Redesigning Poland's Capacity Market and System Flexibility

Part 1

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List of abbreviations

ACER	the European Agency for the Cooperation of Energy Regulators
BESS	battery energy storage system
(C)EEAG	(Climate) Energy and Environmental Aid Guidelines
CM	capacity market
CONE	cost of new entry (in Pol. *CeWe*)
D(S)R	demand (side) response
(E)ENS	(expected) energy not served
ENTSO-E	European Network of Transmission System Operators for Electricity
EEAG	Energy and Environmental Aid Guidelines
EMDR	Electricity market design regulation
ERAA	European Resource Adequacy Assessment
EU	European Union
HMMCP	harmonized maximum and minimum clearing prices
KPI	key performance indicator
LOLE	loss-of-load expectation
MEC	maximum entry capacity
NECP	National Energy and Climate Plan
NRA	national regulatory authority
PSE	Polskie Sieci Elektroenergetyczne (Polish TSO)
RCC	regional coordination center
RES	renewable energy source
RS	reliability standard
SDAC	single day-ahead market coupling
SIDC	single intraday market coupling
SR	strategic reserve
TFEU	Treaty on the Functioning of the European Union
TSO	transmission system operator
TY	target year
VRES	variable renewable energy resource
VOLL	value of lost load

Executive summary

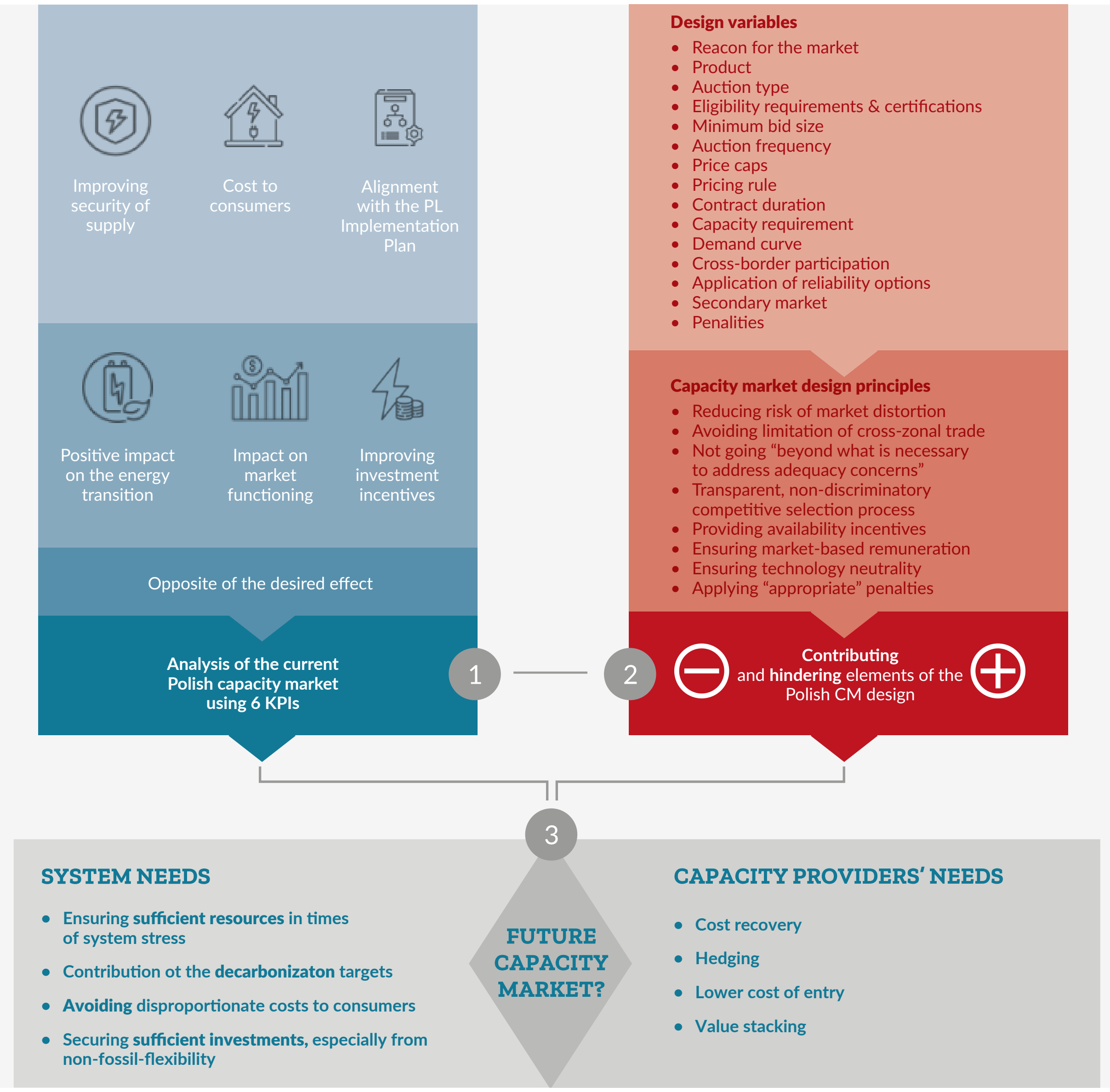
Polish capacity market at the crossroads

The latest European Resource Adequacy Assessment (ERAA) indicates that **Poland faces significant adequacy challenges in the next decade, especially as it seeks to decarbonize an energy system heavily reliant on coal.** As Poland is integrating more renewable sources (RES) like solar, the need for technologies that provide firm capacity, able to run in a stable manner over a longer period, as well as flexible capacity, able to ramp up quickly to offset RES volatility, is increasing.

The capacity market was approved by the European Commission for 10 years. This means that the last auction will take place in 2025, in which capacity will be contracted for 2030. **The question arises, what is next for the capacity market in Poland?**

This study evaluates the performance of Poland's capacity market, identifies design elements that may hinder or help achieve its goals, and considers whether the capacity market should continue operation and what improvements and/or complementary measures are necessary.

Approach in the study



In this study, the authors used 6 key performance indicators (KPIs) to evaluate the performance of 8 capacity auctions in terms of their contribution to, e.g., system security, decarbonization, boosting new investments or reducing costs for consumers (1). In a detailed design analysis of the Polish capacity market, we discussed which of its design elements contributed or hindered the compliance with the capacity market design principles set out in the Electricity Regulation (2). In the last step, we defined a target model for the future capacity market based on the system and participants' needs (3) and used the outcomes from the two previous steps to provide recommendations for adapting the capacity market design as well as additional measures that in combination could achieve the target model more efficiently.

Way forward for the Polish capacity market beyond 2025?

Poland's adequacy gap is growing as the current scheme did not support enough new investments. A complete removal of the capacity market may exacerbate already existing and growing adequacy gap, especially post-2028 once capacity contracts of coal generation expire. Therefore, this report suggests keeping the capacity market while adapting its design, setting the main focus of the reform on incentivizing and securing as much new investment as possible. We recommend combining this approach with the flexibilization of the demand side and generation.

This report reviewed the Polish capacity market (CM) design and its performance across eight auction rounds. It highlighted that while the CM was mostly aligned with energy system goals, new investments largely responded to the phasing out of coal due to emissions limits rather than proactive CM design improvements. Despite recent progress, coal remains the largest reserve provider, and CM costs have been rising, indicating a need for further improvements to meet adequacy and energy transition goals.

The report suggests that the CM's effectiveness in supporting low-carbon technologies is limited, as it mainly contracts for availability rather than actual energy activation. To improve the CM's contribution to decarbonization, the report recommends tightening the conditions for green bonuses and possibly excluding non-hydrogen-ready gas-fired generation. Additionally, it proposes reducing the minimum bid size and applying volume-based penalties for non-delivery to encourage participation from smaller providers and new market entrants, along with advanced aggregation rules to facilitate mixed-resource portfolios and a simplified certification process for portfolio adjustments.

Recommendations

Mixed-technology aggregation (incl. review of de-rating factors), sub-metering and simplified certification	**Reduced min. bid size and volume-based penalties**	**Rolling auctions** (e.g. Y-5, Y-3, Y-1)	**Complementary measures:** Tax rebates for new investments Review of the green bonus Review of cost allocation for DSR	**Separate procurement of firm and flexible capacity products**

In order to account for the evolving system needs but also for the needs of capacity providers, we recommend a number of market design adjustments as well as complementary measures. Future improvements to the CM include increasing auction frequency and introducing rolling auctions to balance long-term signals with system flexibility. The report cautions against splitting auctions by technology, advocating instead for a two-product approach that distinguishes between firm and flexible capacity that jointly contribute to the Polish system's resilience in times of scarcity while attracting a broad range of low-carbon technologies. The design of this proposal is addressed in detail in Part 2 of this report.

Finally, to protect consumers and ensure adequate returns, introducing reliability options and exploring tax rebates for carbon-free technologies are recommended. Overall, the CM should complement broader market adaptations, particularly in balancing, to support the diversification and decarbonization of Poland's energy system.

1. Introduction

1.1. Motivation

In 2016, the Polish TSO, PSE, announced its plans to introduce a capacity market in the country citing serious concerns about the availability of generation resources past 2020 as well as then accelerating mothballing trend of old units. The Polish capacity market has been approved by the European Commission for 10 years, in line with the EU regulatory provisions[1]. This means that in 2025 the last auction will take place, in which capacity will be contracted for 2030. **The question arises, what is next for the capacity market in Poland?**

The European Resource Adequacy Assessment evaluates resource availability across the EU Member States and the probability of supply not being able to cover demand. If an adequacy concern is identified, it serves as a legal basis for introducing additional measures, including capacity mechanisms, to ameliorate the situation. The most recent ERAA2024 shows that Poland is expected to be one the Member States with the highest adequacy concern in the upcoming 10 years. At the same time, the country has been making more efforts to decarbonize its energy system that still to a large extent relies on highly CO_2-emissive coal generation. This is also highlighted in the recently published national resource adequacy assessment prepared by PSE, Polish TSO (PSE, 2024). While more intermittent renewable generation, especially solar, is entering the generation mix, the old coal generation will continue to progressively exit the market. This creates an impetus to enable the entry of other technologies providing firm capacity, able to run in a stable manner over a longer period, but also flexible capacity able to ramp up quickly to offset RES volatility, is growing. The auction round of 2023 and 2024 has for the first time attracted significant volumes from a broader range of providers, such as demand response and storage, to the capacity market, yet it remains insufficient to cover the growing adequacy gap. In the future, the need for new capacity and new investment is going to further increase to secure a robust Polish energy system.

Against this backdrop, the study addresses the key questions about the Polish capacity market:

- How did the capacity market perform in the eight auction rounds of its existence based on selected criteria, such as the impact on security of supply, promoting new investments or costs of end users?
- What elements of the capacity market design contributed to or created barriers for the achievement of its main goals?
- Is a continued operation of the capacity market justified and, if yes, which changes, or complementary measures might be needed to improve its performance and achieve the objectives of the evolving Polish energy system?

To address these questions, this study uses 1) a KPI approach to evaluate the performance of the current market (Section 2.2); 2) contrasts the capacity market design with the design principles listed in the Electricity Market Design Regulation (see Annex I for details) and 3) uses a target-state-based approach to propose and evaluate multiple measures to adapt or complement the capacity market (Section 3). Finally, in Section 4, we provide recommendations.

It is important to understand how the system needs have evolved and will evolve to propose a way for capacity mechanisms (potentially in combination with other mechanisms) to contribute to their achievement in a cost-efficient manner.

Both the Polish and the European energy system is evolving in terms of its technological mix and, as a consequence, in terms of the system needs. The exponential growth of variable renewable generation, phaseout or mothballing of thermal generation, increasing electrification of heating and mobility sectors create new system challenges. The Polish but also overall European energy system requires reliable firm capacity, for instance to react to longer periods of low or high residual load. Next to it, it requires increasing volumes of flexibility to compensate their ramping needs in times of strong RES volatility. Especially after the adoption of the Electricity Market Design Regulation in June 2024, the interrelation between resource adequacy and flexibility has become stronger. **In the second part of the study, we put the topic of capacity mechanisms into a broader context and build a bridge between adequacy and flexibility.**

1 Approved under the *Decision "State aid No. SA.46100 (2017/N) – Poland – Planned Polish capacity mechanism*, the mechanism was intended to ensure long-term generation adequacy through market-wide, technologically neutral capacity auctions (European Commission, 2018).

1.2. Resource adequacy

A capacity market is essentially one of the tools that can be used to address a resource adequacy concern. Article 2(68) System Operation Guideline (SOGL) defines **adequacy as "ability of in-feeds into an area to meet the load in that area" (SOGL, 2017).** Often, adequacy further refers to a longer (planning) timeframe rather than to the operational timeframe.

In order to evaluate the presence and degree of an adequacy problem, ENTSO-E in cooperation with all of its members is required to produce a European Resource Adequacy Assessment (ERAA) on an annual basis (Art. 23 of Regulation (EU) 2019/943, henceforth "the Electricity Regulation"). ERAA considers the inputs from individual countries and does so not in isolation but rather considering the interconnected national grids and markets.

Article 23 further creates the legal foundation for national resource adequacy assessments (NRAAs). The results of a RAA form the foundation for – in case an adequacy problem is indeed identified – a formal application for the establishment (or a renewal) of a capacity mechanism in a Member State[2]. The RAA has just been published by Polish TSO.

The Electricity Regulation and, more recently, the Electricity Market Design Regulation (EMDR), prohibits EU Member States from implementing capacity mechanisms unless the European Resource Adequacy Assessment (ERAA) and National Resource Adequacy Assessment (NRAA) identify a resource adequacy concern. Article 21.4 specifies that capacity mechanisms cannot be introduced without these assessments confirming a concern. Similarly, Article 21.6 mandates that Member States must review existing capacity mechanisms and stop new contracts if no adequacy concern is identified by these assessments. Thus, capacity mechanisms must be justified based on the ERAA and/or NRAA findings.

Member States have the right to determine their own security of supply levels, so-called "reliability standard"[3]. However, those with capacity mechanisms should quantify this security using a reliability standard based on the VOLL/CONE/RS methodology, as specified in ACER Decision No 23/2020. Note that Poland has not yet set a reliability standard or a VOLL in line with the Methodology, the decision of the Ministry is pending (ACER, 2023).

Article 25 of the recast Electricity Regulation/EMDR mandates that Member States must have a reliability standard when applying capacity mechanisms. According to Article 25(3), this standard must be calculated using the value of lost load (VoLL) and the cost of new entry (CONE) over a specified timeframe. The reliability standard should be expressed as expected energy not served (EENS) and loss of load expectation (LOLE). Further studies are necessary if these indicators exceed the following thresholds: LOLE greater than 1 hour and EENS exceeding 0.001% of annual demand (ACER/CEER, 2019)[4].

2 For reference, the most relevant articles of the Electricity Regulation/EMDRcan be found here: https://energy.ec.europa.eu/topics/markets-and-consumers/electricity-market-design_en.

3 Recital 46 of the Electricity Regulation.

4 The cited metrics are meant to represent: VOLL – the price consumers are theoretically willing to pay to avoid an outage; CONE – the estimated annualized cost for a new generation resource to enter the market and achieve a competitive return; LOLE – an estimation of the frequency (in hours per year) in which the electricity demand might exceed supply, leading to potential supply shortages; EENS – the projected total amount of electricity demand (in MWh) that cannot be met by supply over a specific period. Further analysis is provided in Section 2.2.1.

1.3. Capacity mechanisms

1.3.1. Goals and types

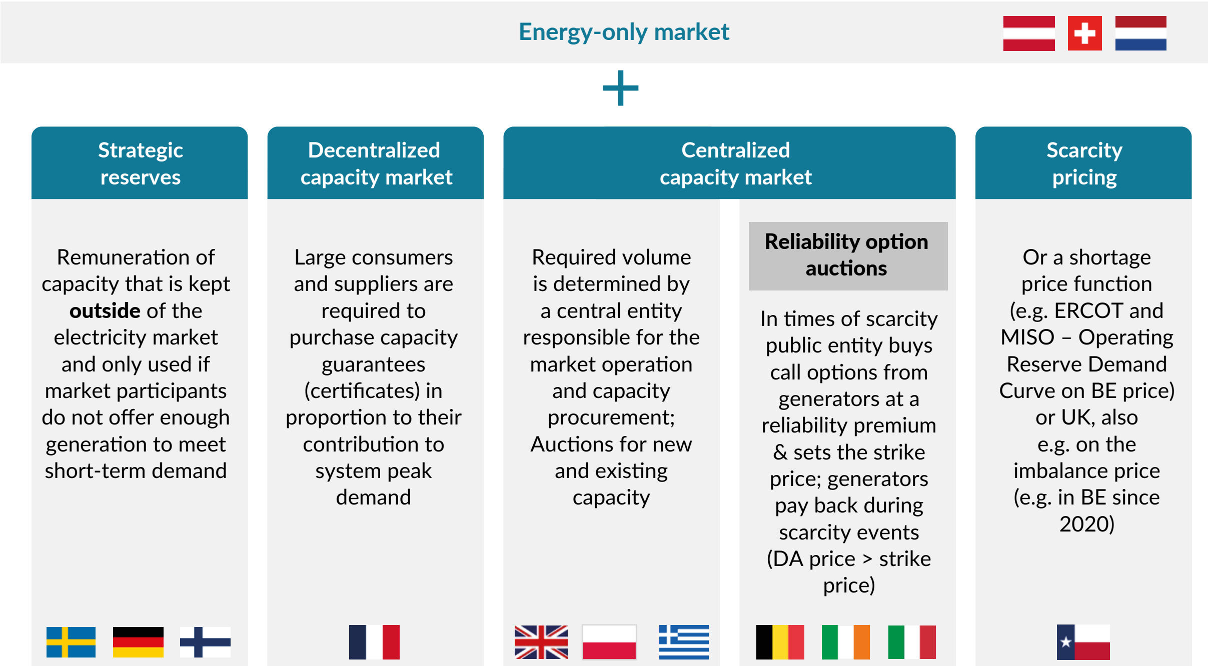
Article 2.22 of the Electricity Regulation defines a capacity mechanism as "*a measure to ensure the achievement of the necessary level of resource adequacy by remunerating resources for their availability, excluding measures relating to ancillary services or congestion management*". Essentially, capacity mechanisms (including capacity markets) are a means to **ensure security of supply** via generation capacity (or demand response) in the long term by providing financial incentives to power plants that would otherwise not be competitive from an economic perspective. Beyond that, capacity mechanisms are also becoming important means to **support the energy transition** by allowing sustainable technologies to secure the much-needed investment.

Since the 1990s, power systems have undergone significant restructuring with the liberalization of electricity markets, leading to competitive environments replacing monopolistic ones. Vertically integrated state-owned utilities were unbundled, allowing private generation companies to compete and consumers to choose their suppliers. This together with a drive towards more sustainable energy systems led to the rise of renewable energy, which was further supported through subsidy regimes. However, as the volumes of intermittent RES became significant, their weather-dependent variability increased concerns about security of supply. Another effect of RES integration from the market side is the merit-order effect, that is, large volumes of RES with near-zero marginal costs pushing out other (conventional) technologies out of the merit order and at times leading to very low or even negative prices. The main concern was that wholesale markets then may not adequately signal the need for new investments, leading to the "missing money" problem where market price caps and volatility hinder long-term viability and investment. To address these issues, some deregulated markets Europe (and elsewhere, e.g. in some US markets) introduced capacity mechanisms to ensure secure supply by remunerating providers for their readiness to produce energy (or reduce consumption) in times of scarcity through long-term contracts.

In terms of securing sufficient capacity, many of the countries in the EU opted for one or another capacity mechanism while others are in different stages of considering their introduction (e.g. most recently, Spain, Sweden, Germany and Denmark). Yet, **the debate about the necessity of capacity markets has been ongoing for over a decade and still not fully resolved. What is true is that, following the energy crisis of 2022-2023, the attitude towards capacity mechanisms has been shifting towards accepting them as an integral part of the overall EU market design** (more on this in Section 1.3.2).

It is a common misconception that a capacity market is a uniform approach, easily comparable across national borders. In fact, even in those countries that apply centralized CMs, these markets vary substantially in terms of their design and participation requirements. In general, CMs can be designed with various features, such as differentiating between technology types, determining eligibility and availability criteria, duration of contracting obligations, and remuneration methods. They also involve allocating costs and establishing rules for the operation as well as possibility for the contracted capacity to participate in energy markets. Both the choice of the mechanism and its design is rather different and largely grew out of countries' national legacies. Some examples, of the choices made in different EU countries are shown in Figure 1.

Figure 1. Types of capacity markets and examples of countries using each of them



8 The figure above also shows that the countries relying solely on energy-only markets are in the minority while most EU Member States that opted for a capacity mechanism went for centralized capacity markets – with or without reliability options (see Annex I for details of reliability options).

1.3.2. Regulatory underpinnings

On the EU level, capacity mechanisms are regulated through a number of documents:

- Regulation (EU) 2019/943 (henceforth "the Electricity Regulation") of 2019 superseded by,
- Electricity Market Design Regulation of 2024,
- Climate, Energy and Environmental Aid Guidelines (CEEAG) of 2022 concerning provisions related to state aid.

Two elements of the definition of capacity mechanisms in the Electricity Regulation (see Section 1.3.1) that deserve special attention are:

1) a necessary level of resource adequacy must be achieved. This level is quantified with the help of adequacy indicators briefly discussed in Section 1.2 and which are determined nationally,

2) in terms of goals, the EMDR excludes ancillary services (e.g. balancing or congestion management) from the use cases addressed by capacity mechanisms.

EU Member States using capacity mechanisms as of July 4, 2019, needed to adjust them to comply with the recast Electricity Regulation, while honoring commitments made before December 31, 2019 (Forum Energii, 2019). This obligation included Poland's capacity market, as will be discussed in Section 2.

In June 2024, the Electricity Market Design Regulation (EMDR) and Directive (EMDD) were formally adopted. This marked a turning point in the treatment of capacity mechanisms in Europe – turning them from an exception to more of structural element to ensure resource adequacy and a path towards carbon neutrality.

According to Recital 49, *"while capacity mechanisms should no longer be considered to be measures of last resort, their necessity and design should be periodically assessed in light of the evolving regulatory framework and market circumstances"* (EMDR). A provision about **the temporary status of capacity mechanisms was removed as a result.**

In addition to clarifying the goal for capacity mechanisms and their place in the European market design, the **EMDR also sets the way forward to a simplified process for their approval.** To streamline and simplify this process, the European Commission is expected to submit a detailed report assessing potential process improvements within six months of the Regulation's entry into force. The Commission should also request ACER to amend the European resource adequacy assessment methodology and, after consulting Member States, propose further simplifications within nine months[5] (Rec. 49 and Art. 69.3, EMDR).

At the same time, it limits their approval to a period of 10 years (Art. 21.8, EMDR) while requiring a reduction of committed capacities based on an implementation plan. What this essentially means is that, **instead of the previous requirement to phase capacity mechanisms out, the EMDR provides for their continued operation, yet requiring a regular review.**

At the same time, for the first time in the history of the EU electricity market regulation, these main documents address the need for system flexibility and providing means to support flexibility-providing resources. This latter point will be addressed in detail in the second report.

General principles

The overarching principles concerning capacity markets (CMs) and strategic reserves (SRs) are addressed in Art. 21 of the EMDR. According to the Electricity Regulation and the EMDR, strategic reserves should be the first mechanism considered by Member States, who must assess their effectiveness before adopting other types of mechanisms.

Art. 22 of the EMDR focuses on the main design features for capacity mechanisms. It emphasizes that they must be proportional and not distort the market or limit cross-zonal trade. As highlighted above, **the application of capacity mechanisms is no longer required to be temporary.** The procurement of capacity must be transparent, competitive, and non-discriminatory, with proper penalties for unavailability (Art. 22.1). Strategic reserves must minimize market distortions and maintain price signals (Art. 22.2), while other mechanisms should avoid overcompensation, support efficient operations, and comply with EU environmental targets by setting emission limits (Art. 22.3-4). Finally, the EMDR requires existing mechanisms to be adapted to meet these requirements (Art. 22.5).

