

Holmberg, Pär; Maurer, Christoph; Morawiecka, Monika; Roques, Fabien;
Zachmann, Georg

Research Report

Europe's electricity capacity mechanisms need to be better coordinated

Bruegel Policy Brief, No. 30/2025

Provided in Cooperation with:

Bruegel, Brussels

Suggested Citation: Holmberg, Pär; Maurer, Christoph; Morawiecka, Monika; Roques, Fabien; Zachmann, Georg (2025) : Europe's electricity capacity mechanisms need to be better coordinated, Bruegel Policy Brief, No. 30/2025, Bruegel, Brussels

This Version is available at:

<https://hdl.handle.net/10419/334012>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Europe's electricity capacity mechanisms need to be better coordinated

Pär Holmberg, Christoph Maurer, Monika Morawiecka, Fabien Roques and Georg Zachmann

Executive summary

Pär Holmberg is a Senior Research Fellow at the Research Institute of Industrial Economics

Christoph Maurer is Managing Director of Consentec

Monika Morawiecka is a former Senior Advisor at the Regulatory Assistance Project

Fabien Roques is an Executive Vice President at Compass Lexecon

Georg Zachmann (georg.zachmann@bruegel.org) is a Senior Fellow at Bruegel

The authors thank Conall Heussaff and Eva Jüngling who contributed substantially to early versions of this paper, and Thomas Mramor for research assistance.

- **A GROWING NUMBER** of European governments believe that guaranteeing adequate energy supplies requires specific 'capacity mechanisms' to compensate power plants for their availability, not solely for electricity generation. Capacity mechanisms appear set to become a permanent feature of electricity market design across much of Europe.
- **HOWEVER, POORLY COORDINATED** national capacity mechanisms could undermine consumer gains from the expansion of interconnectors and years of progress in coupling Europe's power markets. A patchwork of capacity mechanisms developed according to national preferences would erode predictability for market participants, undermine investment efficiency and weaken competition. Improving the design of capacity mechanisms and, in particular, their cross-border coordination is thus important to prevent potential distortions from spilling over to other energy market segments, which would hinder scaling up of efficient solutions for secure, affordable and sustainable electricity supplies in Europe.
- **CONVERSELY, JOINT OR CLOSELY COORDINATED** capacity mechanisms at regional level that allow access to neighbours' portfolios will increase security of supply and save money for households and industry.
- **COORDINATING OR JOINING UP** national capacity mechanisms is politically and technically challenging. EU countries prefer to retain sovereignty over their electricity mixes and adequacy levels, and national policymakers baulk at solutions perceived as sending consumers' money abroad or as financing domestic capacity that ends up addressing adequacy shortfalls elsewhere. Technically, coordinating capacity mechanism design and ensuring confidence in delivery of power across borders in times of scarcity is an important prerequisite. Harmonising the commitments traded in national capacity mechanisms or creating interfaces between very different mechanisms is complex.
- **OVERCOMING SUCH INEFFICIENCIES** requires high-level political commitment to compromise, including on rules for energy sharing during scarcity, cost-sharing, cross-border compatibility of capacity mechanisms and credible institutions that can perform regional adequacy assessments and enforcement. Compromise must emerge through a political process that builds trust among stakeholders. The EU could make approval of national capacity mechanisms conditional on engagement in regional coordination. Done right, this could reduce the cost of securing adequate capacities, reinforce the internal electricity market and strengthen broader energy-policy coordination across borders.

Recommended citation

Holmberg, P., Maurer, C., Morawiecka, M., F. Roques and G. Zachmann (2025) 'Europe's electricity capacity mechanisms need to be better coordinated,' *Policy Brief* 30/2025, Bruegel



EU countries are under increasing pressure to decide whether and how to implement a capacity mechanism

1 Introduction

Electricity generated from wind and solar power is on its way to replacing fossil fuels as the dominant energy carrier in Europe (European Commission, 2024). To accommodate this change, massive investment is required to maintain some existing power plants and to develop electricity storage and end-use appliances. Investment will come, alongside more direct public intervention, primarily from companies and households, which respond to incentives within an administratively designed market framework.

If investment can be directed to building the right amounts of the right assets in the right places at the right time, the cost of the European energy system could be reduced substantially. An integrated energy market, compared to isolated markets, would need less total capacity to ensure adequacy of energy supply¹. However, ending up with capacity that is inadequate to meet demand would have substantial economic and political costs. Maintaining enough supply capacity for sometimes prolonged periods when the wind is not blowing and the sun is not shining is thus becoming increasingly important.

Against this backdrop, European Union countries are under increasing pressure to decide whether and how to implement a capacity mechanism – a way to pay market participants for a commitment to make electricity generation, storage or demand response available when needed, particularly during periods of high demand or system stress². Many EU countries have already established some form of national capacity mechanism. Several more are debating whether to introduce one or shift to more comprehensive mechanisms (see section 4). The design and development of national capacity mechanisms in EU countries will play an increasingly important role in shaping investment decisions within the EU internal electricity market.

Capacity mechanisms remunerate qualified market participants for their contribution to the maintenance of system adequacy. That is, generators, storage operators or flexible consumers receive remuneration for committing, for one or several years, to offer generation capacity at times when it is needed to maintain the balance of demand and supply in the electricity system. Most capacity payments have historically gone to generators³, although in recent years, demand response and storage resources have been awarded substantial capacity payments in some countries. Such payments supplement revenues from selling electricity.

Capacity payments have increased overall in the EU, including an exceptional peak in 2023 related to a nuclear availability crisis in France⁴ (Figure 1). In France, for example, such capacity payments now exceed 10 percent of wholesale market revenues (ACER, 2024a). The expected introduction of a capacity market in Germany (Box 2 in section 2) is already affecting discussions on the issue in neighbouring countries.

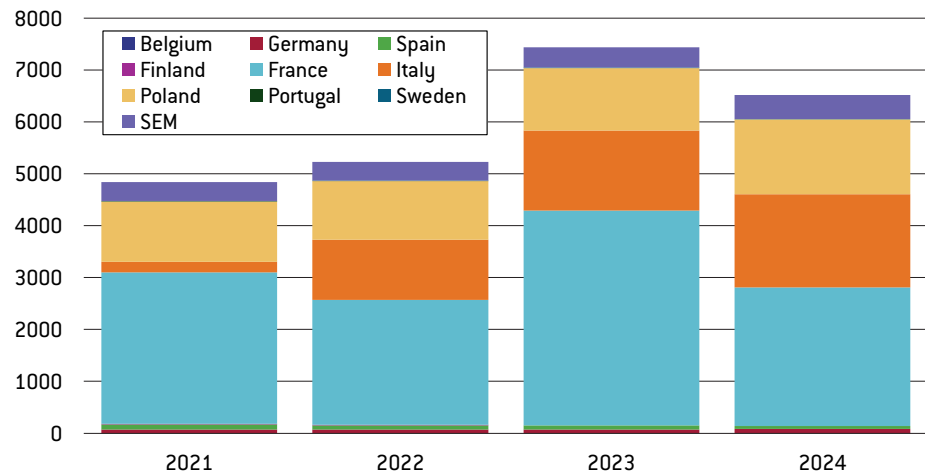
1 Zachmann *et al* (2024) estimated that back-up capacity could be 19 percent less in 2030 in an integrated European energy market, relative to isolated markets.

