ENTSO-E Policy Paper

The role of Capacity Mechanisms to enable a secure and competitive energy transition

April 2025

ENTSO-E Mission Statement

Who we are

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the **association for the cooperation of the European transmission system operators (TSOs)**. The **40 member TSOs**, representing 36 countries, are responsible for the **secure and coordinated operation** of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E **brings together the unique expertise of TSOs for the benefit of European citizens** by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

Our mission

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the **security of the interconnected power system in all time frames at pan-European level** and the **optimal functioning and development of the European interconnected electricity markets**, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

Our vision

ENTSO-E plays a central role in enabling Europe to become the first **climate-neutral continent by 2050** by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires **sector integration** and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources.

ENTSO-E acts to ensure that this energy system **keeps consumers at its centre** and is operated and developed with **climate objectives** and **social welfare** in mind.

ENTSO-E is committed to using its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

Our values

ENTSO-E acts in **solidarity** as a community of TSOs united by a shared **responsibility**.

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by **optimising social welfare** in its dimensions of safety, economy, environment and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and **innovative responses to prepare for the future** and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with **transparency** and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

Our contributions

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its **legally mandated tasks**, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, Network Codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (**Ten-Year Network Development Plans, TYNDPs**);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.

ENTSO-E supports its members in the **implementation and monitoring** of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

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Executive Summary

Background and objectives of the paper

Capacity mechanism have long been a key feature of market design in several European and international electricity markets. Their primary role is to ensure resource adequacy by providing incentives to capacity providers – generation, storage, or demand side response assets – to help mitigate the risk of supply shortages, particularly during peak demand periods or system stress. The recent reform of the EU's electricity market design marks a significant policy shift, acknowledging CMs as a potential structural component of European electricity markets rather than merely a temporary, last resort measure.

As the energy system evolves, it is critical to ensure that capacity mechanisms (CMs) not only address immediate resource adequacy concerns but also consider additional system needs and align with broader objectives such as decarbonisation, market efficiency, and cross-border integration. To support policymakers in making informed decisions, ENTSO-E actively engages with all relevant stakeholders to enhance the effectiveness and sustainability of CMs.

This paper examines the evolving role of CMs in the energy transition, offering a detailed analysis of their design and implementation challenges. It evaluates various design options and provides strategic recommendations to enhance their effectiveness, ensuring they support a competitive and sustainable energy transition.

The role of capacity mechanisms in the energy transition

To speed up the energy transition, the European power system must undergo a profound transformation, driven by significant investment across the entire value chain. To enable these investments, electricity markets must deliver stronger and more effective long-term investment signals, particularly for resources critical to ensure resource adequacy and system security.

As the share of variable renewable generation increases, dispatchable resources – critical for maintaining system adequacy during periods of low renewable output – face declining running hours and greater price uncertainty. To remain viable, these resources must either generate sufficient revenues during scarcity periods, secure long-term commercial contracts (which are not widely available in Europe), or rely on state-backed support.

The 2022 energy crisis exposed the limitations of energy-only markets, as political and public resistance to high prices led to regulatory interventions at both EU and national levels, weakening price signals and introducing revenue clawbacks. In addition to volume and price risks, the risk of regulatory interventions is incorporated by investors as a risk premium in capital costs, further reducing profitability.

When revenues – either actual or expected – are insufficient, essential resources may exit the market, and new investments may fail to materialise, creating adequacy concerns. Without sufficient capacity, the power system risks shortages during periods of high demand or low renewable and carbon-neutral generation. By providing revenue certainty to market participants – including generators, storage providers, and demand side response assets – not only for their generated energy or flexible consumption but also for their available capacity during critical periods, CMs help establish a viable business case for the investments needed to maintain system adequacy.

Against this backdrop, CMs are increasingly likely to become a long-term feature of many European electricity markets. Ensuring security of supply during periods of limited renewable output while keeping electricity affordable – especially as electrification expands across sectors – is a fundamental public service. While CMs can bridge this gap, their design must balance adequacy needs with decarbonisation goals and broader system needs. To avoid locking in fossil fuel technologies beyond their necessary contribution, CMs must evolve to support the clean energy transition, prioritising low-carbon and flexible resources in the longer run.

Key design challenges and considerations

The design and implementation of CMs should address both current and future adequacy challenges while ensuring compatibility with system needs. A well-functioning CM framework should ensure sufficient revenue certainty for market participants, encourage investments in dispatchable generation, storage and demand side response assets. Thus, the choice of CM model – whether market-wide or targeted, centralised, decentralised or hybrid – should reflect the specific needs of each market while remaining adaptable to evolving system needs and conditions. Given the inevitable trade-offs involved, it is crucial to incorporate design features that foster a system-friendly, future-proof approach, allowing for adjustments as adequacy concerns evolve (whether due to market conditions or technological advancements).

For this purpose, the following design features and principles, carefully considered throughout section 2 of this position paper, are essential for ensuring CMs support both resource adequacy and long-term system efficiency:

Ensuring effective contribution to adequacy and cost efficiency is essential in the design of CMs to ensure resource adequacy at the lowest possible cost for consumer. This can be achieved by minimising over-procurement and excess profits, incorporating penalties for non-performance, and carefully calibrating strike prices. In this regard, reliability options must be designed with appropriate strike prices and risk mitigation mechanisms to encourage participation without deterring critical technologies to limit excessive remuneration for capacity providers. Equitable cost distribution is also essential, with approaches such as consumer segmentation and dynamic tariffs incentivising demand-side adjustments while promoting fairness.

Fostering technological inclusivity and cost-efficient innovation is essential to prevent the lock-in of fossil fuel technologies in the long run, and to encourage cleaner, more flexible and innovative technologies. CM design must address unique barriers faced by technologies like demand side response (e.g., baselining accuracy, strike price calibration) and storage (e.g., revenue stacking potential) to enhance participation and system flexibility. Design features like investment thresholds (longer contracts in function of CAPEX expenditures) and multi-year contracts can ensure fair participation of diverse technologies. Lastly, derating factors (to assess the reliability contribution of different capacity types) coupled with flexible service level agreements and aggregation options can facilitate the participation of energy-constrained resources like storage and demand side response.

Promote efficient integration of demand in the CM and fair cost distribution. The distribution of CM costs should be equitable, reflect contribution to system stress periods, and incentivise demand flexibility. Despite their potential to enhance system efficiency, (implicit and explicit) demand side response resources remain underutilised within CMs. To this regard, capacity subscriptions (or limited grid access agreements) can be a promising design feature to both incentivise more flexible consumption during system stress and to promote a cost-distribution of CMs more in line with individual consumer preferences and contribution to adequacy.

Ensuring compatibility with energy markets. The interaction between CMs and short- and long-term energy markets must also be carefully managed. As on the one hand, CMs can reduce hedging opportunities for market participants in long-term markets. On the other, they may exert downward pressure on prices, altering dispatch signals for demand side response and other flexible solutions that rely on efficient price signals. A sequential auctioning approach, combined with improved volume dimensioning methodologies that consider both implicit and explicit flexibility contributions, can help mitigate these effects. Additionally, greater coordination of CMs across Member States may be warranted to address emerging challenges. In particular, the interplay between European market rules on curtailment sharing and national adequacy objectives could impact the effectiveness of CMs, highlighting the need for a more integrated approach.

Promote practical solutions for cross-border participation. Cross border participation can reduce overall CM costs and encourages investments in both domestic and cross-border capacity. However, implementation remains complex. Clear agreements on cost-sharing are essential to ensure equitable arrangements, while steps must be taken to prevent double payments for assets participating in multiple CMs. To address these challenges, robust coordination between TSOs is required for data sharing, operational alignment, and dispute resolution. EU rules on cross-border participation to CM should allow simpler and more practical solutions while reflecting real contribution to resource adequacy. Implementation should follow a stepwise approach, avoid complex design features, and allowing exceptions in case the benefits outweigh the costs (e.g. in case of limited maximum entry capacities). Direct participation of interconnector capacity in the CM should be allowed as a possible solution.

Ensuring meaningful contributions to broader system needs. While CMs primarily aim to address adequacy concerns, they also offer potential benefits for ancillary services, non-frequency services, and/or locational signals. Incorporating these additional objectives into CM designs increases

complexity but could lead to cost savings, depending on national specificities. Where necessary, integrating a local component within the CM design could enable capacity providers in congested areas to offer necessary system services, thus reducing redispatching costs and ensuring the sufficient redispatching potential required for system security.

Addressing cross-border externalities is becoming increasingly important as more Member States are expected to implement CMs in the coming years. The policy debate is placing growing emphasis on cross-border interactions and how best to address these issues. It is thus pertinent to assess challenges and opportunities of increasing coordination of national capacity mechanisms and of further harmonisation of design features. As a starting point to address cross-border externalities, we recommend indentifying harmonisation opportunities, which do not compromise the need for national specificities. In the longer run (2035-2040), if a sufficient level of CM design harmonisation will be reached, further integration possibilities could be explored, for instance at regional level. ENTSO-E and TSOs are available to contribute to the debate about challenges and opportunities of streamlining CMs features, leveraging on their experience with CMs design, implementation and cross-border participation.

Building on the key design challenges and considerations outlined above, as well as the evolving role of capacity mechanisms in supporting the energy transition, ENTSO-E recommends:

- Introduce capacity mechanisms where needed and make them fit for the energy transition
- Design capacity mechanisms which ensure effective capacity delivery at the lowest cost for consumers
- Promote technology inclusivity rather than technology neutrality
- Adapt capacity mechanisms to reward flexibility and broader system needs (e.g. congestion management), while balancing complexity and market efficiency
- Enhance cross-border through practical and coordinated solutions.
- Assess evolution opportunities of capacity mechanism frameworks in the European context

Further details on these recommendations can be found in section 4.

Background and Objectives of the Paper

Capacity mechanism have been an integral part of the electricity market design in many European and international jurisdictions. Their primary function is to ensure resource adequacy[1] by providing incentives to capacity providers, thereby addressing the risk of electricity supply shortages, particularly during periods of peak demand or system stress.

According to ACER nearly half of EU Member States currently operate or have previously implemented a CM. Furthermore, several National Resource Adequacy Assessments (NRAAs) have identified 11 adequacy concerns in the short (2024–2025), medium (2026– 2029) or long term (2030-2033) across the Union – with six Member States facing adequacy concerns as early as 2025[2]. In response, more countries are considering or introducing CMs, driving an active academic and policy debate on their role in supporting a secure, competitive, and decarbonised power system.

ENTSO-E plays a central role in enabling Europe's transition to climate neutrality while ensuring system security and affordability. In line with its legal mandates, ENTSO-E assesses resource adequacy across Europe, fosters efficient electricity markets, and promotes cross-border cooperation. As TSOs are often directly involved in the design, implementation, and operation of CMs, they ensure that mechanisms are tailored to national market needs while aligning with European objectives.

A critical dimension of ENTSO-E's role in CMs is its analysis on resource adequacy at European level[3] via the European Resource Adequacy Assessment (ERAA). It is based upon state-of-the-art methodologies and probabilistic assessments, aiming to model and analyse possible events which can adversely impact the balance between supply and demand of electric power. The ERAA, which can be complemented by national assessments, is a cornerstone for determining the necessity of CMs across Europe as if it identifies an adequacy concern, a Member State may justify the implementation of a CM, provided that other market-based measures to address the adequacy concerns are also implemented and that the CM complies with EU state aid guidelines and internal market principles.

Beyond adequacy assessments, ENTSO-E developed the technical specifications enabling the participation of foreign capacity providers in national CMs, adopted by ACER[4] to enhance competition, ensuring optimal resource allocation across borders while preserving the integrity of the European internal electricity market. Through ongoing monitoring and reporting, ENTSO-E provides transparency on CM implementation, identifies best practices, and highlights areas for improvement in cross-border participation[5].

As the energy system evolves, CMs must not only address short-term adequacy concerns but also align with broader objectives, including decarbonisation, market efficiency, and enhanced cross-border integration. By engaging with policymakers and stakeholders, ENTSO-E aims to support informed decision-making to improve the effectiveness and sustainability of CMs.

This paper examines the evolving role of CMs in the energy transition, providing an in-depth analysis of their design and implementation. It identifies key challenges, explores alternative design options, assesses synergies with other market instruments, and ultimately offering actionable, evidence-based recommendations to guide their future development.

1 Resource adequacy refers to the ability of an electricity system to generate and deliver enough power to meet the expected demand at all times, even during periods of high demand or when some generation sources are unavailable. It ensures that there is sufficient capacity (both from existing and new generation plants, including reserves) to cover peak demand and to maintain reliability in the grid.

2 ACER (2024): Monitoring report on security of EU electricity supply

3 As mandated by Article 23 of the Regulation (EU) 2019/943

4 ACER (2020): ACER Decision on technical specifications for cross-border participation in capacity mechanisms

5 ENTSO-E (2024): Annual report on cross-border participation in capacity mechanisms

1 The role of capacity mechanisms in the energy transition

Capacity mechanisms in today's context

To speed up the transition to carbon neutrality, the European power system must undergo a profound transformation, driven by significant investment across the entire value chain. This transformation must be underpinned by robust system reliability and resilience to integrate a higher share of both variable generation as well as flexible demand. To enable these investments, electricity markets must be designed to deliver stronger and more effective long-term investment signals[6], particularly for resources critical to ensure resource adequacy and system security.

The increasing reliance on weather-dependant generation highlights the need for robust back-up and flexible resources, especially considering the electrification of the economy and the increasing socio-economic impact of electricity disruptions. During periods when wind and solar output are insufficient to cover demand – such as the "dunkelflaute"[7] in December 2024, which saw consecutive days of low-RES generation and high demand – such insufficient RES infeed leads to surging wholesale prices and exacerbates concerns about resource adequacy. Such challenges will likely intensify in the future, reinforcing the need for complementary mechanisms to ensure system stability.

