Presentation to the industry

Investment and Flexibility market design

Industry workshop

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18 January 2022

Investment elements

In examining the investment options, critical issue is the extent to which the technology mix is determined by the Government vs the market

Investment[1]

1. Low Carbon Central Planning → Bespoke arrangements | Inter low carbon tech competition | Broad Investment Mechanism
2. Capacity Adequacy → Bespoke arrangements | Traditional capacity market | Broad Investment Mechanism | Wholesale price signals only[2]

Ruled out in Phase 2 – see note

Note 1: We will cover the Flexibility element in a separate category due to the wide-ranging linkages across both the investment and operational elements

Definition of system needs

- Identification and definition of the **system needs** (incl. who is in charge and frequency of update) – assume the Government sets an overall target
- Assume market participants do not self-determine the needs
- Two main dimensions: **firm and low carbon capacity** (and maybe third dimension: flexibility)

Mechanism to address the identified need

- Development of mechanism to **procure** the required products to **deliver** on the defined system needs
- A wide range of different levels of central and market-based involvement possible
- Can be **technology neutral or specific**

Output of process

- Centralised procurement mechanisms expected to generate **predictable technology mix…**
- …whereas output of market-based mechanisms is largely **unknown upfront**.

The key consideration here is **the extent to which the technology mix is determined by a central authority vs the market and to what extent is dependent on Operational market design elements**

DRAFT FOR DISCUSSION

Bespoke arrangements for low carbon support mechanisms are tailored to specific technologies, with central authority deciding technology mix

Central authority identifies the system needs

Separate technology-specific or geographically-specific sub-targets to fit within overall system needs for low carbon

Tech categories & eligibility	Units and/or Volume
	X units
	X units
	X units in Area A Y units in Area B
	X units
CO_2	X tCO_2 ↓

- Potential unis: volume-based (MWh) vs capacity based (MW).
- Explicit CO2 impact relevant for net-negative techs

Mechanism to address the identified need

Bespoke contracts or regulatory arrangements for a specific low-carbon technology (may lead to multiple schemes for different technologies)

Multiple options of detailed design (second-order elements in Phase 2):

- Separate mechanisms (or different risk allocations) implemented across different tech or tech groups…
- …hence potential <u>within</u> category competition (e.g. through auctions), but not <u>between</u> technologies
- Typical examples: feed-in premiums / feed-in tariffs, CFDs, Renewable Certificates, capacity-based remuneration or regulated revenues

Key design dimensions:

- Eligibility criteria
- Support type (e.g. capacity or volume)
- Form of support (e.g. FIT/FIP, CFD)
- Auction / pricing mechanism and frequency
- Duration of support

Outputs

- Mostly predictable tech mix, driven by tech definition and units
- Support based on central authority's assessment
- May be targeted to support (perceived?) emerging technologies

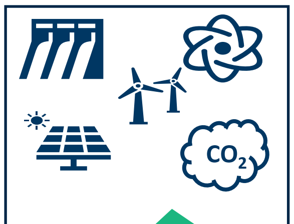
These dimensions are necessary for:
(1) defining the allocation of risk, the financeability and the cost of capital
(2) the interplay with operation elements of the market design

Conversely, a single low carbon support mechanism could be designed for all low-carbon technologies to compete against each other

Central authority identifies the system needs

Single support mechanism to achieve the same system need objective.

Tech categories & eligibility



Units and/or Volume

MW of capacity; MWh of output or CO2 abatement

Centralised decisions needed:

- "De-rating" or carbon factors to compare techs on a like-for-like basis
- May include impact on network operation (e.g. due to intermittency)
- Accounting for net-negative techs (BECCS)

Mechanism to address the identified need

Single contract mechanism / regulatory arrangement that facilitates competition between low carbon technologies

Multiple options of detailed design (second-order elements in Phase 2):

- Can be achieved by centralised **auctions or decentralised supplier obligations** (the overall low carbon target is still set centrally, but suppliers select how to achieve it)[1]
- Interaction with the exposure to wholesale prices (e.g. solar correlation with demand profiles)

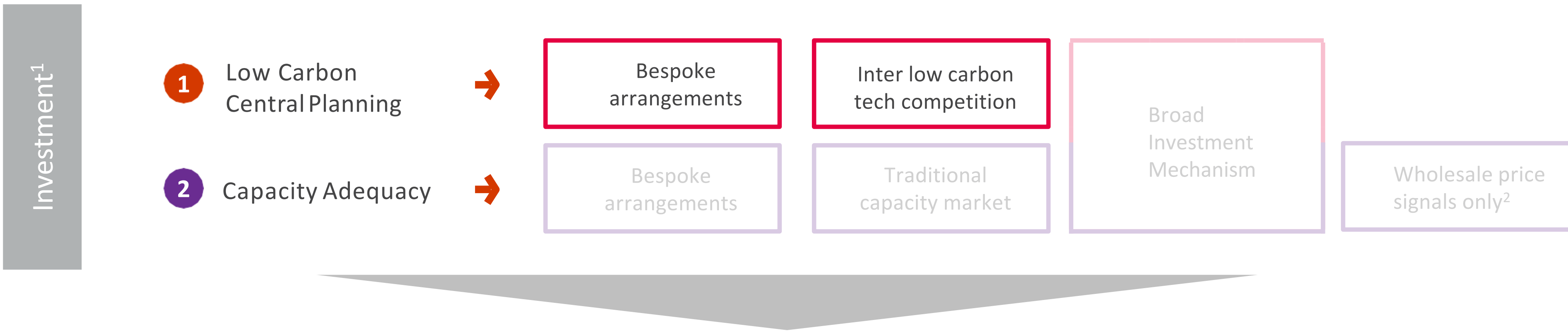
Key design dimensions:

- Eligibility criteria (e.g. exceptions for very immature tech)
- Support type (e.g. capacity or volume)
- Form of support (e.g. FIT/FIP, CFD)
- Auction / pricing mechanism and frequency
- Duration of support

Outputs

- Technology mix unknown ex-ante (portfolio or dominant technologies)
- Support based on competitive outcomes (incl between technology categories)
- Targeting emerging technologies not possible (unless via an exception to provide a bespoke arrangement)

In practice, the choice between bespoke arrangements and inter low carbon tech competition is somewhat blurred



- Inter low carbon tech competition and bespoke arrangements exist on a "spectrum", rather than a binary choice
- Mature technologies can be grouped together in competitive processes…
- …while exceptions can be made for emerging / immature technologies that are perceived as potentially benefitting from supply chain developments

Contract for Difference Allocation Round 4 ("AR4")	
Pot 1: Onshore Wind, Solar PV, Energy from Waste with CHP, Hydro, Landfill Gas and Sewage Gas	• 5 GW • Max onshore wind 3.5 GW • Max solar 3.5GW
Pot 2: ACT, AD, Dedicated Biomass with CHP, Floating Offshore Wind, Geothermal, Remote Island Wind, Tidal Stream, Wave.	• Min floating offshore wind £24m • Min tidal stream £20m
Pot 3: Offshore wind	

DRAFT FOR DISCUSSION

Low carbon support options exist on a spectrum, but many pros and cons have been hypothesised for the ends of that spectrum…

	1 Technology specific support	2 Inter low carbon tech competition
Hypothesised advantages	✓ Greater certainty to deliver desired technology-specific outcomes (e.g. total MW or MWh) & a portfolio of technologies ✓ Straightforward to deliver as current mechanisms could continue to be used and targeted at different technologies (e.g. H2, CCS etc) ✓ Lowest WACC and inframarginal rents ✓ Can be tailored to account for different level of maturity of specific technologies, and support supply chain development (e.g. offshore wind)	✓ Greater competition across technologies may lead to more innovation and lower prices (although depends on the precise design of the mechanism) ✓ Reduction of (potentially undue) discrimination between technologies ✓ Some reduction in central authority's burden in defining technology mix & strengthens the role of the market ✓ Single support mechanism ✓ Lower WACC compared to a broad investment mechanism
Hypothesised disadvantages	× Cherry-picking winning technologies (inefficient tech choices) / undue discrimination (hence central authority being exposed to lobbying) × Administrative burden & assumes that the central planner has a better view of future cost evolution than the market × Multiple mechanisms can be difficult to manage × Value for money concerns when technology costs lower than anticipated (e.g. solar FiT) × Long-term contracts limit adaptability	× Complexity of auction arrangements, e.g. ensuring level playing field between technologies (e.g. is 1MW of wind vs nuclear vs BECCS) × Competitiveness of techs changes (e.g. LCOE evolves over time), which could limit the benefits of competition × Greater risks for investors compared to technology-specific support × Risk that a single dominant technology wins, thus restricting the portfolio of new generation × Long-term contracts limit adaptability

…and we will discuss shortly if there any other pros and cons.

