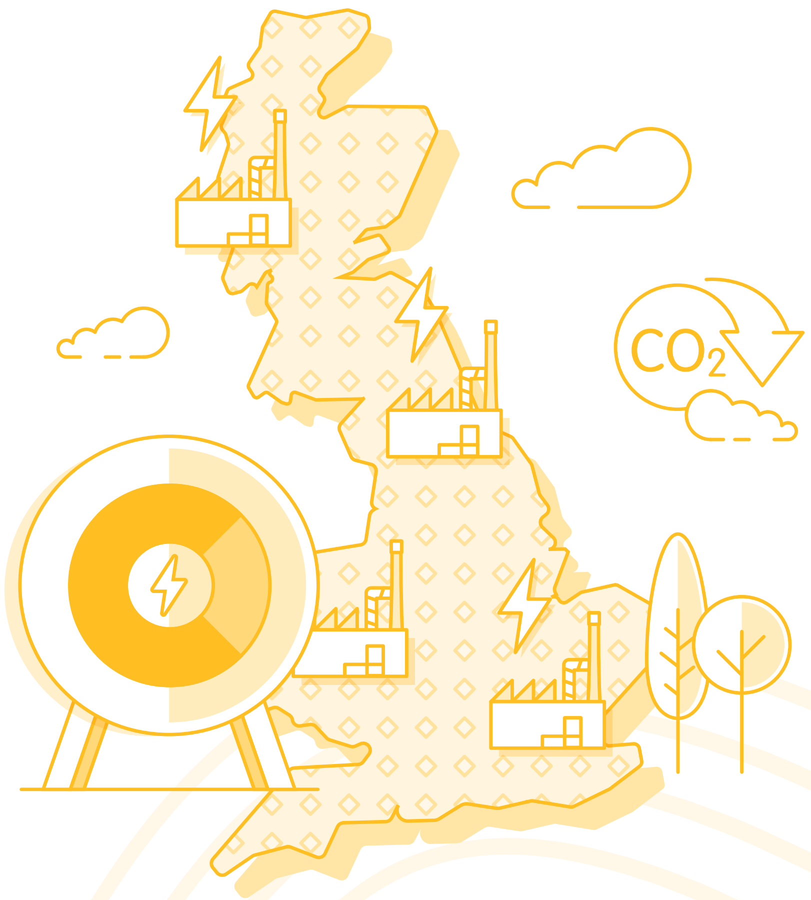
2b) Updated list of market design and investment policy options to be assessed

With Baringa, we reviewed the list of market design and policy options to be assessed. This also involved cross referencing our initial set of options, as set out in our options assessment framework from Phase 2 of the programme, with those being considered in the 2022 REMA consultation, and any others found in literature and stakeholder proposals. The list of options assessed is shown in Figure 7.

2c) Baringa complete an independent assessment of market design options

Baringa then qualitatively assessed the updated list of market design and investment policy options against the assessment criteria and sub-criteria using an extension of the status quo as the counterfactual (shown in Figure 7).

Whilst there was a particular focus on investment policy options in the Phase 4 assessment, we also asked Baringa to reassess the wholesale market design location and dispatch options, which had initially been assessed in Phase 3 to ensure our findings on this crucial element are robust.



Net Zero Market Reform / Phase 4 37

Methodology

Figure 7. Our NZMR assessment framework overlayed on the REMA schematic set out in the Summer 2022 consultation.

View 1: REMA options being assessed in Phase 4

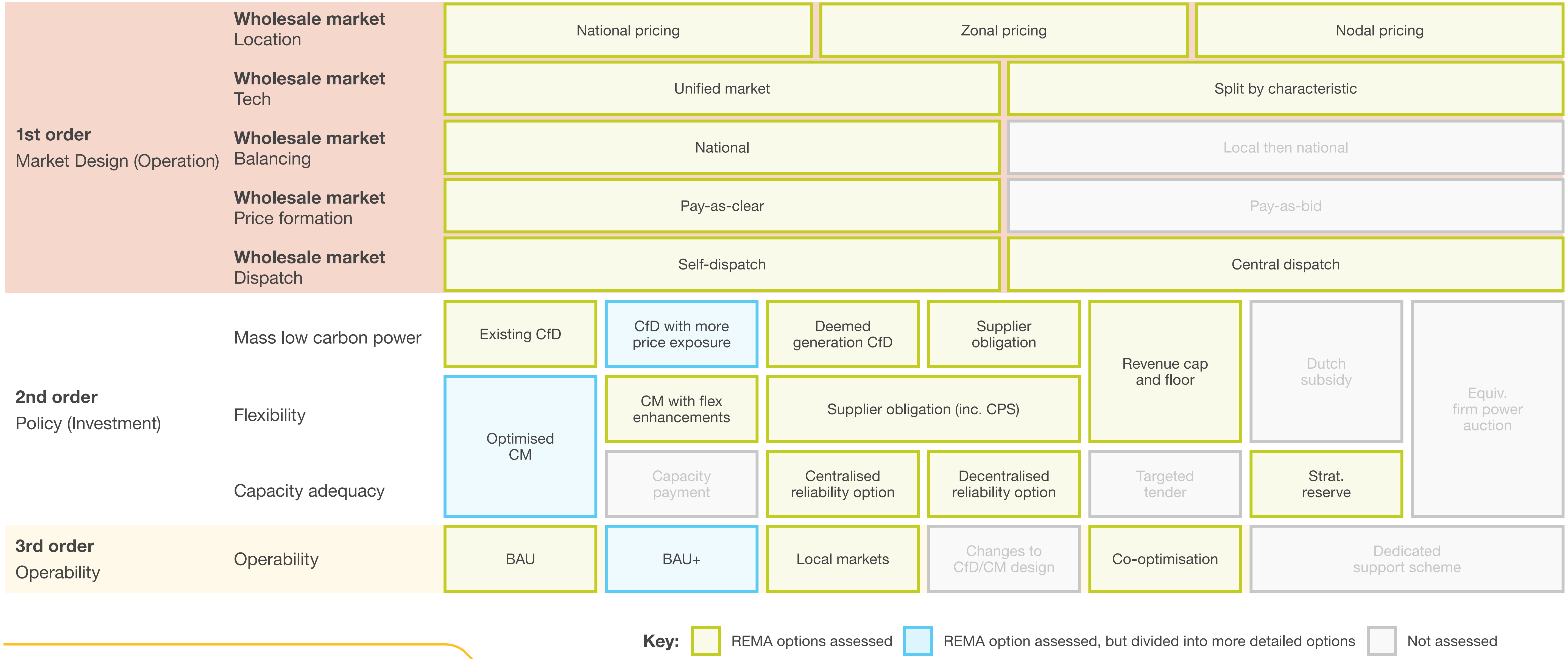


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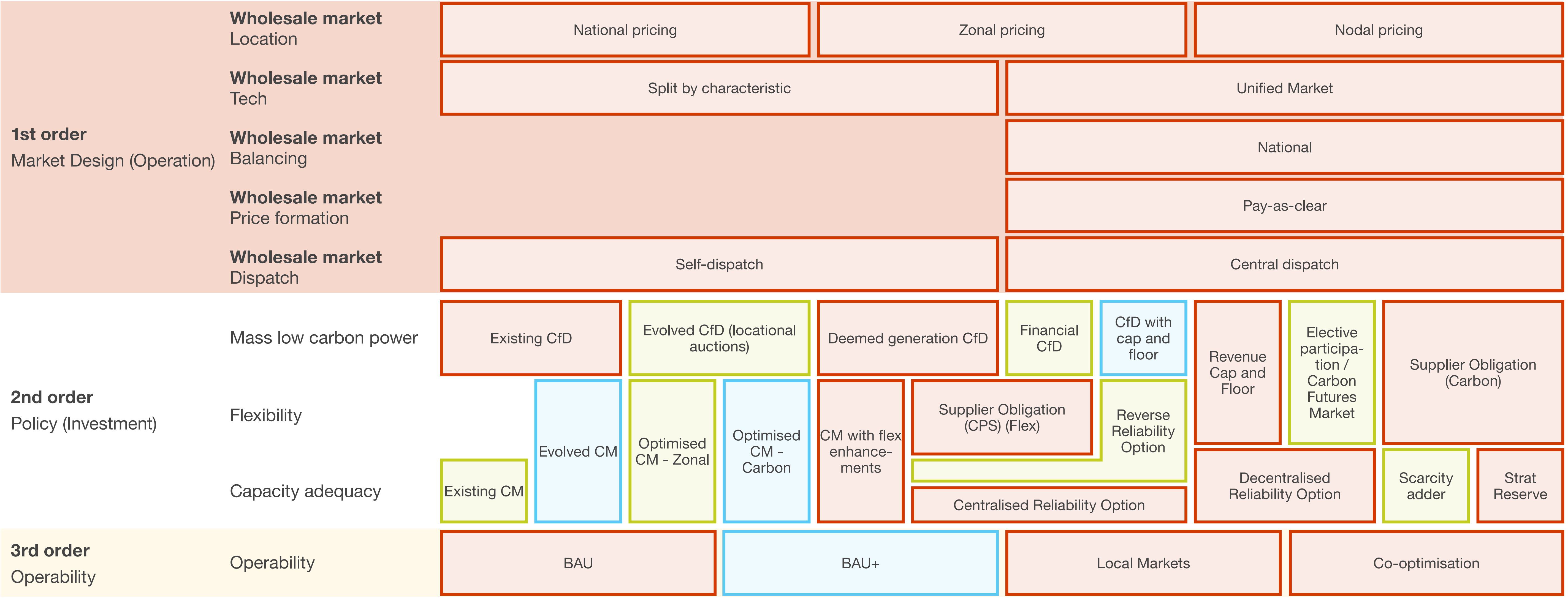
Figure 7. Our NZMR assessment framework overlayed on the REMA schematic set out in the Summer 2022 consultation.

View 2: All options being assessed in Phase 4



Key: REMA options assessed; REMA option assessed, but divided into more detailed options; New options introduced

2d) Baringa build illustrative market reform packages

Baringa created a high-level structure of national, zonal and nodal packages, because (as highlighted in Phase 3), it is important to agree on the operational market design element first, before deciding on the appropriate investment policy support to complement.

The next stage involved layering on investment policies and other options to create holistic market reform packages. For each location option, Baringa created two packages illustrating opposite ends of a spectrum. Baringa used 'baseline' and 'build' categorisation to represent this:

Baseline: For a given pricing mechanism (national, zonal, or nodal), what is a least change but cohesive set of policies, which address, to some extent, the key areas in the case for change.

Build: For a given pricing mechanism, and a longer implementation time, what comprehensive set of policies would increase the confidence in achieving the REMA objectives (i.e. score more strongly against the assessment criteria).

Our baseline/build approach based on national, zonal, and nodal pricing is a practical framework that helps illustrate and explore the effects of combining individual market design and investment policy options. The NZMR programme continues to engage with the REMA team on the emerging insights using this approach.

2e) Baringa complete an independent assessment of market reform packages with illustrative pathways

Using the same assessment criteria and sub-criteria set out in 2a, Baringa then qualitatively assessed their packages. The scoring was completed twice; first with equal weighting across our assessment criteria and then with greater weighting on the trilemma (value for money, energy security and system operability, and decarbonisation).

2f) Baringa develop illustrative implementation pathways for introduction of their packages

We then worked with Baringa to develop illustrative implementation pathways for each package. This exercise highlighted the importance of having an end state package to work towards when implementing different market design and investment policy options as part of a package which evolves over time. We continue to engage with DESNZ to support the debate on implementation pathways.

3 We developed ESO's best view market reform package with proposed implementation pathways

Drawing on Baringa's qualitative assessment, we then completed our own assessment of investment policy options for net zero (preliminary results presented at our July 2023 Phase 4 conclusions webinar).

Since the webinar, we have incorporated stakeholder feedback, input from other pieces of work (including Ofgem's technical study) and expertise from across the ESO to further inform the conclusions.

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Investment Policy Assessment

ESO

Introduction to Investment

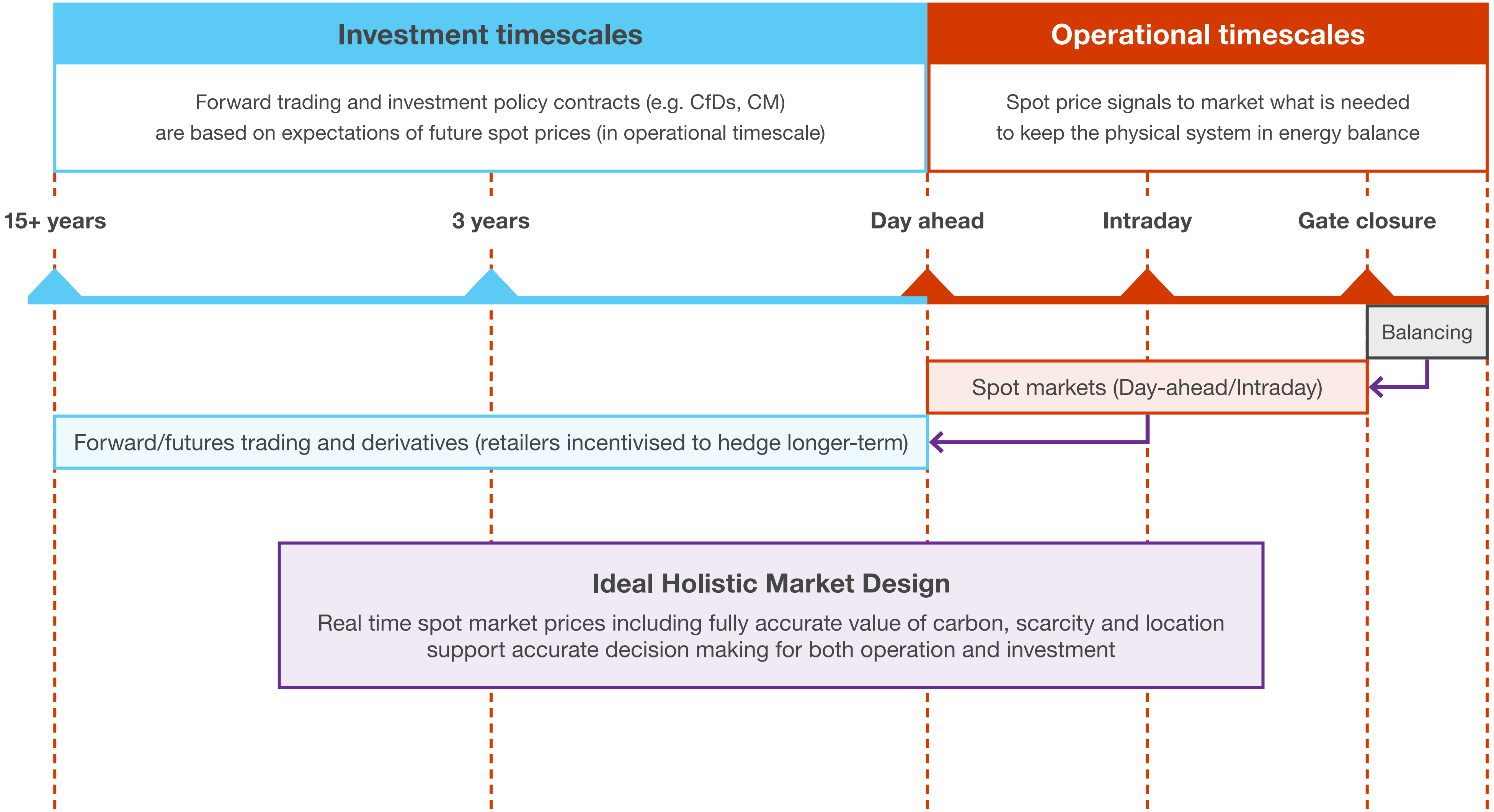
Our approach is underpinned by the principle that effective electricity market design starts with accurate real time price signals via spot markets.

Our assessment framework, described in the Methodology section, covers the various components of electricity market design and their options. Crucially, this framework was designed sequentially: our assessment began by considering what accurate price signals in operational timescales should look like, before then considering how investment policy support should integrate with those real time price signals.

The logic for this, as illustrated in Figure 8, is that confirmation of the market design underpinning wholesale revenues is a prerequisite to determining the extent of investment support that may be needed. If spot prices do not fully capture all the characteristics that determine value, this creates "externalities". These are costs (or benefits) caused (or provided) by market participants that are not financially incurred (or received) by them.

Figure 8. How electricity markets and policies over different timescales facilitate investment

View 1: Ideal electricity market design, underpinned by accurate real time price signals via spot markets



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Introduction to Investment

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Figure 8. How electricity markets and policies over different timescales facilitate investment

View 2: Current deviations from ideal electricity market design

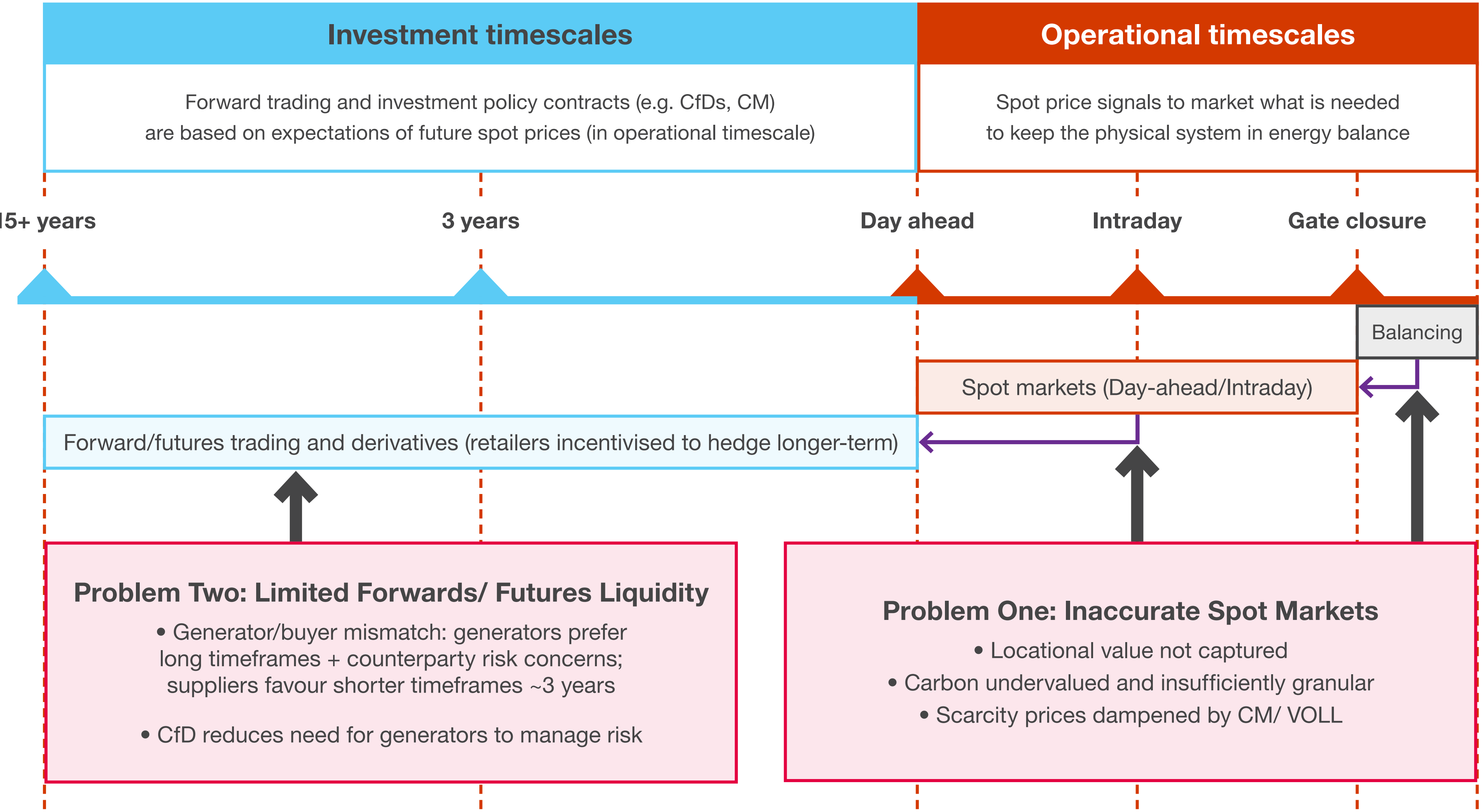

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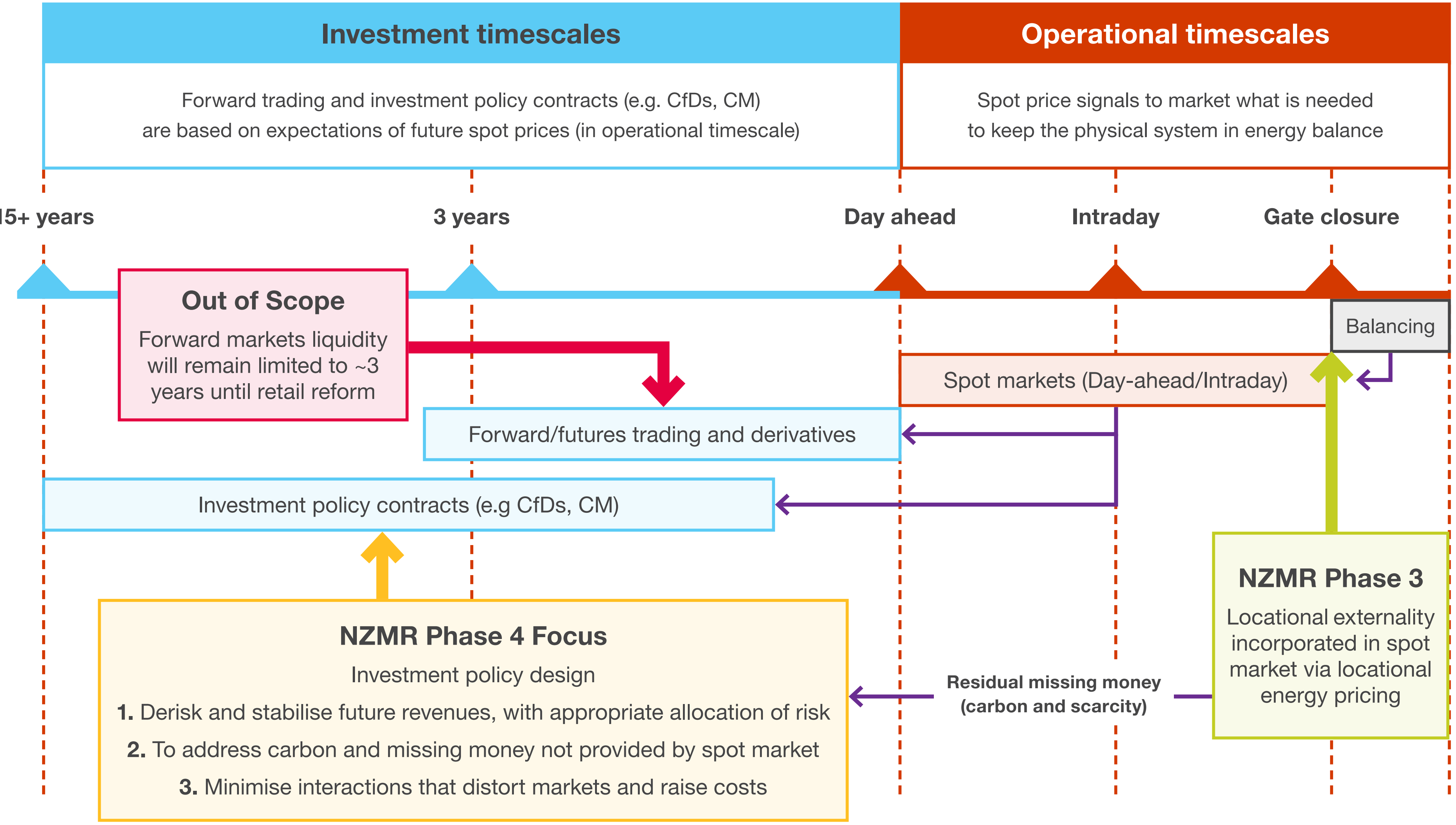
Figure 8. How electricity markets and policies over different timescales facilitate investment

View 3: Focus of Investment Analysis



Introduction to Investment

We believe that wholesale energy prices that capture as fully as possible the true value of electricity, including major externalities (e.g. carbon, system constraints), are fundamental to efficient investment as well as efficient dispatch. It is the market's expectation of future wholesale prices that drives forward contracting, hedging and investment.

There are three critical categories of externality of particular relevance to net zero electricity market design which, if missing or undervalued in wholesale prices, have to be corrected via investment policy.

The first, to be discussed in 'Low Carbon Investment', is the externality of carbon emissions. The status quo electricity market design does already include a cost for this via the UK's Emissions Trading System (UK ETS) and Carbon Price Floor, with allowances that are included in unabated plants' marginal costs, which feed through to spot prices when these plant are price-setting. However, these allowances are currently under-priced in the electricity market as its decarbonisation targets are more ambitious than the economy as a whole.

The locational externality, whereby some assets operate at times and places that cause or alleviate constraints, but are not rewarded accordingly, is a critical example. As set out in our conclusions in Phase 3 of the programme, this externality can be effectively addressed by restoring this locational value into the wholesale market itself through locational energy pricing. Under either nodal pricing or, to a lesser but still significant extent, under zonal pricing, the locational externality is embedded in wholesale prices, aligning both operational and investment incentives with system needs.

Lastly, an externality is created in all wholesale markets in which spot prices are artificially depressed at times of system stress, such that they do not allow prices to fully reflect scarcity value. A common phenomenon in electricity markets, this is often driven by a combination of a lack of effective demand elasticity and a political aversion to high prices.

The locational externality can be readily and effectively addressed via wholesale market reform, the carbon and scarcity externalities will likely require further policy intervention.

If wholesale market reform in isolation cannot fully address the carbon and scarcity externalities, then a market failure exists and policy intervention may be justified to restore the "missing money" in addition to other policy justifications. The following chapters, Low Carbon Investment and System Adequacy, explain our reasoning why we believe continued policy intervention will be required for carbon and scarcity respectively.

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Illustration of missing money

Figure 9 illustrates missing money in the context of unrewarded locational value with the right hand illustration restoring missing locational value through locational wholesale pricing.

Missing money is commonly thought of as a positive amount (e.g. when spot prices are not as high as they should be to reflect a period of scarcity). However, the opposite occurs whenever wholesale prices are higher than they should be because they do not fully reflect a negative externality (e.g. system constraints), as shown in Figure 9.1. In essence, inaccuracies mean that while some market actors may be under-compensated, faced with missing money, others are over-compensated to the detriment of energy bills.

Missing money also exists in the GB market relating to resource scarcity value and carbon value. If wholesale market reform in isolation cannot fully address the carbon and scarcity externalities, then a market failure exists and policy intervention may be justified to restore the "missing money" in addition to other policy justifications.

Figure 9. Total revenue for plant operating in alignment with system needs

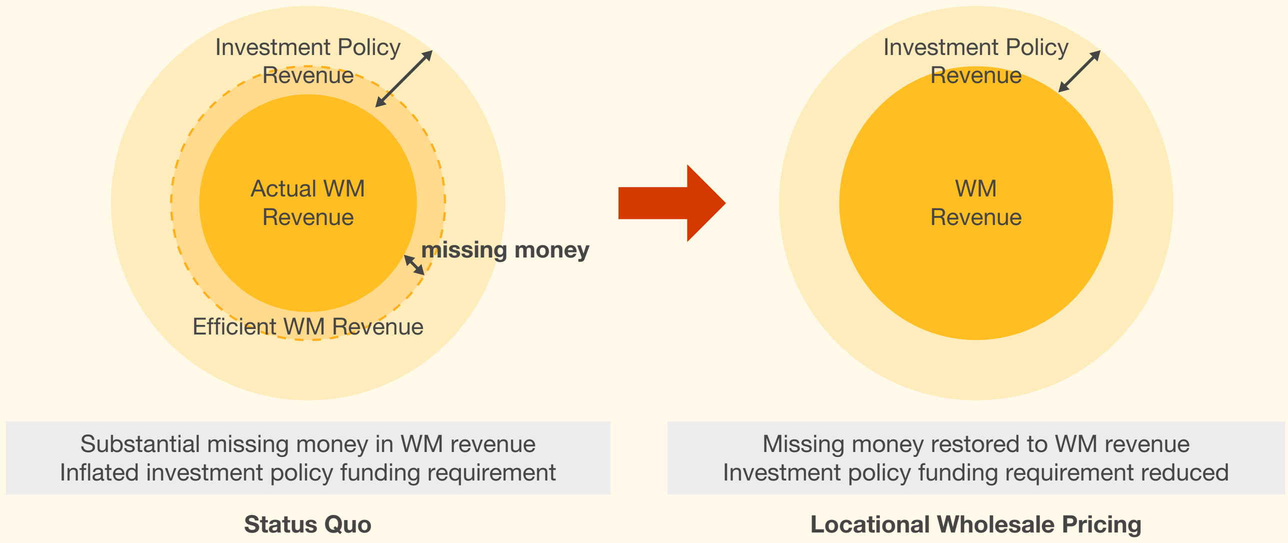
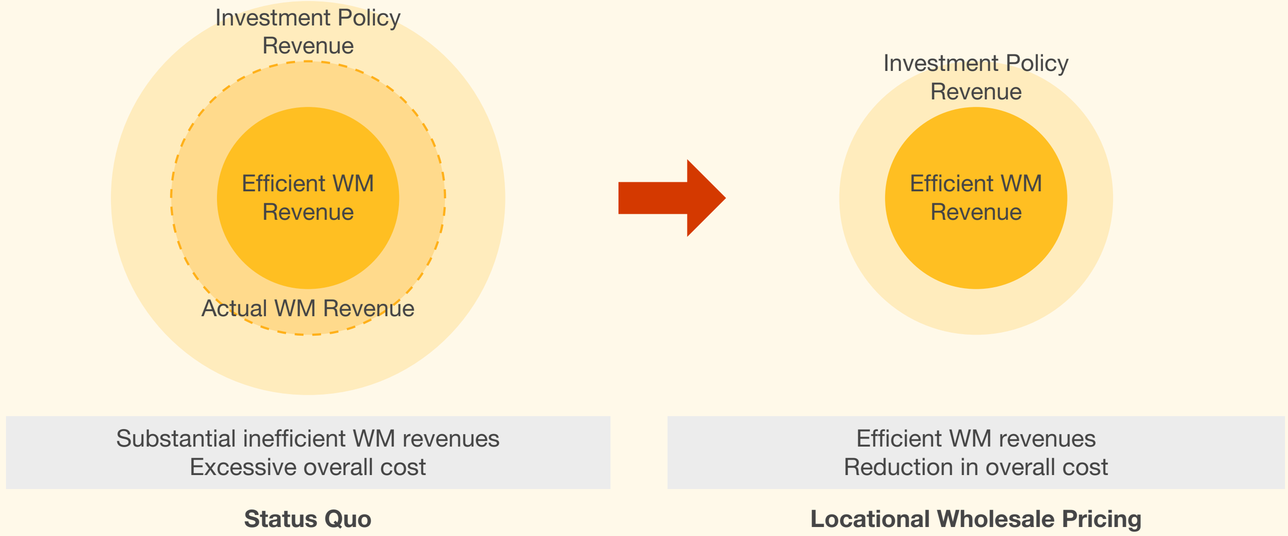


Figure 9.1 Total revenue for plant operating out of alignment with system needs



Low Carbon Investment

Investment Policy Assessment

ESO

Introduction

In its representation of the fundamental building blocks of holistic market design and investment policy, ESO's NZMR assessment framework explicitly disaggregates two key market design elements relating to low carbon investment. The first is the "Low Carbon Centralised Procurement" element, defined as the degree to which the low carbon technology mix is determined by the Government, including the extent of competition between technologies. The second is the "Low Carbon Support Mechanism", which considers the degree to which variable renewables generation should be protected from wholesale price volatility.[1]

This section sets out our conclusions for both of these market design elements, taking into account both Baringa's assessment and our own analysis. Crucially, it emphasises how the conclusions on the extent of competition in Low Carbon Centralised Procurement are pivotal to the consideration of the design of support mechanism via which such assets are renumerated.[2]

1 In the REMA framework, the former consideration is discussed in Chapter 4, which addresses cross-cutting questions including the extent of competition between technologies, whereas REMA Chapter 6 "Mass Low Carbon Power" examines options for support mechanisms.
2 This logic underpinned our framing of Low Carbon Centralised Procurement as a first order market design element in Phase 2, with Low Carbon Support Mechanism framed as a second order element due to its high level of dependency.

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Low Carbon Centralised Procurement

This section focuses on the first of our two fundamental questions on low carbon investment policy; the degree to which the low carbon technology mix should be determined by the Government, including whether its procurement should be centralised. We set out our reasoning and evidence supporting four key conclusions on Low Carbon Centralised Procurement:

1. **Centralised, directed procurement is necessary to achieve the 2035 decarbonisation objective, attract low cost international finance and counter regulatory risk**
2. **The longer term vision should be to evolve centralised procurement towards demand-led investment facilitated by retail market reform**
3. **There are greater challenges in determining optimal procurement levels under centralised procurement compared to demand-led contracting**
4. **For inter-tech competition to be effective, the support mechanism must ensure incentives align with market signals which themselves are cost reflective and free of distortions**

1 Centralised, directed procurement is necessary to achieve the 2035 decarbonisation objective, attract low cost international finance and counter regulatory risk

The UK electricity system is undergoing a transformation to a low-carbon future. Investors are used to dealing with market forces, which determine both the electricity price itself and also the carbon price, via the European Union Energy Trading System (EUETS). However, as the UK Emission Trading Scheme's (ETS) coverage is broader than the power sector, and electricity decarbonisation targets are more onerous than other sectors, this instrument cannot be relied upon to deliver the power sector specific emissions reduction trajectory to zero emissions by 2035. Given the UK ETS is outside the scope of REMA, it is therefore generally accepted that the UK ETS will need to continue to be supplemented with additional GB power sector specific carbon-related policies.

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Low Carbon Centralised Procurement

Alongside the UK ETS, the CfD scheme is proving to be a crucial mechanism for delivering investment in low carbon capacity and carbon emissions reductions. While CfD auctions have brought forward investment in some 30GW of capacity since the scheme's introduction in 2014 (delivery by 2030), there exist some challenges.

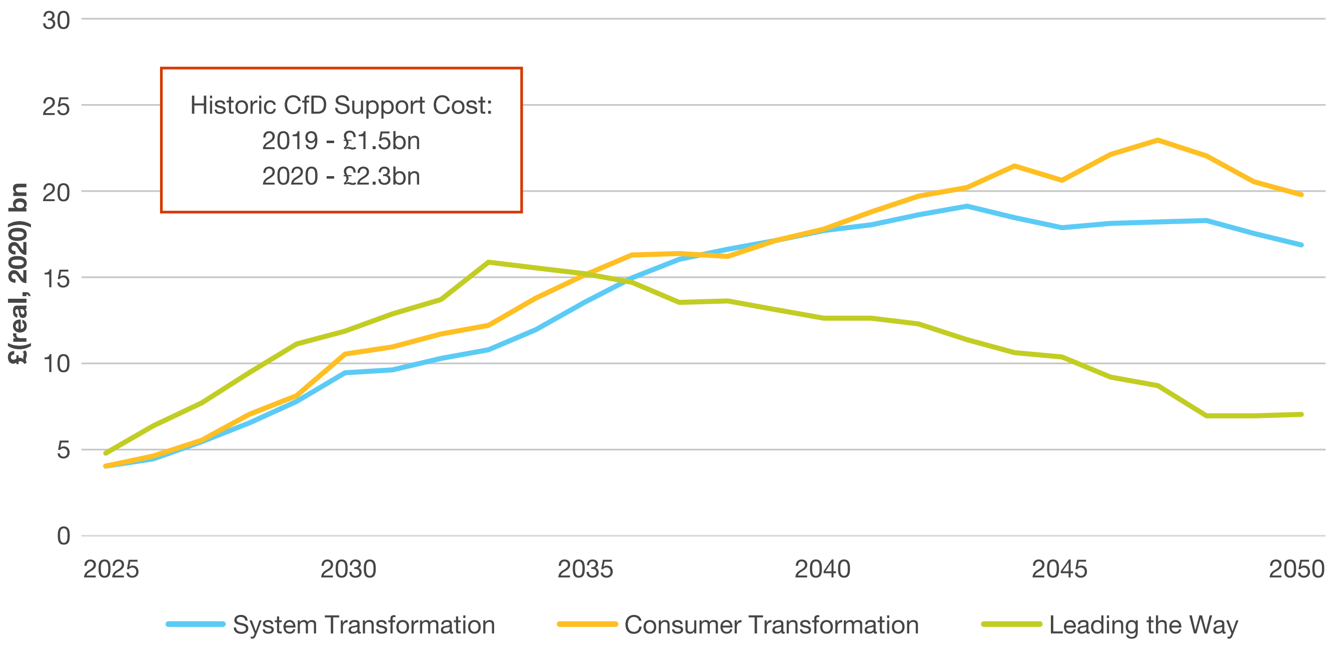
The procurement through CfD auctions is limited by administered prices and budget caps. This means the capacity volume procured might fall short of what is needed to achieve the offshore wind capacity target and the Government's carbon objectives. The recent AR5 auction allocated 3.4GW for delivery years 2025-8, which leaves a considerable shortfall against the Net Zero compliant Future Energy Scenarios (FES). In the absence of carbon constraints on the demand-side, this shortfall is unlikely to be met through the merchant route. This means auctions, which are now annual, should target larger capacity volumes, which may require changes to the auction methodology.

As subsidies paid through the CfD scheme are based on the differential between the strike price and the reference price (linked to the day-ahead wholesale price), the budget caps are based on projections of day-ahead wholesale market prices. Future prices, however, will be impacted by the extent to which market reforms unlock system flexibility, particularly on the demand side, which depends on reform decisions for both wholesale and retail markets. Figure 7 illustrates how support costs vary for different FES scenarios, with lower costs under Leading the Way scenario due to more demand-side flexibility, including through electrolysis.

Another challenge is the uncertainty regarding the contribution that demand-led contracting (e.g. PPAs) can provide and the need to ensure it is encouraged rather than crowded out. The CfD auctions combined with demand-led contracting must deliver adequate capacity volumes at the needed rate, which may require facilitating intervention, explained in more detail later.

Building capacity, however, does not guarantee achievement of carbon objectives as much depends on system flexibility, considering the carbon intensity of resources that provide flexibility and the extent to which renewable generation is efficiently used. This depends on market design reforms.

Figure 10. Total Contract for Difference support (£bn): All scenarios



Source: ESO NZMR Phase 2

At a minimum, this policy, regulatory and market reform uncertainty, will impact revenues for low carbon assets during their "merchant tail" period. Ongoing regulatory risk creates two major impacts: in addition to making the long-term investment signals more unpredictable, it also increases the option value of a 'wait and see' approach, resulting in delays in investments even where there is a prevailing price signal that suggests an investment would be economic.

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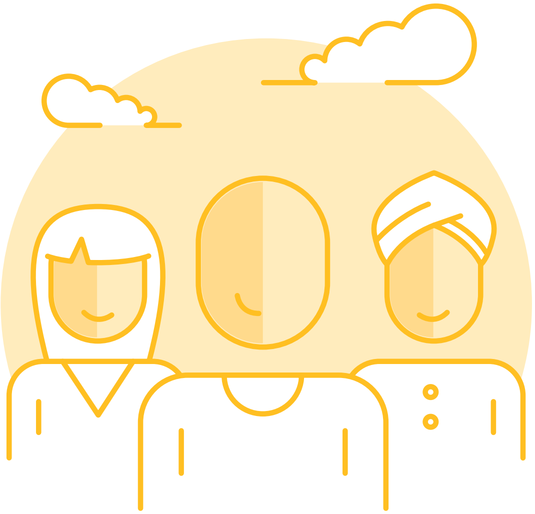
Low Carbon Centralised Procurement

Meanwhile, both the US and the European Commission have recently unveiled billion-dollar investment plans to boost renewables to meet their net zero goals. The US' Inflation Reduction Act (IRA), passed in August 2022, includes tax incentives, grants, loans and other measures to support low carbon energy development, manufacturing and supply chains. As highlighted by a recent RenewableUK report (2023), the US now provides a $120m subsidy to the supply chain of each new 1GW wind farm, and in total it is estimated that the IRA will drive $370bn into the modernisation of the US energy system.

The identification, in the original 2010 Electricity Market Reform consultation document (DECC, 2010, p.31), of policy uncertainty as one of the key reasons for insufficient investment signals, therefore remains as valid as ever. There is a credible danger that the perceived risk-reward balance in the current GB regulatory environment may not be conducive to attracting high volumes of relatively low cost finance. Stable policy intervention to de-risk investment is therefore necessary to deliver low carbon assets at unprecedented pace and scale to meet our net zero ambitions.



2 The longer term vision should be to evolve centralised procurement towards demand-led investment facilitated by retail market reform

In our NZMR Phase 2 assessment framework, we set out a range of options for determining the net zero asset mix. The options were presented on a spectrum, spanning market-led determination of the asset mix, with greater inter-tech competition, and decentralised decision making. Whilst neither the extent of competition between technologies, nor the extent of decentralisation are identified explicitly as distinguishing features in REMA's presentation of market design options, they are instead identified as cross-cutting themes in Chapter 4 of the consultation document. The two are closely linked in that greater decentralisation of procurement is commonly associated with greater competition between technologies. It is important to note however, that centralised procurement can accommodate a range of levels of competition between technologies.

There are some compelling arguments to why decentralising the procurement responsibility should theoretically produce more efficient outcomes relative to centralised contracting. Decentralised approaches are inherently more compatible with the new paradigm of modulating demand to meet unpredictable supply, rather than vice-versa. They can more easily incorporate both supply and demand-side technologies, meaning they are more likely to support electricity demand reduction and flexible demand. A market-wide, technology-neutral mechanism driving demand for low carbon power and energy services could stimulate greater consumer choice and evolving business models.

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Low Carbon Centralised Procurement

Given the potential advantages of a decentralised approach, we therefore believe that reforms should begin to pave the way in the direction of longer-term, demand-led investment driven through markets to deliver more efficient outcomes. Figure 11 details some interim measures to facilitate longer-term decentralisation of low carbon procurement in conjunction with retail reforms.

Figure 11. Measures to facilitate longer-term decentralisation of low carbon procurement

Reforms should begin to pave the way in the direction of longer-term, demand-led investment driven through markets to deliver more efficient outcomes. The possibility to mobilise innovative demand-side solutions that capitalise on the digitalisation opportunity is much greater through transparent, accessible and tech-neutral markets with accurate price signals. To pave the way in this direction, the focus of policy in the interim period should be on two key enablers.

The first of these, retail market reforms that remove barriers and align/strengthen incentives for retailers/consumers, is out of scope of REMA.

The second is policy to introduce measures to stimulate demand-led contracting and greater consumer choice. We elaborate some potential options here:

Elective Participation with carbon constraint

On the demand-side, there already exists in the UK strong demand among corporates for low carbon power procured through power purchase agreements (PPAs) that should not be discouraged, especially if their decarbonisation ambition exceeds that of government (Stet, 2022). Expanded use of a Low Carbon Mechanism to derisk investment at large-scale could shrink PPA markets, considering the CfD scheme is already contributing to the existing declining liquidity in forward markets (Energy UK, 2022). This would make it more difficult to eventually phase out subsidies that could be possible once the power system has decarbonised and wholesale market reforms have been implemented.

Corporates purchasing PPAs typically remain exposed to CfD settlement payments, which could mean they are 'over-hedged' and this could act as a disincentive to contract for more low carbon power. As part of Baringa's work supporting Phase 4 of NZMR, they set out how a form of opt-out of government led contracting could be introduced, coined as "Elective Participation". Certain customers would be allowed to opt out of the centralised low carbon support scheme (and therefore be exempt from levies) but would need to demonstrate they are meeting their decarbonisation objectives through their own contracting, which would require monitoring, reporting and verification (MRV). More detail on this option is included in 'Appendix 2'.

Demand-side visibility of granular carbon signals and access to verified low carbon products/services

Research shows that consumers of all sizes can be motivated as much or even more by reducing carbon as by cost savings. Providing more granular temporal carbon signals could therefore drive a lot of behaviour change, helping supply-demand matching of low carbon resources by settlement period.

Globally, there is evidence of growing support for, and demand for, more granular timestamped energy certificates, including from large corporates, cities, trade associations, research/expert/regulatory institutions, and governments. For example, EnergyTag, a non-profit standards body, has developed a framework and standard for the issuance of time-stamped energy certificates, various Energy Attributes Certificate (EAC) registries are developing the capability to add a timestamp to EACs, and projects are underway to develop market rules/changes for application (Afry, Granular Energy and Nord Pool, 2023).