The energy-only market model[8], while fundamental to the operational efficiency of electricity markets, has faced increasing challenges in delivering sufficient investment signals to ensure long-term resource adequacy.

The 2022 energy crisis exposed its limitations, as public and political resistance to very high prices resulted in regulatory interventions at both EU and national levels[9]. High prices alone have proven insufficient as a driver for investment, particularly in cases where investors cannot rely on infrequent high-price periods to recover costs.

Against this backdrop, CMs have been a critical driver to achieve energy security in certain Member States. These mechanisms complement energy only markets models by remunerating capacity providers – such as dispatchable generation, demand side response, and storage – not for the energy they produce, but also for their availability of reliable capacity during periods of stress.

The recent reform of the EU's electricity market design reflects a shift in perspective, recognising CMs as a possible structural component of a well-functioning electricity market rather than a temporary, last resort measure. This evolution acknowledges that energy-only markets face inherent imperfections and are influenced by certain policy choices (e.g. regarding the promotion of certain technologies to drive decarbonisation). Additionally, the slower growth in power demand compared to the rapid installation of renewable generation has shifted market dynamics. Spot prices are now predominantly supply-driven, exerting downward pressure on prices and undermining the economic viability of assets essential for system security.

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6 See further details on how to strengthen long-term signals on page 4 of ENTSO-E Position on the EC proposals on Market Design

7 German term used to describe periods characterised by low solar and wind power generation, typically due to overcast skies ("dunkel" meaning dark) and low wind speeds ("flaute" meaning lull). These conditions can lead to reduced electricity production from renewable sources, posing challenges for energy systems reliant on variable renewable generation.

8 An energy-only market model is a design for electricity markets – including forward, day-ahead, intraday, and balancing markets – where generators, storage, and demand side response are solely compensated for the energy they produce, store, or avoid consuming. This model does not include separate payments for capacity but relies on energy prices, including scarcity pricing during periods of high demand or low supply, to incentivise investment and operational efficiency.

9 For instance, the revenue cap on inframarginal rents introduced at EU level, or price caps for both wholesale and retail markets introduced in some countries. For an overview of different regulatory measures see ACER 2023 Monitoring Report on Emergency Measures

Evolution of the European legal framework on capacity mechanisms

Historically, CMs were regarded as temporary, last resort measures to address resource adequacy concerns. However, their role has evolved significantly, reflecting the increasing need for reliable mechanisms to complement energy-only markets and ensure resource adequacy in a decarbonised energy system.

Section 4.8 of the Climate, Energy and Environmental Aid Guidelines (CEEAG) provides the State Aid framework that governs the approval of CMs and other security of supply measures. Additionally, the 2019 Clean Energy Package introduced a significant step forward with the adoption of the Electricity Regulation (EU 2019/943). Articles 20 to 27 of the regulation outline critical requirements for CMs, establishing robust safeguards to ensure their necessity and effectiveness. These include that Member States must demonstrate the necessity of CMs through European or National Resource Adequacy Assessments (NRAAs); and that CMs are also required to adhere to specific design principles, such as technology neutrality, carbon emissions limits, cross-border participation, and mechanisms to prevent market distortion.

Since 2014, the European Commission has approved 10 CMs as compliant with State aid rules: 4 strategic reserves (in Belgium, Germany, Finland, and Sweden); and 7 market-wide capacity mechanisms (in Belgium, Greece, France, Ireland, Italy, Poland, and in the United Kingdom[10]). Additionally, since the update of the CEEAG[11] in 2022, two additional security-of-supply measures have been approved including amendments to the market-wide capacity mechanism in Belgium introducing preferential contractual conditions for non-fossil technologies; and a measure supporting non-fossil dispatchable assets that contribute to intraday flexibility, structured as a contract for difference on CM revenues in France.

More recently, the EU electricity market design revision (EMDR) has further solidified the role of CMs, moving beyond their initial classification as temporary and last resort measures. The new regulation reflects the growing consensus that – in many countries – CMs can be essential for maintaining resource adequacy as part of a well-functioning market.

The recently amended regulation introduces several enhancements to implementation, including:

1. A mandate for the European Commission to assess options for simplifying and streamlining the CM application process, including a request for ACER to amend the ERAA methodology to ensure adequacy concerns are addressed promptly[12].
2. Stronger alignment with decarbonisation targets, requiring Member States with CMs to consider adaptations that promote the participation of non-fossil flexibility resources, such as demand-side response and energy storage[13].
3. The removal of the "last resort" and "temporary" classification of CMs, while maintaining a maximum duration of 10 years[14].

10 Since the United Kingdom's withdrawal from the EU in 2020, its capacity mechanism has evolved and is now subject to domestic regulatory frameworks, independent of EU State aid rules.

11 Guidelines on State aid for climate, environmental protection and energy (2022/C 80/01)

12 Article 69, Regulation 2024/1747

13 Article 19 g, Regulation 2024/1747

14 Article 21, Regulation 2024/1747

CMs role in future electricity markets

The capacity expansion of wind, solar, and other net-zero emission technologies is driving a reduction in the running hours of non-renewable power plants. With fewer running hours (i.e. volume risk) and higher price uncertainty[15] (i.e. price risk), in an energy-only market model, incumbent plants needed to maintain resource adequacy and/or system stability in times of low renewables output, must either earn sufficient revenues during scarcity periods, secure long-term commercial contracts (which are not widely available in Europe), or rely on state-backed support. In addition to the volume and price risks, expected profitability of non-renewable dispatchable generation is also affected by regulatory risks[16]. As a result, risk premiums are incorporated by investors in capital costs, further reducing plants' profitability.

On the positive side, the newly introduced Article 66a on access to affordable energy during an electricity price crisis in the Electricity Directive[17] establishes clear parameters for when and how Member States may intervene in electricity markets during a price crisis. By defining the scope of potential measures to protect consumers from extreme prices, this provision offers greater regulatory clarity, reducing uncertainty for investors. This should give investors better clarity on the size of the regulatory risk going forward. Nevertheless, future updates of the EU regulatory framework regarding wholesale price spikes cannot be excluded.

Against this backdrop, it appears increasingly likely that CMs will remain a long-term feature of many European electricity markets. These mechanisms play a vital role in enabling non-weather-dependent generators to stay operational, thereby supporting resource adequacy and ensuring low Loss of Load Expectations (LOLE) [18]. Ensuring the reliability of electricity supply during periods of low renewable energy generation – while keeping prices affordable for consumers – is crucial, especially as we continue electrifying our economies and final energy uses.

While CMs can bridge this gap, at the same time their design must ensure adequacy needs while supporting decarbonisation and other system needs. To avoid locking in fossil fuel technologies beyond their necessary contribution, CMs should recognise the value of diverse firm and flexible resources – such as demand side response, energy storage, and low-carbon generation – thereby supporting resource adequacy in a sustainable and system-friendly manner.

To this regard, enhancing system flexibility will be crucial, as highlighted in the ENTSO-E Vision[19], by several stakeholders[20] as well as the recent Electricity Market Design reform (EMDR), as enabling the system to absorb higher shares of low-carbon and RES energy leads to cost-effective solutions to achieve system adequacy. In the transition towards climate neutrality, the costs of delivering secure energy at affordable prices will be driven less by the direct cost of energy but increasingly be driven by the system costs of adapting to a RES-dominated power system. The cost of ensuring adequacy through CMs represents such a system cost and should not be viewed in isolation but instead be viewed as a necessary component in the context of the total energy system cost composition.

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15 The frequency and duration of periods with limited RES generation when wholesale spot prices raise to a level that is profitable for dispatchable plants to generate are hard to predict. This uncertainty is translated in risk premium negatively affecting profitability of investments in such plants.

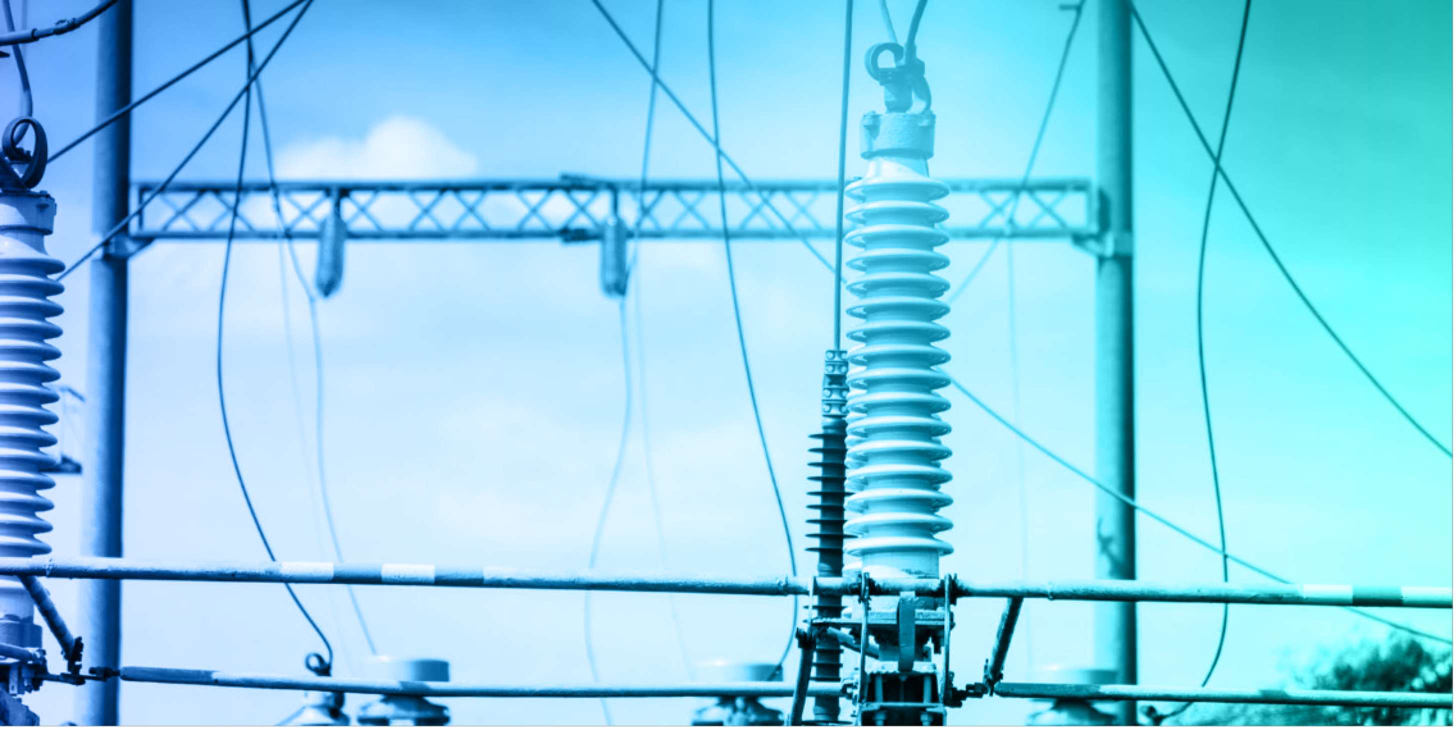
16 As explained above, and based on recent experiences, expectations of regulatory interventions (e.g. price caps, revenue caps, windfall profit taxes) in case of future increases of wholesale prices are not uncommon in European countries.

17 Article 66a, Directive 2024/1711

18 A reliability metric used to assess the likelihood that electricity demand will exceed supply during a given period. Essentially, LOLE represents how often, on average, the system is expected to experience an "unserved energy" event.

19 ENTSO-E Vision: A Power System for a Carbon Neutral Europe

20 ACER & EEA (2023) – Flexibility solutions to support a decarbonised and secure EU electricity system



The role of the European Resource Adequacy Assessment

The European Resource Adequacy Assessment (ERAA) plays a central role in shaping the implementation of CMs across Member States. Conducted by ENTSO-E as a legal mandate under the Clean Energy Package, the ERAA provides a comprehensive evaluation of resource adequacy across Europe, using harmonised methodologies to assess risks and identify gaps. The ERAA contributes to ensure that CMs are implemented only where necessary, based on transparent and consistent evidence of resource adequacy challenges, and the ERAA methodology provides the framework for National Resource Adequacy Assessments (NRAAs).

By standardising the assessment of adequacy risks, the ERAA facilitates aligning NRAAs with EU-wide objectives, fostering greater market integration and cooperation among Member States. While most Member States have relied on NRAAs to justify the introduction of CMs, ERAA provides a broader, system-wide perspective, helping to validate adequacy concerns and inform decision-making at the EU level.

The ERAA's findings have had a significant influence on the design and implementation of CMs in several ways:

- As the share of RES increases, the ERAA[21] underscores the importance of flexible resources – such as storage and demand side response – in ensuring adequacy across various timeframes.
- The ERAA promotes market-based solutions by helping Member States to assess expected contributions of imports during system stress (and thus identifying opportunities for cross-border participation in CMs where these are present), contributing to reducing costs, and improving system efficiency.
- The EMDR mandates the European Commission to explore ways of streamlining and simplifying the CM approval process. This may include proposals to amend the ERAA methodology, where appropriate.
- Under the EMDR, the methodology for assessing flexibility needs must align with the ERAA, ensuring consistency in the approach across Member States.

21 And when implemented, complemented by the national Flexibility Needs Assessment.

Designing CMs for a net-zero future

One intrinsic challenge of some CM designs from a climate perspective is the requirement for "technology neutrality." While this neutrality is intended to foster competition and ensure a fair selection of capacity resources, it can inadvertently provide an advantage to carbon-emitting incumbent power plants when they compete in capacity auctions against newer, low-carbon technologies. These newer technologies, such as hydrogen-ready turbines, nuclear, storage, and demand side response, have the potential to provide system adequacy with significantly lower emissions. However, while fossil-fuel plants can remain available to the system as a backup during periods of low renewable output, their actual generation is limited to avoid high emissions as a key requirement in the for implementing a CM in any Member State is ensuring that capacity market units respect emission limits[22].