The EMDR highlights the overarching principle of technology neutrality of capacity mechanisms. The EMDR provides for Member States' implementation of support schemes for non-fossil flexibility by providing payments for available capacity. Additionally, those with existing capacity mechanisms should redesign criteria to encourage participation from non-fossil flexibility resources like demand response and energy storage. Interestingly, Recital 55 further justifies the participation of gas turbines (but not coal generation) in capacity mechanisms – provided they observe the stipulated CO_2 limits as per Art. 22.4

Carbon intensity

The Polish technological mix and a long history of coal mining means that the country has been long reliant on coal-based generation and its participation in the national CM. Therefore, the question of how carbon intensity with regard to CMs is regulated on the EU level is highly relevant.

Concerning emissions of technologies participating in capacity mechanisms, CO_2 emission limit requirements for capacity mechanisms are primarily specified in Art. 22.4 of the Electricity Regulation and the EMDR. Notably, these requirements must be applied even to mechanisms that were already operational and compliant with EU state aid rules.

5 Based on the version of the EMDR available at the time of writing (June 2024).

The above article specifies CO_2 emission limits for capacity mechanisms as follows:

a) generation capacity that began commercial production after July 4, 2019, and emits more than 550 g CO_2/kWh of electricity from fossil fuels cannot be committed or receive payments under a capacity mechanism,

b) generation capacity that began commercial production before July 4, 2019, emitting more than 550 g CO_2/kWh and over 350 kg CO_2/year per installed kW_e, must not receive payments under a capacity mechanism after July 1, 2025.

In the EMDR, however, the Council introduced a possibility of a derogation from Art. 22.4(b) in Art. 64.2(b) allowing generators to receive support from capacity mechanisms despite their exceeding CO_2 emission limits after July 1, 2025, provided the capacity mechanism was approved by the European Commission before July 4, 2019. Recital 56 clarifies that such a derogation should only be applied for "on an exceptional basis, and as a mechanism of last resort" (EMDR).

When requesting a derogation, a Member State must provide a report assessing the impact on greenhouse gas emissions and the energy transition, along with a plan for transitioning away from non-compliant generation capacity in capacity mechanisms. **If granted, non-compliant generation capacity can only be procured for up to one year within the derogation period.** Additionally, an initial procurement process must aim to maximize participation of capacity that meets CO_2 limits, **even allowing capacity prices to rise to incentivize such investments (Rec. 56, EMDR). That is, energy transition takes priority over the socialized costs of securing resource adequacy.**

Article 64.2(d) further clarifies that a request for derogation must include a report from the Member State detailing:

a) the impact on greenhouse gas emissions and the transition towards renewable energy, flexibility, energy storage, electromobility, and demand response; and

b) a plan with milestones to phase out non-compliant generation capacity from capacity mechanisms by the end of the derogation period. This plan should include strategies to procure necessary replacement capacity, align with national renewable energy targets, and assess investment barriers that caused insufficient competitive bids.

Poland is currently actively pursuing such a derogation for its capacity market.

State-aid-related provisions

The European Commission has the authority to approve capacity mechanisms in EU Member States as a means to avoid the distortion the internal energy market, according to Art.3 (9) of the European Commission Guidelines on State aid for environmental protection and energy 2014-2020 (extended to 2021, EEAG).

The CEEAG[6] updated the EEAG in 2022. Capacity mechanisms, aimed at ensuring generation adequacy and security of electricity supply, fall under Section 4.8 of the CEEAG on State aid for generation adequacy. The CEEAG incorporates design principles from the Electricity Regulation, emphasizing that security of supply measures, such as interruptibility schemes and network reserves, must support market efficiency and preserve operating incentives and price signals (para. 369 CEEAG). It further includes criteria used by the European Commission to determine whether the proposed mechanism is compatible with the internal market, namely:

- contributing to an objective of common interest,
- justified necessity of state intervention,
- appropriateness,
- incentive effect,
- proportionality,
- avoiding undue negative impacts on competition and trade,
- transparency (CEEAG, 2022).

6 "C" stands for "climate".

Note that the Commission is legally bound by the text of the guidelines.

In terms of decarbonization provisions, the CEEAG requires capacity mechanisms to account for the following:

- EU environmental protection objectives.
- Include safeguards to ensure consistency with EU climate targets (e.g. hydrogen readiness for gas-fired generation etc.).
- Clean technologies may receive additional support in the form of "green bonuses", longer contracts, or additional premiums.
- Authorities are to always conduct broad public consultations of the proposed scheme if fossil-fuel-based generation may benefit from the proposed mechanism.
- Capacity mechanisms are still treated as a measure of last resort in the CEEAG.

Finally, under the CEEAG, Member States may have several capacity mechanisms, which would, for instance, allow creation of a strategic reserve for the still-needed coal generation next to a capacity market (see also Section 3 for analysis) – while observing the threshold of 350 kg CO_2/kW/year, as required by the EMDR from July 2025.

Cross-border participation

According to Article 26, Electricity Regulation/EMDR, **capacity mechanisms, including SRs must allow cross-border participation of capacity providers from other EU Member States.**

On December 22, 2020, ACER adopted Decision No 36/2020, detailing technical specifications for this participation (Annex I). The Annex outlines the following:

- common rules for identifying eligible foreign capacity for cross-border participation (Arts. 26–28),
- terms for the registry managed by ENTSO-E to document such capacity providers (Arts. 21–25).

ACER's report on EU supply security of October 2023 notes that cross-border participation is currently limited but progressing. Poland as well as Belgium, France, Ireland and Italy, already have provisions for such participation, though their implementation varies. Poland started contracting foreign capacity in the auction of December 2021.

In contrast to capacity markets, strategic reserves must include cross-border participation *only if technically feasible* (Art. 26.1 EMDR). Currently, according to our knowledge, no strategic reserve schemes allow for this.

The Electricity Regulation introduced the concept of "maximum entry capacity" (MEC) to facilitate foreign participation in capacity mechanisms (Art. 26), reflecting the expected contribution of foreign resources to supply security during system stress[7]. The Electricity Regulation mandates that MEC allocation in capacity mechanisms should be market-based, allowing for potential revenue generation (Art. 26.9). These revenues reflect the value for foreign resources to have a right to participate in a foreign capacity mechanism. In Poland's case, these revenues are calculated and are based on the clearing prices from the capacity auctions for both Polish and foreign bidding zones using a 50-50 split between PSE and the neighboring TSO.

Article 26(7) assigns the task of calculating the maximum entry capacity for foreign providers and recommending it to TSOs to regional coordination centers (RCCs). This calculation must align with the European Resource Adequacy Assessment (ERAA) methodology, with ENTSO-E providing necessary data.

The methodology for MEC estimation is detailed in the Technical Specifications for cross-border participation, requiring RCCs to calculate MECs using the ERAA or a similar regional study. **The Regulation expects RCCs to calculate MECs, with national TSOs taking RCC recommendations into account, if deemed appropriate by the NRAs.**

Currently, without an approved ERAA, most capacity mechanisms rely on national assessments with varied approaches. Looking at Poland, the country relies on the ERAA results and applies the method described in Article 8 of the Technical Specifications, i.e. based on cross-zonal exchanges (ACER, 2020).

7 MEC is assessed for each bidding zone border based on the likelihood of *simultaneous* scarcity and available interconnection capacity.

1.3.3. Zoom on strategic reserves

The strategic reserve (SR) is designed to operate only when the market fails to provide enough capacity, and it should be dispatched at a price above a scarcity reference level. Ideally, the reserve should only be dispatched at a price close to the value of lost load (VoLL) to avoid market interference, ensuring natural price formation and maintaining investment incentives for generators (ACER, 2013).

Capacity for the strategic reserve is secured through a tendering process for a specified capacity amount (in MW), typically on an annual basis. The required capacity amount and type are usually determined by a reliability study. Compensation for strategic reserve providers is to be outlined in the tender documents and can vary nationally. At the same time, the costs of SRs are generally covered through system charges, which are passed on to electricity consumers.

Out of all capacity mechanisms applied in the EU, SRs are seen as the least market-invasive measure. This is motivated by the fact that SRs are not allowed to participate in the energy-only market. They are predominantly meant to avoid mothballing or a premature phaseout of generation which is no longer considered economically viable yet could support resource adequacy as one of the measures of last resort in emergency situations. This also means that *new* investments are ideally still driven by the energy-only market.

This understanding underlies the fact that SRs are seen more as a measure to bridge the time gap between a market improvement and an investment decision or between the latter and the capacity actually coming online.

Art. 22.2 EMDR specifies SR's last-resort character in that these shall be activated only if balancing reserves were fully exhausted in a scarcity situation, which also means that the imbalance in that period is settled at VoLL. Thus, SR is either withheld from the market or bid at very high prices (VoLL) and, when dispatched during *extreme* scarcity.

Thus, strategic reserves, at least in theory, do not affect the market under normal conditions and can support transitions away from fossil fuels or facilitate nuclear phase-outs. They have worked well with energy-only markets, e.g. in the Nordics, causing minimal distortion (European Commission 2016). Proper implementation is crucial to avoid keeping prices artificially low, which could lead to high emissions from old plants and hinder new technology development. ACER's analysis also notes that strategic reserves ensure security of supply in *exceptional* circumstances, indicated by price spikes in the day-ahead, intra-day, or balancing markets.

In terms of possible market distortions, there are several negative effects that the presence of SRs can potentially entail. According to ACER, the main issues concerning SRs are the price at which SR is offered into the market, the rules of its activation and, finally, its impact on market prices.

The implementation of strategic reserves can have unintended consequences. By curbing price surges, they may discourage investment in new capacity, worsening the initial shortage. This effect, known as **"crowding-out,"** is similar to what occurs with tenders for new capacity and targeted capacity mechanisms. To mitigate this, it is suggested that reserves are only used when the market fails and prices are capped appropriately high. Additionally, strategic reserves could distort cross-border markets, prompting the EU Commission to work on a regional resource-sharing framework (European Commission, 2016).

Moreover, strategic reserves might prompt plants to close prematurely to join the reserve, speeding up market exit. For instance, Belgium's experience illustrates this "slippery slope" effect, where generators announced closure to enter the reserve, shrinking the competitive market. There's also concern that incumbents in the reserve could manipulate the market withholding other capacity to trigger scarcity, profiting from reserve activation. Lastly, if few candidates compete for reserve inclusion, tendering might lack competitiveness, reducing the reserve's effectiveness in addressing generation adequacy (European Commission, 2016).

In sum, SRs do provide an extra "safety net" for resource adequacy yet can also have a negative impact on the overall market functioning. If the underlying issue of (insufficient) available capacity in not treated since SR *per se* do not create incentives for new investments. It is thus necessary to ensure that their application is transitional, and the participating generation is out-of-market, as per the EMDR.

The assessment of the potential pitfalls of SRs and their combination with a capacity market will be provided in Section 3.

2. Capacity market in Poland

2.1. Evolution

Poland demonstrated market failure via a detailed probabilistic assessment based on the 2017 mid-term adequacy forecast. Based on the identified adequacy concern, Poland submitted an application for the introduction of a capacity market to the European Commission in 2017. As a result, a centralized capacity market was kicked off in 2018 with first three capacity auctions held in the country for the delivery years from 2021 to 2023. Back at its start, the CM was predominantly used as a tool to support otherwise unprofitable coal-fired generation (Forum Energii, 2019b).

When it comes to technological evolution, in the five delivery years (2021-2025) the by far largest share of capacity was awarded to coal-fired generation. However, following the introduction of stringent emissions limits for generation participating in capacity markets in 2019, the volume of coal-based capacity fell precipitously from being the technology with the largest share of the auctioned capacity to only covering a small fraction in 2025 and no longer participating from 2026 onwards (auction of 2021).

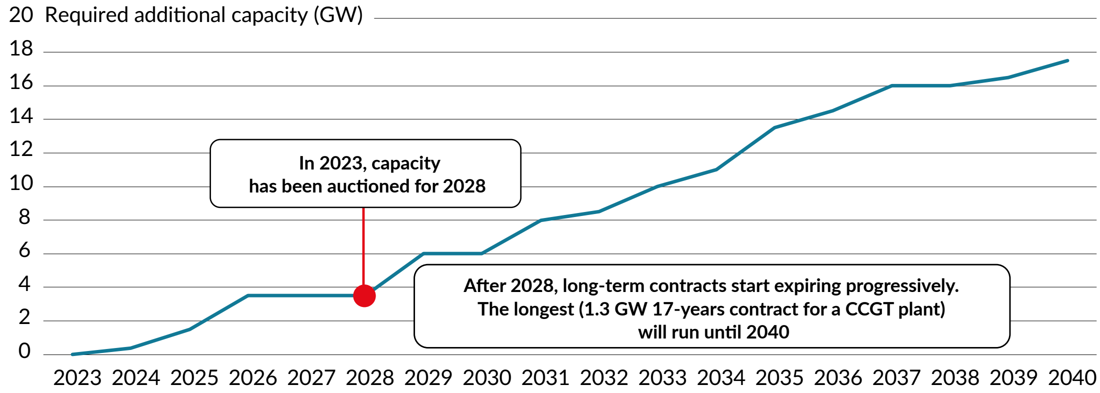
In terms of price evolution, capacity market prices experienced significant fluctuations over the 8 auctions of its existence, which was to a large extent driven by the changing mix of participating technologies. In terms of cost evolution, a broad overview of the auction results conducted by Forum Energii shows that Polish CM was rather expensive and its cumulative costs are on the rise. The capacity fee was designed in such a way that it shielded households. Whereas it has had the biggest impact on medium-sized enterprises. In the meantime, every year, the cost of the capacity market amounts to 5-6 billion Polish zloty. At the same time, it did not result in much new investment, increasing significantly flexibility or in allowing Poland to limit CO_2 emissions (see Section 2.2 for details).

The last capacity auction under current framework is planned for 2025, for delivery in 2030. After this, the missing capacity is estimated to range between 8 and 18 GW, according to adequacy forecasts of 2022 by PSE (2022b). Action 111 of the Polish 2024 draft NECP aims at a continuation of the capacity market after 2025 to ensure continuity of supply (Ministerstwo Klimatu i Środowiska, 2024). **It is, however, important to understand how the system needs have evolved and will evolve to propose a way for capacity mechanisms (potentially in combination with other mechanisms) to contribute to their achievement in a cost-efficient manner.**

One key issue is how to cope with the phase out of coal-fired (and, in the future, gas-fired) power plants while ensuring security of supply and incentivizing diversification of low- and zero-carbon energy resources. Coal power plants cannot participate in capacity auctions with delivery after 2025, as they far exceed the EU emission limit of 550 g CO_2/kWh. This reduction of participants in the auctions poses the **risk of insufficient supply and high cost** (Figure 2). To address this challenge, Poland is currently working on securing a derogation from this limit, pursuant to the updated provisions of the updated Electricity Regulation of 2024 (see more details in Section 1.3.2). If approved, it can be applied at most until 2028.

Certainly, the primary goal of the CM is adequacy rather than driving the country's CO_2 emissions down. But it is obvious that a CM, depending on its design can even contribute to the stagnation of the energy mix or speed up the transition. Thus, it can either serve the future energy system or quite the opposite. Following the analysis of the current CM design in Poland in the remainder of this Section, we address measures that would help align the CM design with a long-term vision for the Polish system in Section 3.

Figure 2. Additional capacity required in the Polish powers system between 2023 and 2040



Source of data: PSE and Forum Energii, 2023.

2.2. KPI-based analysis

In order to comprehensively assess the functioning of the current Capacity Market (CM), in this section we conduct a qualitative analysis based on several critical evaluation criteria. These criteria encompass a broad spectrum of factors that influence the efficacy and impact of the CM on the Polish electricity sector.

1. **Improving Security of Electricity Supply** – the primary objective of the CM is to ensure the security of electricity supply in Poland. This report evaluates the effectiveness of the CM in achieving this goal, particularly by examining the generation adequacy assessments beyond 2030. Ensuring a reliable and sufficient electricity supply is vital for the stability and resilience of the Polish energy system.
2. **Investment Impetus for New Projects and Modernization** – the CM is designed to, among others, stimulate investments in new generation projects and the modernization of existing facilities. This section delves into the types and structures of these investments, analyzing their contributions to the overall capacity. The goal is to understand how the CM influences the technological and environmental landscape of energy production in Poland.
3. **Impact on the Energy Transition** – as Poland is navigating towards a more sustainable and low-emission future, the role of the CM becomes increasingly critical in contributing to the Polish energy transition. This report assesses how the CM supports or hinders this transition, considering factors such as the integration of renewable energy sources and the phase-out of high-emission power plants.
4. **Impact on the Functioning of the Electricity Market** – the CM's influence extends to the broader electricity market in Poland. This section explores the CM's effects on wholesale market dynamics, including price levels, market competitiveness, and the participation of different market players.
5. **Evaluation of the Implementation of the Polish Implementation Plan**[8] – the success of the CM is also measured by its alignment with the Polish Implementation Plan. This evaluation focuses on how effectively the CM has been integrated into the national energy strategy, identifying any deviations, challenges, or successes encountered during the implementation process.
6. **Costs to End Users** – lastly, the report examines the financial implications of the CM for end users. This includes an analysis of the costs imposed by the CM on electricity consumers and how these costs have evolved over time. The objective is to assess the economic burden of the CM on the general population.

This section aims to provide a nuanced understanding of the impact of the current capacity market in Poland on the energy system security, energy transition and costs, highlighting its strengths, weaknesses, and areas for improvement.

8 A national implementation plan is a document submitted by a Member State to the European Commission, which describes the proposed measures to tackle an identified adequacy concern.

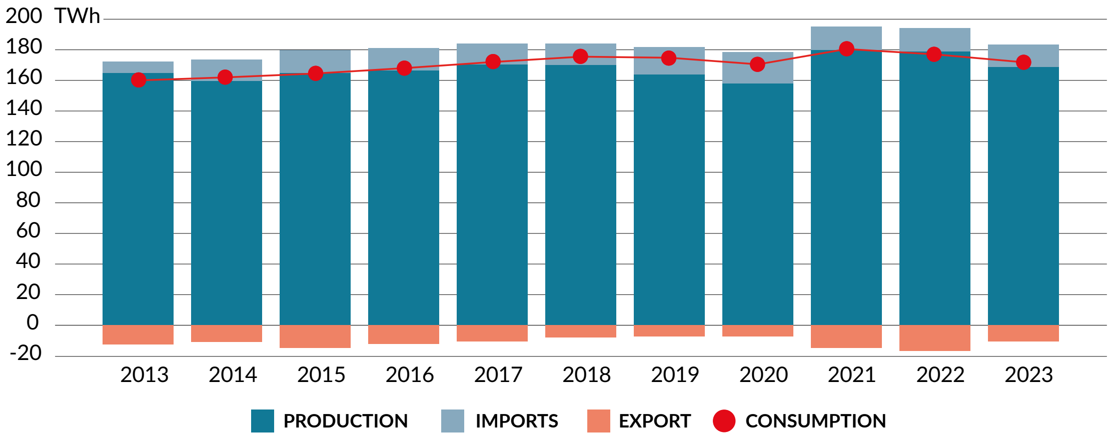
2.2.1. Improving the security of electricity supply in Poland

In the coming years, Poland's electricity sector will undergo substantial changes as a result of its planned transition to a low-emission system. In line with broader European goals, the decarbonization of its electricity supply combined with increased electrification mandates and replacement of conventional generation poses a significant risk to the continuous security of Poland's energy supply.

Current adequacy gap

For the time being, Poland's national electricity production exceeds the final consumption to a large extent thanks to historically large shares of generation from hard coal and lignite. Looking at the overall annual import-export volumes, Figure 3 shows that the country has been largely self-sustaining (with the exception of 2019 and 2020) – although certainly there can also be deviations in individual days.

Figure 3. Evolution of total production and consumption in Poland between 2013 and 2023



Source of data: Forum Energii, 2023; Ember, 2023; ENTSO-E Transparency Platform, 2024.

Future adequacy gap

The 2023 ERAA report defines two modelling scenarios:

- Scenario A (central reference) – this scenario aims to expose investors to a similar number of price spikes in both ERAA modules.
- Scenario B (sensitivity) – this scenario exposes investors to fewer price spikes in the Economic Viability Assessment than in the Economic Dispatch Module.

The central reference scenario forms the basis for identifying resource adequacy concerns. The sensitivity scenario complements this by illustrating how the adequacy assessment varies with different climate year weightings.

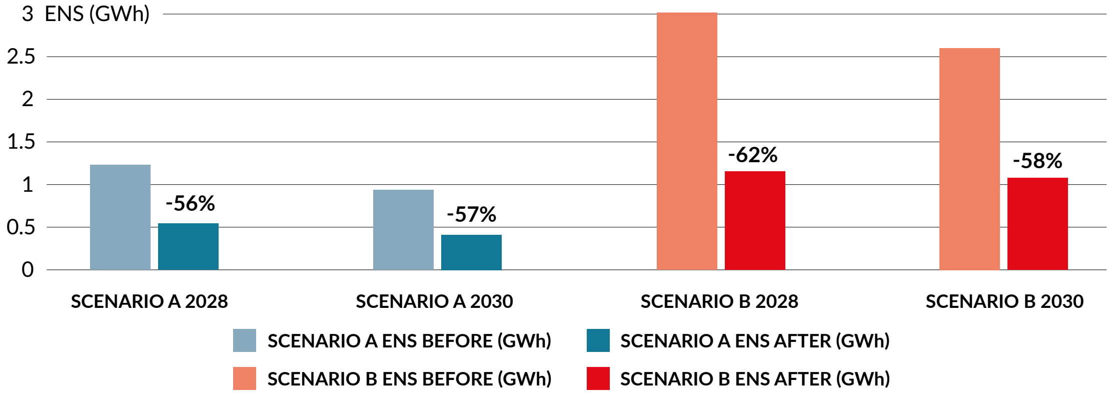
When evaluating the current and future adequacy gap in Poland, the European Resources Adequacy Assessment (ERAA) serves as the primary source[9]. The data provided for the latest approved ERAA, that of 2023, includes information on already concluded contracts in the Polish CM. This encompasses the results of all CM auctions held up to the moment of data collection, covering delivery periods up to 2027. It does not include results or estimations for subsequent years.

9 Note that the Polish national resource adequacy assessment (NRAA) was not performed in line with the ERAA methodology, according to ACER (ACER, 2023).

ERAA results provide outcomes concerning the main reliability indicators, loss of load expectation (LOLE) and Energy Not Served (ENS)[10].

The assessment includes a comparison of the ENS & LOLE for target years 2028 and 2030, before and after the implementation of the Capacity Market and DSR, which are illustrated in Figure 4 (for ENS) and Figure 5 (for LOLE).

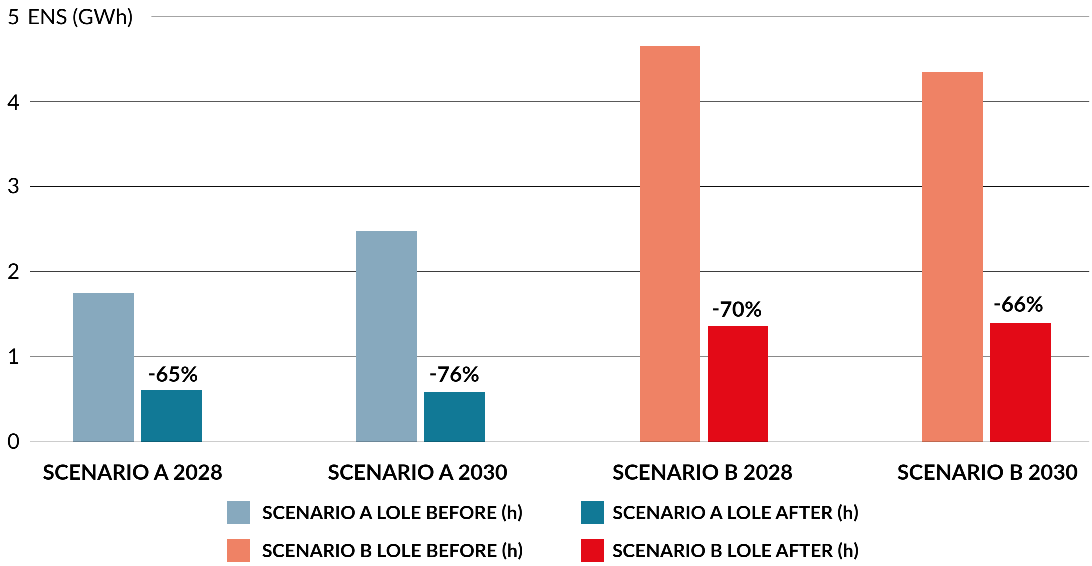
Figure 4. ENS values for Poland for target years 2028 and 2030 according to ERAA 2023, Scenarios A (left) and B (right)



Source of data: ENTSO-E (2024b).

