Capacity Remuneration Mechanisms in EU Electricity Markets: A Critical Analysis and Future Directions

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Abstract

This article explores the implementation of Capacity Remuneration Mechanisms (CRMs) in the European Union (EU) electricity markets to ensure long-term supply. CRMs provide extra payments to capacity resources, addressing market needs. The EU supports CRM when resource adequacy concerns arise. However, challenges in determining adequacy metrics persist. The European Resource Adequacy Assessment (ERAA) framework is used in the EU, but its acceptance by the Agency for the Cooperation of Energy Regulators (ACER) has been problematic, hindering consistent EU-wide capacity market creation. The article discusses CRM-induced market distortions, emphasizing the need for alternative solutions. Recent EU reforms promote non-fossil-based flexibility, yet concerns persist, emphasizing the importance of careful CRM amendments, with a focus on flexibility, decarbonization, and efficient investments.

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1. Introduction

CRMs are introduced into electricity markets with the objective of ensuring medium- and long-term security of supply. This is achieved by providing additional remunerations to capacity resources, such as generators, demand-response, or storage units, for their contribution to the power system's adequacy, on top of any revenues from the wholesale energy market.

The implementation of CRMs is supported by several arguments, the most being the missing money and missing markets problems. The missing money problem in electricity markets is primarily caused by energy price caps, inadequate remuneration due to administrative procedures implemented by system operators in emergency situations, and inefficiently low energy prices. The missing market problem refers to the absence of market mechanisms for long-term hedging instruments, the absence of a market for reliability, and the absence of a market for certain ancillary services, among others [1, 2].

2. Capacity remuneration mechanisms in Europe

According to Regulation EU 2019/943 (Clean Energy Package), EU Member States (MSs) are required to monitor resource adequacy based on the ERAA. In the event of resource adequacy concerns in an MS, the State must develop and publish an implementation plan for adopting measures to eliminate any identified regulatory distortions or market failures. In case of persistent resource adequacy issues, an MS may introduce a CRM as a last resort to eliminate any residual resource adequacy concerns [3].

Various types of CRMs exist, and they can be classified based on different aspects. The taxonomy of the main CRMs is depicted in Figure 1.

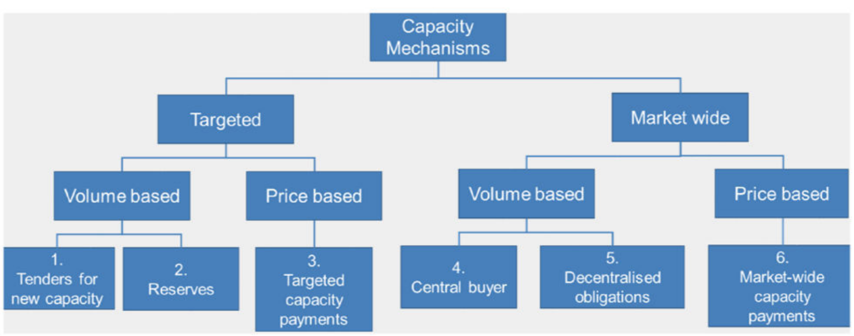

Figure 1: Taxonomy of CRMs [4]

As of 2022, 8 out of 27 MSs have active CRMs, as depicted in Figure 2. It is essential to mention that the European Commission (EC) does not impose a standard design for CRMs across the MSs but prefers the strategic reserve framework.

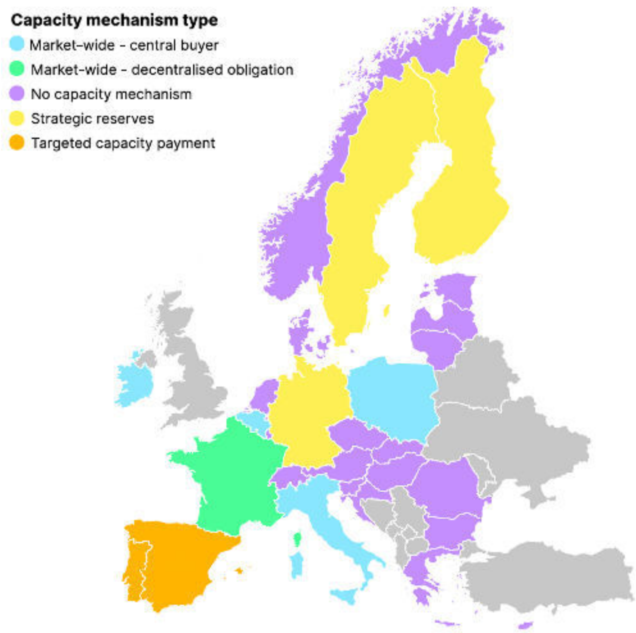

Figure 2: Status of CRMs in the EU – 2022 [5]

3. Resource adequacy assessment

Resource adequacy is the power system's ability to meet demand over medium- and long-term. According to the Clean Energy Package, resource adequacy assessment shall identify resource adequacy concerns by assessing the overall adequacy of the electricity system to supply current and projected electricity demand. In this context, CRMs may be introduced to eliminate residual resource adequacy concerns.