To drive emissions reductions, the electricity sector is part of the EU Emissions Trading Scheme (EU ETS), which mandates that all generation capacity emitting CO_2 must purchase CO_2 certificates. Over time, as the EU tightens its emissions reduction targets, the number of available certificates will decrease, pushing up their price. This will gradually make fossil-fuel-based capacity less viable from both a financial and regulatory standpoint. The combination of reduced operating hours and increased carbon costs will make these plants increasingly less competitive, but the need for CM support may remain if they are still required for system reliability.

To ensure that CMs evolve in line with energy transition goals, one potential approach could be to set gradually decreasing emissions limits with a clear trajectory. This would incentivise generators to transition to low-carbon fuels, such as hydrogen or biogas, where possible, and encourage the deployment of low-carbon capacity.

Alternatively, CMs could provide preferential treatment for low-carbon or carbon-neutral resources, moving away from the strict technology-neutral approach. These options are discussed further in Section 2.3.

At the same time, it is important to recognise that integrating decarbonisation objectives into CMs should not be mandatory for all Member States. Other regulatory tools or market mechanisms may be better suited to supporting specific policy objectives or technologies, including the long-term goal of achieving carbon neutrality.

Key messages

- **Dispatchable back-up plants, facing declining operating hours and growing price uncertainty, will increasingly rely on CMs to remain financially viable.**
- **Public and political tolerance for very high electricity prices is limited even during short-term price spikes. This heightens the risk of regulatory intervention, which in turn increases risk premiums for dispatchable generation. This reinforces the growing necessity of CMs to complement energy-only markets in many European countries.**
- **With the EMDR, CMs are now acknowledged as a structural component of a well-functioning electricity market rather than a temporary, last resort measure. This shift acknowledges the growing consensus that CMs are essential where energy-only markets fail to deliver sufficient capacity to meet system needs.**
- **CMs should be designed to deliver adequacy while avoiding lock-in effects of fossil fuel technologies. Their design should align with long-term decarbonisation goals, enabling the transition to cleaner energy sources while meeting system requirements.**
- **Achievement of decarbonisation objectives should be mainly pursued with dedicated policy tools and market mechanisms, CMs must evolve to support the clean energy transition, prioritising low-carbon and flexible resources in the longer run.**

22 According to Article 22, paragraph 4 of the EMD Regulation, two conditions must be met within the framework of capacity mechanisms: from 4 July 2019 at the latest, generation capacity that started commercial production on or after that date and that emits more than 550 g of CO_2 of fossil fuel origin per kWh of electricity shall not be committed or to receive payments or commitments for future payments under a capacity mechanism; from 1 July 2025 at the latest, generation capacity that started commercial production before 4 July 2019 and that emits more than 550 g of CO_2 of fossil fuel origin per kWh of electricity and more than 350 kg CO_2 of fossil fuel origin on average per year per installed kWe shall not be committed or receive payments or commitments for future payments under a capacity mechanism

2 Key aspects and challenges in Capacity Mechanisms design

Designing robust CMs requires a thorough assessment of several key features to ensure resource adequacy, system reliability, promote efficient investment signals and alignment with the targets set by the energy transition.

CM designs can vary depending on various parameters such as:

- Targeted[23] (as strategic reserves) or market-wide[24] (capacity auctions, capacity certificates, reliability options)
- Centralised[25] or decentralised[26] procurement
- Contract lengths (for existing or new assets, differentiated by technologies, etc.)
- Participation of resources (derating factors[27], prequalification requirements[28], treatment of low carbon generation, storage, or demand side response)
- Penalties[29]
- Financing mechanisms and cost distribution among grid users
- Auction design (e.g. frequency, price caps, pay-as-bid, pay-as-cleared)
- Type of cross-border participation;[30] either explicit by foreign market participants, direct interconnector participation or implicit participation
- Decarbonisation features (emission limits, quotas, etc.)

The following sections will review the main design and implementation challenges of CMs, assessing some of the different options, and proposing recommendations when relevant. At the end of Chapter 2, a dedicated text box summarises ENTSO-E considerations on such design options.

23 Where specific generation units are kept outside the electricity market and dispatched only in case of system adequacy concerns.

24 Allowing all eligible resources to participate, typically through capacity auctions or reliability options.

25 When a single entity, usually the TSO, procures capacity on behalf of the system.

26 Market-based system where multiple actors, such as electricity suppliers or large consumers, are responsible for securing adequate capacity.

27 A correction factor applied to a resource's nominal capacity to reflect its expected availability and contribution to system adequacy.

28 Criteria that capacity providers must meet to participate in a CM, such as technical, financial, or operational conditions.

29 Financial sanctions applied to capacity providers that fail to deliver the committed capacity when needed.

30 The extent to which foreign capacity providers or interconnectors can participate in a national CM, either explicitly (foreign units bidding directly), through direct participation in the CM by the interconnector capacity or implicitly (the cross-border capacities value for security of supply in the CM is taken into account but not remunerated).

2.1 Addressing Resource Adequacy: When and where are CMs needed?

Countries that have introduced CMs have done so primarily to address identified adequacy concerns, which would not have been solved by the energy-only market. The need is often linked to the so-called "missing money problem", a concept widely discussed in economic literature[31], which refers to cases when market parties expect insufficient revenues from selling their electricity across various market segments, including forward and futures markets, day-ahead and intraday (also known as spot markets), and balancing markets.

Three key factors contribute to this issue:

1. Reduced operating hours (volume risk) – as the share of RES generation increases, conventional plants run fewer hours.

2. Price uncertainty (price risk) – short-term energy prices may not be sufficiently high during operating hours to cover the cost of dispatchable generation assets.

3. Investment risk – due to risk aversion of relying on highly variable revenues from energy-only market models in very few hours.

Impacts of insufficient revenues of system adequacy: the 'missing money' problem

When generators face insufficient revenues, either actual or expected, dispatchable plants may exit the market, and new investments in generation may fail to materialise. This creates adequacy concerns, as the power system may lack the necessary capacity during periods of high demand or -low-RES generation. By providing certainty on revenues to market participants (generators, storage, or demand side response assets) not only for their generated energy or flexible consumption but also for their (installed) capacity being available at times of need, CMs facilitate a positive business case for a sufficient amount of capacity which is considered essential for system adequacy during periods of low-RES output. Remunerating capacity, or more specifically the availability of capacity at times of need, is justified by the need to ensure continuous supply even in times of system stress or, more formally, to ensure that a country reaches its target level of system reliability[32].

Other drivers for the introduction of CMs

In recent years, increasing RES, planned capacity phase outs for environmental and climate policies (for instance, coal-fired but also nuclear), projected increases of electricity demand, and limited interconnection has led several countries in Europe to introduce or consider the introduction of CMs. Introducing a CM which provides an income stream that is independent of the number of plant operating hours and the level of wholesale prices – both of which can be unpredictable especially over several years – provides some revenue certainty for power plant operators. This certainty and transparency in part of their revenues allows plant operators to negotiate lower financing costs with capital providers, which can be CAPEX-intensive[33] assets such as power plants. The increasing needs for CMs highlight the importance of addressing not only the current system challenges and electricity demand, but also to consider future adequacy concerns, especially as RES penetration grows and system flexibility becomes increasingly vital to manage fluctuations in generation and demand.

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31 See for instance P.L. Joskow, Capacity payments in imperfect electricity markets: Need and design, Utilities policy, September 2008; L. Meeus, How to ensure adequate investment in power plants? – The Evolution of Electricity Markets in Europe, 2020

32 This target level is known as the reliability standard, and normally defined in terms of Loss of Load Expectation (LOLE), e.g. 3h per year. This is defined according to a common European methodology

33 Capital Expenditure(CAPEX) refers to the funds that a company or entity spends on acquiring, upgrading, or maintaining physical assets such as power plants, transmission and distribution networks, storage facilities, and RES installations. These expenditures are usually long-term and intended to enhance the capacity or efficiency of an asset over its lifespan.

Key lessons from the energy crisis

The recent energy price crisis of 2022-2023 brought renewed focus on energy independence and self-sufficiency, highlighting the role of CMs in electricity markets. The crisis also prompted the European Commission to reform the electricity market design, clarifying when CMs can be introduced, the conditions under which they can be implemented, and the design principles to be followed. The EMDR changed the previous approach of considering CMs as only a last resort mechanism, and further initiatives are expected in 2025 by the European Commission with the goal to facilitate the introduction of such mechanisms when they are deemed needed[34].

The reaction to the 2022 price crisis brought evidence that: 1) there is little public or political tolerance for extremely high electricity prices that cannot be mitigated or hedged against; 2) many suppliers were poorly hedged against price increases and governments did not have enough fiscal leeway to compensate consumers to shield against the very high prices; and 3) the risk of market-distortive regulatory interventions (e.g. price or revenue caps, retail market regulations, windfall profit taxes, etc.) is particularly high when prices rise sharply[35].

All these elements significantly affect investors' confidence and related risk premiums for financing generation investments relying solely on wholesale revenue streams, in a context where investments without any form of income stability (via public support, for example) were already reducing prior to the crisis.

The evolution of CM design

CMs serve different objectives depending on system needs, market conditions, and policy priorities. While offering different products, on different time horizons, such as short-term and long-term power availability. For instance, CMs can be designed to keep existing capacity in the market and those aimed at incentivising new capacity investments. However, these involve various levels of risk and design considerations. On this note, a flexible CM design may encourage greater participation of new capacity providers that previously could not compete with large incumbent power plants in CMs. These aspects are further discussed in Section 2.3.

As the energy transition accelerates, new drivers might increase the need for CMs. Rising electrification and the need to speed-up the development of flexibility resources of and ancillary services alternative to conventional power plants[36] might be two such examples. Further links between CMs, flexibility and ancillary services are discussed in Section 3.

While some countries may require CMs to maintain resource adequacy, others may find that market-based solutions, interconnection, and flexibility resources are sufficient. CMs should be aligned with national and European resource adequacy assessments. Policymakers should consider the following key drivers when deciding whether to introduce, maintain, or phase out CMs.

34 Article 69, Regulation 2024/1747

35 Namely, various (applied or announced) price and revenue caps reduce the possibility for generators, which can be available at times of system stress to make sufficient revenue from selling their energy at times of very high prices.

36 As of February 2024, the ruling coalition in Germany is considering holding auctions to support the construction of new gas-fired power plants in the short term, which would be able to run on hydrogen in the later point in time to be defined. Furthermore, a capacity mechanism should be in place by 2028 to ensure investment in the power plants deemed necessary for resource adequacy.

This list, though not exhaustive, highlights critical factors that influence the necessity of CMs:

1. RES integration and demand growth

High-RES targets and rapid electrification increase reliance on intermittent generation and drive peak demand growth, making firm capacity more necessary. Conversely, lower RES penetration and gradual electrification may ease adequacy concerns.

2. Market interventions and investment signals

A history of government interventions in prices or previous CM implementation suggests a greater likelihood of future interventions. In contrast, regulatory stability and strong scarcity pricing can incentivise market-driven investments, reducing the need for CMs.

3. Generation fleet and capacity phase-out

The planned retirement of coal or nuclear plants, coupled with an aging generation fleet, may reduce dispatchable capacity and create adequacy risks. However, sufficient firm capacity, including flexible resources such as hydro and storage, can mitigate these concerns.

4. Neighbouring countries' policies

The introduction of CMs in adjacent markets can create spillover effects, increasing the likelihood of similar measures being adopted. Conversely, strong interconnections and well-functioning cross-border markets can improve adequacy without CMs.

5. Hedging and contracting opportunities

Limited access to long-term contracts and hedging mechanisms can weaken investment signals for firm capacity, making CMs more likely. Where robust hedging markets exist, investors may be sufficiently incentivised without additional support.

6. Interconnection and regional adequacy

Low interconnection capacity can limit access to external resources during scarcity events, increasing reliance on national adequacy measures. In contrast, high interconnection levels, coupled with sufficient non-weather-dependent generation across borders, reduce the need for CMs.

7. Political and social considerations

Strong political or social opposition to CMs may discourage their implementation, while public support for market-based solutions can reinforce reliance on scarcity pricing and flexibility markets.

8. Presence of system flexibility and related support schemes

The availability of flexibility resources, such as demand side response and storage, can reduce the need for CMs by enhancing system adaptability. In contrast, a lack of flexibility may heighten adequacy concerns.

It cannot be excluded that countries, which need capacity mechanisms now might evolve to a more favourable adequacy situation, hence opening the possibility for the phase out of CMs – especially in case of significant technological breakthroughs or market design evolutions – is crucial to ensure that the volume of capacity procured aligns with actual system needs while avoiding overcompensation or under compensation of resources.

The effectiveness of CMs in addressing adequacy concerns depends primarily on the design of the chosen CM model. Since the initial European taxonomy introduced in the mid-2010s, there has been a shift towards more nuanced approaches.

CMs now encompass a broad spectrum of solutions, ranging from targeted models to market-wide mechanisms, which can be either quantity-based or price-based. Targeted mechanisms include strategic reserves and targeted tenders, while market-wide options apply to all capacity providers and feature designs such as market-wide capacity auctions, reliability options, and decentralised obligations.

The table below summarises the key features of several quantity-based and price-based mechanisms, offering a comparison of their respective characteristics.