The data indicates that the implementation of the Capacity Market and Demand Side Response has a significant positive impact on both the ENS and the LOLE for the target years 2028 and 2030 in both scenarios (A and B). However, the overall LOLE value is nonetheless projected to increase substantially, from 0 in 2025 to 8.5 hours in 2033 in Scenario A, and 0.3 – 12.3, respectively, in Scenario B (4000% increase, Figure 7).

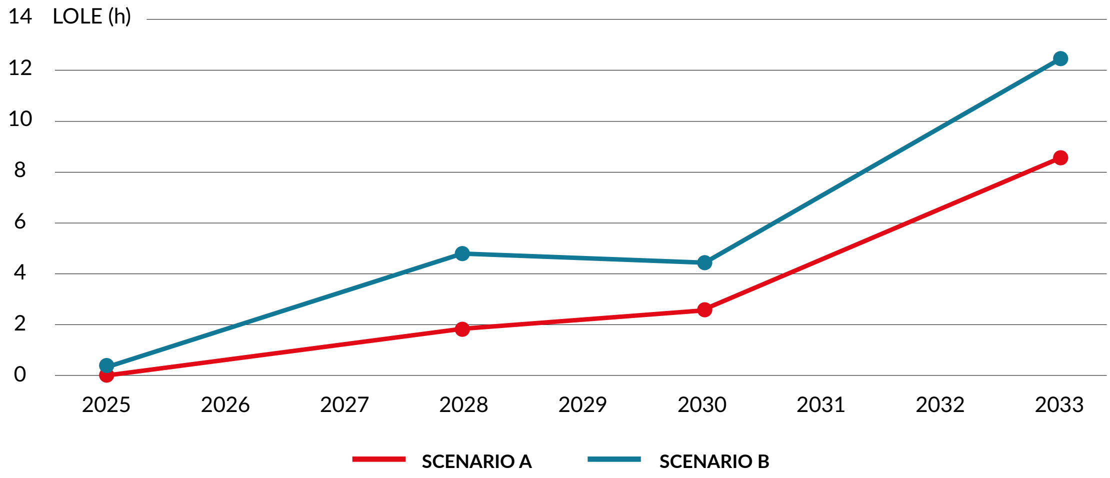
Figure 5. LOLE values for Poland for target years 2028 and 2030 according to ERAA 2023, Scenarios A (left) and B (right)



Source of data: ENTSO-E (2024b).

10 ENS refers to the total amount of energy (in MWh) that is not supplied to consumers when the power system is unable to meet the demand. This metric quantifies the volume of electricity that consumers would have received if the system had been able to deliver it without interruptions and quantifies the severity of supply interruptions. In turn, LOLE is the crucial indicator of the likelihood of supply-demand imbalances. It is a statistical measure that represents the expected number of hours in a given year during which the electricity supply will be insufficient to meet the demand (Electricity Regulation, 2019).

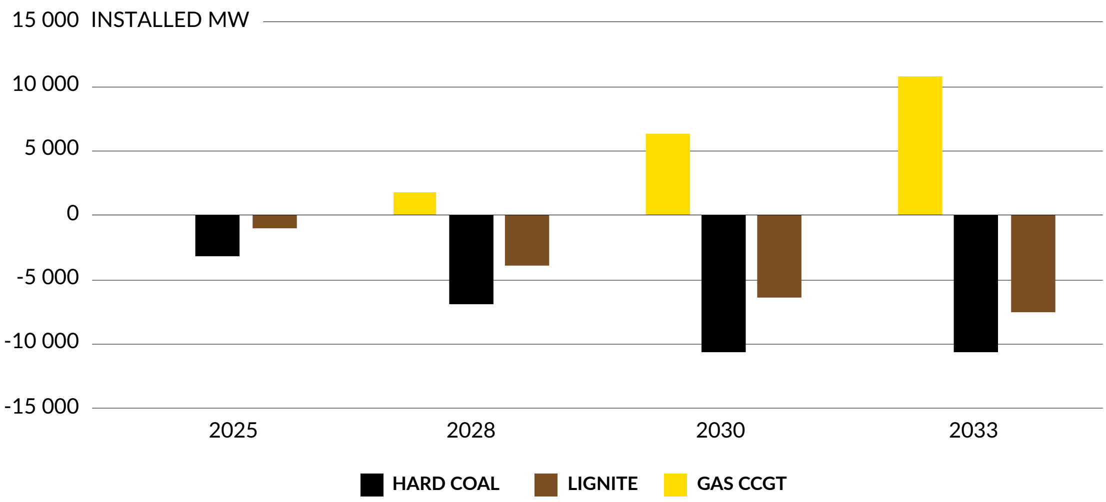
Figure 6. Projected loss of load expectation in Poland from 2025 to 2033



Source of data: ERAA, 2023.

Based on the forecasted changed in thermal generation from the ERAA report, hard coal and lignite are expected to witness a fairly linear decrease until 2033, while installed gas capacity is expected to increase by 10.8 GW, compensating for this shortfall (Figure 7).

Figure 7. Forecasted change in thermal generation between 2025 and 2033 in Poland



Source of data: ERAA, 2023.

The assessment found that **Poland is one of the countries with the largest amount of capacity at risk in Europe based on the LOLE and EENS values, according to the ERAA 2023.** The report indicates that a significant amount of fossil-fueled capacity may become economically non-viable in the next five years, necessitating the right incentives or interventions to avoid likely adequacy risks.

As Poland's energy system is integrated in a broader EU context from the grid and market perspectives, it is important to keep in mind that adequacy issues in one country are closely tied to neighboring countries, emphasizing regional interdependencies and the need for regional coordination. Between 2030 and 2033, the assumed thermal generation fleet faces significant risks, with potential new investments mainly in natural gas power plants (based on ERAA modelling results).

Looking at Poland's direct neighbors, in countries like Germany, the Czech Republic, and Slovakia, significant capacities risk decommissioning by 2025 and 2028 whereas no substantial new investments are expected. According to ERAA 2023, Central and Northern Europe, along with island states, face mid-term adequacy risks, exacerbated by expected extreme climatic conditions. Overall, besides Poland, major adequacy risks are noted in Italy, Greece, Bulgaria, Spain, Czech Republic, Bosnia and Herzegovina, Serbia, and Ireland. These are not only likely to increase the costs of capacity but, in the worst case, provoke chain reactions endangering regional security of supply.

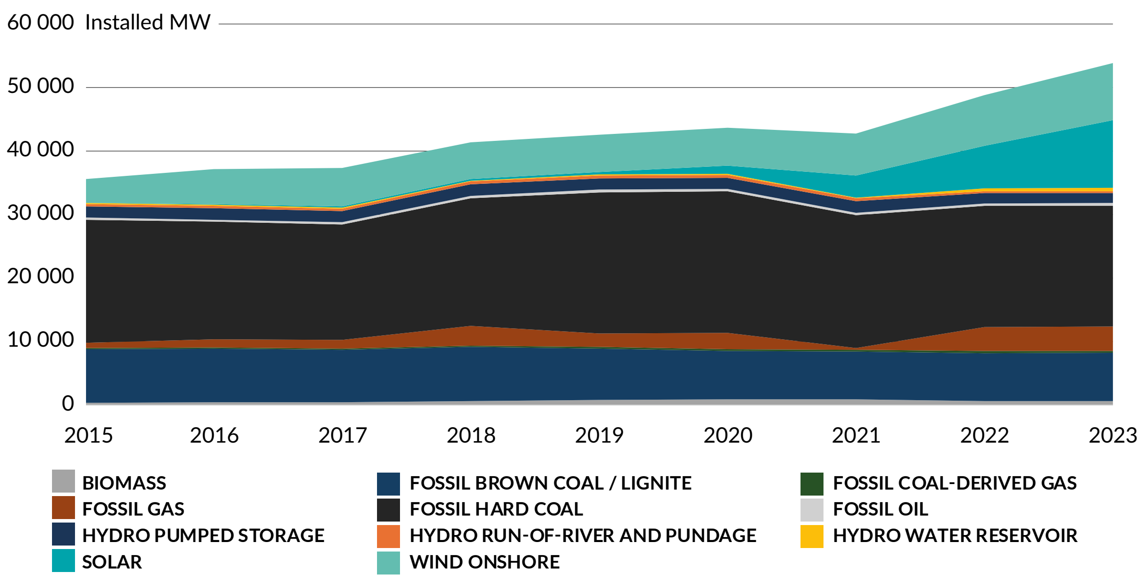
The findings highlight **substantial future challenges for Poland's energy system adequacy, revealing that current measures up to 2027 are inadequate for mitigating upcoming risks, especially in light of projected capacity gaps for 2028 and 2033.** Both scenarios evaluated show that, while the implementation of CM DSR significantly reduces both the ENS and LOLE, the improvements are insufficient to counterbalance the significant risks posed by decommissioning fossil-fueled capacities. This is particularly critical as Poland faces a decline in coal and lignite capacities without sufficient replacements, leading to a projected negative gap between installed capacities and peak residual demand that grows from -3 GW in 2027 to -13 GW in 2035 (Forum Energii, 2023). The latest results of the 7th and 8th capacity auction in Poland further show that the investment in gas-fired generation, which is the likeliest candidate to close the coal gap, has been lower than hoped for, which was particularly driven by geopolitical uncertainties and lack of gas-fired generation in the 8th auction. Figure 7 demonstrates a sharply increasing LOLE trend in both scenarios, with Scenario B indicating a higher risk of power outages. **These observations emphasize the urgent need for strategic investments in new capacities, especially in flexible and responsive technologies.**

2.2.2. Investment impetus for new projects and modernization

Following from the previous section, we aim to examine the driving forces behind investments in new projects and modernization of installed capacity in Poland. In particular, we first look at the rate of change of Poland's energy mix and then at the capacity market results for different technologies.

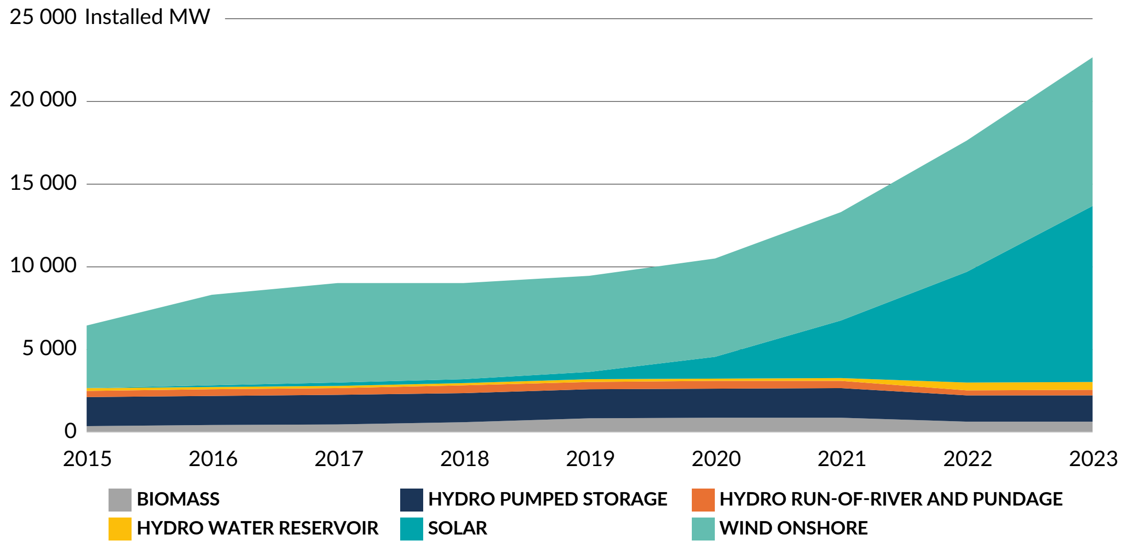
Since 2015, the Polish energy mix has been progressively shifting towards renewable sources, with wind and particularly solar energy experiencing significant growth since 2021 while hard coal remained the major generation source with about 13% reduction in total installed capacity between 2018 and 2023 (Figure 8 and Figure 9). Solar generation has grown exponentially between 2019 and 2023 with more than a 40-fold increase. What is also shows is that, although the overall "size of the pie" grew in this period, this growth is attributed to variable renewable generation with limited flexibility.

Figure 8. Polish Energy Mix 2015–2023



Source of data: ENTSO-E (2024b).

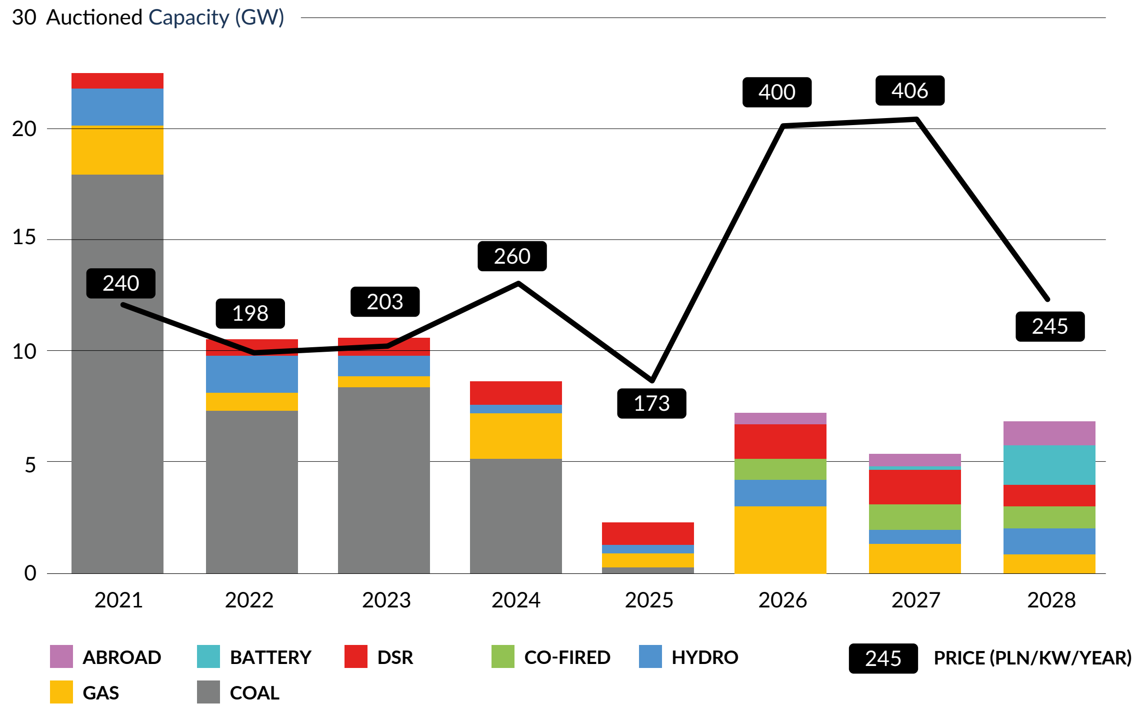
Figure 9. Polish renewables growth in 2015–2023



Source of data: ENTSO-E (2024b).

The figure below also illustrates the country's transition towards a cleaner mix in the capacity market and a more diversified range of participating technologies starting from delivery year 2026. Yet, the bigger picture is more nuanced.

Figure 10. Newly auctioned capacity and prices (purple line) in the Polish capacity market for the delivery years 2021–2028



Source of data: PSE, 2023.

Looking at the price results of the eight auctions, the main auction[11] for 2027 secured 5.4 GW of capacity at about €87,000 (PLN 370,600)/MW which is similar to the results of the 2021 auction for delivery in 2026. In contrast, the prices in the 2019 and 2020 auctions ranged between €55,000 (PLN234,300)/MW and €37,000 (PLN 157,600)/MW. Quarterly auctions were also held in 2022 for delivery in 2023, with prices between €41,000 (PLN 174,600) and €78,000 (PLN 332,200) per MW and capacity ranging from 0.4 GW to 1.3 GW.

What can be observed in Figure 11 is a significant drop in auctioned capacity for delivery year 2025. There are several contributing factors that appear to have caused this reduction:

1. The change in EU regulation limiting the eligibility of high CO_2 emitters from receiving capacity payments went into effect on July 1st, 2025, and thus existing coal-fired plants were excluded from the auction (ICIS, 2020). The market did not appear to immediately respond to this, and there was a delay to the entry of new technologies[12].
2. The target demand set by PSE for delivery years 2025–2026 was substantially lower leading to substantially lower bid volumes as compared to the previous ones. In other words, the low procured volume can be traced back to the low overall demand for capacity in that year rather than low capacity available.
3. A substantial amount of capacity had already been awarded with multi-year contracts in previous auctions. This pre-awarded capacity reduced the need for additional capacity in the auction for delivery year 2025.

Looking at the recent results, Poland's 7th capacity market auction for delivery year 2027 highlighted the country's energy transition challenges, balancing high costs and the need for clean energy. The auction saw a diverse range of technologies, including the first contracts for battery storage, but coal still plays a significant role, with many coal units contracted for the period of up to 2028. Despite the emergence of new energy storage facilities and gas-fired units, the market remains expensive, with auctions closing at record-high prices and limited new projects, driving costs up for consumers and the economy (Forum Energii, 2023). Compared to these results, the latest 8th auction has seen the emergence of large volumes of battery storage while no new gas generation was awarded and the price almost halved (406 vs. 245 PLN/kW/year). The auction results underscore the difficulty in ensuring adequate power supply and new investments amidst the aftermath of the energy and regulatory changes while the market tends to react to such changes with a time lag, as seen through the evolution of the CM technology mix.

The overall cost of the capacity mechanism has risen sharply, with substantial funds supporting new low-carbon capacities and modernizing existing ones. However, these measures are insufficient to fully balance the system. More investments in energy efficiency, storage, and clean technologies are crucial for Poland's energy transition. Despite progress, the auction reveals that significant challenges remain in achieving a sustainable and reliable energy system (Forum Energii, 2023)

Can the building of new capacity be attributed to the CM?

The findings of a study focused on delivery years 2021-205 conducted by Kaszynski (2021) reveal that existing units, including those refurbishing, were the primary beneficiaries, securing almost 90% of the contracted capacity obligation volumes for that period. Planned units, which accounted for 12% of the assignments to CM units through long-term contracts, were already in advanced stages of construction before the capacity market's implementation and thus did not rely on its financial support.

Based on the empirical evidence during the investigated period, the capacity market primarily set up to support coal generation did not effectively incentivize the construction of new power generation units but primarily supported existing and refurbishing thermal units. While the mechanism improved system reliability in the long term, it did not fulfill its objective of creating market signals for new investors (Kaszynski et al., 2021).

11 The Polish CM is organized in main auctions taking place 5 years ahead of delivery and supplementary quarterly auctions a year ahead. Further details are provided in Annex I.

12 It is noteworthy that coal-fired generation concluded half-a-year contracts in 2025.

The share of awarded existing capacity was considerably lower as a result of the 4th to the 7th auction, as compared to the first 3 auctions, ranging between 23% and 53% (Forum Energii, 2023). It, however, still constitutes the bulk of the total awarded capacity. In the same time period, the shares of awarded new capacity grew at an average rate of 16% over the last 4 auctions (Forum Energii, 2023).

The Polish CM was originally conceived to support uneconomic coal generation, thus no real incentive to invest in new generation or diversity the technology mix existed before the emission limits entered into force (see Table 1). Looking at the specific outcomes, in the first few years of CM operation, the highest clearing price, 57.1 EUR/kW/year, was observed in the main auction for delivery in 2024, with another significant price of 52.8 EUR/kW/year in the initial auction, both associated with high volumes of planned power units (Table 1). In contrast, the auctions for 2022 and 2023 saw relatively low prices and minimal contracted capacity for new/planned units (Kaszynski et al., 2021). This observation can be explained by the difference between the CONE (market entry price of a new generating unit) and the auction clearing price. Given the clearing price in these auctions was lower than the CONE, the revenue from the capacity market is not sufficient to cover the costs of building new generation capacity. As a result, fewer new units were incentivized to enter the market, leading to minimal contracted capacity for new or planned units.

A year later, this trend did not improve significantly as, according to the auction results for delivery years 2021–2026, coal units are the still main beneficiaries, receiving over 67% of the total budget. These units were set to gain EUR 412–917 million annually during this period (Komorowska et al., 2023). Based on auction data, a notable clearing price jump is observed for delivery years 2026–2027 with almost 90 EUR/kW/year and 90.3 EUR/kW/year, respectively, which coincides with the exit of the coal generation from the auctions and a limited capacity procured from other technologies (Table 1).

Table 1. Final results of the main capacity auction for 2021–2025 delivery years

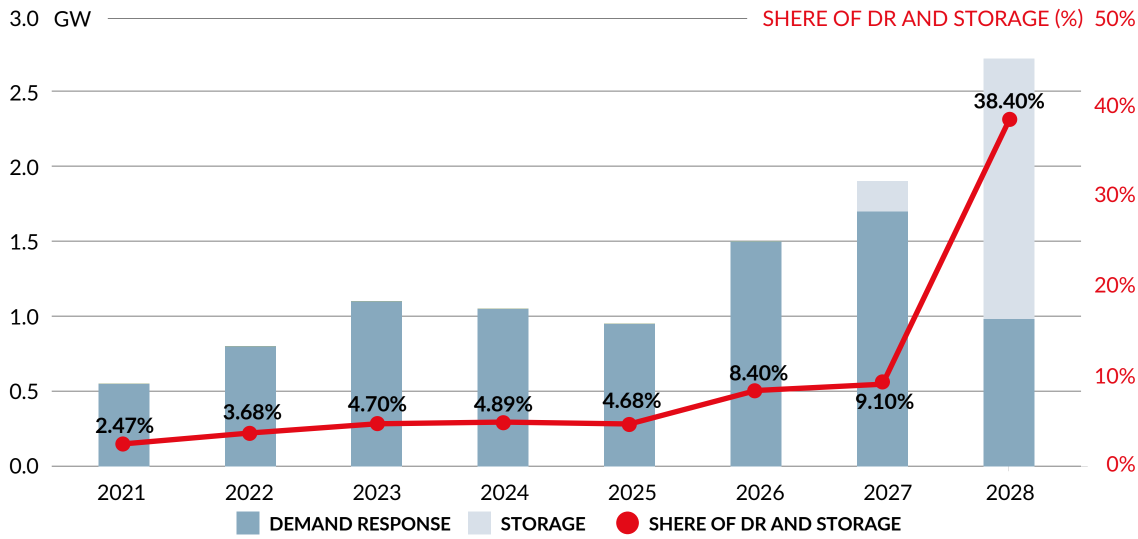
Parameter	Unit	2021	2022	2023	2024	2025	2026	2027	2028
Auction price cap	EUR/kW	72.1	80.5	89.5	88.9	91.2	91.8	93	94.2
Market entry price of new generating unit (CONE)	EUR/kW	65.5	67	68.8	68.4	70.1	71	72.5	73.8
Auction clearing price	EUR/ kW/year	52.8	45.5	44.6	57.1	38	88.98	90.3	54.42
Capacity obligation purchased	MW	22,472.1	10,580.1	10,631.2	8,671.2	2,367.3	7,188.584	5,379.156	7,070.951
Total capacity obligations	MW	22,427.1	23,038.9	23,215	22,107.6	21,472.8	18,821.9	18,712.43	21,150.61
Number of winning bids	–	160	120	94	103	55	128	95	159

Source of data: PSE, 2024.