2 In simple terms, energy-only markets remunerate megawatt hours of energy actually provided, while capacity mechanisms remunerate megawatts of firm capacity to ensure enough is installed – avoiding early exit and enabling new entry – so that adequacy is maintained.

3 According to Rodilla *et al* (2023), demand response accounts for only 3 percent of demand for firm capacity in the EU.

4 Elise Wu, ‘Unplanned outages at French reactors hit 4-year high – study’, *Montel News*, 19 September 2024, <https://montelnews.com/news/0ed04362-8b60-42fd-9727-c811f91d451d/unplanned-outages-at-french-reactors-hit-4-year-high-study>.

Figure 1: Capacity payments in EU countries, € millions, 2021-2024*



Source: Bruegel based on ACER (2024a). Note: Incurred and expected (for 2024 payouts from capacity mechanisms in the EU). * = see Figure 4 for the status of capacity mechanisms in the EU. SEM = the Single Electricity Market on the island of Ireland.

In regulatory terms, capacity mechanisms were originally treated in the EU as a temporary measure of last resort to address resource-adequacy concerns (see Article 20 in the original Regulation (EU) 2019/943 on the internal market for electricity). This shifted with an EU-level electricity market design reform finalised in 2024 (codified in Regulation (EU) 2024/1747). Language on “*last resort*” and “*temporary*” was removed from the legal texts. Further rules adopted by the European Commission in June 2025 also provide for “*fast track*” approval of capacity mechanisms that meet specific design criteria (see section 3)⁵.

However, notwithstanding the experience and regulation so far, consensus on a single best-practice capacity mechanism has not yet emerged⁶. Mechanisms introduced by EU countries since the early 2000s have been continuously refined and some countries have chosen to change the type of mechanism they employ⁷. About 25 years of academic research into, and practical experience with, a wide variety of capacity-mechanism approaches shows that the trade-offs between different approaches are both complex and context specific. No two European countries have set up similar capacity mechanisms, and there are not yet convincing comprehensive proposals for a single mechanism that could work for all of Europe, given real-world constraints.

In this Policy Brief, we map the national capacity mechanism *status quo* in the EU, discuss the impact of capacity mechanisms on cost and security in the EU electricity system, and evaluate the potential gains and challenges associated with further coordination of capacity mechanisms at regional and European levels. We set out reasons for the increasing number of capacity mechanisms in recent years. We discuss their variety and major design differences, the needs they cater to and the difficulties that arise from the uneven development of capacity mechanisms in EU countries. Finally, we set out principles to facilitate effective coordination of capacity mechanisms across EU countries, focusing on regional coordination. This relies on agreement and enforcement of rules in an environment that fosters trust and fairness.

5 See European Commission press release of 25 June 2025, ‘New State aid framework enables support for clean industry’, https://ec.europa.eu/commission/presscorner/detail/en/ip_25_1598.

6 See for example Roques and Verhaeghe (2022, 2025); Cramton (2022) stated that “*even state-of-the-art capacity markets [...] have serious flaws*”.

7 France for example is transitioning from a decentralised capacity mechanism to a centralised approach, Belgium has moved from a strategic reserve to a capacity mechanism, and Germany will potentially follow suit (see Box 2). See section 4 for a discussion of different capacity mechanism models.

2 Reasons for the introduction of capacity mechanisms in Europe

Capacity mechanisms are increasingly seen as a necessary incentive to develop and maintain the capacity needed to meet expected demand (European Commission, 2025; Eurelectric, 2025; ENTSO-E, 2025). Some general points explain the increasing attention paid to these mechanisms.

First, EU countries worry that they cannot ensure their national energy-supply reliability standards⁸ based only on a common wholesale market that features a harmonised price cap and wholesale prices that reflect electricity market interventions in neighbouring countries. Investors might not deploy enough capacity to meet its very high reliability standard in one country, if 1) the EU-wide price cap is too low to ensure an expectation that investments will be profitable, and 2) a neighbouring country provides effective support to additional domestic capacity that lowers regional prices in scarcity situations, though this capacity might not be available for consumers in the first country in a crisis.

Second, capacity mechanisms are a second-best solution (see Box 1) to address a number of market failures⁹ that prevent adequate capacity levels, and the relevant issues differ from country to country (Table 1). Third, the desired green transition of the energy system should substantially increase electricity supply, grids and demand, while implying a lower share of variable (fuel) costs in the overall system cost. Capacity mechanisms can be a competitive tool¹⁰ to more efficiently coordinate the required investment¹¹, while avoiding politically contentious episodes of very high prices.

Box 1: Alternatives to capacity mechanisms

The economic literature shows that in theory, capacity mechanisms may not be needed. In principle, the expectation of high prices in scarcity situations should sufficiently encourage private investment in an efficient system-wide portfolio of capacities, assuming that: 1) policymakers do not interfere with prices at times of scarcity, and 2) market participants are willing to pay for security of supply – which may not be possible in practice because of a lack of smart meters or the option of individual disconnection.

Alternative market designs have been proposed that aim to solve the issue of the missing market for long-term hedging, eg by implementing mandatory forward electricity markets (Cramton *et al*, 2025). This would reduce the need for traditional capacity mechanisms. Here, consumers or their agents must hedge their electricity demand for certain periods into the future, which makes a higher price cap viable.

8 The reliability standard in Sweden was set by the Swedish authorities at one hour of expected loss of load per year, whereas in Czechia it is 6.7 hours per year (ACER, 2024).

9 In theory, an energy-only market could be able to provide enough capacity to meet expected demand, and forward hedging should protect consumers. But market failures such as a lack of demand-side participation and the non-market-based procurement of ancillary services, as documented by Roques (2008), can prevent efficient investment. In addition, a range of institutional issues may create the need for capacity mechanisms, for instance when policymakers cannot commit credibly to accept the occasional high scarcity prices needed to remunerate rarely-used capacities and market participants anticipate state intervention (such as payments for competing capacities, changing energy system plans), such that private investors underinvest.

10 Well-designed tendering and planning systems can become the driving force of efficiency gains from letting market participants “compete for the market” (Roques and Finon, 2017).

11 There is a mismatch between the hedging horizons of investors and consumers, with forward markets providing price signals only three to four years ahead. This contributes to the perceived lack of an investment case for new assets in the absence of dedicated capacity payments (Roques *et al*, 2025a).