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Unfortunately, there are two major impediments to a decentralised approach in the current market climate. Firstly, it would unavoidably introduce counterparty risk for generators with suppliers/offtakers that may not be sufficiently credit worthy. Although financial regulation may be able to address this to some extent, counterparty robustness remains a key concern of such model given the well-documented recent history of retailer failures.

More fundamentally, a structural mismatch exists between supply and demand side appetites for long-term fixed price contracts. Most mass low carbon power is looking for a fixed price to be able to finance it while suppliers are generally limited in their ability to take on long term fixed price commitments due to the dynamic retail price cap. The asymmetrical exposure between generators and retailers has a debilitating impact on forward markets and would be equally problematic for a decentralised low carbon obligation. Indeed, the ability to hedge electricity price risk over a longer period was identified as a prerequisite to the envisaged eventual withdrawal of CfD support prior to EMR implementation (DECC, 2012).

Other disadvantages of a decentralised approach include that it is more challenging to implement, and less able to drive and coordinate investment in large infrastructure. For example, it may be less compatible with a Strategic Spatial Energy Plan (SSEP), as recommended by the Electricity Network Commissioner's August 2023 report on accelerating the delivery of UK electricity transmission infrastructure.

Though this approach would deliver benefits from greater inter-tech competition, it does not provide the opportunity to reduce inframarginal rent for consumers, which is seen as an attractive feature of other approaches, particularly considering the current challenging economic conditions. Unlike centralised procurement where different pots can be used to reduce inframarginal rent, a decentralised approach would treat all technology types in the same manner, such that the full market value of the carbon externality would be factored into electricity prices.

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Low Carbon Centralised Procurement

We conclude that full reliance on decentralised market-based discovery of an optimal net zero asset mix is not viable in the short-term. We agree with DESNZ's decision, confirmed in its REMA Consultation Response publication earlier this year, not to pursue a Supplier Obligation as the main mechanism for driving low carbon investment in the short-term. We should continue with government-led contracting whilst at the same time exploring steps that support demand-led investment, subject to these being efficiently implementable alongside centralised procurement.

Options not shortlisted

We have ruled out two options following a shortlisting exercise (see our response to the REMA consultation for more information)

Equivalent Firm Power Auctions
While we believe generators should be more exposed to market signals so they contribute to reducing system costs, forcing renewables to bear the system costs of their variability on an individual project basis is highly inefficient from a whole system perspective and could be more efficiently achieved though the electricity markets and centralised scheduling/dispatch.

Dutch subsidy scheme (i.e. payment for carbon avoided)
We identified that this scheme is complex with consequent risks and it should be more economically efficient to mitigate the externality of carbon emissions more directly.

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Low Carbon Centralised Procurement

3 There are greater challenges in determining optimal procurement levels under centralised procurement compared to demand-led contracting

Any form of centralised procurement necessitates central decision-making of how much low carbon generation to procure, and under what timescales, based on assumptions on overall demand. As we embark on a period of extreme transformation in our energy system, we face uncertainties on the evolution of electricity demand. This is illustrated by the range of outcomes portrayed by the ESO's Future Energy Scenarios. In this context, it is critical to ensure symmetrical treatment of demand and supply in policy measures. There must also be coherency in the assumptions across key decision-making processes for resource procurement and network reinforcement.

In addition to the overall demand level itself, there are also difficulties in forecasting the demand profile as we evolve towards an increasingly more technically flexible and economically elastic demand side.

A final challenge with centralised procurement is that target procurement levels are generally based on capacity, rather than deliverable generation. As highlighted in Phase 3 of NZMR, the inability to deliver centrally procured CfD generation due to transmission constraints is an increasingly worrying impediment to the achievement of our net zero targets. Under the status quo market design, the negative impact on the consumer is compounded, as not only is a significant proportion of the low carbon support wasted, additional costs are incurred to curtail the relevant generators in the Balancing Mechanism, explained in more detail in the next chapter.

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Low Carbon Centralised Procurement

Greater inter-tech competition is desirable as technologies mature but involves a trade-off against higher inframarginal rent.

Further to the decision to procure centrally, and appropriate procurement levels, is the decision on how much to directly control the low carbon asset mix – in other words, the extent of competition.

Our NZMR Phase 2 assessment framework identified three categories of approach for this; bespoke arrangements, inter-tech low carbon competition and lastly a broad-based mechanism. These options are broadly represented in Figure 12 with greater competition to the right, and less to the left.

The existing CfD regime in the form of AR5 inhabits a large range of this spectrum, with the various pots including examples of technology-specific support and inter-tech competition.

The Government has since committed bespoke support for nascent technologies such as advanced nuclear power and carbon capture, usage and storage (CCUS). The REMA consultation also confirmed its focus on mature technologies, stating that it will not consider immature “first of a kind” technologies (e.g. power generation with CCUS).

Bespoke arrangements as defined in our framework also include any technology-specific support, such as any CfD technology group (“pot”) which is exclusive to a single technology. CfD Allocation Round 4 had three such examples; a dedicated group, Pot 3, for offshore wind, and also applied minima contributions from both tidal stream and floating offshore wind for Pot 2 (BEIS, 2021a). In contrast, Allocation Round 5 features far less bespoke technology support (DESNZ, 2023a). AR5 did not have a dedicated pot for offshore wind (subsumed into Pot 1 with onshore wind and solar), nor a Pot 2 minimum for floating offshore wind. Its only remaining bespoke technology support was the minimum that still applies to tidal stream within Pot 2.

However, this recently changed again with the recent announcement[3] to reintroduce a dedicated pot for offshore wind in the next round, AR6, as offshore wind failed to win any contracts in AR5. This means the benefits of inter-tech competition between wind and solar will be lost but the diverging costs between these technologies would mean high inframarginal rent for solar assets if offshore wind assets were to win contracts in the same auction as solar assets. The divergence is significant as the maximum strike price has been increased by 66% for offshore wind.

Figure 12. Determining the technology mix spectrum

Government dominant in choosing technology mix ⟵	⟷	⟶ *Market dominant in choosing technology mix*
Technology specific support for new and existing low carbon	**Inter low carbon technology competition for support where possible**	**Broad investment mechanism for all technologies**
Market chooses between:		
…projects within technology classes	*…some low carbon technologies and new and existing capacity*	*…all technologies (low carbon and thermal)*
CfD AR5 (Delivery Years 2025-28) Pot 2 Tidal Stream Minimum Ringfenced Budget	CfD AR5 (Delivery Years 2025-28) Pot 1 (incl. Fixed Offshore Wind, Onshore, Solar PV) Pot 2 (incl. Floating Offshore, Tidal, Wave)	Stated ambition of Phases 3 & 4 of original EMR CfD policy

Source: Frontier Economics/ DESNZ

3 See: gov.uk/government/news/boost-for-offshore-wind-as-government-raises-maximum-prices-in-renewable-energy-auction

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Low Carbon Centralised Procurement

4 **For inter-tech competition to be effective, the support mechanism must ensure incentives align with market signals (which themselves should be cost reflective and free of distortions).**

The EMR vision implicitly recognised that the relative importance of the advantages and disadvantages of inter-tech competition would evolve over the relevant time horizon. On one hand, the learning effects driving cost reductions in less mature technologies will decline over time. However, as our system requirements become more complex, it will be more difficult to determine the most efficient solutions administratively.

Establishing a level-playing field for economically efficient inter-tech auctions should also take account of implicit subsidies or indirect support (including externalities such as carbon dioxide emissions or network congestion which remain unpriced), as well as implicit risk transfers (e.g. value of revenue stabilisation provided through a support scheme) and whole system costs and benefits (e.g. capacity adequacy costs, balancing costs, network costs) (Frontier, 2018). This is particularly important in relation to achieving more symmetrical treatment of the supply-side and demand-side, including for energy efficiency (Sandys and Pownall, 2020).

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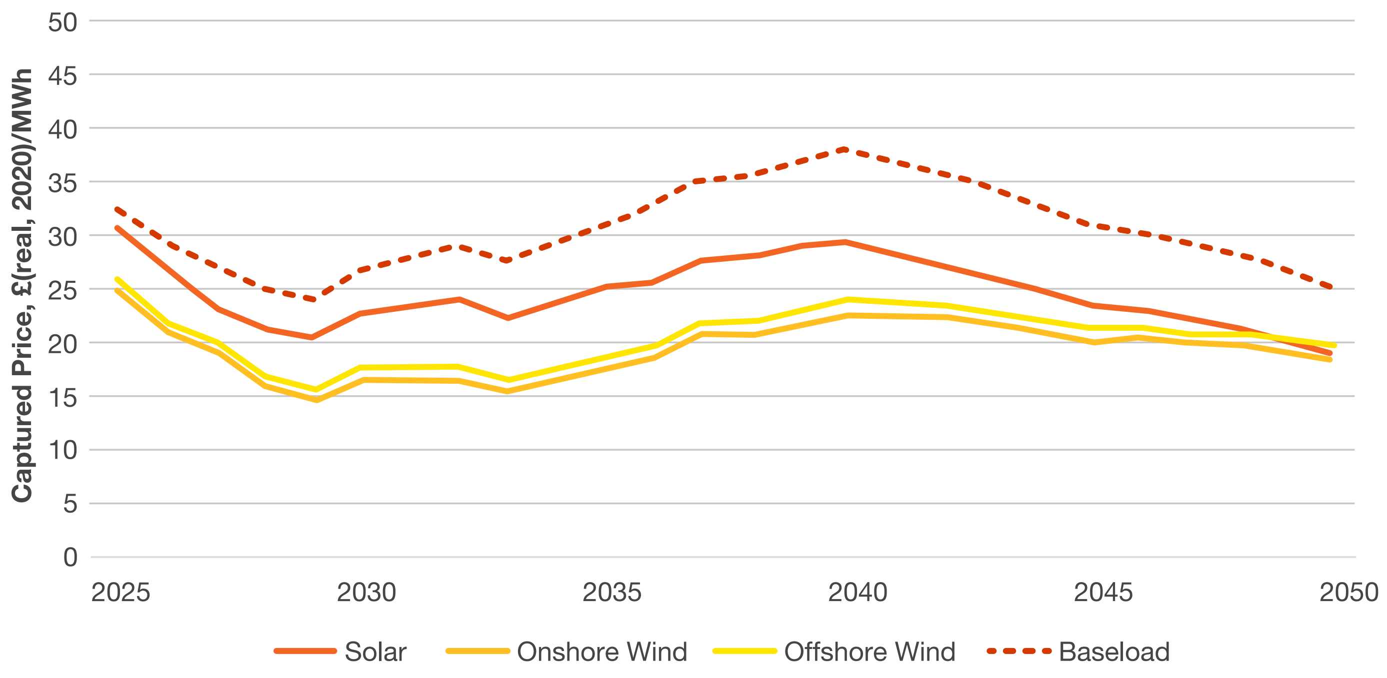
Low Carbon Centralised Procurement

The problems arising from a combination of inter-tech competition with a low carbon support mechanism that does not reflect whole system costs and benefits can be illustrated via the example of the CfD AR5 Pot 1, in which solar PV projects (>5MW) will be competing against both onshore (>5MW) and offshore wind projects. Under the current CfD design, each MWh procured from this pot will be renumerated equally. However, as demonstrated by Figure 13 to the right, the average value of the procured energy, as measured by their equivalent merchant capture prices, varies dramatically between the technologies. Solar PV's captured prices are likely to be far higher than those for either onshore or offshore wind, as solar generation does not occur in the lowest periods of demand (overnight) and is not correlated with the high periods of wind which drive the baseload prices down. Modelling conducted by consultants LCP on behalf of ESO during NZMR Phase 2, based on the FES Leading the Way scenario, suggests solar captured prices may be consistently below the baseload price by £4/MWh by 2030 and between £5-10/MWh from 2035 onwards.

Figure 13. Illustrative capture prices for CfD AR5 Pot 1 technologies (based on FES 2021, Leading the Way)



Source: LCP (ESO NZMR Phase 2 analysis)

This effect is illustrated for FES Leading the Way but is even more pronounced for the other scenarios, as these have less solar capacity so lower levels of solar capture price cannibalisation.

All other things being equal, the lack of exposure to the temporal variations in wholesale prices is therefore likely to lead to over-procurement of wind relative to solar. Furthermore, greater consumer costs will then also result from the need to curtail more wind at times of low demand. A key conclusion is therefore that with more inter-tech competition, it is becoming even more important that the low carbon incentive mechanism respects wholesale prices.

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Low Carbon Support Mechanism

As we concluded in the previous section, the greater the extent of inter-tech competition, the more important it becomes for the low carbon support mechanism to align with market signals. This section focuses on the support mechanism via which low carbon assets are renumerated, and specifically the extent to it exposes assets to the wholesale price and aligns generators' incentives with market signals.

The existing CfD scheme has been successful in securing ~30GW of low carbon capacity to be delivered by 2030, two thirds of which is offshore wind generation (LCCC, 2023). The scheme has enabled technology learning and commercialisation of wind and solar technologies, driving down costs through competitive auctions. By providing a hedge against price risk, the scheme dramatically reduces financing costs[4] and brings forward targeted capacity volumes in large, high capex infrastructure.

However, as set out in this section, there is mounting evidence that the current CfD design disincentivises assets from delivering added system value and also has a distorting impact on wider markets.

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4 According to Blyth et al 2021, the current CfD scheme lowers WACC by around 4% relative to merchant investment with full exposure to prices.

Case for Change in Low Carbon Support Mechanism

The distortive impacts of the current CfD scheme can be categorised into:

1 **Operational distortions** – short-run perverse commercial incentives for CfD contracted assets to operate in a manner distinct from equivalent merchant assets and is not aligned with system needs, which can be either:

a) First-order – as a direct result of fundamental CfD design; or

b) Second-order – as an indirect result of further policy amendments designed to correct first-order distortions.

2 **Investment distortions** – long-run commercial incentives for CfD contracted assets to invest in a manner that differs from equivalent merchant assets and is not aligned with system needs.

1a First-order operational distortions

CfD design causes wholesale and balancing market distortions

As the current CfD is linked to output, supported generators are incentivised to ignore low wholesale price signals and to continue to oversupply in the day ahead and intraday markets, as they would otherwise lose CfD revenue. They will continue to bid negative in the short-term wholesale markets until their costs exceed the subsidy. This contributes to "price cannibalisation" and wholesale market price suppression, which in turn increases levies. Figure 10 earlier in this chapter illustrates how levies could increase if current policy and market arrangements remain unchanged.

This distortion has been partly addressed via the negative pricing rule in AR4 and future auctions, where revenues are not topped up for any periods in which prices are negative.[5] However, supported generators can still bid into the DA market below their marginal cost down to zero and the negative pricing rule has not been applied to the intraday market or the Balancing Mechanism (BM). Furthermore, as the attempt to fix this problem was essentially a workaround, rather than a solution that addressed the fundamental root causes, it has introduced a second order distortion, the "herding effect", which we explore in more detail later.

5 In previous auction rounds (i.e. AR 1-3), the rule is no compensation for power exported to the grid if day-ahead prices are negative for six hours or more.

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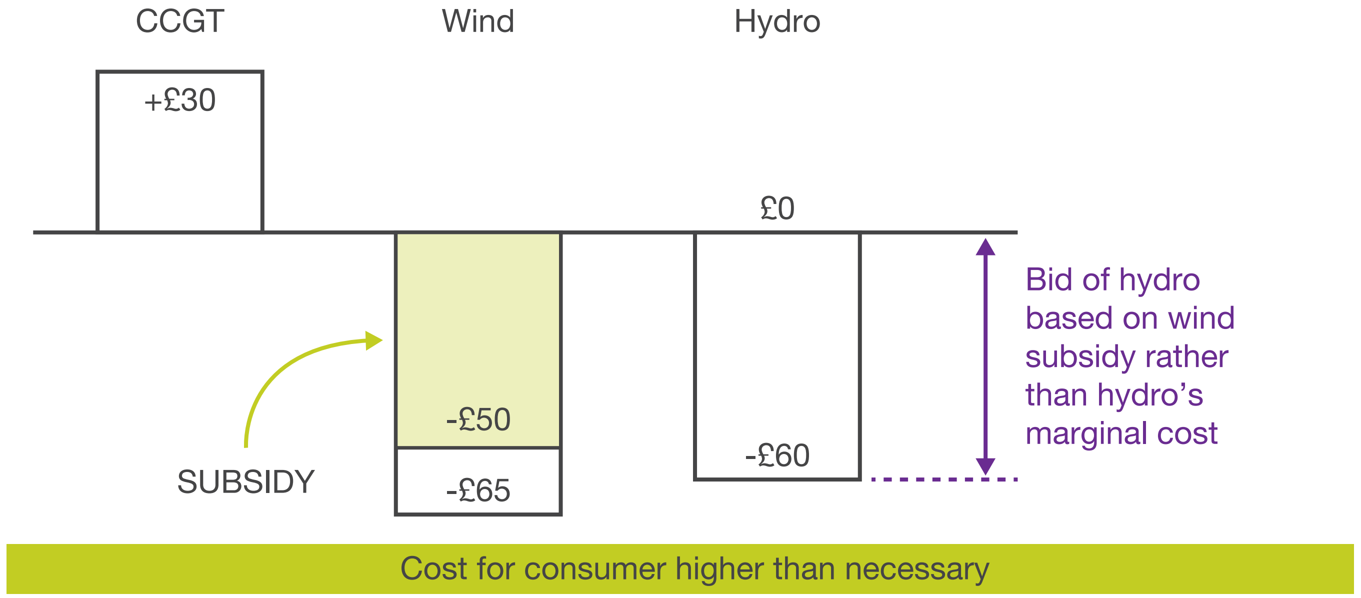
Case for Change in Low Carbon Support Mechanism

Furthermore, reward based on ex-post output relative to a reference price, means that not only are CfD assets factoring lost subsidy costs into their BM bid prices, but non-subsidised participants are also adjusting their bid prices to similar levels, as would be expected in competitive markets. For example, as illustrated below, for the case of a hydro plant bidding in the BM, the plant is incentivised to adjust its bid price to a level that will just undercut the subsidised generator.

Figure 14. Example of bidding behaviour in the BM



There is a weak incentive to provide ancillary services

As illustrated in Figure 15, intermittent renewable generation such as wind and solar are technically capable of providing ancillary services, for which markets are generally open or are opening up to these technologies. Unfortunately, provision of ancillary services by these variable renewable generators is currently very limited. Indeed not all ancillary service markets are fully accessible yet, but for those that are accessible, renewable generators are typically not participating.

Figure 15. The technical capability of wind and solar to provide ancillary services

Service	Wind			Solar		
	Tech capable	Access	Providing	Tech capable	Access	Providing
Response	✔	✔	✖	✔	✔	✖
Positive reserve	✔	✖	✖	✔	✖	✖
Stability	✔	✔ (In future)	✖	✔	✔ (In future)	✖
Reactive	✔	✔	✔	✔	✔	✔
Local constraint market/MW Dispatch	✔	✔	✖	✔	✔	✖

CfD design is currently discouraging provision of ancillary services from CfD-contracted assets because the ancillary services' value would need to exceed the CfD strike price in order for the generator to be incentised to provide the service. Generators usually have to choose between providing energy or ancillary services as they cannot provide both at the same time and must have enough headroom to increase output for providing some ancillary services. As generators will only receive subsidy if they generate, they will always aim to maximise their output and so there will be no headroom to provide ancillary services.

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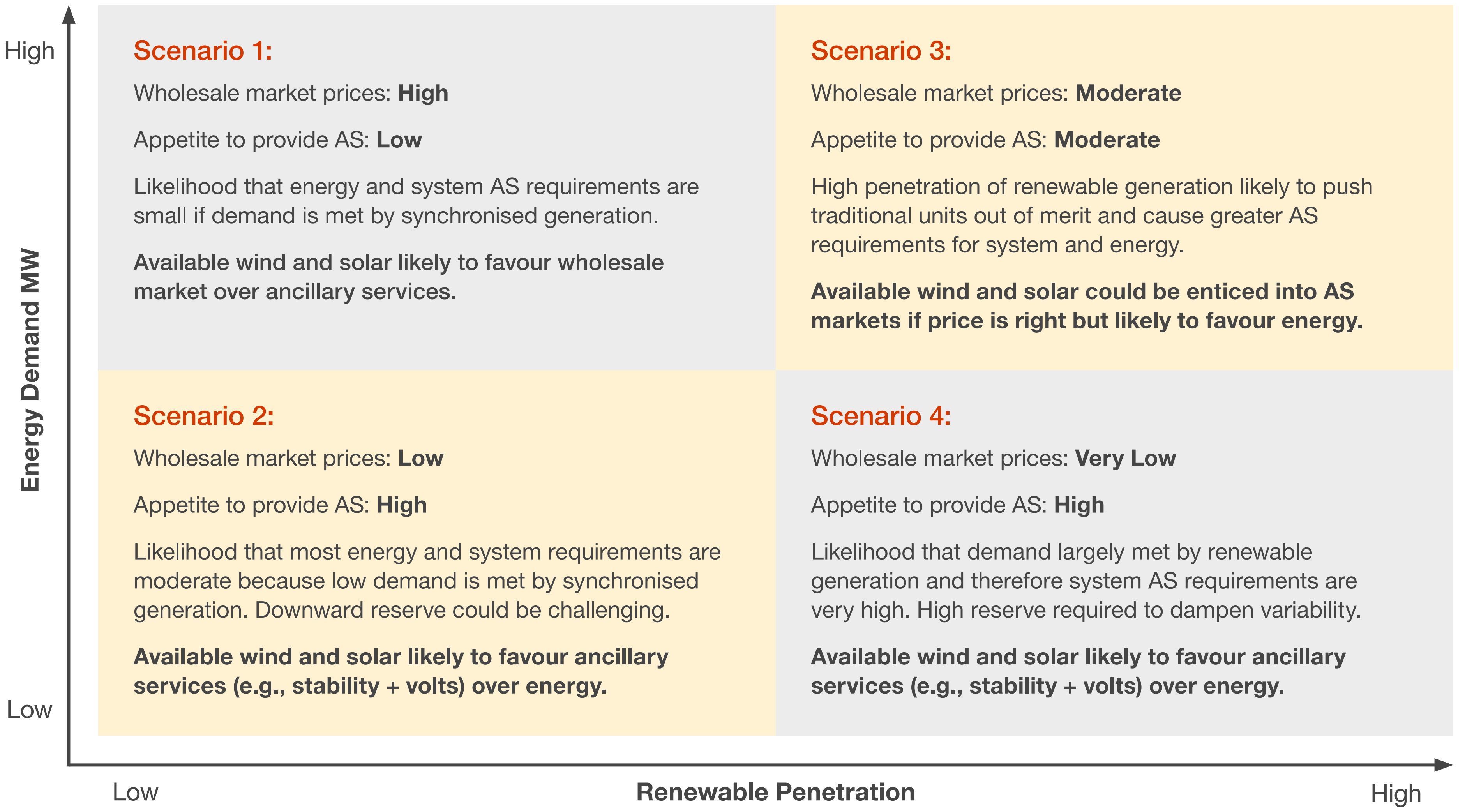
Case for Change in Low Carbon Support Mechanism

This current reality is in stark contrast to a market design that incentivises generators to respond to prices, providing whatever is most valuable to the system at any moment in time. Analysis by Aurora (2018) indicates that 'revenue-stacking' under current market arrangements (as per time of study, 2018) could increase revenues for offshore wind in the range of 9-14% versus a merchant wholesale-only model, (even after accounting for the loss of wholesale revenue required to provide power in the BM and ancillary service markets).

If generators' incentives would be aligned with market signals, their appetite to provide AS and to invest in technology capable of doing so would depend on wholesale energy prices and the share of renewables in the power mix, as illustrated in Figure 16. In a future with locational energy pricing, the different scenarios could co-exist across the geography of the GB market at any moment in time with variation in energy prices and resource distribution.

Figure 16. Scenarios for provision of ancillary services by renewable generators



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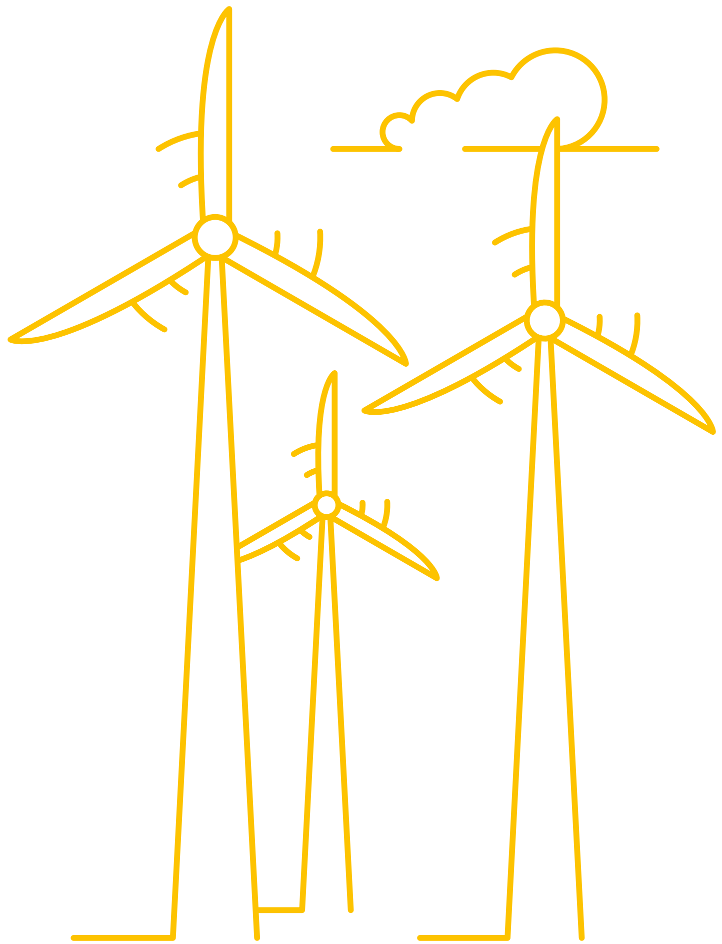
Case for Change in Low Carbon Support Mechanism

CfD design negates incentive to align scheduling of maintenance with system needs

Merchant assets are automatically incentivised to schedule maintenance at times of expected low power prices, in order to optimise their revenues. The lack of exposure to wholesale price in the current CfD design removes this incentive, since all output will be rewarded at the same strike price regardless of when it is generated. This means that maintenance schedules may coincide with periods of system scarcity particularly as revenues above the strike price are returned to consumers and load factors are more likely to be low in times of scarcity.

With the introduction of the negative pricing rule, assets could theoretically be incentivised to schedule maintenance in periods where they expect not to receive difference payments due to negative prices. In practice however, the unpredictability and relatively short length of these periods may nullify this incentive and for wind turbines, it may not be physically possible to conduct maintenance during very windy conditions.

Lack of price exposure in CfD design reduces benefits of multiple technologies competing in the same pots.
As explained in the previous section, lack of exposure to wholesale prices in the CfD design dilutes the benefits of greater inter-tech competition. Significant differences in the temporal output profile of different supported technologies, and hence the value of the procured generation as reflected in varying average merchant capture prices, are not taken into account in the auction process.



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Case for Change in Low Carbon Support Mechanism

1b Second-order operational distortions

CfD design increases the overall ancillary services requirements

While growth in renewables is expected to increase the demand for some ancillary services, there are elements of the CfD design that inadvertently increase overall ancillary services requirements, such as:

- The lack of response to low day-ahead and intraday prices (see above) driven by CfD supported generators results in the need for increased ESO turn-down instructions in the Balancing Mechanism, as there is an artificially high volume of intermittent plant on the system.
- As illustrated in Figure 17, when prices reach zero or turn negative, due to the negative pricing rule, CfD supported generators exhibit cliff edge behaviour as they all stop generating at the same time. If there is insufficient liquidity in the intraday market, ESO must resolve the steep drop in output in the BM. In contrast, if generators were exposed to market prices, they would dispatch under a wider range of prices reflecting their marginal costs. Furthermore, with locational energy prices there would likely be greater variation in applicable reference prices and hence greater variation in generator response, reducing the aggregate impact.

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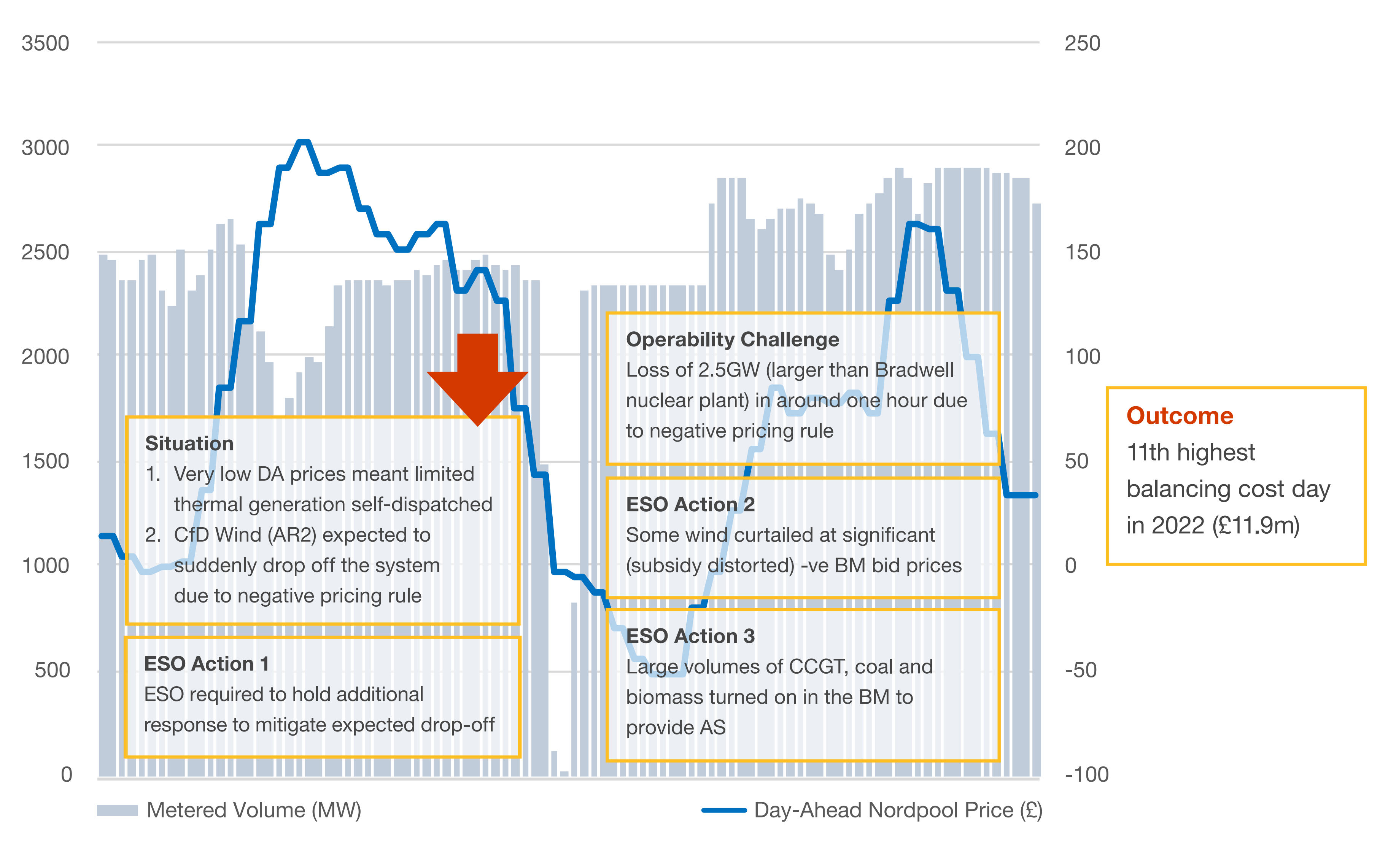
Case for Change in Low Carbon Support Mechanism

Figure 17. Aggregate output of wind generating units de-synched over 28/ 29 December due to negative prices[6]



This graphic illustrates how the herding effect, very negative Balancing Mechanism bids and limited ancillary services provision from renewables can contribute to higher balancing costs.

Situation: On the 28th and 29th December 2022, day ahead prices were very low, which meant limited thermal generation self-dispatched. It also meant that with six hours of continuous day-ahead negative CfD reference prices, the negative pricing rule kicked in for multiple AR2 offshore wind units which dropped off the system at exactly the same time.[7]

Operability Challenge: This presented ESO with an operability challenge similar to losing a nuclear plant, with the potential loss of 2.5GW in a short space of time.

ESO took several actions to manage this:

1) procurement of additional response to mitigate the dramatic drop off;

2) curtailment of some wind at very negative, distorted BM bid prices; and

3) the turn on of thermal plant in the BM to provide ancillary services.

6 Day-Ahead Nordpool Price shown as proxy to CfD intermittent reference price.
7 Note that these units did not remain desynchronised for the entire DA negative pricing period as within-day prices subsequently recovered, making generation profitable without difference payments.

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Case for Change in Low Carbon Support Mechanism

2 Investment distortions

Supported generators can earn more than their strike price to be constrained off via the BM - perverse incentive to locate where high likelihood of curtailment.

When the day-ahead wholesale market price exceeds the strike price, generators must return revenues to consumers via LCCC but only if they have self-dispatched. However, if a generator elects not to self- dispatch but is subsequently dispatched in the BM, it can keep the revenues earned through the BM offer acceptances. Generators typically incorporate lost CfD subsidy into their BM bids but bids can sometimes reflect more than the lost subsidy. As day ahead prices were frequently higher than strike prices over 2022, this interaction resulted in net excess consumer cost of approximately £91.7m over 2022 based on ESO modelling.[8]

Recent analysis by Aurora (2023) has highlighted that rising costs for renewable generators, including higher interest rates and metal prices, are leading developers to find revenue optimising opportunities. Such strategies include optimised siting to actively target additional revenue by solving energy imbalances due to grid congestion via BM system actions.

The fact that generators can earn more than their strike price to be constrained off in the BM creates a perverse incentive to locate where there is a high probability of curtailment. Indeed, recent analysis from Aurora (2023) suggests that this results in a premium of 23-28% due to (what Aurora refers to as) "Technology-specific Balancing Mechanism System Locational Value" for onshore wind assets in the North of Scotland relative to National Average.

Reduced incentive to invest in ancillary services capability

In future, growth in renewables will drive up the demand for ancillary services. If renewables do not provide these services, they must be provided by other resources that could be much more expensive. As illustrated in Figure 18, generators' revenues from the ancillary services markets are uncertain and will depend on the wholesale energy value relative to the ancillary service value, which could vary dynamically by location if locational energy pricing introduced. Demand for ancillary services and renewable generators' incentives to provide ancillary services will likely be greatest in locations with high concentration of installed renewable capacity. This is because in such locations when some congestion exists in the transmission network, there is relatively greater likelihood that the value of an ancillary service will be greater than the locational energy price.

The current CfD scheme design discourages providers from installing the relevant equipment to provide ancillary services. For example, if wind / storage developers voluntarily choose to install grid-forming technology to deliver inertia and short circuit level (stability), project capex would increase. If the operational distortion described above is unresolved, they would remain disincentivised to utilise this stability capability, such that this additional capital expenditure could not be recovered.

Case for change conclusion

In conclusion, several unintended consequences of current CfD design in combination result in supported generators driving up system costs they are not exposed to. These distortions are impacting both short-run operational decision making and long-run investment. The fundamental root cause of the majority of issues described above is the lack of wholesale price exposure caused by the existing CfD design. Introducing some price exposure or aligning generators' incentives to market signals could address the issues that will be problematic and costly if they remain unaddressed. The following section evaluates various alternatives.

8 ESO modelled all CfD units across 2022 using accepted bid prices, volumes, strike prices and day ahead prices.

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Low Carbon Support Mechanism Options

This section describes the main options for the design of Low Carbon Support Mechanisms, which are then analysed in detail in the following section.

The representation of centralised procurement options for mass low carbon in the REMA consultation differentiates primarily on the basis of payment structure, specifically whether payment is coupled with output, with further sub-categorisation based on the level of price exposure.

Payment coupled with output

Existing CfD scheme[9]

This is a financial hedge on existing output guaranteeing a pre-determined 'strike price' for every MWh generated. If the Intermittent Market Reference Price (IMRP), based on the day-ahead price, is below this, they receive a top-up. If it is above, they must pay back into the scheme. In each round the strike price is set through a competitive auction and contracts are awarded for 15 years. Under latest rules applied in all contracts since Allocation Round 4, which opened in December 2021, generators will not receive difference payments when the IMRP is negative (DESNZ, 2022a).

CfD with Price Cap & Floor

Instead of a single strike price, generators are guaranteed a maximum and minimum price per MWh output, with market exposure within that range. Above the cap, all revenues (i.e. hard cap) or a proportion of the excess revenue (i.e. 'soft' cap, to align generators' incentives with markets) could be paid back and the floor could similarly be 'hard' or 'soft'.

Evolved CfD

Under a zonal or nodal wholesale market the reference price used to calculate difference payments, known as the Intermittent Market Reference Price (IMRP), would need to be changed to either the respective locational index or a national average system price. For the purposes of the assessment, Baringa assumed the former. This would equalise the level of difference payments across locations, effectively removing the long-run locational signal. Therefore, it is assumed that some degree of locational differentiation may be included in the Evolved CfD approach.

Other

Decreasing contract duration to increase the corresponding "merchant tail"

This option would increase total price exposure over the lifetime of the asset by reducing the number of years covered by the support mechanism.

Changes to the reference price methodology

Changes could be introduced to set CfD top-up payments for an entire week, for example, with opportunities for profit and loss if assets do better than average in the market for the week.

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9 For more detail, see LCCC website

Low Carbon Support Mechanism Options

This section describes the main options for the design of Low Carbon Support Mechanisms, which are then analysed in detail in the following section.

The representation of centralised procurement options for mass low carbon in the REMA consultation differentiates primarily on the basis of payment structure, specifically whether payment is coupled with output, with further sub-categorisation based on the level of price exposure.

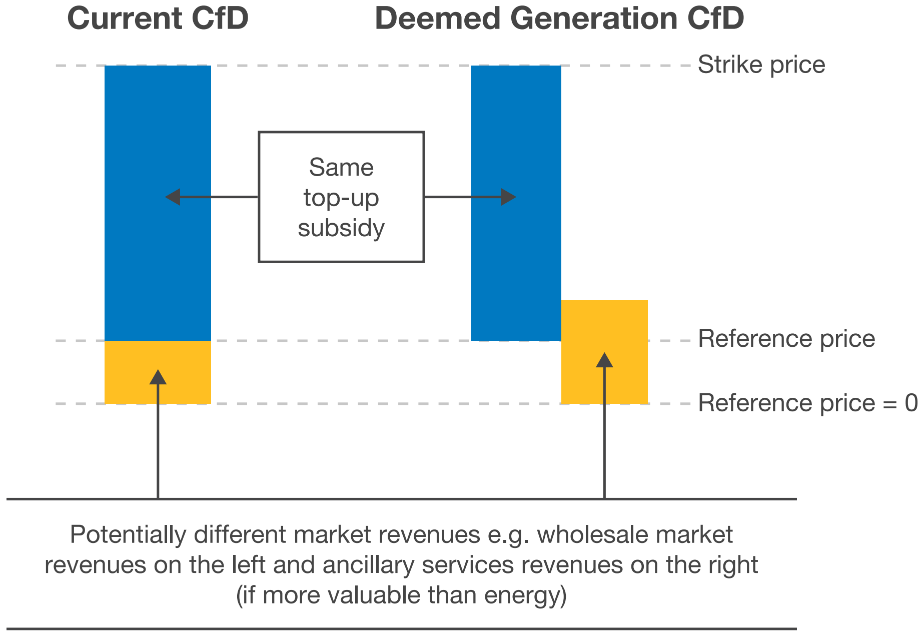
Payment decoupled from output

Financial CfD

Under this model, the CfD counterparty makes a fixed monthly payment to the asset. In turn, the low carbon generator pays the counterparty the spot market revenue of that month. These revenues are not the actual revenues of any given asset, but the revenues of a reference asset – benchmark revenues.

Deemed Generation CfD

Generators are paid based on their potential to generate in a particular period, rather than their actual generation output. Generators would not have to export energy to receive the CfD top-up payment (based on the product of the reference price and the deemed generation (MWh) in this model) as they do currently but if they do not participate in any market (i.e. energy, ancillary services, BM) then they do not collect market revenues in addition to the top-up. This aims to remove dispatch distortions by decoupling support from (their own) output.



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Low Carbon Support Mechanism Options

This section describes the main options for the design of Low Carbon Support Mechanisms, which are then analysed in detail in the following section.

The representation of centralised procurement options for mass low carbon in the REMA consultation differentiates primarily on the basis of payment structure, specifically whether payment is coupled with output, with further sub-categorisation based on the level of price exposure.

Partially decoupled from output

Revenue Cap & Floor

This option is categorised within the REMA consultation as "decoupled from output". However, since revenue within the floor to cap envelope (and beyond for the soft cap or soft floor) is largely a product of both volume and price, it could more accurately be described as "partially decoupled from output with price exposure".

Generators would be guaranteed a minimum revenue or "floor" in each relevant Cap & Floor period (e.g. per year). They would compete in the full range of markets (capacity, wholesale, balancing, ancillary services), and if they do not meet their minimum revenue, then they would be topped up to the floor revenue. Two key variants of this option are whether or not the cap and floor are 'hard' (i.e. fully binding) or 'soft'. Under the latter, a proportion of the excess revenue above the cap is paid back (i.e. 'soft' cap) and the floor could similarly be 'soft'. There would be no transfer to consumers if revenue was between the floor and cap.

An established precedent exists for this option in the application of a revenue cap and floor regime for interconnectors, where it was selected in order to "strike a balance between commercial incentives and appropriate risk mitigation for project developers" (Ofgem, 2016). The applicability of the precedent may be reasonably challenged given the very different nature of business model for low carbon generation compared to interconnectors, which are a flexible asset. In addition to supporting mass low carbon power, this option could be applied to low carbon flexibility. There are also similarities between this option and the soft cap on additional revenues imposed under the Electricity Generator Levy (HMRC, 2023).

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Summary Assessment of Low Carbon Support Mechanism

The table below summarises Baringa's scoring for the six options (following shortlisting) for the Low Carbon Support Mechanism against the ten assessment criteria described in the Methodology section.

● ◕ ◑ ◔ ○ ◔ ◑ ◕ ●

Deterioration on status quo | Neutral | Improvement on status quo

	Existing CfD	Evolved CfD	CfD + Price Cap/Floor	Revenue Cap/Floor	Deemed CfD	Financial Wind CfD
Value for Money	○	○	◔	◑	◔	◑
Energy security and system operability	○	○	○	○	○	○
Decarbonisation	○	○	◔	◔	◔	◔
Competition	○	◔	◔	◔	◔	○
Challenge to implement	○	○	◔	◑	◑	◑
Investor confidence	○	○	◔	◔	○	◔
Full chain flexibility	○	○	◔	◑	◑	◔
Whole system	○	○	◑	◑	◑	◑
Adaptability	○	○	◔	◔	○	◔
Consumer fairness	○	○	○	○	○	○
Total	○	◔	◑	◑	◔	◑
Total - prioritise VfM, Security and Decarb	○	◔	◑	◕	◑	◑

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Summary Assessment of Low Carbon Support Mechanism

The Baringa assessment suggests that several alternative options for the low carbon support mechanism are likely to perform better than the status quo design. However, amongst the four most promising options identified, none stands out as being clearly superior across all criteria. The Revenue Cap and Floor appears to be the best option when the trilemma criteria are prioritised. It offers significant improvement on several criteria, notably value for money, full chain flexibility and whole system considerations, but would be challenging to implement and closer scrutiny of variants with hard or soft cap and floor is necessary.

The Baringa analysis suggests that either the Deemed CfD and Financial Wind CfD options would also offer significant improvement performance against several criteria. Lastly, the CfD with price cap and floor offers a more modest improvement to the existing design across several criteria but would be less challenging to implement than the alternatives.

To complement the Baringa analysis, we have analysed the extent to which the four best options it identifies could mitigate the issues we identified in the case for change. Figure 18 summarises the results of this analysis. In order to present a fair comparison against the status quo, in addition to the options above we have also included an incremental improvement to the current CfD based on a potential BSC Modification Proposal P462 that would partially address some of the issues identified.[10]

Figure 18. Comparison of low carbon mechanism support options and capability to address issues

Key: not addressed, partially addressed, addressed

CATEGORY OF DISTORTION FROM CURRENT CFD	OPTION ISSUE	Current CfD with code BSC Modification Proposal P462	CfD with Price Cap & Floor*	Revenue C&F (i.e. annual revenues with soft cap and soft floor)	Deemed generation CfD	Financial CfD
1st order operational distortions	Day Ahead and intraday market distortions	Same	If within C&F If outside C&F	If within C&F If outside C&F	Bid based on marginal cost	Bid based on marginal cost
1st order operational distortions	Balancing Mechanism distortion	Subsidies removed from bids	Largely the same	If within C&F If outside C&F	Bid based on marginal cost	Bid based on marginal cost
1st order operational distortions	Ancillary service disincentive	Same	Depends on floor level, incentives largely remain misaligned.	If within C&F If outside C&F	Bid based on marginal cost	Bid based on marginal cost
1st order operational distortions	Scheduling maintenance & being available in times of scarcity	Same	Largely the same	If not expected to reach cap If cap reached	If revenues not capped If revenues capped	Strong incentive
2nd order operational distortions from fixes to 1st order distortions	Herding behaviour	Same	Same, assuming negative pricing rule applied	If long time period (annual)	If –ve pricing rule removed If rule stays	If -ve pricing rule removed If rule stays
Investment distortions	AS capability incentive	Same	Largely the same	If within C&F If outside C&F		

* Assumptions: applied per settlement period; hard price floor and hard price cap

10 BSC Modification Proposal P462 would effectively remove BM bidding distortions, importantly for existing supported generators as well as future generators, but it would not address other market and system integration issues that could be addressed through the alternatives.