Targeted	Quantity-based	Targeted tender	Centrally coordinated process to secure the construction of a specified quantity of new capacity
		Strategic reserve	Aims to secure a defined quantity of capacity, with a focus on existing generation and demand side response, with the contracted capacity ring-fenced from the wholesale market
	Price-based	Targeted capacity payment	Payment of an administratively determined capacity price to a subset of capacity
Market-wide	Quantity-based	Availability product	An availability obligation based on a centrally determined capacity requirement, needed to meet a defined security standard, through a competitive bidding process
		Decentralised obligations	An obligation typically placed on electricity retailers to contract with capacity providers such that each retailer secures sufficient capacity to meet their overall demand
		Centralised reliability options	An alternative approach under which capacity providers have a financial obligation for delivery of energy rather than any physical obligation
		Decentralised reliability options	Market participants and even consumers actively trade options with capacity providers to secure their own reliability requirements (conceptual approach)
	Price-based	Market-wide capacity payment	Sets an explicit price for capacity, set either on an administered basis or via defined algebra

Figure 1: Comparison of key features of quantity and price-based mechanisms
Source: AFRY (2024) based on the final report of the sector inquiry on capacity mechanisms [SWD (2016) 385 final]

Among targeted mechanisms, strategic reserves are the most common model in Europe today with countries such as Sweden, Finland, and Germany implementing them. Under this model, a limited number of capacity providers – often mothballed fossil fuel plants – are contracted by the TSO as reserves. These reserves are only activated in cases of scarcity, typically when the day-ahead market cannot clear, often during extreme situations. In exchange for remaining available, these assets are compensated but are excluded from participating in wholesale markets. While this model is effective in addressing temporary or localised adequacy risks, it is better suited to preventing the exit of essential assets rather than incentivising new investments. Consequently, strategic reserves are generally seen as more appropriate for addressing short-term adequacy concerns rather than long-term, structural ones. Additionally, they tend to be easier to introduce and phase out, cause fewer distortions in wholesale markets, and have limited cross-border effects.

In contrast, market-wide CMs, which are currently implemented in countries such as Italy, Poland, France, Belgium, and Ireland, can be centralised, decentralised, or potentially hybrid/combined. In centralised models, the CM operator (typically the TSO) procures capacity through periodic auctions that take place ahead of the "delivery year." In decentralised models, capacity is procured directly by suppliers or consumers, who contract capacity from providers through tradeable certificates. Capacity providers are remunerated for maintaining available capacity in addition to their market revenues from wholesale and balancing markets. Market-wide CMs are more suited to addressing structural adequacy issues, as they provide long-term investment signals to generators and other capacity providers. However, their design is typically more complex than that of targeted mechanisms, and they tend to have a greater impact on wholesale markets and cross-border externalities, as discussed in section 2.4.

While national specificities must be carefully considered, there are potential benefits in agreeing on some common CM design features if these mechanisms become more structural and widespread across the EU. The challenges and potential benefits of a more harmonised approach are briefly explored in section 3.

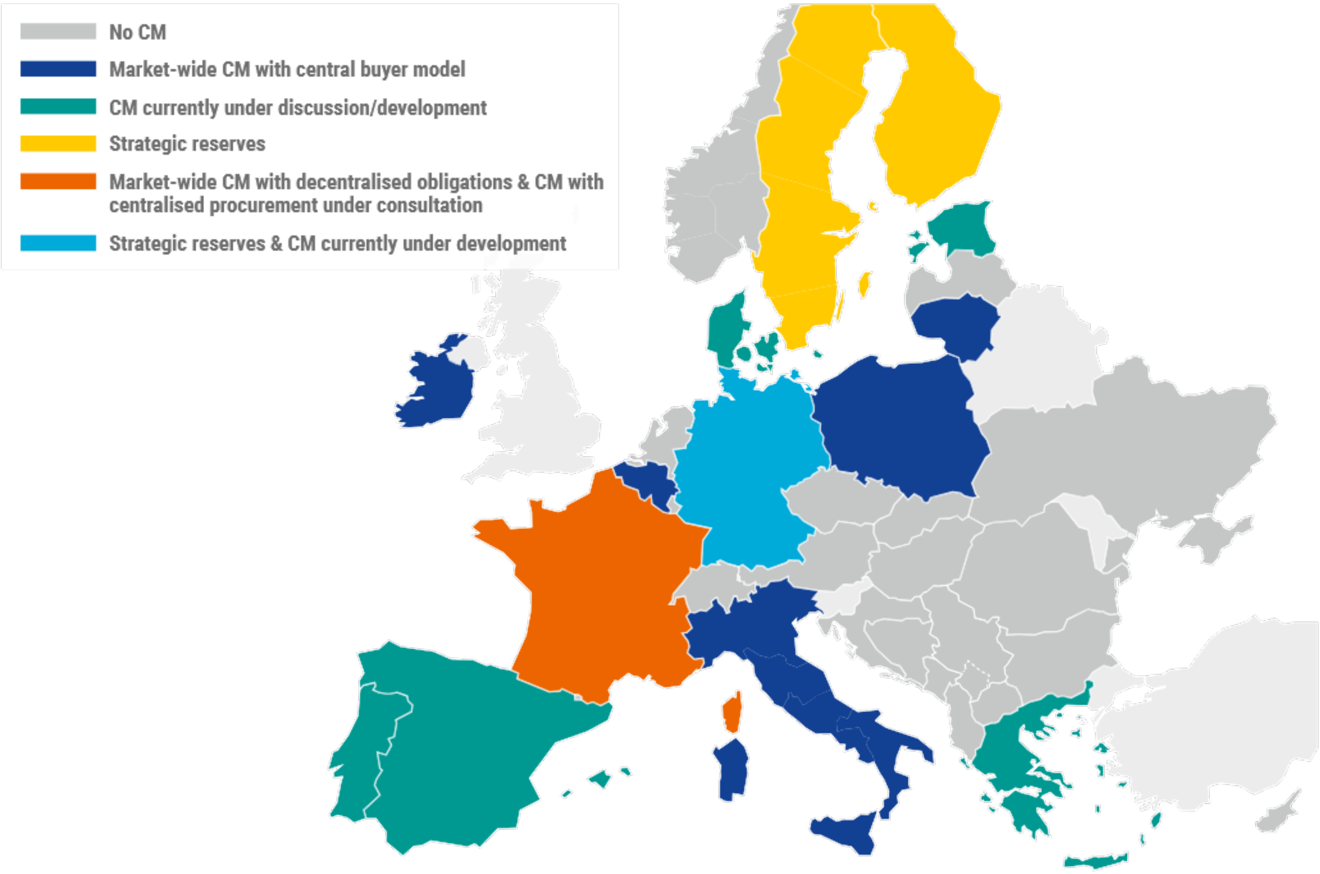

Figure 2: Status of CMs across the ENTSO-E membership countries as of 2025
Source: ENTSO-E elaboration based on ACER (2024): Monitoring report on security of EU electricity supply and TSOs input

Key Messages

- CMs should be introduced where energy-only markets fail to ensure sufficient available capacity to meet system needs.
- CMs should be designed to address both current and future adequacy challenges, with design evolution being an ongoing process that reflects the changing dynamics of the system
- CMs should provide revenue certainty to market participants efficiently, incentivising investment in dispatchable generation, storage, and demand side response assets, while minimising negative impacts on energy markets.
- The choice of CM model (e.g., market-wide, or targeted; centralised, decentralised, or hybrid) should be tailored to the specific requirements of each market, based on factors such as the desired level of reliability, energy mix, interconnectivity, and the need to maintain existing capacity or incentivise new investments.
- CMs should be flexible, allowing for the phase-out of CM payments once adequacy concerns are resolved, potentially due to technological breakthroughs. Additionally, CMs should be adaptable to learning effects, changes in wholesale markets, and regulatory shifts, without requiring a new notification of state aid mechanisms.
- The EU regulatory framework should facilitate the prompt introduction and streamlined implementation of CMs in countries where they are necessary, as well as expedite the extension of existing mechanisms where needed.

2.2 Economic efficiency and cost distribution

From an economic standpoint, CMs present two main challenges: a) how to procure the needed capacities to overcome the adequacy concerns at the lowest cost possible, and b) how to distribute the associated costs in an affordable and fair manner. Achieving these objectives requires careful consideration of procurement efficiency and cost distribution mechanisms. This section will explore these two key aspects, setting the stage for further discussion on specific solutions, such as reliability options and the role of demand side response, which help address these challenges.

Procurement efficiency

To minimise procurement costs, the design of CMs must strike a balance between securing adequate capacity and avoiding over-procurement, which could inflate costs unnecessarily. This chapter explores various design approaches that help mitigate over-procurement risks and ensure efficient use of resources. For a given procured capacity, ensuring economic efficiency also requires mechanisms to reduce excess profits and incentivise delivery, such as implementing appropriate penalties for non-performance[37]. According to ACER, penalties must closely reflect the value placed by consumers on an uninterrupted service. In other words, they should contribute significantly to recovering the costs incurred by the system. Currently, beneficiaries do not always receive adequately strong signals to be available when the system needs them.

Market-wide CMs encompass all kind of capacities contributing to reaching a country's reliability standard, including generation, storage, and demand side response. Unlike strategic reserves – where capacity is reserved for predefined adequacy stress events and participation in other markets is typically prohibited – market-wide CMs allow participating units to earn revenue from other electricity markets, such as the day-ahead, intraday, balancing, and system services markets. However, this also introduces the risk of excessive profits, where CM revenues exceed what is necessary to ensure the continued operation of existing assets or to support new investments, creating market distortions, higher costs for consumers, and unintended distributional effects. To ensure adequacy at minimal cost to consumers, CM design must incorporate mechanisms to minimise excessive remuneration. These mechanisms include reliability options, differentiated remuneration based on "missing money" or investment needs, and tailored price caps and contract lengths.

Reliability options

As outlined in of the European Commission's sector inquiry on capacity mechanisms[38], reliability options[39] offer a promising tool to address the issue of excess profits. Under this scheme, capacity providers receive regular payments but must pay the difference between a market reference price and a pre-determined strike price whenever the reference price exceeds the strike price.

For reliability options to effectively mitigate excess profits, the strike price must be carefully calibrated. It should capture only the portion of energy market revenues deemed excessive while avoiding levels so low that they discourage participation or inflate CM bids.

Regularly updating the strike price[40] to reflect significant market changes (e.g., sharp increases in operating costs) can help maintain a fair and balanced mechanism. At the same time, reliability options introduce financial risks for participants, including payback obligations when market prices exceed the strike price and penalties for unavailability. To limit these risks and encourage participation, mechanisms like "stop-loss limits" can be introduced. These limits cap potential payback amounts based on the fixed capacity remuneration a provider receives annually, ensuring a balanced risk-reward framework. Nonetheless, reliability options must be designed with caution to avoid discouraging participation from certain technologies or market actors critical for resource adequacy.

37 Non-performance refers to the failure of being available at times of system stress.

38 Section 5.4.2.1, COM (2016) 752 final

39 Definition: scheme in which "the capacity provider will receive a regular payment […]. In return for this regular payment, the capacity provider that has sold a reliability option will be required to pay the difference between a market reference price and a strike price whenever the reference price goes above the strike price".

40 In Belgium, the strike price is updated monthly throughout the delivery period to continuously reflect a price level above which revenues are deemed excessive, while in Italy, it is updated daily to even closer reflect variations in the price of natural gas and CO_2.

Cost distribution

The fairness of cost distribution is critical. When costs are not taxpayer-funded, they ultimately fall back on end-consumers – directly or indirectly via suppliers. Using network tariffs as a distribution method for CM costs is contentious. While network tariffs allocate grid costs based on connection size and grid usage, this approach may be unfair for flexible consumers, such as industrial users, aggregated pools of electric vehicles and e-boilers, or households with thermal storage and electricity buffering capabilities, who consume less during scarcity periods. If the cost recovery is instead based on peak demand, it would also consider the flexible part of the load.

The 2024 Annual Monitoring Report on Security of Supply by ACER provides valid recommendations for improving cost allocation mechanisms, with a focus on consumer segmentation and communication, which include:

1. Differentiating between system stress periods – aligning cost assessments with system stress periods ensures that consumers receive clear incentive signals during critical times. For CMs, this could involve designing charges that reflect system adequacy challenges only during periods of peak stress, encouraging behavioural responses.

2. Differentiating rates within the same day – incorporating intra-day differentiation allows incentive schemes to encourage consumers to shift energy use to off-peak hours. This approach not only improves fairness in cost distribution but also enhances grid efficiency by reducing demand peaks.

3. Sending clear price signals and recommendations – transparent billing is critical. Energy bills should clearly detail the CM cost and provide actionable advice on how consumers can adjust their behaviour, such as reducing consumption during peak hours or participating in flexibility schemes. Enhanced communication with consumers fosters awareness and aligns their behaviour with system needs.

One potential solution is **capacity subscription contracts**[41], allowing consumers to pay less in exchange for limited electricity delivery during scarcity. These contracts ensure a minimum supply for essential needs while incentivising consumers who value system security less or can shift consumption to save on costs. Another potential solution is that of limited grid access for specific kinds of consumers or generators, where the consumer or generator pays a lower grid connection fee, while accepting the risk of being disconnected.[42] Such approaches would require robust consumer awareness, automation support, and physical mechanisms to limit supply during scarcity. It must be noted that dynamic retail prices that reflect day-ahead prices could also serve a similar function by signalling scarcity to consumers and encouraging demand reduction, if also complemented with consumer awareness and automation.

41 The potential of capacity subscription contracts – Florence School of Regulation

42 Limited grid access for RES generation capacity and load assets is being implemented in Denmark. It is possible that this concept will be permanent for some load assets (or even generators) in the future, depending on the system value of the concept, how flexible the assets are and the trade-off between a lower grid access fee and the risk of being curtailed.

Participation of demand (implicit vs explicit)

As outlined above, incorporating consumer preferences into CMs could contribute both to a fair cost distribution and economic efficiency of CMs. This lies at the heart of the decentralised capacity market design. Notably, fostering demand side response has been identified in various publications as one of the key challenges for future-proofing CMs[43] and further ideas on benefits and challenges associated with demand participation in CM can be found in literature[44]. Additionally, other ways for integrating demand resources in CMs should be explored as they can potentially reduce overall costs and provide flexibility, which will be further elaborated in section 3 of this paper.