In terms of participation of new technologies in the existing Polish CM, renewable generation – albeit formally allowed (see Annex I for the details for current design) – did not participate, which is driven by low de-rating factors[13] and separate support schemes. According to PSE, in the latest 2023 certification process for the main auction, over 6 GW of wind generation got certified (PSE, 2024). The experience of other capacity markets (e.g. in the UK) shows that RES are more likely to enter the CM once other support schemes expire. However, due to their inherent volatility (and thus low de-rating factors) it is questionable whether the CM should be used as yet another support mechanism for them – in particular as long as these are not supported by sufficient backup capacity to guarantee firmness.

The share of demand response grew rather steadily from about 0.5 GW for delivery year 2021 to about 1.7 GW for 2027, showing a limited, yet positive impact of technological diversification and investment (Figure 12). Battery storage in turn has witnessed an entry relatively recently: for the first time, for delivery 2027, its contracted capacity amounted to 0.2 GW (Forum Energii, 2023).

Figure 11. Contracted capacity of storage and demand response in the Polish capacity market as well as their shares as compared to the total procured volume



Source: ACER; PSE, 2024.

2.2.3. Impact on the energy transition in Poland

While the installed capacity in Poland remained relatively static since 2015, there has been an exponential increase in solar capacity from 2020. The overall increase of Poland's installed capacity – from over 35.5 GW in 2015 to over 55 GW in 2023 – was approximately 55% realized by solar installations (as shown in Figure 12). The remaining increase in installed capacity was predominantly realized by wind onshore generation (26.5%) and fossil gas (15.5%).

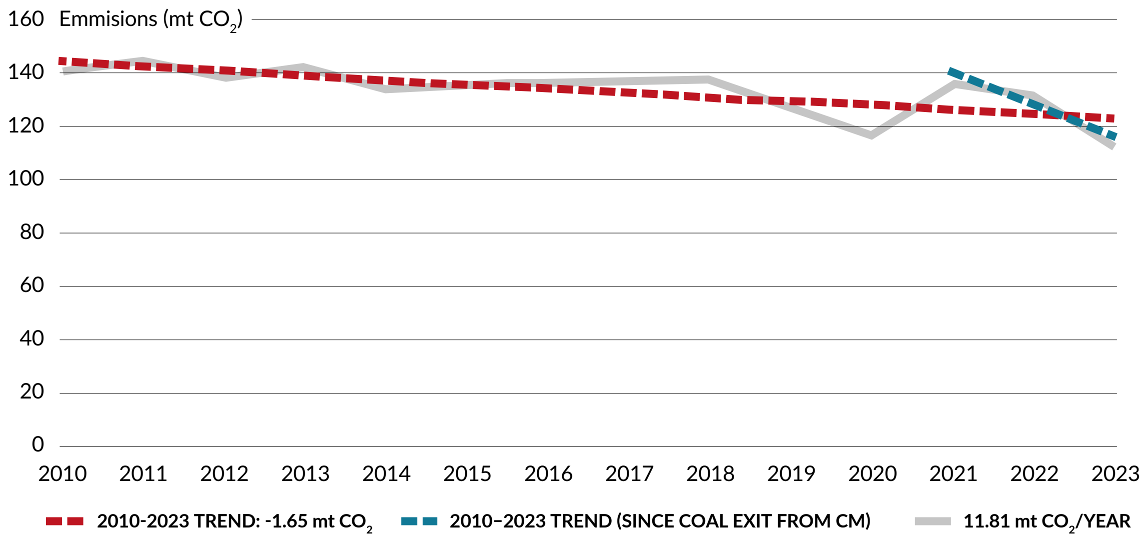
However, based on the analysis in section 2.2.2, there is no evidence that the CM was responsible for the greater shares of renewables in the energy mix. While relatively small shares of hydro generation have been awarded in the capacity market, its total installed capacity has remained stable at about 2 GW and the focus has been on maintaining and refurbishing existing assets rather than on the construction of new projects. Specifically rapid solar expansion, both residential and utility-scale, was driven by a combination of factors such as financial subsidies for residential installations, reduced costs of solar panels, introduction of net metering as well as announcements by PSE of major infrastructure investments.

13 In the context of capacity markets, de-rating factors are applied to account for the reduced reliability or availability of different types of technologies to actually deliver power when needed. These factors adjust the capacity value based on historical performance and availability, which is meant to ensure that capacity commitments more accurately represent dependable supply.

Looking into the future, recent analysis forecasts a 250% increase of installed non-dispatchable renewable generation in by 2030 (from 24 GW in 2023 to 62 GW in 2030). Over half of the added capacity is expected to be financed through government subsidies (22GW out of 38 GW, Aurora Energy Research, 2023).

Concerning the effect on the emission levels, the overall Polish electricity sector has seen a marginal reduction in CO_2 emissions between 2010 and 2023 (Figure 13). The figure shows a sudden decrease in overall emissions in 2019-2020 (blue line), which correlates with the COVID-19 pandemic and overall decrease in electricity consumption, in particular by the industry. The shift away from coal towards less emissive gas-fired generation, which is the most carbon-intensive form of generation, has played a role in a slight reduction since 2022 – yet has been so far insufficient to meaningfully decrease emissions.

Figure 12. CO_2 emissions in the Polish power sector in the period between 2010 and 2021



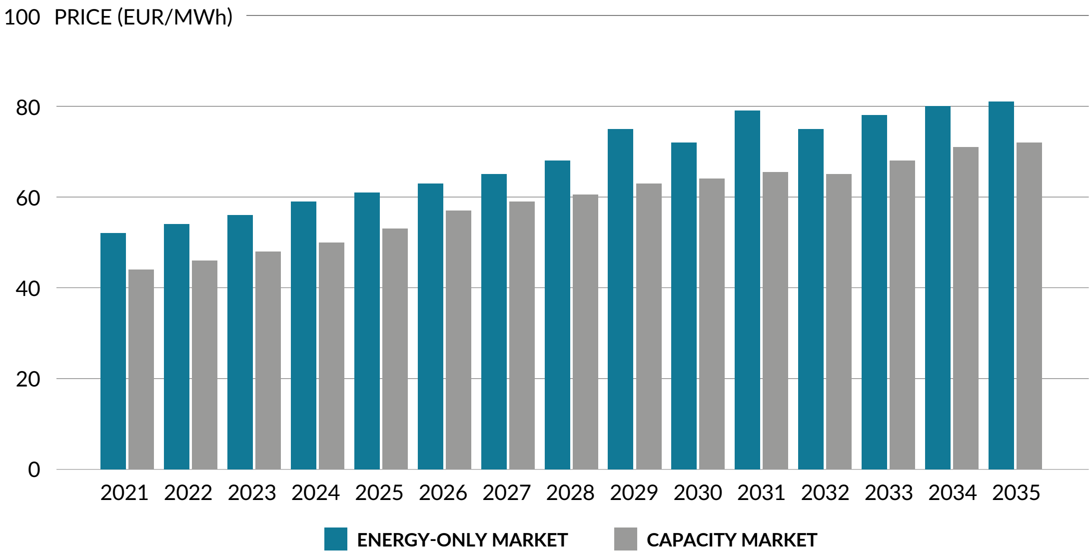
Source of data: EMBER, 2024.

Did the CM specifically contribute to the decarbonization of the Polish system? It is true that especially the last 2 auctions (delivery years 2027 and 2028) were dominated by a diverse mix of carbon-free and low-carbon technologies, such as DSR and batteries, hydro and co-fired generation. What is, however, important to keep in mind is that **capacity mechanisms remunerate power rather than energy that does or does not emit CO_2 while the activation of the reserved capacity is by definition rare. As a result, a direct contribution to decarbonization is at most limited.** Looking at the actual generation, as of July 2024, coal-fired generation still remains the largest source of electricity production in the country. A CM can, however, contribute to the energy transition indirectly, primarily by creating (additional) investment incentives for low-carbon or carbon-free technologies that can then participate in energy-based markets (wholesale, balancing, etc.) in addition to the CM. In the Polish CM, one such incentive was created with the introduction of a so-called green bonus, which refers to a 2-year extension of contracts for technologies emitting less than 450 g CO_2/kWh. However, now that Poland is seeking a derogation from the emissions limits under the EMDR, the slight downward trend observed in the last 3 years risks being reversed.

2.2.4. Impact on the functioning of the electricity market in Poland

This section examines the economic implications of the capacity market on the functioning of the broader electricity market in Poland, considering the evolution of day-ahead (DA) electricity prices and cross-border electricity exchanges as well as the ongoing balancing market reform. Additionally, it addresses the participation of CM-awarded assets in wholesale markets and the impact of cross-zonal capacities on price levels.

Figure 13. Simulated electricity prices in the scenarios with the capacity market and in an energy-only market in 2021–2035



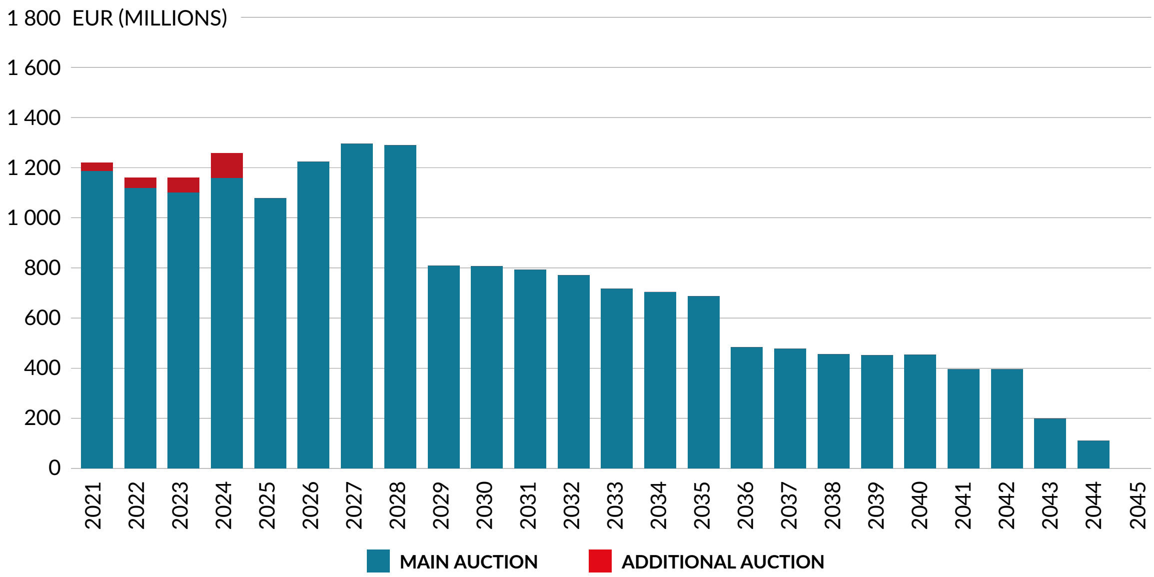
Source of data: Komorowska, 2020.

Relevant analysis of the economic consequences of a CM implementation for the first 6 auctions (delivery years 2021–2026) was presented in Komorowska, 2020 and 2023. Based on the associated auction data analysis, in the first 6 years, coal-based generation obtained 67% of the total allocated budget, which translates into 412–917 € million per year (Komorowska, 2023). Research conducted by the same author a few years earlier delves into a comparison of prices in two scenarios, 1) energy-only -market scenario; 2) scenario with a capacity market (Komorowska, 2020). Prices in the Energy-Only Market (EOM) scenario are consistently higher than in the CM scenario, with the difference peaking at €11.8/MWh in 2031 (Figure 14). This price difference appears to hold true even when accounting for capacity payments. Note that these results do not consider the actual effects during the energy crisis of 2022–2023 when wholesale prices in Europe reached record highs due to high gas prices and exceptional scarcity of supply. As a result of these events, the actual price difference in the absence of a CM would have likely been even higher. **Although dating to some years ago, the results of this research are still relevant: since no data for a counterfactual (EOM in Poland) is available, it can only be simulated.**

Based on the literature, the presence of a capacity market appears to have enhanced the availability of capacity, leading to generally lower and more stable wholesale prices compared to an electricity-only scenario. The CM might have limited Day-Ahead market prices spikes during peak demand periods, since its introduction. This aspect can be seen both favorably since it appears to "stabilize" Day-Ahead prices but also critically as this effect is likely to be counterproductive in incentivizing much needed flexibility to enter the energy market (more on this is Section 3).

In terms of total costs of capacity contracts, when we consider the cumulative total, as presented in Figure 15, the total cost of capacity contracts shows variability over time (between 2021 and 2028 delivery years) rather than a consistent upward or downward trend. The peaks and troughs observed in 2023 and 2024 appear to result from the volume of capacity obligations purchased in the preceding years, rather than any discernible variation in the auction clearing price that may have stemmed from the change in technological mix.

Figure 14. Cumulative total cost of capacity contracts in Poland 2021–2045



Source of data: Table 1 and Forum Energii, 2024.

Evolution of day-ahead electricity market prices

Since capacity markets allow capacity providers to participate in other markets, their availability and price levels have an impact on the overall business case of the participating technologies as well as on the amounts of associated risk. It is important to remember that a CM only remunerates capacity and not energy, so the revenues stemming from actual activation need to be obtained elsewhere.

Figure 16 depicts the evolution of day-ahead (DA) electricity prices in Poland from 2017 to the start of 2024. The prices are shown on an hourly basis in EUR/MWh. The data indicates two main periods of increased price volatility: end of 2017 to 2019 and end of 2021 to early 2023. The reduced price volatility and lower prices from early 2020 to end of 2021 suggest the impact of the COVID-19 pandemic, which led to decreased industrial activity and overall electricity demand.

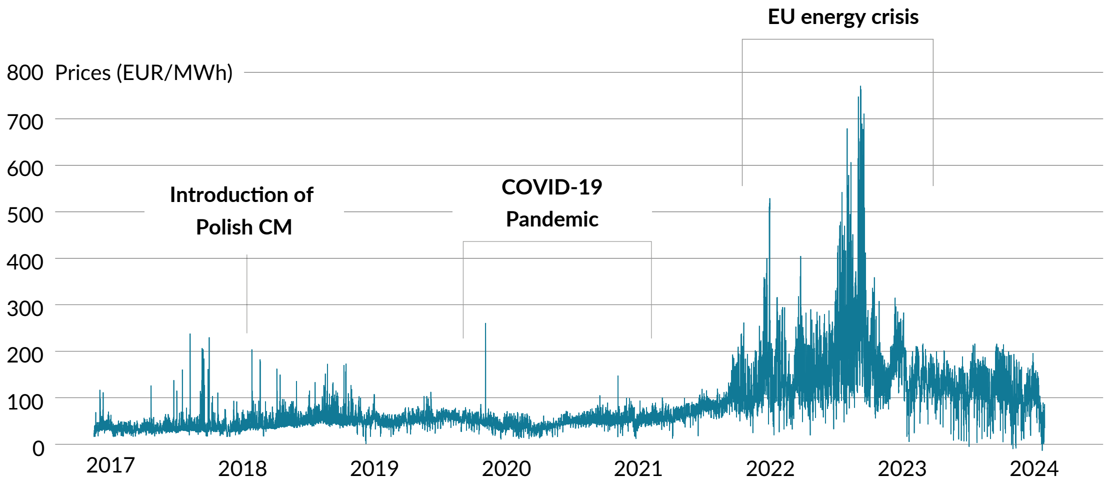
The sharp price spikes observed in 2022-2023 coincide with global energy market disruptions (especially gas), making the onset of the European energy crisis and *average* monthly DA price exceeding the mark of 700 EUR/MWh on multiple occasions (Figure 16). **These events highlighted the EU's and Poland's exposure to international market dynamics and the importance of maintaining a diversified energy mix and reliable capacity reserves.** It's worth noting that compared to the rest of the EU, Poland was somewhat less affected by the crisis, to a large degree thanks to its generally limited reliance on imports, as compared to its neighbors.

From mid-2023, prices begin to show a downward trend, stabilizing somewhat but still exhibiting higher variability compared to the pre-2020 period. Prices generally remain below 200 EUR/MWh, indicating some recovery and stabilization in the market that persists today, yet are very far from the pre-Corona averages of 40-60 EUR/MWh. **The increasing price volatility in the wholesale markets creates an additional price risk making market participants seek out additional hedging options. A CM is one of such option** and the higher energy price volatility is, the higher the incentive of a market actor to lock in a stable revenue stream to offset at least part of their portfolio risk.

It is also observed that Poland experienced its first instances of negative prices around mid-2023, with several instances following this (Figure 17). **Negative prices have become more common across Europe** with the expansion of installed renewable capacity, and therefore it is unsurprising these inevitably occurred in Poland. **The implications of for the CM could potentially be significant. Persistent negative prices could undermine the economic viability of certain generation assets, in particular less flexible ones with relatively long ramp-up or ramp-down times.**

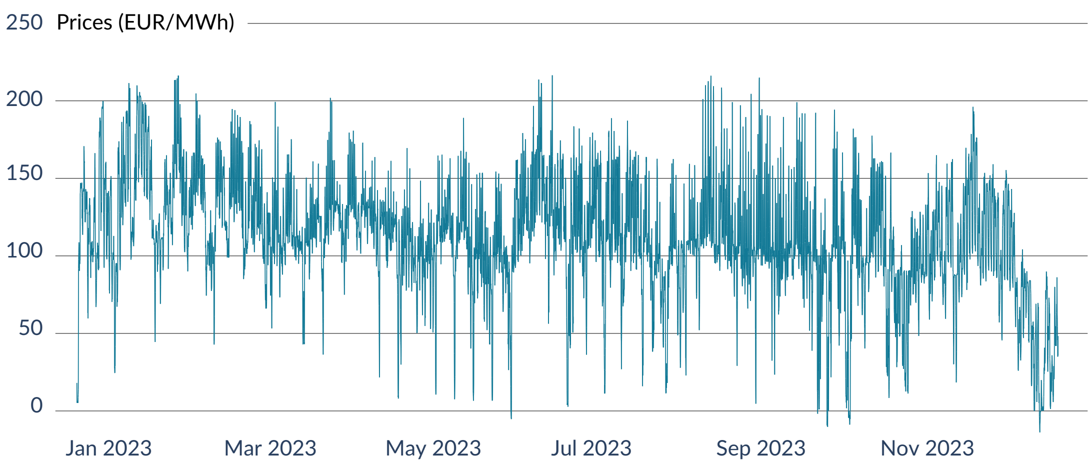
It then makes it more challenging for them to justify ongoing operation and investment. This could further increase the prices in the CM and necessitate adjustments to its design. As well, frequent negative prices might prompt a reassessment of the incentives for renewable investments and the adequacy of storage and demand response solutions to absorb excess generation.

Figure 15. Evolution of day-ahead prices in Poland between 2017 and 2024



Source of data: ENTSO-E Transparency Platform, 2024.

Figure 16. Day-ahead prices in Poland in 2023

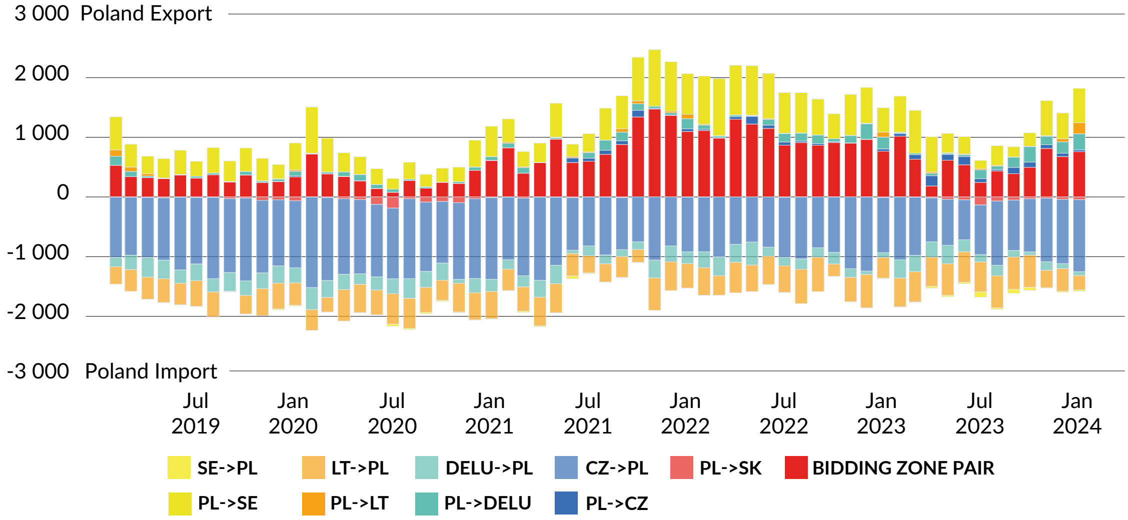


Source of data: ENTSO-E Transparency Platform, 2024.

Poland's cross-border exchanges

Figure 17 shows the average import and export volumes on Polish borders. The colors correspond to the same border exchanges (e.g. dark blue for export from Poland to Czechia, lighter blue is import from Czechia to Poland). It demonstrates that the direction of exchanges is consistent across time. Notably, Poland is consistently importing from Germany and Luxembourg while rarely exporting (only small volumes in 2021–2024), as is also the case with Sweden. Conversely, Poland is consistently exporting toward Czechia and Slovakia.

Figure 17. Mean monthly cross border exchanges (2019–2024)



Source of data: ENTSO-E (2024b).

While cross-border exchanges provide crucial support, the role of a capacity market in ensuring sufficient domestic capacity remains a key consideration from the point of view of self-sufficiency or contracting additional foreign reserves. The graph above demonstrates seasonal peaks in cross-border electricity exchanges across the entire time range. The mid-year reduction in cross-border exchanges, likely due to increased domestic renewable generation, highlights the importance of renewable energy in Poland's energy mix. Particularly during winter and summer months, Poland leverages imports to meet peak electricity demand. This reliance on cross-border exchanges during high-demand periods suggests the beneficial role these exchanges play in maintaining system reliability. **However, as Poland's imports have actually exceeded its exports on multiple occasions (last time in 2023), it is important to consider the value of a CM as one of the measures to ensure energy security – next to cross-border exchanges and technological diversification.**

Ongoing balancing market reform

The comprehensive balancing market reform which was initiated in June 2024 will take a significant place in the overall Polish market landscape, in particular affecting the supply in the capacity market from both new and existing technologies. Note that the balancing market reform came later than originally planned and its impact on the CM has only been observed in the latest, 8th, auction (Forum Energii, 2024).

Poland's ancillary services framework is closely aligned with systems in the neighboring countries. That is, the country will introduce standard balancing products in the sense of the EU Electricity Balancing Guideline, FCR, aFRR and mFRR[14]. Under this structure, certified balancing service providers would receive payments for the commitment and availability of capacity with actual energy activated to ensure system stability compensated through additional balancing electricity payments.

Similar to other balancing markets in Continental Europe, FCR product will serve as the quickest responding reserve, activated within first 30 seconds of a frequency deviation. Typically, this service is provider by peaker plants, such as gas turbines but also hydro generation or, more recently, battery storage with almost instant reaction to a control signal. It is anticipated that the Polish FCR market capacity will be around 170 MW, procured separately for upward and downward reserves on a daily basis, a day ahead of delivery (Aurora Energy Research, 2023 and URE, 2024). The other two products, aFRR and mFRR, activated after the initial FCR response, are meant to restore system frequency to its normal state. Larger market capacities are expected in these two markets while, based on the experience of other countries, the remuneration is substantially higher compared to FCR. These services are provided by a broader range of technologies as they are less limited by ramp-up constraints but are required to be activated for longer periods of time.