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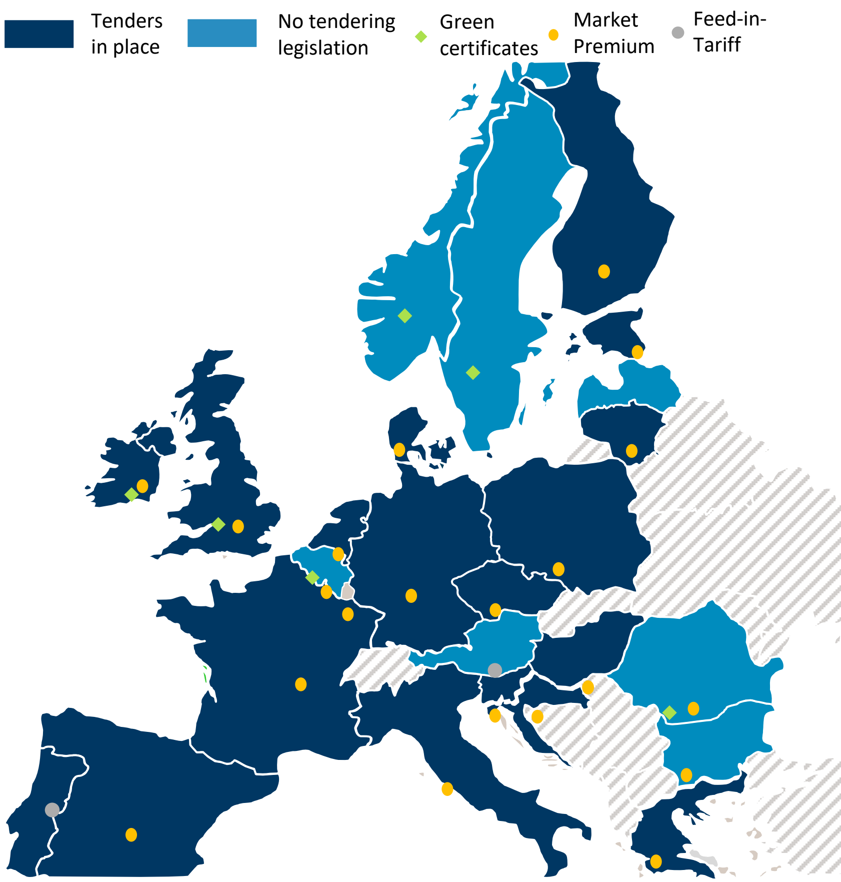
There is no uniform approach in procuring low carbon support across Europe (or even within an individual country)

Support schemes for utility-scale RES

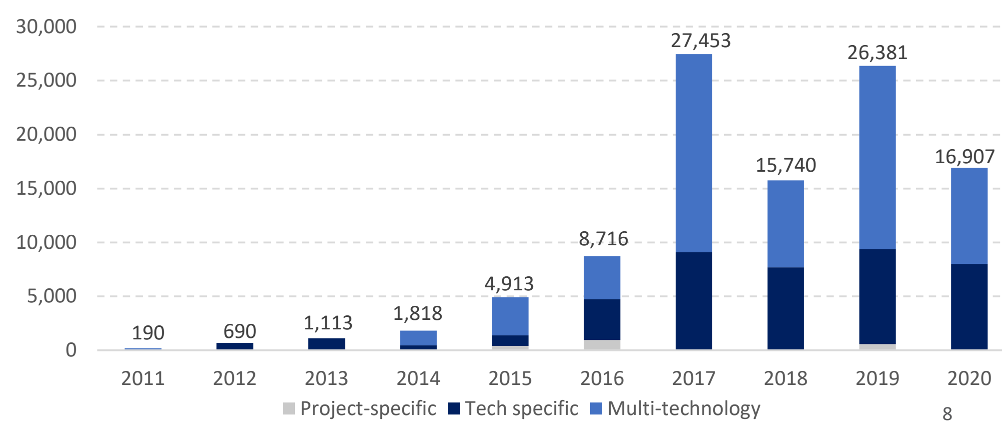


Sources :
European Commission - Final Report of the Sector Inquiry on Capacity Mechanisms
European Commission - RES Legal
CEER - 2nd CEER Report on Tendering Procedures for RES in Europe
CEER - Status Review of Renewable Support Schemes in Europe for 2016 and 2017
European Commission - Final Report of the Sector Inquiry on Capacity Mechanisms
CEEM – Capacity Remuneration in power markets : an empirical assessment of the cost of production

Low Carbon Support

- The European RES support schemes have evolved in recent years towards competitive auctions of Feed-in-Premiums and Green Certificates, but there is limited coordination / harmonisation of approach across Europe
- Competitive auctions across multiple-technologies have been becoming more popular (see chart below)…
- …however, the eligible technologies are usually narrowly-defined to a few technologies only…
- …and the auctions tend to pre-determine limits on the quantity of each technology
- Contract duration varies between 15 and 20 years depending on the country and technologies allowing to support bankability of project developers

Awarded capacity to low-carbon technologies through auctions



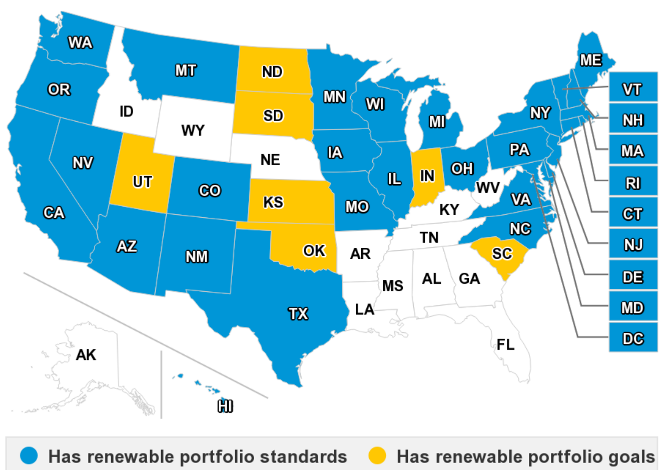
Sources :
AURES database

Tech-neutral competitions can shift some risks to retailers, and encourage innovating in contracting; while long-term contracts can reduce WACC

Renewable Portfolio Standards in the US

- Central determination of an overall low-carbon target, established at a state level, which the retailers (Load-Serving Entities) must meet.
- Retailers then determine the exact mix of technologies, by selecting which generators they contract with…
- …and also select their preferred contracting mechanism (often a PPA)

Most states have renewable portfolio standards and goals



eia Source: Database of State Incentives for Renewable Energy & Efficiency®, September 2020

- Risk of getting the technology mix "wrong" can be placed onto utilities (rather than consumers, if centrally determined).
- Encourages innovation in PPA markets (US markets now world leader in this area).
- By contrast, development of European PPAs has arguably been hampered by targeted mechanisms and the contracting approaches in place.

Renewable Obligation Certificates in Europe

- Renewable Obligation Certificates have been perceived as increasing the cost of capital (WACC) for market participants.
- At the time of transitioning to Contracts for Difference (CFDs), the UK energy ministry (DECC) assessed the impact of moving from RO to CFDs…
- …and identified an expected reduction in the WACC (excl counterparty risk), as summarised below.

WACC reduction CfD/RO	DECC (IA)	DECC (White paper)
CCGT + CCS	NA	-0.1%
Coal + CCS	NA	-0.4%
PV	-0.9%	NA
Onshore wind	-0.5%	-0.3% to 0%
Offshore wind	-1.1%	-0.8% to -0.5%
Biomass	0%	-0.5%
Nuclear	-0.8%	-1.5%

Source: DECC, 2011 and 2012

- Long-term contracts in the form of a CFD provide a robust reference price guarantee compared to ROs
- This has been estimated to translate into a reduction in the cost of capital of up to 1.1%
- Directionally, the effect would likely be lower now (10 years onwards)

Capacity Adequacy

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Bespoke capacity adequacy arrangements can be tailored to meet technology-specific sub-targets for the procurement of firm capacity

Central authority identifies the system needs

Number of technology-specific sub targets for the procurement of capacity (this can be "de-rated" to reflect its "firmness")

Tech categories & eligibility	Units and/or Volume
	X MW
	X MW
	X MW
	X MW
	X MW

Unlike low-carbon support, capacity adequacy manages both:

- Retirement of old plants (management of an orderly exit); and
- New capacity build out (requiring new investments to be made)

Mechanism to address the identified need

Bespoke contracts or regulatory arrangements for capacity adequacy from individual technologies (e.g RAB, cap and floor) beyond existing low carbon incentives

Multiple options of detailed design

- Technology specific targets (by technology class, or group of technologies)
- May be additional to low carbon support
- Typical examples: strategic reserve; strategic technology support (e.g. Victorian Big Battery (Aus), Energy Storage mandate (US), potential RAB regime for new nuclear (GB))

Key design dimensions:

- Eligibility criteria: existing plants vs new build
- Support type (e.g. capacity obligation or reliability option)
- Auction / pricing mechanism and frequency
- Potential combination with low carbon support and/or flexibility (e.g. ramping rate)
- Duration of support
- Penalties for non-delivery

Outputs

- Technology mix mostly predictable
- Support based on central authority's assessment
- May be targeted to support classes of capacity based on age / technology / maturity
- Bespoke mechanisms can lead to distorted outcomes (i.e. through progressive widening of the scheme)…
- …but can help reduce windfall payments to existing capacity (under a market-wide mechanism)

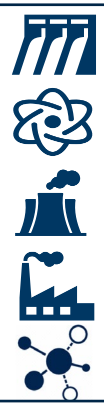
Potential measures to manage the risk of market distortion?