For this section, the participation of demand resources in capacity markets can be classified into two main categories:

- Explicit participation, where consumers actively participate in capacity markets by taking on binding commitments, can occur in two ways:
  - On the demand side: consumers define their demand for firm supply, contributing directly to capacity market operations.
  - On the supply side: consumers sell demand side response services equivalent to the reliability services offered by generators.

- Implicit participation, where consumers do not explicitly participate in capacity markets or take on binding commitments to reduce their load. Instead, they adjust their demand in response to CM charges during market operation. If CM charges are well-designed, consumers' modifications to their demand can reduce their contribution to scarcity conditions and lower their CM-related costs.

Among these approaches, explicit participation on the supply side is the most used in Europe. It aligns well with the centralised capacity procurement model, which offers significant operational benefits for CM functioning. However, the participation of demand side response resources in CMs remains limited. For instance, according to the Annual Monitoring Report on Security of Supply by ACER, only 4.5 % of all contracted capacity in 2024 came from demand side response resources[45].

Decentralised approaches, where consumers participate on the demand side by contracting their desired level of adequacy, are often highlighted in academic discussions as more equitable in terms of cost distribution. Under such models, consumers pay for the adequacy they contract, ensuring a fairer allocation of costs. However, real-world implementation has revealed significant operational complexities that can undermine the effective delivery of resource adequacy[46]. Going forward, it needs to be assessed how decentralised capacity markets could work in practice, especially driven by the technological development with costs of non-fossil flexible assets falling drastically, and with the increasing digitalisation and automation on the demand-side. Examples of market design elements to assess in that regard are the allowed trading period of capacity certificates in advance of delivery (shorter trading period support demand side and flexible assets participation) and whether trading of certificates should be possible after delivery, as well as the consequences of wholesale energy market price controls (such as the ARENH in France) on the price of capacity certificates.

43 Next to compatibility with decarbonisation, potential evolution to "system security" mechanisms, and cross-border aspects (Capacity mechanisms – Florence School of Regulation (eui.eu)).

44 The Challenge of Integrating Demand side response in Capacity Remuneration Mechanisms: Providing a Comprehensive Theoretical Framework | IEEE Journals & Magazine | IEEE Xplore

45 ACER (2024): Monitoring report on security of EU electricity supply

46 Consider, for example, the French capacity mechanism, which is moving from a decentral to a central mechanism, due to – among other things – these operational complexities mentioned.

Key messages

- To ensure resource adequacy at the lowest cost for consumers, CMs should minimise over-procurement and excess profits, while including mechanisms such as penalties for non-performance and calibrated strike prices to maintain economic efficiency.
- Reliability options can limit excessive remuneration for capacity providers, but they must be carefully calibrated with strike prices and risk mitigation mechanisms like stop-loss limits to encourage participation without deterring critical technologies.
- The distribution of CM costs should be equitable and reflect contribution to system stress periods, with methods like consumer segmentation, intra-day differentiated rates, and dynamic tariffs incentivising demand-side adjustments while improving fairness.
- Demand resources can contribute to CM efficiency through explicit and implicit participation, but current uptake remains low, with only 4.5 % of contracted capacity from demand side response resources in 2022. Barriers for demand participation should be further identified and addressed.
- Decentralised CMs can improve cost fairness but face operational complexities, making their large-scale implementation challenging.
- Capacity Subscriptions (or limited grid access agreements) can be a promising design feature to incentivise more flexible consumption during system stress as well as promoting a cost-distribution more in line with individual consumer preferences and contribution to adequacy.

2.3 Technology inclusiveness

CMs have traditionally supported fossil-fuel generation plants due to their ability to provide firm capacity during scarcity situations. As illustrated in the figure below, 85 % of the forecasted contracted volume under CMs in 2035 is still expected to go to fossil-fuel plants.

However, as the generation mix changes and new technologies and market actors can contribute to resource adequacy, CMs need to ensure effective participation diverse tools in a fair and non-discriminatory manner. Moreover, CM design should also consider decarbonisation targets and related EU and national policies. Such need has also been highlighted and further reinforced in the EMDR, which asks Member States applying a capacity mechanism to *"consider to make the necessary adaptations in the design of the capacity mechanisms to promote the participation of non-fossil flexibility such as demand side response and energy storage"*[47].

One of the key design challenges is how to remove entry barriers for new capacity providers including non-fossil flexibility (e.g. storage, demand side response, distributed resources) while ensuring fair and non-discriminatory treatment of existing technologies. This presents a trade-off: CMs should encourage the continued operation of efficient existing assets while attracting sufficient investment in new assets necessary for ensuring system adequacy. New investments, often associated with high CAPEX, cannot typically be supported by a one-year capacity contract.

Higher CAPEX is not restricted to specific technologies: virtually all technologies, including demand side response, could benefit from long-term contracts to support larger investments needed to unlock flexibility. However, certain units may prefer short-term contracts due to their more limited planning horizon, which prevents them from forecasting their contribution in advance. In this context, offering the option of contracts of different lengths is beneficial. At the same time, long-term contracts could lead to a lock-in effect, so eligibility criteria for multi-year contracts must be carefully developed. Ideally, these criteria should not be based solely on technology, as this could result in one technology being locked in for extended periods. A more balanced solution is to set investment thresholds, where capacities become eligible for longer contracts based on the amount of CAPEX they need to carry out. This approach allows for a balanced procurement of both new and existing capacities.

Another potential mechanism for long-term contracts involves technologies that are otherwise too expensive but could provide valuable system services due to their flexibility. For these technologies, longer contracts could also be considered.

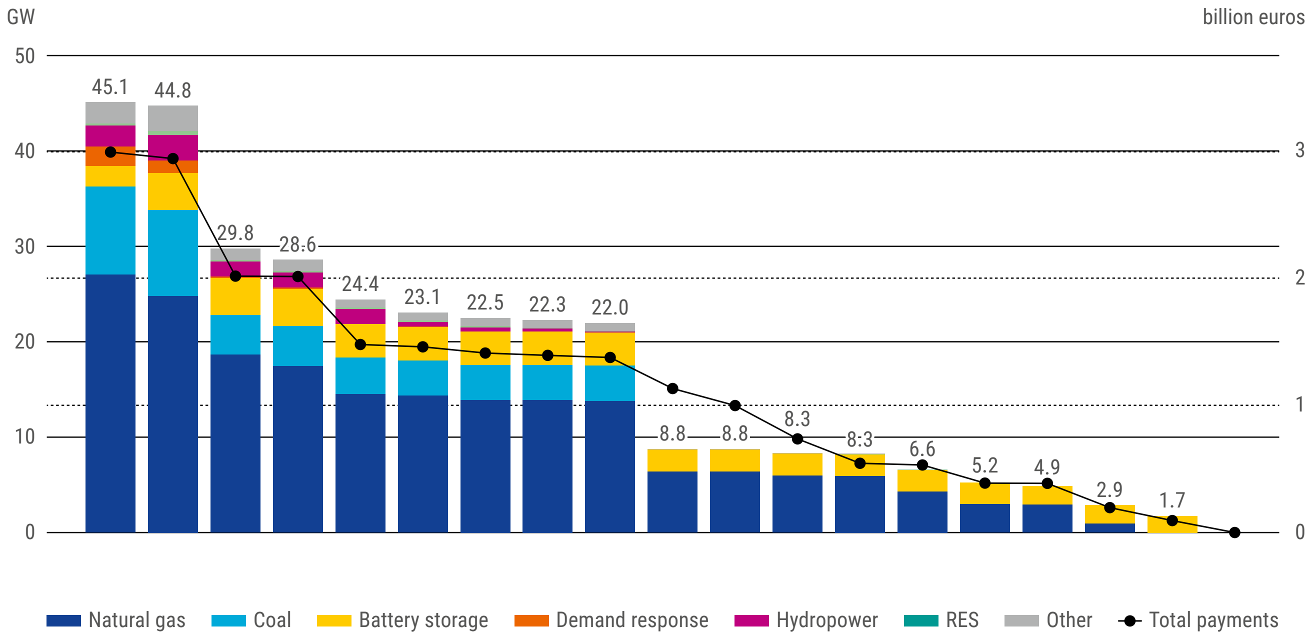

Figure 3: Total payments and capacities awarded long-term contracts under market-wide capacity mechanisms by technology
Source: ACER (2024): Monitoring report on security of EU electricity supply

47 Article 19g, Regulation 2024/1747

The role of derating factors

To ensure security of supply, derating factors are commonly used in CMs to reflect the contribution of different technologies to system reliability. A derating factor represents the proportion of a unit's nominal capacity that performs satisfactorily during system challenges. These factors can evolve over time, as highlighted by Downey[48], for example, batteries' actual contribution decreases when more storage assets enter the market. For each capacity auction new derating factors are determined based on a new assessment of each technology's contribution during scarcity. The capacity with which a unit then participates in the auction is derated to reflect its contribution to security of supply and create a level playing field between the different capacity providers competing for CM contracts. The derating factor is typically based on:

- The unit's technology class (e.g., gas, wind, solar, hydro, demand side, storage, interconnection);
- The size of the unit, as larger units tend to contribute less per MW, especially for energy-constrained technologies such as storage and demand side response;
- The duration for which the unit can operate at full output. Energy-constrained technologies, like storage or demand side response, typically contribute less to reliability if they can only operate for short durations.

To facilitate participation of energy constrained technology such as storage and demand side response, it is beneficial to allow capacity providers to choose among different options of service level agreement (e.g. number of consecutive hours to be available in times of scarcity) in the CM contract. Indeed, by leaving capacity providers the freedom to select this number of hours, they are not forced to take some risks by committing to deliver an unrealistic level of performance, which could then lead to costly unavailability penalties. Moreover, they can also adapt their service level agreement (and the associated de-rating factor) by aggregating together to reach a higher contribution in periods of scarcity.

Phased auction designs

A potential approach to ensure that all kind of technologies with varying lead times and investment cycles can participate in a CM is to reserve some volume across different auctions linked to a single CM delivery period. This phased reservation approach can offer several benefits:

- Multiple auction timelines (e.g., Y-4 and Y-1) enable the inclusion of technologies with different construction lead times, broadening the range of solutions available to address security of supply and resource adequacy challenges.
- A mix of auction volumes and contract lengths tailored to the investment cycles of different projects can help balance cost-efficiency with long-term supply security, incentivising both short- and long-term investments.
- Phased reservations can help reduce over-reliance on fossil-based generation, preventing lock-in effects by enabling cleaner technologies with shorter lead times to enter the market, thus accelerating the transition to decarbonisation. Since non-fossil flexibility often only has a clearer view of its potential participation shortly before delivery, reserving some volumes in a Y-1 auction (or even closer, such as Y-0.5) ensures better alignment with these technologies.

48 Downey, A (2024) Transforming the power system for future generations – the role of dynamic capacity markets and de-rating factors. CIGRE conference paper

Addressing technology-specific challenges – demand side response & storage solutions

One technology that stands out due to its unique characteristics is demand side response (DSR). DSR faces specific challenges in participating in CM auctions, primarily because the capacity remuneration CMs provide is designed to address the "missing money" issue. The question arises regarding whether DSR can be eligible for capital expenditure CAPEX allowances, given that it is not directly involved in the production of electricity like traditional generation units. However, CMs can still allow the participation of units from other technologies that require minimal CAPEX but incur fixed operational and maintenance costs. Thus, CMs can serve as an important enabler for greater demand-side participation in the energy market, particularly with shorter-term auctions like Y-1, see also above.

For DSR units, accurate metering is crucial to assess their contribution to system security. Baselining – determining the reduction in demand compared to a unit's expected consumption – is essential for ensuring DSR units are effectively contributing. Baselining can be either self-assessed or externally verified, and its methodology is key to ensuring that DSR units are contracted in a way that reflects their actual contribution.

Additionally, many CMs feature a reliability option designed to capture excess profits. This raises the question of whether all participating technologies are subject to the same treatment regarding windfall profits. Calibration of the strike price is critical, as it sets the threshold above which profits are considered excessive. For DSR units, which may have high variable costs that the strike price does not cover, a lower strike price could effectively exclude them from CM participation. To facilitate DSR participation in CMs with a reliability option, one approach could be to use a different strike price for DSR units with higher variable costs. Alternatively, DSR units could be excluded from the reliability option, particularly as they do not generate windfall profits when reducing demand during high-price periods.

Another technology worth discussing is energy storage. Storage solutions, such as batteries, can have multiple revenue streams, including inframarginal rents and income from energy arbitrage, balancing, and congestion management. As battery technology matures, its market share is expected to grow, enabling storage units to develop strategies around energy arbitrage, charging when electricity prices are low and discharging when prices are high. This evolution aligns with the EU's 2030 goals for renewable energy integration and 2050 goals for a fossil-fuel-free electricity system.

Given the diverse characteristics of these technologies, CMs can be designed to target specific portfolios of technologies or exist alongside other mechanisms, as discussed in Section 2.1. The decision to use CMs to incentivise specific technologies versus using separate mechanisms requires careful consideration of the trade-offs involved.

Some countries with existing CMs have already adapted their design in anticipation of future needs. Flexibility in the approach is essential, especially considering the dynamic nature of the energy market. For example, countries with a coal-heavy energy mix may use CMs to stimulate investment in low-emission generation units and batteries, bridging the gap left by decommissioned fossil-fuel plants. Conversely, countries with low or no coal generation may focus on incentivising the development of flexible assets through CMs.

As the costs of fossil fuels rise, increasing the cost of fossil energy production, the competitive disadvantage for European industries grows. The construction of new low-emission generation sources and storage is crucial for accelerating the energy transition and enhancing Europe's competitiveness. A well-designed CM can act as a catalyst for building new generation units and storage, as well as unlocking new DSR.