Table 1: Drivers of capacity mechanisms in Europe

Underlying local market characteristics	Anticipated challenges	Main objectives of capacity mechanisms	Comments
• National reliability standards differ; meeting some of them would require prices above the EU-wide price caps. Internal grid constraints and lack of locational granularity of price signals; • Outsize thermal sensitivity of demand (because of electric heating); • Policy-driven phase-out of dispatchable generation; • Limited interconnections; • Dispatchable plants losing profitability in the face of strong renewables growth; • Insufficient flexible hydro capacity; • Demand growth in line with electrification of transport, heating, industry.	• Missing money for dispatchable generation leading to early retirements => missing capacity; • Weak investment case for new generation/storage/demand flexibility; • Mismatch between consumer and producer hedging horizon; • Risk of price spikes and price volatility.	• Ensure system adequacy: – Keep existing plants online; – Invest in new dispatchable capacities to cover peak demand/low-renewables events; – Replace retired nuclear and coal assets; – Incentivise demand-side flexibility. • Limit price spikes and volatility.	• Policy and regulatory interventions drive most investment risk: – Price caps; – Regulatory interventions in wholesale and retail markets; – Unreliable decommissioning plans; – Insufficient price signals that limit implicit demand-side flexibility. • Short-term price volatility is a necessary feature of the market; • Prolonged periods of very high prices should be avoided.

Source: Bruegel based on Roques and Verhaeghe [2022]. Notes: the table offers a selective overview, focusing on the main drivers for the introduction and design of capacity mechanisms in Europe. Capacity mechanisms are not always the most cost-efficient way to deal with this range of issues.

While safeguarding resource adequacy is the main reason for capacity mechanisms, specific adequacy issues vary across countries. Differences arise from the unique characteristics of each country's energy system, infrastructure, market design and the anticipated evolution of demand and supply patterns (Roques and Verhaeghe, 2022). For instance, countries where electric heating accounts for a high proportion of electricity demand will likely focus more on ensuring sufficient capacity to meet peak demand during winter, while countries with high shares of volatile renewables are more concerned with periods of low generation. Grid constraints, particularly limitations in transmission capacity between different regions within countries (as in Germany) or between neighbouring countries, can also drive the need for localised capacity additions to ensure supply adequacy in specific areas. This can be done through capacity mechanisms or other types of market and regulatory mechanisms¹².

Table 1 summarises how local energy-market characteristics and anticipated challenges underlie perceptions of the necessity of introducing capacity mechanisms in Europe. This emphasises the importance of an honest assessment of the underlying policy and regulatory issues that amplify this need.

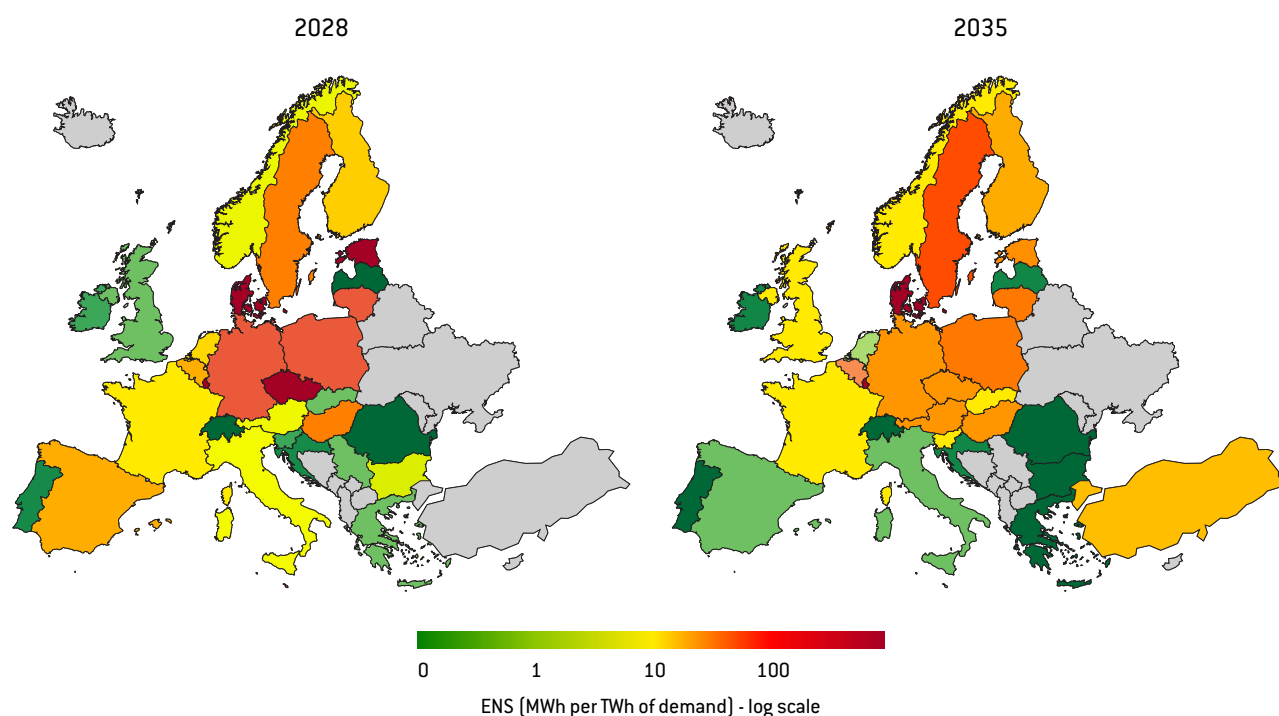
12 Unlike most EU countries, the Nordic countries have network tariffs and/or small zones that give both producers and consumers incentives to invest at locations that are favourable from the perspective of the grid constraints on the power system. This reduces the need for capacity mechanisms that are designed to steer investment to such locations.

Box 2: Germany

Germany has the most liquid power market and the most interconnected system in Europe. Its market-design choices thus influence the electricity policies of its neighbours. Germany has been discussing the introduction of a capacity market for more than ten years. In 2015, after a comprehensive stakeholder consultation, it was decided not to introduce a market-wide capacity market, but to introduce a limited strategic reserve involving paying for 2 gigawatts of capacity that is not allowed to participate in the market. This was designed to not impact price formation in long- and short-term electricity markets, and to be dispatched only as a last resort (which so far has not happened).

While the German system still faced significant overcapacity around 2015, early retirements of coal and nuclear plants have since tightened capacity margins. Several episodes in 2024 of electricity spot prices substantially exceeding the variable cost of gas-fired power plants were consistent with occasional scarcity. The adequacy assessment by Bundesnetzagentur (2023), Germany's federal utilities regulator, estimated that Germany would need roughly 20 gigawatts of new dispatchable capacity up to the early 2030s to handle rising peak demand and to complete the coal phase out. However, it was concluded that, in theory, existing market signals and targeted support (eg for combined heat and power) should spur sufficient investment in new capacity. By contrast, the ENTSO-E European Resource Adequacy Assessment (ERAA; ENTSO-E, 2024)¹³ warned that Germany's loss-of-load expectation (a reliability metric estimating how frequently the electricity supply might not meet electricity demand) might breach its reliability standard in the future (Figure 2).