3.1. Adequacy metrics

Adequacy metrics of a power system can be classified as deterministic or probabilistic. Deterministic metrics, such as reserve and capacity margin, are simpler compared to the probabilistic ones, but they overlook random facility failures and the variability of renewable energy sources (RES), among other random effects. In contrast, probabilistic metrics involve simulating a probabilistic model based on random occurrences of facility failures or the availability of primary resources. Common probabilistic metrics include Loss of Load Probability (LOLP), Loss of Load Expectation (LOLE), and Expected Energy Not Served (EENS).

3.2. Reliability standards

Electricity markets operate on the premise that it is not feasible to design a power system with "absolute" resource adequacy without "infinite" investments. Therefore, in practice, electricity markets set a reliability target, also known as a reliability standard, to achieve the best compromise between cost-effectiveness and reliability. Hence, system failures are accepted when the resulting drawbacks for customers are at an acceptable level, or when there is no willingness to pay for increasing reliability.

Two main approaches are adopted to define reliability standards across different electricity markets. One approach involves establishing a reliability target without a technical or economic justification, such as the widely adopted “1-day-in-10-years” (LOLE = 0.1 days/year) in several US electricity markets. Conversely, another approach entails the application of a methodology to calculate the reliability standard, as followed by the EU with a methodology involving the Value of Lost Load (VOLL) and the Cost of New Entry (CONE).

3.3. European resource adequacy assessment methodology

The adoption of the Clean Energy Package and the ERAA framework directly impacts the design and implementation of CRMs. Building upon the Mid-Term Adequacy Forecast (MAF), ERAA demonstrates the interconnectedness of resource adequacy in each MS and the evolution of generation capacities across Europe, driven by Economic Viability Assessment (EVA), which is purely based on energy market economics without considering other revenue streams.

In October 2020, ACER published the methodology for ENTSO-E to implement ERAA [6]. The detailed workflow of ERAA is shown in Figure 3. The input data is based on the national forecasts provided by TSOs for each year within a ten-year timeframe from the evaluation date. The European energy system is intensively simulated with the application of various models. For adequacy and EVA analysis, the PLEXOS modeling software is being currently used.

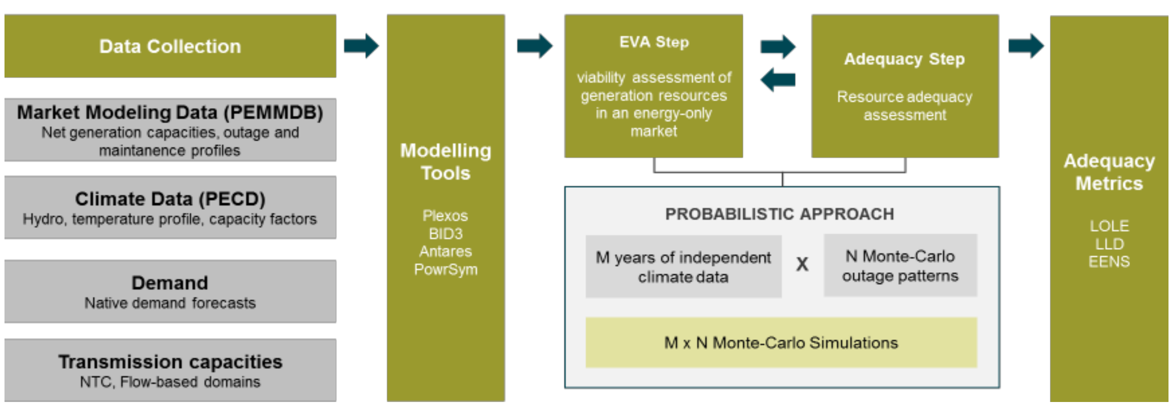

Figure 3: Framework of ERAA

The validity of the ERAA resource adequacy simulation results is conditional upon the evolution of the power system according to the EVA scenarios. Ideally, in the long-term, the ERAA methodology, as required by ACER, should result in a LOLE value that is equal to the marginal

CONE of the cheapest available investment candidate per unit VOLL. However, due to the complexities of the EVA model, some simplifications are applied, which are not part of the adequacy model. This leads to deviations from the long-term equilibrium. Consequently, the ERAA report has been rejected by ACER for the second time in a row and the EU-wide way for the introduction of a capacity market or further national CRMs is still unrealized [7].

In addition to the ERAA, the MSs may conduct National Resource Adequacy Assessments (NRAA), considering the contribution of available interconnection capacity. MSs should review existing capacity mechanisms and ensure no new contracts are concluded without the alignment between ERAA and NRAA. ACER will be involved in the process in case the two assessments yield different outcomes.