Alternatively, traditional capacity mechanisms that are eligible to a wider range of technologies can be used to procure firm capacity

Central authority identifies the system needs

Single support mechanism to achieve the capacity system need objective

Tech categories & eligibility



Units and/or Volume

MW of de-rated capacity, which may be linked to a low carbon measure (e.g. capacity, output or CO2 abatement)

Mechanism to address the identified need

Technology-neutral single target for firm capacity, facilitating competition between different providers of capacity

Multiple options of detailed design

- Different degrees of centralisation possible (e.g. by placing obligation on retailers instead of a centralised auction).
- Mechanism such as "de-rating" factors, based on expected contribution to capacity adequacy, required to compare techs on a like-for-like basis (e.g. GB CM de-rating for storage, interconnectors and intermittent renewables)
- May include firming capacity requirements (e.g. via physical co-location or VPPs)

Outputs

- Technology mix largely unknown ex ante (unlike a bespoke mechanism)…
- …which can lead to unexpected outcomes (e.g. gas reciprocating engines, instead of CCGTs, a 'surprise' winner in the GB CM)
- Support to emerging techs only possibly on a by-exception basis…
- …but future rounds may allow participation of new resources that become cost competitive.

Key design dimensions:

- Eligibility criteria (including condition e.g. new, refurb or existing)
- Support type (e.g. capacity obligation or reliability option)
- Auction / pricing mechanism and frequency (e.g. centralised auctions or decentralised obligations)
- Potential combination with low carbon specific support
- Potential combination with other flexibility system needs (e.g. ramping rate)
- Duration of support
- De-rating set centrally vs "bid in" by resources
- Penalties for non-delivery

The GB Capacity Market, introduced in 2014, is now an integral component of the GB energy market

1 Roles & basic parameters

The ESO develops **scenarios** of **peak demand**, and advises on the amount of capacity needed to meet the **reliability standard.**

De-rating Factors are calculated for relevant participants.

Capacity is mainly procured through 2 types of Capacity Auctions, **T-4 and T-1**.

De-rating factors for T-4 Delivery Year 2024/25

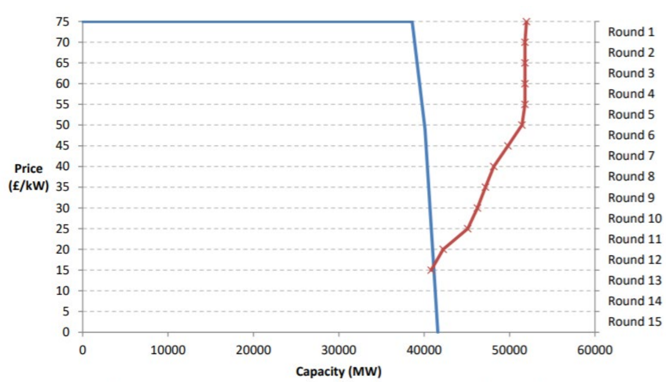
Technology type	De-rating factors
Oil, OCGTs & Recips	95.22%
Nuclear	81.43%
Hydro	90.99%
Storage	Varies by duration
CCGT & CHP	90.00%
Coal, Biomass & EFW	84.80%
DSR	79.21%
Intermittent RES	2.34% – 7.81%
Interconnectors	Varies individually

2 Example demand/supply curve from a recent auction

Auction **sets the price** for capacity and determines which providers are issued with **capacity agreements.**

During the auction, Bidders are able to **adjust their strategies** based on the **information** they receive before each Bidding Round.

Clearing price for T-4 Delivery Year 2024/25



Total Capacity percentage procured and not procured in the Capacity Auction

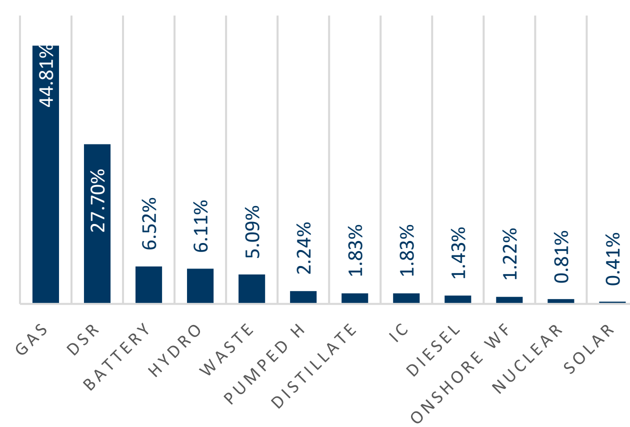
3 Auction results

The clearing price for the T-1 2021/22 auction was **£45/kW/year**, a **significant increase** on recent auctions.

The T-4 2024/25 auction cleared at **£18/kW/year**.

Technology split is determined by the market, with the majority of contracts to **existing generators.**

Technology mix for T-4 Delivery Year 2024/25



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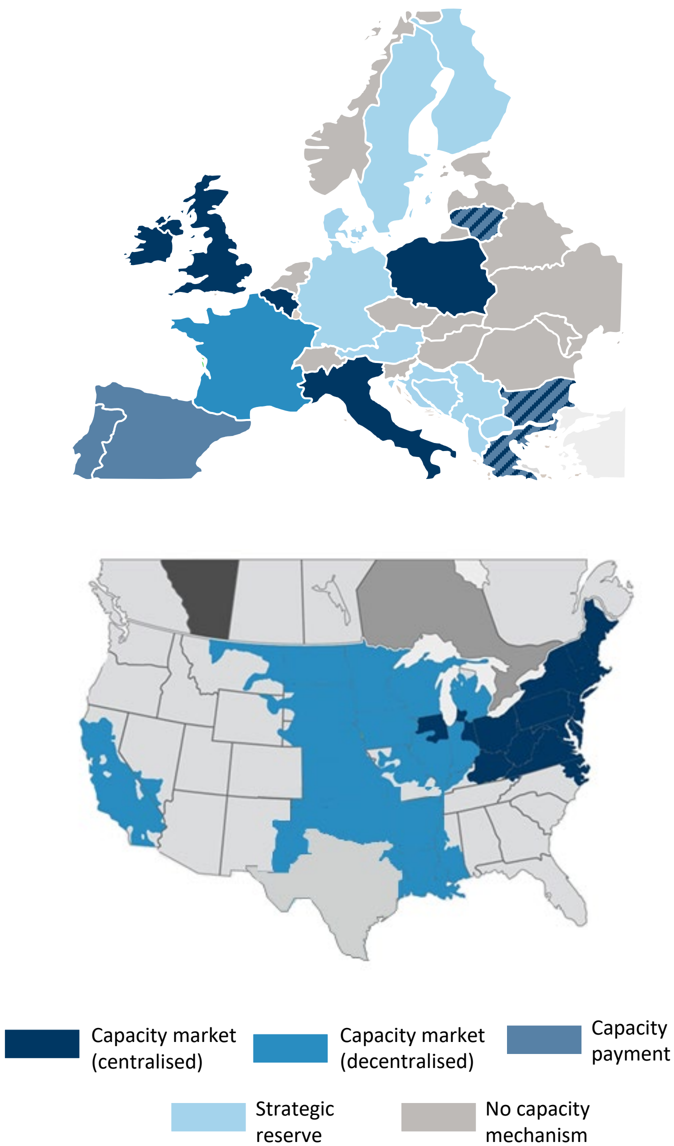
Globally, a wide range of capacity mechanisms have been developed, with a growing trend towards market-wide mechanisms

Capacity remuneration mechanisms



Market-wide mechanisms are increasingly becoming the preferred type of CM

- Market-wide mechanisms are becoming the preferred approach when there is a significant needed to maintain existing capacity and attract new investment to replace ageing fleet or phase-out of existing capacity (e.g. nuclear or coal)
- Targeted mechanisms (or other bespoke arrangements) have been used in jurisdictions that desire to maintain an energy-only market design or to manage the exit of excess capacity in an orderly fashion…
- … however, some traditional energy-only markets such as ERCOT and the NEM in Australia are considering introducing CMs.

Possible combination of CM for new build and bespoke arrangements for existing plants?

No consensus on how low-carbon should be incorporated in capacity mechanisms

- In Europe, renewables are typically allowed to participate in the CM if subsidy-free (e.g. GB) or their subsidy is adjusted (e.g. Ireland, Italy).
- In the US, low carbon intermittent generation is allowed to receive both federal renewable subsidy and capacity payments. There are some restrictions on capacity market resources receiving state level subsidies in ISOs with retail competition (notably NYISO, ISO New England and PJM).

Scarcity price adders

- Scarcity pricing could also be a **wholesale market design option**, and complementary to bespoke arrangements or traditional CM…
- …and have been considered in some US and European jurisdictions.
- Its implementation will influence the residual need hence implementation of scarcity pricing could re-open the decision on targeted vs central CM.
- Due to challenges in compatibility with self-dispatch, may be more workable with central dispatch models.

Possible second-order option… …for potential consideration even though pure wholesale energy price signals were ruled out in Phase 2?