Following the evolution of EU regulations regarding non-fossil flexibility, differentiated auctions with varying lead times may be necessary if countries wish to achieve long-term strategic goals (e.g. creating a significant quantity of Long-Duration Energy Storage "LDES" (i.e. 100+ hours)) which are new to a market but would not be attractive investments in current market conditions.

Key messages

- › Design features like investment thresholds (longer contracts in function of CAPEX expenditures) and multi-year contracts can ensure fair participation of diverse technologies.
- › CMs use derating factors to assess the reliability contribution of technologies. Flexible service level agreements and aggregation options can facilitate the participation of energy-constrained resources like storage and demand side response.
- › Phased auctions can accommodate varying lead times and investment cycles, enabling both short- and long-term solutions while preventing fossil fuel lock-in and encouraging cleaner innovative technologies.
- › CMs must address unique barriers faced by technologies like demand side response (e.g., baselining accuracy, strike price calibration) and storage (e.g., revenue stacking potential) to enhance participation and system flexibility.

2.4 Minimising side-effects in electricity markets

The different design of CMs – whether targeted or market-wide, quantity-based or price-based- can introduce different levels of distortions in the Internal Electricity Market, both in terms of energy market functioning and cross-border impacts. Thus, side-effects must be carefully managed to ensure market efficiency.

Impacts on energy markets

Regarding the impact in the different energy markets, this can span from long-term markets to short-term markets:

- › Long-term energy markets: the introduction of CMs may reduce liquidity in these markets, which in turn could limit hedging opportunities for market participants. CM providers, whose capital costs are secured, may have reduced incentives for long-term contracts. However, these providers might still seek to maximise revenue by exploiting optionality value in the future, including through hedging on forward markets, thus mitigating some of the impact.
- › Short-term energy markets: CMs may depress average energy market prices, particularly as marginal units rely less on short-term revenues to cover long-term marginal costs. This could reduce price volatility, which might be beneficial for consumers, but also undermine efficient dispatch signals. Technologies that depend on price fluctuations for flexibility, such as storage and demand-side response, may suffer. Additionally, CM revenues might exacerbate the "missing money" problem, with non-CM resources seeing reduced energy market revenues, leading to a decoupling of investments from energy market signals.

Cross-border impacts

CMs are typically designed to address national adequacy needs, which can create divergent conditions across countries. For example, differing CM (e.g. derating factors, penalties, and other design requirements) may lead to distortions, especially where neighbouring countries operate CMs while others do not. Countries without a CM may still experience market disruptions due to the implementation of CMs in adjacent nations. These unintended effects can be mitigated by reducing the risk of excess profits, as discussed in section 2.2. of this paper, or by ensuring appropriate capacity dimensioning to limit the market share held by CM providers.

Optimising volume dimensioning, flexibility and curtailment sharing

To minimise over-procurement, a careful CM design is crucial. This includes improving volume dimensioning methodologies that account for the contribution of flexibility, both explicitly and implicitly, and considering seasonal adequacy needs.

A critical consideration when introducing a CM is the dimensioning process, specifically determining how much capacity should be auctioned to meet the required adequacy level. This decision can be highly influenced by cross-border factors, especially in countries with high interconnection. Volume dimensioning typically relies on the results of resource adequacy assessments (ERAA and NRAAs[49]).

However, differences in underlying assumptions and methodologies across these assessments may impact the robustness of CM decisions, potentially leading to either excessive procurement – resulting in unnecessary market intervention – or insufficient procurement, leaving adequacy risks unaddressed. To manage procurement risks more effectively, adjusting auction frequency and volumes – such as through main and adjustment auctions – can help mitigate over and under procurement. Other market rules also play a role in CM dimensioning, particularly those governing demand curtailment during system stress situations[50]. To ensure a comprehensive approach, long-term resource adequacy assessments should account for the effects of curtailment sharing within short-term coupled markets.

Market signals alone may not be sufficient to address challenges arising from simultaneous scarcity events across multiple countries. In such cases, cooperation among Member States, TSOs, and NRAs is essential, with clear, pre-agreed rules. Curtailment sharing is a key element in ensuring that resource adequacy is maintained during system stress, particularly in interconnected regions. However, as energy security becomes a higher political priority, and more Member States introduce CMs, managing simultaneous scarcity and curtailment sharing based on voluntary rules is no longer solely a technical challenge but also a political one.

As a way of conclusion, while recognising that side-effects in the European electricity market regardless the type of CM are unavoidable, a good strategy to mitigate these effects is to set a sequential auctioning approach on top of improving the volume dimensioning methodologies to consider both the contribution of flexibility (implicitly and explicitly) and potential seasonal nature of adequacy needs. Additionally, careful consideration must be given to the interplay with market rules governing curtailment sharing in short-term markets.

Key messages

- **Implementing sequential auctions (i.e., main and adjustment auctions) and refining volume dimensioning methodologies to account for flexibility and seasonal adequacy needs can help mitigate the risks of over-procurement and market distortions caused by capacity mechanisms.**
- **Adequate designs are essential to reduce negative impacts on long-term and short-term energy markets – i.e. preserving liquidity, efficient price signals, and investment incentives.**
- **Over-procurement can be avoided through careful dimensioning and periodic adjustments, such as the introduction of main and adjustment auctions.**
- **Additionally, greater coordination across Member States may be warranted to address emerging challenges such as possible impacts of European market rules on curtailment sharing on the effectiveness of CMs to tackle national adequacy issues (including their dimensioning).**

49 ERAA is performed assessing central reference scenarios crucial for analysing the evolution of the electricity system across EU that determines the expected hours of loss of load based on a number of assumptions. NRAA are performed with greater liberty degrees allowing for a finer reflection of the domestic electricity landscape.

50 Sharing of demand curtailment is a voluntary measure integrated in the market coupling rules for the day-ahead market. Curtailment sharing is a solidarity mechanism to smoothen out load loss across the Member States (bidding zones) that are affected by load loss at the same time. For more details, see here.

2.5 Cross-border participation

The Electricity Regulation[51] establishes the objective for capacity mechanisms (other than strategic reserve) to allow direct cross-border participation of capacity providers located in another Member State, subject to the conditions laid down by ACER[52].

As highlighted in previous sections of the paper, cross-border participation in CMs can bring significant benefits in at least three key areas:

- **Cost minimisation** by allowing capacity from neighbouring countries to participate in the CM, competition can reduce overall system costs, creating more efficient market outcomes.
- **Appropriate incentives to investments in foreign capacity[53] and to investments in new cross-border capacity[54]:** allowing foreign capacity to participate in the CM provides strong incentives for investment in both new cross-border capacity and the retention of existing competitive capacity in neighbouring countries. Furthermore, if capacity payments are shared with cross-border capacity according to relative scarcity, this can encourage further investment in cross-border infrastructure.
- **Mitigation of cross-border impacts:** explicit cross-border participation creates a level playing field. ensuring that capacity from different countries is remunerated based on its contribution to security of supply, avoiding discrimination between domestic and foreign resources.

However, implementing cross-border participation in CMs presents several challenges that need careful consideration. Some of the most prominent issues are outlined below:

- **Foreign generator and/or Interconnector participation** a pragmatic approach allowing for direct participation of interconnectors[55] should be adopted (either as an enduring solution or as an interim step). Direct participation by the interconnector should be allowed as an enduring solution when it is assumed to be an efficient solution, which is the case if the scarce resource first of all is the cross-border capacity and not the foreign capacity. Direct participation by the interconnector should also be allowed as a first step in a stepwise implementation of a more efficient solution, where in a second step the cross-border capacity payment is shared between the cross-border capacity and the foreign generation capacity.
- **Accurate identification of scarcity:** the design of solutions for cross border participation should consider that both the cross-border capacity and the foreign generation capacity can be the scarce resource that should be remunerated. The model for cross-border participation should take this into account by splitting the revenue between the relative scarcity of these two types of capacity to ensure that the scarce capacity is incentivised. Different models for revealing the correct split of the cross-border capacity payment between foreign generation capacity and the cross-border capacity are possible (e.g., proportional allocation, capacity-based, market-based). The key point is that the foreign generator access to the capacity market over the border would need to be rationed so that generators in the foreign country cannot sell more capacity into the capacity market than the derated cross border capacity, defined as Maximum Entry Capacity. This rationing process, which can be a local auction in the neighbouring country, must be used to determine eligible foreign participants in the CM and to adequately split the cross-border payments between the foreign generation capacity and the cross-border capacity.

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51 Article 26, Regulation 2019/943 further amended by Regulation 2024/1747

52 ACER Decision No 36/2020 (Annex I)

53 Capacity providers located in another country that can be used to meet domestic energy needs or contribute to energy security

54 Physical capacity of interconnections

55 Article 26(2) of Regulation 2019/943 allowed this participation for a limited time: "Member States may allow interconnectors to participate directly in the same competitive process as foreign capacity for a maximum of four years from 4 July 2019 or two years after the date of approval of the methodologies referred to in paragraph 11, whichever is earlier."

- **Bilateral contracts between TSOs:** cross-border participation necessitates the establishment of bilateral contracts or at least an alignment between TSOs from different countries. These agreements are necessary to ensure coordinated processes for data sharing, alignment of operational procedures, timelines, and communication with capacity providers. They also include essential rules for liability terms, contract length, dispute resolution, and other critical aspects to facilitate smooth and efficient cross-border cooperation. Negotiating these contracts can be complex, time-consuming, and resource-intensive. The specifics of responsibilities, liabilities, applicable law, and operational protocols all need to be carefully outlined and agreed upon, which can delay the overall implementation process. Key points in TSO negotiations include:

  - **Responsibility allocations must be clearly defined and negotiated.** This includes determining which TSO is responsible for what aspects of the cross-border participation. The electricity regulation provides an overview of 3 tasks to be fulfilled by the foreign TSO (article 26 (10). However, the different implementations of CMs per country do not always make it apparent which task should be performed by the foreign TSO. This can lead to misunderstandings and misalignments, complicating cross-border collaboration and compliance efforts.

  - **Establishment of new data processes:** Effective cross-border participation often requires the creation of new data exchange processes. This may involve developing new IT systems, data standards, and communication channels to ensure that all relevant information is accurately and efficiently shared between parties. These new processes can be costly and time-consuming to implement.

  - **Cost coverage:** Determining who bears the cost for the work required to establish cross-border participation is another critical issue. This includes costs associated with negotiating contracts, developing new data processes, and aligning different mechanisms. Clear agreements on cost-sharing are essential to avoid conflicts and ensure that the necessary investments are made.

- **Diverging mechanisms:** Different countries may employ completely different capacity mechanisms, which can complicate efforts to harmonise cross-border participation. Aligning these mechanisms in a way that is fair and effective for all parties involved is a significant challenge that requires careful consideration and negotiation.

- **Assets connected to low-voltage grids:** In those countries where TSOs lack visibility on capacities connected to the DSOs grid, including these capacities in cross-border capacity mechanisms is a substantial challenge. DSOs often operate under different regulatory and operational constraints compared to TSOs, and their participation may require the establishment of new data processes and communication protocols. This can be a significant hurdle, adding layers of complexity to the process.

- **Small Maximum Entry Capacity[56] (MEC) Values:** Another consideration is the practicality of cross-border participation for small maximum entry capacity values. In such cases, the benefits of cross-border participation may not justify the costs and complexities involved. Therefore, it is essential to assess whether cross-border participation makes sense for smaller MEC values on a case-by-case basis.

- **Multiple commitment** (one asset can participate in several CMs): When asset can participate in multiple capacity markets, it becomes a challenge to have proper ways to avoid double payments and potential non-delivery of capacity due to simultaneous scarcity. To ensure system security, maintain fairness and prevent overlapping benefits in CMs, the asset's total capacity must be split and allocated proportionally to each market according to its commitments, ensuring that the combined commitments do not exceed the asset's total capacity. Allowing a power plant's capacity to be contracted in multiple capacity markets simultaneously could lead to overcompensation for the same capacity, distorting market signals and potentially undermining the efficiency and reliability of the electricity grid. By ensuring that each MW is only committed in one capacity market, we can promote equitable competition, prevent market manipulation, and ensure that the financial support provided through CMs is effectively utilised to enhance grid stability and security of supply.

56 'maximum entry capacity' means the maximum allowed entry capacity on a given CM border for a given delivery period. The calculation of the MEC shall be done annually for each CM border, taking into account the expected availability of interconnection and the likely concurrence of system stress in the system where the CM is applied and the system in which the foreign CMUs are located. See: https://www.acer.europa.eu/sites/default/files/documents/Individual%20Decisions_annex/ACER%20Decision%2036-2020%20on%20XBP%20CM%20-%20Annex%20I%20-%20technical%20specifications_0.pdf

In conclusion, while cross-border participation in capacity mechanisms has potential benefits both in terms of adequacy, cost efficiency and competitiveness, it also presents several challenges that must be addressed. Solutions for cross border participations should therefore not be more complex than necessary to enable efficient allocation of the cross-border capacity payments.

Another option for cross-border participation that is being discussed in the literature is implicit cross-border participation. This means that the value for security of supply of the cross-border flows for the CM is considered, but there is no explicit participation from market participants located in neighbouring countries or from the cross-border capacity itself. In practise it means that neither market participants located in neighbouring countries or the cross-border capacity itself is remunerated for its contribution to security of supply in the CM. This option is easy to implement for the TSOs compared to explicit cross-border participation but has some significant drawbacks. It restricts cross-border competition between market participants and reduces incentives for investments in cross-border capacity.