Figure 2: Average share of electricity not served across ERAA* scenarios 2028 and 2035



Source: Bruegel based on ENTSO-E (2024). Note: * = the European Resource Adequacy Assessment; this is built on 540 scenarios for the development of supply and demand in the EU power system for specific future years. The complex modelling assesses politically and market-driven developments. The figure shows the average across the scenarios of the volume of energy not served (ENS); in more adverse scenarios, this is much higher.

13 The ENTSO-E assessment is disputed because of methodological issues. See, for example, the critical appraisal of some aspects of ERAA in ACER, 'Decision 07/2025 on the European Resource Adequacy Assessment for 2024', 11 August 2025, <https://www.acer.europa.eu/sites/default/files/documents/Individual%20Decisions/ACER-Decision-07-2025-ERAA-2024.pdf>.

In practice, investors have balked: higher renewables output has slashed expected running hours during which capacity is called on (load factor), making cost recovery dependent on a few scarcity hours. Meanwhile, volatile policies and emergency interventions during the 2022 energy crisis eroded confidence in regulatory stability, while policymakers' statements have fuelled expectations of future public support schemes. With the energy transition still underway in Germany, ways to accommodate renewable energy scarcity have become central to the policy debate (dena, 2025).

To break the investment deadlock – without formally admitting an adequacy shortfall – in 2022, the German government proposed a 'power-plant strategy': it would buy up to 20 gigawatts of new gas capacity, labelled as support for decarbonisation rather than as a capacity mechanism. Complex state-aid approval processes and fiscal constraints delayed and down-sized the scheme and it lapsed when the government was voted out of office in 2025. At that time, in discussion with the European Commission, Germany pledged to limit the initial procurement to 12.5 gigawatts, viewing it as a stepping stone to the introduction of a market-wide capacity market in 2028.

While all major parties agree on urgency, it remains unclear whether the original hybrid design will prevail or if the current German coalition will opt for a different model. A November 2025 German coalition agreement stipulates that an initial eight gigawatts of gas-fired power plants will be tendered in 2026¹⁴.

3 Insufficient cross-border capacity-mechanism coordination

EU criteria to assess capacity mechanisms were first introduced with the 2014 guidelines on state aid for environmental protection and energy (EEAG; European Commission, 2014). An EU energy framework reform, the Clean Energy Package¹⁵, adopted in 2019, then provided a binding rulebook of preconditions for the introduction of capacity mechanisms:

1. A capacity mechanism must be based on a resource-adequacy concern, substantiated by a medium to long-term resource-adequacy assessment. The introduction of a harmonised resource-adequacy assessment represented an improvement compared to the preceding EEAG framework (Florence School of Regulation, 2024).
2. Capacity mechanisms can only be introduced if adequacy concerns cannot be alleviated by removing market distortions.
3. Priority is given to strategic reserves as a means to address adequacy concerns, with some leeway in case reserves prove insufficient.

Additionally, the Clean Energy Package facilitated cross-border participation of capacity providers and required no specific type of resource be favoured (Roques and Verhaghe, 2022; Florence School of Regulation, 2024). It also put forward design principles on the demand side, aggregation, technology neutrality and emissions limits. While moving towards a more rules-based EU-wide governance approach, capacity mechanisms were not seen as a stand-

14 Rachel More and Andreas Rinke, 'German coalition agrees to subsidised power price for industry', *Reuters*, 13 November 2025, <https://www.reuters.com/business/energy/german-coalition-agrees-subsidised-power-price-industry-2025-11-13/>.

15 See ENTSO-E, 'Clean Energy Package (CEP)', undated, <https://www.entsoe.eu/cep/>.

ard feature but were considered a measure of last resort. The subsequent 2022 guidelines on state aid for climate, environmental protection and energy provided further guidance on the design of capacity-remuneration mechanisms (European Commission, 2022).

In response to the energy crisis brought about by Russia's invasion of Ukraine, and the changing nature of the power system with the large-scale development of renewables, the role of capacity mechanisms fundamentally changed from a measure of last resort to a 'structural' feature of the EU's electricity market design, as proposed in the EU's 2024 electricity market design reform (European Commission, 2024). As part of this major reform, attention was focused on the role of non-fossil fuel flexibility in ensuring adequacy, in the form of demand-side responses and energy storage, thereby emphasising the need for the EU to meet its climate targets.

In 2025, the European Commission adopted the Clean Industrial Deal State Aid Framework (CISAF), via which new rules for capacity mechanisms have been adopted. However, it remains to be seen whether CISAF will: 1) accelerate convergence of national capacity mechanism designs across the EU, and 2) enable faster approval by the Commission (Eurelectric, 2025; European Commission, 2025).

In summary, the focus so far at EU level has been on ensuring that capacity mechanisms do not have significant adverse effects on the operation of the internal electricity market. Limited efforts have been made to encourage more cross-border coordination of capacity mechanisms, but these have not led to substantive progress on cross-border cooperation.

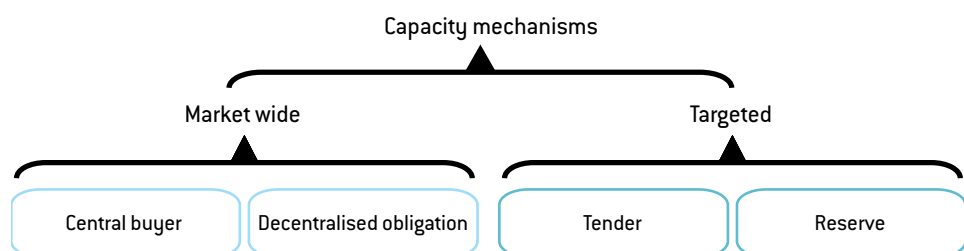
Countries trade different forms of capacity and cross-border exchange of these remains limited. For example, the costs of capacity in national mechanisms in the EU differ widely, ranging in 2024 from €13 per kilowatt for the Finnish strategic reserve, to €33/kW for the French capacity mechanism, to €76/kW for capacity procured for the German strategic reserve.

Without mandatory coordination rules and enforcement mechanisms (eg in state aid approval) for cross-border elements, current EU rules fall short of fostering the integrated and efficient development of adequate capacities in a regional or European setting.

4 Capacity mechanisms differ significantly

The term 'capacity mechanism' covers a range of different instruments that serve the purpose of ensuring adequate capacity¹⁶. They differ widely in type and scope. Price-based mechanisms set a fixed payment for capacity, while quantity-based mechanisms procure predefined amounts. Figure 3 shows a scheme of the main types of price-based capacity mechanisms implemented and discussed by EU countries, while Figure 4 shows which types of capacity mechanism different EU countries have implemented, or whether they are currently being developed.