As with low carbon, there is a spectrum of options for capacity adequacy mechanisms, and many pros and cons have been hypothesised…

	1 Bespoke arrangements	2 Traditional Capacity Market
Hypothesised advantages	✓ **Straightforward to implement** as a complement to existing mechanisms ✓ Can be **fine-tuned for specific technologies** (e.g. Demand Response, peaking plants, only new or only existing plants) or **specific system needs** (e.g. locational need for adequacy as in France or Germany) ✓ Targets a small **subset** of the market (hence no payments to capacity that would have been online anyway) ✓ More **flexibility to decide on bespoke arrangements** given UK is now out of the EU ✓ Lowest WACC and inframarginal rents	✓ Status quo in GB ✓ Provides **remuneration to all capacity** contributing to the system need (including existing plant) ✓ Single support mechanism which can provide **investment certainty** (if long-term and seen as credible, hence solve “missing money” problem) ✓ **Transparency** on instances of non-delivery of capacity (compared to relying on the market) ✓ Lower WACC and inframarginal rents compared to a broad investment mechanism
Hypothesised disadvantages	× Requires **central body assessment** which technologies are required to deliver a secure net zero system × Creates **discrimination between technologies** within and outside of the mechanism that in principle contribute to the same system need × May **accelerate the retirement of technologies** not covered by the mechanism, exacerbating the adequacy issue in the long run (“slippery slope”)	× Can be considered a **too expensive measure** since requires remunerating large volumes of capacity that is economic without the mechanism (Belgium) × **Complexity of creating level playing field** between new and existing technologies and further between technology classes (de-rating) × Additional complexity of **cross-border participation** × Effectiveness may depend on a robust **penalty regime** which is typically difficult to design and/or implement

Note: In the assessment we have assumed that no scarcity price adder is implemented.

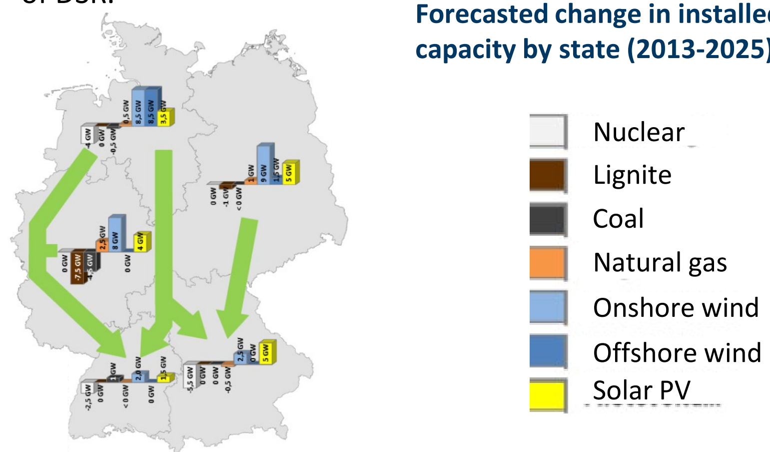
…and we will discuss shortly if there any other pros and cons.

Case study: Strategic reserves in Germany are used as a bespoke capacity adequacy mechanism to meet system needs

Key issue	*Does there need to be a single strategic reserve mechanism to meet security of supply requirements, or can there be multiple ones?*

- In Germany, specific strategic reserves meet specific supply needs :
- **Capacity reserve:**
  - Introduced in **2016** to ensure continued security of supply under the changing situation of the German electricity market, while not distorting price signals on the *energy-only* market
  - **Targeted, volume-based, technology-neutral mechanism** aiming at ensuring overall adequacy between production and demand in times of system stress for the electricity system
- **Climate reserve:**
  - Introduced to ensure security of supply while limiting carbon emissions
  - Lignite-fired plants are forced into the climate reserve and cannot participate in the capacity reserve.
  - Capacity reserve is dispatched in priority, while climate reserve being called upon as a last resort by TSOs
- **Grid reserve:**
  - In place since 2011**, the grid reserve aims at addressing grid bottlenecks** (triggered by regional supply-demand imbalances and delay in grid expansion) and thereby **maintaining grid stability**
  - **It is a volume-based mechanism** targeted at generation capacities essential for re-dispatching. **Not technology-neutral** with exclusion of DSR.

Forecasted change in installed capacity by state (2013-2025)

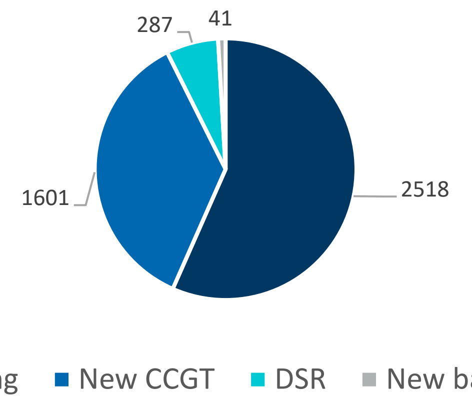


Key insights	Bespoke arrangements can be developed to include other system requirements in addition to capacity targets (e.g. emission criteria and locational factors)

Case Study: Belgium's transition from strategic reserve to a market-wide Capacity mechanism

Key issue — *Are strategic reserve mechanisms and a capacity mechanism each better suited for different categories of capacity (e.g. existing build vs new build)?*

Distribution of capacity contracts in the first auction held in 2021 (AL-4, 2024/25) (MW)



- The first auction (held in October 2021 for delivery in 2025/26) secured 4.5GW of capacity contracts, including **1.6GW of new investments**, via 15-year contracts.

- **Strategic Reserve initially implemented:**
  - Initially implemented in 2014 in Belgium to ensure security of supply in a context of ageing thermal power plants phase-out.
  - Targeted mechanism remunerating capacity units which are outside of the market, to meet a residual demand and to ensure adequacy in the short-term, through 1-year contracts. It is therefore unsuitable to support new investments.
- **The need for a capacity market:**
  - However, the planned nuclear phase-out between 2022 and 2025 (-5.9 GW, i.e. half of the dispatchable capacity of system) had led a need for new capacity (Elia anticipated in 2019 a deficit of at least 3.9 GW in 2025 in the energy-only market).
  - A market-wide capacity mechanism has been introduced to foster investment through long-term contracts
  - Pay-as-bid auction to avoid inframarginal rents in the capacity market and to reduce the cost. Legacy from the strategic reserve.

Key insights

- Strategic reserves may be useful in specific conditions (e.g. supporting transitional arrangements during phase-out of plants)…
- …but are typically unsuited to bring forward significant new investments

Broad-based mechanism

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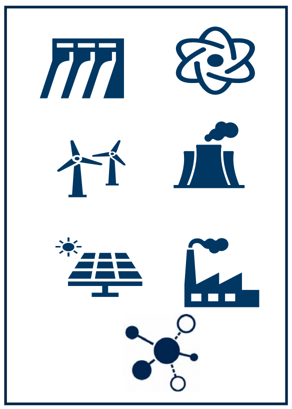
Broad-based mechanisms can be used to integrate low-carbon and capacity adequacy objectives

Central authority identifies the system needs

Single support mechanism to achieve the capacity and low carbon system need objective in a coordinated manner

Tech categories & eligibility



Units and/or Volume

MW of de-rated capacity, contributing to both capacity and low carbon objectives

Contribution of resources to dual objective of low-carbon and capacity adequacy is reflected simultaneously

Mechanism to address the identified need

Technology-neutral mechanism that facilitates competition between capacity providers, while accounting for low carbon measure

Multiple options of detailed design

- Single mechanism, but can have a variety of auction products and/or auction prices
- Mechanism may range from relatively simple options (e.g. centralised capacity mechanism, with de-rating factors that incorporate carbon emission factors and availability) to form one auction product and one or two auction prices…
- … or with greater complexity (e.g. use of an algorithm that adjusts ahead of an auction and/or ex-post) with potentially two auction products and two auction prices

See worked example in the following slides.

Outputs

- Technology mix largely unknown ex ante (unlike a bespoke mechanism)
- …but existence of two products with one price ensures multiple requirements are satisfied…
- … and potential efficiency benefits through joint-optimisation.

One example of co-optimised procurement of capacity adequacy and low-carbon generation is a ‘One process, two products, two prices’ auction…

1 Market submissions

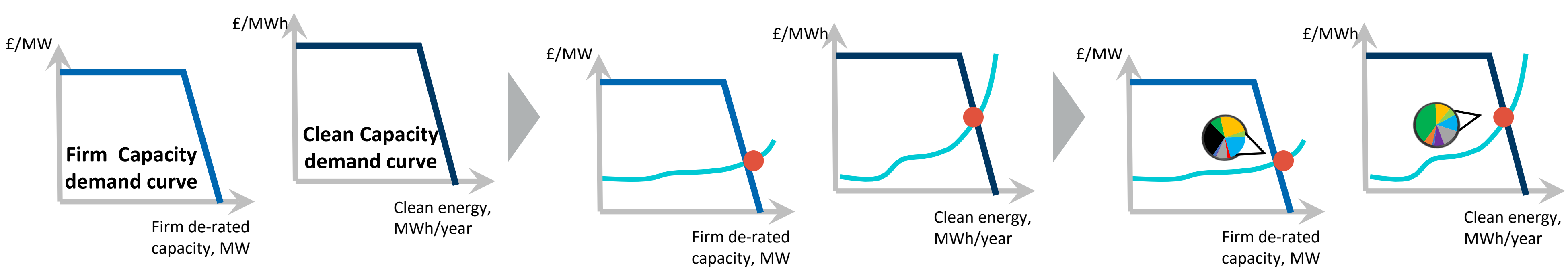
- Procuring entity has a **separate demand curve** for each product
- Offers are structured with a **single offer price covering both products** (adequacy, clean power)
- Offer price reflects the unit’s **annual revenue requirement** across both products

2 Co-optimised auction/assessment process

- Specific objectives can be set for de-rated installed capacity and/or clean electricity procured.
- Bid assessment **co-optimises based primarily on price**, aiming for least-cost solution…
- …but solution is **constrained** by minimum targets set.