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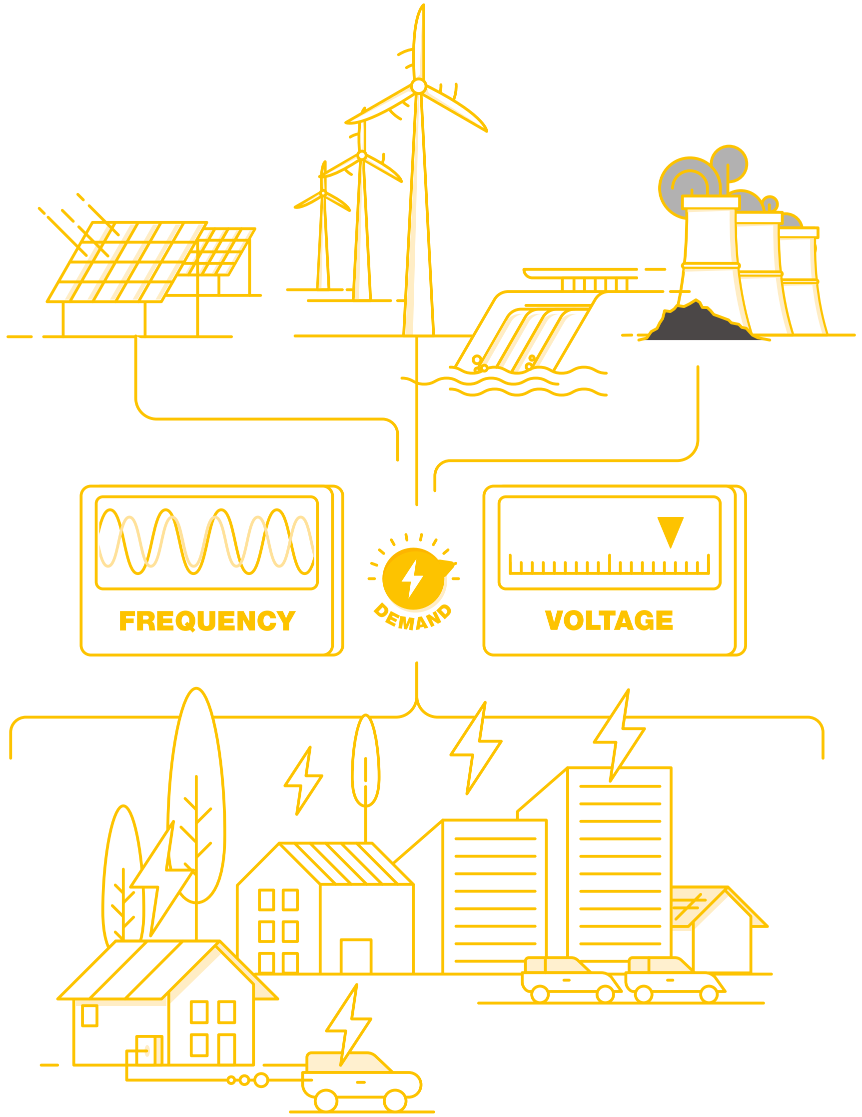
Summary Assessment of Low Carbon Support Mechanism

Figure 18 shows that of the four best options as identified by Baringa, the CfD with Price Cap and Floor would be the least effective at addressing the distortions in both operational and investment behaviour. The three remaining options – a soft Revenue C&F, Deemed Generation CfD and Financial CfD all have potential to remove several of the distortions, subject to the specific design. Notably, the effectiveness of the Revenue C&F will depend heavily on revenues being within the floor to cap window.

There is a direct trade off between cost of capital and effectively addressing distortions for options involving direct price exposure such as Revenue C&F. While price exposure increases incentives to support the system, it also increases price risk and therefore the cost of capital. This can be avoided through the deeming approach, depending on design. Risk could be reduced by ensuring the deemed output closely matches that of the actual plant and because incentives are now aligned with price signals, there would be no need to apply the negative pricing rule. For the Deemed Generation CfD, the downside risk could potentially be lower compared to the current CfD; for the Financial CfD, downside risk is expected to be higher given the requirement to return spot market revenues. The extent to which the support mechanism can lower WACC is an important consideration when evaluating how market reforms and policies should be packaged together, as discussed further in the 'Packaging' chapter.

In conclusion, taking both Baringa's assessment and our complementary analysis on distortion resolution, the leading options for an enduring reform of low carbon mechanism, when considered in isolation, would be either a Revenue C&F or a benchmark revenue model (Deemed Generation CfD or Financial CfD).

Consideration, however, needs to be given to the interaction with reforms in other areas of holistic market design, most notably future wholesale market design. For example, the extent to which central dispatch could resolve some of the distortions discussed above merits further analysis. As a CfD scheme under central dispatch could facilitate co-optimisation of energy and reserves, it would be possible for the wholesale market operator to allocate CfD-contracted assets between energy and ancillary service in a way that maximises social welfare. We refer elsewhere to the proposed BSC Modification Proposal P462 to decouple CfD payments from Balancing Mechanism settlements. Central Dispatch markets use complex bid formats that may also facilitate avoidance of similar distortions in intraday markets, although this would significantly depend on the specific dispatch mechanism design implemented. A holistic assessment also must consider the overall impact and appetite for simultaneous major reforms in different elements of the overall market design. Such considerations for the wider market reform package and sequencing are explored further in the 'Packaging' chapter.



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System Adequacy

Investment Policy Assessment

ESO

Introduction

The Capacity Market was introduced to bring forward investment and address market failures.

When GB's electricity markets were first privatised, "capacity payments" were provided to generators for being available without any need to generate. These payments were abolished as the UK moved to a self-dispatch energy-only market that came with the implementation of the New Electricity Trading Arrangements (NETA, 2001) in England and Wales that were later expanded to Scotland (BETTA, 2005).

In late 2011, a Government White Paper identified a gap between demand and generation of potentially 20GW as a result of retiring coal, oil, and nuclear plant (DECC, 2011b). It was thought that the self-dispatch market would not be able to bring forward the needed investment in time due to two market failures:

Market failure 1:

Reliability is a public good. "Customers cannot choose their desired level of reliability… and consumers do not respond to real-time changes in the wholesale price. It can therefore be expected that capacity providers will not provide the socially optimal level of reliability in the absence of intervention."

Market failure 2:

The 'missing money' problem. "An energy-only market may fail to send the correct market signals to ensure optimal security of supply and to enable investors to obtain project finance for building new capacity. Current wholesale energy prices do not rise high enough to reflect the value of additional capacity at times of scarcity."

In response to the case for change and based on the rationale of these market failures, the Government brought in the Electricity Market Reform (EMR) policy, which included the Capacity Market (CM) intended to address capacity adequacy issues. The CM is designed to procure enough capacity to meet the single largest modelled demand peak for a cold winter evening. This capacity is estimated 4 years out for the T-4 auction and then updated for the T-1 auction a year before the delivery period. The majority of capacity is procured four years out (i.e T-4) and most of the capacity receives 1-year contracts with a small share of the revenues flowing to new capacity through longer term 15-year contracts.

Since its introduction in 2014, the CM has run 16 auctions that have increased margins, reduced LOLE[1] and provided revenue certainty for capacity providers.

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1 In GB, the reliability standard is the Loss of Load Expectation (LOLE), which is currently set at 3 hours.

Case for Change in System Adequacy

Our analysis shows there are fundamental limits to the CM’s ability to address future system security challenges, particularly with respect to targeting and fairly rewarding accurate response to bidirectional, long duration stress events throughout the year. We present four key conclusions outlining the case for change in the system adequacy support mechanism:

1. **The nature of system stress is changing**
2. **Market failures are becoming invalid with mobilisation of demand-side elasticity**
3. **High carbon retirements are required that could negatively impact reliability**
4. **Penalties for non-delivery are weak**

1 The nature of system stress is changing

System needs are increasingly bidirectional

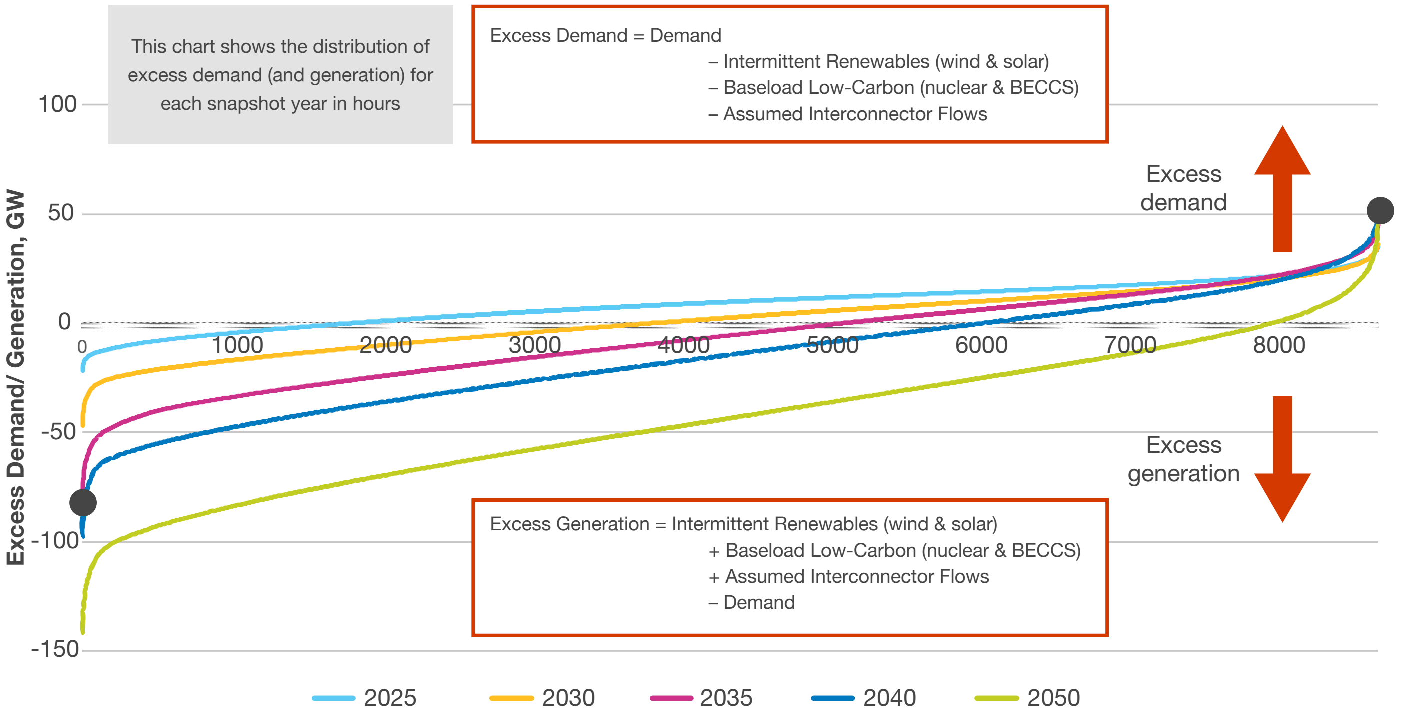
Stress events will increasingly involve generation excess as well as scarcity, during which times there needs to be enough capacity with the right capabilities to ensure system security is maintained and curtailment is economically optimal.

In the Leading the Way Scenario, which assumes a system predominantly based on weather-dependent renewables, excess generation could exist in 50% of hours by 2030 and 92% by 2050. In times of excess generation, ESO must “bid off” generation at a significant cost to the consumer, which is set to increase going forward.

More efficient flexibility is needed to manage this system security challenge more effectively, which requires:

- Efficient investment in 2-way and demand-side resources as well as supply side resources, requiring fair treatment of resources
- Temporally and locationally granular energy price signals that accurately reflect the state of the system and inform these resources precisely when, where and how to dispatch

Figure 19. Demand/Generation Distribution (GW): Leading the Way



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Case for Change in System Adequacy

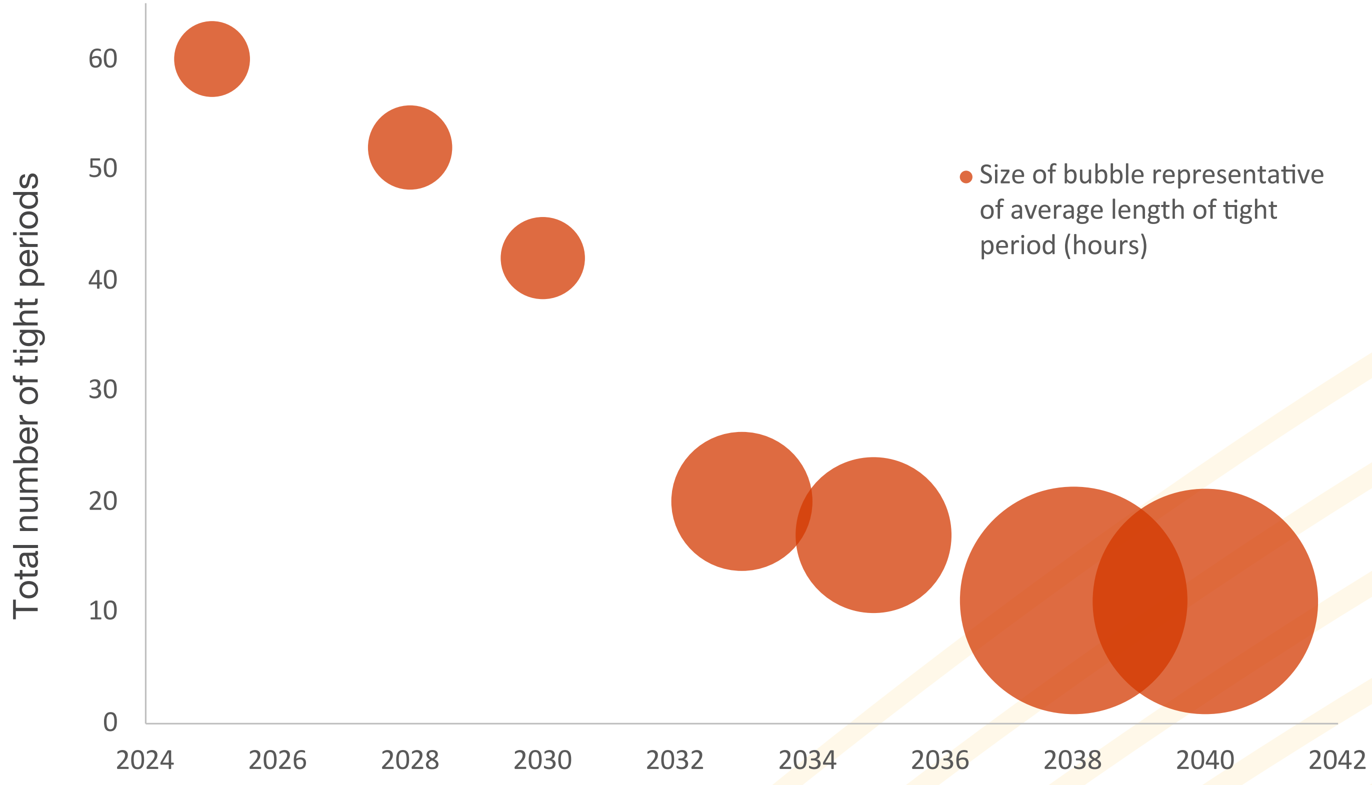
The CM is not designed for a bidirectional system as it was established to ensure sufficient capacity during times of specific stress, that is, time periods when margins are low and generators would need to respond. It would be challenging to adapt the CM to address this, requiring an additional auction or mechanism.

From 2030s - rare, long duration stress events

Through the 2020s, stress events are expected to be short-duration and costly as they will be impacted by network constraints. In time, this will be alleviated with network build delivery, locational energy pricing implementation and flexibility mobilisation. From the 2030s, however, tight periods will be less exclusively driven by winter peak and distributed throughout the year, often lasting for days/weeks rather than hours, and are potentially extremely expensive to serve. New modelling approaches and metrics[2] will likely be required to assess risks to adequacy in a fully decarbonised power system (Afry, 2022).

The current CM will be challenged to meet the emerging system stress conditions as it is designed to meet winter peak. It would need to be redesigned to accommodate the different possibilities for periods of highest system stress and there would be implications for de-rating factors given their variation through different seasons.

Figure 20. Frequency and duration of tight periods over time*



Source: NG ESO

* Tight periods are periods where energy prices reach VoLL.

2 Great Britain currently has a statutory reliability standard of 3 hours loss of load expectation (LOLE).

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The CM does not reward the duration of response and it would be challenging to achieve this efficiently compared to wholesale energy prices. The potential remedy of optimising the CM to target long duration response would require definition of long duration response and decisions on volume requirements and de-rating factors. Such targeted procurement could face challenges relating to liquidity issues and unfair treatment of flexibility resources. Using a market-wide mechanism to target such resource for very rare events could also be very costly.

2 Market failures are becoming invalid with mobilisation of demand-side elasticity

Market failure 1 – Reliability is a public good

The justification that "reliability is a public good" was based on the premise that consumers do not respond to real-time changes in the wholesale price. Whilst this assumption was reasonable ten years ago, it will become increasingly inaccurate. Previously untapped demand elasticity is being unlocked via a powerful combination of technical enablers (e.g. smart metering) and improved power price exposure (e.g. time-of-use-tariffs). Under the intended net zero paradigm of electricity demand increasingly fluctuating to meet intermittent supply, rather than vice-versa, this market failure will become obsolete. It is critical that any continued intervention to ensure system adequacy facilitates demand elasticity.

The extent and speed of change in unlocking demand-side elasticity, however, will depend on reforms that:

a) **restore missing money to the wholesale energy market**. This is covered to a large extent in our Phase 3 report, which concludes more granular locational energy price signals are needed and that support policies should be designed to respect the integrity of wholesale energy price signals (see next section on 'Market failure 2').

b) **ensure incentives reach consumers via suppliers/ retailers so they can provide accurate response**. This is partly considered in this report as decentralised policy can drive demand-led contracting more strongly (see 'Low Carbon Centralised Procurement') and the CM design results in unfair treatment of demand-side resources.

While the CM rules have been changed since its introduction in order to facilitate participation of demand-side resources, there are some structural features that hamper demand-side response that will be highly challenging and perhaps not possible to address:

- **Ex-ante derating factors:** Derating factors are used to reflect the probable availability of asset types, impacting the reward that can be received via the CM. These factors need constant updating to accommodate innovation and cannot accommodate business model innovation, which could particularly impact demand-side energy services.

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Case for Change in System Adequacy

- **Illiquid secondary trading:** Secondary trading of CM contracts is technically possible but in reality trading is constrained with low liquidity due to the fact that the CM contracts are physical, based on derating factors. Strengthened penalties could improve liquidity, but trading potential of physical contracts will always be limited compared to financial agreements that do not impose physical restrictions. Financial contracts would provide greater opportunity for any resource to contribute during a system stress event.
- **Consumers treated all the same:** The CM methodology is based on a static demand and blanket VOLL for demand. Yet, as demand response is increasingly enabled through reforms to market arrangements, consumers are becoming more able to express their willingness to pay and so a wider and more dynamic VOLL range will develop across demand. It will be difficult to adapt the CM to accommodate this change.

Increasing demand-side flexibility also means it is becoming more difficult to accurately define the capacity that needs to be procured to meet system needs as demand becomes a larger proportion of flexible capacity. Previously, the capacity volume to procure was based on demand that was largely inflexible and capacity was dispatchable with known load factors.

Policy driving electrification of demand will drive growth in demand but much of this is potentially flexible and policy will also drive greater energy efficiency. Errors in demand estimates for the T-4 auction could increase.

Market failure 2 – The missing money problem

The root of the 'missing money' market failure lies in wholesale market design. Our Phase 3 recommendations to introduce locational energy pricing would go a considerable way to efficiently restoring missing money for flexibility providers. Part of the missing value in power markets also relates to the carbon emissions market failure, and policy will need to address this.

The capacity market has the effect of dampening scarcity prices in the wholesale market by providing additional revenue to generators, allowing them to bid more aggressively into the wholesale market closer to their marginal cost (Mastropieri et al, 2017). The lower wholesale energy prices resulting from the CM creates missing money for flexibility providers that do not have access to the CM.

As the CM is the reason for this market distortion, changes to the CM cannot directly remove this distortion, and can only treat the symptoms rather than the cause.

To effectively address the various market failures and distortions in a way that delivers greater value for money for consumers, it will be necessary to carefully coordinate market design and policy reforms. With more missing money restored following implementation of market design reforms, any capacity renumeration mechanism would play a different role.

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3 High carbon retirements are required that could negatively impact reliability

Between now and 2035, timely retirements of unabated gas plant are necessary in order to align with decarbonisation objectives for the power sector. There are two key issues relating to this:

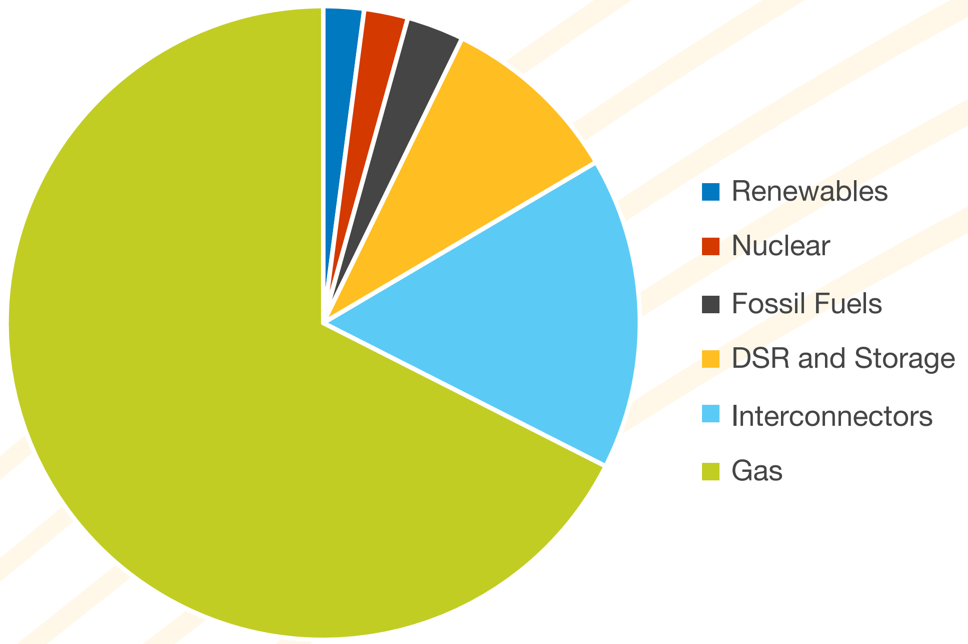
Carbon policy mechanisms applicable to the power sector are insufficient

The CM has procured significant levels of flexibility but the majority of this has been high carbon CCGT plant, as illustrated in Figure 21. This is largely because the carbon policy for the power sector is not yet aligned with the Government's 2035 objective to decarbonise power. The lack of granularity for the carbon signal strongly impacts revenues (or missing money) for low carbon flexible resources. Going forward, the carbon emissions reduction trajectory for the power sector needs to be aligned with the 2035 decarbonisation target through market reforms and policy mechanisms.

Risk of untimely or disorderly exit of high carbon plant

Unabated gas plant can be expected to retire as load factors reduce and as low carbon alternatives become competitive. When an uneconomic plant exits the market, load factors of remaining plant and wholesale prices can be expected to increase. There is a risk, however, especially given the lack of locational granularity in wholesale energy prices, that several assets will retire at the same time, potentially reducing margins below the reliability standard. However, the CM will play an important role in determining which plant stay in the market. There is also a risk that low carbon alternatives do not become competitive fast enough and that we may need to rely on fossil fuelled assets in emergencies. Near or from 2035, this may therefore require intervention to retain plant for such emergencies while managing carbon emissions.

Figure 21. T-4 Auction results (2026/27) breakdown of CM agreements awarded by fuel type



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Case for Change in System Adequacy

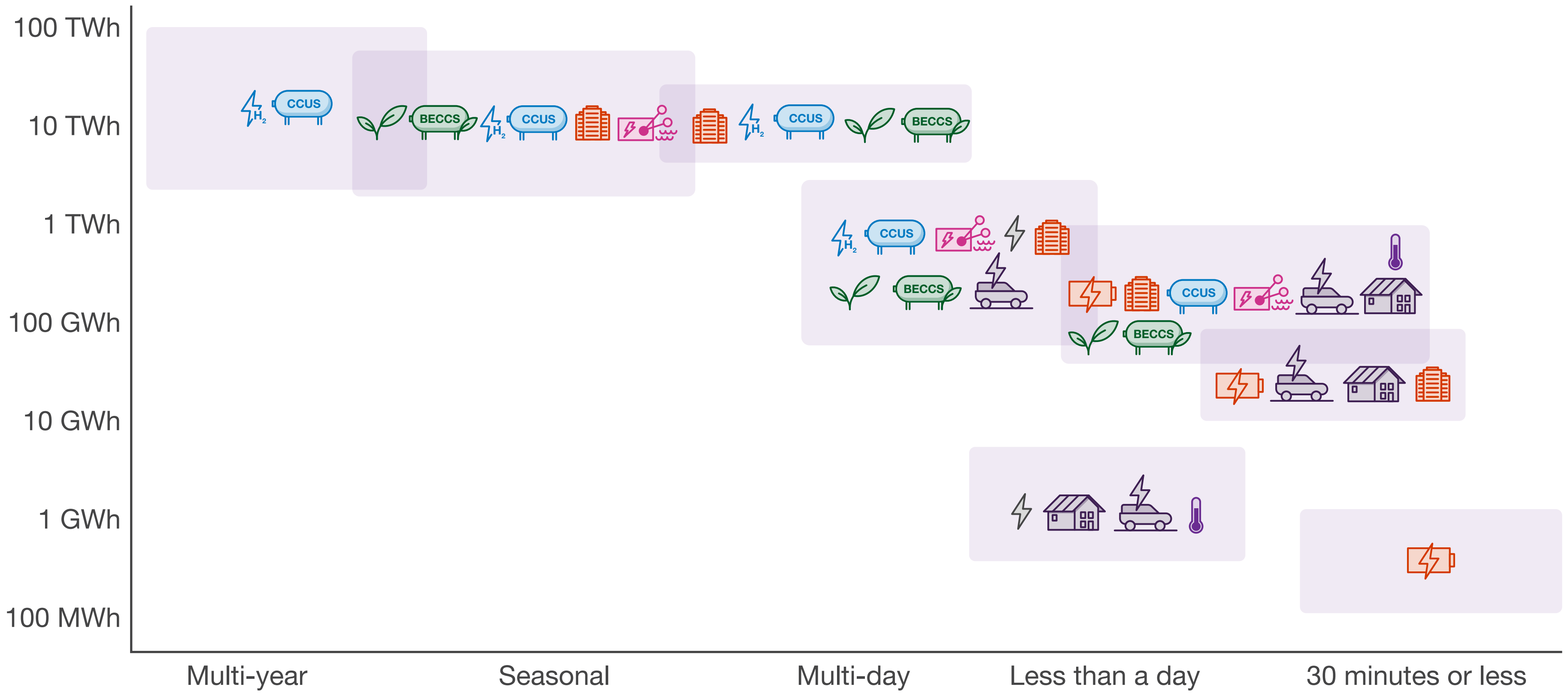
Given that reform of the UK ETS is out of REMA's scope, the main options to reduce carbon emissions from dispatchable resources include the following, which are discussed in more detail below:

- Innovation/investment policy to bring forward firm and flexible low carbon alternatives where market failures exist
- Intervention to reduce the carbon intensity of any capacity procurement though the exit of high carbon capacity may need to be managed
- Improved coordination of demand with available weather-dependent generation

Innovation/investment support for low carbon dispatchable capacity

Figure 22 shows the flexibility requirements for a fully decarbonised power system in 2050 and indicates asset types that could provide them, including for the longer multiyear and seasonal timeframes. The type of assets that will be able to serve prolonged events includes: turbines fuelled by hydrogen, gas/CCUS or bioenergy; pumped hydro; compressed or liquid air; and interconnectors.

Figure 22. Different levels and types of energy system flexibility for the year of 2050



Key: **Electricity storage:** Batteries Long Duration Energy Storage (e.g. pumped hydro, compressed air, liquid air) **Interconnectors:** **Electrolysis:** **Thermal energy storage:** **Oil:** **Demand Side Response:** Domestic or industrial EV flexibility **Gas storage:** Natural gas Natural gas with CCUS Hydrogen **Bioenergy:** Biomass BECCS

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Case for Change in System Adequacy

The majority of these assets are already being supported by bespoke derisking and innovation support, as set out in the table. Inefficient overlap between the innovation support schemes and any capacity support scheme needs to be avoided to ensure consumers receive value for money.

A key question is whether these support schemes are intended to be innovation policy only, to support technology learning and cost reduction for commercialisation, and/or whether they are derisking policies to facilitate low cost financing, as for mass low carbon power (e.g. wind, solar).

Figure 23. Bespoke support schemes for low carbon, flexible capacity

Asset Type	Support Mechanism	Description
Interconnector	Revenue cap and floor (Ofgem, Unknown date)	Revenues are subject to minimum and maximum levels. Below the ‘floor’ customers top-up revenues, and earnings above the ‘cap’ are returned in whole or in part to customers.
Gas/CCUS	Dispatchable Power Agreement (DPA) (BEIS, 2022b)	£20 billion earmarked for CCUS in the UK. Support will be provided through the Dispatchable Power Agreement business model (HMT, 2023). This is a private law contract between a carbon emitting electricity generator and the Government which sets out the terms for capturing and storing carbon and the compensation which the generator will receive in return.
Hydrogen Turbines	No support for green hydrogen-powered turbines but support in place for production of green hydrogen: Hydrogen Production Business Model / Net Zero Hydrogen Fund (DESNZ, 2023c)	Support for production of clean hydrogen focusing initially on electrolytic & Carbon Capture Usage Storage (CCUS)-enabled hydrogen production (DESNZ, 2023c). Target of 5GW of hydrogen production capacity by 2030 (BEIS, 2021b)
BECCS	Dual CfD combining CfD and DPA for CCUS (DESNZ, 2022b)	Business model support in development. Dual CfD involves separate strike prices for electricity generation and negative emissions.
LDES Support	To be decided	Government has committed to “put in place an appropriate policy framework by 2024 to enable investment in large scale long duration electricity storage (LLES), with the goal of deploying sufficient storage capacity to balance the overall system.”

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Case for Change in System Adequacy

Intervention to reduce the carbon intensity of procured capacity and manage exit

An Emissions Performance Standard (EPS) is already applied to the Capacity Market targeting coal. While the EPS could be tightened to target unabated gas, a gradual approach is needed to ensure reliability during the transition and to give time for investment in low carbon capacity to take place, for supply chains to develop and for consumer response to be activated.

To align with the power sector's 2035 decarbonisation trajectory, the Government has already applied an emissions intensity limit to new build plants from October 2034.

Improved coordination of demand with available weather-dependent generation

The introduction of locational energy pricing, as recommended by our Phase 3 NZMR report, will improve the coordination of supply and demand near real-time, reducing curtailment of renewable generation and redispatch of the market post gate-closure. The coordination of supply and demand could be further enhanced through more granular carbon signals that are visible to consumers, either through verified carbon tracking and certificate trading (e.g. see Figure 8 and Afry, Granular Energy and Nordpool, 2023) and/or through the granular allocation of the costs associated with support schemes (i.e. CfDs, CM, schemes in Table 23). The Government is exploring the latter through its Alternative Energy Market Innovation Programme (BEIS, 2022c).

4 Penalties for non-delivery are weak

Penalties for non-delivery are weak and not linked to short-term wholesale prices[3] and resources have limited opportunity to trade out of their position near real-time, such that if a stress event were to occur, there is a considerable risk that some resources would not be able to deliver.

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3 The penalty rate is set at 1/24th of the relevant auction clearing price, adjusted for inflation. Penalties are capped at 200% of a provider's monthly capacity revenues and an annual cap of 100% of annual revenues.

System Adequacy Options

The Government is considering reforms to the Capacity Market and alternatives as part of its Ten-Year Review and the REMA process. We have therefore adapted the scope of our assessment to include most[4] of the options considered under REMA and have added the additional options of Reverse Reliability Option (RRO) and the Scarcity Adder. In its consultation document, the Government leans towards retaining a centrally led intervention (i.e. Capacity Renumeration Mechanism (CRM)) that naturally fall into three categories:

Capacity value in energy price

Scarcity Adder

Scarcity price adders provide additional remuneration for electricity by providing top-up revenue to assets that are available to generate via a wholesale price premium. The value of the top-up increases as the supply margin decreases, reflecting the added value of availability at times of limited supply, including reserves. The objective of scarcity adders is to strengthen the forward-looking investment signal to assets that can be available at times of system stress, in addition to that already provided via wholesale and other balancing markets.

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4 Equivalent power auctions is an option that we did not take forward to full assessment, following our shortlisting exercise (see our response to the Government's consultation here).

System Adequacy Options

The Government is considering reforms to the Capacity Market and alternatives as part of its Ten-Year Review and the REMA process. We have therefore adapted the scope of our assessment to include most[4] of the options considered under REMA and have added the additional options of Reverse Reliability Option (RRO) and the Scarcity Adder. In its consultation document, the Government leans towards retaining a centrally led intervention (i.e. Capacity Renumeration Mechanism (CRM)) that naturally fall into three categories:

Revenue additional to energy price

CRO and optimising variants

Centralised Reliability Options (CRO): An instrument that has similar objectives and features to the Capacity Market but involves financial rather than physical contracts. The mechanism is based on the concept of a 'call option contract', which gives the buyer of the contract (i.e. the market participant) the right to buy a commodity at a predefined strike price. A central authority decides the capacity volume to be procured through Reliability Options and procures the options by paying a reliability premium (i.e. a flat fee), determined through the auction process. When the reference price (e.g. day ahead wholesale energy price) exceeds the strike price, the market participant that receives the fee for the option must pay the difference to the option holder (i.e. the central authority). The strike price is set based on an expectation of marginal costs of a peaking generator.

Optimised CRO - zonal: Creating a zonal version of the CRO by including major transmission boundaries and ensuring that the capacity adequacy requirement could be met in each zone. This would create multiple zonal clearing prices from the auction algorithm.

Optimised CRO - minimum low carbon requirement: A CRO with a minimum requirement for low carbon capacity (that increases over time). This would create two separate clearing prices in the auction, one for low carbon and one for other technologies.

Optimised CRO - enhanced flexibility: A single auction CRO with minimum volume requirements for more responsive technologies, creating multiple clearing prices with more flexible technologies receiving a higher price.

Decentralised Reliability Options: The DRO model works similarly to CRO, however, the role of the Transmission System Operator is stripped out, and suppliers are required to secure reliability options to meet their peak demand by contracting directly with capacity providers. If they fail to procure enough capacity to ensure security of supply, or a generator overestimates its performance during a certain period, penalties apply. However, the Government has already ruled out decentralised options (BEIS, 2022a).

Reverse Reliability Options (RRO): The Reverse Reliability Option model is a mirror of the CRO. The mechanism is based on the concept of a 'put option contract', which gives the buyer of the contract (i.e. a central authority) the right to sell a commodity at a predefined price. A key objective of the RRO would be to provide revenue stabilisation for demand turn up including long duration storage. The market participant would need to pay back the option holder (i.e. the central authority) the difference between very low prices and the strike price in return for the option fee. See full description in Appendix 5.

4 Equivalent power auctions is an option that we did not take forward to full assessment, following our shortlisting exercise (see our response to the Government's consultation here).

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System Adequacy Options

The Government is considering reforms to the Capacity Market and alternatives as part of its Ten-Year Review and the REMA process. We have therefore adapted the scope of our assessment to include most[4] of the options considered under REMA and have added the additional options of Reverse Reliability Option (RRO) and the Scarcity Adder. In its consultation document, the Government leans towards retaining a centrally led intervention (i.e. Capacity Renumeration Mechanism (CRM)) that naturally fall into three categories:

Revenue additional to energy price

CM and optimising variants

Existing Capacity Market: Assets participate in auctions for capacity agreements of differing lengths to be available during periods of system stress when called upon by the system operator. A capacity volume requirement is recommended by the EMR Delivery Body. Auctions are settled on a pay as clear basis at a price per unit of capacity. The contracts are physical contracts (as opposed to financial contracts) and therefore incorporate physical specifications or requirements, including “de-rating” according to expectations about the technologies’ availability at times of system stress.

Evolved Capacity Market: Evolution of the existing Capacity Market design to incentivise capacity that has more value to the system, for example, using locational de-rating factors to send a locational signal not to site new generation behind transmission constraints, or including scalars on the clearing price to reward flexible capacity more highly. These are minimal changes as opposed to those considered in an optimised CM.

Optimised CM - zonal: Creating a zonal version of the CM by including major transmission boundaries and ensuring that the capacity adequacy requirement could be met in each zone. This would create multiple zonal clearing prices from the auction algorithm.

Optimised CM - minimum low carbon requirement: A CM with a minimum requirement for low carbon capacity (that increases over time). This would create two separate clearing prices in the auction, one for low carbon and one for other technologies.

Optimised CM - enhanced flex: A single auction CM with minimum volume requirements for more responsive technologies, creating multiple clearing prices with more flexible technologies receiving a higher price.

Other

Supplier Obligation (capacity adequacy): An obligation on electricity suppliers to demonstrate that they have secured sufficient electricity in advance to meet a reliability standard on behalf of their customers. The Government already ruled out decentralised options (BEIS, 2022a).

4 Equivalent power auctions is an option that we did not take forward to full assessment, following our shortlisting exercise (see our response to the Government’s consultation here).

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System Adequacy Options

The Government is considering reforms to the Capacity Market and alternatives as part of its Ten-Year Review and the REMA process. We have therefore adapted the scope of our assessment to include most[4] of the options considered under REMA and have added the additional options of Reverse Reliability Option (RRO) and the Scarcity Adder. In its consultation document, the Government leans towards retaining a centrally led intervention (i.e. Capacity Renumeration Mechanism (CRM)) that naturally fall into three categories:

Revenue instead of energy price

Strategic Reserve

Some generation capacity is targeted or competitively procured to ensure security of supply in exceptional circumstances. This back-up capacity is only used if the market has failed to meet demand, so as not to interfere with price formation in the wholesale market even under tight conditions such that generators receive the same investment incentive as if there were no Strategic Reserve. Successful providers receive a payment for being available and a separate activation payment that is linked to prices in the day-ahead, intra-day or balancing markets increasing above a certain threshold level reflective of scarcity, such as the value of lost load (VoLL). Capacity for strategic reserves is procured through a tendering procedure for a specified amount of capacity (in MW), for example on a year-to-year basis. The Strategic Reserve may consist of existing or new generation specifically built for the purpose of providing reserve capacity and may include demand resources. The latter would typically be required to reduce electricity consumption to a certain level within a required timeframe when called upon.

4 Equivalent power auctions is an option that we did not take forward to full assessment, following our shortlisting exercise (see our response to the Government's consultation here).

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Summary Assessment of System Adequacy

Assessment of options

In the discussion that follows, we draw on Baringa's assessment and other evidence to arrive at conclusions on whether and how the CM should be evolved over time. The results of Baringa's assessment of the individual options are set out in the table below.

● (red) ◕ (red) ◑ (red) ◔ (red) ○ ◔ ◑ ◕ ●

Deterioration on status quo | Neutral | Improvement on status quo

	Revenue additional to energy price											Revenue instead of energy price	Capacity value in energy price
Criteria	Evolved CM	Optimised CM - Zonal	CM - Minimum Carbon	CM + Enhanced Flex	CRO	Optimised CRO - Zonal	CRO - Minimum Carbon	CRO + Enhanced Flex	DRO	RRO	Supplier Obligation CA	Strategic Reserve	Scarcity Adder
Value for Money	◔	◔	◔	◑	◔	◑	◔	◕	○	◑	◔	○	◔
Energy security and system operability	◔	◔	○	◑	◔	◑	◔	◕	○	○	◔	◑	◔
Decarbonisation	○	○	◑	◔	○	○	◑	◔	○	◑	○	○	○
Competition	○	○	◔	◑	◔	◔	◑	◕	◔	◑	◔	◔ (red)	◑
Challenge to implement	○	◔ (red)	◔ (red)	◔ (red)	◑ (red)	◑ (red)	◕ (red)	◑ (red)	◕ (red)	◕ (red)	◑ (red)	◔ (red)	◔ (red)
Investor confidence	○	○	○	◔	◔	○	◔	◔	◔	◔	○	○	◔
Full chain flexibility	○	○	○	◑	◑	◑	◔	◕	○	◑	○	○	◑
Whole system	○	○	◔	◔	◑	◔	◑	◑	◑	◔	◔	○	○
Adaptability	◔	◔	◑	◑	◔	◑	◕	◕	◑	○	◑	◔	◔
Consumer fairness	○	○	○	○	◔	◔	◔	◔	◔	○	◔	○	○
Total	◔	◔	◑	◑	◑	◑	◑	◕	◔	◑	◑	◔	◑
Total - prioritise VfM, Security and Decarb	◔	◑	◑	◕	◑	◑	◑	◕	◔	◑	◑	◔	◔

Note to table:

1 Full assessment and scoring rationale found in separate document: www.nationalgrideso.com/document/276841/download

2 Counterfactual for CRO is the respective CM or optimised CM. For the three Optimised CRO options, the counterfactual is the Status Quo. Counterfactual for the RRO is the CRO.

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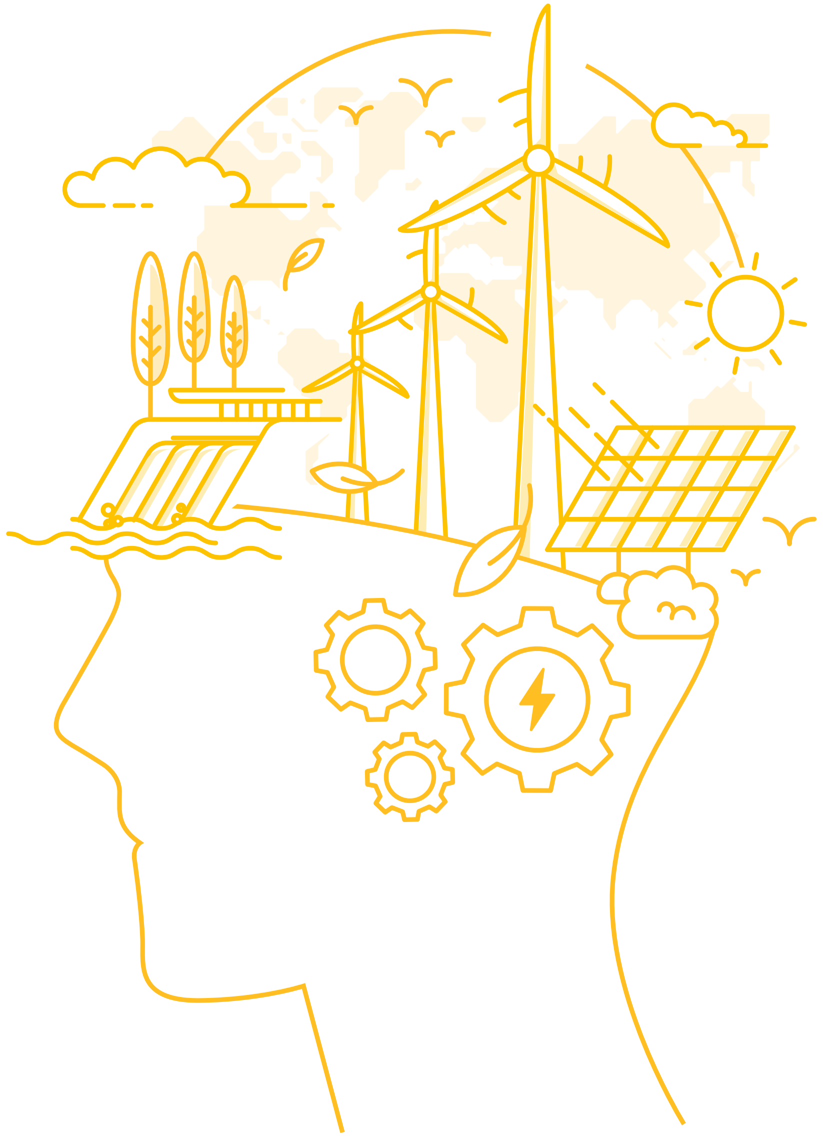
Summary Assessment of System Adequacy

CM could be improved but limited capability to meet future system needs

Baringa's assessment reveals that optimisation of the CM could deliver significant improvements relative to the status quo. Direct comparison of CROs and the CM, including optimisation variants, shows CROs to be higher performing relative to the CM, particularly against criteria relating to value for money, energy security and system operability, competition, full chain flexibility and adaptability. Optimising the CM by splitting auctions or through a single auction with multiple clearing prices to target certain attributes can deliver significant added value relative to the status quo.