Key messages

- **To facilitate smoother integration of cross-border capacity, the requirements for cross-border participation should be streamlined to decrease implementation complexity.**
- **Gradual implementation, allowing direct interconnector participation and implicit participation as an interim solution, can facilitate a faster approval and stepwise implementation process, ensuring that implementation of cross-border participation does not unduly delay the procurement of capacity through a capacity mechanism. Finally, it should be explored under which conditions implicit participation can be allowed as an enduring solution.**
- **Common principles on cross-border participation foster a level playing field, but safeguards are necessary to avoid double payments and delivery challenges.**
- **Strong TSO collaboration for data sharing, alignment, and dispute resolution is essential. Case-by-case cost-benefit analyses should be conducted for smaller MEC values to ensure efficient investment decisions.**

Recap of main design features and ENTSO-E considerations

The following core design elements are essential in discussions surrounding CMs

Targeted vs market-wide mechanisms

CRMs can either be targeted, such as strategic reserves, or market-wide, such as capacity auctions, certificates, or reliability options. While targeted mechanisms focus on securing specific resources that are only deployed during system stress, market-wide mechanisms provide remuneration to all resources contributing to resource adequacy, ensuring broader market participation and a more competitive approach to securing capacity. The choice depends on the specific adequacy risks and market context of each Member State.

Centralised vs decentralised procurement

Centralised procurement involves a single buyer, often the TSO, which simplifies coordination and ensures capacity is procured based on system-wide needs. Decentralised procurement (i.e. where market participants secure capacity individually) allows for greater market flexibility and competition but can lead to challenges in ensuring system adequacy and equity in cost allocation.

ENTSO-E recognises that decentralised procurement risks fragmented outcomes and can result in suboptimal capacity allocation across the system. Centralised procurement enables greater coordination, reduces transaction complexity, and allows TSOs to balance local and regional adequacy requirements effectively.

Contract lengths

The duration of CM contracts significantly impacts investment decisions. Longer contracts for new assets, such as low-carbon generation or storage, can reduce financing risks and encourage capital-intensive investments. Differentiating contract durations can ensure adequate investment signals for capital-intensive technologies while minimising over-compensation for existing resources.

Participation of resources

CRMs must ensure non-discriminatory participation of all resource types, including renewables, storage, demand side response, and interconnectors. Broad participation increases competition, lowers costs, and ensures that CRMs support innovation and decarbonisation objectives.

For this purpose, derating factors must accurately reflect the reliability of different technologies and streamlined prequalification requirements should balance the need for rigorous standards without excluding valuable resources.

Penalties

Effective penalty mechanisms incentivise capacity providers to deliver during system stress. Penalties must be sufficiently stringent to ensure reliability but should avoid creating excessive risks for participants, which could deter investments or lead to higher procurement costs.

Financing mechanisms and cost distribution

The cost of CMs must be allocated fairly among grid users to avoid disproportionate burdens on specific customer groups. Financing mechanisms should be transparent, ensuring costs are recovered equitably while reflecting the benefits provided to all system users. Special attention should be given to minimising distortions in the broader electricity market.

Auction design

Well-designed auctions including frequency, pricing mechanisms (pay-as-bid or pay-as-cleared), and price caps are critical to increase competition and minimise procurement costs while ensuring robust investment signals. Reliability options, which link capacity payments to performance during high-stress periods, can provide strong incentives for resource availability. Auction design must also account for market liquidity and the risk of over- or under-procurement.

Cross-border participation

Facilitating cross-border participation can enhance system efficiency and leverages the benefits of the single electricity market. CMs should allow for participation via explicit contracts with capacity providers in neighbouring countries or direct interconnector participation. Implicit participation should be allowed as an interim solution and as enduring solutions under certain conditions to be further assessed. Common rules on prequalification, derating factors, and availability criteria are essential in this regard, and effective coordination among TSOs, regulators, and market participants is essential to unlock the full potential of cross-border participation.

Decarbonisation features

To align with climate targets, CMs must integrate decarbonisation measures such as emission limits, quotas, or preferential treatment for low-carbon technologies.

While CMs are not the primary tool for governing the decarbonisation of the power sector, integrating decarbonisation features ensures CMs align with EU climate targets while maintaining system security.

3 Synergies associated to Capacity Mechanisms implementation

Over the past decade, the objectives of CMs have evolved from merely addressing capacity exit to supporting investments in new firm capacity, and more recently, addressing broader system needs such as system flexibility.

This chapter explores the diverse synergies inherent in CMs, focusing on their potential to meet a wide array of system requirements, including ancillary services and locational needs. It also considers the opportunities and challenges associated with increased harmonisation across national CMs, which could enhance efficiency and coordination. However, it is essential to account for the unique circumstances and needs of each Member State to ensure that these synergies are effectively realised.

3.1 Additional system needs

While CMs primarily aim to address adequacy concerns, if well-designed, they can also deliver benefits for other system needs, such as ancillary services, non-frequency services, and/or locational signals. However, incorporating these additional objectives and features into a CM design inevitably increases complexity. For instance, remuneration structures may differ between capacity bidders, and the merit order curve could become harder to interpret. The increased complexity and potential changes to EU regulations should be carefully assessed before integrating additional system needs into CM designs. It is also worth noting that synergies may be realised without explicitly incorporating payments for these services into the CM. For instance, if locational signals are integrated in the CM design (see further below for specific examples), capacity providers in congested areas could provide the necessary system services without needing dedicated congestion management payments.

Although adding features to a CM may increase the cost of procured capacity, the overall costs of ensuring supply security and system stability could decrease if the CM is well-designed. Leveraging synergies could be more cost-effective than procuring each system need separately.

Here is an overview of additional features that could be integrated into a CM to exploit synergies:

Flexibility

In systems dominated by variable renewables, flexible resources are crucial to maintaining secure system operation. As discussed in Section 2.3, current and future CM designs aim to facilitate the efficient participation of all technologies, including flexible resources. Various design options exist, including implicit and explicit flexibility contributions, tailored product designs (e.g., contract length, activation time, de-rating factors), and mechanisms to support flexibility. However, achieving effective flexibility contributions remains a challenge, as highlighted by stakeholders like the European Commission and associations representing demand side response and storage.

To enhance flexibility integration, the European Market Design Reform (Art. 19) has introduced flexibility support schemes. Going forward, careful consideration needs to be given to how to best efficiently coordinate CMs and non-fossil flexibility support schemes.

Some general questions and design options on the relationship between the two mechanisms can be summarised as follows:

- Firstly, the ERAA/NRAA determines the adequacy risks.
- Secondly, the National Flexibility Needs Assessment (NFNA) determines the flexibility needs (which is based on ERAA/NRAA input).

- If both a CM and Non-fossil flex support scheme (NFFSS) is introduced, we see the following options in terms of auctions interactions:
  - Non-Fossil Flexibility Support Schemes (NFFSS) are held first, then contracted volumes may be subtracted from the dimensioning of the CM; or
  - Auctions are held in parallel to ensure that market participants have equal access to participate in both auctions and to pool liquidity; or
  - NFFSS auctions are held after the CM-auction to use the NFFSS as a 'top-up' on the volumes contracted through the CM-auctions.

The pros and cons of the different design options must be assessed to identify which would best support the integration of non-fossil flexibility in a central CM in combination with a NFFSS.

When a CM is in place, as shown above, NFFSS can either be integrated within the CM through additional criteria or implemented as separate mechanisms. As adequacy and flexibility are closely interconnected, it may be beneficial to procure both simultaneously[57].

Non-frequency ancillary services

Synergies can also be realised through increased liquidity in ancillary service markets or by enabling units with grid-forming capabilities (such as inertia and dynamic responses). Additionally, fostering non-fossil fuel flexibility, as discussed in recent debates during the EMD reform, can be beneficial.

While generation capacity is required for secure operation, system services – especially non-frequency-based ones – are increasingly critical. Non-frequency ancillary services, such as reactive power, voltage stability, black start capabilities, and short-circuit current feed-in, have traditionally been provided by large power plants or TSO-owned equipment, often outside of market-based mechanisms. As the energy system transforms, many of the sources of these services are no longer available.

To address this, market-based procurement of non-frequency ancillary services as established in Article 40 of Directive 2019/944 could be more viable, provided it does not compromise grid security. Including these services within CM designs, through specific requirements or incentives (e.g., longer contracts, premiums, or dedicated products), could fill this gap. However, it is crucial to adhere to Directive (EU) 2019/944, Art. 40(5), distinguishing between the provision of ancillary services and the "potential for provision." The actual provision of these services must be ensured through separate market mechanisms, while the CM can incentivise assets' technical potential to provide ancillary services. An example of this would be the planned "southern bonus" of the German Power Plant Strategy. This would give plants a better position in the bid ranking if they were located in certain regions. This procedure could also be extended to ancillary services, whereby plants that have the potential to provide certain ancillary services would also receive an individual improvement in the bid ranking for each of these potentials.

57 Compass Lexecon, for instance, suggests integrating adequacy and flexibility remuneration, either through a double-product system or by adjusting derating factors (Compass Lexecon, 2024). This option along with other design options needs to be assessed in more detail in future work.

Locational signals and geographical needs

Another example for synergies could be to include locational incentives in the CM design. The reason for this could be to accommodate the different paces of both new capacities and grid reinforcement or to avoid an extra need for grid reinforcement and reduce redispatching costs, for example if certain congestions and redispatch needs will have to be addressed at a higher than BZ granularity, or if new interconnectors or offshore wind farms leads to increased N-1 security needs [58]. These elements could potentially lower overall system costs eventually borne by consumers and enhance overall system flexibility. Another reason for introducing locational signals in CMs could be to address the potential inefficiencies in a national energy market if there is a considerable mismatch between the market outcomes and the physics of the underlying power system, which distorts locational investment signals in the energy markets and thereby limits the ability to efficiently integrate assets that e.g. can deliver firm or flexible capacity.

New power plants and flexible loads should be incentivised to be located at appropriate locations in the grid in countries facing increasing challenges to manage congestions and to procure essential ancillary services. In the framework of energy transition, increasingly local ancillary services – also because of closure of plants providing such services – will also have to be covered by renewables, flexible consumers, or storage facilities, for example. This potentially leads in some cases to increasing discrepancies between physical reality of the grid and market outcome.

In those cases, the overall system costs (e.g. for grid expansion, congestion management or ancillary services procurement) are usually not adequately considered in the investment and operating decisions of market participants. The system could benefit from solutions that geographically and objectively differentiate payments and consequently generates market incentives that serve the system. This could be by limiting how much capacity could be located in a certain area, or to allow for a higher capacity market clearing price in certain geographical areas [59]. Thus, its basic approach would work in addition to a central capacity market, including a higher spatial granularity and enhanced by the consideration and implementation of ancillary services.

Thus, for example, a capacity market with a local component can ensure a sufficiently large, local redispatch potential in the long term, which could help the system during times of non-system stress (during system stress situations with adequacy risk, these assets would be activated and would hence not be available for redispatch purposes).

Considering all the above, it is still important to assess the impact of including, for instance, higher geographical granularity in the CM design than in the ordinary markets, as this could interfere with the merit order curve in the CM and decrease transparency and understanding of CM auctions results. This could also be viewed as unduly distorting competition. Further, it is important not to diverge from, nor to allow for derogations from pre-qualification requirements and other design parameters, to obtain certain locational outcomes, as it may come with a risk of new investments not to be delivered on time.

Current boundaries for CM design

Despite the potential rationale for including other parameters and system needs into the CM design, one should not forget that the current regulatory and legal framework does not foresee additional system needs in the current CM design. CMs are subject to state aid approval by the EC. Design options, such as taking local signals and non-frequency based ancillary services into account, are not yet part of known CMs. A justification of the necessity is required as part of the state aid approval. However, it is relevant for the regulatory framework to explicitly allow for the inclusion of more objectives in the CM design, or to deviate from default solutions.

The former could be the need for specific ancillary services, the latter to introduce a finer granularity than BZ's, even as for instance ACER argues, that BZ configurations are suitable locational resolutions for CM's, and method of choice in case of structural congestions in view of CACM. While BZ configurations provide benefits in terms of limiting congestions in the grid, a CM design with high locational granularity could provide more precise investment incentives to locate flexible power generation close to consumption or to locate storage assets close to variable RES, so to minimise grid expansion and/or redispatching costs.

58 In practice, TSOs would first decide to allow for connected assets larger than the current N-1 by increasing the size of the N-1, not the other way around (i.e. assets bigger than the current N-1 cannot be built unless the TSO allows this and then triggers and increase of the size of the N-1).

59 These type of locational features are in place in the Irish CM and have been considered for instance in the recent consultation about the German market-wide CM

Dealing with increased complexity

The inclusion of more design features and parameters in the CM design will result in an increased complexity, both in terms of overall design, participation, and auctioning, but also overall governance and operation. It is therefore important to consider which parts should be included in the design, and whether the ambition to achieve more goals with one market design could compromise the outcome. Part of this is to consider, if more targeted market initiatives could achieve comparable results for ancillary service or local flexibility. On the other hand, applying separate market schemes, which are closely interlinked could also be difficult.

In general, the more complex the design gets, the more difficult it is for market participants to participate in auctions and to submit cost-efficient bids, and too much complexity could exclude potential bidders. To mitigate this, there is an obligation for the TSO or other relevant authority to properly explain conditions and requirements for participating. This also accounts for auction results, as optimising again several parameters will make the interpretation of results, including the fairness of these, more difficult. Consideration should also be given to potential needs for adaptations in regulations, such as state aid approvals, to facilitate these more holistic approaches in CM design.

3.2 Harmonisation challenges and opportunities

Considering the diverse capacity mechanisms in place across the EU, this diversity offers an opportunity for improvements by addressing potential inefficiencies and enhancing investments and cross-border electricity trade. Therefore, a certain degree of harmonisation can play a key role by creating a common framework that facilitates better coordination and integration of national CMs. This approach can also ensure a level playing field in cross border participation, promoting fairness and equal opportunities for all market participants.