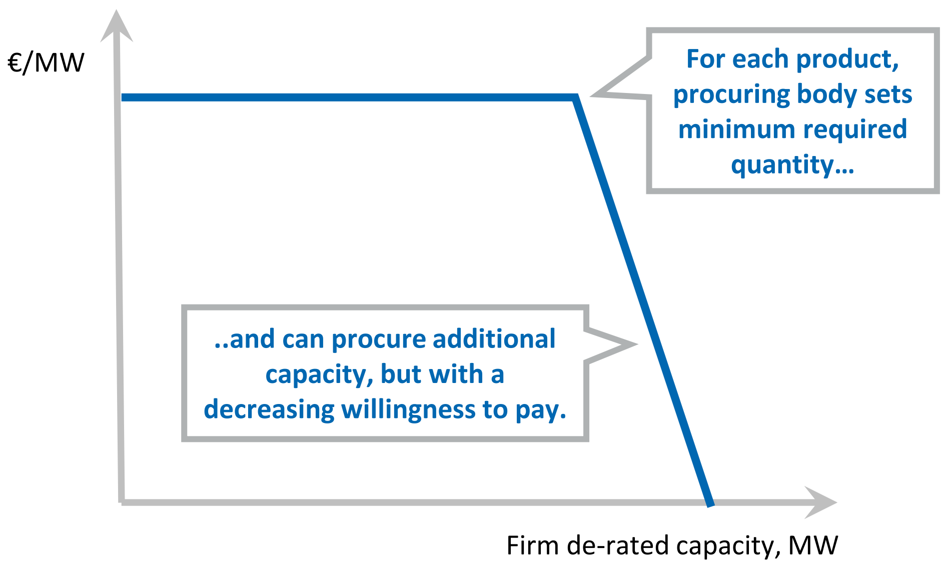
3 Clearing results

- Adequacy and clean energy products **clear at different prices**…
- …set at the **marginal cost** of meeting additional demand **for each product**.
- Each product clears with a **different generation mix** (due to differing carbon contents).



A separate demand curve is developed for each product, with bidders submitting offers with one price covering two quantities

Indicative firm capacity demand curve



- Procuring entity develops a **separate demand curve for each product**, representing its respective willingness to pay for capacity adequacy and low-carbon electricity.
  - For capacity adequacy, a minimum de-rated capacity in MW.
  - For low-carbon generation, minimum GWh.
- Procuring entity sets a **minimum required capacity** for each product, with a decreasing willingness to pay for additional capacity/generation.

Hypothetical bids by technology

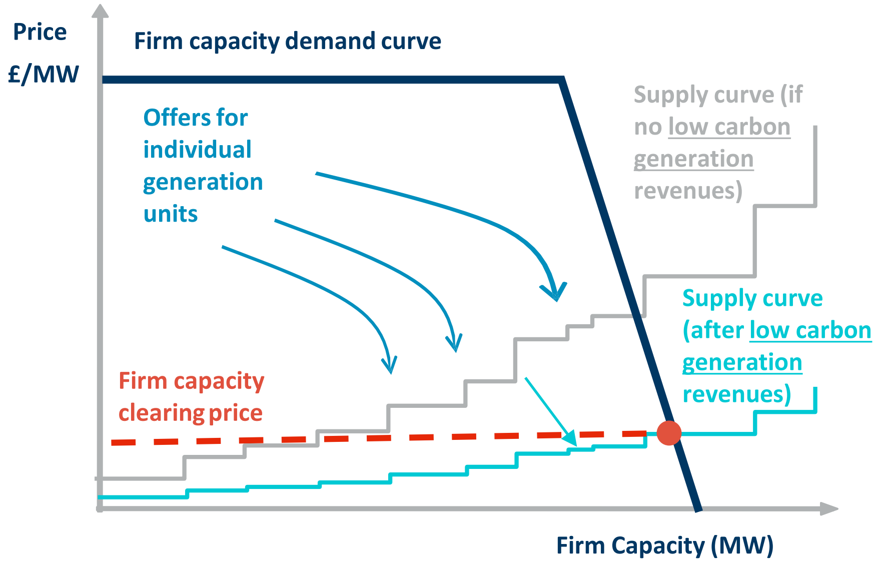
	De-rated firm capacity (MW)	Low-carbon generation (MWh)	Total bid (£/MW)
Gas	60	0	£4
Solar	30	80	£5
Nuclear	60	60	£7

Bidders submit a single offer price covering both products.

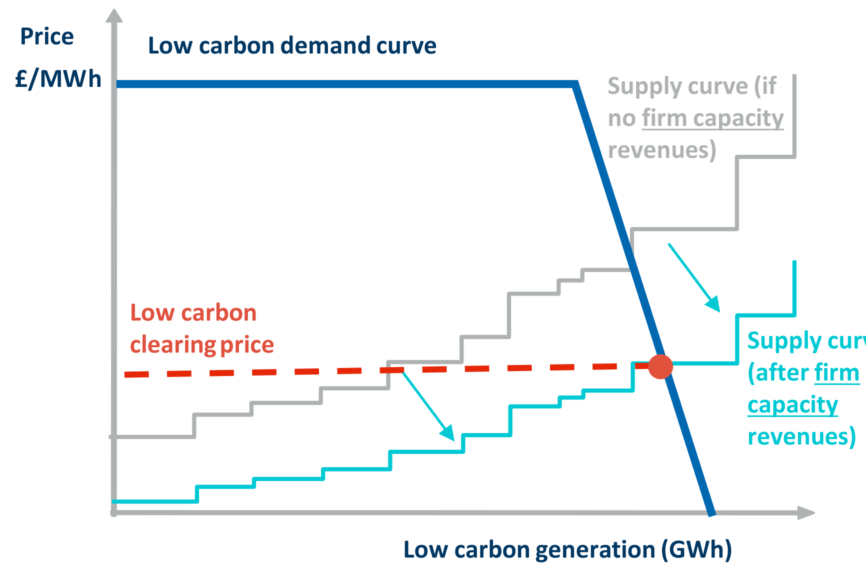
- Bidders submit offers with **one price** (£/MW) and **two quantities**:
  - **De-rated capacity** available for the auction period (MW)
  - Expected **low-carbon generation** across the auction period (MWh)
- Single price represents the **minimum total payment** a bidder requires **across the two products** to deliver the offered volumes of capacity and low-carbon electricity.
- Bidders are **indifferent** to whether revenue is earned through the capacity or low-carbon support mechanism, as long as they receive **at least their offer price** across the two products.

The two products clear at different prices, targeting the least-cost solution that meets the minimum requirement for both products