Our deeper analysis of the case for change and the extent to which options can address the emerging issues of particular concern for ESO, however, reveals there are fundamental limits to the CM's capability to adequately address future system security challenges. This is particularly with respect to targeting and fairly rewarding accurate response to bidirectional and long duration stress events throughout the year and accommodating growth in demand-side flexibility. The issues and challenges relating to the CM are summarised in the following table and options that could potentially better address these particular issues are identified. However, these alternatives may be associated with different issues, as identified in Baringa's assessment and our analysis presented in 'Appendix 3'. A holistic view of the available evidence, and importantly as part of a wider package, is necessary in order to draw robust conclusions.



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Summary Assessment of System Adequacy

Figure 24. Emerging issues and extent CM or alternatives can address

	Emerging issue	Extent CM reform could address	Comment on potential alternatives
Buying the right thing	Targeting winter peak is no longer appropriate - stress events depend on weather fluctuations, can occur throughout the year.	CM currently procures to meet winter peak. Instead, would need to identify periods of highest system stress and procure capacity accordingly.	Deciding how much and what to procure is a potential challenge for all mechanisms.
Buying the right thing	From early 2030s, stress events getting longer and probability of event occurrence reducing.	CM does not accurately reward duration of response and remedies (e.g. split auction) would be crude. Could become very expensive to meet peak demand for continuous days/weeks via CM.	Could be more cost-effectively addressed through a Strategic Reserve and/or targeted innovation/ derisking support policies for capacity with long duration capability and/or Reliability Options as they accurately reward duration of response.
Buying the right thing	System security is becoming two-way for supply and demand.	Currently CM is designed to ensure supply meets demand not vice versa. Challenging to redesign CM to address this – would require additional auction or separate mechanism.	RROs can be implemented alongside CROs to address the over-supply issue, providing revenue stabilisation for demand/storage resources.
Buying the right thing	CM does not value attributes of capacity needed in future, particularly flexibility.	Could optimise CM to reward flex more highly but crude as flexibility must be defined, and access issues for DER remain.	Cost-reflective wholesale energy prices accurately reward flexibility – Reliability Options, Scarcity Adder or Strategic Reserve better align with wholesale energy prices.
Buying the right thing	CM procures high carbon technologies.	Could optimise the CM for carbon to align with government targets by applying multipliers or minimum requirements.	Accurate and aligned carbon signal needed in all markets, particularly the wholesale market.
Incorrect reward	Weak, arbitrarily set, binary penalties of the CM do not accurately reflect system stress.	CM penalties and the notification process could be reformed but need to be linked to wholesale prices to be effective.	Cost-reflective wholesale energy prices provide accurate incentives – Reliability Options, Scarcity Adder or Strategic Reserve better align with wholesale energy prices.
Incorrect reward	Dilution of wholesale price scarcity signals – CM assets bid more aggressively in other markets, harming competition.	It is not possible to address this through CM reform. Would need to remove CM to re-establish scarcity signals in wholesale market.	Reliability Options, Scarcity Adder or Strategic Reserve are less distorting.
Fair treatment	Ex-ante derating factors – need constant updating to accommodate tech innovation and can not accommodate business model innovation.	Cannot address as physical contracts rely on derating factors for technologies.	As ROs are financial rather than physical contracts, generators manage risk relating to their response capability, removing need for derating factors.
Fair treatment	Illiquid secondary trading – CM places physical limits on units, which reduces secondary trading.	Strengthened penalties could improve liquidity, but potential is limited compared to financial agreements.	As standardised financial instruments/contracts, ROs would be more easily tradeable compared to CM, enabling market participants to effectively manage risk associated with delivery.
Fair treatment	Marginalised end consumers - CM designed to meet a static demand profile based on blanket assumption about consumers' WTP (i.e. VOLL).	As demand response enabled and grows, consumers more able to express a wider and more dynamic VOLL range. The CM can not be reformed to adequately accommodate this.	Reliability Options, Scarcity Adder or Strategic Reserve are more compatible with consumers expressing WTP for reliability via wholesale market. ROs provide optionality for consumers.

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Replacement of CM with enduring alternative needed by the 2030s

Our view is that the CM will eventually need to be replaced with an alternative that is more closely aligned with the wholesale market and capable of adequately addressing the identified challenges, particularly considering the radically different nature of system security requirements from 2030 onwards. The rationale to replace the CM with alternatives that better align with wholesale energy prices becomes much stronger with growth in demand-side response and with implementation of locational energy pricing that would deliver accurate cost-reflective price signals.

Based on our analysis, we conclude that **the CM should be replaced by Reliability Options, Scarcity Adder and/or Strategic Reserve by the early 2030s though choices and design must be informed by the decision on wholesale market design and assessment of market conditions** (particularly for the retail market and mobilisation of demand-side response, and regarding the availability of risk mitigation products and services through forwards/futures markets) that will likely exist at the time of going live with the new wholesale market design.

If retaining a market-wide revenue stabilisation mechanism, **Reliability Options (ROs) are a preferable alternative to the CM** as the incentives it provides are much stronger and closely aligned to energy price signals and it is more adaptable to growth in demand-side response. ROs achieve a more balanced allocation of risk-reward between consumers and producers, particularly as: they provide a hedge for consumers; have a less distorting impact on wholesale prices that is important for price-based DSR; and as financial instruments they provide secondary trading opportunities for capacity providers such that more risk can be transferred to market delivery with stronger incentives and greater opportunities for the market to support the system in times of system stress. **Reliability Options can also be designed to be symmetrical, with Reverse Reliability Options providing revenue stabilisation for demand-side resources.**

In time, depending on how the retail market and DSR develops, ROs could be decentralised with the demand-side rather than the Government driving reliability requirements. Given the implementation challenges experienced in the few countries that have adopted ROs to date, sufficient resource and time must be allocated to a high-performing, robust design and effective implementation.

A Strategic Reserve or Scarcity Adder do not provide revenue stabilisation if implemented as standalone mechanisms but could be combined with ROs to achieve this (see 'Reform Pathways' for further discussion). A Strategic Reserve has the potential to reduce the costs associated with rare stress events and to manage carbon emissions in order to align with the 2035 decarbonisation objective but best practices must be closely followed to ensure the 'slippery slope' phenomenon can be avoided. A Scarcity Adder has the advantages of directly restoring missing money to spot prices and mitigating market power if it exists.

It is necessary to consider the combining of options with each other and also with the new wholesale market design. For example, implementing ROs as a symmetrical instrument for supply and demand, through CROs with RROs, can provide a significant contribution to the future challenge of bidirectional stress events. Particularly important, is that alternatives such as ROs, a Scarcity Adder and or a Strategic Reserve, are more complementary to the wholesale energy market, respecting the integrity of its price signals. The packaging and sequencing of options is discussed further in the 'Packaging' section.

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Flexibility

Investment in Flexibility

In our Phase 2 Options Assessment Framework, we identified Flexibility as one of the key investment elements to be assessed alongside Low Carbon investment and System Adequacy. Specifically, a key question is the degree to which both the overall flexibility requirement itself, as well as the flexibility technology mix, is determined by government. Unlike Low Carbon investment and System Adequacy, the government does not currently determine overall flexibility requirements (e.g. via a flexible capacity target).

The flexibility challenge and current landscape

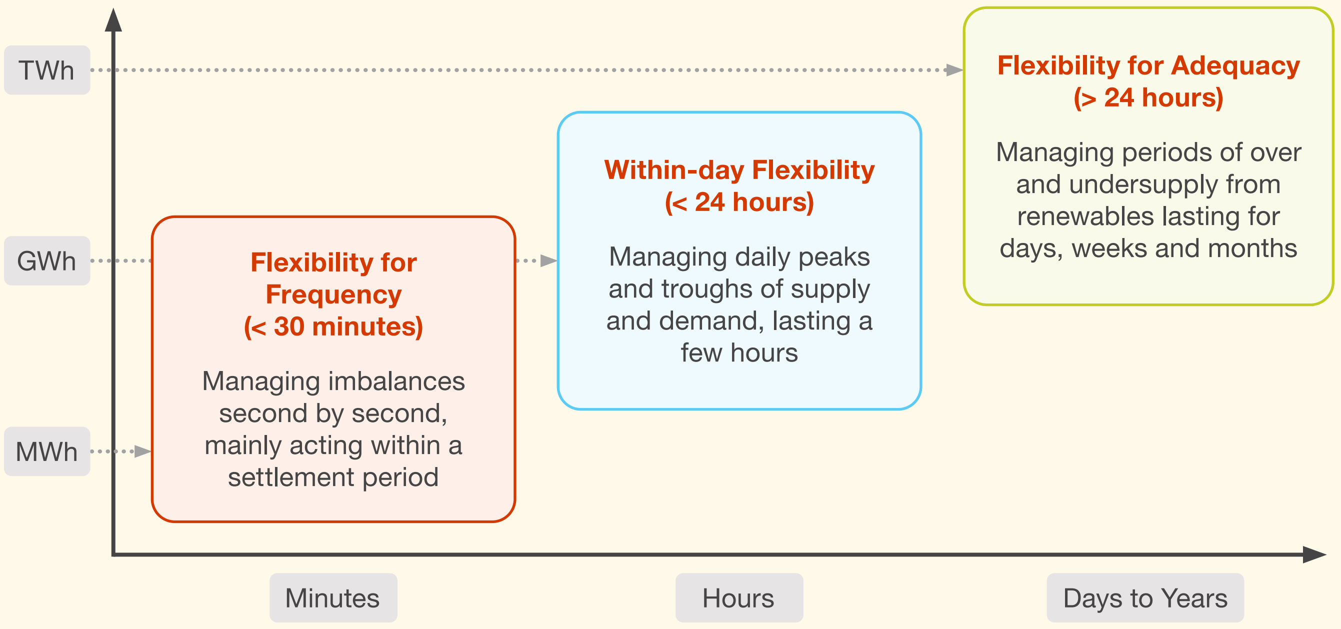
Flexibility cuts across the three core challenges that we identified in Phase 2 of our NZMR programme (see Figure 6). We identified the need to manage dramatic energy imbalances with flexible and firm technologies across both supply and demand, and system requirements for tight periods will be based on rare, long duration events. Considerable investment will be needed in flexible resources to meet the changing system needs in all timescales driven by growth in weather-dependent renewables. Locationally and temporally accurate market signals are needed to incentivise flexible assets to locate and dispatch where they can minimise whole system costs.

What is Flexibility?

Flexibility is the ability to shift the consumption or generation of energy in time or by location. The current GB market evolved in a system where consumer demand profiles were predictable and where conventional dispatchable generation provided a high degree of flexibility for energy balancing and system security. In a decarbonised system, the market must coordinate new sources of flexibility – such as flexible consumption, batteries and other storage, interconnectors, flexible generation - around a weather-dependent generation mix and inflexible demand.

In our Phase 2 Assessment, we identified Flexibility as one of the key market design elements that need to be addressed when exploring holistic market reform for net zero. As illustrated, flexibility can be deployed over various timescales to support different aspects of system operation:

1. Frequency 2. Within-Day Flexibility 3. Adequacy



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Investment in Flexibility

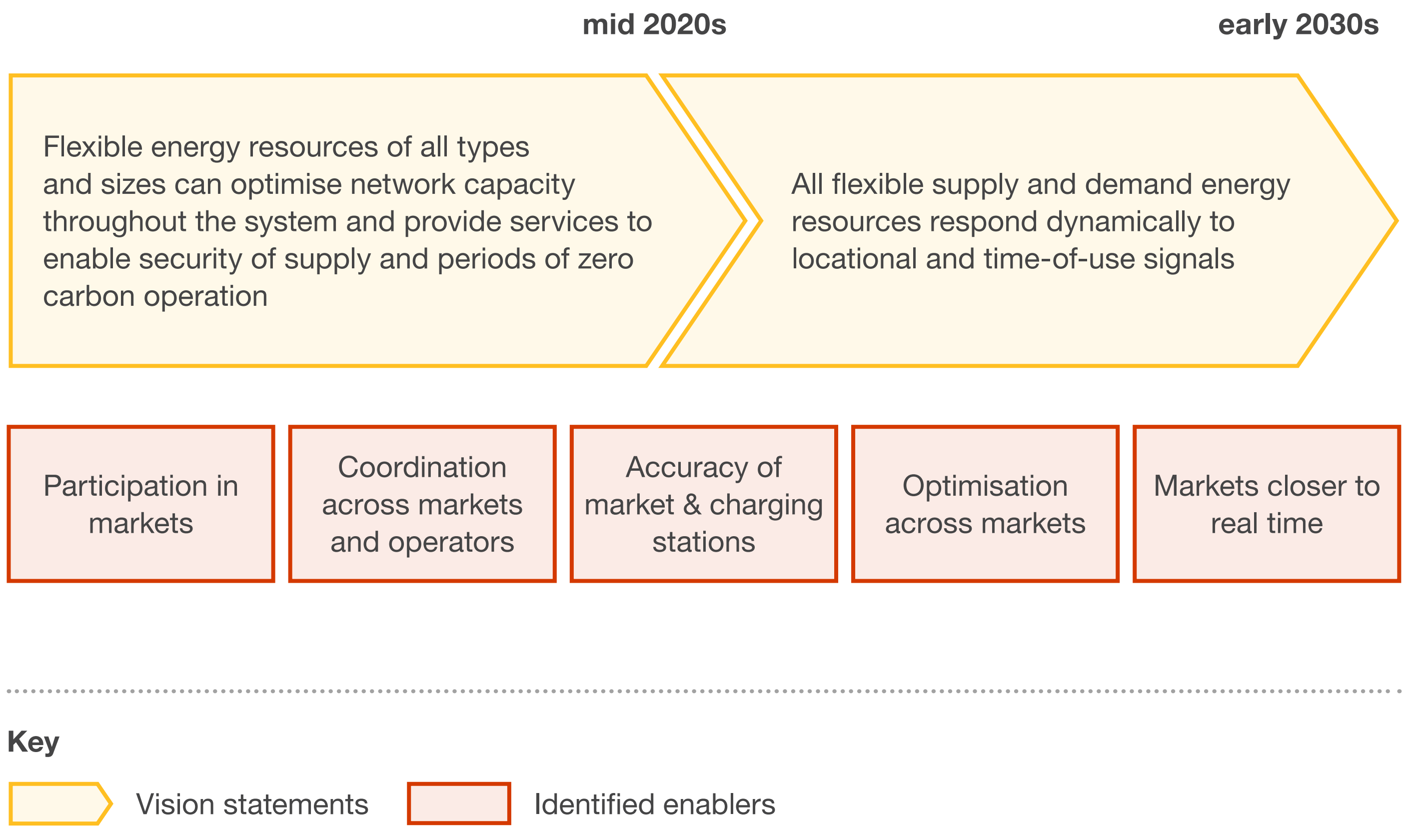
The Government recognised the need to unlock flexibility given system change and the digitalisation opportunity, with the launch of the Smart Systems and Flexibility Plan (SSFP) in 2017.[1] The SSFP has since been progressively implemented and continually developed. The plan encompasses a plethora of actions and initiatives, responsibility for which is shared between the Government, Ofgem, ESO, DNOs and the rest of industry. Many of the actions that are currently being implemented are enablers (e.g market-wide half-hourly settlement; regulatory frameworks for interconnectors and storage; cyber-security provisions), providing a critically important foundation for market reforms.

Updated in 2022, four themes underpin the current vision of the SSFP: 1. facilitating flexibility from consumers; 2. removing barriers to flexibility on the grid; 3. reforming markets to reward flexibility; and 4. the Energy Digitalisation Strategy.[2] The vision and identified enablers relating to the third theme on market reform is set out in Figure 25 to the right.

The short-term focus of the SSFP, within the scope of the current market design (i.e. BETTA), is on enabling access to existing markets and improving coordination across markets and operators.

Current reforms relating to response, reserve and the Balancing Mechanism are outlined in the Markets Roadmap along with delivery plans. The general direction of travel has been towards wider access, pay-as-clear auctions and procurement closer to real-time (e.g. day-ahead) in order to drive down costs through more accurate responsiveness to system needs and greater competition.

Figure 25. SSFP vision theme “Reforming markets to reward flexibility”



Source: slide 16 of “Smart Systems & Flexibility Plan Forum – March 2022” available at ofgem.gov.uk/smart-systems-and-flexibility-forum

1 assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/633442/upgrading-our-energy-system-july-2017.pdf
2 See slide 16 of “Smart Systems & Flexibility Plan Forum – March 2022” available at ofgem.gov.uk/smart-systems-and-flexibility-forum

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Investment in Flexibility

Long term vision - flexibility requirements

Looking further out to the early 2030s, the SSFP vision targets optimisation across markets, accurate market signals and markets closer to real-time. The launch of REMA expands the potential scope of future actions.

System needs – frequency and within-day flexibility

The ESO Operability Strategy Report explains in detail how our frequency and within-day flexibility needs are changing as the electricity system decarbonises. The size of our frequency requirements are dictated by the inertia levels on the system and the size of both generation and demand losses. These requirements may change and are heavily impacted by how the system evolves. The following table sets out our 2025 requirement and assumes the inertia provided by the market falls as low as 102GVA.s:

Figure 26. Response and reserve requirements to 2025 for the GB market

Frequency service	System need	Required
Dynamic Regulation and Dynamic Moderation	**Regulate** steady-state frequency within the statutory limit of +/-0.5Hz	up to 300MW each
Dynamic Containment	**Contain** the frequency for events within standards	up to 1,400MW
Quick Reserve	**Recover** frequency back towards 50Hz, mainly during normal operating conditions	up to 1,400MW
Slow Reserve	**Restore** frequency to the operational range (+/-0.2Hz) within 15 minutes	up to 1,400MW
Balancing Reserve	**Flexibility in real-time** to ensure balance between supply and demand	up to 2,500MW

The capacity of within-day flexibility is currently small but will grow rapidly over the next 10 years, driven by demand-side policies. FES shows that by 2030, the system is expected to have 25-45GW of within-day flexibility mainly from smart charging of electric vehicles, vehicle-to-grid, smart electric heat, smart domestic appliances and battery storage with duration of a few hours. The extent to which within-day flexibility is mobilised will influence the extent of curtailment and how much dispatchable generation will be needed, impacting costs and emissions.

System needs - adequacy

Adequacy relates to whether there are sufficient available resources to meet electricity demand throughout the year. As set out in the 'System Adequacy' chapter, system needs for adequacy are expected to change considerably. Post 2030, stress events are expected to become less frequent but much longer in duration.

We recently commissioned AFRY to undertake a long-term resource adequacy study to assess the risks to security of supply in a fully decarbonised power system and the resources needed to ensure adequacy in the 2030s (AFRY, 2022). The study, which explored different pathways for adequacy and examined implications and trade offs, identified that adequacy could not be achieved by a system reliant on batteries only and that investment needs to be brought forward in clean, reliable technologies that are not weather-dependent - such as new nuclear, CCS, hydrogen power generation and new electricity storage - capable of delivering energy on a TWh scale. Many of these technologies have long lead times, very high capex and are yet to be commercialised.

While different combinations of these technologies could meet adequacy requirements, the degree of their flexibility could significantly impact operational costs. Exposure to competition and market signals will be important in driving a cost-efficient power mix.

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Investment in Flexibility

Long term vision – market design for flexibility

Accurate market signals

We are certain that in the coming years the need to manage both energy imbalances and system constraints will require significant changes in how low carbon flexible resources are coordinated.

Market signals have two key roles to play:

1. Short-run: Short-term prices reflect system needs and therefore incentivise assets to turn up or down to support efficient dispatch for system balancing.

2. Long-run: Average prices over a period of time act as a signal for investment or exit.

Key considerations for market design decisions concerning flexibility are:

- Flexibility is valuable to the electricity system because it can respond to unforeseen system needs. It is therefore most efficiently procured close to real time.
- Flexible resources' revenues are partly derived from arbitrage. 'Sharp' or frequently varying price signals therefore support investment decisions for flexible resource, and the arbitrage actions by flexible resource to smooth price volatility.

We consider cost-reflective, granular temporal and locational signals are ultimately needed in the wholesale market to provide real-time transparency of system needs across supply and demand and to maximise flexible resources' arbitrage revenues. As discussed in our Phase 3 report, we consider these signals would be most effectively deployed via shorter settlement periods and locational energy pricing.

Prior to locational energy pricing, it is important to develop greater transparency of locational system needs where possible. Locational signals in operational timeframes are currently revealed through the BM and network charges. ESO has also developed a trial Local Constraint Market (pay-as-bid) for non-BM resources on the highly constrained B6 boundary. ESO is considering whether or how this design could be expanded in the short/medium term. However, this market design is limited in how far it can address congestion: non-BMUs are currently excluded, in part because there is significant potential for inc-dec gaming[3] between the Local Constraint Market and the BM. Furthermore, there is an urgent need to address deficiencies in the existing market-based TNUoS charging arrangements for demand users (elaborated in the 'Packaging' chapter).

In a similar vein, ESO's Demand Flexibility Service (DFS), introduced for winter 2022/23, is also an interim market designed to unlock consumers' flexibility while enduring arrangements are implemented. The DFS has successfully unlocked considerable demand response when system margins have been tight. During the 2022/23 winter period, over 1.6 million households and businesses across 31 providers actively participated in 22 service events (2 live events and 20 test events) that reduced electricity consumption by approximately 3,300MWh during crucial time periods.[4]

3 Inc-dec gaming is used to describe a phenomenon involving gaming between the wholesale market and balancing services markets to resolve network constraints. Where the clearing mechanism is pay-as-bid, generators in front of network constraints can increase their prices knowing they will still be dispatched, while generators behind the constraint can decrease their prices to ensure they will be compensated for downward redispatch.
4 Demand Flexibility Service, Winter 2022/23 (August 2023) download (nationalgrideso.com)

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Investment in Flexibility

The DFS was introduced in response to slow progress in removing barriers that prevent the pass through of accurate price signals (i.e. wholesale energy prices, policy/network costs) to consumers. Such barriers include lack of Market-Wide Half Hourly Settlement (MHHS) and weak incentives for suppliers to unlock demand response from their customers. MHHS is expected to be implemented by 2027, while implementation of retail market reforms is not expected until 2024 at the earliest.[5] With reforms in place, it could be expected that suppliers would offer a wider range of retail service propositions and tariffs that reward demand response, including supplier-managed asset control that can maximise the asset's flexibility value in multiple markets. With pass through of accurate price signals, demand response would be orientated around avoiding settlement periods when energy costs are high as opposed to receiving payments, as through the DFS.[6] Unlocking flexibility via the wholesale electricity market (either through explicit or implicit response)[7] is more cost-efficient due to much greater competition between resources and avoids the gaming risk associated with procurement of demand response, given the need to establish a baseline against which to measure the response.[8]

Optimisation across markets

While the BM design allows ESO to procure multiple products simultaneously, implicitly stacking[9] and co-optimising,[10] there is considerable scope to improve transparency and efficiency. ESO's Enduring Auction Capability, introduced this year, enables the explicit co-optimisation and stacking of day-ahead response (and later, reserve) products, while the Balancing Programme will considerably improve efficiencies. In the longer term, however, replicating the BM's efficiency while maintaining separate reference prices for individual products would require a market design that explicitly stacks and co-optimises not only response and reserve but also energy and potentially non-energy products such as stability. ESO is exploring the economic benefits of co-optimisation under a centralised dispatch model both with and without locational pricing via a Network Innovation Allowance project.

5 Delivering a better energy retail market: a vision for the future and package of targeted reforms
6 Over winter 2022/23, the average price paid for DFS test events was £3,000/MWh. For live DFS events, the average price paid was £4,559/MWh.
7 Explicit demand-side flexibility is committed, dispatchable flexibility that can be traded (similar to generation flexibility) on the different energy markets (wholesale, balancing, system support and reserves markets) while implicit demand-side flexibility involves consumers' reaction to price signals.
8 See slide 37, DFS pre-consultation webinar 9th June 2023
9 Stacking allows a single asset to provide multiple services simultaneously.
10 In a market context, co-optimisation is when a single algorithm is used to clear multiple products simultaneously. Assets submit bids and offers for the separate products and are chosen to provide the product that maximises profits and social welfare. Stacking and co-optimisation are separate but compatible processes.

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Evolving role of complementary investment policy

As set out in the 'Introduction to Investment', our approach is underpinned by the principle that effective electricity market design starts with accurate real time price signals. If these signals do not fully capture all the characteristics that determine value, this creates "externalities". These are costs (or benefits) caused (or provided) by market participants that are not financially incurred (or received) by them.

Our market design recommendations set out in Phase 3 would significantly contribute to restoring "missing money" to energy prices through more locationally and temporally granular price signals. Market design reforms that replace missing money will reduce the need for a capacity renumeration mechanism (CRM). Missing money is one of two key market failures underpinning the rationale for the existing capacity market (CM). The second market failure relates to the idea that consumers can not choose their desired level of reliability, which could change significantly as the demand-side becomes more flexible. Once market design reforms are implemented, several years from now, the rationale for a CRM might be much weaker or no longer exist.

However, ahead of implementing such reforms – given continued existence of missing money for flexibility providers, particularly given the dampening effect of the CM on scarcity prices and with demand-side flexibility in transition - a key question is whether complementary policy is needed to support investment in flexibility and how this could be achieved through existing mechanisms in alignment with the preferred enduring arrangements that will be implemented later.

Capacity Renumeration Mechanism (CRM)

As set out in the System Adequacy chapter, the extent to which the CM can be adapted to meet the future system challenges is limited as alternatives can meet the changing system needs more effectively and better accommodate the demand side due to closer alignment with wholesale energy prices. For example, Reliability Options align directly to wholesale energy prices and can be implemented as a symmetrical instrument (with Reverse Reliability Options, see 'Appendix 5') to provide revenue stabilisation for demand turn-up resources, including LDES. This mechanism can also be decentralised in time, trengthening incentives for suppliers to unlock flexibility from their resource portfolios.

If the CM remains in place, however, it can be optimised to reward flexible resources more highly though this is not straightforward and would involve trade offs. Forecasting volume requirements for flexibility is complex, since system needs driven by multiple interlocking factors including weather, generation mix, demand patterns, consumer price-responsiveness, and the market design itself. Flexible resources would be supported more fairly by the CM if sufficiently strong penalties would exist (ideally aligned with wholesale energy prices) and if secondary trading would be possible near real-time. A priority should also be to ensure the CM aligns with carbon reduction commitments and the CM may also need to be locational in a zonal or nodal market, reducing the scope to add greater design complexity by defining different types of flexibility given the risk of illiquidity (explained in more detail in the 'Packaging' chapter).

Bespoke financing support

Many of the assets that will be relied upon to provide flexibility in the future, receive bespoke financing support as they are not yet commercialised or because they are very large capex investments with long lead times. For example, interconnectors are supported by a revenue cap and floor mechanism while innovative technologies such as hydrogen, gas with CCUS and BECCS, receive bespoke financing support (see Figure 23). As emphasised earlier in this report, it is necessary that any support policy is designed in a way that respects the integrity of market signals. The revenue cap/floor and dispatchable power agreement models aim to keep the capacity providers' incentives aligned with market signals and to minimise distortions. Bespoke policies will need to be monitored and reviewed over time to ensure they are adapted as technologies mature and are commercialised, and should evidence of material distortions emerge.

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Investment in Flexibility

Distributed flexibility, governance and new role of Market Facilitator

We need to enable flexibility to deliver whole system value. We are rapidly moving away from passive operation at lower voltage levels, and are seeing system needs arise across distribution networks, leading to new revenue opportunities for flexibility service providers. Already so far this year 2.4GW of flexibility has been contracted by the DNOs and so there is both a real need and opportunity for low carbon flexibility assets to deliver whole system value.

The key factor to achieve this is coherent and co-ordinated market access across the GB market. We need to maximise consumer value by using distributed flexibility to relieve local and national constraints in a coordinated manner, so market operators can dispatch flexible assets without fear of conflict and service providers can access stackable revenue streams. This coherence must extend beyond ESO and DSO services to consider the wholesale and retail markets, Balancing Mechanism and price signals from network charging. Revenue opportunities need to be stackable to create efficient markets, and we must also seek to implement common data standards and coherent digital infrastructure that minimises the cost of investment for flexibility service providers seeking to play in these markets.

Clarity of roles and clear governance continues to be called for across industry when discussing how to unlock the value of flexibility across the whole system, and the creation of a Market Facilitator will ensure there is a body with clear accountability to deliver accessible, transparent and co-ordinated flexibility markets across transmission and distribution networks.

We will be working with Ofgem and industry to establish the Market Facilitator role in the coming years and coordinate and standardise DNOs' and ESO's services.

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Packaging

ESO

Packaging Principles

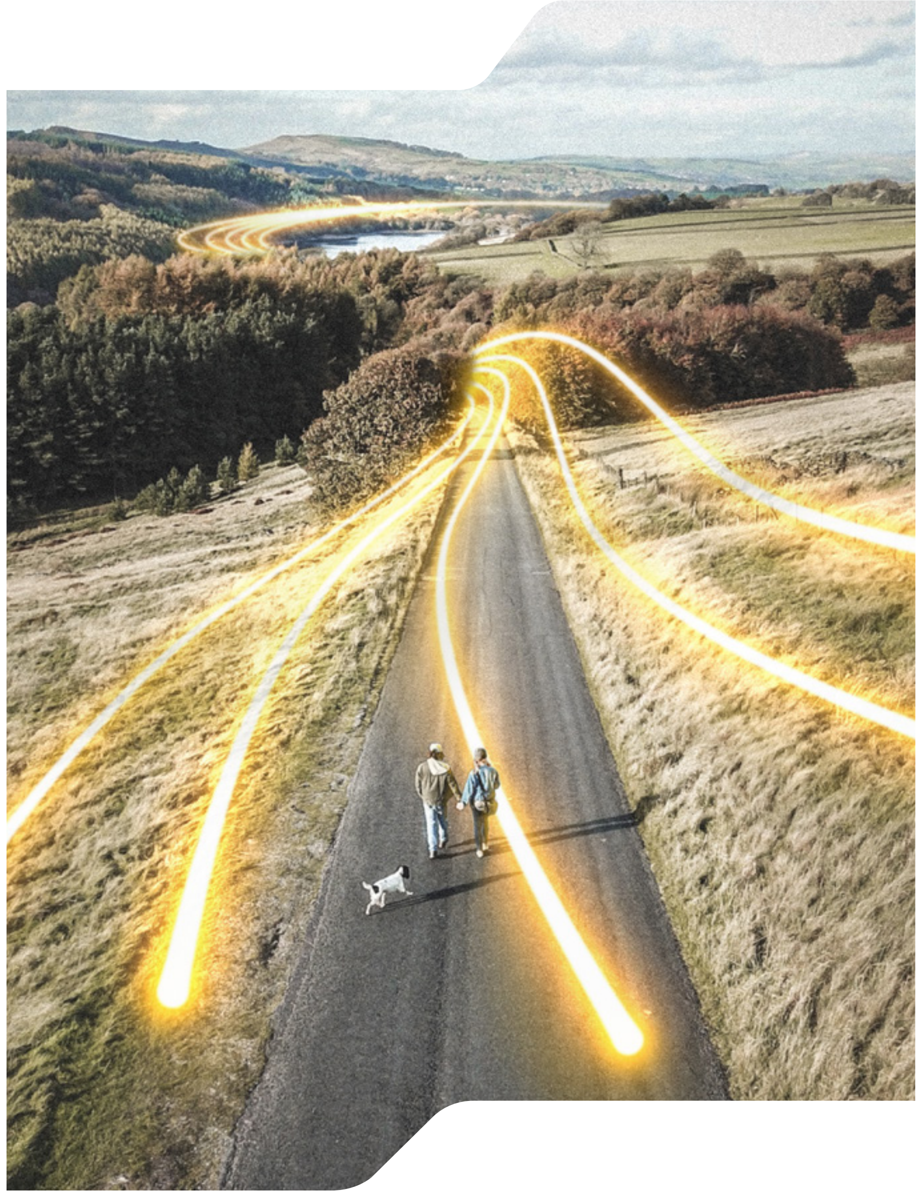
In this chapter we firstly set out some key principles and wider considerations concerning packaging of market and policy reforms. We discuss the extent to which we see potential for shorter-term reform options, prior to major wholesale market reform, to provide incremental improvements which satisfy the criterion of moving us in the direction of our enduring market design. Crucially, we highlight the significant limitations of these short-term measures. Lastly, we present an indicative generic strawman pathway comprising three distinct phases, with the aim of framing and stimulating debate on this fundamental aspect of the REMA process.

There are three distinct types of considerations when exploring the implementation of any holistic reform package; static compatibility, dynamic coherency and payback efficiency.

Static compatibility considers the extent to which the individual component market design element options work together effectively, such that each individual component acts to enhance or complement, rather than dilute or frustrate, the benefits of the other components. It also considers whether any de-minimus changes to other policies may be required or additional arrangements put in place to honour existing investments/agreements. This perspective assumes simultaneous coexistence of all components of the package, ignoring phasing considerations.

Dynamic coherency considers, for all packages where sequencing of components of a reform package is required, the extent to which the first components to be implemented represent a step in the right direction towards the complete package end-state, with respect to both the underlying principles and continuity of strength of signals. It also considers whether any additional problems may be created via the phasing of the components that may be avoided via alternative phasing and/or synchronous implementation.

Payback efficiency considers the cost/ benefit of reform package components that may be implemented for limited periods of time before being replaced by the more enduring components in the reform package. This is a pragmatic consideration that takes into account one-off implementation costs across industry, including the ESO and market participants, in addition to any impact on investor confidence.



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Illustrative packaging

In our February 2023 report, we presented Baringa's Baseline and Build packages for each of the three locational granularity options: national, zonal and nodal pricing. The Baseline packages represent, for each of these pricing mechanisms, a least change but cohesive set of policies. The Build packages represent a comprehensive set of policies that would increase confidence in achieving the REMA objectives, relative to the Baseline package, for each pricing mechanism.

These packages are illustrated in full detail in 'Appendix 1.1', and are summarised below:

Baseline Packages

	National Baseline	Zonal Baseline	Nodal Baseline
Pricing	National	Zonal	Nodal
Dispatch	Self		Centralised
Mass Low Carbon	Evolved CfD (locational auctions); Elective Participation	Revenue Cap and Floor; Elective Participation	
Cap Adequacy	Evolved CM (de-ratings or scalars - location, flex and/ or carbon)	Optimised CM: (auction splitting - location, flex and/or carbon)	
Operability	BAU+; Revenue Cap and Floor for low carbon flexibility		Co-optimisation; Revenue Cap and Floor for low carbon flexibility
Other	Network Access and Charging Reform	PTRs/ FTRs	FTRs; 5 min settlement

Build Packages

	National Build	Zonal Build	Nodal Build
Pricing	National	Zonal	Nodal
Dispatch	Centralised		
Mass Low Carbon	Revenue cap and floor (locational auctions); Elective Participation	Revenue Cap and Floor; Elective Participation	
Cap Adequacy	Optimised CM: (auction splitting – location, flex and/or carbon)	CRO and RRO (locational auctions); Scarcity Adder; Strategic Reserve	
Operability	Co-optimisation; Revenue Cap and Floor for low carbon flexibility		
Other	Network Access and Charging Reform; 5 min settlement; Carbon Intensity Reporting	FTRs; 5 min settlement; Carbon Intensity Reporting	

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Baringa's packaging

In compiling the packages for the three different pricing options, Baringa's consideration of static compatibility influenced their packaging choices in the following ways:

Dispatch:

Compared to self-dispatch, centralised dispatch/scheduling performs very strongly against the assessment criteria in Baringa's assessment (and aligns with the conclusions of ESO's Phase 3 assessment). This option is therefore present in all Build packages. The choice of dispatch has important implications for static compatibility, as indicated below. (Note that our current work on scheduling and dispatch will provide deeper analysis of what dispatch mechanism designs would be appropriate for operating a net zero system, and under what circumstances more centralisation is needed.)

Low carbon:

While several low carbon mechanism options could improve significantly on the status quo, static compatibility is an important consideration. In order to retain a locational signal for CfD projects under locational energy pricing, settlement would have to be made against an administered average system reference price. However, the dispatch distortions that can result due to the negative pricing rule, explained in the earlier section, would be far more prevalent under locational energy pricing as very low marginal cost generators would be price-setting more frequently. These distortions could be mitigated by either applying the negative price rule to the local price, which would have an upward impact on cost of capital, or by settling against the locational price but at the expense of removing the locational incentive for the supported generator.

Consequently, a price-based CfD mechanism was not selected for the zonal or nodal packages. The Revenue Cap and Floor model was selected for all packages, apart from Nodal Baseline, due to its overall stronger performance compared to alternatives, based on certain assumptions (see the 'Low Carbon Support Mechanism' chapter), but also because it is compatible with all locational pricing models and can therefore ensure dynamic coherency for different pathways. It is important to note that the Deemed Generation CfD model was a close second choice and it is also compatible with locational energy pricing.

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Illustrative packaging

Capacity Adequacy:

Baringa identified a strong rationale for replacing the CM with Centralised Reliability Options (CROs) for the Build packages based on locational energy pricing. This is largely because such wholesale market reform would significantly improve the accuracy of the cost-reflectiveness of energy prices and strengthen the need for policy to respect the integrity of the improved price signals.

Another statically compatible solution for either zonal or nodal pricing implemented with central dispatch based on a centralised clearing algorithm, could be a Scarcity Adder. This could directly restore missing money to energy prices, with values linked to the scarcity of reserves.

Reliability Options can be designed to be symmetrical, with Reverse Reliability Options complementing CROs to provide revenue stabilisation for demand-side resources, including long duration energy storage (LDES). In time, depending on how the retail market and DSR develops, ROs could be decentralised with the demand-side rather than the Government driving reliability requirements.

Given the implementation challenges experienced in the few countries that have adopted variants of RO schemes to date, sufficient resource and time would need to be allocated in order to achieve a high-performing, robust design and effective implementation. As there are few, if any, examples of an entirely “pure” CRO scheme, its static compatibility cannot be judged on the basis of international precedents.

A Strategic Reserve is statically compatible with market-wide options such as the (optimized) CM and CROs so long as the reserves are only used if the market is unable to clear or deliver, as otherwise participation of these resources in the wholesale market would cause distortions.

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ESO's view on low regret short-term measures

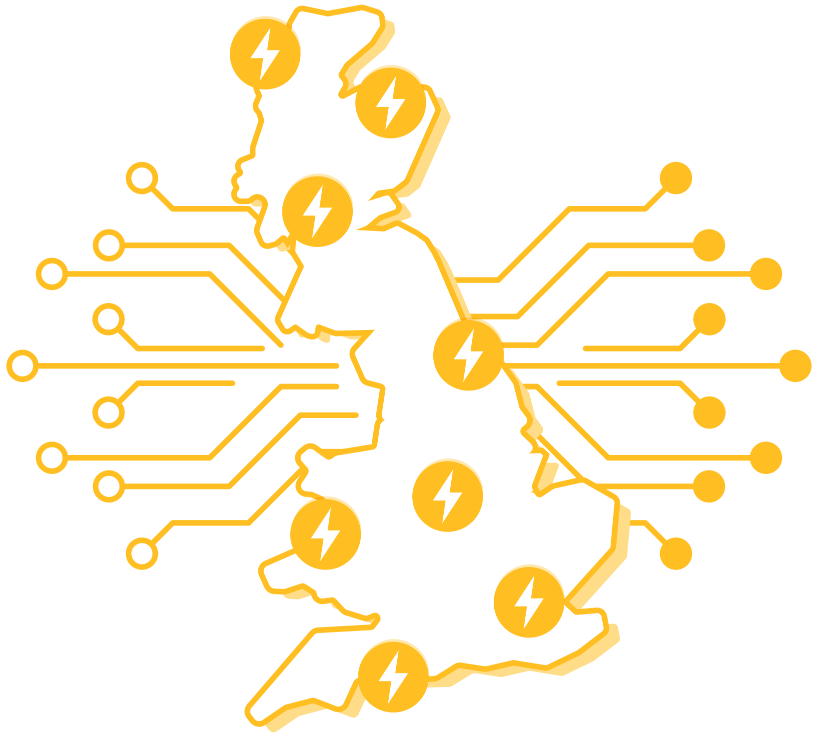
In addition to medium-term changes to existing arrangements that can be delivered from the mid-2020s, and longer-term transformational reforms, the REMA consultation is also considering low regret 'quick wins' which could be pursued on accelerated timelines and implemented regardless of the end package of reform. In relation to investment, we believe there is scope for incremental short-term improvements in three areas: locational signals; Capacity Market; Contracts for Difference.

Locational signals

Since the publication of our Phase 3 report which focused on operational market design, several stakeholders have advocated alternative approaches to improving locational signals in the holistic market arrangements. We maintain our view that these are substantially inferior solutions since, unlike locational wholesale pricing, none are capable of providing accurate real-time dynamic locational signals for all resources that align behaviour with system needs, especially for assets with two-way flows.

Nevertheless, this does not preclude the improvement of locational signals as much as is practicable in the status quo market design prior to wholesale market reform.

One specific issue raised by several stakeholders is the need to address deficiencies in the existing TNUoS charging arrangements for demand users. Following the implementation of the Transmission Charging Review in April 2023, and the removal of residual charges from locational tariffs, demand tariffs have been collared at zero for more than half the total number of demand zones. Initially intended as a stop-gap measure to avoid perverse incentives to increase demand at times of system peak, collaring has had a severe negative impact on the efficacy of locational signals for demand. Firstly, there is no longer any locational differential at all between tariffs in northern zones. Secondly, there is a far reduced locational differential between collared zones and non-collared zones. Lastly, the triad avoidance incentive has effectively been completely removed for half-hourly demand users in northern collared zones. We agree that short-term changes to TNUoS methodology to correct this unintended distortion should be explored as soon as possible. Such changes would represent a no regret measure that is coherent in principle with our longer-term vision for locational wholesale pricing, given the central role of efficient exploitation of demand elasticity in an enduring net zero market design.



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ESO's view on low regret short-term measures

For the CfD mechanism, BM distortions could be addressed by introducing a BSC Modification Proposal P462, that would essentially remove CfD subsidies from BM bids. This could be applied to existing plant as well as new plant. This would not, however, address many of the other issues (see Figure 18).

DESNZ (2023b) recently issued a consultation on including non-price factors (e.g. system flexibility and operability, sustainability) in the CfD mechanism. While the objectives of some of the non-price factors are worthy and might justify support, we are sceptical that they should be introduced through the CfD as they:

- risk adding to existing distortions considering the strong interaction of the CfD design with electricity markets;
- would involve complex administration that could take a couple of years, during which time the development of an alternative to the CfD to address its various issues could be considerably advanced for implementation;
- potentially create an unlevel playing field between generators, considering any projects already built or being built without support, and if the CfD scheme is replaced soon by an alternative that does not include non-price factors.

More specifically, in relation to specific attributes that DESNZ have identified could be targeted through non-price factors:

Location

Locational CfDs (as included in Baringa's National Baseline package) would involve incorporating a locational signal, potentially through a non-price factor approach. We do not believe this would be an efficient interim solution.

Firstly, on static compatibility, we have concerns regarding the coexistence of additional locational signals for a subset of assets, alongside transmission network charging for all market participants. This would result in a divergence of incentives for different assets imposing the same cost on the transmission system, resulting in inefficient investment decisions.

Secondly, on dynamic coherency, a key principle supporting locational wholesale pricing is the symmetry of locational signals it produces, especially between supply and demand. As locational CfDs would weaken, rather than enhance, this symmetry, we do not believe they would be a step in the right direction towards the longer-term enduring vision.

Lastly, on a pragmatic level, we do not believe that locational CfDs would satisfy the requirement of demonstrating sufficient value over a short-term implementation period, to justify the negative perception of additional regulatory risk, and the implementation costs, both centrally and for project developers, especially taking into account the negative impacts described above.

Flexibility

As outlined in the 'Flexibility' chapter, we believe that implementation of wholesale market reform alongside other key enablers are integral to addressing the market failure relating to investment in flexible/firm assets. Our NZMR assessment has also identified that bespoke support is needed to support innovation and investment in LDES. Introducing flexibility non-price factors into the CfD mechanism would not align with the static compatibility principle as provision of support outside of the wholesale market will inevitably distort wholesale energy prices, impacting incentives for flexibility.