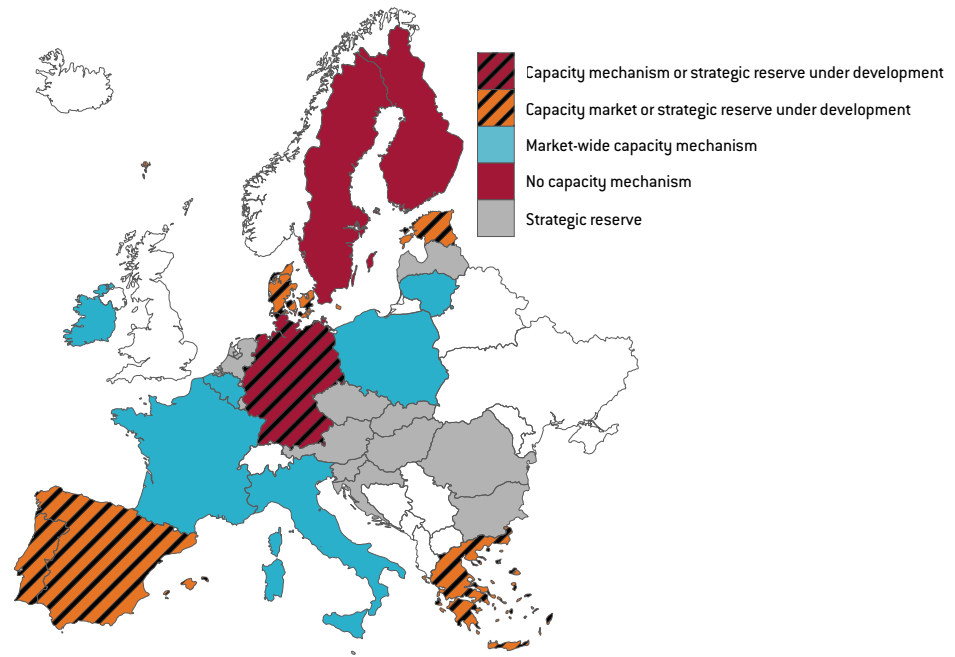
Figure 3: Main types of capacity mechanism



Source: Bruegel.

¹⁶ Classifying different approaches is not easy, as they can be classified according to several criteria. See for instance Mastropietro (2016) and Roque and Verhaeghe (2022).

Figure 4: Status of capacity mechanisms in the EU



Source: Bruegel based on ENTSO-E (2025) and ACER. Note: Germany currently has a strategic reserve, with a capacity market under discussion (Box 2). In addition, many central and eastern European EU countries have legacy schemes that resemble capacity markets or strategic reserves, eg in Romania, Bulgaria and the Balkans. Czechia, the Netherlands and Sweden are discussing the introduction of capacity mechanisms.

Governments of course play important roles in terms of security of electricity supplies and adequacy issues, most importantly by setting reliability targets, ie defining the trade-off between the cost of the mechanism and the acceptable risk of unserved load. They also decide who can or must participate in capacity mechanisms. The definition of what is being procured via a capacity mechanism is also important and varies across countries. Variable elements can include availability during peak hours or firm capacity for longer shortages. Designs of mechanisms also need to clarify how far in advance capacity should be procured, duration of delivery periods and whether what is procured is differentiated according to location. Commitment formats vary, from upfront payments to contracts with penalties or performance obligations, shaping how providers manage risk and ensure reliability. While the procured capacity is typically paid the same amount per kilowatt per year, capacity with less availability, such as renewables, would typically be derated¹⁷. One potential problem with procured capacity, as shown by experience in the United States with some of the early capacity mechanisms, is that availability may not be guaranteed when needed most (Batlle *et al*, 2015; Rose *et al*, 2014; Cramton, 2022; CAISO, 2021).

National capacity mechanism design reflects the multitude of choices involved, each influenced by national priorities (Figure 3), energy mix, regulatory capabilities and market structures. A typology of the different mechanisms would include the following categories:

4.1 Market-wide capacity market

In a **market-wide capacity market**, resources are procured to ensure that the power system can reliably meet peak demand, limiting the risk of electricity shortages to reach the reliability standard. Capacity payments reflect the value of the obligation to remain available when

¹⁷ Derating assigns capacities a value reflecting expected availability, which is used to calculate the capacity payment. For conventional plants, derating is mainly related to technical availability. For other capacity types, the assessment includes their unavailability in correlation with periods when there are resource-adequacy concerns.

needed. Producers are also compensated for delivered energy through sales in the wholesale market.

These capacity markets can be **centralised** or **decentralised**. In centralised capacity markets, a designated public authority – eg a system operator – assesses system-wide capacity requirements and procures sufficient resources to ensure reliability. This raises the question of the incentives and governance of the system operator in procuring capacity. One potential problem, especially with centralised capacity markets, is that system operators tend to over-procure because of their risk adversity (Newbery and Grubb, 2014).

In a decentralised capacity market, individual buyers – such as electricity suppliers or distribution companies – procure the capacity needed to meet their obligations to procure a certain margin over the demand they expect. In this model, adequacy is a **shared responsibility**, with market participants responding to their own forecasts and obligations rather than adhering to a central plan.

One possible refinement in the design of market-wide capacity mechanisms is to connect them explicitly with energy price hedging mechanisms, often referred to ‘reliability options’. Organising such capacity markets and their interfaces with energy markets involves substantial complexity. Some evidence shows that reliability options may have contributed to reduced availability of capacity (McRae and Wolak, 2019). Reliability options can increase the risk for producers and thus are often accompanied by a stop-loss mechanism¹⁸, which in turn may distort availability incentives.

To work properly, sellers in capacity markets need to be certified, which can be a cumbersome and relatively costly process, especially for smaller players. To foster the participation of small players, mechanisms such as aggregation are possible.

Another issue that requires attention when designing capacity mechanisms is their interplay with competition policy, particularly in concentrated markets. Addressing such market-power issues is possible but implies further sophistication of the tool, through, for example, bid caps and monitoring.

Partly for the reasons outlined above, capacity markets are often complex to implement and especially in the first years require substantial resources from the transmission system operator (TSO), regulator and market parties. This has led to concerns, such as in the US, that regulators may not have enough competence and resources to regulate this complex market (Aagaard and Kleit, 2022). However, recent efforts in Europe to streamline and define a standard design for capacity mechanisms under CISAF rules could alleviate to some extent this burden.

4.2 Targeted options

Targeted options, such as procurement of a **strategic reserve** by the system operator, are an alternative to the market-wide capacity market. Strategic reserves are typically only activated when there is a shortage of power. The reserve cannot take part in the power exchange and is compensated separately through a capacity payment. Production outside the reserve does not receive any capacity payment.