To ensure transmission and resource adequacy in the transition to a carbon-neutral European power system, the capacity requirements must be forecasted well in advance, taking different technical and economic parameters into account. An accurate assessment of resource adequacy and capacity requirements is strongly dependent on the availability of data on generation and transmission infrastructure, development of power demand, weather, and climate conditions. A comprehensive methodology, therefore, must consider the stochastic superposition of random variables like power imbalances, fluctuated generation from RES, unplanned generation outages, etc.

4. The interplay between CRMs and energy markets

The introduction of a CRM inherently engenders distortions in the energy market in the medium-to long-run, and even in the short-run, not only at the MS level but also at the pan-European level. These distortions are mainly because CRMs influence investment decisions, can impact prices in the short term by affecting production decisions and cross-border competition, exhibit redistribution effects, and can also result in additional distortions from incorrect design or implementation. Due to the potential conflicts with EU sustainable goals and the risk of distortions posed by CRMs, the Clean Energy Package mandates that these mechanisms be implemented temporarily and as a last resort to resolve adequacy concerns.

Hence, we argue that CRMs cannot be completely excluded from the energy market due to their second-order effect. Therefore, we contend that CRMs be carefully designed to minimize eventual distortions in the energy markets and the competition among the MSs' electricity markets. To mitigate such drawbacks, we suggest the EU promote alternative solutions, like implementing scarcity pricing based on operating reserve demand curves or a real-time market for reserve capacity [8].

5. Aligning CRMs with the future TSO and DSO's service needs

The EU energy crisis, which followed the COVID-19 lockdowns and Russia's invasion of Ukraine, raised questions about the electricity market design. As per an EC assessment, the existing design has offered efficiency and integration in the EU's energy market, promoting economic gains, security, and decarbonization, however, it reveals specific shortcomings, necessitating reforms to protect consumers from high energy costs, enhance resilience, and expedite the goals of the European Green Deal and REPowerEU Plan [9]. Earlier this year, the EC released the "REMIT Proposal" and "Market Reform Proposal" to reform among others the EU electricity market by amending key regulations and directives primarily "Electricity Regulation" [10]. These reforms aim to incorporate lessons from the recent energy crisis and enhance market resilience against price shocks.

The Commission is introducing additional measures to enhance the flexibility market, particularly the capacity mechanism for low-carbon flexibility providers. These measures involve setting CO_2 emission caps and allowing the creation of non-fossil-based flexibility support schemes. These schemes include offering additional capacity payments to demand-side response and storage providers, with the requirement of a competitive bidding process. These initiatives aim to meet the needs of market participants, especially TSOs and DSOs, amid rising intermittent generation and irregular consumption patterns.

ENTSO-E acknowledged the priorities outlined by the Commission but pointed out that certain crucial elements were absent, while others, added without a comprehensive impact assessment, could adversely affect market operation, system security, or consumer costs [11]. It proposed to account for the following when amending the legislation:

- The need for CRMs to secure investment in flexible generation must be recognized.
- Regulation should facilitate MSs' introduction or amendment of CRMs through faster, clearer, and fit-for-purpose approval processes.
- CRM design should be consistent with accelerating the decarbonization of the power system and avoiding lock-in effects of fossil fuel technologies beyond their necessary contribution to adequacy.
- National granularity and sensitivity analysis are needed to address location-specific scarcities for adequacy, transmission capacity, and ancillary services. Moreover, local context should also be considered in the design of CRMs, ensuring improved efficiency of investments.

6. Recommendations

Building on the insights gained from this analysis, we propose several recommendations to address the issues surrounding CRMs and ensure a more secure and sustainable energy future in the EU.

- **Locational factors must be considered in resource adequacy assessments and CRMs.** It is crucial to improve national granularity and sensitivity analysis in resource adequacy assessments to address specific locational scarcities for adequacy, transmission capacity, or ancillary services provision. Furthermore, the incorporation of locational considerations in CRM design can optimize new capacity investments and prevent grid congestion, ensuring that investments are strategically placed in the most suitable areas.

- **Sustainable CRM design:** CRMs must be designed with a focus on accelerating the decarbonization of power systems by ensuring that their design aligns with sustainability goals and avoids entrenching fossil fuel technologies beyond their necessary contribution to adequacy.

- **Promote Non-Fossil-Based Flexibility:** The EU should continue to promote schemes that support demand-side response and storage providers, with an emphasis on competitive bidding processes, and eliminate barriers to their participation in CRMs, as is currently proposed [10].

- **Mitigate Market Distortions:** The EU should focus on minimizing market distortions caused by CRMs. This may involve designing CRMs with the same objectives among the MSs, such as a certain level of resource flexibility and fair competition conditions. Taking a step forward might include implementing scarcity pricing based on operating reserve demand curves and establishing a real-time market for reserve capacity.

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