On dynamic coherency, we do not believe that mass derisking support for flexibility would be a step in the right direction towards the longer-term enduring vision.

Operability

As discussed previously, many renewable generators are not investing in technologies that are able to provide system services as this could raise the capex, rendering auction bids uncompetitive. However, we do not believe that introducing non-price factors to reward operability capability would effectively address this investment issue as it would not change operational decisions. This is because the design of the CfD scheme incentivises assets to maximise output and tops up the revenue to a strike price. The value of an ancillary service would therefore still need to exceed the strike price in order for the generators to provide the service. See 'Case for Change in Low Carbon Support Mechanism' for further explanation.

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ESO's view on low regret short-term measures

Short-term measures

In 2019, the Government's Five-year Review of the Capacity Market concluded that it had been successful in meeting its core objectives: to ensure security of electricity supply, to do so at the least possible cost to consumers, and to avoid unintended design consequences, including by complementing the wider decarbonisation agenda (DESNZ, 2019). However, following its Call for Evidence published in July 2021, the Government recognised a rapidly evolving context and the need to reform the Capacity Market in the short term in order that it can continue to meet its objectives during the transition to net zero (DESNZ, 2022c). The Government has since come forward with various proposals including:

- Improving delivery assurance by strengthening the non-delivery penalty regime
- Improving carbon intensity through an emissions intensity limit applicable to new build plants from Oct 2034

Potential further options to improve the CM in the short term (2020s)

Through the 2020s, stress events are expected to be short-duration and will be impacted by network constraints. This is expected to be alleviated over time with network build delivery, the mobilisation of flexibility and the implementation of improved locational signals. In the near-term, however, resources supported by the CM could contribute more proactively in times of system stress, ahead of expensive BM actions and demand disconnection. To achieve this:

- Penalties could be strengthened by making them more accurately cost reflective. For example, ISO-NE, USA, introduced a Pay-for-Performance design feature that provides incentives (both payments and charges) for resources that perform during capacity scarcity conditions, based on the actual energy or reserves they provide during scarcity conditions.
- Secondary trading arrangements could be improved to facilitate trading nearer real-time, making it easier for any resources to contribute to reliability if they are available.
- The definition of a stress event and the notification process could be changed to ensure earlier, economically efficient response.

All of the above would deter less flexible resources from participating in the CM and attract reliable resources that are able to deliver.

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ESO's view on low regret short-term measures

Additional short-term measures to complement the CM

Strengthening ambition of innovation and de-risking support for low carbon dispatchable, sustained-response resources. Recent reports highlight the need for this and to better understand barriers and risks given considerable uncertainty with emerging technologies (e.g. Afry (2022); The Royal Society (2023)).

More robust energy efficiency policy, particularly for heat and buildings, to unlock greater demand reduction and the need to better understand delivery risks (CCC (2022); CREDS (2021)). We believe energy efficiency policies should be driven through proven traditional approaches (e.g. market transformation based on standards, incentives and information) rather than through power sector policies such as the CM. Demand reduction can reduce the system peak demand requirement and therefore the capacity requirement that needs to be met by new low carbon generation/storage capacity or new/existing unabated gas plant during the transition.

Developing new reliability metrics for changing nature of system stress. The GB system is expected to evolve from one where tight periods are relatively short to one where they could be much longer. Even though the duration of tight periods increases, the LOLE of the system remains broadly similar (AFRY (2022)), which means that the inherent risk profile of the system is changing but the key metric is not. Industry and the Government should work together to understand how to improve current approaches to the way that adequacy is measured.

Strategy for managing the transition for unabated gas. Existing unabated gas plant will either need to retire or be converted to low carbon solutions (e.g. H2P; CCUS). For retiring plant, their transition needs to be achieved in a way that does not jeopardise security of supply, unnecessarily raise costs for consumers or slow the transition to lower carbon alternatives. For converting unabated gas plant, support may be necessary.

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ESO's view on CfD reform as part of wider package

The reform package must address distortions while achieving a sufficiently attractive risk-reward balance and an appropriate allocation of risk between consumers and producers. The decision on CfD reform will depend on the wholesale market design and how to allocate risk between consumers and producers.

The Deemed Generation CfD model has the following advantages:

- It is very similar to the existing CfD (as shown in Figure 29), minimising disruption
- It tackles the distortions of the existing CfD, while retaining low cost of capital for generators. Models involving direct price exposure (e.g. Revenue C&F) are not able to achieve this due to trade offs between distortions and WACC
- If locational signals are to be sent to generators through energy prices, the model is still compatible (see Figure 30)

Our assessment of low carbon support mechanisms concludes that the Deemed Generation CfD most efficiently tackles the distortions of the existing CfD, while retaining low cost of capital for generators. However, the distortions can also be tackled through other means, primarily wholesale market and dispatch design (as shown in Figure 27), so whether or not we need to reform the current CfD depends on these wider market design choices and consideration of cost/benefit payback efficiency.

Figure 27. Main distortions caused by CfD and possible options to address

Main distortions	Possible options to solve
1 **Balancing Mechanism –** bidding based on lost subsidies and perverse incentive to locate where congestion exists	• BSC Modification Proposal P462 to remove subsidies from BM bids (could be applied to either new or existing plant, and under central dispatch as well as self-dispatch). • Deemed Generation CfD
2 **Wholesale short-term markets –** bidding below marginal cost; herding behaviour	• Locational energy pricing reduces herding impact • Deemed Generation CfD • Central dispatch*
3 **Ancillary services** – no incentive for CfD generators to provide services as bidding based on lost subsidies	• Deemed Generation CfD • Co-optimisation of energy and ancillary services (central dispatch)

* Central dispatch markets use complex bid formats that may facilitate avoidance of distortions in short-term markets, including intraday markets, although this would significantly depend on the specific dispatch mechanism design implemented.

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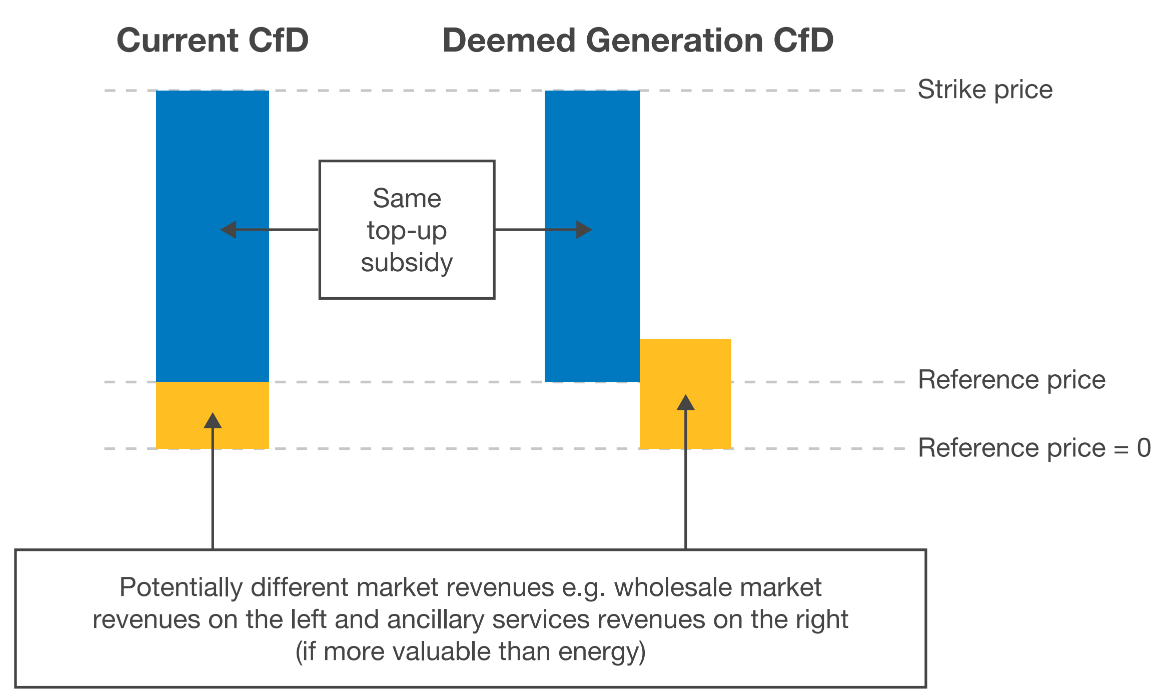
ESO's view on CfD reform as part of wider package

How does deemed CfD work vs existing CfD? Largely the same

Figure 28. Comparison of key features of Current CfD and Deemed Generation CfD

	Existing CfD	Deemed CfD
Strike price	Decided through auction, revenues topped up from reference price (e.g. day-ahead price) to strike price, in each settlement period.	
Top-up (subsidy)	Based on product of metered output and price differential between reference price and strike price.	Based on product of maximum output generator could have theoretically delivered (i.e. deemed) and price differential between reference price and strike price.
Market revenues	Wholesale market revenues only.	Revenues from different markets (though mainly wholesale energy).
Curtailment	No incentive to self-curtail as would lose top-up, so negative pricing rule introduced.	Incentivised to self-curtail when wholesale energy price is below their SRMC, and so the **negative price rule doesn't need to apply.**

Figure 29. Comparison of revenues for Current CfD and Deemed Generation CfD



ESO's view on CfD reform as part of wider package

The choice of CfD, whether to retain the existing CfD or adopt the Deemed Generation CfD, and the design features relating to the reference price and the negative pricing rule, depend on the desired allocation of risk between generators and consumers.

- If locational energy pricing introduced, there are different ways to send long-run locational signals to assets.
- We believe it is preferable to send the locational signals to generators via energy prices rather than transmission charges to ensure efficient investment as well as dispatch.
- Assuming Financial Transmission Rights (FTRs) (bespoke for renewables) would be introduced alongside locational energy pricing, generators would be able to manage locational price risk, arguably more easily compared to the status quo arrangements (TNUoS).
- Generators are less able to manage volume risk, which is problematic due to application of the negative pricing rule with the current CfD.
- Combining locational energy pricing with the Deemed Generation CfD makes it possible to settle against the national average price (to send a market-based long-run locational signal) while retaining low investor cost of capital as the negative pricing rule need not apply, so reducing volume risk at low prices.
- However, more work needs to be done to determine the appropriate allocation of risk between generators and consumers, as well as understanding the interaction between locational pricing and the Strategic Spatial Energy Plan, before these design decisions are firmed up.

Figure 30. Comparison of key features of Current CfD and Deemed Generation CfD

	More risk on generators	More risk on consumers
Negative price rule	**Current CfD with negative price rule** • A **negative price rule is needed** to stop generators producing when prices negative as generators must produce to receive subsidy. • If settling against national price, packaging the current CfD with locational energy pricing would require **applying the negative pricing rule to the local price in order to prevent dispatch distortions** (when national price positive but local price negative), increasing volume risk for some generators.	**Deemed Generation CfD without negative price rule** • No need for negative pricing rule as **generators self-curtail** when wholesale price below marginal cost, therefore significantly less volume risk for generators at low wholesale prices as they would always receive a top up (from zero), even when prices negative. • However, **double payments** (through BM) must be avoided.
Reference price	**Current CfD or Deemed Generation CfD settled against national price w/ locational energy pricing** • More locational price risk for generators in congested areas as top-up revenues will be lower, which may result in higher strike prices. In less constrained areas, assets may become more competitive. • Locational price risk can be mitigated with bespoke **Financial Transmission Rights (FTRs)**, which improves upon status quo (i.e. challenging for generators to manage risks associated with TNUoS).	**Current CfD or Deemed Generation CfD settled against local price w/ locational energy pricing** • No locational price risk for generators. • However, this design would need an **alternative locational signal** that would not be market-based (as locational energy pricing requires removal of locational signal from transmission charges to avoid double-charging), which would transfer more risk to consumers compared to status quo (i.e. TNUoS).

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ESO's view on CM reform as part of wider package

There are limits on the extent to which the CM can be adapted to effectively address the power system's changing system needs. Adequate arrangements need to be in place by the early 2030s.

- Stress events are expected to become less frequent but potentially much longer, so we need to consider more fundamental reform to the CM
- Policy choices will depend on:
  - decision on wholesale market design as this potentially restores missing money to the wholesale market and choice of market design could impact choice of mechanism
  - status of market failures that underpin the CM given wider reforms, particularly concerning the flexibility of demand
- Interventions must be able to:
  - target procurement more accurately to system needs, which requires linking renumeration to wholesale prices
  - treat resources fairly
- There are limits to the CM's capability to achieve this, even if reformed.

- Possible alternatives to the CM, which can be implemented as standalone options or packaged together, include:
  - **Reliability Options –** similar to the CM as they provide revenue stabilisation for capacity providers but different as they are financial contracts (i.e. call or put options) instead of physical contracts. They align closely with wholesale energy prices, provide strong incentives to deliver, enable market actors to trade out of position near real-time and provide optional hedge for consumers against extreme prices. However, implementation in other jurisdictions has been limited and not always effective, so considerable effort would be needed to ensure the design effectively achieves targeted objectives.
  - **Strategic Reserves –** these are availability contracts awarded through competitive procurement but resources can not compete in the wholesale energy market in order to prevent distortions. They could help cost-effectively manage the exit of high carbon assets so long as their design effectively mitigates the "slippery slope" risk.
  - **A Scarcity Adder –** administratively restores capacity value to wholesale energy prices, directly restoring missing money for flexibility.

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Conclusions and Next Steps

Summary conclusions on market reforms

Phase 4 conclusions: Wholesale market reform decisions should precede and determine investment policy choices. Policy reform should respect market signals and achieve appropriate allocation of risk.

Wholesale market reform: decision on market design should precede and determine investment policy choices

- **Temporally and locationally granular wholesale energy prices** are fundamental to achieving REMA's objectives as they: drive **efficient investment** by signalling assets to site efficiently; restore 'missing money'; and ensure efficient use of renewables and flexible resources e.g. interconnectors and storage.
- It is therefore crucial that investment policies are designed to **respect the integrity of accurate wholesale market signals**.
- Wholesale market reform will alter the **risk profile** for investors. Therefore, securing large volumes of low cost finance requires continued **de-risking support** along with **grandfathering** for existing investments and improved **wider investment conditions.**

Mass low carbon support: market reform decision and appropriate risk allocation should guide choices

- The design of the low carbon support mechanism should safeguard consumers' interests through **low cost of capital for investment, reduced distortions (to reduce costs) and appropriate allocation of risk.**
- **Today's CfD does not necessarily need to be overhauled** - both the existing and a deemed generation CfD could work in a locational market. **Whether and how to reform the CfD depends on decisions relating to:**

  1. Wholesale market design reform.
  2. How to allocate risk between producers and consumers.

- CfD auctions combined with **demand-led contracting**, must deliver adequate capacity volumes each year.

System security/adequacy policy: adapt to changing system stress and market failures

- System adequacy policy needs to be adapted to deliver: 1) **more effective response** to stress events in the 2020s; and 2) **sustained response** for rarer events of long duration as we move into the 2030s. Market reform decision, risk allocation and market failures should guide choices.
- More **ambitious bespoke innovation policy** for **emerging low carbon dispatchable technologies** that can sustain response for days/weeks.
- **More ambitious energy efficiency policy**, through traditional approaches rather than through power policies.

We see the market reform journey in 3 parallel phases:

1. **Flex mobilisation (today to 2028):** implement enablers of flexibility ASAP ahead of wholesale market reform.
2. **Wholesale market reform:** make decision as soon as possible, design market through 2020s, implement by early 2030s.
3. **Investment policy realignment (2025-2030):** once wholesale market design decision made, reform investment policy as appropriate.

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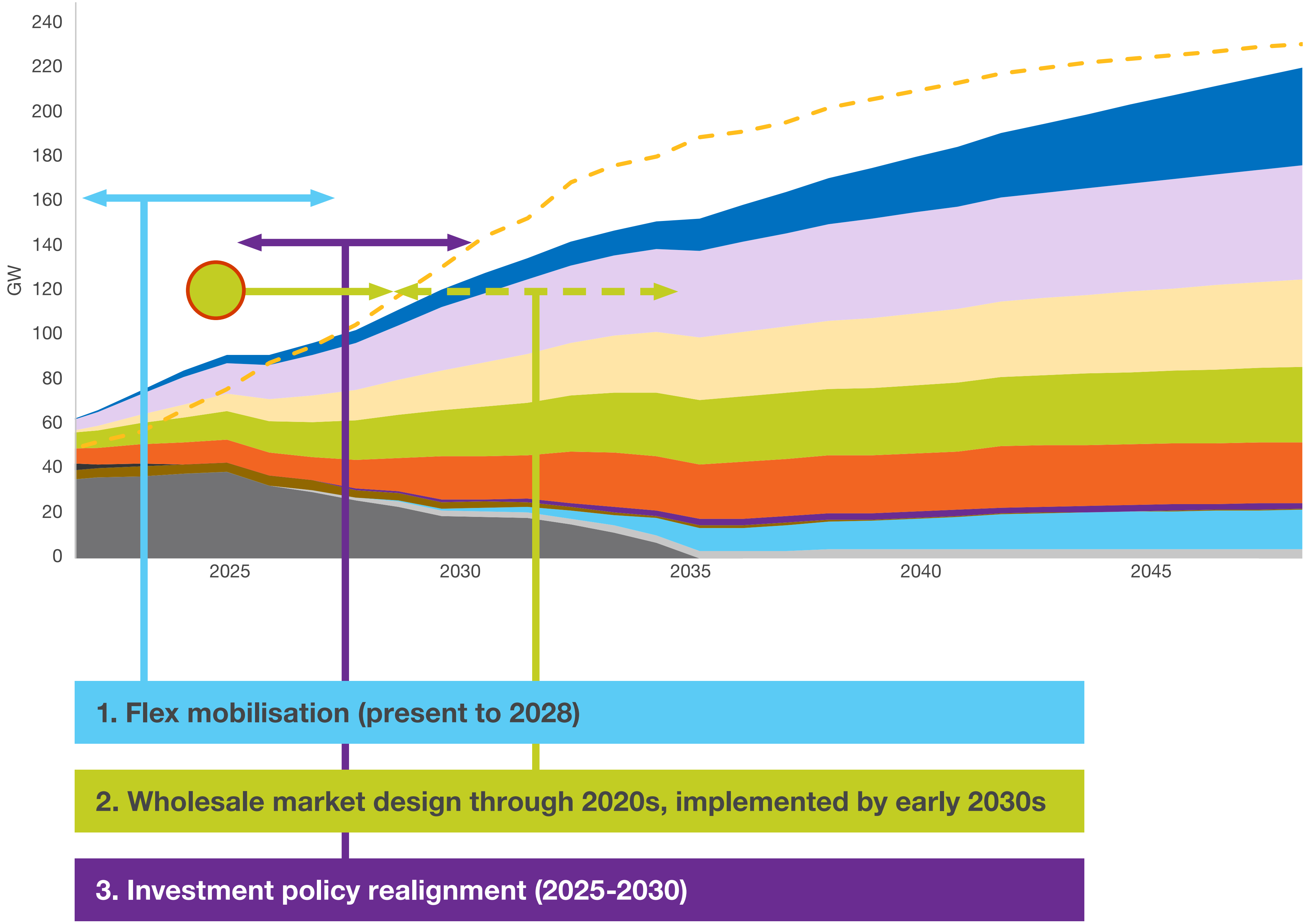
Three implementation phases for holistic market reforms

We see the market reform journey in three parallel phases:

Massive expansion in both renewables and dispatchable resources are foreseen over the time period to 2050. Dispatchable capacity is likely to be dominated by two-way resources such as interconnectors, storage and demand-side response (DSR). Granular locational energy price signals are critical to the efficient investment and dispatch of these two-way resources, and complementary investment and innovation policies are also needed.

Figure 31. Dispatchable supply & demand versus renewable capacity, 2020-2050



Key

- Renewables
- Electrolysis
- Storage
- V2G
- DSR
- Interconnectors
- Coal
- BECCS
- Biomass
- Hydrogen
- Gas CCUS
- Gas

- Wholesale market decision from 2024
- Wholesale market design and implementation
- Wholesale market implementation complete depending on design
- Flex foundation
- Investment policy realignment

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

Net Zero Market Reform / Conclusions and Next Steps 114

Three implementation phases for holistic market reforms

We see the market reform journey in three parallel phases:

Massive expansion in both renewables and dispatchable resources are foreseen over the time period to 2050. Dispatchable capacity is likely to be dominated by two-way resources such as interconnectors, storage and demand-side response (DSR). Granular locational energy price signals are critical to the efficient investment and dispatch of these two-way resources, and complementary investment and innovation policies are also needed.

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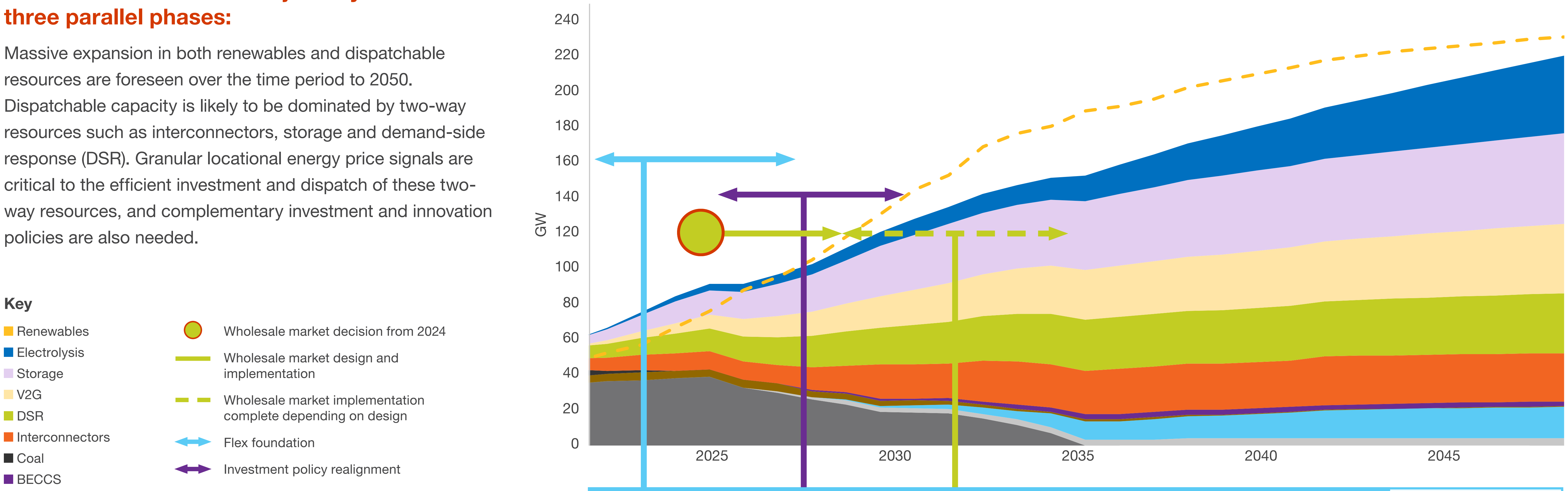

1. Flex mobilisation (present to 2028)

Drivers for phase: rapid expansion in flexible capacity

Focus: expedite enabling processes including:

- Smart metering rollout
- Market-wide half-hourly settlement
- Retail market reforms
- Remove market barriers
- Connections and tariff reform
- Coordinate markets across whole system
- Standardise communication protocols across whole system markets
- Transform digital infrastructure

Three implementation phases for holistic market reforms

We see the market reform journey in three parallel phases:

Massive expansion in both renewables and dispatchable resources are foreseen over the time period to 2050. Dispatchable capacity is likely to be dominated by two-way resources such as interconnectors, storage and demand-side response (DSR). Granular locational energy price signals are critical to the efficient investment and dispatch of these two-way resources, and complementary investment and innovation policies are also needed.

Key

- Renewables
- Electrolysis
- Storage
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- Wholesale market design and implementation
- Wholesale market implementation complete depending on design
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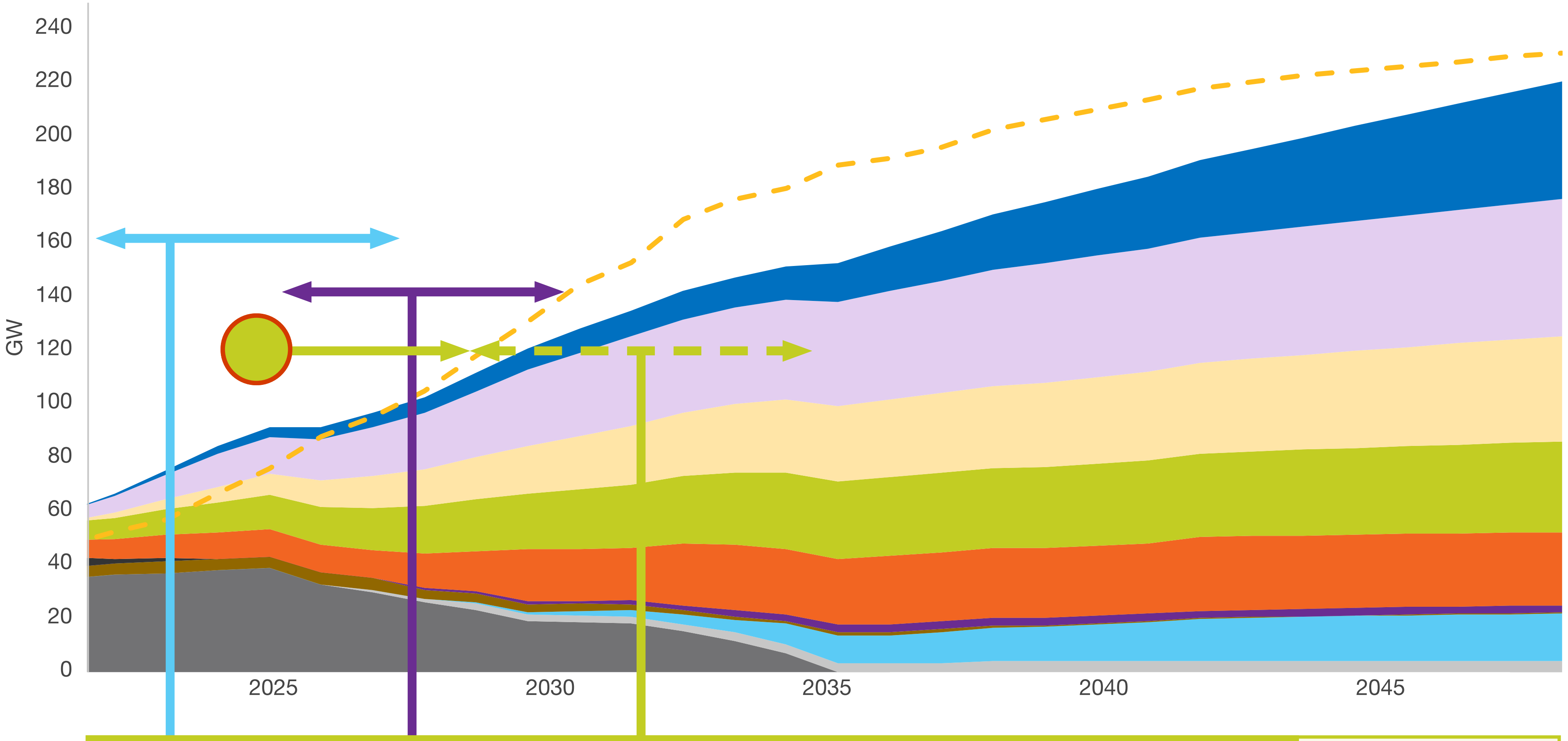

2. Wholesale market design through 2020s, implemented by early 2030s

Drivers for phase: Demand flexibility, storage and interconnectors dominate GB's dispatchable capacity

Focus:

- Locational energy pricing required to unlock the full potential of flexible assets as well as renewables align assets with two-way flows with system needs
- Reform to dispatch/scheduling may be required to maximise participation of flexible resources

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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Three implementation phases for holistic market reforms

We see the market reform journey in three parallel phases:

Massive expansion in both renewables and dispatchable resources are foreseen over the time period to 2050. Dispatchable capacity is likely to be dominated by two-way resources such as interconnectors, storage and demand-side response (DSR). Granular locational energy price signals are critical to the efficient investment and dispatch of these two-way resources, and complementary investment and innovation policies are also needed.

Key

- Renewables
- Electrolysis
- Storage
- V2G
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- Wholesale market decision from 2024
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- Investment policy realignment

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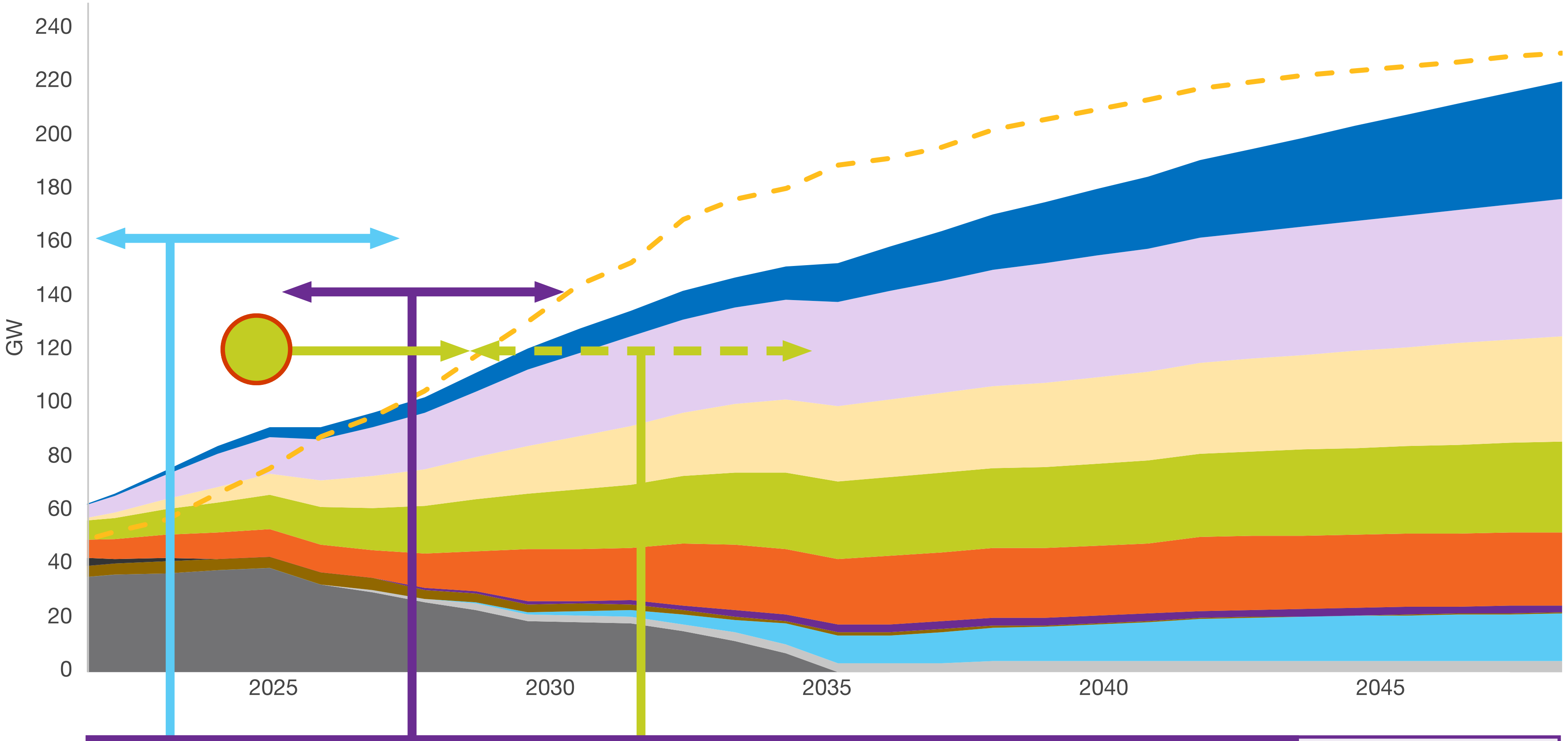

3. Investment policy realignment (2025-2030)

Drivers for phase: Total £bn CfD support triples between 2025-35* and costly distortions caused by the CfD could become unsustainable with scale up of investment using CfDs. Stress events become bidirectional with excess demand and excess generation and swings between the two while average length of tight periods triples between 2030-35 though frequency of tight periods reduces.

Focus:

- In the short term, implement improvements to the CfD and CM, ensuring coherence with chosen wholesale market design
- In second half of 2020s, decide on system security arrangements for post 2030, capable of cost-efficiently meeting radically different system needs

Note: Year ranges represent illustrative implementation dates, * ESO Net Zero Market Reform Phase 2: analysis by LCP.

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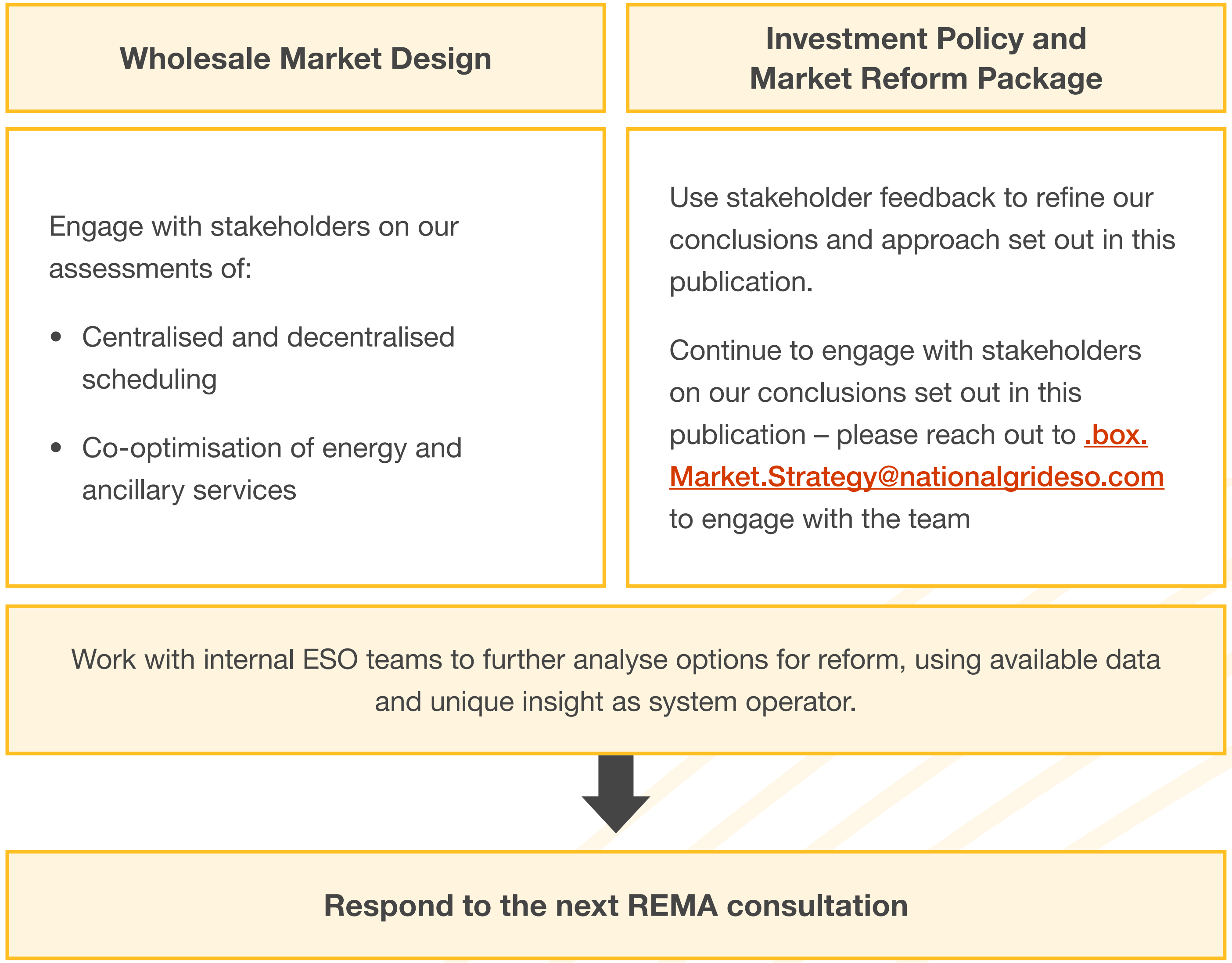
Next Steps

Figure 32 sets out the next steps for our NZMR programme following this report. We will continue to analyse wholesale market design, investment policy options and coherent market reform packages, working closely with other ESO teams to further develop our view on efficient market reform for net zero. We will draw on this, along with all stakeholder feedback, to respond to the next REMA consultation expected this autumn.

In parallel, from our unique position as electricity system operator, and as a trusted strategic partner in REMA, the ESO will continue to support the Government and Ofgem on the design and implementation of reform options as they are narrowed down in REMA, specifically advising on their impact on GB electricity system operation. This is a role we expect to continue beyond the consultation as we continue the transition to a Future System Operator (FSO).

Figure 32. Next steps for the NZMR programme



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Appendix

Appendix 1.1 Baringa Packages

Nodal build

1st priority Market Design (Operation)	**Wholesale market** Location	National pricing; Zonal pricing; Nodal pricing
	Wholesale market Tech	Split by characteristic; Unified Market
	Wholesale market Balancing	National
	Wholesale market Price formation	Pay-as-clear
	Wholesale market Dispatch	Self-dispatch; Central dispatch
2nd priority Policy (Investment)	Mass low carbon power	Existing CfD; Evolved CfD (locational auctions); Deemed generation CfD; Financial CfD; CfD with cap and floor; Revenue Cap and Floor; Elective participation / Carbon Futures Market; Supplier Obligation (Carbon)
	Flexibility	Supplier Obligation (CPS) (Flex); Reverse Reliability Option
	Capacity adequacy	Existing CM; Evolved CM; Optimised CM - Zonal; Optimised CM - Carbon; CM with flex enhancements; Centralised Reliability Option; Decentralised Reliability Option; Scarcity adder; Strat Reserve
3rd priority Operability and more	Operability	BAU; BAU+; Local Markets; Co-optimisation
	Other	Physical transmission rights/Financial transmission rights; Network access and charging reform; Settlement period reform; Carbon intensity reporting

Key: Package

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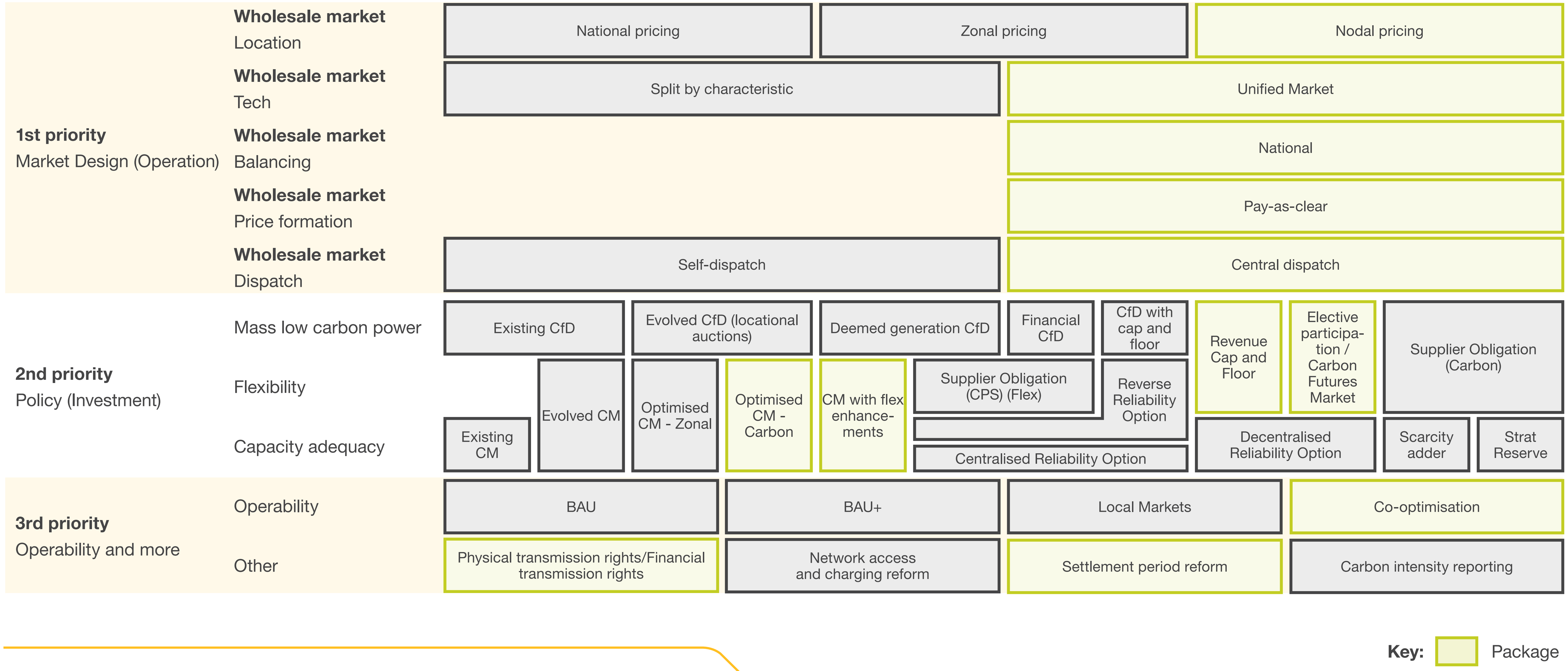
Appendix 1.1 Baringa Packages

Nodal baseline



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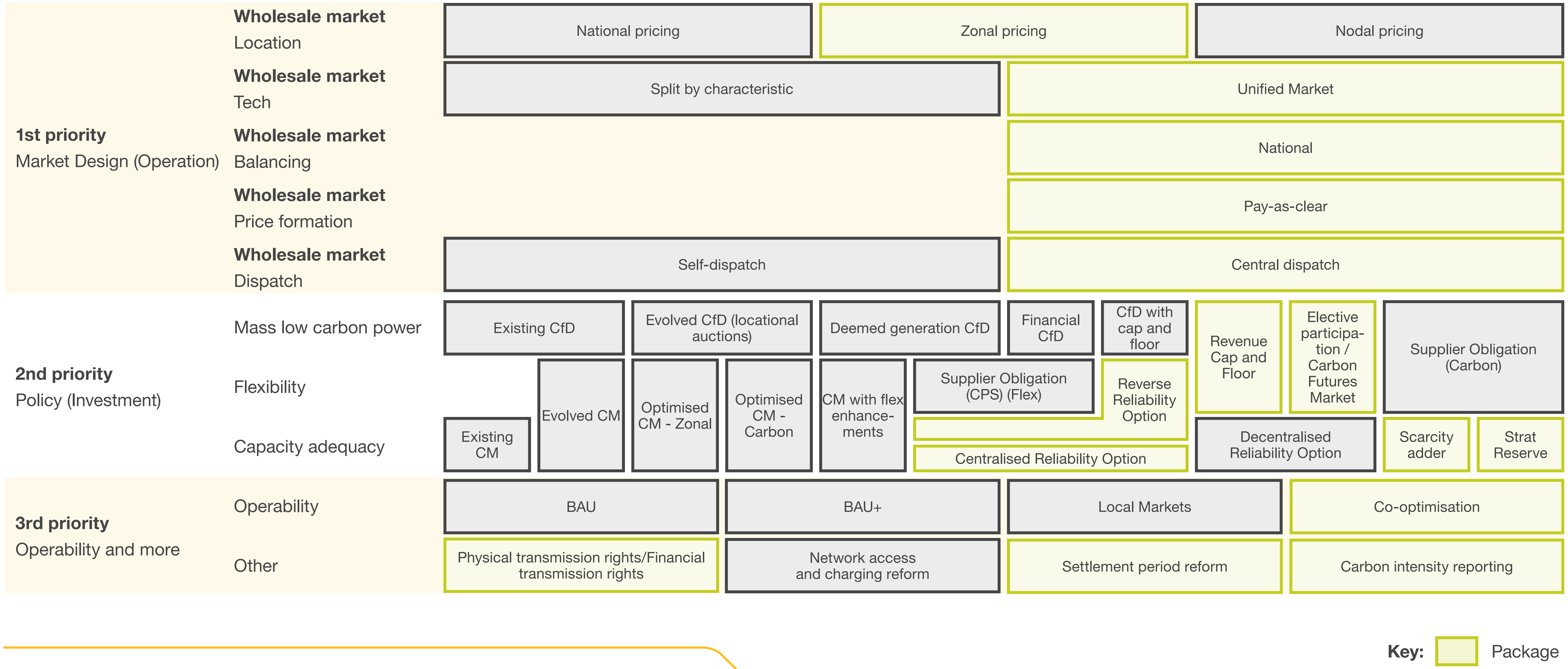
Appendix 1.1 Baringa Packages