14 Frequency containment reserve, automatic/manual frequency restoration reserve.

Considering that some of the prime future contributors to the Polish capacity market are gas-fired plants and batteries, it is important to keep in mind that the CM can compete with the balancing markets for flexible capacity as its operators will likely attempt to maximize their revenue from multiple streams, a strategy called “value stacking”. In contrast, empirical evidence shows rather low participation of (industrial) demand response in balancing markets, mostly due to still high barriers to entry, lack of clarity concerning DR baseline as well as higher energy costs compared to generation technologies. Thus, it is more probable for DR to focus on the capacity markets where actual activation remains limited whereas a stable revenue stream of a longer contractual period is ensured.

Exhibit 1
Participation of battery storage in capacity and in balancing markets

The availability for (several) balancing products BESS can provide improves its overall business case and value-stacking opportunities driving overall investment in the technology. Same can be said about other emerging technologies such as heat pumps or e-mobility.

However, the underlying understanding is that one cannot “double-book” the same capacity: so if one is awarded in the CM, one cannot offer the same capacity in the balancing capacity auctions. If this assumption holds, this would imply that a BESS operator would optimize between the two revenue streams and split their total capacity between them.

Hence, participation in **both** the capacity market and the balancing market significantly influences the incentives for battery storage operators:

- **Participation in the balancing market** allows battery storage operators to earn additional revenue from both reserved balancing capacity and activation of balancing energy. The fast response times of battery storage systems make them ideal for balancing services, where quick adjustments to supply and demand imbalances are critical. A big benefit of the BM is not just generally higher revenues but also the absence of de-rating factors. Thus, one can argue that with the same power a storage operator can earn more per MWh.
- **The main value of the CM** is stability and duration of the revenue stream stemming from longer-term commitments. This revenue stream ideally ensures costs recovery, constitutes an important part of a battery’s hedging strategy and serves as a signal for future investments. To receive capacity payments, battery storage operators must ensure their systems are available and reliable during peak periods. The TSO requires a minimum availability of 4 hours, which is already technically challenging for smaller-scale storage. But an actual system stress event can in the worst case last for an entire peak period from 7am to 10pm, which may be technically infeasible for BESS unless back-up capacity in the pool is available (Cichocki, 2024).

By participating in both markets, battery storage operators can diversify their revenue streams, improving the financial viability and return on investment for their projects. Yet, **battery storage operators participating in both electricity capacity markets and balancing markets face several potential conflicts which should be considered when defining the design of either market.**

Batteries need to maintain a certain state of charge to meet their capacity market obligations, ensuring they can provide energy during period of system stress. However, to participate effectively in the balancing market, they must be flexible in charging and discharging to respond to grid needs. Mismanagement could lead to penalties for non-compliance in either market. Here it is important to keep in mind that balancing energy markets either only remunerate capacity (the case for FCR) or both capacity and energy (the case for aFRR and mFRR). **Market strategies of storage are very much linked to its technical characteristics.** As the total number of (charge-discharge) cycles are limited, a battery storage operator uses complex algorithms to optimize the battery use in a way to limit the cycling of the battery.

One of the results of this constraint is that participation in the balancing capacity market is valued highly since it provides a guaranteed revenue without necessarily having to delivery any energy. As a second consequence, it is common for BESS to enter balancing energy markets with very high €/MWh bids in order to avoid activation while still getting paid for reservation.

Operators need to strike a balance between securing stable revenue from capacity payments and capitalizing on potentially higher but less predictable balancing market revenues. Overcommitting to one market could limit the ability to maximize overall revenue. Based on the experience of other EU countries, the more saturated the balancing markets get, the more focus is placed on value stacking, i.e. maximizing the use of storage across marketplaces and products, including short-term wholesale markets. As a result, the share of storage participating in each individual market decreases.

Last but not least, **availability of several marketplaces to commercialize capacity or flexibility creates inherent opportunity costs.** These costs are directly or indirectly factored into the bids. If, for instance, the balancing capacity market prices increase over time, it is likely that the capacity market prices may go up as well, especially if the share of the technology participating in both markets is tangible.

2.2.5. Evaluation of the implementation of the Polish implementation plan

The Polish Implementation Plan, in alignment with Art. 20 of the Electricity Regulation, outlines a plan to address Poland's resource adequacy concerns. This plan identifies regulatory distortions and market failures, proposes necessary improvements, and outlines targeted market reforms to ensure, among others, sustained generation adequacy and security of supply.

Targeted reforms span various aspects of the electricity market, including:

- Wholesale market – enhancements to price formation and market transparency.
- Balancing market – implementation of market-based procurement of balancing capacities and the introduction of an administrative scarcity pricing mechanism.
- DSR and decentralized generation – increased participation of DSR units and support for distributed renewable energy generation.
- Cross-border exchanges – measures to increase interconnection capacities and improve cross-border electricity trading.

The Implementation Plan outlines the Polish capacity mechanism as a crucial component of the market reforms, designed to address identified resource adequacy issues.

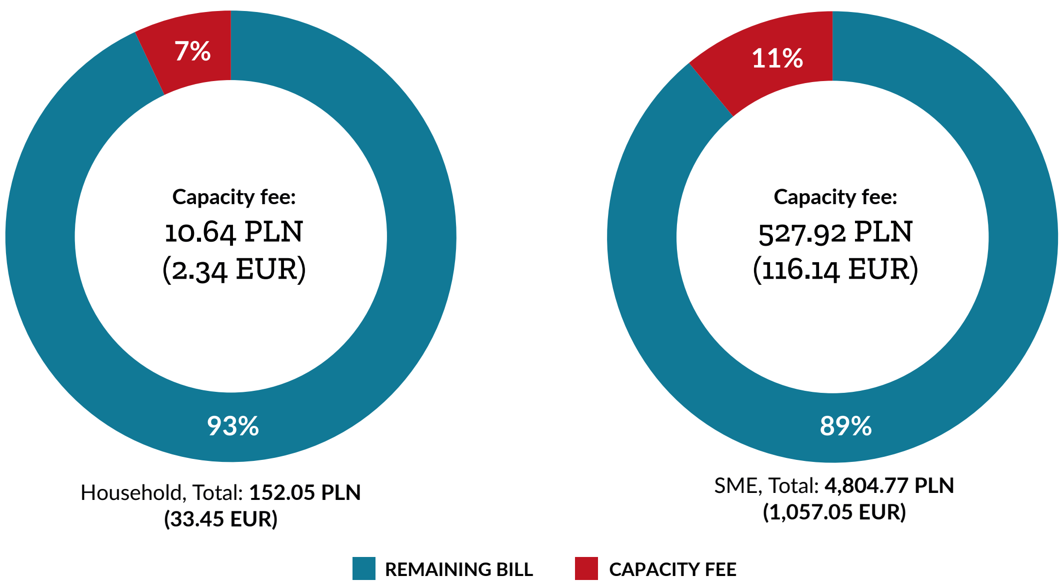
Since entering operation in 2016, we can say that the capacity mechanism has successfully conducted auctions and contracted sufficient capacity to mitigate Poland's adequacy concerns – at least up until 2028. This implementation has demonstrated positive impacts on security of supply (Section 2.2.1) and mitigation of extreme price spikes in the wholesale market (Section 2.2.4). We can also say that the inclusion of DSR and energy storage technologies in the capacity mechanism, which is defined as a target of the plan, confirms the countries movement towards a more flexible and resilient energy system. What is also true, however, is that the results of the eight auctions demonstrate a time lag between the exit of coal generation and the entry of new technologies in tangible volumes. In comparison to the total procured volume, the combined share of DSR and energy storage did not exceed 10% (as of 2022, see Section 2.2.2). The decision of June 2024 to further reduce the de-rating factor of battery storage will likely be detrimental to further storage integration. This shows that there is still room for improving the extent to which new technologies and investments in them are incentivized through removing overall barriers to market participation as well as through a capacity market, as will be discussed in detail in Section 3.

2.2.6. Costs to end users

Every year, the cost of the capacity market amounts to several billion zloty, which is reflected in Polish electricity bills, with the charges increasing annually (Figure 19, Forum Energii, 2024). For a household consuming an average of 2 MWh of electricity per year, the capacity fee constitutes 7% of the bill as of 2024. For a small business, it is as much as 11%. The value of capacity obligations contracted for the current year is PLN 6.1 billion (about EUR 1.4 billion).

For an average household, the flat rate of the capacity fee will be PLN 10.64 per month (in 2021 it was PLN 7.47), while for other consumers it depends on the amount of electricity taken from the grid during selected hours of the day and amounts to PLN 0.1267/kWh (against PLN 0.0762/kWh in 2021). The addition of the capacity fee to bills coincides with high electricity prices, currently still frozen by the government (Forum Energii, 2024).

Figure 18. Capacity free on monthly electricity bill in 2024 (Euro and Zloty)



Source: Forum Energii, 2024.

However, to assess the overall costs to grid users, we must consider the costs *avoided* through the existence of a CM. Based on the research results presented in the previous section, the combination of electricity prices and capacity payments to sustain the capacity market were shown to be systematically lower than price levels in a "what-if" scenario with an energy-only market in the same period (Section 2.2.4).

2.2.7. Results of the KPI-based analysis

The sections above provide a broad picture of the impact of the current Polish CM on several aspects of the Polish energy system, based on the results of the 8 capacity auctions held thus far for delivery years 2021-2028.

To substantiate the qualitative assessment above, we color-coded the assessed criteria as follows:

- **Blue** – positive contribution.
- **Grey** – insufficient contribution.

Criteria	Assessment
Improving security of supply	Implementation of a capacity market and demand side response jointly more than halves the expected loss of load expectation and energy not served in Poland, based on the results of ERAA 23. This supports the argument for a positive contribution of a capacity market to the security of supply. This contribution, however, is likely insufficient based on the capacity market's current design – in particular after 2028. **The CM in its current design on its own will not be able to cover the future adequacy gap beyond 2028 when most of the contracts awarded to coal generation expire**
Improving investment incentives	Based on the results of the eight auctions, participation in the CM has been predominantly driven by the need to secure existing assets' revenues rather than the incentive to build new units. Beginning with delivery year 2026 the Polish CM has been observing a more diversified range of technologies, notably battery storage. The average share of new investments in generation and storage amounted to about 16% in the last 4 auctions, **most of CM costs are still allocated to highly emitting coal generation.** **The capacity gap is expected to reach between 10 and 12 GW by 2033 and almost 18 GW by 2040. Insufficient investment will become a particularly pressing concern beyond 2028 once legacy contracts run out**
Positive impact on the energy transition	The Polish capacity market does not seem to have contributed to the increasing shares renewable energy resources, which was rather driven by government policies and economic factors. There is further no evidence that the capacity market contributed to the overall reduction of CO_2 emissions of the power sector in Poland due to legacy contracts for coal generation as well as typically largest share in the wholesale markets coupled with still insufficient contribution of new technologies. **A potential derogation from the EU** CO_2 **limits on technologies participating in CMs, risks reversing the slight downward emissions trend observed in the last 3 years**
Non-distortional effect on electricity market functioning	Based on previous research and empirical data, the presence of a capacity market in Poland **likely had a dampening effect on its wholesale market prices.** This can be seen as an effect of wholesale market distortion. **The CM will further have an effect on the emerging balancing markets** in Poland. The effect is likely to be reciprocal as they will compete for flexible assets that are eligible to participate in both markets, impacting availability and driving up prices. **Positive signs have been observed in the 8th auction with the entry of larger volumes of DR and storage** showing how a reaction to market design and rule changes occurs with a time lag
Lowering costs to end users	Comparing to a hypothetical energy-only market scenario, the total costs to end users (energy costs and capacity fees) have likely been lower overall. However, this contribution is very much linked not just to the capacity market but to the actual price developments (cf. COVID-19 vs. price freeze during the energy crisis). Note, however, that this outcome is based on a modelling result of the alternative scenario. The actual effect can hardly be estimated as a counter-factual is not available. In addition, **given the growing adequacy concern, the upward trend for future costs to consumers is expected. The magnitude is highly uncertain as it will depend on the mix of technologies and the existing vs. new entries**
Compliance with the Polish implementation plan	Overall, **Poland is on track regarding a formal fulfillment of the Implementation Plan, with positive impacts** observed in both supply security and mitigation of extreme prices, demonstrating progress towards the plan's stated goals. However, **room for improvement is observed with regard to an ensuring an effectively technology-neutral approach and incentivizing a growth of investments** in DSR and energy storage

3. Analysis of possible market design changes

The current application period of the Polish capacity market is nearing its end, and the country finds itself at a crossroads: shall the capacity market be retained and if so, how should it be adjusted? Or is a new solution altogether is needed to fulfil the future system needs?

The EMDR institutionalized capacity mechanisms as an integral – rather than an exceptional – part of the electricity market design (as described in Section 1.3.2). Yet, the value of capacity mechanisms has been disputed with multiple arguments on both sides of the debate. We briefly summarize these in the subsequent sections before introducing **a target-state-based approach to a proposal for the market design reform in Poland.**

3.1. Arguments for

The arguments for CMs would be rather different from the perspective of the users, i.e. TSOs, and of capacity providers.

From the TSO perspective, CMs' benefits are multifold:

Capacity markets provide a way to ensure that there is always enough generation capacity available to meet peak demand and maintain system reliability. This is particularly important during periods of high demand, high-RES fluctuations or unexpected outages. Capacity markets can further help manage electricity uncertainty by ensuring that there is a predetermined amount of capacity available, regardless of fluctuations in energy prices or demand providing a greater stability and predictability for TSO operations.

From a market actor's perspective, by providing a stable revenue stream for generators or DSR, they can attract investment in new generation capacity. This stability helps generators secure financing for new projects and ensures ongoing operations, especially during periods of low energy market prices. It is also crucial for ensuring that there is enough capacity to replace retiring plants and to meet future demand growth. A CM is further seen by participants as a way to manage financial risks by limiting exposure to market price volatility.

3.2. Arguments against

The reason why capacity mechanisms have been subject to over a decade of heated debates were multiple concerns associated with their implementation and impact on the electricity markets.

Capacity markets can distort the wholesale electricity market by artificially inflating capacity beyond what is economically efficient. This, among others, can lead to price suppression in the energy market as generators receive payments outside the market, reducing their need to recover costs through energy prices. This **undermines the short-term electricity price as the robust price signal, which should ideally guide investments and flexible behavior.** As mentioned above, the actual effect will depend on 1) the share of CM units as compared to the total installed capacity and 2) on the probability of system scarcity events.

Besides distorting wholesale price signals, CMs can send mixed signals to investors: on the one hand, they should incentivize investment, on the other hand, they also reduce an incentive to invest in flexible assets by dampening wholesale prices and price spikes.

Furthermore, the costs of capacity payments are passed on to consumers through higher electricity bills. This argument, however, needs to be seen in comparison with the prices that the consumers would have otherwise had in an energy-only market (see also Section 2.2.6 for more context).

Capacity mechanisms can incentivize the continued operation of older, less efficient power plants that would otherwise be retired thus **delaying the energy transition rather than enabling it.** This can be further aggravated by additional (considerable) administrative effort placed on prospective participants, which would act as an additional deterrent.

In the subsequent sections, we will look at how these potential drawbacks of capacity markets can be mitigated.

3.3. Target-state-based approach

This section looks towards the future. It is important to keep in mind that the fundamentals of the energy system in Poland and beyond are changing. The exponential growth of variable renewable generation but also electrification of other sectors promises frequent occurrences of highly positive or highly negative residual load. This will drive the need for additional generation and storage technologies to ensure system reliability. These developments in system needs underpin a revision of the electricity market design and the place of the capacity market in it.

Slowly but surely, Poland's energy mix and, consequently, its system needs, are evolving. In particular from the end of 2020s, Poland is transitioning from coal-fired generation being the most dominant power (and capacity) source in the electricity sector. It is being gradually substituted by less polluting gas-fired generation as well as storage and to an extent RES – albeit not without difficulties. Unlike some of its neighbors, Poland is at the start of the entry of other, less conventional sources of flexibility. In the last 2 capacity auctions, battery energy storage was awarded for the first time while the share of (industrial) demand response has been steadily increasing. Yet, as the analysis above has shown, these still marginal shares will likely be insufficient to cover the adequacy gap identified in Poland between 2028 and 2035 (ENTSO-E, 2023). Other existing technologies, such as co-fired generation but also combined heat and power (CHP) plants can contribute more to the future. Other types of technologies, such as distributed energy resources (DERs) or hydrogen production are still in their embryonic states.

The Electricity Market Design Regulation added a new dimension to the capacity market discussion. Not only did **it, so to say, institutionalize capacity mechanisms within the EU electricity market design, it also made explicit a link between capacity mechanisms and flexibility.** According to the EMDR each Member State is expected to publish a flexibility needs assessment report. Based on these reports, so-called **national indicative objectives for non-fossil flexibility must be defined. The EMDR touches upon several ways to achieve these targets, among which is the adaptation of existing capacity markets.** In this way, CMs must provide adequate incentives to new investment in non-fossil flexibility, especially demand response and energy storage.

But first, it is crucial to determine the target state. Which goals are pursued considering the needs and constraints of the evolving electricity system? Only then can we determine if there are proper means in place or what needs to be done to achieve that target state.

In order to define a target state for the future Polish electricity and capacity markets, we review the **system needs but also actors' needs** and how these will change in the foreseeable future.

From the system perspective, ACER makes the primary goal of resource adequacy assessments clear, which is *"to identify resource adequacy concerns and to provide a robust and objective basis for policy decisions, in particular when assessing the need for capacity mechanisms"* (ACER, 2023c). At the same time, resource adequacy refers to the ability of the power system to supply sufficient electricity to meet consumer demand at all times, in particular during situations of system stress[15]. This includes ensuring that there is enough capacity to generate, transport, and distribute electricity to satisfy all expected loads. Notably, the definition of a system stress event does not imply the actual lack of supply but rather as capacity reserve in excess of demand becoming too low, more specifically, below the reliability margin.

Thus, **from the system point of view the main goal for a capacity market as a *tool* for ensuring resource adequacy is having "sufficient resources to meet demand in the coming decade."** The TSOs further specify that this includes flexible resources and grid interconnections (ENTSO-E, 2023c). Finally, the implementation of a CM should ideally avoid disproportionate costs to consumers.

Concerning the overall goals of the Polish energy system, the vision is to improve the decarbonization of energy supply as well as energy independence while further exploring potential for increased system robustness. Specifically, the draft of the National Energy and Climate Plan (NECP) 2021–2030 strives to achieve a target of 23% of renewable energy in the gross final energy consumption (i.e. incl. the power and transport sectors as well as heating and cooling) by 2030. In the electricity production, the RES share is expected to achieve 56% in 2030 and 40% in 2040.

15 In the Commission's decision concerning the introduction of the Polish capacity mechanism, "a system stress event is defined as an hour in which the planned dispatchable capacity reserve available to PSE (in excess of demand) is lower than the level of reserve margin required to safely operate the grid. A system stress event may occur in any hour of peak demand between 7:00 and 22:00 hours on working days. No limitation is introduced as to the number and duration of breaks between sequentially occurring system stress events. A system stress must be preceded by a warning issued by PSE at least 8 hours in advance" (the European Commission, 2018).

Poland's latest NCEP highlights the significance of nuclear energy for ensuring a stable and zero-emission electricity supply while diversifying energy sources. The Plan schedules the first nuclear power unit, with a capacity of around 1–1.5 GW, to be operational by 2036 – with further five units projected to come online every 2–3 years, cumulatively providing approximately 6-9 GW of power (Ministerstwo Klimatu i Środowiska, 2024). The NCEP does not yet contain other technology targets, such as battery storage or hydrogen production.

Since the adequacy concern is projected to increase beyond 2028 – despite the capacity market – the current pace of investment is projected to be insufficient and needs to be accelerated turning it into one of the most pressing system needs (Figure 19). The start of planned operation of nuclear generation will help alleviate the adequacy gap at least partially. However, in the best case, at least 5 years (between 2028 and 2033) remain dangerously exposed to adequacy risks if no additional steps are taken.

On the provider side, CMs are primarily meant to ensure cost recovery. However, the reasoning for providing capacity is more nuanced. A capacity market, first and foremost, is (another) source of revenue for a capacity-providing asset. Since this source of revenue is MW-based, i.e. independent of the actual activation, it is also **more stable and less risky** than energy-based markets. For the same reason and since participation in other markets is not prohibited to capacity market providers, additional revenue can be then generated through MWh-based markets, e.g. wholesale or balancing. This accomplishes two objectives:

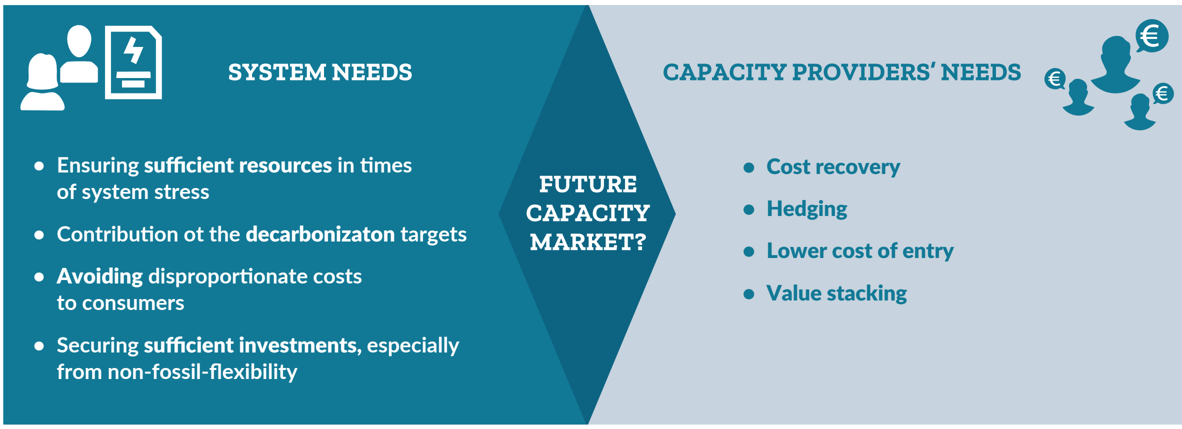
1) **value stacking,** i.e. maximizing the value of a resource across multiple markets/use cases, in particular as a lot of the energy markets are becoming increasingly saturated,

2) **hedging**, i.e. mitigating price risk and overall price volatility by securing a long-term MW-based contract, in particular in times of economic and regulatory uncertainty.

The providers' goals matter as they translate into incentives that they would or would not have to participate in a CM with an existing unit or to invest in a new asset. In particular in the future, after the balancing market reform in Poland is finalized, available capacity could also be bid in the balancing markets, creating competition between the two.

To summarize, the target state for an electricity market, including a capacity market, is the one that maximizes the contribution to the goals described above, as is illustrated in Figure 19.