As also highlighted in section 2.5, a viable way forward is to consider implicit cross-border participation. Indeed, this approach greatly simplifies the interaction of capacity mechanisms in neighbouring Member States while avoiding some of the complexities and side-effects of explicit participation.

This section aims to develop several lines of thinking on how national capacity mechanisms can converge in their design, with respective challenges and opportunities. National capacity operators can on a voluntary bilateral (or regional) basis already examine the elements that they perceive as low-hanging fruit and implement them to achieve better attuned mechanisms mutually beneficial for all parties. Even though harmonisation harbours many possible benefits, Member States could perceive these efforts – if imposed by EU regulation – as relinquishing control over their energy policies and priorities (on e.g. security of supply, generation mix, consumer protection or decarbonisation pathways). Additionally, the process harmonisation can be complex and time-consuming, requiring significant coordination and negotiation.

Furthermore, and as also mentioned in section 2.3, capacity mechanisms might offer capacity contracts spanning multiple years. When, for the sake of harmonisation, changes are made to capacity mechanisms in which multi-year contracts have already been signed, a careful assessment must be made on the impact on these existing contracts. Indeed, the retro-active application of these changes (or the lack of) can create complex contractual situations.

Against this background, a balanced approach is essential: on the one hand, the unique circumstances and needs of each member state should be considered; on the other hand, a certain degree of meaningful and optimised integration should (can) be sought. This approach should aim to maximise the benefits of harmonisation, such as improved market efficiency and security of supply, while minimising the drawbacks by allowing for flexibility and adaptability in implementation.

It must be noted that harmonisation is easier when the core characteristics of the involved CMs, i.e. the product that is being auctioned, are similar. For instance, it is much easier to establish common elements between two centralised CMs rather than between a centralised and a decentralised mechanism. In the following sections, several aspects identified as relevant to the discussion on harmonisation will be analysed in detail. Harmonisation is much more difficult between capacity mechanisms that are, for example, designed as a reliability option on the one hand and a contract for difference on the other.

Methodology for assessing resource adequacy risks

The starting point for any capacity mechanism is the Adequacy Assessment, which monitors whether there are concerns for adequacy, and what measures must be taken to ensure it. For a CM to be efficient, the design of CMs needs to be adapted to national specificities and adequacy needs. Complete European-wide CM design harmonisation would hamper the possibility and efficiency of such mechanisms due to limited adaptability for different national needs.

In this framework, the European Resource and Adequacy Assessment (ERAA) is a useful tool and forms a stepping stone towards adequacy of Europe as a whole. Moreover, it can be used as a foundation for a Member State's National Resource and Adequacy Assessment (NRAA), based on which the necessity for a capacity mechanism can be identified.

This approach ensures that the starting point for each NRAA is the same, while allowing space to address nationally specific elements.

As elaborated in Section 2.5, the implementation of cross-border participation in CMs can benefit from a reasonable degree of harmonisation. As the CMs can differ substantially across countries, cross-border participation becomes more challenging and increasing efforts are needed to provide a level playing field for all parties involved.

A viable option to consider in this context would be greater harmonisation of reliability standards, although this would imply removing national flexibility to define their own targets.

Bilateral TSO – TSO agreements

One area where improvements can be made is the bilateral TSO – TSO agreement. Since TSOs will inevitably have to exchange data when capacities participate in capacity mechanisms abroad, a framework needs to be set up that describes the necessary exchanges for such participation. However, experience has shown that concluding such agreements is not always an easy feat. As also mentioned by the Florence School of Regulation[60], setting up a standardised TSO – TSO agreement could significantly increase transparency, and reduce time and costs related to negotiation efforts. Topics that can be tackled by such a standardised TSO – TSO agreement include:

- Liability Clauses, clearly defining the scope and limit of liability for the involved parties;
- Applicable Law, determining the jurisdiction's laws governing the contract and outline dispute resolution processes;
- Confidentiality, defining how sensitive information is treated

A standardised TSO – TSO agreement can serve as the starting point for negotiations between TSOs that handles all the points that would be discussed in any case, while still leaving the options for the negotiating parties to include any specific details that need to be added.

Data processes

Capacity mechanisms furthermore suffer from a lack of **common data processes**. Member States have their own data frameworks, and it often proves difficult to find data that is perfectly equivalent between different capacity mechanisms.

There are already multiple ongoing initiatives to further harmonise data processes throughout Europe, such as the System Operator Guidelines (SOGL). When looking for data that can be used for cross-border capacities it is useful to not look at how different data streams across different Member States are different, but rather what they have in common[61].

Multi-CM participation

The need for harmonisation is driven by the possibility of multi-CM participation as well: In accordance with Article 26 of Regulation (EU) 2019/943 on the internal market for electricity, capacity providers shall be able to participate in more than one capacity mechanism. This possibility offers opportunities to maximally put their capacity to use.

However, strongly diverging CM designs require the capacity providers to invest significant time and money in order to accommodate the specific stipulations of each mechanism. The goal is by no means to eradicate these specific requirements for each CM, seeing as they often serve to tackle the unique challenges that each region faces.

However, strongly diverging CM designs require the capacity providers to invest considerable time and money to accommodate the specific stipulations of each mechanism. The goal is by no means to eradicate these specific requirements for each CM, since they often serve to tackle the unique challenges that each region faces. However, it can be useful to establish common processes and principles at prequalification, auction, a pre-delivery, and a delivery phase, simplifying capacity owners to participate in a different CM. These building blocks can be high-level, leaving sufficient freedom to the organising entity to tackle specific details whilst still marking the important milestones in the CM process.

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60 Florence School of Regulation, "An easy fix to streamline capacity markets", November 2024

61 For example, Article 46 of Commission Regulation (EU) 2017/1485 requires the implementation of a data exchange between TSOs and power generating facility owners. In Belgium, this is implemented as the Daily Schedule, which is used to carry out the monitoring of a contracted unit's availability. Dutch and German units contracted in the Belgian capacity mechanism are then evaluated based on the "Generation Forecast" or "Generation Block Unit" data, their respective implementation of the EU regulation. Even though the data differs, the Regulation ensures a common legal framework on what is included.

Prequalification process

The prequalification process offers multiple possibilities to streamline operational efforts for both the capacity providers and TSOs. Without going too much into detail, the prequalification process in general verifies whether and with how much capacity a unit is eligible to participate in the CM, and it is unnecessary that capacity providers wishing to participate in multiple CMs must carry out the same type of process twice. On the condition that some common ground[62] can be found, it should be possible that a successful prequalification in one CM is automatically valid for another CM as well. In particular, this includes permit verifications as well. Further options to align the prequalification process could include a common minimum capacity threshold (e.g. 1 MW) for units and common high-level principles to opt out of participating in the CM auction.

Auction clearing timings

Moreover, cross-border participation makes it inevitable that the results of one Member State's auction impacts participation of capacity owners in subsequent auctions from other Member States. To efficiently cross-check multi-CM participation, common auction clearing timings for common and/or overlapping delivery periods can be an ambitious but worthwhile endeavour.

CMs in the European context: what degree of coordination, harmonisation or integration is feasible and desirable?

Given that European regulation now allows CMs to be a permanent element of electricity market design and that more and more Member States are expected to introduce them in the coming years, increasing focus is emerging in the policy debate regarding cross-border interactions and how to best address them. Assuming CMs become the norm in most European countries after 2030, or at least in certain regions, it is thus pertinent to discuss what extent national capacity mechanisms can and should be coordinated, harmonised or possibly be even integrated in the long run.

As a starting point to address cross-border externalities, it would be beneficial to identify harmonisation opportunities which do not compromise the need for national specificities in CMs design. Some possible examples can be found in the previous sections. In case there is consensus on best practices such design features, an increased harmonisation of CMs could progress either voluntarily or guided by EU regulation, with the necessary flexibility.

In the long run (2035–2040), if a sufficient level of CM design harmonisation will be reached, further integration possibilities could be explored, for instance at regional level. It must be noted, however, that given the strong link between CMs and national policy prerogatives (e.g. security of supply, generation mix, retail markets organisation & consumer protection, decarbonisation pathways) as well as the diversity of national adequacy needs, it appears particularly challenging to reach agreements on all specific design features of CMs. Against this background, we do not consider feasible at this stage to reach a level of "coupling" similar to the one of wholesale markets or balancing markets. This is also due to the intrinsic nature of "capacity" as a product, which has multiple attributes and national specificities, as opposed to "energy" which is easier to standardise similar to commodities.

In any case, ENTSO-E and TSOs are available to contribute to the debate about harmonisation challenges and opportunities leveraging on their experience with CMs design and cross-border participation.

62 E.g. similar volume calculation methodology, identical technology categorisation

4 Conclusions and recommendations

The successful implementation and evolution of Capacity Mechanisms represents a key element in Europe's energy transition. By addressing both adequacy concerns and broader system needs, CMs can contribute significantly to the stability, flexibility, and resilience of the electricity system. However, achieving these outcomes will require a careful balancing act between efficiency, flexibility, complexity, and the unique national contexts that shape energy policy in each Member State.

Recommendation 1: Introduce Capacity mechanisms where needed and make them fit for the energy transition

1. CMs are an important tool to complement energy markets for ensuring resource adequacy in many regions.

2. CMs should be introduced where energy markets fail to ensure sufficient available capacity to cover system needs.

3. While decarbonisation objectives should be mainly pursued with dedicated policy tools and market mechanisms, CMs should be designed to support the energy transition, prioritising low-carbon and flexible resources hence avoiding lock-in effects of fossil fuel technologies beyond their necessary contribution.

4. CMs should be designed to address both current and future adequacy challenges. State Aid framework should allow swift and periodic design adaptations to address evolving capacity gaps and national targets, including mechanisms to discontinue CMs when no longer necessary.

Recommendation 2: Design CM which ensure effective capacity delivery at the lowest cost for consumers, and with a reasonable cost recovery

1. To ensure resource adequacy at the lowest cost for consumers, CMs must be designed to minimise over-procurement risks and excess profits, while also including mechanisms such as penalties for non-performance and calibrated strike prices to maintain economic efficiency.

2. The distribution of CM costs should be equitable and reflect consumers' contribution to adequacy during system stress periods. Capacity subscriptions, limited grid access agreements, consumer segmentation, or dynamic/time-of-use pricing incentivise demand side response during system stress, improve fairness and lower overall procurement costs.

3. Decentralised CM models face higher implementation challenges compared to centralised ones. Further analysis is necessary to identify the potential of effective design features.

4. To mitigate negative externalities on the IEM it is recommended introducing sequential auctioning approaches and improving volume dimensioning methodologies to consider both the contribution of flexibility (implicitly and explicitly) and potential seasonal nature of adequacy needs.

5. CM operators must be able to fully recover related costs and to keep financial exposure within reasonable limits

Recommendation 3: Promote technology inclusivity rather than technology neutrality

1. Capacity Mechanisms must address unique barriers faced by capacity providers like demand side response (e.g., baselining accuracy) and storage (e.g., revenue stacking potential) to enhance participation of low-carbon resources and overall system flexibility.

2. Design features like investment thresholds (longer contracts in function of CAPEX expenditures), flexible service level agreements linked to derating factors, and multi-year contracts can increase participation of diverse technologies.

3. Phased auctions can accommodate varying lead times and investment cycles, enabling both short- and long-term solutions while preventing fossil fuel lock-in and encouraging cleaner innovative technologies.

Recommendation 4: Evolve Capacity Mechanisms to address broader system benefits and flexibility, while balancing complexity and market efficiency

1. Where necessary, Member States should consider Capacity Mechanisms evolving from being purely capacity-based mechanisms to solutions that reward flexibility and benefits for other system needs, such as frequency and non-frequency ancillary services and congestion management.

2. A local component in a Capacity Mechanism design may be necessary in certain Member States, depending on the efficiency of locational signals provided by other market arrangements. In addition to payments to power plants/flexibilities, reduced system costs (ancillary services, redispatch, grid connection & reinforcements) need to be considered when guiding optimal siting decisions, so to reduce overall costs.

3. Going forward, careful consideration needs to be given to how to best coordinate Capacity Mechanisms and flexibility support schemes (where introduced), so to exploit synergies and avoid negative interactions.

4. To accelerate Capacity Mechanism implementation, their design should strike a balance between simplicity and efficiency. Design calibrations should be conducted regularly – in close consultation with relevant stakeholders – to reflect the latest market and technological developments.

Recommendation 5: Promote further Member States cooperation as well as simpler and more practical solutions for cross-border participation

1. Capacity Mechanisms should be designed to facilitate regional collaboration between Member States across capacity markets, increasing overall efficiency and enhancing system reliability beyond national borders.

2. Design solutions should minimise unnecessary complexity and administrative burden while ensuring fair and efficient allocation of cross-border capacity payments. This includes harmonising key processes and establishing clear and practical frameworks for coordination.

3. To facilitate smoother integration of cross-border capacity, the requirements for cross-border participation should be streamlined to decrease implementation complexity.

4. Gradual implementation, allowing direct interconnector participation and implicit participation as an interim solution, can facilitate a faster approval and stepwise implementation process, ensuring that implementation of cross-border participation does not unduly delay the procurement of capacity through a capacity mechanism. Finally, it should be explored under which conditions implicit participation can be allowed as an enduring solution.

Recommendation 6: Assess evolution opportunities of capacity mechanisms framework in the European context

1. New EU rules to streamline and simplify the approval process of national Capacity Mechanisms should avoid too restrictive criteria for MS to apply for fast-track procedures. The objective should be an effective shortening of Capacity Mechanisms implementation process, including the pre-notification stage.

2. EU and national regulatory frameworks for Capacity Mechanisms should allow for regular adjustments in response to market developments, technological innovations, and evolving energy policies.

3. Policymakers, in cooperation with Capacity Mechanisms operators and relevant stakeholders, should assess opportunities and challenges of streamlining Capacity Mechanisms design and of their possible coordination at regional or European level.

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