Illustrative firm capacity demand curve



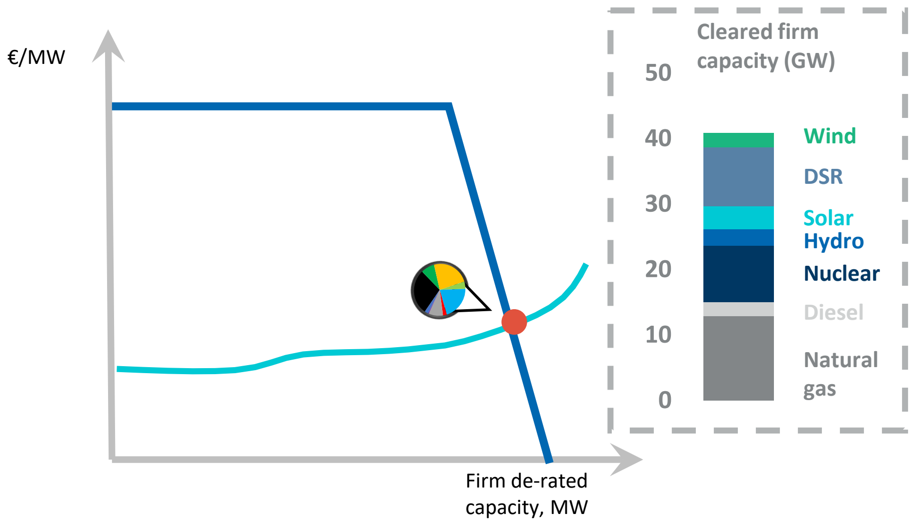
Illustrative low-carbon demand curve



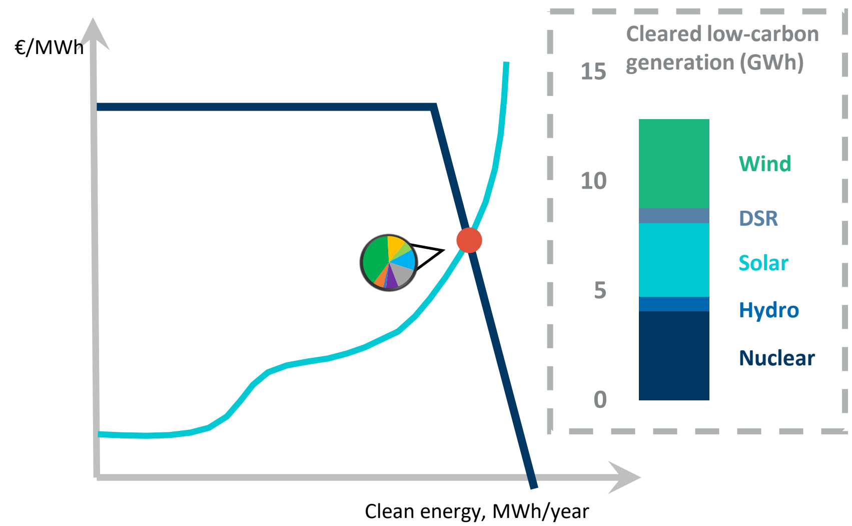
- Co-optimised process targets the **least-cost solution** that meets the **minimum requirement for both products**.
- Capacity and low-carbon generation clear at **two different prices**: (i) **£/MW** of de-rated capacity; and (ii) **£/MWh** of low-carbon electricity.
- Crucially, the clearing price for each product is set at the **marginal cost** of securing an additional unit **after accounting for revenues the provider would earn for the other product**.
- For low-carbon generators, any additional unit of firm capacity provided will also receive revenues for the low carbon product (lowering marginal cost), but for emitting generators, revenues can only be earned for the firm capacity product.
- The auction algorithm identifies the optimal resource mix across the two products (maximising the value of cleared resources minus cost of procurement)…
- …by repeatedly altering the mix of bids across the two products, calculating the relevant clearing price for each product (accounting for revenues earned for the other product), and assessing which bids would clear at those prices, until the optimal solution is found.

With each product clearing at different prices, with different eligible technologies, the procured generation mix varies between the products

Illustrative firm capacity demand curve



Illustrative low-carbon demand curve



- Each product clears at a **different price** and with a **different generation mix**.
- A co-optimised auction could **enable low-carbon generators to be more competitive** in auctions for capacity adequacy, procuring a cleaner mix of technologies…
- …as the '**price required**' by a low-carbon generator for an additional unit of **firm capacity** would be **partially offset** by the additional revenues it would earn for its **increased contribution to the low-carbon product**.
- By combining the two processes, the co-optimised auction essentially **internalises 'spillover benefits'** from the two services, potentially **reducing the combined cost of procurement** (compared to procuring the same quantities of each product separately).

DRAFT FOR DISCUSSION

We will explore hypothesised advantages and disadvantages of a broad mechanism addressing both low-carbon support and capacity adequacy

	1 Broad-based mechanism
Hypothesised advantages	✓ Maximises **competition and efficiency** of supporting providers of low-carbon energy and capacity ✓ Accounts for the **contribution of each resource to each system need** (clean energy and firm capacity[1]) ✓ **Avoids negative impact** of one support mechanism (RES) on the investment signals necessary to meet other system needs (adequacy), i.e. internalises 'spillover benefits' and helps synchronise provision of support ✓ Reduces the **combined costs of procurement** across two mechanisms
Hypothesised disadvantages	× In case of a single price mechanism - existence of a single price **could lead to the higher price** paid (larger inframarginal rents) × Higher WACC compared to low carbon and capacity alternatives explored previously due to investor uncertainty from the novelty of the regime × **Implementation complexity** of meeting multiple system needs within the same mechanism, and challenging to deliver quickly × Complexity of developing a **level playing field** across technologies accounting for their contribution to different system needs × Less mature technologies may not be competitive in the absence of a bespoke arrangement × Price clearing algorithm across multiple products can be seen as a 'black box'

Flexibility elements

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We have separated flexibility as a separate element as delivering on its requirements will span across both investment an operational elements

- Flexibility refers to the resources' ability to adjust supply and/or demand so that they are balanced in real time. Based on Phase 2 analysis, the focus is on energy flexibility (i.e. not voltage or inertia requirements).
- Flexibility is a wider concept than ancillary services design (which is a second order element).
- As part of Phase 2, the challenge of managing energy imbalances is shown to be a growing issue, with periods of both excess generation and demand expected to become more *"extreme and prolonged"*. To address this challenge, a range of options to support flexibility investments have been identified:

3 Flexibility

- Bespoke arrangements
- Long-term flexibility contracts
- Joint procurement with firm capacity
- Short-term market revenue stacking only — *Ruled out in Phase 2 as a sole mechanism**

Definition of system needs

- No central authority currently determining an overall flexibility requirement in GB (unlike for low-carbon and capacity)…
- … this is instead guided by market participant incentives from the balancing regime

Mechanism to address the identified need

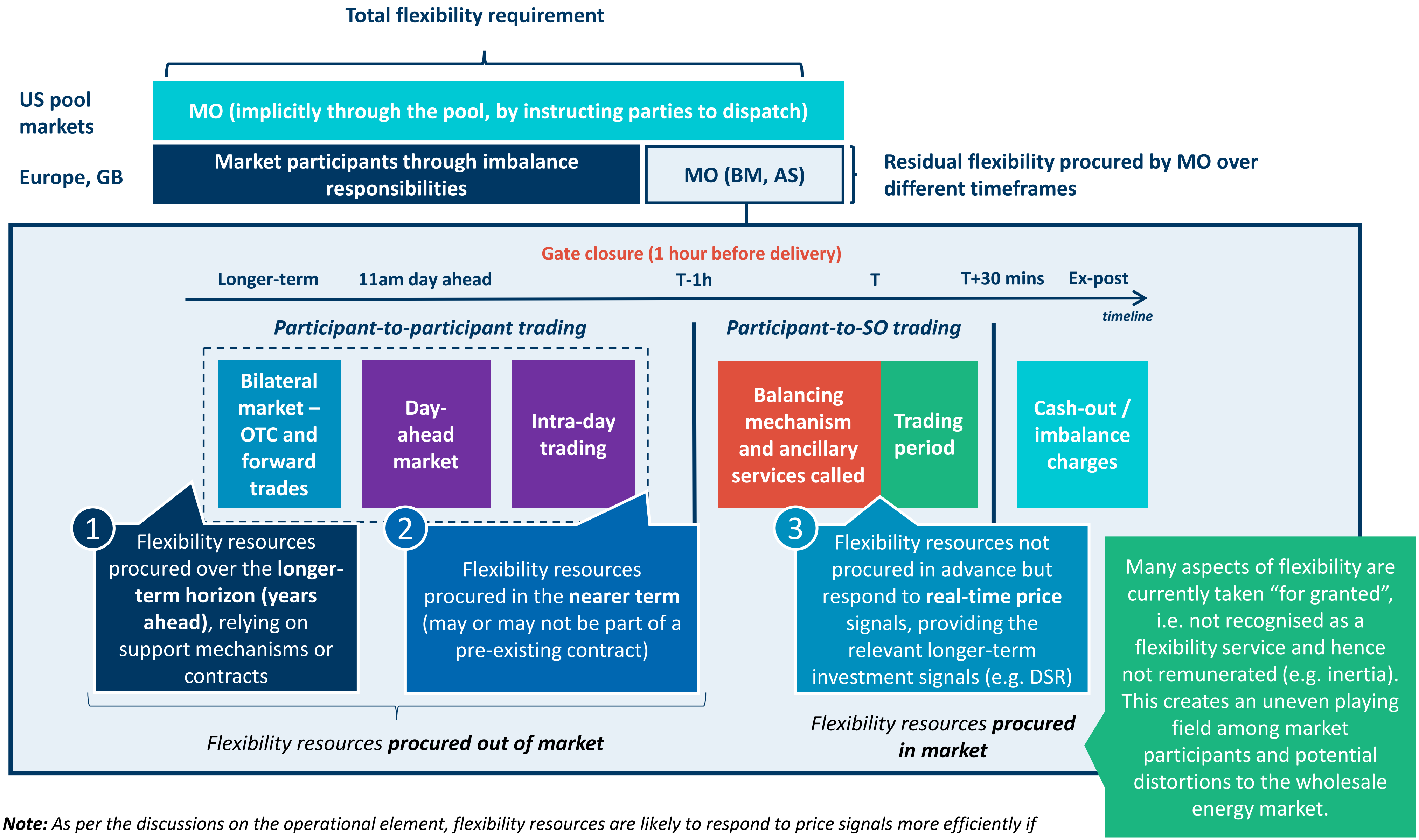
- Development of procurement mechanism to deliver the flexibility requirement
- Development of the activation mechanism to utilise the flexibility resources efficiently as and when required

Key considerations

1. Should **an overall flexibility requirement be determined by a central authority?**
2. To what extent is **the technology mix determined by a central authority vs the market?**

** Note: We understand that the Phase 2 outcome has ruled out the provision of short-term markets for flexibility as the sole source of revenues. However we understand that such markets can remain in place alongside potential additional mechanisms.*

The share of flexibility that is met by market participants, or centrally by the MO is to a significant extent driven by the dispatch model in place



Note: *As per the discussions on the operational element, flexibility resources are likely to respond to price signals more efficiently if there are shorter balancing periods.*

In the European context, overall (residual) flexibility requirements are typically determined centrally by the SO, but other options are available

- A Government-defined energy flexibility requirement requires a clear definition of "flexibility", and measurable units
- Defining an overall flexibility requirement is a likely to be a very complex process as it is multifaceted and reflects a range of technical needs in the system.
- Diagram below sets out a range of approaches to determining the flexibility requirement:

Key challenge: Definition of energy flexibility

- Ramping up/down speed?
- Minimum stable load?
- Difference between MSL and nameplate capacity?
- Min on/off times?
- Duration of response?