Holmberg and Ritz (2020) identified circumstances in which the strategic reserve is as efficient as an energy-only market and a market-wide capacity market. However, inefficiencies in relation to strategic reserves can arise when, for example, it is efficient to use a plant in the reserve before a plant outside the reserve (Bublitz *et al*, 2019).

Strategic reserves have historically typically been seen as a second line of defence to manage the pace of decommissioning of existing plants, activated outside the power market to handle temporary shortages, while capacity markets are designed as a structural complementary mechanism to the energy market to ensure efficient investment decisions. Accordingly, capacity markets are more complex than strategic reserves, though EU rules

¹⁸ A stop-loss mechanism limits a generator’s exposure to financial risk when it underlies a capacity supply obligation. For example, to protect producers, total penalty charges might be limited during an extended period of high prices.

now require the latter to be open to all technologies, which reduces the distinction. In the ideal design, reserves are fully isolated from the market and hence do not affect spot prices. In the past, mainly existing plants have been shifted from the market into the reserve. This implies higher spot prices, and thus indirectly encourages new capacity, including small-scale investments.

Tenders, another form of targeted capacity mechanism, are one-off auctions or calls for proposals to provide a specific amount of capacity. As the years-long discussions on the German government plan to tender 20 GW of gas-fired capacities illustrate (Box 2), obtaining state-aid approval for such tenders is difficult and uncertain¹⁹.

In summary, reserves and tenders are simpler and focused on short-term adequacy, while capacity markets are structural mechanisms aimed at long-term adequacy, but are associated with greater complexity.

5 Capacity mechanisms in one country can impact other countries

As national capacity mechanisms become increasingly important in shaping investment decisions in the power sector, questions arise about the dynamic implications of such mechanisms in driving investment choices – for instance, if they could induce overinvestment or investment in the wrong locations/types of capacity, and the associated implications for costs to consumers in the long term. In particular, poorly coordinated and/or designed national capacity mechanisms can lead to a range of issues that could undermine the reliable and cost-effective supply of electricity across borders.

One danger is overinvestment resulting from an uncoordinated determination of capacity needs, and bias on the part of national decision-makers that leads them to underestimate non-domestic contributions²⁰. Overcapacity might also stem from inconsistencies between national, rather than EU-wide or at least regional, scenarios used in adequacy analyses to determine capacity demand. In addition, the methodology for determining potential cross-border contributions could be improved, as, for instance, it often neglects contributions from more distant bidding zones.

Inefficiency could also result from being unable to access the most economic sources of available capacity in the absence of efficient cross-border participation. Most capacity demand, in particular costly new-build capacity, is currently procured several years ahead of the delivery period in auctions that are, in practice, not open to cross-border competition. In addition, revenues from cross-border participation in a capacity mechanism can be very limited (as shown by Menegatti and Meeus, 2024) if the cost of booking transmission capacities from transmission system operators (TSOs) is very high. As a consequence, cross-border participation can become unattractive, even when economically efficient.

A major driver behind this is that EU countries distrust the functioning of the EU electricity market during scarcity events (Roques and Verhaeghe, 2022). Because of fears that cross-border transmission capacity will be reduced, or flows limited in times of scarcity, reliance on cross-border capacity may be perceived as riskier than domestic procurement.

19 Carolina Kyllmann, 'Germany's plans for 20 GW of new gas power plant capacity face EU setback – media', *Clean Energy Wire*, 21 October 2025, <https://www.cleanenergywire.org/news/germanys-plans-20-gw-new-gas-power-plant-capacity-face-eu-setback-media>.

20 In self-sufficient scenarios, the need for dispatchable power plants, as represented by the differences in residual demand (including demand reduction and storage), is about 15 percent higher than in the integrated scenario. Residual demand is calculated by subtracting renewables and nuclear generation from load (Zachmann *et al*, 2024).

Reducing cross-border capacity or limiting flows in such scenarios would violate EU internal market rules, but perceived doubts about the enforceability of those rules may skew procurement of capacity in capacity mechanisms in favour of domestic suppliers. National TSOs may also be reluctant to consistently maximise the interconnection capacity available for cross-zonal trade, as they may need to keep margins to manage some operational issues.

In contrast to the risk of overinvestment, some countries might be tempted to freeride on capacity remuneration across the border to contribute to national adequacy. Since internal market rules prevent restrictions on foreign access to domestically procured capacity, capacity mechanism benefits spill over to neighbouring markets. Without coordination of reliability standards and responsibility for cost recovery, freeriding may arise, creating fairness concerns and risking under-procurement. This risk could materialise even unintentionally. If a capacity mechanism in one country leads to overinvestment and lower wholesale prices in tight market conditions in neighbouring countries, the profitability of plants in those connected countries will be reduced. If the latter are not backed by a capacity mechanism, some might be closed. When capacity mechanisms in one country crowd-out capacities in connected countries that do not have capacity mechanisms, the original adequacy assessment might be undermined.

Lastly, many non-coordinated rules and methodologies, such as the determination of national reliability standards or derating factors, may cause unintended consequences and undermine the efficient functioning of cross-border capacity mechanisms. Moreover, with numerous national capacity mechanism designs (rather than a single European design) interacting with other electricity-market segments (hedging, short-term, ancillary-services, potentially upcoming flexibility instruments), there is a risk of increased complexity that could undermine effective competition.

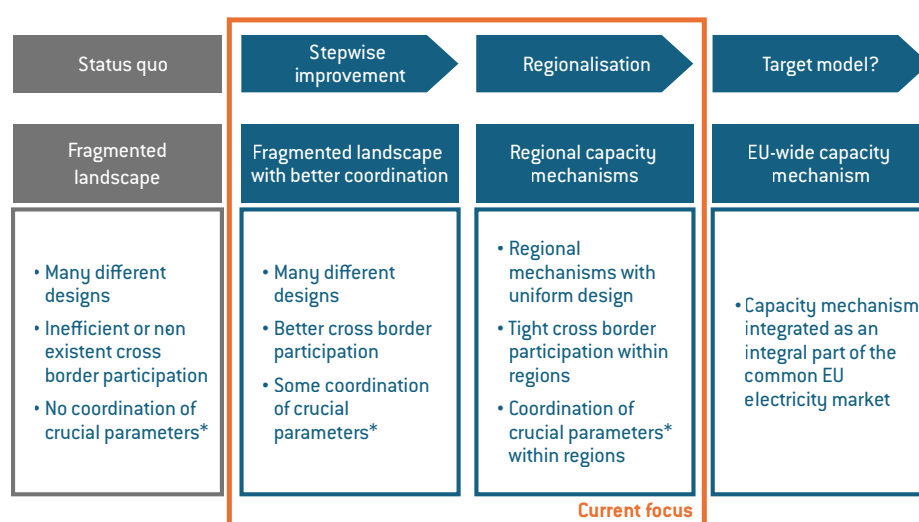
This will likely require several fundamental issues to be addressed: 1) inconsistent input data across national systems; 2) limited transparency of modelling of adequacy assessments, which are insufficient to understand the dynamics that drive the results; 3) regulators with constrained tools, effectively limited to a last-resort veto over the entire process; and 4) potential institutional and governance issues that may warrant shifting some responsibilities from national TSOs to an independent European public authority.