Zonal build



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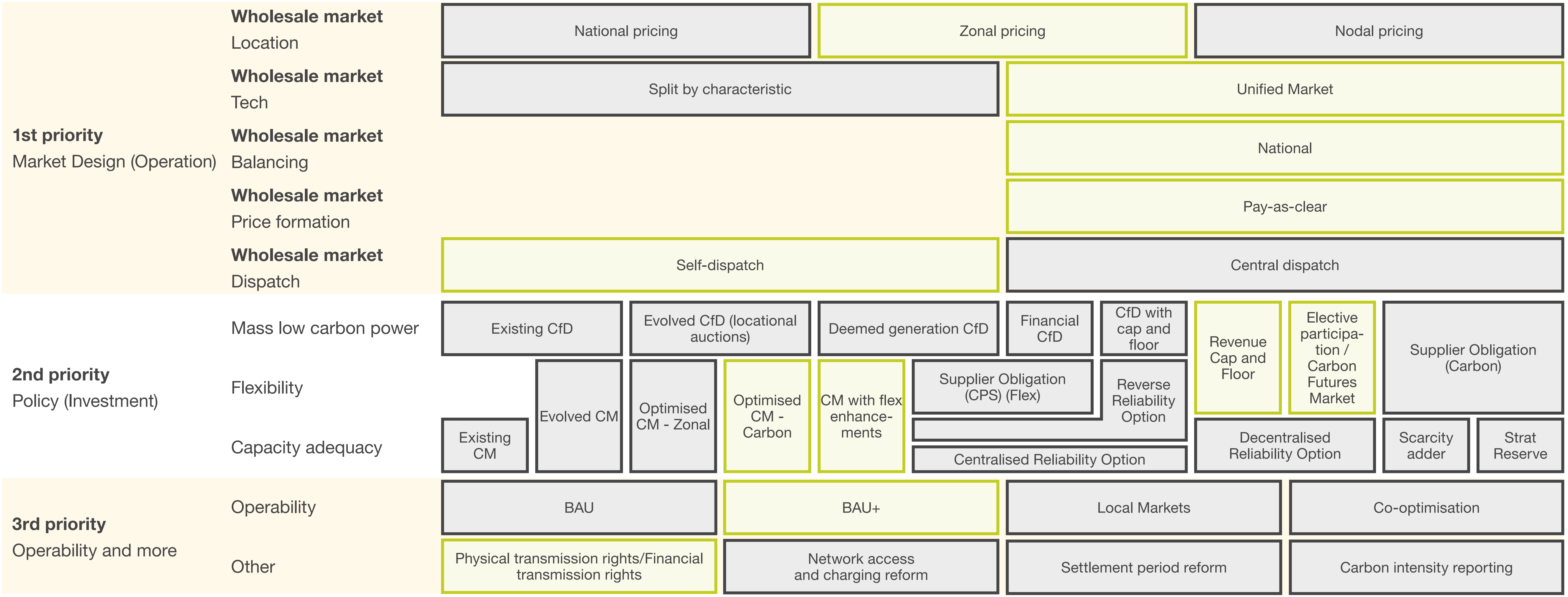
Appendix 1.1 Baringa Packages

Zonal baseline



Key: Package

Net Zero Market Reform / Appendix 123

Appendix 1.1 Baringa Packages

National build

Priority	Area	Options
1st priority Market Design (Operation)	**Wholesale market** Location	National pricing; Zonal pricing; Nodal pricing
	Wholesale market Tech	Split by characteristic; Unified Market
	Wholesale market Balancing	National
	Wholesale market Price formation	Pay-as-clear
	Wholesale market Dispatch	Self-dispatch; Central dispatch
2nd priority Policy (Investment)	Mass low carbon power	Existing CfD; Evolved CfD (locational auctions); Deemed generation CfD; Financial CfD; CfD with cap and floor; Revenue Cap and Floor; Elective participa-tion / Carbon Futures Market; Supplier Obligation (Carbon)
	Flexibility	Evolved CM; Optimised CM - Zonal; Optimised CM - Carbon; CM with flex enhance-ments; Supplier Obligation (CPS) (Flex); Reverse Reliability Option
	Capacity adequacy	Existing CM; Centralised Reliability Option; Decentralised Reliability Option; Scarcity adder; Strat Reserve
3rd priority Operability and more	Operability	BAU; BAU+; Local Markets; Co-optimisation
	Other	Physical transmission rights/Financial transmission rights; Network access and charging reform; Settlement period reform; Carbon intensity reporting

Key: Package

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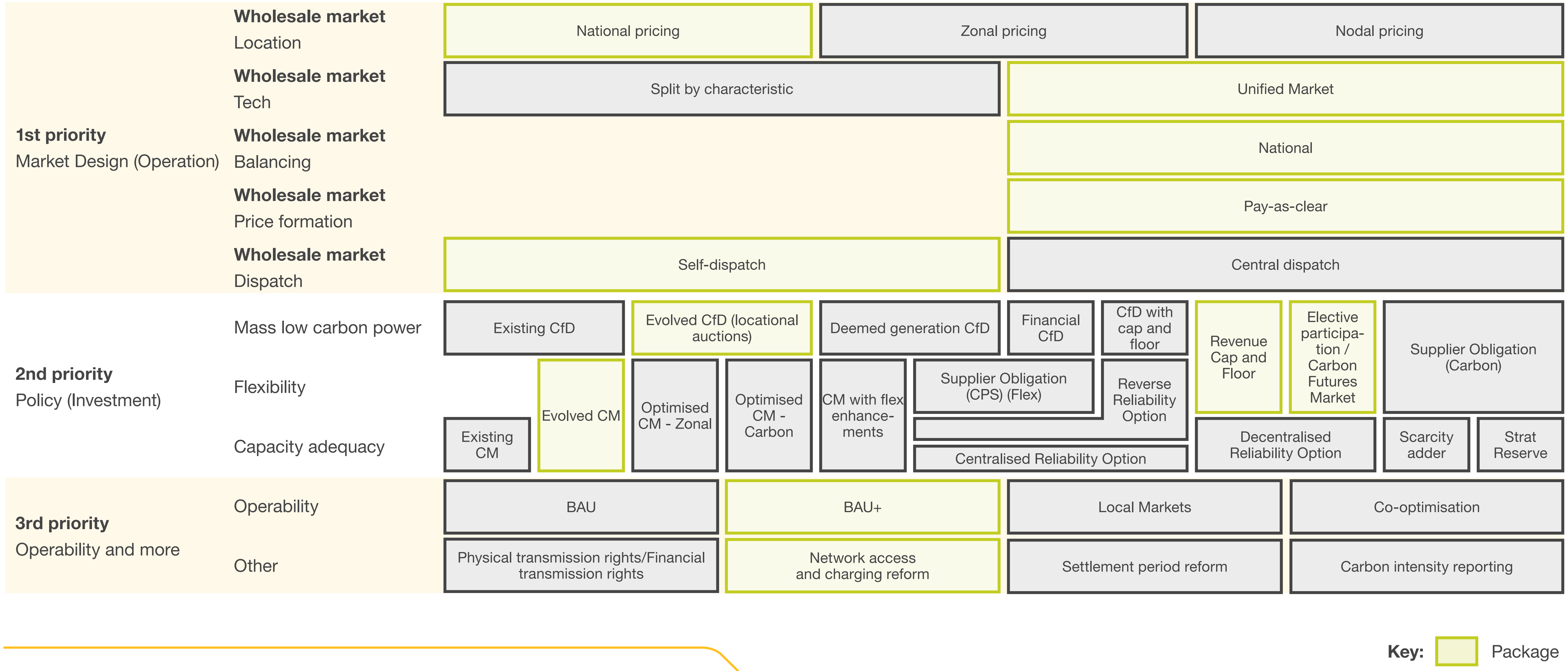
Appendix 1.1 Baringa Packages

National baseline



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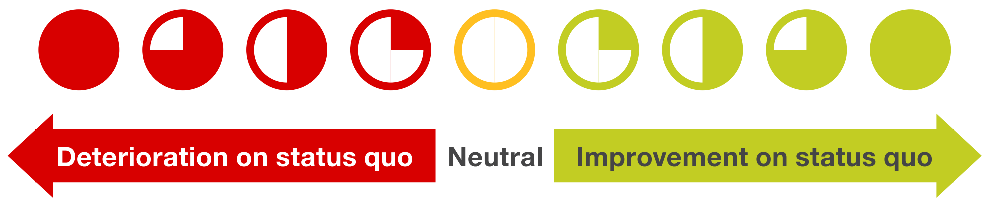
Appendix 1.2 Baringa Scoring



Scoring of individual options, by category

Wholesale pricing and dispatch	Assessment criteria scores	Sub-criteria scores
Mass Low Carbon	Assessment criteria scores	Sub-criteria scores
Capacity Adequacy	Assessment criteria scores	Sub-criteria scores
Operability	Assessment criteria scores	Sub-criteria scores
Additional Options	Assessment criteria scores	Sub-criteria scores

Scoring of different packages of options

Package Assessment	Assessment criteria scores	Sub-criteria scores

Note: The scores are represented here for convenience but for full explanation and discussion, see the full report “Assessment of Investment Policy and Market Design Packages”, available at: nationalgrideso.com/document/276841/download

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Appendix 1.2 Baringa Scoring

Wholesale Pricing and Dispatch (Assessment criteria scores)

	Pricing System			Dispatch		Additional
Criteria	National	Zonal	Nodal	Self	Central	FTR/PTR
Value for Money	○	◑	◕	○	◔	○
Energy security and system operability	○	◔	◔	○	○	○
Decarbonisation	○	◔	◑	○	◔	○
Competition	○	◑	◔	○	◑	◔
Challenge to implement	○	◕	●	○	◑	◑
Investor confidence	○	◑	◑	○	◔	◔
Full chain flexibility	○	◑	◕	○	◑	○
Whole system	○	◑	◕	○	◑	○
Adaptability	○	◔	◑	○	○	○
Consumer fairness	○	◔	◔	○	○	◑
Total	○	◑	◕	○	◕	◑
Total - prioritise VfM, Security and Decarb	○	◑	◕	○	◕	◑

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Appendix 1.2 Baringa Scoring

Wholesale pricing and dispatch (Sub-criteria scores)

		Pricing System			Dispatch		Additional
		National	Zonal	Nodal	Self	Central	FTR/PTR
Value for Money	Reduce relative proportion of redispatch	○	◕	●	○	◑	○
	Improve operational efficiency of interconnectors	○	◑	◕	○	○	○
	Ensure appropriate risk allocation and efficient cost of capital	○	◔	◑	○	○	○
	Increase system flexibility	○	◕	●	○	◔	○
	Reduce in efficient inframarginal rent	○	◔	◑	○	○	○
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	○	◔	◔	○	○	○
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	○	◔	◔	○	○	○
	Ensure sufficient responsive capacity to maintain system operability	○	○	○	○	◑	○
	Manage external shocks and unintended consequences	○	○	◔	○	◔	○
Decarbonisation	Increase probability of achieving decarbonisation objective	○	◔	◑	○	◔	○
Competition	Align markets/avoid distortions	○	◕	●	○	◑	○
	Better target system costs through market signals	○	◕	●	○	◑	○
	Promote greater inter-technology competition	○	○	○	○	◔	○
	Promote greater market transparency	○	◑	●	○	◕	◑
	Reduce barriers to entry	○	◑	◕	○	◔	◑
	Reduce risk of gaming or exploitation of market power	○	◑	◔	○	○	○
Challenge to implement	Minimise policy complexity/interdependencies	○	◑	●	○	◔	◑
	Minimise market disruption	○	◕	●	○	◑	◔
	Reduce implementation cost	○	◕	●	○	◕	◑
	Reduce risk of unproven solutions	○	◔	◑	○	◔	○
	Expedite implementation	○	◑	●	○	◕	◑
Investor confidence	Respect existing legal framework and rights	○	◕	●	○	○	◕
	Provide assurance for debt holders	○	◑	◕	○	○	◑
	Provide suitable incentives for equity	○	◑	◕	○	○	◔
	Promote market liquidity	○	◑	◕	○	◑	◔
	Minimise ongoing regulatory risk	○	◕	◔	○	◔	○
Full chain flexibility	Optimise investment in flexibility	○	◑	◕	○	◔	○
	Optimise dispatch of flexibility	○	◕	●	○	◕	○
	(Manage large and extended mismatches between supply and demand	○	◔	◑	○	○	○
	Promote demand side participation	○	◔	◕	○	◑	○
Whole system	Align investment incentives for cross-vector assets	○	◔	◑	○	○	○
	Align dispatch incentives for cross-vector assets	○	◑	◕	○	◔	○
Adaptability	Facilitate new and evolving business models	○	◔	◑	○	○	○
	Reduce risk of lock-in or asset stranding	○	◔	◑	○	○	○
	Adapt to changing technology trends	○	◔	◑	○	○	○
Consumer fairness	Limit adverse distributional impacts for consumers	○	◕	●	○	○	◕
	Allow greater consumer choice	○	◔	◑	○	○	○
	Facilitate fair allocation of costs, based on cost-reflectivity	○	◔	◑	○	○	○

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Appendix 1.2 Baringa Scoring

Mass low carbon power (Assessment criteria scores)

Criteria	Existing CfD	Evolved CfD	CfD + Price Cap/Floor	Revenue Cap/Floor	Deemed CfD	Elective Participation	Supplier Obligation	Financial CfD
Value for Money	○	○	◔	◑	◔	○	◔	◔
Energy security and system operability	○	○	○	◔	◔	○	◔	◔
Decarbonisation	○	○	◔	◔	◔	◔	◑	◔
Competition	○	◔	◔	◔	◔	○	◔	○
Challenge to implement	○	○	◔	◑	◑	◑	◕	◑
Investor confidence	○	○	◔	◔	○	◔	◔	◔
Full chain flexibility	○	○	◔	◑	◑	○	◑	◑
Whole system	○	○	◑	◑	◑	◑	◕	◑
Adaptability	○	○	◔	◔	○	◔	◕	○
Consumer fairness	○	○	○	○	○	◔	◑	◔
Total	○	◔	◑	◑	◔	◔	◑	◔
Total - prioritise VfM, Security and Decarb	○	◔	◑	◕	◑	◔	◑	◑

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Appendix 1.2 Baringa Scoring

Mass Low Carbon Power (Sub-criteria scores)

		Existing CfD	Evolved CfD	CfD + Price Cap/ Floor	Revenue Cap/Floor	Deemed CfD	Elective Participation	Supplier Obligation	Financial CfD
Value for Money	Reduce relative proportion of redispatch	○	◔	◔	◑	◔	○	◑	◔
	Improve operational efficiency of interconnectors	○	◔	◔	◔	◔	○	◔	◔
	Ensure appropriate risk allocation and efficient cost of capital	○	○	◔	◑	○	◔	◑	○
	Increase system flexibility	○	○	◑	◕	◕	○	◕	◕
	Reduce in efficient inframarginal rent	○	○	○	○	○	○	◑	○
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	○	○	○	○	○	○	○	◔
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	○	○	○	◔	○	○	○	◔
	Ensure sufficient responsive capacity to maintain system operability	○	○	◔	◑	◑	○	◑	◑
	Manage external shocks and unintended consequences	○	○	○	○	○	○	○	○
Decarbonisation	Increase probability of achieving decarbonisation objective	○	○	◔	◔	◔	◔	◑	◔
Competition	Align markets/avoid distortions	○	◔	◑	◕	◕	◑	●	●
	Better target system costs through market signals	○	◔	◕	◕	●	○	●	●
	Promote greater inter-technology competition	○	◔	◑	◑	◔	◑	●	◔
	Promote greater market transparency	○	○	○	◔	○	◔	◑	○
	Reduce barriers to entry	○	○	◔	◔	○	◔	◑	◑
	Reduce risk of gaming or exploitation of market power	○	○	○	◔	◑	○	○	◔
Challenge to implement	Minimise policy complexity/interdependencies	○	○	○	○	◔	◔	◑	◔
	Minimise market disruption	○	○	◔	◑	◑	◑	◕	◑
	Reduce implementation cost	○	○	◔	◑	◑	◑	◕	◑
	Reduce risk of unproven solutions	○	○	○	◔	◑	◔	○	◑
	Expedite implementation	○	○	○	◑	◑	◑	◕	◑
Investor confidence	Respect existing legal framework and rights	○	○	○	○	○	○	○	○
	Provide assurance for debt holders	○	○	◔	◔	◔	○	◕	◔
	Provide suitable incentives for equity	○	○	◑	◑	○	◔	◕	○
	Promote market liquidity	○	○	◑	◑	○	◑	◕	○
	Minimise ongoing regulatory risk	○	○	○	○	◔	◔	○	◔
Full chain flexibility	Optimise investment in flexibility	○	○	◔	◔	◔	○	◔	◔
	Optimise dispatch of flexibility	○	○	◑	◕	◕	◔	◔	◕
	(Manage large and extended mismatches between supply and demand	○	○	◔	◑	◑	○	◑	◑
	Promote demand side participation	○	○	○	○	○	○	◔	○
Whole system	Align investment incentives for cross-vector assets	○	○	◔	◔	◔	◔	◕	◔
	Align dispatch incentives for cross-vector assets	○	○	◑	◑	◑	◑	◕	◑
Adaptability	Facilitate new and evolving business models	○	○	○	○	○	◔	◔	○
	Reduce risk of lock-in or asset stranding	○	○	◔	◔	○	◑	◑	◔
	Adapt to changing technology trends	○	○	◔	◕	○	◔	●	○
Consumer fairness	Limit adverse distributional impacts for consumers	○	○	○	○	○	○	◔	○
	Allow greater consumer choice	○	○	○	○	○	◑	●	○
	Facilitate fair allocation of costs, based on cost-reflectivity	○	◔	◑	◑	◔	○	◑	◔

Appendix 1.2 Baringa Scoring

Capacity adequacy (Assessment criteria scores)

Criteria	Evolved CM	Optimised CM - Zonal	CM - Minimum Carbon	CM + Enhanced Flex	CRO	Optimised CRO - Zonal	CRO - Minimum Carbon	CRO + Enhanced Flex	DRO	RRO	Supplier Obligation CA	Strategic Reserve
Value for Money	◔	◔	◔	◑	◔	◑	◔	◕	○	◑	◔	○
Energy security and system operability	◔	◔	○	◑	◔	◑	◔	◕	○	○	◔	◑
Decarbonisation	○	○	◑	◔	○	○	◑	◔	○	◑	○	○
Competition	○	○	◔	◑	◔	◔	◑	◕	◔	◑	◔	◔
Challenge to implement	○	◔	◔	◔	◑	◑	◕	◑	◕	◕	◑	◔
Investor confidence	○	○	○	◔	◔	○	◔	◔	◔	◔	○	○
Full chain flexibility	○	○	○	◑	◑	◑	◔	◕	○	◑	○	○
Whole system	○	○	◔	◔	◑	◔	◑	◑	◑	◔	◔	○
Adaptability	◔	◔	◑	◑	◔	◑	◕	◕	◑	○	◑	◔
Consumer fairness	○	○	○	○	◔	◔	◔	◔	◔	○	◔	○
Total	◔	◔	◑	◑	◑	◑	◑	◕	◔	◑	◑	◔
Total - prioritise VfM, Security and Decarb	◔	◑	◑	◕	◑	◑	◑	◕	◔	◑	◑	◔

Appendix 1.2 Baringa Scoring

Capacity adequacy (Sub-criteria scores)

Criterion	Sub-criterion	Existing CM	Evolved CM	Optimised CM - Zonal	CM - Minimum Carbon	CM + Enhanced Flex	CRO	Optimised CRO - Zonal	CRO - Minimum Carbon	CRO + Enhanced Flex	DRO	RRO	Supplier Obligation CA	Strategic Reserve
Value for Money	Reduce relative proportion of redispatch	○	◔	◔	○	◔	○	◔	○	◔	○	◔	○	○
	Improve operational efficiency of interconnectors	○	◔	◔	○	◔	○	◔	○	◔	○	○	○	○
	Ensure appropriate risk allocation and efficient cost of capital	○	○	○	○	○	◔	◔	◔	◔	◔	◔	◔	○
	Increase system flexibility	○	○	○	○	◕	○	○	○	◕	○	◕	◔	○
	Reduce in efficient inframarginal rent	○	◔	◑	◑	◑	◑	◕	◕	◕	◑	◑	○	◔
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	○	◔	◑	○	◔	○	◑	○	◔	−◔	○	−◔	◑
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	○	◔	◔	○	◕	◑	◕	◑	●	◔	○	◑	◔
	Ensure sufficient responsive capacity to maintain system operability	○	◔	◔	○	◑	○	○	○	◑	○	◔	◔	◔
	Manage external shocks and unintended consequences	○	○	○	○	◑	○	○	○	◔	○	○	◑	◕
Decarbonisation	Increase probability of achieving decarbonisation objective	○	○	○	◑	◔	○	○	◑	◔	○	◑	○	○
Competition	Align markets/avoid distortions	○	○	○	○	○	◑	◑	◑	◑	◕	◑	◑	−◔
	Better target system costs through market signals	○	○	◔	○	◑	○	◔	○	◑	◔	○	◑	○
	Promote greater inter-technology competition	○	○	○	◑	◑	◔	◔	◕	◕	◑	◑	◑	○
	Promote greater market transparency	○	○	○	○	◑	◑	◑	◑	◕	◔	◑	◔	−◔
	Reduce barriers to entry	○	○	○	◕	◕	◔	◔	◕	◕	−◔	◕	−◔	○
	Reduce risk of gaming or exploitation of market power	○	○	−◔	○	○	◔	○	◔	◔	○	◔	○	−◑
Challenge to implement	Minimise policy complexity/interdependencies	○	○	○	○	○	◔	◔	◔	◔	◔	−◑	◑	−◔
	Minimise market disruption	○	○	−◔	−◔	−◔	−◑	−◕	−◕	−◕	−◕	−◔	○	○
	Reduce implementation cost	○	○	−◔	−◔	−◔	−◑	−◕	−◕	−◕	−◑	−◑	−◑	−◔
	Reduce risk of unproven solutions	○	○	○	−◔	−◔	−◔	−◔	−◑	−◑	−◑	−◕	○	○
	Expedite implementation	○	○	−◔	−◔	−◔	−◑	−◕	−◕	−◕	−◑	−◕	−◑	○
Investor confidence	Respect existing legal framework and rights	○	○	○	○	○	○	○	○	○	−◔	○	○	○
	Provide assurance for debt holders	○	○	○	○	◔	○	○	○	◔	−◔	◑	−◑	○
	Provide suitable incentives for equity	○	○	○	◔	◑	○	○	◔	◑	○	○	◑	○
	Promote market liquidity	○	○	○	○	◔	◑	◑	◑	◑	◑	◑	◔	○
	Minimise ongoing regulatory risk	○	○	−◔	○	○	−◔	−◑	−◔	−◔	−◑	−◔	−◔	○
Full chain flexibility	Optimise investment in flexibility	○	○	○	○	◕	◔	◔	◔	●	◔	◑	○	○
	Optimise dispatch of flexibility	○	○	○	○	◑	◔	◔	◔	◕	◔	◔	−◔	○
	(Manage large and extended mismatches between supply and demand	○	○	○	○	◑	◑	◑	◑	◕	◑	◑	−◔	◔
	Promote demand side participation	○	○	○	○	◑	◑	◑	◑	◕	◑	◑	◔	○
Whole system	Align investment incentives for cross-vector assets	○	○	○	◔	◔	◔	◔	◑	◑	◔	◔	◔	○
	Align dispatch incentives for cross-vector assets	○	○	○	○	○	◔	◔	◔	◔	◔	◔	◔	○
Adaptability	Facilitate new and evolving business models	○	○	○	◔	◑	◔	◔	◑	◕	◑	◑	◑	○
	Reduce risk of lock-in or asset stranding	○	◔	◑	◑	◔	○	◑	◑	◔	○	−◔	◔	◔
	Adapt to changing technology trends	○	◔	○	◑	◑	◔	◔	◕	◕	◑	○	◑	◔
Consumer fairness	Limit adverse distributional impacts for consumers	○	○	○	○	○	○	○	○	○	−◔	○	○	○
	Allow greater consumer choice	○	○	○	○	○	◔	◔	◔	◔	◑	○	○	○
	Facilitate fair allocation of costs, based on cost-reflectivity	○	○	○	○	○	◔	◔	◔	◔	◔	◔	◑	○

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Appendix 1.2 Baringa Scoring

Operability (Assessment criteria scores)

Criteria	Operability BAU+	Co-optimisation	Local Markets
Value for Money	◔	◔	◔
Energy security and system operability	◔	○	◔
Decarbonisation	◑	◔	◑
Competition	◔	◑	◑
Challenge to implement	○	◕	◕
Investor confidence	◔	◔	◔
Full chain flexibility	◑	◑	◕
Whole system	◔	◔	◔
Adaptability	◔	◔	◔
Consumer fairness	○	◔	◔
Total	◑	◑	◕
Total - prioritise VfM, Security and Decarb	◑	◑	◑

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Appendix 1.2 Baringa Scoring

Operability (Sub-criteria scores)

		Operability BAU+	Co-optimisation	Local Markets
Value for Money	Reduce relative proportion of redispatch	○	◑	◑
	Improve operational efficiency of interconnectors	○	○	◔
	Ensure appropriate risk allocation and efficient cost of capital	○	○	○
	Increase system flexibility	◑	◑	◕
	Reduce in efficient inframarginal rent	○	○	○
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	◔	○	◑
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	◔	○	○
	Ensure sufficient responsive capacity to maintain system operability	◑	◑	◑
	Manage external shocks and unintended consequences	◔	◔	○
Decarbonisation	Increase probability of achieving decarbonisation objective	◑	◔	○
Competition	Align markets/avoid distortions	◔	◑	◑
	Better target system costs through market signals	◔	◑	◕
	Promote greater inter-technology competition	◑	◔	◑
	Promote greater market transparency	◑	◕	◑
	Reduce barriers to entry	◔	◑	◑
	Reduce risk of gaming or exploitation of market power	○	◔	○
Challenge to implement	Minimise policy complexity/interdependencies	◔	◕	○
	Minimise market disruption	○	◑	◔
	Reduce implementation cost	○	◕	◑
	Reduce risk of unproven solutions	○	◔	◕
	Expedite implementation	○	◕	◕
Investor confidence	Respect existing legal framework and rights	○	○	○
	Provide assurance for debt holders	◔	○	○
	Provide suitable incentives for equity	◑	◔	◑
	Promote market liquidity	○	◑	◕
	Minimise ongoing regulatory risk	○	○	◔
Full chain flexibility	Optimise investment in flexibility	◑	◑	◑
	Optimise dispatch of flexibility	◑	◕	●
	(Manage large and extended mismatches between supply and demand	◔	○	◔
	Promote demand side participation	◑	◔	●
Whole system	Align investment incentives for cross-vector assets	○	○	○
	Align dispatch incentives for cross-vector assets	◔	◔	◑
Adaptability	Facilitate new and evolving business models	◑	◔	◑
	Reduce risk of lock-in or asset stranding	◔	◔	○
	Adapt to changing technology trends	◔	◔	◑
Consumer fairness	Limit adverse distributional impacts for consumers	○	○	○
	Allow greater consumer choice	○	◔	◔
	Facilitate fair allocation of costs, based on cost-reflectivity	○	○	○

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Appendix 1.2 Baringa Scoring

Other options (Assessment criteria scores)

Criteria	FTR/PR	Scarcity Adder	Access and Charging Reforms	Split Market	Settlement Period Reform	Carbon Intensity Reporting
Value for Money	◔	◔	◔	○	◔	○
Energy security and system operability	○	◔	◔	○	○	○
Decarbonisation	○	○	○	◔	○	◔
Competition	◔	◑	○	○	◔	◔
Challenge to implement	◑	◔	◔	◕	◑	◔
Investor confidence	◔	◔	○	○	○	○
Full chain flexibility	○	◑	◔	○	◑	○
Whole system	○	○	◔	○	◔	◔
Adaptability	○	◔	○	○	◔	○
Consumer fairness	◑	○	○	○	○	◔
Total	◑	◑	◑	○	◑	◑
Total - prioritise VfM, Security and Decarb	◑	◔	◑	○	◑	◑

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Appendix 1.2 Baringa Scoring

Other options (Sub-criteria scores)

		FTR/PTR	Scarcity Adder	Access and Charging Reforms	Split Market	Settlement Period Reform	Carbon Intensity Reporting
Value for Money	Reduce relative proportion of redispatch	○	○	◔	−◔	◔	○
	Improve operational efficiency of interconnectors	○	◔	○	○	○	○
	Ensure appropriate risk allocation and efficient cost of capital	◑	◔	◔	−◔	◔	○
	Increase system flexibility	○	◔	◔	○	◑	○
	Reduce in efficient inframarginal rent	○	◔	○	◕	○	○
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	○	◕	◔	○	○	○
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	○	◔	○	○	○	◑
	Ensure sufficient responsive capacity to maintain system operability	○	○	○	○	◔	○
	Manage external shocks and unintended consequences	○	○	○	○	○	○
Decarbonisation	Increase probability of achieving decarbonisation objective	○	○	○	◔	○	◔
Competition	Align markets/avoid distortions	○	◔	○	−◑	○	○
	Better target system costs through market signals	○	○	◔	○	◔	○
	Promote greater inter-technology competition	○	◑	○	○	◑	○
	Promote greater market transparency	◑	◑	◔	◑	◕	◕
	Reduce barriers to entry	◑	○	○	○	○	○
	Reduce risk of gaming or exploitation of market power	○	●	○	○	◔	○
Challenge to implement	Minimise policy complexity/interdependencies	−◑	−◔	−◔	−◕	−◑	◔
	Minimise market disruption	◔	○	○	−◑	−◑	○
	Reduce implementation cost	−◑	−◔	−◔	−◕	−◔	−◔
	Reduce risk of unproven solutions	○	◔	−◔	−◑	−◔	○
	Expedite implementation	−◑	−◔	−◔	−◕	−◑	○
Investor confidence	Respect existing legal framework and rights	◕	○	○	○	○	○
	Provide assurance for debt holders	◑	○	○	◔	○	○
	Provide suitable incentives for equity	−◔	◔	○	○	○	○
	Promote market liquidity	◔	○	○	−◔	○	○
	Minimise ongoing regulatory risk	○	◔	○	○	○	○
Full chain flexibility	Optimise investment in flexibility	○	◑	◔	○	◑	○
	Optimise dispatch of flexibility	○	◕	◔	○	◕	○
	(Manage large and extended mismatches between supply and demand	○	◔	○	○	○	○
	Promote demand side participation	○	◕	◔	○	◔	○
Whole system	Align investment incentives for cross-vector assets	○	○	○	○	○	◔
	Align dispatch incentives for cross-vector assets	○	○	◔	○	◔	◔
Adaptability	Facilitate new and evolving business models	○	◔	○	○	◔	○
	Reduce risk of lock-in or asset stranding	○	◔	◔	○	◔	○
	Adapt to changing technology trends	○	◔	○	○	◔	○
Consumer fairness	Limit adverse distributional impacts for consumers	◕	○	−◔	○	○	○
	Allow greater consumer choice	○	○	○	○	○	◑
	Facilitate fair allocation of costs, based on cost-reflectivity	○	○	○	○	○	○

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Appendix 1.2 Baringa Scoring

Package assessment (Assessment criteria scores)

Criteria	National Baseline	National Build	Zonal Baseline	Zonal Build	Nodal Baseline	Nodal Build
Value for Money	◑	◕	◑	◕	◕	●
Energy security and system operability	◔	◑	◔	◑	◔	◕
Decarbonisation	◔	◑	◑	◕	◑	◕
Competition	◔	◕	◑	◕	◕	●
Challenge to implement	◔	◑	◑	◕	●	●
Investor confidence	◔	◑	○	◔	○	◔
Full chain flexibility	◔	◑	◑	◕	◕	●
Whole system	◔	◑	◑	◑	◑	◕
Adaptability	◔	◑	◔	◑	◑	◕
Consumer fairness	○	◔	○	○	○	◔
Total	◔	◑	◑	◑	◑	◕
Total - prioritise VfM, Security and Decarb	◔	◑	◔	◕	◑	◕

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Appendix 1.2 Baringa Scoring

Package assessment (Sub-criteria scores)

		National Baseline	National Build	Zonal Baseline	Zonal Build	Nodal Baseline	Nodal Build	National Baseline	National Build	Zonal Baseline	Zonal Build	Nodal Baseline	Nodal Build
Value for Money	Reduce relative proportion of redispatch	◑	◑	◑	◕	●	●	◑	◕	◑	◕	◕	●
	Improve operational efficiency of interconnectors	◔	◔	◑	◑	◑	◑						
	Ensure appropriate risk allocation and efficient cost of capital	◔	◔	◔	◔	◔	◑						
	Increase system flexibility	◑	◑	◕	◕	◕	●						
	Reduce in efficient inframarginal rent	○	◑	◔	◕	◑	●						
Energy security and system operability	Ensure sufficient capacity to meet peak system needs	◔	◑	◔	◑	◔	◑	◔	◑	◔	◑	◔	◕
	(Ensure sufficient available capacity and demand response to manage extended low renewable output	◔	◑	◔	◑	◔	◕						
	Ensure sufficient responsive capacity to maintain system operability	◔	◑	◔	◔	◔	◕						
	Manage external shocks and unintended consequences	○	◑	○	◑	◑	◑						
Decarbonisation	Increase probability of achieving decarbonisation objective	◔	◕	◔	◕	◑	◕	◔	◑	◔	◕	◑	◕
Competition	Align markets/avoid distortions	◔	◔	◑	◕	◕	◕	◔	◕	◑	◕	◕	●
	Better target system costs through market signals	◔	◔	◑	●	◕	◕						
	Promote greater inter-technology competition	◑	◑	◑	◕	◑	●						
	Promote greater market transparency	◔	◔	◑	◕	●	●						
	Reduce barriers to entry	◔	◔	◔	◔	○	◑						
	Reduce risk of gaming or exploitation of market power	○	◔	○	○	○	◔						
Challenge to implement	Minimise policy complexity/interdependencies	○	◔	◔	○	◔	◑	◔	◑	◑	◕	●	●
	Minimise market disruption	○	◑	◑	◕	◕	●						
	Reduce implementation cost	◔	◑	◑	◕	◕	●						
	Reduce risk of unproven solutions	○	◔	◔	◑	◑	◕						
	Expedite implementation	◔	◑	◑	◕	●	●						
Investor confidence	Respect existing legal framework and rights	○	○	○	◑	◔	◑	◔	◑	○	◔	○	◔
	Provide assurance for debt holders	○	○	◔	◔	◔	◔						
	Provide suitable incentives for equity	◔	◑	◑	◕	◔	◔						
	Promote market liquidity	○	◔	◔	◑	◔	◑						
	Minimise ongoing regulatory risk	○	○	◑	◔	◔	○						
Full chain flexibility	Optimise investment in flexibility	◔	◑	◕	◕	◕	●	◔	◑	◑	◕	◕	●
	Optimise dispatch of flexibility	◔	◕	◕	●	●	●						
	(Manage large and extended mismatches between supply and demand	◔	◑	◑	◑	◔	◕						
	Promote demand side participation	◔	◑	◑	◕	◕	●						
Whole system	Align investment incentives for cross-vector assets	○	◑	◔	◑	◑	◕	◔	◑	◑	◑	◑	◕
	Align dispatch incentives for cross-vector assets	◔	◑	◑	◕	◕	◕						
Adaptability	Facilitate new and evolving business models	◔	◑	◑	◑	◑	◕	◔	◑	◔	◑	◑	◕
	Reduce risk of lock-in or asset stranding	◔	◕	◔	◕	◑	◕						
	Adapt to changing technology trends	◔	◑	◑	◕	◑	◕						
Consumer fairness	Limit adverse distributional impacts for consumers	○	○	○	○	◔	◔	○	◔	○	○	○	◔
	Allow greater consumer choice	○	○	◔	◔	◑	◑						
	Facilitate fair allocation of costs, based on cost-reflectivity	○	◔	◔	◔	◑	◔						
	Total	◔	◑	◑	◑	◑	◕	◔	◑	◑	◑	◑	◕
	Total - prioritise VfM, Security and Decarb	◔	◑	◔	◑	◑	◕	◔	◑	◔	◑	◑	◕

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Appendix 2 – Low Carbon Support Mechanism assessment

Baringa's full rationale for their scoring is provided in a separate report. Here we comment on the comparative performance of options under Baringa's scoring against our ten assessment criteria where there exists clear differentiation between the status quo and alternatives. We also comment on any areas where our opinion diverges from Baringa's assessment. The need to align generators' incentives with market signals, whilst avoiding new distortions and retaining the benefits of the CfD, is considered throughout the assessment, factoring into scoring across the assessment criteria.

● ◕ ◑ ◔ ○ ◔ ◑ ◕ ●

Deterioration on status quo | Neutral | Improvement on status quo

	Existing CfD	Evolved CfD	CfD + Price Cap/Floor	Revenue Cap/Floor	Deemed CfD	Financial Wind CfD
Value for Money	○	○	◔	◑	◔	◑
Energy security and system operability	○	○	○	○	○	○
Decarbonisation	○	○	◔	◔	◔	◔
Competition	○	◔	◔	◔	◔	○
Challenge to implement	○	○	◔	◑	◑	◑
Investor confidence	○	○	◔	◔	○	◔
Full chain flexibility	○	○	◔	◑	◑	◔
Whole system	○	○	◑	◑	◑	◑
Adaptability	○	○	◔	◔	○	◔
Consumer fairness	○	○	○	○	○	○
Total	○	◔	◑	◑	◔	◑
Total - prioritise VfM, Security and Decarb	○	◔	◑	◕	◑	◑

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Appendix 2 – Low Carbon Support Mechanism assessment

The Revenue Cap and Floor (C&F) mechanism scores highest overall against the assessment criteria when the trilemma weighting is applied. Four of the options assessed – CfD Price C&F, (annual) Revenue C&F, Deemed Generation CfD, Financial CfD – align generators' incentives to market signals to some degree. Baringa's scoring suggests that greater exposure of generators to market prices and system conditions would positively support flexibility of the electricity system, efficient interaction with other energy vectors (whole system development) and decarbonisation, delivering greater value for money. Baringa's results also suggest that the resultant increase in revenue risk due to price exposure need not necessarily lead to lower investor confidence.

1. Value for money

The value for money criterion relates to the degree of redispatch and system flexibility, the operational efficiency of interconnectors, inefficient inframarginal rent, as well as appropriate risk allocation between producers and consumers and efficient cost of capital.

According to Baringa's assessment, options involving price exposure and decoupling revenues from output improve significantly on the status quo in relation to value for money. By aligning generators' behaviour with system needs, increased price exposure encourages generators to operate flexibly and reduces redispatch as generators would be less likely to generate when prices are below their marginal costs. The options also vary considerably with respect to their impact on cost of capital and allocation of risk between generators and consumers, but none worsen the status quo.

Baringa's scoring for the Revenue C&F model has been based on an assumption that the revenue generally outturns in the window between the cap and the floor. However, there are several credible circumstances in which the minimum revenue may not be reached for all generators. For example, in the case of an unexpectedly low wind year, consumers could be paying to top up these contracts for nothing in return at a time when margins are likely to be tight and prices high. At the other extreme, if the cap were to be reached by all generators, then generators would not be incentivised at all (hard cap) or less incentivised (soft cap) to participate further in all markets for the remainder of the relevant incentive period. They could choose to expedite outages planned for later periods, or introduce additional outages to reduce opex, even in tight margin periods. Indeed, there may be significant gaming opportunities where in the absence of any revenue impact, portfolio generators could deliberately manipulate the overall system length and/or constraints, by choosing whether or not to generate in a particular location, which other assets in their portfolio could profit from. There is therefore clear potential downside to the Baringa scoring for this option proportional to the risk of outturn outside the cap and floor window. Similarly, in the case of benchmark models that rely on inputs to determine deemed generation, gaming is a significant risk, which could impact value for money.

a. System flexibility and redispatch

All other things being equal, cost reductions through more efficient dispatch may be achieved through the Financial CfD and Deemed CfD due to payment being independent of the actual output and so generators' bids into the BM and ancillary services markets would not incorporate the opportunity cost of lost subsidies. There is a risk, however, that generators receive double payment in times where transmission congestion exists and they do not generate i.e. a deemed payment plus a payment via the BM to curtail.

For the Price C&F and Revenue C&F models, cost reductions are achieved due to price exposure between the caps and floors (see 'Full Chain Flexibility below for more detail). Revenue sharing would be needed above caps and below floors to avoid costly dispatch distortions at tail ends (i.e. 'soft' cap/floor). However, this would involve trade-offs with cost of capital increase (soft floor) and partial return of revenues to consumers (soft cap) that would need to be taken into account when considering the overall cost/benefit.

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b. Appropriate risk allocation and efficient cost of capital

The current CfD scheme design reduces the cost of capital significantly, lowering bills for consumers. For example, it was estimated that the value of long-term confidence associated with the current CfD contract design reduced the average weighted cost of capital (WACC) by just over 3% compared to the previous Renewable Obligation Certificates (ROCs) system (Newbery, 2015). Blyth et al (2021, p.21) have illustrated how a change in WACC could significantly raise costs considering the large scale of investment, rising to potentially 80+GW of offshore wind by 2040. The cost could be around £15bn per year if financed at moderate cost of capital but increasing by roughly £1bn/yr for every 1%-point increase in the cost of capital.

Trade off between WACC and total system costs

There is a trade-off, however, between the reduction in total system costs due to any change to the current CfD design and the increase in cost of capital for the sum of individual investments. For example, if generators were fully exposed to market signals, they would be more strongly incentivised to operate and invest efficiently, also resulting in wider market impacts due to increased competition. In operational timescales, generators would never produce when prices would be below their short-term variable costs, they would make efficient choices for selling in different markets (e.g. energy, capacity, ancillary services, forwards, futures) and they would schedule plant maintenance when prices are low. **For such price exposure to drive down system costs, however, it is necessary that prices accurately reflect system costs.** As regards investment, generators would be more incentivised to:

- Efficiently design and site their plant to maximise revenues over its lifetime.
- Achieve efficient retrofit, maintenance investment or repowering for their plant.

The stronger incentives would be combined with many other factors that feed into investors' and developers' decision-making but there is no doubt that they would have a downward impact on total system costs.

Such changed behaviours and impacts, however, are extremely challenging to evaluate. For example, it is difficult to quantify the unknown benefits of innovation that could relate to, for example, asset design, business models (e.g. hybrid projects with storage) and risk mitigation solutions. Due to price exposure, investors/developers might manage risk differently across a portfolio of assets through the way it contracts or operates assets, which could in turn impact the cost of capital for investments.

Reforms to the CfD scheme that would align generators' incentives with market signals should in turn reduce wholesale price cannibalisation and subsidies (as these are inversely correlated to the wholesale price) to be paid by consumers through levies. As levies are applied to retail bills on a flat volumetric basis, the reduced distortion of wholesale prices and the relative reduction of costs payable via levies would result in more accurate signals for demand response that could help further reduce total system costs.

The challenge is to ensure that the CfD reforms align generators' incentives with market signals while minimising WACC. Depending on design details, the Deemed Generation CfD has the greatest potential to achieve this compared with the alternative options assessed.

Consideration of appropriate allocation of risk

When considering efficient cost of capital and appropriate allocation of risk together, none of the options assessed by Baringa worsen the status quo. As regards what is efficient cost of capital, it is necessary to consider the upside risk as well as the downside risk, the extent to which market failures exist (that justify the intervention) and which actor is best placed to manage risk.

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Appendix 2 – Low Carbon Support Mechanism assessment

While downside risks help give an indication of the extent to which investors will need to be compensated for this risk in their returns, the WACC impact will be different to the discount rate impact because different types of investor value risk differently. In particular, the upside risk will be important to those with greater risk appetite, such as equity providers, as upside risk reflects opportunities to maximise profits but linked to this can be greater opportunity for innovation and to reduce total system costs.

The current CfD design has made renewable energy projects attractive to low-risk investors such as pension funds who manage large pools of low-cost capital. **The challenge is to retain the confidence of these investors while attracting new investors, including those with greater risk appetite.**

Under the current CfD design, considerable commercial risk is borne by consumers due to the price shielding of generators, with compensation to the strike price so long as they generate and prices remain positive, and they are compensated if curtailed due to network congestion. Consumers face the risk of consequent higher system costs not only due to the scheme's design distorting prices and dampening generators' incentives to support the system, but also due to growth in levies caused by the price cannibalisation that dampens consumers' incentives to respond to prices and reduce system costs. Expansion of government-led contracting risks imposing solutions on consumers as they have less opportunity to express preferences could potentially further crowd out demand-led contracting and reduce liquidity in forward/ PPA markets. This can be mitigated through changes to the centralised contracting and auction process (e.g. Elective Participation; Low Carbon Futures Market (see 'Appendix 4' for further explanation)) as well as through the support mechanism design, for example, by introducing greater price exposure to the low carbon mechanism's design or by partially covering the investment through the support scheme.