Market-determined volume of flex requirement ← → *Centrally-determined volume of flex requirement*

No mechanism	Market participants' self-provision	Standards and mandatory requirements	Bespoke arrangements	Bilateral flexibility contracts	Flexibility auction (sole or jointly with firm capacity)	Spot markets for individual flexibility services
No central definition of flex requirement. SO procures on an ad-hoc basis. Actual volume of flexible capacity highly uncertain ex-ante.	*Volume of flex capacity driven by market participants' own forecasts of needs.*	*Partly centrally driven volume of flex (e.g. if all technologies must provide a certain frequency response capability)*	*SO determines the volume of certain types of flexibility, e.g. very fast frequency response, which motivates investment in specific types of flex (batteries).*	*SO determines to a significant extent the volume of flex on the system, particularly if the contracts are long-term. This is defined on a product by product basis, not system-wide*	*Overall flexibility need determined by a central authority*	*Central authority (SO) determines demand curve(s) for specific flexibility services, thus determining the exact volume-price relationship of procured services*

Market participants can "self-provide" up to gate closure (or equivalent) if they are incentivised by the balancing or settlement regime

Starting point for most flexibility procurement in Europe / GB. Also SO's (EU-driven) direction of travel towards short-term competitive procurement

Possibility to move to a more centralised approach, with a centrally determined flexibility target(s) – if they can be defined.

NB: In a pool design, a highly centralised role is possible for the SO given its greater role in dispatch.

Once the flexibility requirements are defined, there is a range of procurement approaches to deliver against these requirements

- Different procurement approaches have varying degrees of centralisation

No mechanism	Market participants' self-provision	Standards and mandatory requirements	Bespoke arrangements	Bilateral flexibility contracts	Flexibility auction (sole or jointly with firm capacity)	Spot markets for individual flexibility services
Reliance on SO intervention (e.g. redispatch)	Market participants self procure incentivised by imbalance price	Mandatory provision of services (e.g. frequency response)	Bespoke procurement / support by central authority	Range of contracts (long- / short-term; competitive / non-competitive)	Joint procurement of flex together with capacity and low carbon	Procurement through spot markets for individual flexibility services

Flexibility procured "out of market" by SO or another central body

Note: the procurement approach must be linked to the activation approach to ensure effective utilisation of resources

Bespoke arrangements

- Technology-specific procurement mechanisms
- Assumed to be long-term (to support investability)
- Central authority identifies specific techs to meet system needs

Long-term flexibility contracts

- Assumed technology-neutral to support competition (otherwise akin to bespoke arrangements)
- Definition of specific flex needs can in practice lead to specific tech choices (e.g. batteries in EFR)
- "Lowest common denominator" approach to eligibility criteria may not deliver desired type(s) of flex.

Flexibility auction procurement with firm capacity

- Technology-neutral mechanism (subject to technical performance criteria)
- Similar to a broad-based mechanism

Both of these approaches rely on a definition / metric for "flexibility", which is challenging

Flexibility procured in market through real-time flexibility services

Short-term market revenue stacking via spot markets

- Resources are rewarded based on a real time supply-demand clearance for each flexibility service.
- These services may be "co-optimised" with the real-time spot market for energy
- Short-term price signals may be augmented using CFDs to provide longer-term investments signals for flexible resources

We will explore hypothesised advantages and disadvantages of different procurement approaches for flexibility

	1 Bespoke arrangements	2 Long-term contracts	3 Joint procurement with firm capacity	4 Spot markets for flexibility
Hypothesised advantages	✓ Investor certainty and low WACC, depending on contracting mechanism ✓ Greater discretion to policymakers ✓ Capture a wider range of flexibility needs as they arise ✓ Can be integrated with other capacity adequacy and low-carbon support needs ✓ Ad-hoc procurement, providing the authority its own flexibility esp. amidst volatile market conditions	✓ Investor revenue certainty… ✓ …reducing WACC (to those resources who have access to long term contracts) ✓ Central authority's confidence and forward visibility (well ahead of time) in having access to resources providing required flexibility services	✓ Single mechanism provides simplicity and transparency ✓ Low risks to investors ✓ Joint optimisation of the plant fleet to mitigate inconsistent price signals (avoids 'salami slicing') ✓ Reflects contribution of each resource to all system needs (CO_2, firmness and flexibility) ✓ Levels out playing field between new techs and established techs (who receive CM revenues)	✓ No need for centrally-determined capacity or flexibility value ✓ Clear and accurate real time price signal, which can translate into long-term investment signals ✓ Once designed, can be left to day-to-day operations instead of regular auctions ✓ Inter-technology competition maximised, as all technically capable resources can provide services
Hypothesised disadvantages	× Risk of over-procurement of services… × …or excessive costs (if central authority procures too late and/or non-competitively) × Picking winners × Discourages technology innovation × Slower in keeping up with evolving system needs	× Picking winners in practice (via eligibility criteria) × Risk of over-procurement / technology lock-in × Administrative costs of contracts (& running competitions if applicable) × Inconsistent with SO's (and EU) direction of travel to shorter-term procurement closer to real time	× Complexity setting up a single "flexibility" metric due to numerous technical requirements of the system × Negative impact on less mature technologies that are not cost competitive × Risk of over-procurement of flex / cap / LC if the relative parameters are not set up correctly	× Requires a well-designed short-term energy market that produces efficient price signal × May not be implemented quickly enough to cover near-term flexibility shortfall × May be disproportionate to set up if service only used rarely × Methodology to form demand curve administratively set × Some types of flex difficult to co-optimise in dispatch

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Note: *All options are linked to security and reliability standards.*

Case Study: Traditional capacity markets can be expanded to integrate flexibility resources (e.g. ramping)

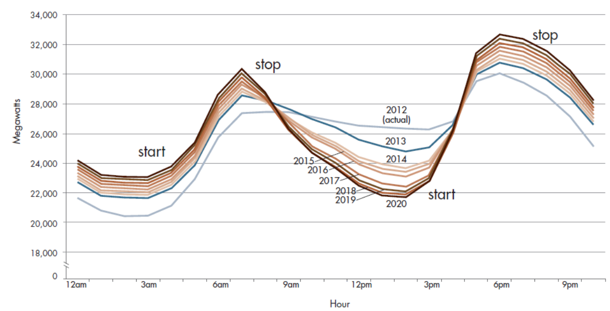
CAISO

Key issue	*How can the need for specific forms of flexibility be addressed within a capacity mechanism design?*

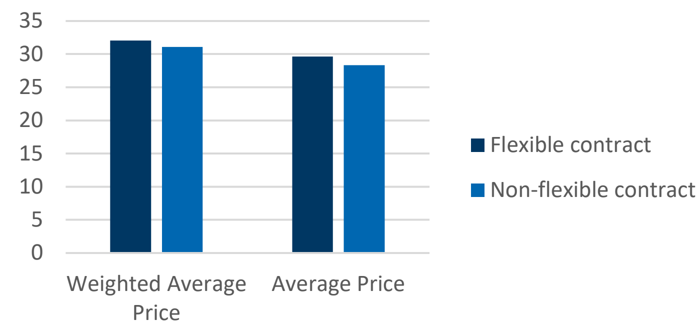
Evidence from CAISO, US:

- The increase in solar's share of California's electricity generation (12% in 2018, to 31% renewables in total) creates operational challenges and supply uncertainty, particularly at sunset, and thus increases a need for flexibility.
- However, this need for flexibility cannot he handled only by the frequency reserves (e.g.: additional reserves costly to build up, CAISO's frequency reserving mechanism unsuitable to cover situations of negative flexibility)
- In 2015, CAISO added a **ramping requirement** in its existing resource adequacy requirement
- Each supplier is required to enter into bilateral contracts with producers in the previous year and the previous month in order to have enough flexible capacity certificates to cover its needs
- Suppliers monthly flexible requirement is set at the forecast maximum consecutive three hour net load ramp during the month
- The average price of annual flexible capacity contracts is not significantly different from capacity price without flexibility, meaning that there is no evidence that there is a premium paid for flexible capacity

Increasing variations in residual demand within a day ("Duck Curve")



Comparison of flexible and non-flexible capacity price



Key insights	Some types of capacity adequacy mechanisms can be augmented to deliver flexibility requirements.