Such cross-border impacts are likely not only a marginal issue. In many EU markets, interconnector capacities could theoretically contribute a very significant fraction (for example, 40 percent in Germany) of the domestic peak load (Stiewe *et al*, 2025).

6 Coordination principles and the way ahead

Capacity mechanisms, with all their potential complexities and inefficiencies, are set to become a standard feature of the EU electricity system. To make them more fit for purpose and to promote efficiency across Europe, a more coordinated approach is needed. While a uniform capacity mechanism in Europe might be impossible (or indeed undesirable, because of complexity and underlying differences in the adequacy issues), the intermediate stages merit careful consideration. Menegatti and Meeus (2025) have proposed a stepwise approach to implementing regional capacity markets to overcome the problems of selecting the least-cost generation and to avoid under- and over-procurement (as we have noted above). We support the idea of a stepwise development of existing capacity markets, which could be done as shown in Figure 5.

Figure 5: Possible development pathway for capacity mechanisms in Europe



*Such as derating factors, reliability standards

Source: Bruegel.

Arriving at commonly accepted principles is a highly political exercise, as national prerogatives, preferences and perceived benefits must be balanced carefully among partners to reach a common solution that is efficient and also makes all parties better off. The more partners trust each other, accept some delegation of sovereignty and accept some distributional effects, the more transparent, simple and efficient the system can be.

While national preferences are safeguarded, complexity and inefficiency will dictate the joint system; the system as a whole will be complex to manage if many countries pursue separate bilateral agreements (though bilateral solutions allow two partners to align their needs). Regional arrangements thus substantially reduce complexity and the scope for inefficiencies, though they still require more individual compromises and still create inefficiency at regional boundaries. EU-wide solutions offer the greatest potential for efficiency. However, this level of integration would require harmonisation across very different systems.

The challenge is to design a system that is politically acceptable and practical so it can be operationalised and maintained with limited changes to the current institutional and governance arrangements. We propose five high-level principles to govern such a system: fairness, transparency, legitimacy, robust governance and solidarity.

Table 2: Principles for a politically sustainable coordination mechanism

Principle	What it means	Why it matters	How to implement
Fairness	Fair sharing of anticipated risks and costs (including within country)	Prerequisite for political agreement among EU countries	For example, rules on energy-sharing in joint scarcity situations, cost-allocation methods
Legitimacy	Broad acceptance and normative support from stakeholders	Reduces risk of non-compliance or exit	Inclusive consultation, procedural justice, adaptive review clauses
Transparency	Open access to methodologies, data and decisions	Predictability improves stakeholder behaviour, supports accountability and increases trust	For example, shared data platforms, harmonised monitoring, regular reporting
Robust governance	Clear institutions and processes	Builds stakeholder trust, and enables interoperability with other parts of the system	For example, network codes and guidelines, a rule revision mechanism with proper oversight and TSOs/RCCs*/ENTSO driving assessment/implementation
Solidarity	Commitment to mutual support in stress or crisis situations	Reinforces trust and aligns with EU Treaty principles (Art. 194(1) TFEU)	Explicit contingency arrangements, political signalling

Source: Bruegel. Note: * = Regional Coordination Centres.

These principles give rise to several recommendations for effective integration of national capacity mechanisms:

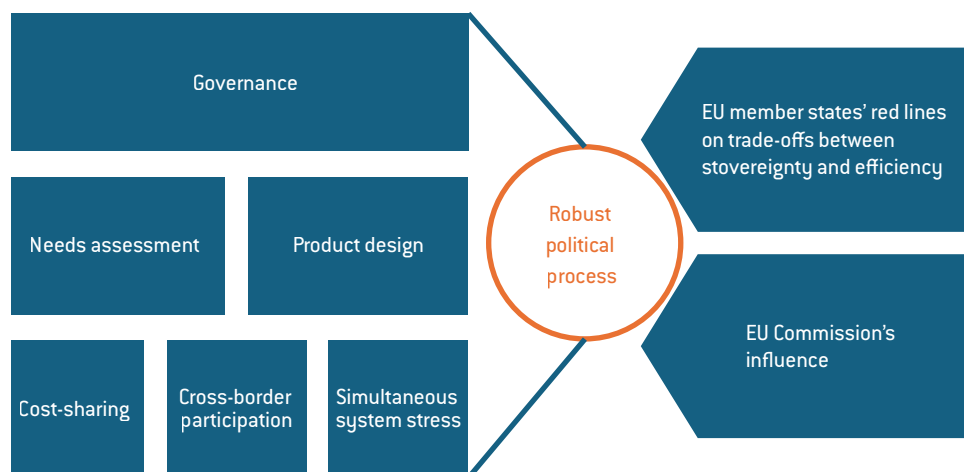
- To coordinate national assessments of system needs effectively, the governance and transparency of the European power-system resource adequacy assessment²¹ (ERAA) should be improved to deliver an unbiased and widely supported basis for decisions. Integrating a more granular regional exercise could support the development of regional capacity markets²².
- **Cross-border participation:** the amount of capacity from specific neighbouring countries that is eligible to participate in each national capacity mechanism should be optimised by coordinating their computation, to get the most out of the potential pooling of adequacy reserves, while still respecting national prerogatives and operational constraints.
- **Product design:** an acceptable level of harmonisation and coordination of product design should be found, to ensure what is purchased via capacity mechanisms reflects common adequacy goals and is deliverable across borders, whilst recognising the necessary differentiation to reflect local adequacy issues.

21 ERAA was developed as a pan-European monitoring assessment to address power system resource adequacy of up to 10 years ahead. See also footnote 12.

22 Roques *et al* (2025b) provided a comprehensive discussion of the shortcomings of current system planning approaches and adequacy assessments. See also Fabien Roques and Charles Verhaeghe, 'Electricity Market design to ensure Security of Supply', *Compass Lexecon*, 11 March 2025, <https://www.compasslexecon.com/cases/electricity-market-design-to-ensure-security-of-supply>.