Efficient risk allocation may result in financing costs that are greater than the minimum possible but still reduce overall system costs and therefore total costs to consumers. **The goal should therefore be to optimise whole system costs, rather than to minimise financing costs**. When it is challenging to determine which actor is best placed to manage risk, risk/reward-sharing mechanisms can be helpful e.g. 'soft' price /revenue caps and floors with sharing of costs or revenues above or below them.

At present, generators with CfD contracts have needed to manage volume risk due to weather and the negative pricing rule. Depending on design, the Financial CfD and the Deemed Generation CfD could cover volume risk and reduce WACC relative to the status quo (Miller, 2018). Given that generators have been managing volume risk until now, with some using weather securities to do so, there does not seem to be a market failure justifying the need to cover this risk. Indeed, when support mechanisms reduce the need to manage risk, they inevitably reduce the need to innovate and dry up the demand for solutions in risk mitigation products/services that could come forward from the private sector.

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Appendix 2 – Low Carbon Support Mechanism assessment

Any future support mechanism design should ideally be future-proofed against any market reforms, including locational energy pricing. The current CfD design, including the Price C&F design, would not be easily compatible with locational energy pricing. While the negative price rule is designed to remove payments whenever a national price is negative, it would continue to subsidise output when the local price is negative but the national price is positive (see Figure 33). Settling a CfD plant against a national/system price would therefore send the right locational signal but introduce a new dispatch distortion, while settling against the local price could avoid this dispatch distortion but would not send locational signals to the generator. Another solution could be to apply the negative pricing rule to the local price, but this would increase volume risk for some generators and have an upward impact on WACC.

The Revenue C&F and benchmark revenue models could, however, be compatible with locational energy pricing. Under the Revenue C&F model, generators would be exposed to prices. Under the benchmark models, Financial CfD and Deemed CfD, the strength of the locational signal would be a function of whether the reference revenue would be linked to a local price or a national average system price, or generators could receive the same strike price but be exposed to a locational signal (e.g. locational TNUoS).

The need to respect investors' existing rights will need taken into account when deciding how and when to reform the CfD scheme. Costs can be reduced if supported generators are exposed to an effective long-run locational signal ahead of more fundamental reforms such as locational energy pricing, to ensure efficient siting at the time of investment.

Figure 33. Trade offs for current CfD design in market, with locational energy pricing

	More efficient signals: Generator bears risk	Based on a national price	Based on the local price
Reference price	A CFD pays the difference between the strike price set by auction and the reference price. With locational energy pricing, the reference price could either be a national benchmark price independent of each generator's location, or the local price at the location of the contracted asset.	If the reference price for a contract is a common national reference price CfDs will not exactly top each generator up to the strike price whenever its local price is different from the national reference price. The generators therefore face locational risk. Because CfD contracted generators would face the locational price difference the CfD design preserves the locational investment incentives of locational energy pricing - including in competition between assets at different locations through CfD auctions.	If the reference price for each generator's contract is the local price at their specific location, then the CfD payment tops the price on each unit of output up to the strike price. CfD contracted output is therefore hedged against locational risk, as under the current design. Since each generator effectively captures the strike price regardless of the level of the local price at its location, locational energy pricing does not provide incentives for siting assets.
Negative-price rule	The negative-price rule specifies that there is no pay-out on any CfD contracted output if the day-ahead reference price is negative. It seeks to remove distortions to despatch incentives when the system value of additional energy is negative.	A negative-price rule that removes pay-outs whenever a national price is negative will continue to subsidise output - and thereby distort despatch incentives - when the local price is negative but the national price remains positive.	If the negative-price rule removes pay-outs whenever the generator's local price is negative, then the CfD does not distort incentives to produce (and invest) whenever the actual system value of its output is negative after congestions. Locational energy prices in high-generation areas could be negative more frequently than a national price, exposing CfD contracted generation to greater volume risk due to congestion.

Source: NERA

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2. Energy security and system operability

This criterion relates to ensuring capacity is available to meet system needs under stress, particularly in times of resource scarcity and to maintain operability by, for example, providing ancillary services.

Incentives for generators to respond to system needs is likely greatest for the Revenue C&F model, which provides greater freedom to pursue profit-maximising opportunities through various markets. Price exposure via the C&F or alignment with market signals under the benchmark models would remove current barriers to providing ancillary services. For the Price C&F model, the strength of incentive to provide ancillary services would depend on the level of the floor and whether it is a 'soft' floor.

The strength of incentives for options that expose generators to prices or decouple revenues from output depend on whether revenues must be returned above revenue or price caps. The coupling of reward with output combined with a hard cap, as per the current CfD design, means the incentive to be available at prices above the cap can be weak if load factors are very low.

The Financial CfD, sends the strongest incentives compared to the alternatives to be available at time of high prices (and system stress) and to schedule maintenance when prices are low. This is due to the spot revenues that must be paid to the Government in addition to revenues not earned.

3. Competition

The competition criterion relates to the ability of the mechanism to align markets and avoid distortions, target system costs through market signals, reduce barriers to entry and risk of gaming or exercise of marker power, and promote greater transparency and inter-tech competition.

The price/revenue C&F and benchmark models offer clear advantages over the existing CfD and Evolved CfD in aligning generators' incentives with market signals and avoiding distortions as well as improving the targeting of system costs through market signals. Better aligning generators' incentives with market signals will result in their increased participation in other markets, competing with other resources.

The Revenue C&F scheme could potentially address distortions most effectively due to stronger alignment with markets compared to the benchmarking models. For the Price C&F, its capability to do this would depend on whether 'soft' cap/floors are implemented.

There is a higher risk of gaming with the benchmarking because of the detailed inputs required to determine benchmark revenues, which could potentially be manipulated by industry. Regulators also face information asymmetry risks and achieving consensus or acceptance across industry on the inputs could be challenging given the direct link to revenues and concerns about fairness.

For example, if hourly deemed payments are to be based on the generation potential of an asset then this in turn needs to be based on, for example:

- **The technical capability/performance of the equipment** – this varies considerably as for example, turbines can be designed to maximise output or optimised to also provide ancillary services. Manufacturers would need to supply parameters.
- **Load factors** – these vary considerably across geography due to topography, microclimate and other factors.
- **Weather data** – these vary across geography but also depend on equipment (weather masts) for accurate readings and masts are prone to outages. Masts are often owned by generators, creating a conflict of interest.

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4. Challenge to Implement

The challenge to implement criterion covers policy complexity and interdependencies, market disruption, implementation costs, unproven solutions and speed of implementation. All options would involve some market disruption and additional cost to implement, except for the Locational CfD, which would be quick to implement. Depending on the complexity of design, the benchmark revenue models are more novel than the C&F options so bring higher risk of unproven solutions. The Price C&F model is relatively simple and could be quick to implement but only if with hard cap/floor. Implementing a Price C&F model with soft cap/floor applied per settlement period would be highly challenging, and likely more challenging than designing a soft cap/floor for annual revenues.

5. Investor confidence

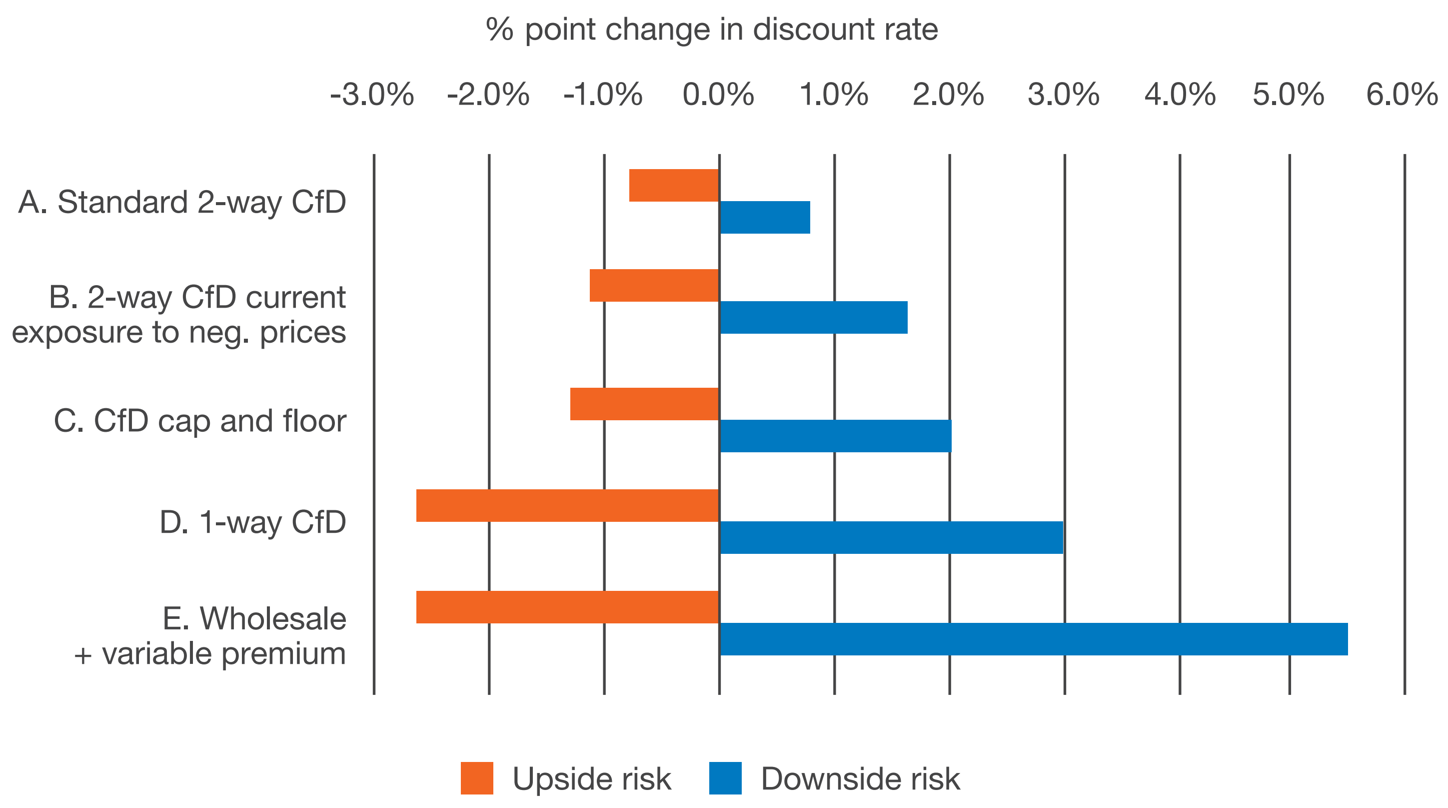
According to Baringa's analysis, none of the options would necessarily lead to any reduction in investor confidence when considering the wider picture.

Investors' preferences for the different types of derisking support scheme will vary as different types of investor value risk differently. The upside risk will be important to those with greater risk appetite, such as equity providers, while the downside risk will be more important to low-risk investors such as pension funds. Investments often incorporate both debt and equity. The challenge is to retain the confidence of existing investors while attracting new investors.

a. Impact of change to CfD design on WACC

Relative to the current CfD design (i.e. option B in Figure 34), Gross et al (2022) estimate an approximate increase of 0.4% in downside risk for the price C&F design and 1.5% for the 1-way CfD (i.e. floor only). Their results also show that the stronger the price floor component of the policy, the greater the effect on keeping financing costs low.

Figure 34. Change in upside and downside risks for different renewable support



Source: Gross et al (2022), p.25

Note: The discount rate impact is calculated as the change in the discount rate required to get back to the same net present value expected in the base case.

Appendix 2 – Low Carbon Support Mechanism assessment

The C&F models reduce exposure to downside risk by fixing a minimum floor price at auction, providing assurance to debt providers, but projects can benefit from any upside if market prices rise above this level, which will be attractive to equity providers, the extent to which depending on whether caps are hard or soft. Given the possibility to keep upside, lower bids could be expected in the auctions (that determine floors) compared to the current CfD design.

For Deemed CfD and Financial CfD, risk exposure would be reduced by regular payments to the generator related to the strike price determined by auction, but risk could be increased due to the basis risk between the reference revenues and actual revenues. If the reference output closely matches the actual plant, the risk would likely be low but the opportunity to beat benchmark revenues reduces and this will be less attractive for equity providers. If the negative pricing rule is not applied, benchmark models would transfer volume risk from generators to consumers, such that the downside risk could be even lower compared to the status quo.

b. Market liquidity

When support mechanisms reduce the need for generators to manage risk, they reduce demand for risk mitigation products and services from the private sector and therefore reduce liquidity in forward/futures markets. This has already happened with the current CfD scheme to some extent (Energy UK, 2022, p.2). Reduction in liquidity in forward/futures also depends on the extent to which the support is applied across the market. If the risks of a very large share of the market (e.g. all/majority of weather-dependent generators) were to continue to be managed through price-shielding CfDs (current design), then liquidity in the forward and futures markets would undoubtedly further decline. Liquid forward markets over different timeframes enable effective sequencing of maintenance, operational planning and risk management.

These issues can be mitigated by incorporating price exposure into the support design, intervening to drive demand-led contracting and facilitating coordination of the supply and demand sides through forward/futures trading, as outlined in ‘Appendix 4’.

As risk exposure varies for the different support option designs, the need to manage some risk through the financial markets varies. For the C&F models, the extent to which the generator would need to manage risk would depend on the size of the gap between the cap and floor and whether the cap and floors are soft or hard. For the benchmarking models, risk exposure could be low, if the negative pricing rule is not applied and the deemed output calculation is accurate for the generator, providing a perfect hedge. This could, however, potentially negatively impact the liquidity of forward/futures markets.

c. Regulatory risk

The benchmarking models come with some regulatory risk due to adjustments that will need to be regularly made to the administered inputs (e.g. parameters for the benchmark plant or revenue calculation) due to change e.g. technological innovation.

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6. Full Chain Flexibility, Whole System and Decarbonisation

All options (apart from Locational CfD) improve optimisation of the dispatch of and investment in flexibility. In times of prolonged excess generation, the Revenue C&F and benchmarking models will ensure generators never produce if market prices are below their marginal costs. This will not be the case for a Price C&F unless a 'soft' floor is implemented. In times of prolonged excess demand, when prices are likely to be high, weather-dependent renewables supported by the benchmark models will operate even under very low load factors, though depends on the extent to which revenues must be returned to consumers when the wholesale price is above the strike price. This will also be the case for Revenue and Price C&F to some extent if 'soft' caps are applied with revenue-sharing above them to ensure incentives remain aligned with market signals, even at very high prices. The improved flexibility links to higher scores for decarbonisation relative to the status quo, due to reduced curtailment.

Exposing generators to prices and decoupling from output delivers substantially greater whole system benefits compared to the current CfD or Evolved CfD designs, both in operational and investment timescales.

7. Adaptability

The adaptability criterion relates to the ability of the mechanism to facilitate new and evolving business models, adapt to changing technology trends and reduce the risk of lock-in or stranding. The C&F models score more highly than the benchmarking models against the adaptability criterion. Both the Financial CfD and Deemed CfD rely on benchmarking rather than true market alignment. Benchmarking requires considerable administrative input to determine the benchmark parameters, which may need updating as conditions change and technologies evolve.

Appendix 3 – System Adequacy assessment

Our analysis that follows, draws on Baringa's assessment, which is summarised in the table below (the full detail of which is provided in a separate document) and wider evidence including system/operability data that ESO has direct access to and feedback received through our stakeholder engagement.

● ◕ ◑ ◔ ○ ◔ ◑ ◕ ●

Deterioration on status quo | Neutral | Improvement on status quo

	Revenue additional to energy price											Revenue instead of energy price	Capacity value in energy price
Criteria	**Evolved CM**	**Optimised CM - Zonal**	**CM - Minimum Carbon**	**CM + Enhanced Flex**	**CRO**	**Optimised CRO - Zonal**	**CRO - Minimum Carbon**	**CRO + Enhanced Flex**	**DRO**	**RRO**	**Supplier Obligation CA**	**Strategic Reserve**	**Scarcity Adder**
Value for Money	◔	◔	◔	◑	◔	◑	◔	◕	○	◑	◔	○	◔
Energy security and system operability	◔	◔	○	◑	◔	◑	◔	◕	○	○	◔	◑	◔
Decarbonisation	○	○	◑	◔	○	○	◑	◔	○	◑	○	○	○
Competition	○	○	◔	◑	◔	◔	◑	◕	◔	◑	◔	◔	◑
Challenge to implement	○	◔	◔	◔	◑	◑	◕	◑	◕	◕	◑	◔	◔
Investor confidence	○	○	○	◔	◔	○	◔	◔	◔	◔	○	○	◔
Full chain flexibility	○	○	○	◑	◑	◑	◔	◕	○	◑	○	○	◑
Whole system	○	○	◔	◔	◑	◔	◑	◑	◑	◔	◔	○	○
Adaptability	◔	◔	◑	◑	◔	◑	◕	◕	◑	○	◑	◔	◔
Consumer fairness	○	○	○	○	◔	◔	◔	◔	◔	○	◔	○	○
Total	◔	◔	◑	◑	◑	◑	◑	◕	◔	◑	◑	◔	◑
Total - prioritise VfM, Security and Decarb	◔	◑	◑	◕	◑	◑	◑	◕	◔	◑	◑	◔	◔

Note to table:

1 Full assessment and scoring rationale found in separate document: www.nationalgrideso.com/document/276841/download

2 Counterfactual for CRO is the respective CM or optimised CM. For the three Optimised CRO options, the counterfactual is the Status Quo. Counterfactual for the RRO is the CRO.

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Appendix 3 – System Adequacy assessment

Our assessment concludes that the Capacity Market can be optimised to resolve some existing issues, but the changing nature of system security may require alternatives by the early 2030s. The current CM promotes high-carbon technologies, does not sufficiently reward flexibility and does not strongly incentivise delivery but this can be addressed to some extent with reforms to the mechanism. We believe, however, there are fundamental limits to the ability of the Capacity Market to adequately address the identified future system security challenges and that alternative mechanisms show comparatively greater promise.

1. Value for money

The auction-based mechanism of the existing CM encourages competition and consequent cost reduction while the revenue certainty it provides has contributed to lowering the cost of capital for new investments for qualifying assets.

However, there are several reasons why the current CM design may provide decreasing value for money in future:

a. At present, the current **CM rewards all capacity the same no matter what its capabilities**, meaning providers of relatively less flexible capacity are over-rewarded, while providers of more flexible capacity are under-rewarded. Procuring capacity with the capabilities needed by the system would reduce total system costs due to the need to procure less capacity, less reserves and through reduced redispatch costs. Baringa's scoring for both **CM+enhanced flex** and **CRO+enhanced flex** reflect this with the options scoring more highly than alternatives against the value of money criterion.

b. It is becoming more **difficult to accurately define the capacity that needs to be procured** to meet system needs as demand becomes a larger proportion of flexible capacity, **increasing the risk of errors and higher costs**. Previously, the capacity volume to procure was based on demand that was largely inflexible and capacity was dispatchable with known load factors. Procuring capacity close to real time allows for a more accurate capacity quantity to be procured. **Decentralised options are better able to address the circularity issue relating to demand as it becomes more flexible**, with retailers being better able than centralised authorities to decide the reliability requirements of their customers taking account of the flexibility they can provide. The retail market, however, is immature with respect to delivering demand-response and so this option could only be implemented if there would be sufficient confidence in the retail market.

c. The expected **rare, long duration events are potentially extremely expensive to serve** through the CM. The CM's role in **replacing 'missing money' is currently inefficient**, over-rewarding some and under-rewarding others due to the weak link to times of actual system stress via wholesale energy prices and lack of recognition of the value of capacity's attributes as needed in the future system. It would be **challenging to adapt the CM** to target such stress events as defining the capacity would involve a trade-off between accurate reward and liquidity with high risk of very high clearing prices. By contrast, **ROs are defined for specific settlement periods, rather than isolated peak events**, ensuring reward is proportional to the duration of the provider's contribution. Business models for long duration storage could be better supported if ROs are implemented as a symmetric instrument for supply and demand with call options applied to times of demand excess through CROs and put options for generation excess through RROs.

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Appendix 3 – System Adequacy assessment

The option of a **Strategic Reserve could reduce the costs of these rare stress events** by procuring capacity that is no longer economic to participate in the wholesale market and would otherwise retire. While a Strategic Reserve pays more per MW compared with a CM, the total cost could be comparatively lower as procurement is highly targeted to ensure the capacity has the right attributes that support the system and the capacity cannot participate in the wholesale market, reducing inframarginal rent and risk of distortions.

Greater energy efficiency could also play a key role in minimising costs (i.e. less generation capacity would need to be built to meet system peak) though stronger market transformation policy on the demand-side would be needed.

d. **The value that the CM provides consumers as a cost neutral mechanism can be challenged**. It is sometimes argued that an advantage of the CM design is its cost neutrality for the end consumer as the amount of money allocated in CM payments means that generators can price more closely to their marginal cost to the extent that the value of the CM contracts would equal the reduction in wholesale market costs (or reduction in inframarginal rent). One specific study on the GB (early auction) CM, however, found that of the £380m awarded to providers through CM contracts, only £170m of this found its way to consumers as savings resulting from lower wholesale energy market costs (Moraiza and Scott, 2022). Extrapolated to the most recent CM auction where the auction expenditure was £2.7bn, this could mean additional spend approaching £1bn.

If savings do find their way through to consumers in the form of lower wholesale prices, however, **interconnector flows can be impacted with price convergence causing price increases for British consumers** and price reductions for neighbours (i.e. in essence, cross-subsidisation, especially if out-of-market support policies are not used to the same extent in the neighbouring country). As the demand-side becomes more flexible, the argument for consumers to be able to access capacity value via wholesale energy prices rather than through CM cost recovery charges will strengthen as the demand response could place downward pressure on wholesale energy prices, unlocking savings for all consumers.

e. Currently the CM rules mean that a “stress event” only occurs if system tightness is at the point of disconnecting demand from the system i.e. last resort. As a result the ESO undertakes numerous BM actions and trades ahead of the CM notification process to ensure demand disconnection does not occur. A potential improvement could be to link the definition of a stress event to the market price such that the generator is incentivised to respond if the price reaches a certain level.

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2. Energy Security and Operability

Multi-day events (i.e. 48hr+) requiring large volumes of dispatchable supply will be occasional (modelling suggests 1 event in 2033, increasing to 4 a year in 2040) and will be driven by weather fluctuations, so could occur at any time throughout the year. It is therefore important that market signals accurately reflect system stress. **However, this is not the case with the penalties of the current CM that are** relatively weak, which means the risk of non-delivery during a stress event is higher than it need to be.

Given the changing nature of system security requirements, the design of any capacity renumeration mechanism (CRM) can no longer be based on winter peak, as is the case with the current CM design. Deciding how much and what to procure is already challenging but this will become much more difficult in future if retaining the CM.

Wholesale energy prices, if cost reflective and granular by time and location, accurately reward the resources that respond to system needs, including the need for sustained response. Sustained high (scarcity) prices can be expected as assets will try to recover their costs. Reliability Options (ROs) strengthen incentives for capacity providers to respond to wholesale energy prices as they must return revenues to the option buyer if the wholesale price is above the strike price, whether or not they deliver during the settlement period. In addition, ROs would provide revenue stabilisation for the capacity provider, facilitating lower cost financing for new investments. Combining CROs with RROs would support investment in 2-way resources including long duration storage.

Bidirectional system stress

As explained in the case for change, system security requirements are becoming two-way for supply and demand but the current CM is designed to ensure supply meets demand not vice versa. Increased penetration of weather dependant renewables means balancing at times of generation surplus will also be important.

The introduction of locational energy pricing would have the greatest impact on improving the system security contribution of two-way resources such as interconnectors, storage and demand response combined with storage. This change would not only ensure efficient dispatch in the direction (i.e. import/export) that supports the system but would also incentivise efficient siting of and investment in these resources.

It would be challenging to redesign the Capacity Market to address the bidirectional nature of the system security challenge, potentially involving an additional auction or separate mechanism that would face design challenges. Bidirectional Reliability Options - involving a CRO and RRO - however, offer a promising alternative.

In Baringa's assessment, the CRO optimised for flexibility scored highest for ensuring efficient capacity and demand response to manage extended low renewable output, as well as for ensuring sufficient responsive capacity to maintain system operability. This is because ROs are a financial instrument, able to provide incentives that accurately reflect the nature of system stress – i.e. speed of response, timing, duration - and link renumeration to actual delivery and relative value of availability across different stress events. Being a financial instrument, ROs enable efficient secondary trading leading to a liquid trading market, facilitating response from the most cost-efficient combination of resources at any point in time. Secondary trading of CM contracts has been limited to date, largely because the contracts are physical (incorporating de-rating factors) and not financial.

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Appendix 3 – System Adequacy assessment

3. Decarbonisation

Investment in assets and business models that are not eligible for bespoke investment support will depend on wholesale energy prices. Reforms that would result in more locationally and temporally granular cost-reflective prices would more efficiently coordinate supply and demand, reducing the need for redispatch and reducing the risk of stress events. If implemented alongside such wholesale market reforms, CRM options that respect the integrity of energy prices – such as a Scarcity Adder or Strategic Reserve - will help accelerate cost-effective decarbonisation more than those that do not.

CRM options that prioritise low carbon flexibility also score better against the decarbonisation criterion. However, this could be offset to some degree due to the dampening effect on wholesale price volatility that flexibility business models depend upon, though there is variation in impact among the options with Reliability Options being less distorting of wholesale energy prices compared to the CM.

4. Competition

The current CM design drives down costs through competitive auctions but at the same time it is selective in order to achieve reliability, decarbonisation and investment. For example, de-rating factors are applied to assets that reflect their likelihood of availability, contracts of different lengths are offered to help attract new investment and an emissions performance standard was introduced to target coal assets. To progress with achievement of the REMA objectives, this prioritisation of outcomes will need to continue with the current CM design.

The current CM could be optimised for low carbon flexibility by using scalars or multipliers or by splitting auctions. There are limitations with optimising the CM if splitting auctions, however, that could impact competition. Splitting auctions to target flexibility, carbon or location risks reducing liquidity. Low liquidity has already been witnessed in some CM auctions. While introducing additional requirements for low carbon flexibility could reduce total system costs, this could be offset if illiquid auctions result in higher than necessary clearing prices.

CM participation presents high transaction costs and market access barriers for small, aggregated and non-traditional assets though design improvements have been made over the years that partially address this. Structurally, however, the wholesale market is a more accessible and transparent market. Market design reforms that aim to streamline value, including capacity value, into wholesale energy prices (e.g. Scarcity Adder) and improve access to the wholesale market (e.g. centralised scheduling/dispatch) will improve access for all resources and result in greater competition. CRMs that have a less distortionary impact on wholesale prices would be preferable compared to the status quo for competition. Relative to the CM, CROs improve competition outcomes since they are a financial overlay on the markets and, if implemented effectively and on a voluntary basis, do not distort the wholesale price in the event of a scarcity event. A Strategic Reserve, if well designed and implemented effectively such that the reserve is only used if the wholesale market cannot clear, minimises distortions and harm to competition as supported assets are not allowed to participate in the wholesale market.

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5. Challenge to implement

Optimising the CM or CRO

The different dimensions for optimising the CM or CRO (zonal, low carbon, flexibility) could be implemented using minimum requirements within a single algorithm producing multiple clearing prices or by splitting auctions. The options would be challenging to implement as flexibility must be defined and dimensions would compound, which creates additional complexity and risks illiquidity with market power exploitation.

It will be difficult to define the basis for splitting a market-wide capacity remuneration mechanism such as a CM or CRO, as flexibility capabilities are wide-ranging and it would be challenging to accurately assess target capacity requirements for different splits. Ultimately the definition of flexibility used to design auctions that aim to reward flexibility will be a compromise for practical reasons, including ensuring sufficient liquidity. This means that inevitably some attributes will be over-rewarded, while others under-rewarded. Splits inevitably create thresholds that will seem unfair for some if they just lose out.

The additional value of including the flexibility dimension in the CM or CRO will depend on the future design of balancing services markets and overlaps should be avoided. The value in optimizing the CM also depends on the design and future role of the wholesale market (including scarcity pricing) that we believe should be strengthened through reforms as set out in our Phase 3 report.

Compared with a CM, there is less need to optimise a CRO auction design for flexibility due to their greater alignment with wholesale energy market signals, stronger penalties and secondary trading that would ensure any resources able to cost-efficiently respond at the particular moment in time could do so.

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CRO implementation

Implementation of Reliability Options can entail a wide range of design decisions that can significantly impact the intervention's effectiveness in achieving targeted objectives. To date, implementation of CROs has been limited to just a few countries. Lessons can be learned from implementation in other countries, including in the Irish Single Energy Market (SEM) where implementation issues, including those set out in the table below, have limited the effectiveness of the RO.

Adequate resource and time will need to be invested in designing an effective RO intervention, to ensure objectives are achieved and known issues are avoided.

Figure 35. Implementation of Reliability Options in Ireland and relevance to potential implementation in GB

Ireland SEM Issues	Relevance to GB market
Herding effect just below the strike price as generators try to avoid dealing with RO payments	Consultants, Ernst & Young (2022), note that this should not occur in a competitive market (like GB), as generators would be looking for scarcity rents
High strike price: The administrative scarcity pricing mechanism has not been calibrated effectively to ensure accurate prices (i.e volatility) at times of system stress	Strike price could be set to better reflect market scarcity and/or could be dynamic so the marginal cost plant is never losing money
Interconnector BM actions are not included in the strike price and as such, interconnectors are not expected to respond to stress events	The role interconnectors play in any CRO would need to be considered, but it would be assumed they are fully exposed to CRO stress events
Mandatory participation for all above 10MW	As we discuss in 'Appendix 5', it would be preferable to implement the CRO on a voluntary basis, conditions allowing

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Appendix 3 – System Adequacy assessment

The table right sets out detail on possible design features for Reliability Options and our view on preferred features.

Key:
Orange text denotes preferred feature

Figure 36. Possible design features of Reliability Options

Feature	Options	Reasons feature preferred
Capacity to procure	Full demand **Capacity to cover low carbon flex generation**	• As the nature of stress events are changing, procuring capacity to cover all the demand is likely not optimal in the near future and for net zero
Participation	Mandatory **Voluntary**	• Allows generators/DSR who have business models that rely on price arbitrage to focus on what is most successful for that business • It allows the wholesale market to do its job, providing consumers and providers with optionality
Strike price	Static **Dynamic**	• Allows macro energy price fluctuations to be taken into account • Ensures generators cover their marginal costs (at least)
Derating factors	Derating by technology type Derating at total capacity **No derating**	• Prioritises asset risk management: essentially placing the risk management of a particular asset with the asset owner as they are most likely to know the expected output/performance of a unit (or portfolio) • With a liquid secondary trading market, generators should be able to trade out positions relatively easily when units are down for maintenance or generally unavailable
Point of procurement	Long time before delivery year **Close to delivery year**	• Reduces the impact of modelling errors • There is less need for long lead times if derisking support provided through other mechanisms to address market failures (e.g. CfDs, DPA)

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Appendix 3 – System Adequacy assessment

Strategic Reserve implementation

A Strategic Reserve can be implemented at relatively short notice as was demonstrated by ESO with the winter contingency arrangements it put in place last winter. There are two main concerns with SR implementation:

a. Gaming risk

b. A perceived "slippery slope"

a. Gaming risk

Implementation of a Strategic Reserve is vulnerable to gaming risk if not implemented effectively. For example, the ESO delivered an SR type product called the Supplemental Balancing Reserve (SBR) in 2014. This was supposed to run for 3 winters but only lasted for two as authorities had concerns about the level of gaming. It was replaced by an "early capacity market" for the 2017/2018 winter. The concerns revolved around generators taking advantage of ESO as a distressed buyer, threatening to leave the wholesale market in order to be awarded a contract when they would have stayed operational in the absence of an SBR.

To reduce the risk of gaming there needs to exist robust and clear rules for the system operator (design and use) and participants (eligibility and participation), along with independent oversight and penalties if rules not respected. Best practices regarding the design and implementation of a Strategic Reserve can be found in the EU Electricity Regulations (2019/943) and in various EU countries including Belgium, Sweden, Finland, Lithuania and Germany (Elia, 2023). An example outside of Europe comes from Australia where AEMO activates the Reliability and Emergency Reserve Trader (RERT) to procure additional resources outside of the main market. The transparent and competitive procurement process, along with independent oversight, has helped prevent gaming in the RERT and ensured its successful operation (AEMC, 2019).

b. Slippery slope

A Strategic Reserve can suffer from the 'slippery slope' phenomenon if not implemented effectively. This can occur when the reserves are deployed when the market is still capable of delivering, albeit at high wholesale prices, which in turn suppresses wholesale prices thereby undermining investment and driving demand for more strategic reserves (Lockwood, 2017).

The EU Electricity Regulation (2019/943) sets out clear guidance and requirements for the design and implementation of a Strategic Reserve that would prevent the occurrence of the slippery slope phenomenon. Strategic reserves should only be dispatched if balancing reserves are likely to be exhausted and imbalance prices are higher than VoLL.

In practice, some capacity has long warming/lead times to prepare for dispatch, which is highly relevant when not used for the majority of the time and ESO would need to intervene to schedule such capacity in advance, which could occur before prices have reached VoLL.

6. Investor Confidence

Changes to the current CM would impact investor confidence depending on whether current market participants lose or gain from the change, or whether new resources would start to win contracts. Options that optimise for low carbon flexibility could boost existing and new low carbon flexibility resources and at the same time reduce the market share of unabated gas assets. Impact on the wider electricity markets should also be considered as investors in assets that exploit energy arbitrage or do not participate in organised markets (e.g. small DER), preferring to respond to wholesale prices, would likely favour options that have a relatively less distortionary impact on the wholesale market.

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7. Whole System

Market distortions created by CRMs that are not linked to wholesale prices can also have significant negative consequences from a whole system perspective. Efficient holistic market design and investment policy should facilitate rational decision-making on the optimal use, transportation and storage of energy across vectors based on true economic costs. However, with a CRM unique to the electricity market, the reduction in peak energy prices will not be replicated in the price of other vectors, distorting their relative cost. All other things being equal, and assuming substitutability across vectors, this would result in allocative inefficiency. It would lead to excessive electricity use and sub-optimal consumption of natural gas and/or hydrogen in sectors such as heating and transport.

8. Adaptability

Policy to support investment in the resources needed to ensure a secure system will need to evolve as the power mix and nature of stress events change. As reforms to the wholesale energy market restore missing money, the role of any CRM should reduce. Increased demand-side flexibility will also mean that consumers can express their willingness to pay and so centralised intervention should be adapted to accommodate this.

The extent to which the CM can be adapted to meet the future challenges is limited. Adapting the CM to support investment in resources with the right capabilities needed by a future system would be extremely challenging as set out above in ‘full chain flexibility’, with high risk of unintended consequence. Wholesale energy prices offer the most efficient and fair reward for response to system stress as they can accurately reflect needed speed, duration, direction (supply/demand) and location of response. Reliability Options offer many of the benefits of the CM but align far more closely to real-time energy prices. They can also be designed to be bidirectional, applicable to both excess generation and excess demand. In time, with retail market innovation, Reliability Options could be decentralised, reducing the role of government in deciding capacity volume requirements or other parameters.

9. Full Chain Flexibility and Consumer Fairness

Any options which provide revenue that is disconnected from or weakly linked to wholesale energy prices risk frustrating demand elasticity by distorting economic incentives to increase or decrease load. Any resource that is able to support the system where and when needed, should be fairly rewarded for doing so. Cost reflective wholesale energy prices, including scarcity prices, are key for the business models of flexibility providers that can exploit energy arbitrage opportunities to balance weather-dependent renewables. Both a Strategic Reserve and Centralised Reliability Options are better at preserving the scarcity prices in the market and a Scarcity Adder provides administered scarcity prices.

In relation to consumer fairness, there are two key areas to note: expression of consumer preference; and fair allocation of risk and reward between producers and consumers.

Freedom of choice and expression of consumer preferences:

For the centralised models, the **CM is the most restricting for retail innovation** and new business models compared to the alternatives of Reliability Options, Scarcity Adder or a Strategic Reserve. This is because the CM is designed to meet a **specified demand profile** and the mechanism involves the **specification of de-rating factors applied** to physical contracts, which does not easily accommodate innovation within a technology class or of business models and constrains secondary trading. The demand profile underlying the CM is static and based on a blanket assumption about consumers’ willingness to pay (WTP) (i.e. Value of Lost Load - VOLL).

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Appendix 3 – System Adequacy assessment

As demand response is increasingly enabled through reforms to market arrangements, consumers are becoming more able to express their willingness to pay and so a wider and more dynamic VOLL range will develop across demand. Furthermore, much of the demand-side will not participate in the CM due to transaction costs but will respond to wholesale energy price signals via retail tariffs/contracts. It will be difficult to adapt the CM to accommodate this change.

By contrast, Reliability Options are more easily tradeable as they are financial (not physical) contracts, so resource providers manage their delivery risk, removing the need for derating factors. ROs also provide optionality for consumers (explained further below).

Fair allocation of risk/reward between producers/consumers:

As the demand-side becomes more flexible, the CM risk/reward balance becomes more unfavourable for flexible consumers not participating in the CM due to the reasons mentioned above (i.e. assumed static demand profile, de-rating factors) and the CM's dampening effect on wholesale energy prices.

Compared to the CM, Reliability Options rebalance risk/reward in favour of consumers as:

- They provide a hedge for suppliers wanting to hedge against very high prices in order to manage risk on behalf of their customers; in this way, consumers receive risk mitigation in return for their fee (allocation of RO costs).
- They provide optionality for the demand-side (best practice dictates the scheme should be optional, not mandatory, such that assets wanting to undertake energy arbitrage would not be forced to participate in the scheme.

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Appendix 4 – Elective Participation/Low Carbon Futures Market

Potential solution of hybrid centralised/decentralised contracting model

Efficient two-way supply/demand balancing, taking network constraints into account, is key to effectively reducing carbon emissions, which more locationally and temporally granular price signals would help achieve. Attention to the price signals sent by other components of the consumer bill and retail market reforms are also necessary. Ambitious large[2] and small consumers,[3] however, can be more motivated by the carbon emissions reductions they can achieve compared to cost savings or financial reward.

On the demand-side, there already exists strong demand for low carbon power procured through PPAs that should not be discouraged, especially if their decarbonisation ambition exceeds that of government. An S&P (2020) report found that around 15% of installed renewable capacity in the UK was tied to a corporate PPA and there is scope for growth as CPPA markets are larger in other countries, including in Europe (Stet, 2022). Corporates purchasing PPAs, typically remain exposed to CfD settlement payments, which could mean they are 'over-hedged' and this could act as a disincentive to contract for more low carbon power.

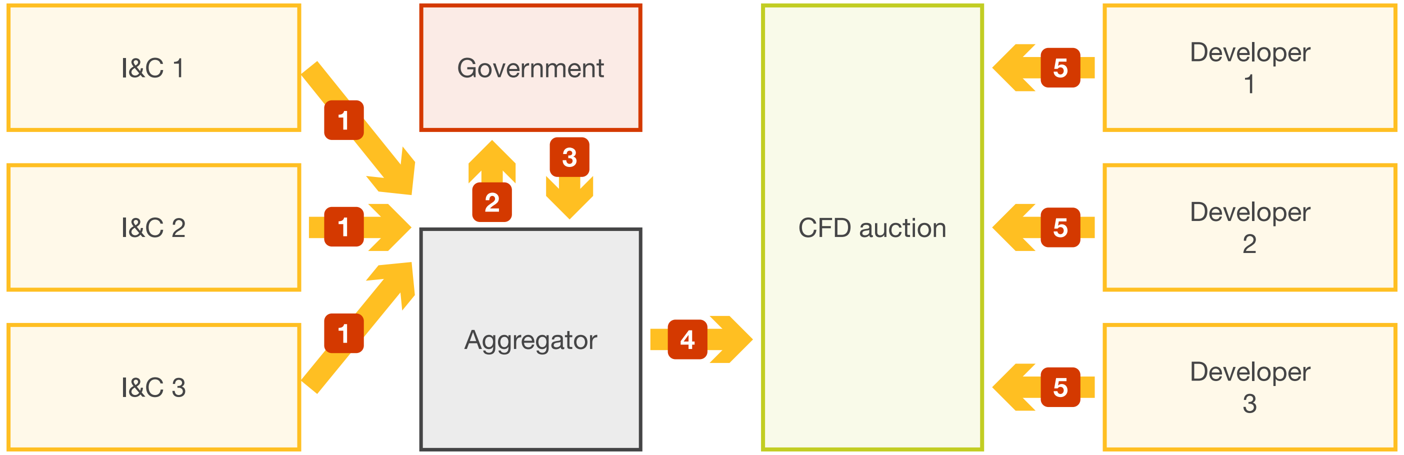
In its assessment, Baringa suggest the following possible solutions that would build government-led contracting around demand-led contracting:

a. Certain customers could be allowed to opt out of the centralised low carbon support scheme (and be exempt from some levies) but would need to demonstrate they are meeting their decarbonisation objectives through their own contracting through demand-side carbon intensity monitoring); or

b. A whole class of customers, for example I&C customers above a certain annual consumption threshold, could be obligated to contract low carbon power (i.e. partial application of the 'Supplier Obligation' concept described above, which could later be expanded across the market if necessary to achieve the Government's 2035 decarbonisation objective.)

These customers may then elect to bid into the auctions for bilateral agreements (giving them access to larger offshore wind projects, for example), as illustrated in Figure 37. The process would require 'elective participation' customers to submit a 'complex' bid that specifies demand at different prices and in different years. The Government could then assess further need on the basis of policy goals (this would likely need to cover demand from residential and smaller business customers) and supplement demand if necessary. A third party aggregator would put the bids together to form a single demand curve and set of auction parameters. Finally, generation developers would submit bids into the auction.

Figure 37. Bilateral participation in renewable support scheme auctions



Source: Baringa, 2023, available at - nationalgrideso.com/document/276841/download

A downside of the process, is that the PPA market is more flexible and so elective participation in CfD auctions could be limited with respect to meeting the needs and preferences of the demand-side unless a range of different financial hedging products would be available.

2 For example, many companies pursue recognition for their environmental achievements, see cdp.net/en/companies/companies-scores
3 For example, see Parag, Capstick and Poortinga, 2011.