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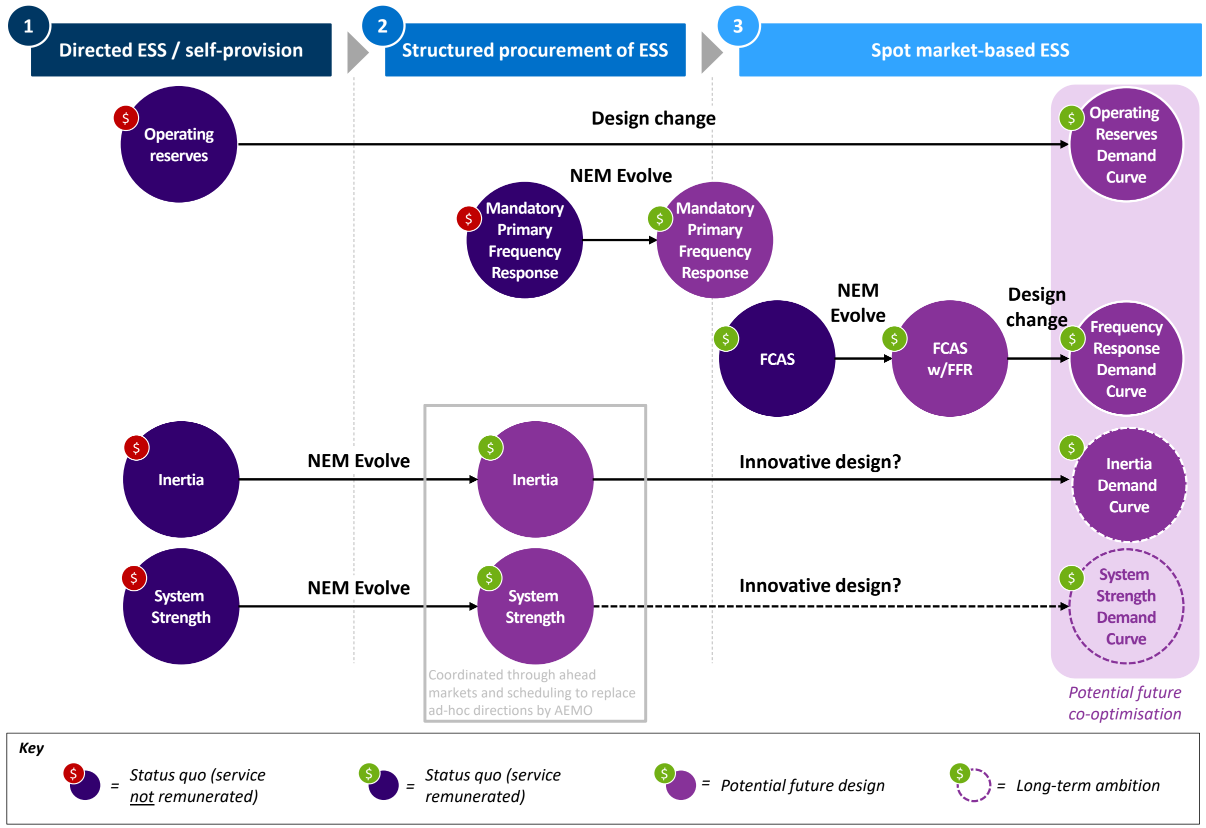
Case study: Direction of travel in the Australian NEM is towards spot-market-based procurement of flexibility

Key issue	*Has provision of flexibility from short-term spot markets been considered in other jurisdictions and how can it be reconciled with the need for long-term investment signals?*

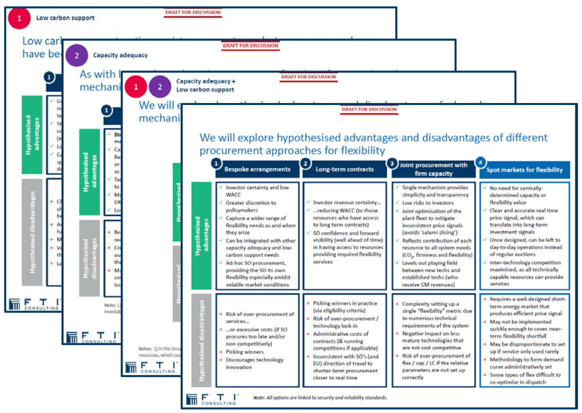
- Australia's National Electricity Market ("NEM") facing growing challenges of decarbonisation and decentralisation
- Post-2025 market design reforms seek to address these challenges
- Growing recognition that services previously taken 'for granted' need to be remunerated explicitly
- Most flexibility services procured by the system operator (AEMO) are on the path towards spot market based procurement (see diagram on the right)
- Recognition that spot price signals may be perceived to be too volatile to provide adequate investment signals…
- …hence potential contract-for-difference mechanism to firm up the revenue stream from investor's perspective…
- …while maintaining a sharp operational price signal



Key insights	- In theory, real-time price signals for flexibility requirements can provide sufficient risk-adjusted remuneration to incentivise the appropriate investments in flexibility resources. - Market-based approach in flexibility procurement and activation is being pursued in some jurisdictions, e.g. the NEM.

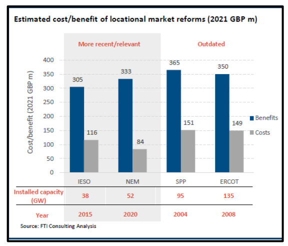
Next steps will focus on examining the hypothesised pros and cons, and evaluating options against agreed criteria, to be presented at Feb workshop

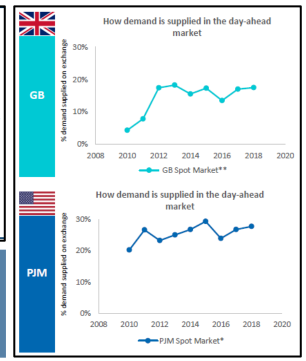
Summarise hypothesised pros and cons of individual options



- Incorporate feedback from today's session…
- …and from follow-up stakeholder input…
- …to consolidate the list of <u>hypothesised</u> pros and cons of each option

Examine hypothesised arguments in light of available evidence





Evidence from stakeholders

- Draw on stakeholders' feedback and evidence provided (if available) to "test" the robustness of the arguments
- Use the combined evidence from stakeholders, case studies, and economic theory, to validate specific arguments

Next workshop - February

Assessment Criteria:	
Decarbonisation	Provides confidence that carbon targets will be met
Security of Supply	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 the cost of finance is minimised
Deliverability	Transition from current market design to target design is deliverable in an appropriate timeframe
Whole System	Facilitates decarbonisation across other energy vectors, across connection voltages and facilitates demand-side participation
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

- Present outcomes of the analysis of the hypothesised pros and cons, and supporting evidence
- Evaluate options against relevant criteria
- Introduce relevant co-dependencies between options

Appendix

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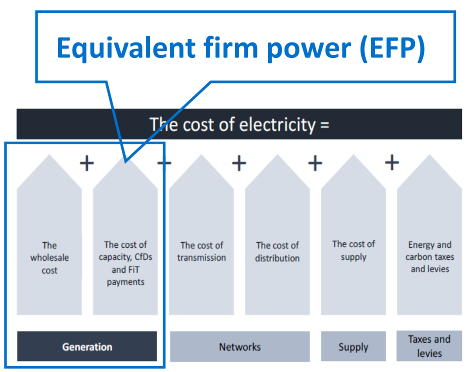
Appendix: A number of proposals to reform electricity markets have been put forward

Weaker — ***Market involvement in identifying system need*** — *Stronger*

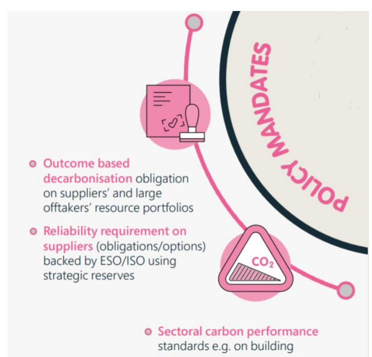
HELM — Cost of Energy Review

- Procure capacity and de-carbonising investments through a **single unified equivalent firm power** ("EFP") auction.
- The auction would be on an equivalent basis. This means that the **de-rated contribution of intermittent capacity is taken into account but…**
- …it **would not take account of carbon intensity**.
- Auction executed by the ESO, who also determines the EFP requirement



Catapult Energy Systems — Rethinking Electricity Markets

- **Phase out centralised contracting** (CfDs & CM) and replace with **decentralised capacity remuneration mechanism** (CRM) that evolves with market performance + Strategic Reserves as backstop
- Initially capacity procurement **requirement and obligation to be set by government** (Decentralised Reliability Obligations)
- This can **later shift onto suppliers** with Government role reduced to supervision only

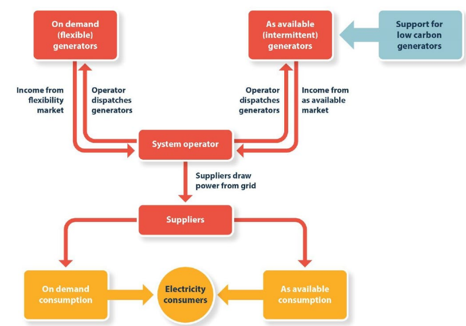


Aldersgate Group — Delivering Competitive Industrial Electricity Prices in an era of transition

- Recommends creation of a market for long-term, zero carbon and tradable electricity contracts via a **'green power pool' (GPP).**
- Consumers holding these contracts would avoid the indirect costs of carbon prices, and the volatility of fossil fuel prices
- The GPP will operate **in parallel to the spot market** which will:
  - incur the cost of buying from the wholesale (spot) market when insufficient renewable power/storage
  - sell back to the spot market when in surplus. The net cost will be charged to its consumers.

The Oxford Institute for Energy Studies — The 'Two Market' Approach

- Suggest creating **separate markets** for different sorts of power ('**on demand**' and '**as available**') at both producer and consumer ends.
- Dispatchable plants would operate in the 'on demand' and intermittent plant would operate in 'as available' with **different levelised cost of electricity**
- Consumers able to select 'on demand' or 'as available' power (for which they would normally have separate meter readings) or combinations of the two sources.



Position of the broad investment mechanism described previously

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