Figure 19. Target state based on addressing the system and capacity providers' goals

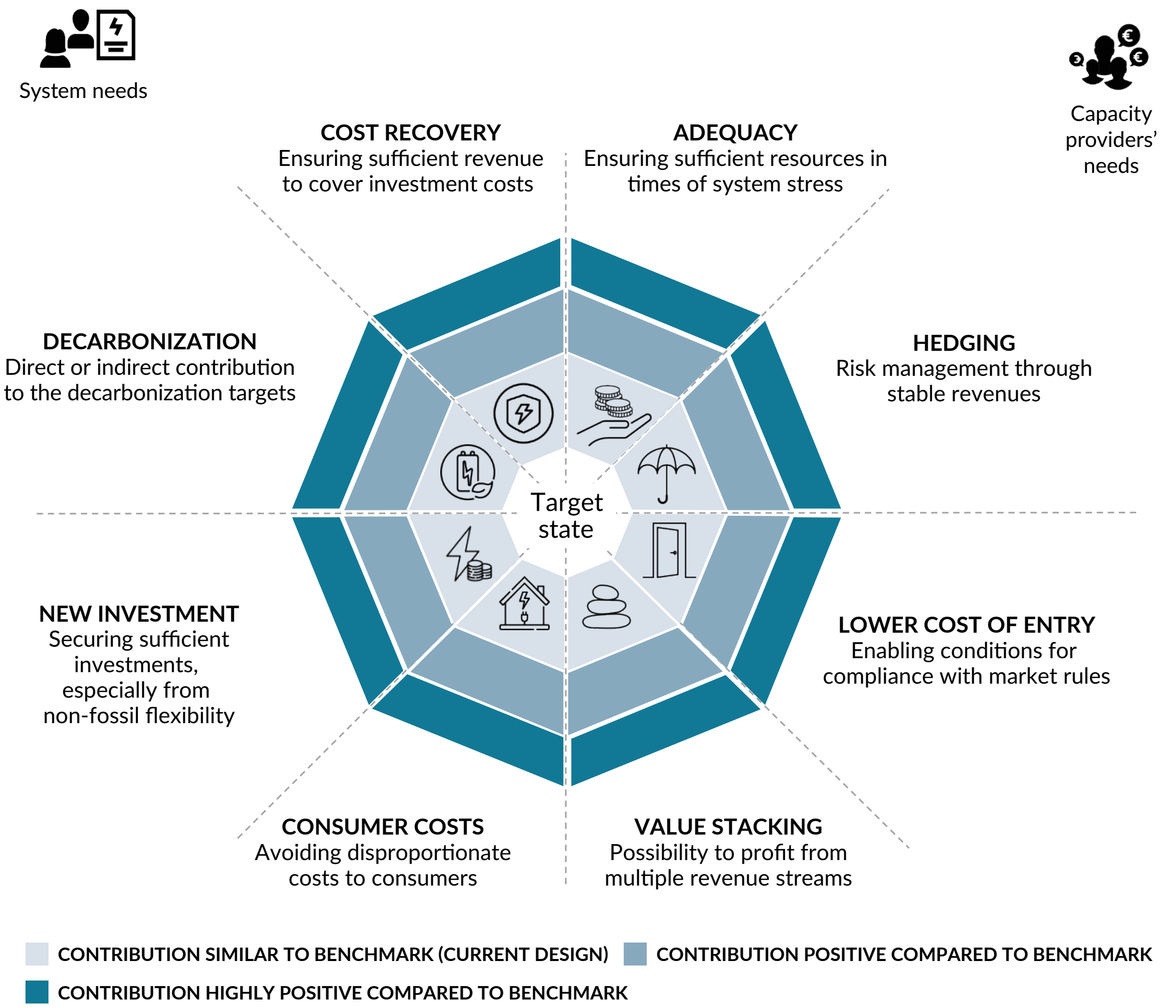


3.4. Possible adaptations of design parameters to improve the functioning of the Polish Capacity Mechanism

The KPI analysis in Section 2.2 and CM design analysis (Annex I) revealed room for improvement to the functioning of the Polish CM, especially in terms of encouraging new investment and contributing to decarbonization efforts, which were incorporated in the target state illustrated in Figure 19. At the same time, **using the CM revision, Poland now has an opportunity to address the emerging trends before they aggravate system risks**. These are not just growing shares of variable RES in the country but also gradual emergence of other technologies, such a storage – not just at the transmission but also at the distribution network levels. A future-proof CM design should ideally account for distributed assets to avoid undue barriers once their amount reaches a critical mass.

Based on the analysis of current capacity market design in Poland (see Annex I for details), there are a number of conceivable measures that could contribute to fulfilling the needs above – at least to an extent. In order to systematically assess them, we use the current design as a baseline and determine in a qualitative manner the extent to which a new measure could contribute to the achievement of the eight goals on the system and participants sides listed in Figure 19. If a positive contribution to a goal is expected, as compared to the baseline, an additional teal block is added. A dark teal block is added on top if a proposed measure is expected to have a particularly high positive effect on a given goal (see Figure 20).

Figure 20. Approach to analyzing proposed market design adaptations based on the eight system and participants' goals (as compared to the baseline, i.e. the current CM design)



3.4.1. Measures to encourage smaller-scale providers: Further reduction of minimum bid size to 1 MW (de-rated) and adjusted penalties

MEASURE FOR SMALLER-SCALE PROVIDERS

This would in particular help new market entrants, including on the distribution network level, with ensuring cost recovery and stable revenue streams. Combined with advanced aggregation and de-rating (see also the next measure), it should allow for technology diversification and enhance overall competition in the CM. However, potential additional administrative cost of certification and verification should be taken into account.

In addition, when pondering bid size reductions as a tool to enable participation of smaller capacity resources, it is crucial to review other barriers to such participation. In the Polish CM, barriers are centered around **a high investment risk and high penalties for failed deliveries**, something that can often be shouldered only by larger, more established actors. Another barrier refers to the contract length: while long-term contracts provide revenue certainty, they also require substantial forecasting capabilities. To submit an offer at the auction, a provider must forecast the price of fuel and CO_2 for 15 years. Such forecasts are highly prone to error: as a (frequent) result, the calculated premium is too low, for instance, in relation to the sudden change in gas and CO_2 prices, thus leading to financial losses of operators having to operate nevertheless in order to avoid even higher penalties for non-delivery (e.g. of CHPs). To an extent, the forecasting issue can be solved with the help of rolling auctions, as described in Section 3.4.6.

That said, although bid size reduction per se is a low-hanging-fruit measure, its effectiveness highly depends on the removal of other barriers to participation. A possible approach to mitigating disproportionate penalty risks could be designing volume-dependent penalties proportional to portfolio size. This is also in line with a more limited system impact of smaller providers.

3.4.2. Updated rules for aggregated, mixed-technology portfolios

AGGREGATED, MIXED-TECHNOLOGY PORTFOLIOS

This design adjustment is related to the integration of renewable energy sources to the CM as well as other mixed portfolios, including thermal flexibility or DSR with on-site generation. The participation of these technologies or their clusters are linked to important challenges:

- **Concerning RES,** de-rating factors adjust the capacity credit of technologies to reflect their actual contribution to system reliability, given their variability and intermittence. Determination of de-rating factors involves probabilistic assessments of performance and availability during peak demand periods. De-rating factors of solar or wind are notoriously low (e.g. 1.56% for solar in the Polish CM), which requires a lot of capacity to make up an attractive case for variable RES. This affects their ability to compete for capacity payments on similar footing with thermal generation or other technologies. Their inherent intermittency and forecasting uncertainty in addition requires high security margins to avoid non-compliance penalties – which further decreases the actual volume that could be bid into the CM. This is also observed in the Polish CM where, although some RES capacity (from wind) was approved in the latest certification process according to PSE, its actual participation is limited due to strong de-rating and restrictions to aggregation (PSE, 2022b).

- **Mixed portfolios of other technologies, such as thermal flexibilities (heat pumps) or DSR with on-site generation** also face aggregation challenges. For instance, the different emissivity of individual assets in a to-be-certified portfolio requires them to apply as separate units in the CM (e.g. DSR with high-emission heating or on-site diesel generation). In addition, modernization or adaptations to any component of the portfolio cannot be conducted without a renewed application for the entire pool. Moreover, according to the current rules, the technology with the lowest de-rating factor of a mixed-technology portfolio sets the factor for the entire portfolio – by definition discouraging the inclusion of RES or other low-factor assets.

Some of the measures to mitigate these limitations include:

1. **Facilitate the aggregation and participation of hybrid resources** (e.g., solar + storage) that combine renewable generation with storage to provide firm capacity and mitigate the intermittency of standalone renewables. Such an approach is certainly not limited to VRES+BESS duo. A technology combination could also for instance include industrial heat pumps or other thermal storage. **According to our understanding, the certification process is allowed for groups of units, yet such units need to be behind the same metering point.** A combination of technologies could make compliance easier to achieve and increase the renewables potential in the CM. A question which would need to be clarified here is the setting up of appropriate de-rating factors to account for such a mix.
2. **Review of the de-rating factors:** A decision by PSE to reduce the derating factor for battery storage significantly likely constitutes a technology-based discrimination, which affects BESS participation in auctions as a larger nominal volume is required to bid the same (de-rated) capacity. This is also contrary to the measures required by the EU Electricity Regulation (see Section 3.3). A potential solution for battery storage would be to set different de-rating factors based on its duration. For instance, in the Belgian CM, for the duration from 1h to 6h the factor ranges between 28 and 69% for 2025 (Elia, 2022). Additionally, instead of applying the lowest de-rating factor to a mixed portfolio, a factor based on a weighted average of all technologies in the portfolio and their volumes seems more reflective of their actual contribution to reliability.
3. **Time-specific de-rating factors:** based on the statistical data on wind and especially solar generation the seasonal or, for solar, daily production patterns are rather stable. That said, for such technologies, derating factors can be distinguished based on the time of the day or the season/month to maximize their contribution to system adequacy.
4. **More flexible certification process:** In line with the current EU regulatory efforts to streamline the prequalification requirements for different products and services (cf. Network Code on Demand Response), the certification conditions can be eased to avoid lengthy processes when only a small adjustment to the whole portfolio is conducted.

It can be argued that by participating in capacity markets, renewable energy sources can be integrated more effectively into the broader energy market, potentially leading to a more market-driven approach to achieving renewable energy targets. However, significant care should be taken with this argument as they fulfil two fundamentally different goals: buildout of RES capacity for achieving sustainability targets vs. adequacy**. In our view, the removal of RES subsidies should not be motivated by their substitution during capacity mechanisms as the latter cannot guarantee the achievement of decarbonization targets.** In this sense, the CM is better suited as an indirect tool to support decarbonization, namely by encouraging investment in low-carbon or carbon-free technologies and advancing sector coupling.

3.4.3. Adjusting rules for cross-border participation

At the moment, the prices of foreign capacity are lower by definition due to a pre-auction they are obliged to participate in. This puts a premium on domestic capacity, which is understandable from the point of view of valuing autonomy and self-sufficiency. However, based on the latest auction results, the potential of available interconnection has not been fully exploited. To achieve it, it is important to ensure that potentially more cost-efficient capacity participates in the Polish CM up to the Maximum Entry Capacity limit. It is questionable if a continued restriction of foreign capacity through pre-auction would be justified in a new CM. It is worth noting, however, during a scarcity event in November 2024, availability of foreign capacity was extremely limited – which is attributed to *regional* scarcity in the same period of so-called "Dunkelflaute"[16].

3.4.4. Technology-specific auctions or separate auctions for new investments instead of single-basket auctions?

The auction results show that the potential of new technologies in the CM is far from exploited. This is true not only for battery storage and DR but also sector-coupled technologies, such as CHPs or, in the future, electrolysers. In order to promote investment into such technologies and diversify the CM mix while contributing to the energy transition, one could argue for the introduction of technology-specific auctions rather than a "single-basket" auction used today.

TECHNOLOGY-SPECIFIC AUCTIONS

A technology-specific approach may yield a number of benefits from accounting for different cost structures as well as encouraging diversification and innovation. Different technologies have varying cost structures and development timelines. Technology-specific auctions can account for these differences, ensuring that each technology type is competitively priced according to its own economic realities. This is particularly relevant for the auctions such as the Polish one where marginal pricing rule is applied to awarded bids. In addition, technology-specific auctions can ensure the inclusion of a wide range of energy sources by setting quotas or targets for specific technologies, such as renewables, storage, or demand response. By providing a dedicated space for emerging technologies, technology-specific auctions can encourage innovation and investment in new, cleaner, and more efficient energy solutions.

At the same time, there are strong arguments against such an approach driven by both economic and regulatory considerations. Generally speaking, single-basket auctions tend to be more efficient by allowing all technologies to compete directly against each other and maximizing liquidity, which should ideally lead to the procurement of the lowest-cost capacity overall. Technology-specific auctions imply a higher complexity and administrative burden in terms of planning, administration and monitoring. The main argument against such auctions is rooted in the fundamental information asymmetries associated with a central planner approach: focusing on specific technologies might lead to an over-reliance on those technologies, potentially neglecting others that could be more cost-effective or better suited. In the worst case, this can distort the market by artificially inflating demand for certain technologies. This can lead to suboptimal investment decisions and higher overall costs if the targeted technologies which are not the most economically viable options available. Last but not least, such an approach runs contrary to the EMDR requirement to set up capacity mechanisms in a technology-neutral way.

That said, we do not recommend the use of technology-specific auction. Instead, we see other approaches such as targeted investment support for certain technologies or tax rebates (see also Section 3.5) as less controversial while achieving a similar result.

16 This, originally German term, refers to a situation of overall low availability of renewable generation, e.g. lack of sun and wind on a winter evening, when demand is typically high.

Concerning the second option under consideration, separate auctions for new investments, such a setup should drive down capacity prices and costs for consumers – at least in theory. The main reason why existing and new generation is combined in a common auction is linked to enhanced competition and liquidity – similar to the discussion of "single-basket" auctions above. Since existing generation tends to have lower capacity costs, this should also help reduce the costs of auctions. In addition, combined auctions are expected to provide a technology-neutral approach where all types of providers compete on par and capacity is allocated in a single process. Finally, a common auction should be able to provide a robust signal reflecting the value of capacity where the higher the price, the higher is the need for extra capacity and thus for additional investment.

DEDICATED NEW-INVESTMENT AUCTIONS

Separating auctions for existing units and new investments in capacity markets, however, could potentially offer several advantages. Separate auctions can provide more accurate signals for new investments, which may act as an extra incentive. Separate auctions can also potentially offer longer-term contracts and more predictable revenue streams, which are essential for securing bankability and financing for new projects.

What also needs to be considered is that existing generation and new investments have different cost structures. New investments typically have higher capital costs and higher risks compared to existing units and separate auctions eliminate the risk of these costlier investments being "undercut" by existing units that primarily face variable costs. Such auctions could also encourage innovation and investment in new technologies or renewables. In the Polish system, where most supported capacity constitutes coal-based generation, this could help reverse the situation in a way compatible with the energy transition.

The arguments for technology-specific and new-investment-specific auctions may appear to be similar. Yet, there are some important distinguishing factors. Dedicated auctions for new investments provide a focused mechanism to ensure the growth and modernization of electricity capacity, fostering innovation and competitive entry while aligning with Poland's long-term reliability and stability. In contrast, technology-specific auctions support diversity and technological advancement but may not directly address capacity expansion and market entry challenges and may end up constrained by specific pre-defined technological choices. By providing a dedicated platform, dedicated auctions for new investments can attract investors and developers who might be deterred by the competitive pressures in a combined auction with existing capacity. That is, **new-investment-specific auctions focus on adding new capacity to the grid, regardless of the technology used, thus also complying with the EU regulatory requirements.** These are also designed to level the playing field for new entrants, potentially reducing the influence of established players or incentivizing them to innovate.

Despite a relatively high score in terms of contribution to the system's and participants' goals, it is useful to see this measure in the context of the technological evolution of the Polish CM. At the moment, most of existing thermal units are ageing and excluded from the CM. New units already have long-term contracts, including „new" coal and gas-fired generation. In addition, many existing capacities can participate in yearly auctions. A likely future outcome would be that more and more new investments will be participating in the CM by default. This would ultimately diminish the value of these measures while not removing a risk of potential market fragmentation.

Hence, neither do we recommend using a separate auction for new investments due to limited expected benefits combined with a risk of non-compliance with the principle of technology neutrality.

3.4.5. Rolling auctions (incl. seasonal differences)


ROLLING AUCTIONS

Staggered auctions, e.g. main Y-5 and quarterly Y-1 ones in the current design (see Annex I) are generally seen as contributing to a more cost-efficient procurement of the needed capacity as compared to simple sequential auctions. Looking at the actual data from the Polish auction rounds, in the current setup the share of capacity procured in supplementary capacity auctions is marginal while the costs of capacity contracted through them are generally lower (Figure 24). At the same time, bidding 5 years in advance is associated with a high degree of uncertainty and thus with a higher risk premium that providers place on such bids.

Two ways to improve the market design in this regard would be:

1. **Improve the ratio of longer-term vs. shorter-term auctions:** A more dynamic distribution of the volume procured in the main and supplementary auctions could both help reduce the costs and potentially the volume of contracted capacity. This refers to increasing the share of capacity procured in supplementary auctions. Depending on their frequency, additional season-specific needs can be considered.

2. **Increase main auction frequency**: Decrease the contract duration of the main auctions and the lead time (e.g. to Y-4) to reduce the lock-in of high capacity prices, a significant component of which is a risk premium. It can also be argued that this is in line with the shorter planning horizons of new types of flexible assets.

In addition to system benefits, this approach can to an extent reduce forecasting errors of capacity providers driven by long contract durations, as observed in Section 3.4.1.

In addition, capacity requirements and probability of system-stress events are not distributed evenly throughout out the year. That said, **adapting the capacity demand to the seasonal needs** might help to allocate capacity costs to the periods when it is needed the most.

3.4.6. Locational component?

The experience of other EU countries with high and rapidly growing shares of renewable generation, such as Germany, the Netherlands or Spain, show that, besides contributing to the system variability, weather-dependent renewables may also aggravate network congestion in the absence of location-specific signals in the zonal market design. Several ways of dealing with this issue are being considered, such as location-specific grid tariffs or connection charges.

In theory, a capacity market could also be used as a lever to encourage investment in more “grid-friendly” locations. For instance, such a local component is currently under consideration among the German TSOs for the inclusion into the German capacity market proposal (Consentec & EcoLogic, 2024). Although this concern is not particularly high on the Polish agenda at the moment, the experience of other countries, for instance the Netherlands, demonstrates that the pace with which congestion concerns may materialize can accelerate rather suddenly, in the course of just a few years. **While pondering its future CM design, Poland could consider the likelihood of such a scenario and ensure that it is countered by providing location-specific incentives to capacity in its auctions.**

From the point of view of implementation, such an approach would be possible thanks to the locational information already submitted by capacity providers during the certification process. What is less trivial is how such a differentiation based on location is made in the auction. Two ways to implement it could be conceivable:

1) by setting up regional auctions,

2) by factoring in the "value" of a specific location into the bid price: the price of a bid that is located in an area where operation or investment is encouraged would receive a markup on its price. Conversely, an asset located in a congestion-prone area would receive a markdown on its price. It should be noted, however, that the definition of such markup or markdown factors is far from trivial.

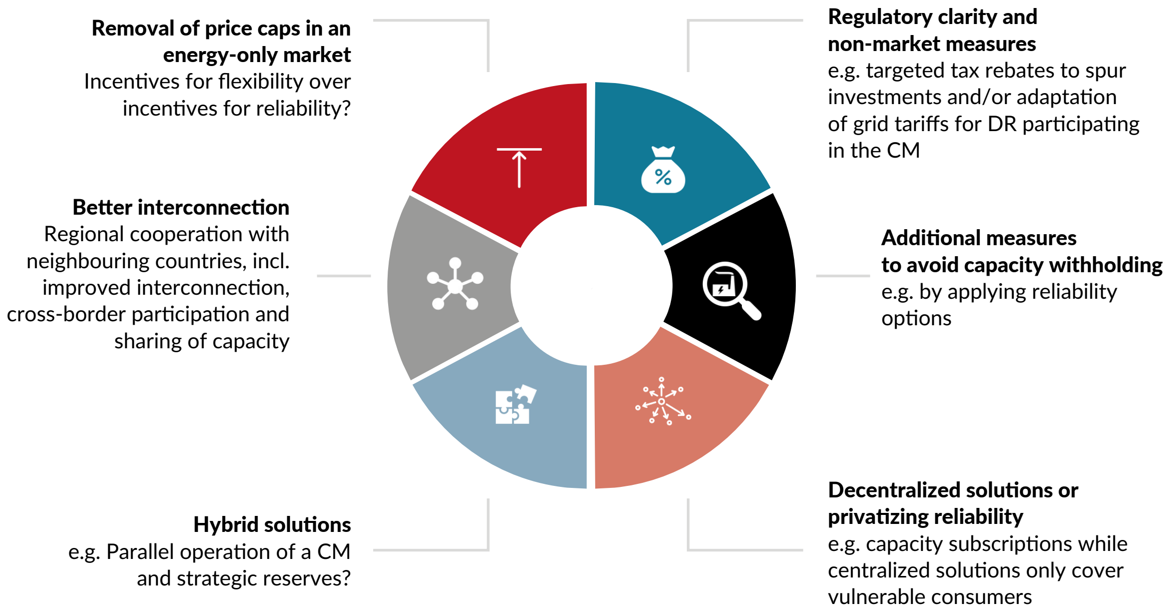
Based on the discussions with stakeholders, the value of such a measure is limited in particular in the view of the grid expansion plans of the TSO.

Although these measures could help contribute to the goals discussed above, especially in improving cost-efficiency and securing additional liquidity and investment, we see that they are unlikely to achieve all the goals on their own.

3.5. What complementary or alternative measures can be considered?

The discussion above shows that the target state should ideally fulfil several goals – beyond formally ensuring system adequacy. If that is the case, then implementing additional measures or even alternatives to capacity markets can be considered (Figure 21).

Figure 21. Possible additional or alternative approaches to capacity markets



3.5.1. Removing of price caps in the wholesale electricity markets and improved interconnection

Two options from the energy-only market would be 1) to remove market price caps (see Annex I) and 2) to ensure better interconnection with the neighboring countries. Such options may sound appealing since the costs of their implementation are much more limited if compared to capacity markets.

Removing price caps in wholesale markets might lead to extremely high prices, yet they may not necessarily be motivated by physical scarcity. Cost recovery of capacity would depend a lot on the frequency of such events. Even though the costs of a capacity market would be saved, potential price spikes may undermine the benefits besides likely not being politically acceptable. This latter point was already observed during the energy crisis 2022-23. A related approach would be an introduction of a scarcity function to reflect situation of extreme shortness of the system. Such a function is usually added to the imbalance price and can either substitute or co-exist with a capacity market (e.g. in Belgium or in ERCOT, Texas).

Similarly, the energy crisis demonstrated the value of interconnection among EU countries, which creates a more resilient system overall. For instance, as two thirds of the French nuclear fleet was unavailable due to maintenance issues and problems with cooling, the French consumers did not experience shortages thanks to the imports from Spain, Switzerland and Germany. In particular smaller states can technically "free ride" of capacity commitments of the neighboring states and thus avoiding national payments for the availability of capacity. However, it is a difficult balance to strike between increased reliance on the neighbors and self-sufficiency. Based on the latest ERAA results, adequacy concerns – albeit to a lesser extent than in Poland – were identified in most EU countries. In the worst case, there is no supply to import from the neighbors. A good middle ground and an option to explore could be an enhanced regional cooperation, e.g. either improved cross-border participation (see Section 3.4) and/or through a common procurement of strategic reserves (see also the next measure).

3.5.2. Hybrid solutions[17]

Parallel operation of a capacity market and a strategic reserve (SR)

The option of a parallel operation of a CM and an SR in Poland is interesting from the perspective of providing a potential way out to solving its "coal dilemma"[18]. That is, it may offer a way to avoid the mothballing of existing coal generation while restricting its access to the CM. Since units forming part of an SR are also excluded from market participation, this approach would also limit coal generation's impact on the wholesale electricity markets. As a result, this would reduce the activation of carbon-intense generation to the times of extreme price scarcity.

At the same time, however, removal of coal-fired generation in the short term can pose serious risk for the electricity markets, security of supply and self-sufficiency. Given that, as of 2023, almost half of the total Polish installed capacity consisted of hard coal and lignite (see Section 2.2.2) that are also the major source of electricity generation, their removal would require a considerable increase in electricity imports from the neighbors and will likely come at the cost of increased electricity prices in the country. It makes it evident that, **if introduced, the transfer of coal-fired generation to SR requires a transition period since an overnight implementation may pose a considerable system risk.**

Two possible adaptations to mitigate these concerns would be:

1. **Introduction of a seasonal SR (such as in France or in Sweden):** this could provide additional security in times of high system stress while the rest of the year coal generation would not be excluded from wholesale market participation. Care should be taken, however, so that this approach does not backfire in the worst case, taking coal-fired generation out of the market when the system is likely to be the shortest can aggravate the adequacy concern instead of relieving it.

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17 This sub-section provides a limited overview of hybrid options. Other variants and their links to flexibility will be discussed in Part 2 of this report.