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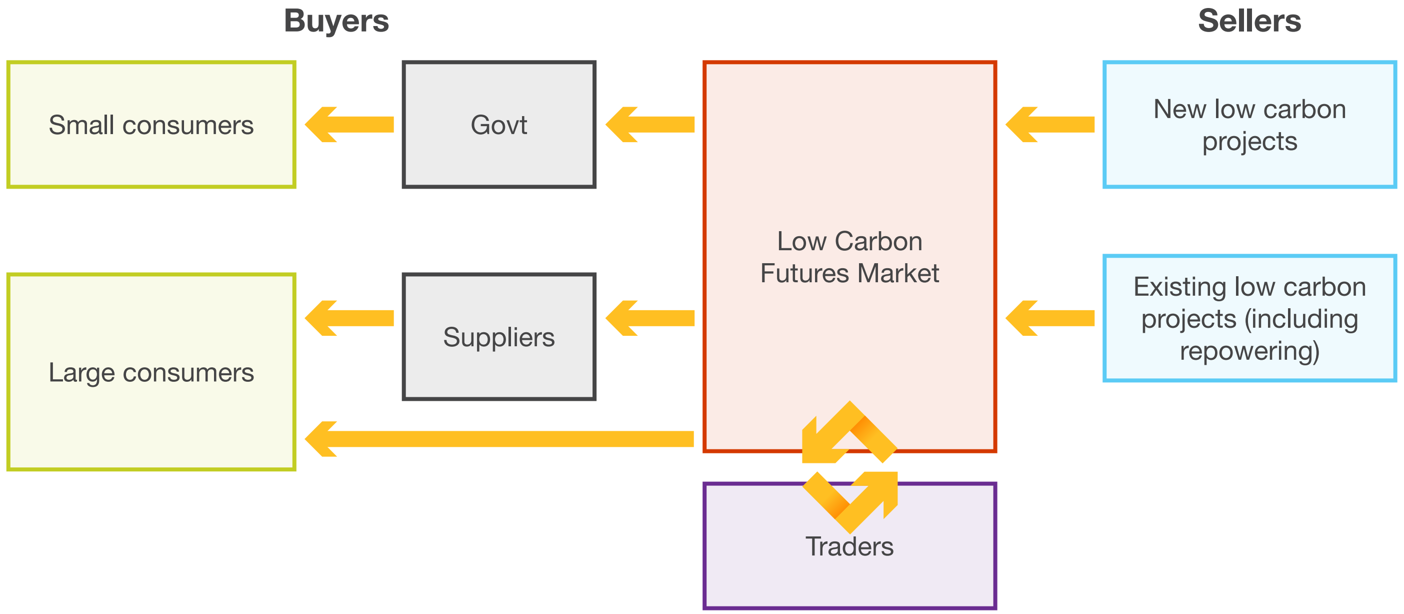
Appendix 4 – Elective Participation/Low Carbon Futures Market

Figure 38. Bilateral participation in renewable support scheme auctions

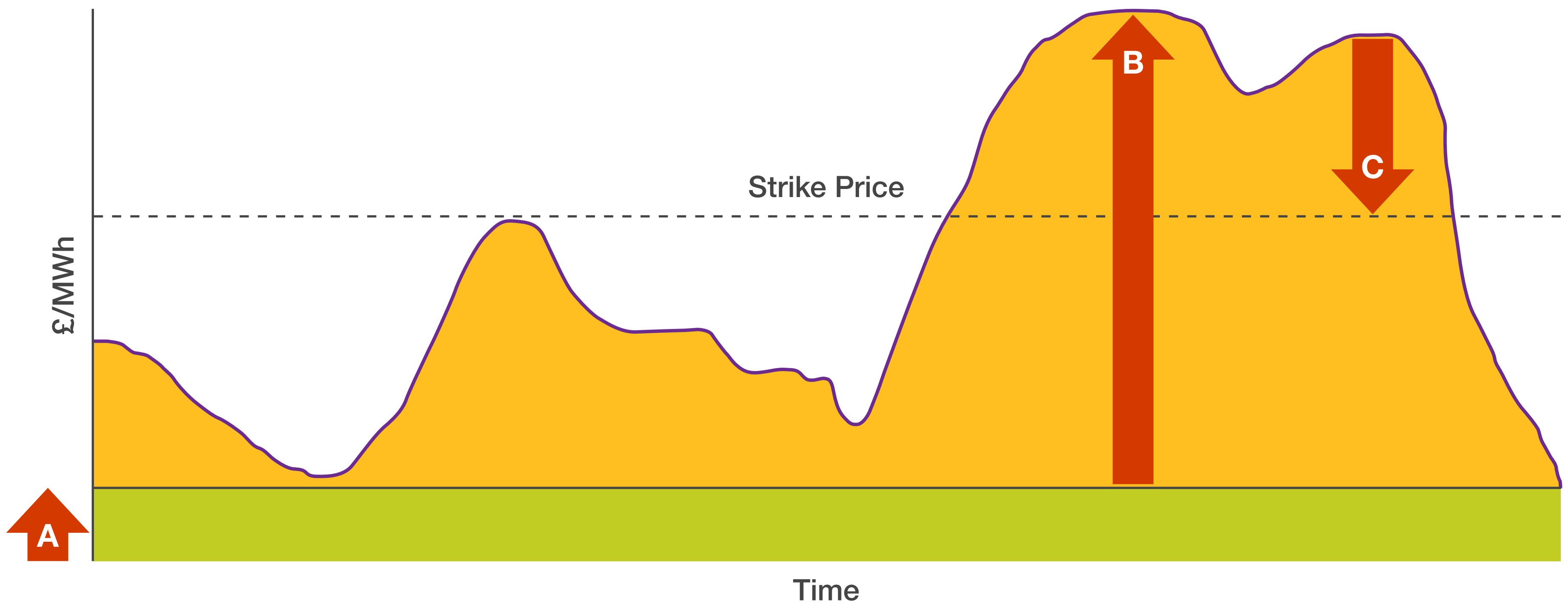


Source: Baringa, 2023, available at - nationalgrideso.com/document/276841/download

To achieve this, CfD auctions with Elective Participation could be evolved into a Low Carbon Futures Market. This would involve replacing the very bespoke CfD contracts with standardised financial swaps with different but standardized contract tenors (e.g. 1 to 15 years), which could be bilaterally traded (see Figure 38). This wider market, facilitated by government, would give access to financial hedging instruments for assets operating outside of a standard CfD e.g. existing RO supported plant, plants whose CfDs have ended, plant looking to repower. This could reduce the risk for investors associated with the 'merchant tail'. Whilst price risk remains, the existence of a liquid futures market backed by government, combined with other reforms to support market development, should increase investor confidence. Government could inject liquidity by buying low carbon futures contracts on behalf of mass market customers, settled through levies.

Appendix 5 – The Reliability option

The Reliability Option – high level process: View 1



CRO = Buy option
(generator has to sell electricity at a set price)

A. Reliability contract premium – fixed payment for the option contracts (£/kWh/day)

B. Revenues in existing Wholesale market (£/kWh)

C. Reliability contract payback – payback the difference between strike price and reference price (£/kWh)

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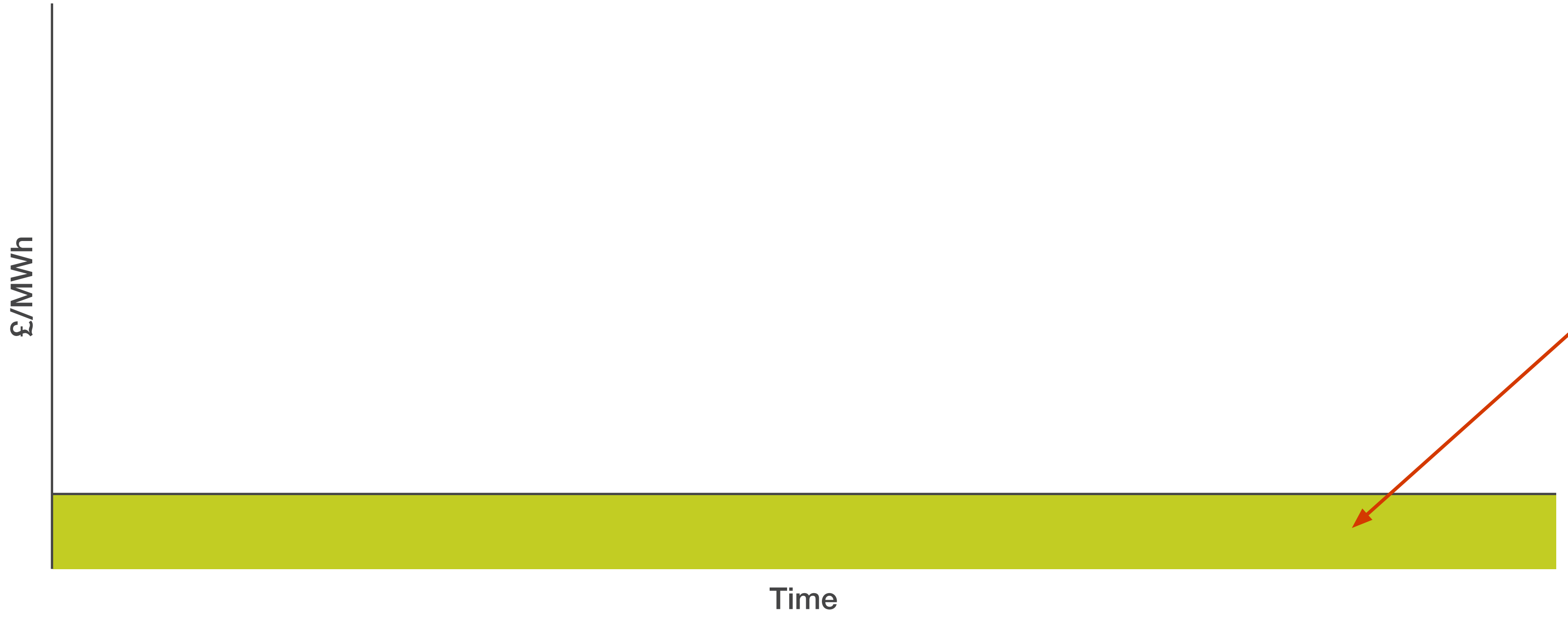
The Reliability Option – high level process: View 2



For taking part in the reliability option, generators get paid a contract premium. This premium is set before the delivery period and will not change.

The premium can be set at the auction (similar to the current GB CM auction), ensuring the correct renumeration for providing a reliability option.

Green part of the graph is for representative purposes only and doesn't assume a consistent income throughout the delivery period that corresponds to the spot price

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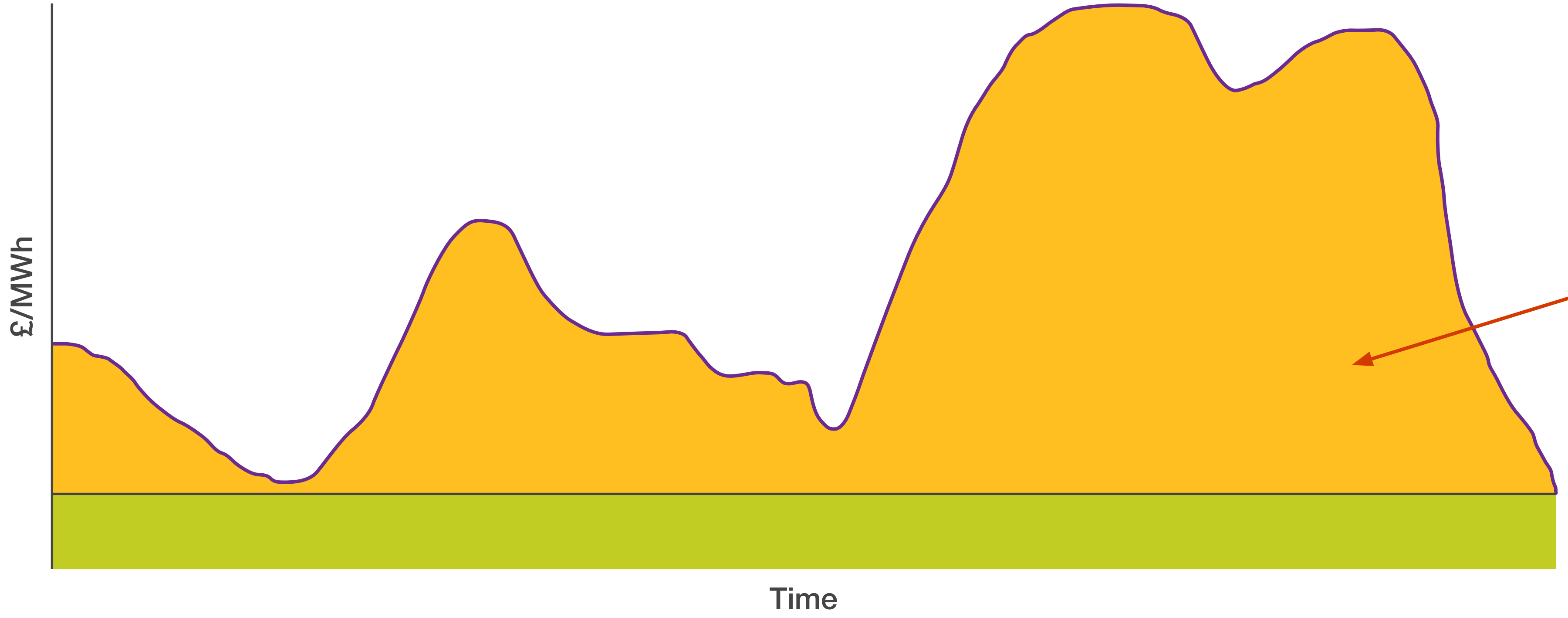
Appendix 5 – The Reliability option

The Reliability Option – high level process: View 3



Those generators with a CRO will receive the spot market price for energy they produce.

The option agreement means that the generator has agreed to sell electricity to the system operator at a set price, this wont be activated if the spot market remains below the set price.

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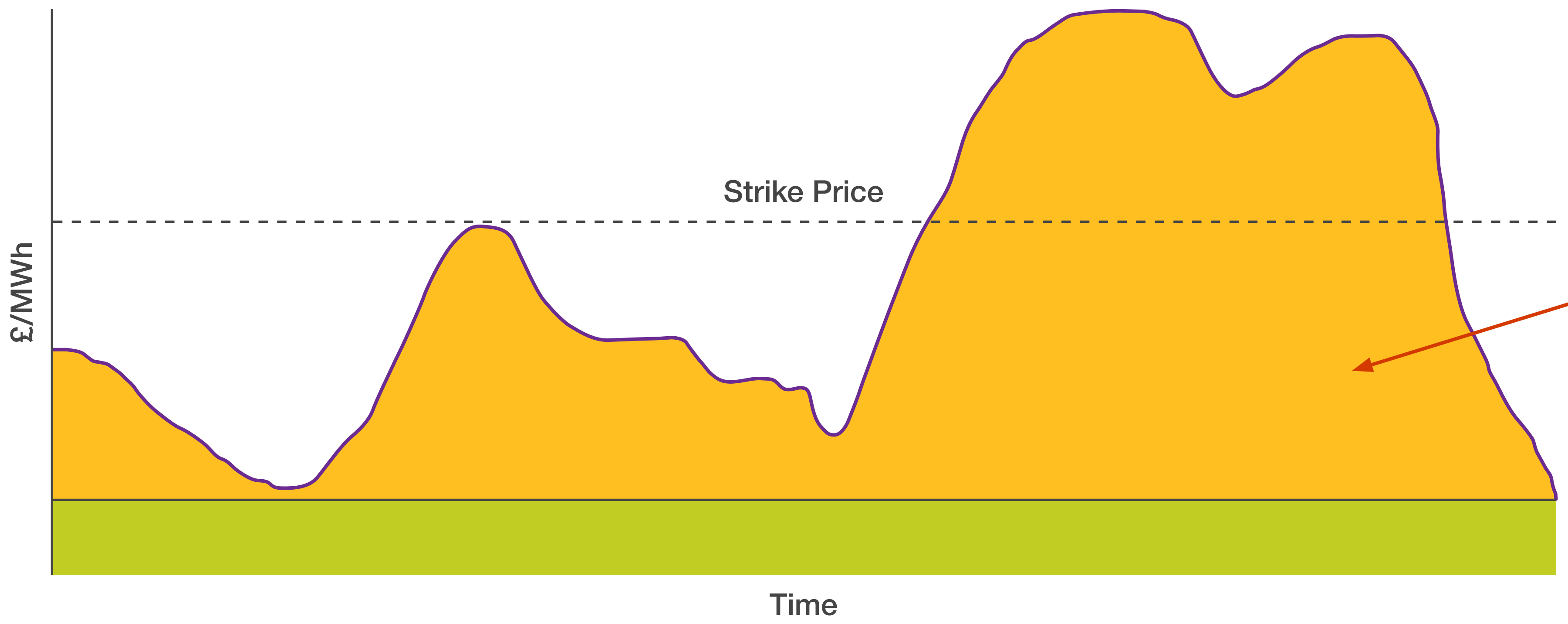
Appendix 5 – The Reliability option

The Reliability Option – high level process: View 4



The only exception is when the spot market price exceeds a predetermined strike price. When this happens the generator has to pay back the difference between the spot market price and the strike price.

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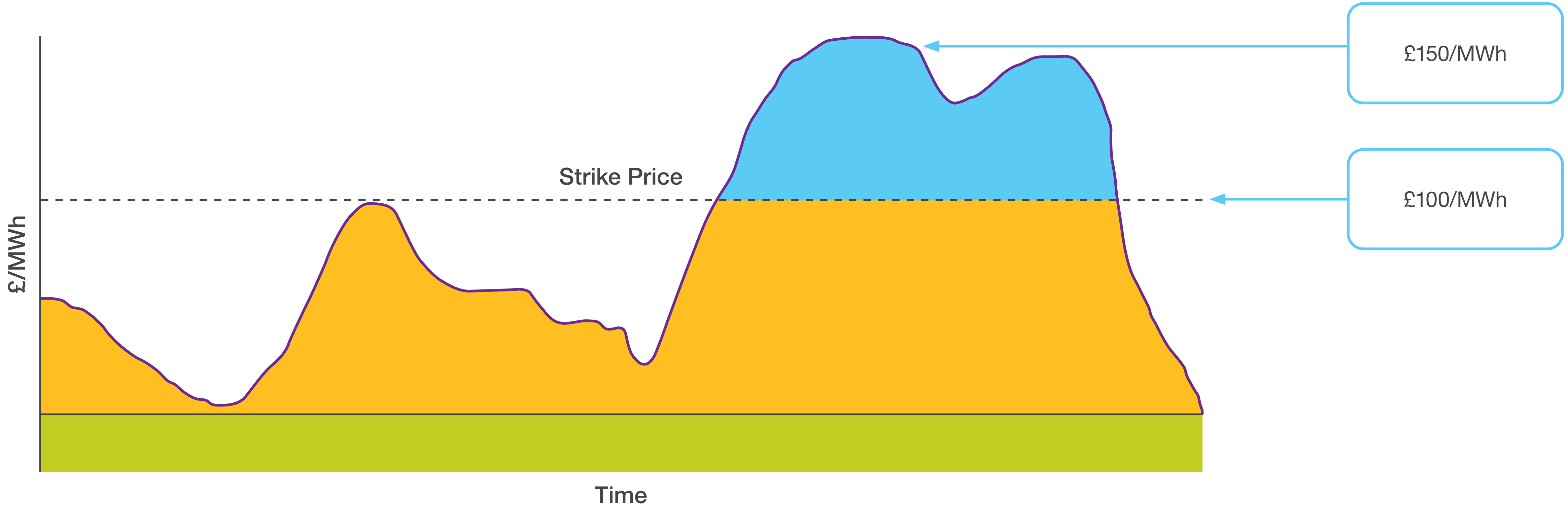
Appendix 5 – The Reliability option

The Reliability Option – high level process: View 5



So if the strike price is £100/MWh and the spot price reaches £150/MWh a generator would receive £150/MWh but would have to repay £50/MWh (the difference between strike and spot price, 150-100) so net position would be £150 - £50 = **£100/MWh.**

If a generator is not generating when prices hit £150/MWh they still would have to repay £50/MWh but wouldn't receive any spot market income so their net income would be **-£50/MWh**.
This acts as a penalty for non-response during times of stress.

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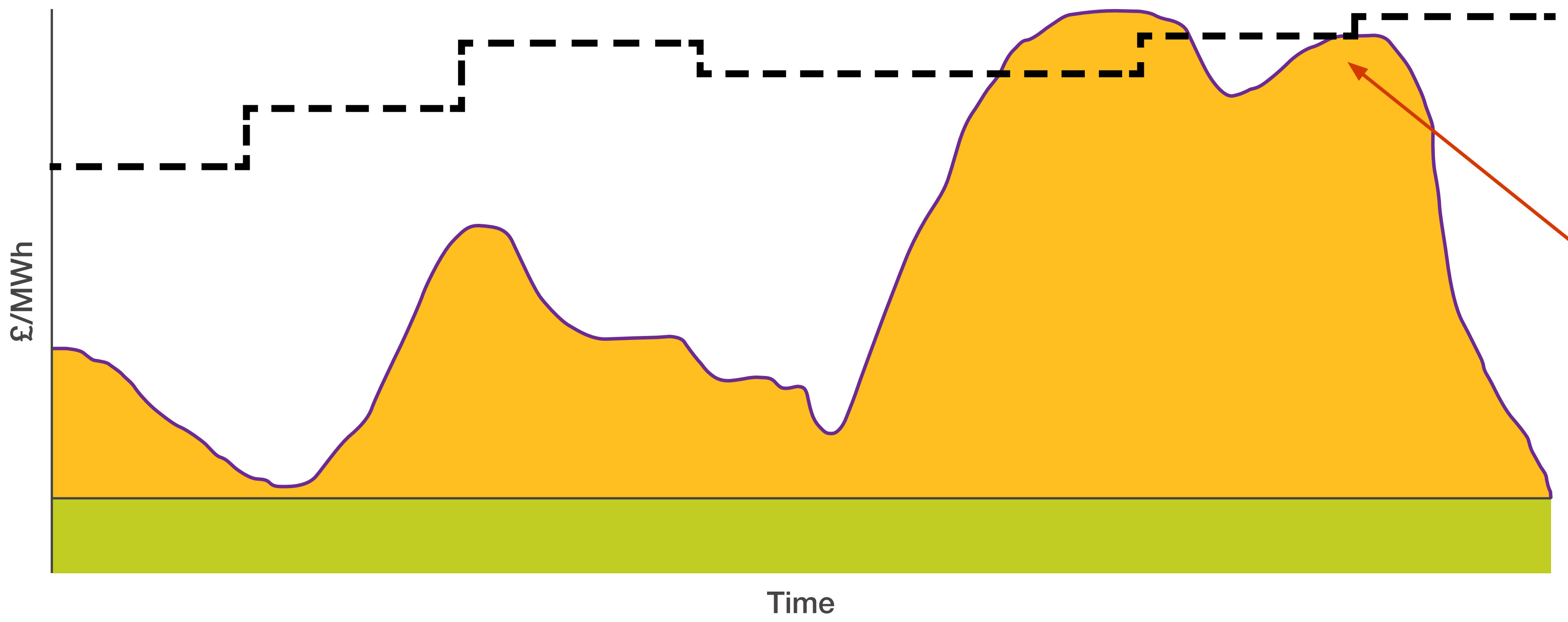
Appendix 5 – The Reliability option

The Reliability Option – high level process: View 6



The strike price can be static or dynamic. Static remains the same for the whole delivery period whereas dynamic can change based on pre-set criteria.

Colombia use a dynamic strike price in their Reliability Option, it is calculated by adding 2% to the technology type with the highest marginal cost.[1] This ensures that no generator receives less than their marginal cost.

1 XM S.A. E.S.P (Colombian system operator website)

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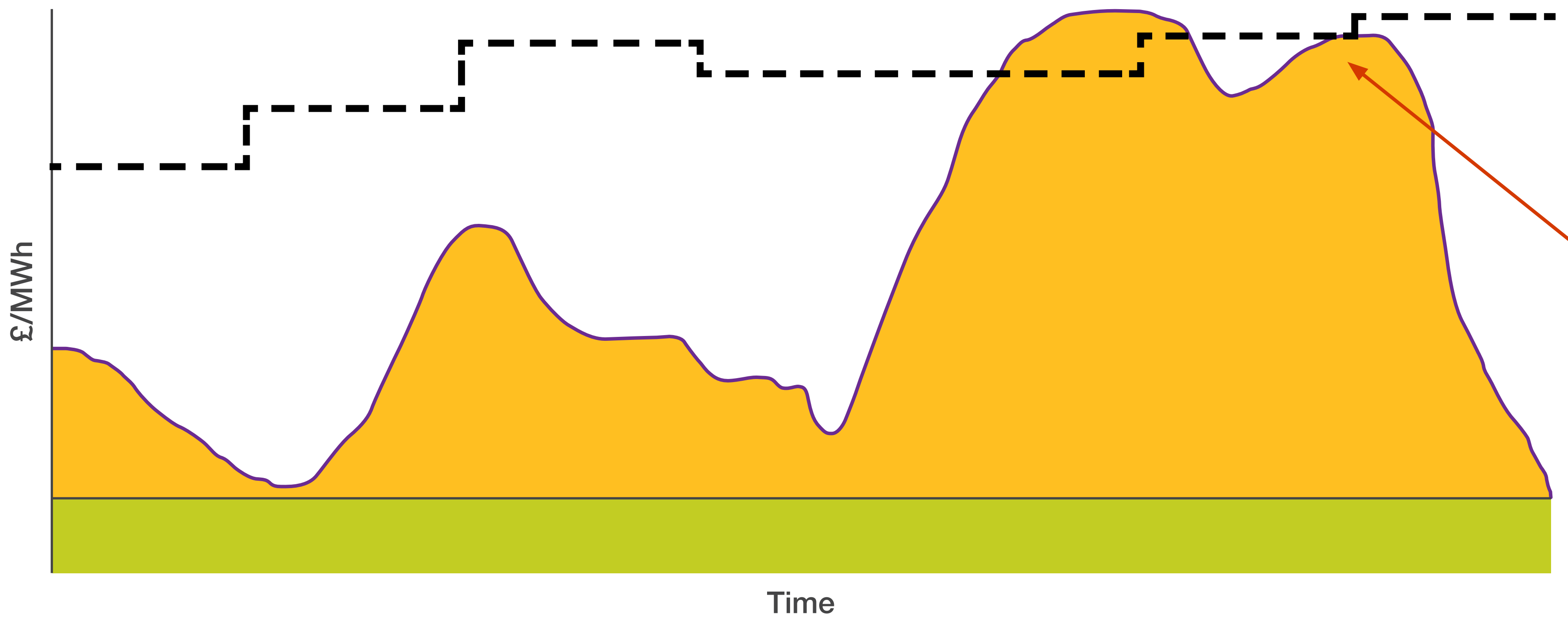
The Reliability Option – high level process: View 7



Why would a DSR/storage unit want to take part in a CRO?

By taking part in a CRO units wouldn't get access to the very high prices in the spot market.

The access to guaranteed revenue is expected to provide enough incentive for certain generators to take advantage of, whilst leaving other assets with different business models free to take advantage of the high spot prices.

This guaranteed payment is like the CM payment but is better for the consumer as the option agreement means that is not a one way payment to units so there is less market distortion, and consumers receive payments back when prices are very high (i.e. a hedge). The mechanism achieves increased security of supply as penalties are reflective of system stress and stress events occur before the point of demand disconnection.

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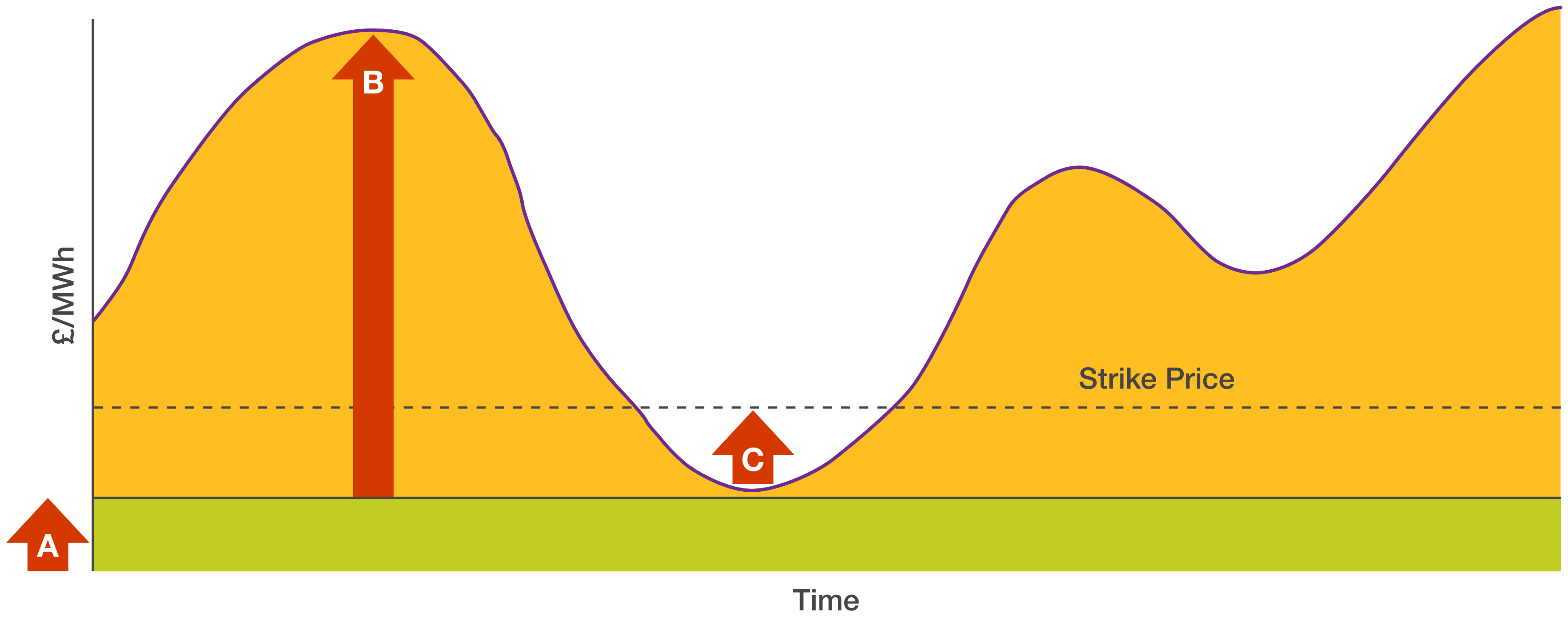
Appendix 5 – The Reverse Reliability Option

The Reverse Reliability Option – high level process - View 1



RRO = Sell option (central body has the ability to sell electricity at a set price)

A. Reverse Reliability contract premium – fixed payment for the option contracts (£/kWh/day)

B. Price paid in existing wholesale market for electricity (£/kWh)

C. Reverse Reliability contract payback – payback the difference between strike price and reference price (£/kWh)

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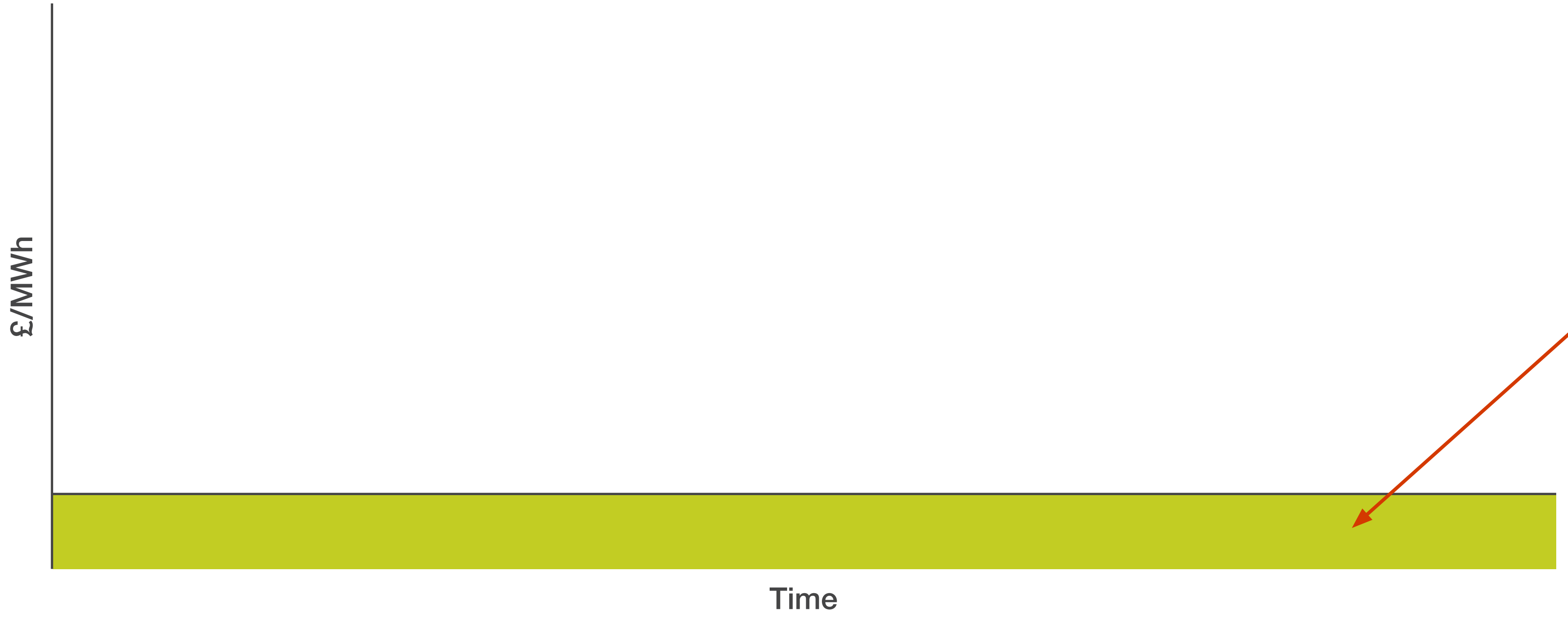
Appendix 5 – The Reverse Reliability Option

The Reverse Reliability Option – high level process - View 2



Similar to the reliability option for taking part in the reverse reliability option, storage/DSR resources get paid a contract premium. This premium is set before the delivery period and will not change.

The premium can be set at the auction (similar to the current GB CM auction), ensuring the correct renumeration for providing a reverse reliability option.

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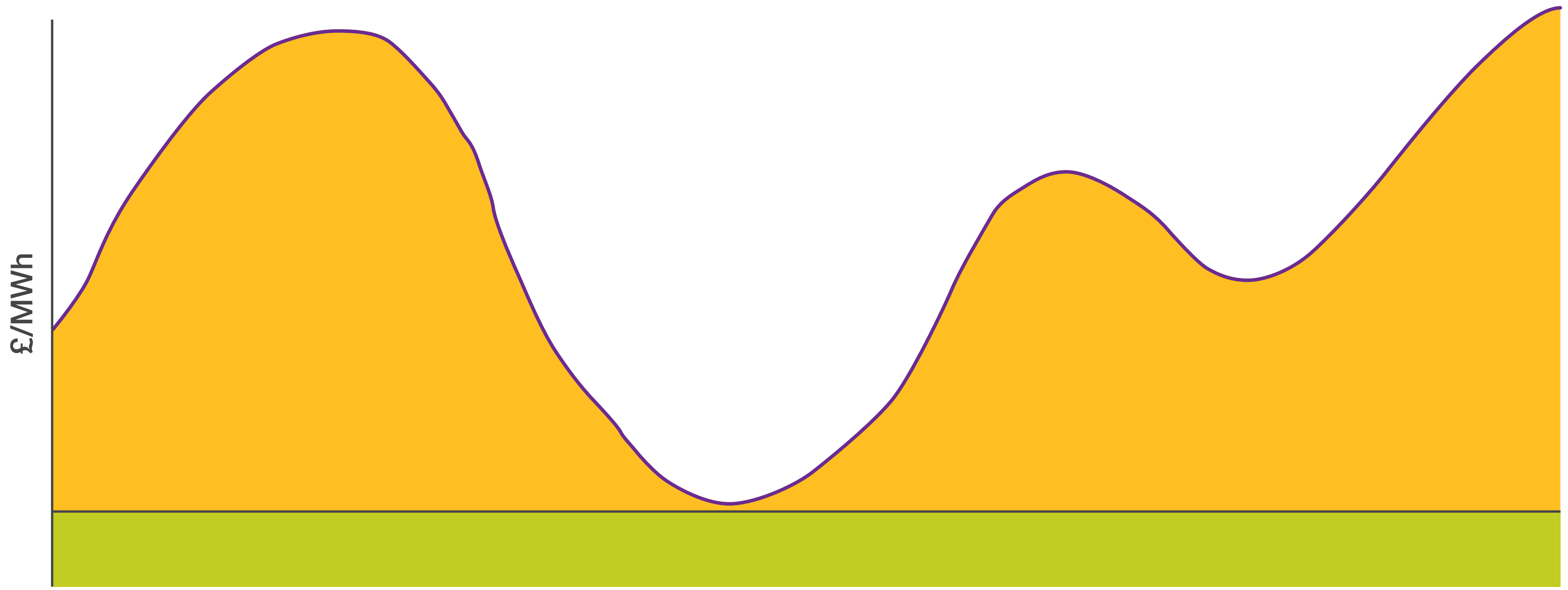
The Reverse Reliability Option – high level process - View 3



Those storage/DSR providers with a RRO will pay the spot market price for energy they consume as normal.

The option agreement means that the storage/DSR provider has agreed to buy electricity from the system operator at a set price, though this won't be activated if the spot market remains above the set price.

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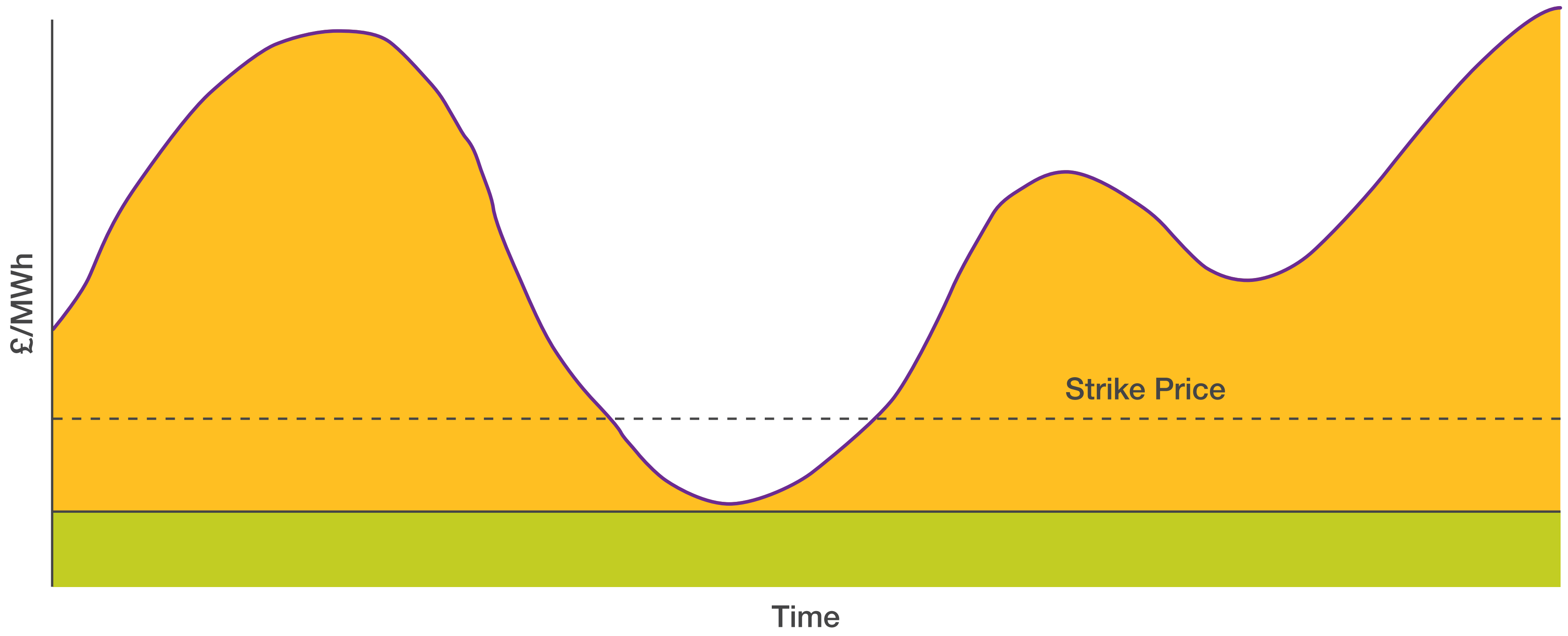
Appendix 5 – The Reverse Reliability Option

The Reverse Reliability Option – high level process - View 4



The only exception is when the spot market price drops below the predetermined strike price. When this happens the storage/DSR resource has to pay back the difference between the spot market price and the strike price.

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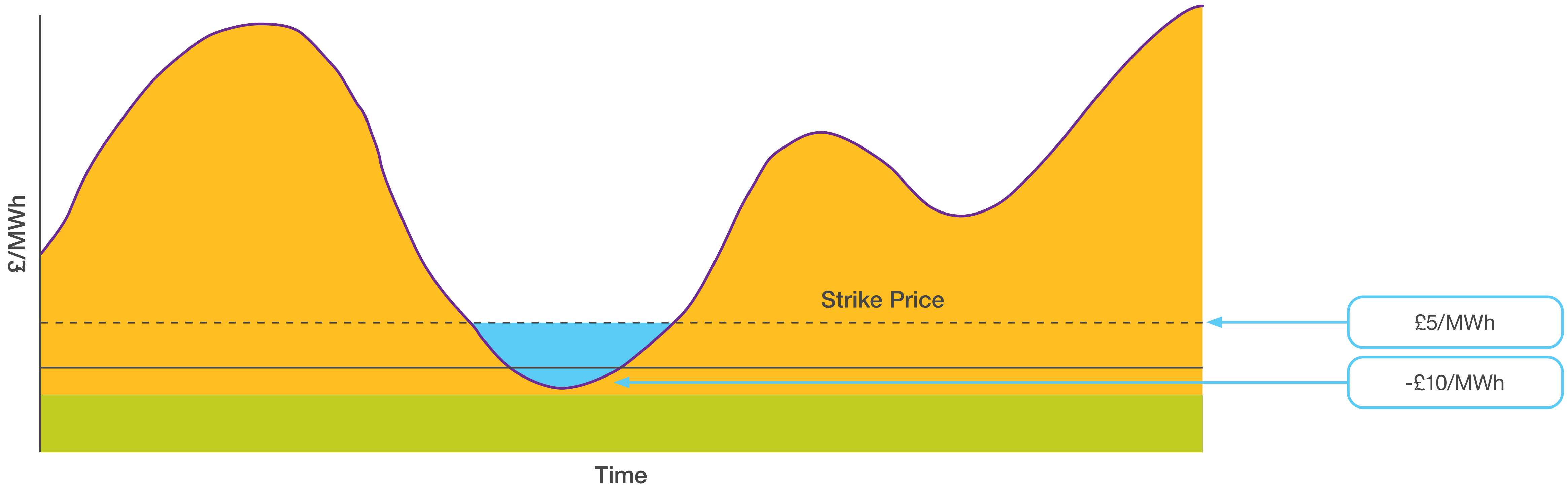
Appendix 5 – The Reverse Reliability Option

The Reverse Reliability Option – high level process - View 5



So if the strike price is £5/MWh and the spot price reaches £-10/MWh a storage asset would pay £-10/MWh and would have to pay an additional £15/MWh (the difference between strike and spot price) so net position would be £-10 + £15 = **£5/MWh (paid)**

If a storage asset/DSR is not consuming when prices hit £-10/MWh they still would have to pay £15/MWh even though they didn't consume any power so their net penalty would be **£15/MWh**

But why take part if you can't access really low prices....?

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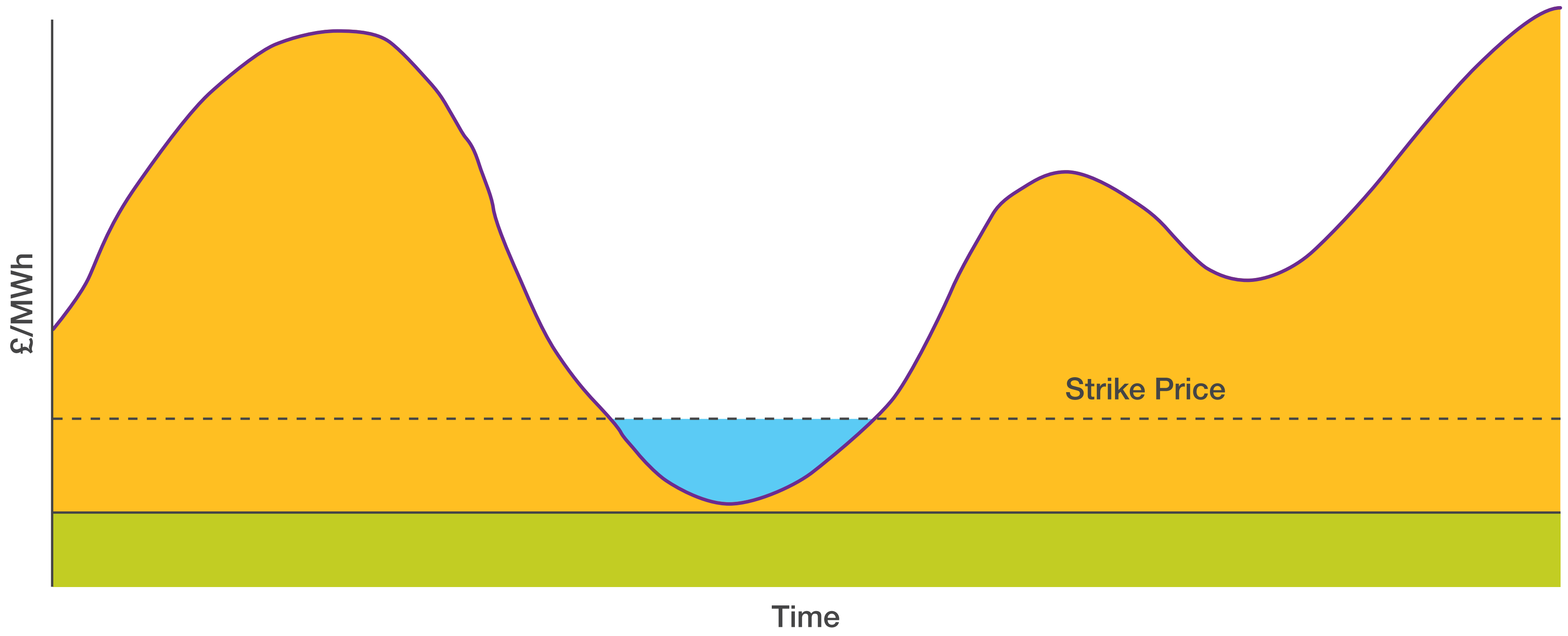
The Reverse Reliability Option – high level process - View 6



Why would a DSR/storage unit want to take part in a RRO?

By taking part in a RRO, units wouldn't get access to the potential very low prices of the spot market. The benefits for the system operator are that it encourages consumption when excess renewables exist, meaning there is less wasted energy and the system is easier to operate.

The units taking part receive a consistent income from the RRO (represented by the green). Some units will prefer the certainty of the RRO payment compared with uncertain spot market revenues, even if they might be able to earn more through the spot market.

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