18 For background, Poland used to apply strategic reserves, yet they were never used as the start-up time was too long (exceeding 12 hours). In the end, the European Commission required Poland to remove the SR on the grounds of it being market-distortive – as well as the removal of an Operational Capacity Reserve. Thus, if re-introduced, a careful consideration of adaptations to its design will be needed.

2. **Cross-border procurement and sharing of strategic reserves**: unlike capacity markets, the EU Electricity Regulation does not oblige Member States to allow cross-border procurement where it is "technically infeasible". Neither does it mention a possibility to share SRs among neighboring Member States. Our understanding is that this would require a joint application to the European Commission[19]. Sharing of reserves can help reduce their overall volume and costs for both/all participating countries. However, care should be taken with regard to several points:
   - finding a balance between cost-effectiveness (sharing of costs among cooperating MSs) and energy autonomy,
   - an issue of cross-subsidization: is it more efficient to "sponsor" capacity elsewhere considering that in a crucial moment of system stress, cross-zonal transfer capacity on the interconnectors might not be (fully) available?
   - special procedures need to be defined for situations where a system stress event is registered in both reserve-sharing States.

From a regulatory perspective, nothing in the EMDR precludes a Member State from applying several capacity mechanisms – provided these were approved by the Commission. However, the EMDR places restrictions on carbon intensity of capacity "mechanisms" and not "markets" (Art. 22.4). This implies that this limit applies to strategic reserves as well. Unless a derogation is secured, this requirement is problematic for Poland as it undermines the main reasoning behind introducing a new SR.

In sum, parallel operation of a CM and an SR seems to have more drawbacks than benefits. At the same time, SRs serve a very narrow objective and do not enable new investments. Two additional options, seasonal SRs or shared cross-border SRs do mitigate some of the associated concerns yet require additional analysis to clarify design questions. From a regulatory perspective, a derogation would be required to enable the inclusion of highly polluting coal generation into an SR, otherwise, its application in Poland is seen as limited. If granted, a transition period is highly advisable to avoid system risks.

3.5.3. Measures to avoid capacity withholding

Lack of sufficient generation to cover demand is not necessarily motivated by physical reality. This is especially true today, when European energy systems are still characterized by higher or lower degrees of overcapacity – despite the growing shares of intermittent RES. And yet, different markets (e.g. day-ahead or balancing) can register scarcity driven by economic considerations or bidding strategies of the participants as well as by the availability of cross-zonal capacity. The more frequent such events – regardless of the underlying reason – the higher is the estimated adequacy concern and the demand for reserve capacity. One way to mitigate such behavior is an obligation of all generation units and DR to bid capacity in the CM. Another approach to the same issue, however, would be the application of reliability options (see Annex I for details).

A CM in many ways acts an insurance mechanism against low-probability, high-impact events of system stress. Reliability options (ROs) could be a way to reflect this insurance-like property. They are already applied in some CMs, e.g. in Belgium, Ireland or Italy.

ROs are essentially call options on capacity that providers sell to the TSO in exchange for a premium (see also Annex I). When selling ROs, producers agree to supply energy to the market and are required to return any excess revenues to the TSO if electricity prices exceed a predetermined strike price. **This obligation to return extra revenues acts as an implicit penalty: it deters producers from withholding capacity to exploit price spikes for higher profits** (Andreis L. et al., 2020).

19 We are not aware of a similar precedent in the EU.

For consumers, ROs two main benefits are:

- **Preventing windfall profits**: Since the capacity provider already receives a capacity payment in addition to energy market revenues, high energy prices would otherwise lead to excess, double compensation. This would be considered an unearned windfall profit.
- **Enhancing availability incentives:** Because capacity providers are required to pay back when energy prices exceed the strike price—moments often associated with system (near-)scarcity—there is an additional incentive for them to ensure they are available to the system during these critical times.

From an economic perspective, ROs are more cost-efficient than capacity auctions alone thanks to their inherent payback mechanism. It, however, relies on the assumption that there is still a certain level of overcapacity in the system and ensures that this capacity is indeed provided to the market against the risk of a payback. As we showed in Section 2.2.1, a capacity gap in Poland is looming past 2028. If this risk materializes, ROs alone may be insufficient to guarantee that additional capacity is actually invested into – unless the option value is significantly raised.

From a design perspective, special attention should be paid to striking the balance between an adequate degree of protection of consumers from extreme costs (i.e. by setting the strike price) and providing sufficient revenue to capacity providers (i.e. through the capacity premium). As this measure is out of the scope of current discussion in Poland, it was not analyzed or pursued further in this report.

3.5.4. Privatizing reliability

An alternative could be using a decentralized approach to reliability, such as capacity subscriptions. **Although yet not implemented, it was suggested in research to potentially treat resource adequacy as a private good, proposing various priority service models with different levels of guaranteed supply at different prices.** Despite historical reluctance to implement these models, current trends suggest it may be time to adopt them to prevent escalating CM costs (Schittekatte & Meeus, 2021). Capacity subscriptions essentially refer to a mechanism that allows consumers to freely decide their desired level of reliability (i.e. uninterrupted supply) instead of it being administratively set by the regulator and the TSO. This would incentivize consumers and specifically demand response to keep the level of demand within the subscription limits. The TSO would then only be responsible for guaranteeing supply to vulnerable consumer groups (either through auctions or potentially through reliability options – see Section 3.5.3). Privatization of reliability could arguably significantly limit overall capacity costs and remove at least one side of the information asymmetry, which can potentially lead to over-procurement and higher auction costs.

On the downside, turning reliability into a private good might not be politically palatable, at least in the short term. In addition, such an approach does not necessarily fulfil capacity providers' needs meaning that the incentive to invest may not be given.

3.5.5. Non-market measures

Apart from the market-specific measures, other approaches might have a positive impact on the security of supply.

As mentioned in Section 3.3, overall regulatory clarity and non-market support could complement CM functioning. Regarding the former, regulatory certainty taps into one of the main needs on the provider side, that of cost recovery and risk management. Frequent adaptations of the regulation surrounding CMs (e.g. the introduction of emissions limits or reduction of de-rating factors for batteries) create a shock for providers whose effects are often difficult to anticipate.

Concerning the latter, **targeted tax reductions** have shown to give a much-needed boost specifically to new investments, which will be urgently needed especially from 2028 and before the new nuclear generation is commissioned.

A good example of positive effects of such an approach comes from the US, which passed its Inflation Reduction Act (IRA) in August 2022. Among others, the IRA introduced two types of tax credits and rebates:

- Investment Tax Credit (ITC) was made more accessible for a variety of clean energy projects, including batteries and other energy storage systems. This credit, which has a similar effect to a grant, covers up to 30% of the investment cost, significantly reducing the financial burden on companies and encouraging more projects to move forward (IRS, 2022).
- Production Tax Credit (PTC) supports the production of renewable energy and extends to energy storage. It provides a kWh-benefit for the first ten years of a facility's operation, making long-term investments more attractive.

The benefit of such an approach is that it can target specific groups of investment thus aiding diversification and decarbonization without affecting market functioning. It should, however, be associated with a "phase-out" plan both for public budget management and regulatory certainty.

The final non-market measure we propose for consideration is linked to the issues of allocation of CM costs[20].

Demand response already constitutes about a fifth of the capacity contracted through the CM. Besides this, so-called explicit DR, implicit (i.e. out-of-market) DR should further be encouraged, following the EMDR. Since adequacy is linked to covering the demand, making the demand side more responsive to price signals helps overall adequacy. The three levers of implicit demand response are linked to the structure of a consumer bill:

1. **The energy component:** consumers may save energy costs through exposure to dynamic pricing linked to electricity market prices and/or system needs.
2. **The grid fee component:** which includes the costs of the CM.
3. **Taxes and levies:** although incentives using this bill component are less common, they could be considered specifically for more vulnerable consumers.

The grid fee component is particularly relevant from the point of view of cost allocation. Participation of demand response in the CM and the subsequent method of allocating CM costs to consumers through grid fees can create a contradiction. This contradiction, first of all, stems from a misalignment of incentives: capacity market costs are typically passed on to consumers through grid fees based on their electricity consumption. This allocation method does not differentiate between consumers who participate in demand response programs and those who do not. As a result, even consumers who actively reduce their demand to help stabilize the grid might still face the same grid fees as those who do not participate in DR programs. This diminishes the financial incentives for consumers to engage in demand response, as they do not receive a direct reduction in their grid fees for their participation.

Since grid fees are usually distributed evenly among all consumers based on their electricity usage, consumers who invest in demand response technologies and strategies may feel unfairly burdened. They contribute to grid stability but do not see a proportionate decrease in their costs, which can be seen as inequitable. This could discourage wider adoption of demand response initiatives. If grid fees do not appropriately reflect the benefits provided by demand response, it may lead to inefficiencies in cost recovery and resource allocation.

For example, creating specific incentives or rebates for consumers participating in demand response programs could align costs and benefits more accurately. Alternatively, designing capacity market cost allocation mechanisms that account for the contributions of demand response participants could ensure a fairer distribution of costs and help create a more balanced and equitable system. More specifically, this can be done by:

- Reducing grid fees during peak demand periods for those who actively reduce their consumption.
- Offering incentive-based reductions of grid fees, which can either be related to explicit volume (MW) of participation in the CM or to implicit demand response during peak hours.
- Providing exemptions or reduced capacity market charges for participating DR to avoid an unfair economic burden on contributors.

20 A more detailed analysis of non-market measures is beyond the scope of this report.

This approach also requires care as in a scenario where high shares of demand provide DSR service in the CM or otherwise, the overall pot of the costs needs to be distributed among a smaller number of consumers. If not managed carefully, this can lead to disproportionately high costs for those consumers for whom the provision of such flexibility is more difficult to accomplish.

3.6. Summary of the outcomes

In the context of the recent developments at the EU level that establish a stronger link between adequacy and flexibility, Poland has a chance to be "ahead of the curve" and incorporate flexibility-related aspects into its market design.

Based on the qualitative analysis provided in this Section, several important observations can be made:

1. Besides purely formal requirements, the capacity market should ideally fulfil multiple goals both from the system's and the participants' perspectives to ensure its efficient functioning and adequate incentives.
2. The analysis indicates that these numerous goals can hardly be fully addressed by the CM alone.
3. A number of capacity market design adaptations can contribute to the achievement of the goals, such as further reduction of the minimum bid size, advanced aggregation rules, rolling auctions or dedicated auctions for new investments.
4. A combination with a strategic reserve appears to be challenging both from the regulatory perspective and from the point of view of contributing to the target state (due to very long activation times, among others), as described in Section 3.3.

5. Several complementary measures can be considered, in particular the implementation of reliability options, which should both help reduce capacity costs and provide a strong incentive to avoid capacity withholding. Non-market measures such as dedicated investment support for key technologies or tax rebates as well as adjustment of grid tariffs, in particular for DR, can further contribute to the achievement of the system goals in the view of its evolving needs.

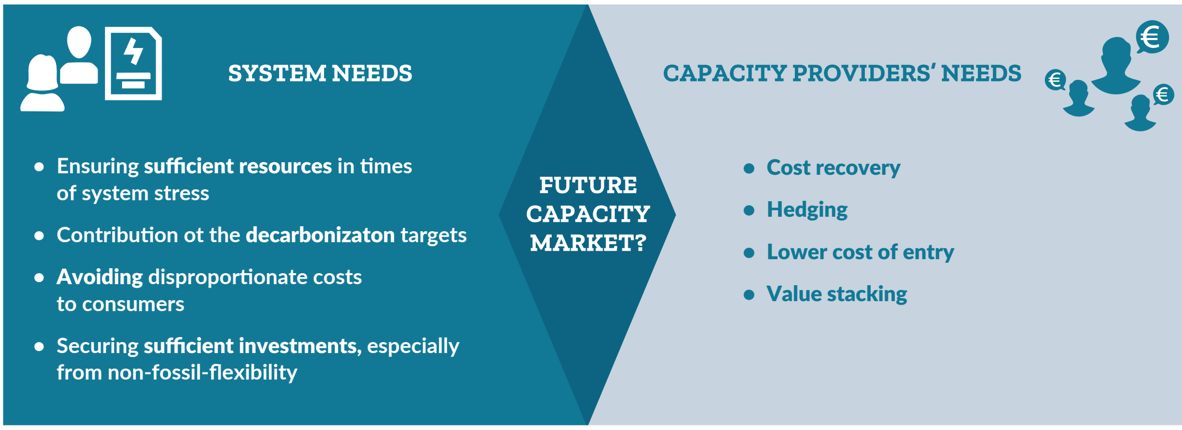
Instead of trying to find alternative ways for financing coal-fired generation, the main focus of the CM reform should be on incentivizing and securing as much new investment as possible. It should then be combined with the increased flexibilization of the demand side, considering CM participation but also associated cost allocation through tariffs.

What we also show is that, in order to understand the way forward for the CM, it is necessary to consider the bigger picture, that is, other marketplaces as well as other instruments affecting providers' incentives, especially grid tariffs and cost allocation.

What this report does not address in more detail is the additional flexibility dimension and its link to capacity markets. A dedicated second part of this report will elucidate this link and possible scenarios for the Polish electricity market in detail.

4. Conclusion and recommendations concerning implementation and complimentary mechanisms

In this report, we reviewed the Polish capacity market design and its performance in the eight auctions of its existence. Generally, the functioning of the Polish CM has been progressively aligning with the overarching goals of the energy system, especially in the last two auction rounds terms of promoting a more diversified resource mix and encouraging low-carbon investments. However, what we also saw is that new investments and technologies largely reacted to the exit of coal generation due to emissions limits rather than thanks to positive adaptation of CM design. This reaction also happened with a time lag so that coal generation is still cumulatively by far the largest provider of reserves in the country. Also, the costs of the CM to consumers have been on the rise.



Looking at the target state defined in Section 3.3 and shown below, there are additional needs that are relevant when discussing the future of the Polish CM. In terms of decarbonization, it is important to remember that the CM contracts availability and is less concerned with the actual energy activation making its contribution to this goal limited. However, a well-designed CM can still provide an indirect contribution to decarbonization by supporting investment in low-carbon and carbon-free technologies, such as battery or thermal storage or demand response.

The success of the future CM also depends on the adequate incentives on the provider side. Cost recovery is one of them. As the wholesale markets are getting more volatile and prices sometimes get negative, capacity providers are on the lookout for stable revenue streams seeing the CM as a good hedging opportunity. Its value certainly also depends on the liquidity and availability of other markets, especially the balancing markets re-designed in Poland only very recently.

That said, what are the measures that can be recommended to improve the CM functioning post-2025?

It seems most likely that the country will reapply for a capacity market. While the original CM application was allegedly driven by a market failure, this time around Poland is exposed to a serious adequacy concern based on the ERAA results (see Section 2.2.1 for details). It is bound to increase post-2028 after the expiration of coal capacity contracts thus increasing the pressure on the CM to deliver significant new investments that would be operational by the end of the 2020s.

In light of a push towards clean energy transition in Poland, it is important to consider **measures that would contribute to enabling clean(er) technologies in the CM.** As mentioned in Section 2, Poland already applies a green bonus extending contracts for low-carbon energy by two years. Following the CEEAG (see Section 1.3.2) and the new EMDR provisions, the conditions of the green bonus should be tightened in alignment with a new CO_2 threshold of 350 g CO_2/kW/year in order to exclude gas-fired generation from profiting in the scheme – unless it is converted to be hydrogen-ready.

In order to increase attractiveness of the CM for the entry of smaller and/or less experienced market actors, it is recommended **not only to reduce the minimum bid size to 1 MW but also accompany it with additional facilitating measures.** High non-delivery penalties have been cited as a frequent barrier. A possible approach could be designing **volume-dependent penalties,** that is, capacity providers with small-scale portfolios will be exposed to lower non-delivery penalties than large portfolios. This is also in line with a more limited system impact of smaller providers.

Updated rules for aggregated, mixed-technology portfolios are recommended to specifically account for:

- allowing mixed-resource portfolios behind the same metering point,
- introducing submetering: this should, among others, allow more DSR providers to participate in the CM despite having carbon-intensive back-up generation (e.g. running on diesel)[21],
- facilitating a more flexible certification process for existing providers in the event of portfolio adaptations – this is further in line with the draft Network Code on Demand Response,
- revising a de-rating factor for portfolios based on the weighted average factor of all participating technologies (instead of using the factor of the technology with the lowest one, as per current rules).

Concerning the frequency of auctions, CMs are expected to both provide long-term investment signals and sufficient flexibility to account to the evolving system needs. Thus, it is recommended to either:

1) increase the frequency of the main auction while increasing the shares of capacity procured in the supplementary auctions or

2) introduce rolling auctions, for instance in a tempo of 5-3-1 (every 5, every 3 and every year) to balance long-term signals with flexibility. This should also allow providers to choose the auction based on their hedging strategy and forecasting capabilities.

Concerning the product design, according to the Recital 47 of the EU Electricity Regulation, countries already applying a capacity mechanism can either integrate the measures facilitating the participation of non-fossil flexibility in the mechanisms or introduce additional flexibility support schemes for such resources. This creates a legal background for the implementation of a two-tier approach to the future Polish capacity market, which still observes the criterion of technology neutrality. In this sense, it is proposed to procure two products on the capacity market based on the key technical characteristic of capacity resources:

1) **firm capacity product** designed to ensure support and investment in reliable generation technologies to offer longer periods of adequacy support in the events of prolonged system stress and

2) **flexible capacity product** designed to quickly react to the situations of system stress, such as various storage technologies (electrochemical, heat) and demand response, in line with the provisions of the EMDR. This product can, for instance, also be made eligible for longer capacity contracts.

Finally, to ensure that consumers are not disproportionately affected by the rising costs of capacity remuneration mechanisms while ensuring an adequate level of return, **it is proposed to introduce reliability options in the Polish CM**, following the examples of other Member States, such as Belgium or Italy already applying reliability options to their CM design (Elia, 2024 and RSE, 2023). Additional analysis is required to define an appropriate strike price and the basis for it (cf. individual hours vs. monthly averages). Combining reliability options with non-market measures, such as **tax rebates or grants for carbon-free technologies and revised cost allocation principles for DSR providers participating in the CM**.

All in all, what is clear from the analysis above is that **the capacity market cannot and should not be seen as a panacea for all the woes of the Polish energy system. Other elements and adaptations of other markets (especially balancing) will be necessary to finally support diversification and decarbonization.**

21 Availability of such highly polluting generation excludes DSR providers on the grounds of exceeding CO_2 limits even if the generator itself does not form part of the portfolio or is intended to be activated as a result of system stress.

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ANNEX I

Analysis of the current Polish capacity market design

Reason for the market

Although from a purely legal perspective the main raison d'être for a capacity mechanism should be an adequacy issue, as identified by a European or national RAA, the introduction (or preservation) of a CM can serve several additional purposes. In Poland, these purposes included avoiding mothballing (i.e. temporarily shutting down) or decommissioning of inefficient generation beyond 2020 and linked to that, the so-called "missing money" problem (the European Commission, 2018).

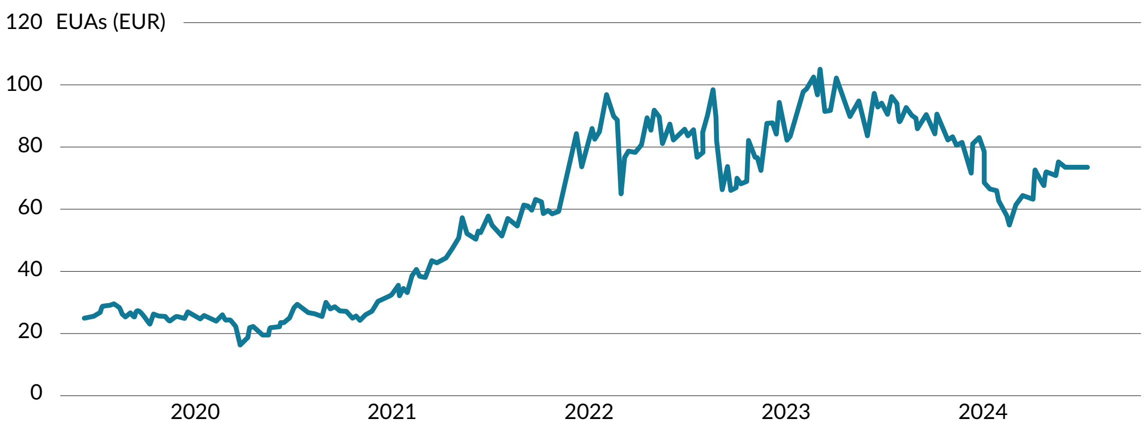
It is rather common to mitigate the missing money problem with a CM, yet its occurrence is very much linked to the design of an energy-only market. For instance, price caps that are set too low to recoup costs and/or guarantee a reasonable margin accelerate the exit of generation capacity. At the same time, "missing money" can be seen as a contradictory argument. The EU countries' supply has been historically characterized by *overcapacity* and lack of sufficient remuneration of certain technologies does not *per se* justify a CM, which is linked to a risk of *insufficient* capacity.

Concerning the price caps, in Single Day-ahead Market Coupling (SDAC), the harmonized maximum and minimum clearing prices (HMMCP) are set to +4,000 EUR/MWh and -500 EUR/MWh. In the intraday (ID) continuous (and since June 13, 2024, also in the ID auctions), the HMMCP are set to +9,999 EUR/MWh and -9,999 EUR/MWh (ACER, 2023b). These limits appear more than sufficient to cover both fixed and variable costs of most generation technologies. However, other similar measures were much more drastic. For instance, in an effort to shield consumers of extreme prices during the energy crisis of 2022-2023, the EU applied a temporary cap on inframarginal rent of maximum 180 EUR/MWh. The efficiency of this measure is still debated; however, it did shake the confidence of market participants and significantly affected the investment climate across the EU (European Parliament, 2023).

In terms of existing, traditional generation technologies such as coal and gas, other factors affecting their economic viability include:

- Prices of CO_2 allowances, which have been increasing both in absolute terms and in volatility since 2020 and at the time of writing exceeded 70€/ton of CO_2 (Figure 22), which becomes a considerable cost component of coal and gas generation.
- The so-called "merit order effect", which materializes as more renewable generation with next-to-zero marginal costs enters the market substituting more expensive generation, thus – sometimes significantly – reducing its capacity factor. In particular variable solar generation reached a 40-fold increase between 2018 and 2023 from barely 1% to almost 20% of the total Polish generation mix.

Figure 22. Evolution of prices of CO_2 allowances in the EU between 2020 and 2024



Source: Ember (2024b).

As a result, a market design may not provide sufficient incentives for generators to invest in new capacity or maintain existing capacity, especially in times of overcapacity or when renewable energy sources, with low operating costs, dominate the market.

When it comes to investment into new generation, one of the main hindering factors is uncertainty:

- **Market-related,** which affects expected revenues, and which is, for instance, driven by high price volatility. This also includes negative prices that are becoming more and more common across the EU countries and were observed in Poland for the first time in 2023. Such volatility is often caused by the abrupt changes in the renewable-based production as well as by the associated forecast errors. As to negative prices, in the Polish market they have already been observed on multiple occasions since 2023 (see Section 2.2.4). The occurrence of negative prices can be in theory beneficial to storage technologies or demand response but negatively affect any generation technology increasing the need for additional revenues from elsewhere.
- **Regulation-related,** which increases overall investment risk (and hence, cost of capital), in particular in the event of a market intervention.

With regard to uncertainty, the industry priorities in favor of CMs seem to be motivated by the fact that these offer a steady long-term revenue stream as a way to hedge against otherwise high risks on energy-only markets. In addition, depending on activation rates, a CM is also an attractive option for market actors as it reduces exposure to fuel price risk while it doesn't affect the lifetime of an asset in the same way a MWh-based market does. Consider for instance a battery storage remaining available through a capacity market, yet not spending cycles for activation while still receiving a payment.

To address the issues of financial viability of generation assets and security of supply, a capacity market was introduced in Poland. It further underpins the fact that actual generation output is not the same across technologies and not the same as installed capacity. That is, the actual generation from RES is much different from the installed capacity driven by weather-related and seasonal factors. It can produce a situation in which a country with 100% renewables might have overcapacity based on peak load yet have an adequacy concern based on their actual availability.

Product and auction type

Similar to other CMs in Europe and following the EU regulatory provisions, capacity is the only product procured and remunerated. That is, actual activation in an event of system stress is mandatory and not remunerated extra.

The Polish CM uses a so-called Dutch descending clock auction type. Such auctions start at a high price that decreases over time, with lower prices announced in several rounds. Capacity bidders indicate the quantity they are willing to supply as the price drops, and the auction ends when supply hits the demand function. This action type is known to encourage an efficient price discovery and that bidders reveal their true minimum acceptable price early (e.g. Ausubel & Cramton, 2004).

In the Polish CM this involves multiple rounds where participants can submit exit offers. Failure to submit an exit offer in a round implies acceptance of the starting price for the next round. The auction concludes either after the final round or when the remaining volume of capacity obligations, after considering exit bids, aligns with the demand indicated by the capacity demand curve for the starting price of the next round. Following the auction, successful capacity providers enter into capacity agreements (PSE, 2022).

On the flipside, Dutch descending clock auctions have notable drawbacks. Bidders might engage in strategic behavior by delaying their bids to lower prices, leading to inefficiencies. The auction's complexity can deter less experienced bidders with less market information. As a result, larger bidders with more market power can manipulate outcomes, potentially squeezing out smaller or newer participants (see also the section on the "Pricing Rule" below).

Eligibility requirements and minimum bid size

In terms of the participation requirements, a wide range of technologies is eligible to get certified and bid into the CM, including demand response and storage. The entry into the registry is subject of a verification and an approval process by the TSO (and relevant DSOs). The certification process for capacity-providing units is also conducted in coordination with a relevant DSO, wherever applicable. No restriction is made concerning the participation of units connected to the distribution grid. All assets on the TSO or DSO level must provide a location (up to substation name). The units for which an application is made should be included in a dedicated registry (PSE, 2020). Both existing and new generating units as well as DR units (with or without an internal energy source) can be certified.

Notably, the CM rules include all types of physical generating units, incl. co-generation (with heat) and storage technologies as well as a broad range of energy production types including variable renewables, wind and solar, or even hydrogen (Section 6.2.2., PSE, 2020). Note that energy storage systems are held to the same capacity obligations as generation units in the capacity market.

The certification requirements are quite comprehensive in terms of the extent of detailed information required as well as an operational plan for a unit over 5 years after the completion of the certification process. This includes for generation units: net maximum monthly capacity in MW or maximum expected output in MWh to co-generation (accounting for the power-to-heat ratio), wind or solar, as well as total planned monthly unavailability. The requirements for DR units include detailing the planned total maximum capacity of all physical demand response units and providing a detailed business plan. This business plan must include the estimated number, capacity range, locations, methods for capacity reduction, technological setup and the progress of acquiring the physical demand side response units (Section 6.3.2.10, PSE, 2020).

In terms of the minimum bid size of 2MW, it is within the typical range between 1 and 5 MW in the EU capacity markets. Yet it would be beneficial to further reduce it to 1MW in order to facilitate the entry of smaller-scale providers. This is in line with the trends in other electricity market where minimum bid size has been gradually decreasing.

One of the ways to avoid the limitation of the minimum bid size is through aggregation. According to the CM rules, a group of physical units may be aggregated to a single unit (e.g. Section 15.1.1, PSE, 2020), however, it tends to significantly limit contract duration (from 5 to 1 year), negatively affecting investment plannability.

In sum, although the participation of a broad range of technologies is formally allowed, the requirements in terms of data provision are rather high – which may make participation substantially less attractive for smaller-scale providers with less experience.

Auction frequency

Polish CM used so-called staggered auctions, that is, in the same year, several auctions are held for different horizons:

1) main auction 5 years ahead (Y-5),
2) supplementary (quarterly) auctions 1 year ahead (Y-1).

The latter were originally designed for combined heat-and-power plants (CHP) given their different production profiles.

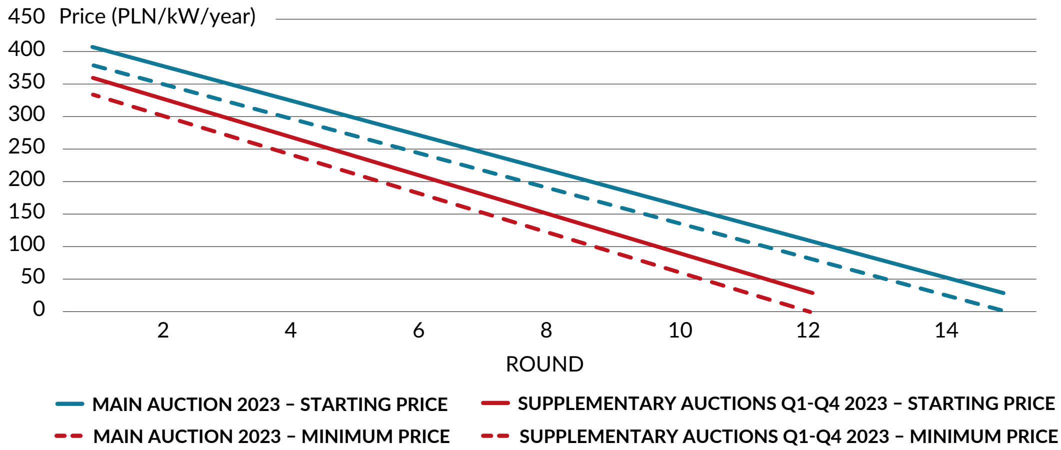
In general, having several auctions at different time resolutions in capacity markets helps balance long-term planning with short-term flexibility. Staggered auctions allow regulators and the TSO to adapt to policy changes, technological advancements, and other external factors while market actors can better manage planning and risk. More specifically:

- Y-5 auctions provide long-term planning and investment signals. In this way, they help ensure that there is adequate time to plan, finance, and construct new generation capacity or DR units. This is particularly important for large-scale projects that have long lead times. In contrast, T-1 auctions allow for shorter-term adjustments based on more recent and accurate information about supply and demand conditions. They provide flexibility to account for changes in demand forecasts, generation availability, regulatory changes, and other factors that could impact capacity requirements (for instance, think of the new information during the energy crisis and its impact on the participation of gas-fired generation).

- Staggered auctions aid risk management of the TSO and capacity providers' sides. By spreading the capacity procurement process over multiple auctions with different time horizons, market participants can adjust their strategies based on evolving market conditions and regulatory environments. It also reduces the risk of over-reliance on a single auction outcome for the TSO.
- Early Y-5 auctions secure a baseline level of capacity, while later auctions can finetune the capacity requirements.
- Finally, different timeframes for auctions could also encourage broader participation from a variety of capacity providing technologies, including those who may prefer long-term commitments and those who can offer shorter-term flexibility. This can lead to more competitive pricing and better market outcomes.

Looking at the specific prices in the main and supplementary auctions in 2023, we can observe that both the starting and minimum prices in the main auction are higher than in the supplementary one (Figure 24).

Figure 23. Starting and minimum prices of the main and supplementary auctions in 2023



Source: PSE, 2023.

There are several reasons why this is likely the case. First of all, longer contracts involve greater uncertainty and risk over time. Capacity providers demand higher prices to compensate for the risk associated with future market conditions, regulatory changes, fuel price volatility, and operational uncertainties over a longer period. Although such contracts represent guaranteed revenue over a longer period, it also comes at a cost since locking in capacity in this way is also associated with an opportunity cost. That is, by locking in capacity for a longer duration, they might miss out on potentially more lucrative short-term market opportunities. Higher prices in long-term contracts compensate for this opportunity cost. Finally, if providers expect the market to be tighter in the future, they will price longer-term contracts higher to reflect the anticipated higher value of capacity.

Pricing rule

The Polish auction uses so-called marginal pricing, that is, each awarded bidder receives the same price for their capacity.

Based on economic theory and extensive research, including in electricity markets, marginal pricing is generally considered superior to pay-as-bid auctions, i.e. auctions in which awarded bidders are remunerated based on own bid prices. It is said to promote efficiency and cost minimization by ensuring that the market clears at the lowest necessary cost to meet capacity requirements. That is, in a *competitive* market environment, this approach encourages participants to bid their true marginal costs, thereby selecting the most cost-effective resources. It also incentivizes market entry, as generators who bid at their marginal cost can potentially receive a higher market clearing price, covering more than their fixed costs (e.g. Joskow P. 2007).

It can further be argued that marginal pricing is crucial to provide a stable price signal, which reflects the current and anticipated scarcity of capacity crucial for long-term planning and investment decisions. Specifically for new or smaller-scale actors, it facilitates transparency and makes outcomes easier to predict and understand. Finally, it encourages demand-side participation by providing consistent price signals that prompt consumers to reduce demand during peak periods.

However, the debate about the most appropriate way to price MWs is far from closed. Particularly in less competitive environments, where the bulk of capacity is provided by the incumbents, it can further exacerbate market distortion, creating substantial cost increases for consumers. This is something to be mindful of in case of the Polish CM. For instance, based on the results of the main auction for delivery year 2027, out of 24 capacity providers, by far the largest shares belonged to 5 large incumbent companies, ENEA, ENEL X, ENERGA, Enspirion and PGE (PSE, 2022b).

In order to mitigate potential risks of marginal pricing, hybrid approaches are sometimes used. See, for instance, the sub-section on Reliability Options below.

Other capacity auction parameters

In the CM, the product offered is the net dispatchable capacity available during the Delivery Period, along with the requirement to provide this capacity during periods of system stress within that same Delivery Period. This requirement is known as the capacity obligation and is formalized through a capacity agreement with the PSE.

The obligation can be transferred to a different (certified) party or market unit and does not require TSO involvement (Section 12.6). Trading in obligations is organized in a secondary market.

The Auction Target Capacity does rely among other inputs on the capacity provided by interconnectors, yet those do not participate in the CM. It determines the maximum volume to be purchased.

The cost of new entry (CONE) is calculated based on the estimated costs, incl. CAPEX for the unit's construction, fixed and variable operating costs as well as the expected margin from the commercialization of generated electricity. The price cap is determined based on statistical data of the TSO using "typical fixed capital and operating costs" (PSE, 2020, Section 8.2.2.1).

Concerning the duration of activation, the gross maximum capacity is based on continuous operation for at least 4 consecutive hours. This requirement is in fact similar to other capacity markets both in the EU and the US (e.g. Italy or PJM in the US (e.g. PJM, 2020 and RSE, 2023)). Yet, the requirement for 4-hour long availability can be limiting for market participants. For instance, battery storage systems often face limitations with the 4-hour availability requirement. Many batteries are designed for shorter discharge durations, typically around 1-2 hours. While batteries can be engineered to meet a 4-hour requirement, it significantly increases costs and complexity. Similarly, RES such as solar and wind are inherently variable and would require substantial backup systems to guarantee continuous 4-hour output. Consequently, energy storage or backup generation systems need to be larger and more robust, increasing capital and operational expenditures. Small-scale or emerging technologies might be discouraged from participating in the market, which is already observed in the recent market results.

Cross-border participation

Participation of foreign capacity providers in the Polish capacity market was enabled for the first time starting from the delivery year 2025, driven by the obligation by the EU Electricity Regulation. To enable cross-border participation mandated by the EU regulation, TSOs must establish bilateral agreements with the neighboring TSOs. The Polish TSO, PSE, has signed agreements with Czech, Slovakian, Lithuanian, German[22] and Swedish TSOs. However, in its 2023 report, ACER raised a concern about the ensuring of a level playing field among domestic and foreign capacity providers in Poland (ACER, 2023). So far, only those foreign assets are allowed to participate in the Polish CM that are *directly connected* to the Polish network (ACER, 2023).

22 Only for assets connected to the network of 50Hertz before December 2023 and of all German TSOs for the subsequent auctions from then on (for delivery from 2028 onwards).

The requirements and eligibility criteria for foreign and domestic resources to participate in capacity mechanisms are essentially the same. However, the participation process for foreign resources in competitive auctions differs (PSE, 2020). Specifically, there are pre-auctions to identify the most cost-effective foreign resources per bidding zone border up to the maximum entry capacity (MEC) limit. But it can also be significantly lower than the MEC. That is, a pre-auction is held separately for each bidding zone (or area, as in the case of Germany, Czechia and Slovakia) and the bids submitted by these assets may *not* be adapted in the main auction (ACER, 2023).

As a result, foreign capacity market units participate in Polish capacity auctions only passively: the capacity provider is not required to take any action during the auction. Offers made during the pre-auction are automatically transferred into the capacity auction as exit offers. If the auction clearing price for a specific zone surpasses the price set by the capacity provider during the pre-auction, the capacity market unit wins the auction; otherwise, it does not. All capacity market units *within a zone* receive the same auction clearing price (PSE, 2022). Successful resources from the pre-auctions then move to the main auction, where they compete with both domestic resources and resources from other zones. The goal of the main auction is to find the cheapest resources, regardless of location, to meet the capacity requirement (PSE, 2020). As a result, foreign resources are paid less than domestic ones by design – except for a situation in which a foreign asset is marginal.

If foreign participation is below the MEC, Poland compensates by procuring additional domestic resources, potentially increasing costs for Polish consumers by selecting more expensive capacities. This situation was evident in the latest auction, where the allocated MEC was not fully utilized for two of the three foreign zones (ACER, 2023).

According to ACER, the two-stage approach used in Poland may disadvantage foreign resources, which must set their prices early with less information and cannot adjust bids similarly to domestic resources. One of the approaches to solving this discrepancy is suggested by ACER: pre-auctions could be used to allocate MEC tickets, allowing foreign resources to compete for these tickets first. In the second phase, all resources would compete in the main auction with the ability to adjust bids. All successful resources would receive the *same* remuneration, with foreign resources paying for the MEC tickets based on pre-auction results (ACER, 2023).

Application of reliability options

Other CMs in Europe (e.g. Belgium or Italy) using a centralized approach complement it with so-called reliability options (e.g. Elia, 2024). These refer to financial instruments designed to ensure the reliability of electricity supply and to control price spikes during scarcity events. Reliability options are not currently applied in the Polish CM.

Under reliability options, generation or DR providers commit to being available to supply a certain amount of electricity during scarcity events ensuring sufficient capacity to meet peak demand, similarly to regular CMs. Their additional elements include an option premium and a strike price. In return for the providers' commitment, they receive an option premium, which is a regular payment compensating them for being available to provide capacity when needed. This helps cover their fixed costs and provides a steady revenue stream.

A strike price is then established to cap the price consumers pay for electricity during scarcity periods. If the market price exceeds this strike price, capacity providers must *pay back* the difference to the market operator, effectively capping the price for consumers. This creates incentives for performance of capacity providers: if they fail to deliver the promised capacity during peak periods, they face financial penalties. This creates a strong incentive for them to ensure their capacity is available and reliable when most needed. At the same time, this mechanism provides a stable revenue stream through option premiums thus encouraging investment in new generation capacity and the maintenance of existing capacity. Further analysis is provided in Section 3.5.

Penalties

If a resource whose capacity was contracted was not available during the contracting period, it is liable for a penalty since non-availability risks aggravating system stress. In Poland, the contracted capacities are expected to be available all year round[23]. The units are called upon based on the day-ahead market outcome where the total offered volume does not exceed total demand in the same hour by more than 4-5%, indicating a high likelihood of a short system.

23 Compare, for instance with Sweden, France or Austria, whose capacity mechanisms (types of strategic reserves for SE and AT) are applicable only during the winter season when the estimated adequacy risk is considerably higher.

In case of non-availability, a capacity provider is subject to a penalty per MWh of non-available volume. As of 2023, it corresponded to 1,015 euro/MWh[24]– the number considerably lower than the VOLL estimated at 17,700 year/MWh, as calculated by the NRA, URE (URE, 2023).

Besides, for new CM units, the contract is terminated in the event of the capacity provider's failure to commission the capacity within 3 years. The developers of new resources are actively monitored on a quarterly basis and are obliged to submit a so-called investment report. During this process, they must prove within 24 months of contract signing that they have spent at least 10% of the required investment and secured agreements worth at least 20% of the investment. Failure to provide this evidence results in contract termination (ACER, 2023). If other resources are then needed to replace undelivered capacity, the share of the replacement costs is levied on the developer as a penalty.

New or refurbished capacity contracts must prove within 12 months of the auction results that they have met the Financial Commitment Milestone (FCM). Compliance is confirmed by submitting an FCM declaration to the TSO through the official register.

In addition, providers with multi-year capacity agreements must demonstrate the achievement of a Substantial Completion Milestone (SCM) before the first delivery period. For new units, this must be by the end of the third delivery year or the contract's end if shorter. An SCM declaration must be submitted to the TSO:

- confirming continuous capacity delivery at 95% of maximum for at least one hour,
- an independent study verifying compliance,
- a total capital expenditure declaration,
- completion of the project's schedule, among others.

In comparison, DSR units must also submit an SCM declaration, including an independent study verification, a capital expenditure declaration and a confirmation of the completed project's schedule.

Such stringent requirements are, on the one hand, meant to ensure actual project realization and/or units' availability, yet on the other hand, they significantly raise an administrative burden on providers, especially those planning new investments.

24 The NRA calculates the penalty on an annual basis.

Summary of analysis

The main design variables of the Polish CM described above are summarized in the table below.

Design variable	Polish market design	Comment
Reason for the market	Mothballing of inefficient generation; “missing money” problem as well as insufficient investments into new generation capacity	Additionally, to a formal adequacy concern
Product	Capacity availability (MW per year)	
Auction type	Centralized auctions	Dutch descending clock auctions
Eligibility requirements & certification	Both existing and new generation are eligible to participate; in terms of technologies, demand response and storage technologies are allowed as well as cross-border participation	Inclusion in a dedicated registry for generation or DR units is required in order to apply for certification Units are subject to performance tests
Minimum bid size	2 MW	Bids may be declared to be divisible (for such bids, it is possible to award only a part of the bid volume)
Auction frequency	Main yearly auctions in Y-5 and 4 quarterly auctions in Y-1	Quarterly auctions are held in parallel at the same time a year ahead of delivery
Price caps	Variable	Price caps ranged between 72.1 €/kW/year and 94.2 €/kW/year (for new capacity) while CONE amounted to 65.5 €/kW/year – 73.8 €/kW/year between the 1st and the 8th auction, respectively
Pricing rule	Marginal pricing	
Contract duration	1 year for existing capacity 5 to 15 years for new capacity depending on the level of capital expenditure with an extension of 2 years possible for low-carbon generation	DSR and refurbished generation capacity is eligible for a contract of max. 5 years
Capacity requirement	Target LOLE of 3h/y	No national reliability standard yet defined
Demand curve	Downward sloping, based on the auction target capacity, the price of market entry of a new generation unit as well as additional factors.	Based on forecasted capacity demand (Auction Target Capacity) The auction target capacity is calculated on a quarterly basis using stochastic analysis
Cross-border participation	Allowed	Participation in a pre-auction required; for selected bidders, prohibition to alter bids in the main auction
Application of reliability options	No	
Secondary market	OTC	The obligation can be transferred to another capacity provider or to another capacity market unit (i.e. certification is required)
Penalties	Yes	

* The CM design information is based on PSE, 2021.

For the sake of completeness, the KPI (key performance indicators) analysis presented in Section 2.2 is complemented by the design principles for capacity mechanisms listed in Art. 22.1 of the Electricity Regulation/EMDR, listed in a summarized form in the table below.

Overall, **the Polish capacity market complies with the design principles set out in the EU regulation, yet room for improvement exists with regard to the risk of market distortion, technological neutrality and cross-zonal participation.** The table below summarizes the elements of the Polish CM design which contribute to or hinder the fulfilment of the design principles set out in the Regulation.

Design principle	Contributing elements	Hindering elements
1. Reducing risk of market distortion	Participation of all technologies and cross-border participation allowed	The effect on wholesale market prices likely tangible due to large shares of overall installed generation in Poland participating in the CM[25]. This is likely to have a price-dampening effect and thus reducing the robustness of the wholesale market price as the main price signal for investments and limiting (short-term) incentives for flexibility. As shown in the Polish example, the introduction of the CM also leads to a delay of the exit of old and polluting generation from coal
2. Avoiding limitation of cross-zonal trade	Current CM design allows cross-border participation with the neighboring countries based on bilateral TSO agreements	Cross-border participation is restricted in terms of an obligation for foreign assets to enter a pre-auction and their inability to adapt bids before main auction limiting the clearing prices for these assets
3. Not going "beyond what is necessary to address adequacy concerns"	Exclusion of coal-fired plants exceeding CO_2 limits from participation in the CM may be seen as a removal of an indirect subsidy to polluting generation	The argument to the left can be reversed if a derogation from CO_2 limits is granted
4. Transparent, non-discriminatory, competitive selection process	A generally transparent process in which all CM units must follow a certification procedure and entered into a dedicated register. Formally, the CM is open to all types of energy carriers and technologies, including DSR, storage or renewables. The market is organized as a descending-clock Dutch auction and the pricing rule based on the marginal bid	Minimum bid size requirement, duration of activation of 4 hours as well as limiting de-rating factors (e.g. consider also recent reduction of derating factors for battery storage) indirectly hinder implementation of a non-discriminatory approach. Extensive certification and compliance requirements are easier for large incumbent providers to comply with. No special rules for small-scale providers available
5. Providing availability incentives	Regular active monitoring and associated penalties for non-availability[26]	
6. Ensuring market-based remuneration	Yes. Staggered auctions further support market efficiency	
7. Ensuring technology neutrality	Yes, although minimum bid size in combination with de-rating factors may hamper participation of certain technologies	See comment to Point #4
8. Applying "appropriate" penalties	Yes	Penalties for non-delivery may be seen as insufficiently high as these were substantially lower than the VOLL

25 Looking at Poland, the total installed generation capacity amounted to about 51.3GW as of 2023. For the same year, the Polish CM counted with over 24GW of contracted capacity (PSE, 2023) – that is almost half of the total capacity. Hence, the impact of the CM participation on the wholesale prices is likely considerable.

26 Note that capacity providers only receive availability payments for their participation (i.e. MW-based) and not for actual activation (i.e. MWh-based). While so far actual activations have been highly unlikely, based on the ERAA results, this is likely to change as early as 2028 (see Section 2.2.1). This may further drive capacity prices upwards as providers will be more likely to price the risk of actual activation into their capacity bids.

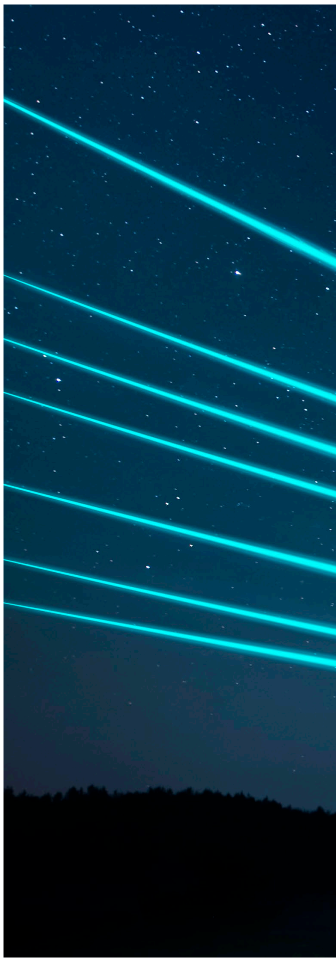
It is a common argument against capacity mechanisms and CMs in particular that these contribute to market distortion, as explained in the table above. In general, however, this risk can never be fully mitigated due to a fundamental information asymmetry between the market facilitator and the market participants. At the same time, market distortion is hard to identify or prove, as the scenario without a CM is hypothetical. From a purely economic perspective, we can note that the dampening effect on wholesale market prices is likely to be pronounced, the larger the shares of total installed capacity participating in a capacity market are.

Notes

Notes

Redesigning Poland's Capacity Market and System Flexibility

Part 1



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