- **Management of system-stress situations:** additional operational agreements to manage major simultaneous system-stress situations could be implemented, at both technical and political levels.
- **Cost-sharing agreements:** Efficiency gains from cooperation are not spread evenly, Therefore, clear and transparent cost-sharing agreements will be needed to dispel concerns about freeriding and to incentivise joint approaches to resource adequacy assessments and capacity procurement.
- The current national framework for the governance of capacity mechanisms is ill-equipped to sustain the development of regional capacity markets. The following steps should be taken:
 - A regional approach to capacity mechanisms would require alignment of responsibilities and adequate coordination between the different responsible entities, whether ministries, regulators or TSOs.
 - Similarly, the EU state aid framework could be adapted to facilitate the implementation of regional/joint capacity mechanisms. One of the main issues is that the process foresees national submissions of schemes for approval. Thus, the EU Electricity Regulation (Regulation (EU) 2019/943), which governs the internal market for electricity, should be updated to include provisions on regional capacity mechanisms.

Figure 6: Key elements for effective integration of national capacity mechanisms



Source: Bruegel.

Taking these steps will require a political process in which trust is built in the discussions between stakeholders. The EU could require countries to engage with their neighbours in regional agreements, both operationally and politically, as a precondition for approving the capacity mechanisms EU countries want to implement.

This could be informed through guidance from EU countries on their political appetites, especially for trade-offs relating to sovereignty versus simplicity and efficiency. By clarifying the political boundaries, a compromise (and therefore convergence) might be more easily achievable.

After what member state can accept has been clarified, the European Commission should propose a framework for an enhanced cross-border participation framework and a regional approach to capacity mechanisms, as the basis for negotiation on a workable system. Compromise could be incentivised by clarifying that failure to reach an agreement will result in an imposed outcome, rather than one reached through the direct inputs of EU countries.

Implementing these principles and recommendations in the development of the European electricity market would help ensure the efficient operation of Europe's power system, while supporting investment in the right capacities in the right places at the right time. The alternative – sliding back to largely isolated national electricity systems – would carry real risks for the common European market, and would ultimately be unnecessarily expensive for European consumers.

References

- Aagaard, T.S. and A.N. Kleit (2022) *Electricity Capacity Markets*, Cambridge University Press
- ACER (2024a) *Security of EU electricity supply, 2024 Monitoring Report*, European Union Agency for the Cooperation of Energy Regulators, available at https://acer.europa.eu/sites/default/files/documents/Publications/Security_of_EU_electricity_supply_2024.pdf
- ACER (2024b) *Transmission capacities for cross-zonal trade of electricity and congestion management in the EU, 2024 Market Monitoring Report*, European Union Agency for the Cooperation of Energy Regulators, available at https://www.acer.europa.eu/sites/default/files/documents/Publications/ACER_2024_MMR_Crosszonal_electricity_trade_capacities.pdf
- Battle, C., P. Mastropietro, P. Rodilla and I.J. Pérez-Arriaga (2015) 'The system adequacy problem: Lessons learned from the American continent', in L. Hancher, A. de Houteclocque and M. Sadowska (eds) *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics*, Oxford University Press
- Bublitz, A., D. Keles, F. Zimmermann, C. Fraunholz and W. Fichtner (2019) 'A survey on electricity market design: Insights from theory and real-world implementations of capacity remuneration mechanisms', *Energy Economics* 80: 1059-1078, available at <https://doi.org/10.1016/j.eneco.2019.01.030>
- Bundesnetzagentur (2023) *Stand und Entwicklung der Versorgungssicherheit im Bereich der Versorgung mit Elektrizität*, Versorgungssicherheit Strom Bericht, available at <https://www.bundeswirtschaftsministerium.de/Redaktion/DE/Publikationen/Energie/versorgungssicherheit-strom-bericht-2022.html>
- CAISO (2021) *Root Cause Analysis Mid-August 2020 Extreme Heat Wave*, California Independent System Operator, available at <https://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf>
- Cramton, P., S. Brandkamp, J. Dark, D. Hoy, D. Malec, A. Ockenfels and C. Wilkens (2025) 'A Forward Energy Market to Improve Reliability and Resiliency', mimeo, available at <https://cramton.umd.edu/papers2020-2024/cramton-et-al-forward-energy-market.pdf>
- Cramton, P. (2022) 'Fostering resiliency with good market design: Lessons from Texas', *Discussion Paper* 145, ECONtribute, available at https://www.econtribute.de/RePEc/ajk/ajkdps/ECONtribute_145_2022.pdf
- dena (2025) *Resource Adequacy Debate in Germany*, Deutsche Energie-Agentur, available at https://www.dena.de/fileadmin/dena/Publikationen/PDFs/2025/Resource-Adequacy_Debate_dena.pdf
- ENTSO-E (2024) *European Resource Adequacy Assessment 2024 Edition*, European Network of Transmission System Operators for Electricity, available at <https://www.entsoe.eu/eraa/2024>
- ENTSO-E (2025) 'The role of Capacity Mechanisms to enable a secure and competitive energy transition', *Policy Paper*, European Network of Transmission System Operators for Electricity, available at https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/Publications/Position%20papers%20and%20reports/2025/entso-e_pp_capacity_mechanisms_250415.pdf

- Eurelectric (2025) *Redefining energy security in the age of electricity*, Flagship Study, available at <https://energy-security.eurelectric.org/>
- European Commission (2024) 'Securing our future Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society', SWD/2024/63 final, available at <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52024SC0063>
- European Commission (2025) 'Report on the assessment of possibilities of streamlining and simplifying the process of applying a capacity mechanism under Chapter IV of Regulation (EU) 2019/943, in accordance with Article 69(3) of Regulation (EU) 2019/943', COM(2025) 65 final, available at <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52025DC0065>
- Florence School of Regulation (2024) 'Capacity Mechanisms', Cover the Basics, 30 July 2024, available at <https://fsr.eui.eu/capacity-remuneration-mechanisms/>
- Heussaff, C. and G. Zachmann (2024) 'The changing dynamics of European electricity markets and the supply-demand mismatch risk', *Policy Brief* 14/2024, Bruegel, available at https://www.bruegel.org/sites/default/files/2024-07/PB%2014%202024_0.pdf
- Holmberg, P. and R. Ritz (2020) 'Optimal capacity mechanisms for competitive electricity markets' *The Energy Journal* 41(Special Issue 1): 33-66, <https://www.jstor.org/stable/27035312>
- Mastropietro, P. (2016) 'Regulatory Design of Capacity Remuneration Mechanisms', mimeo, available at <https://www.diva-portal.org/smash/get/diva2:918381/FULLTEXT01.pdf>
- McRae, S.D. and F.A. Wolak (2019) 'Market power and incentive-based capacity payment mechanisms', mimeo, available at <https://web.stanford.edu/group/fwolak/cgi-bin/sites/default/files/2019-03-mcrae-wolak-capacity.pdf>
- Menegatti, E. and L. Meeus (2024) 'Cross-Border Participation: A False Hope for Fixing Capacity Market Externalities?' *Working Paper* RSC 2024/53, Robert Schuman Centre for Advanced Studies, available at <https://doi.org/10.2139/ssrn.5029186>
- Menegatti, E. and L. Meeus (2025) 'Three Steps to a Regional Capacity Market in the EU' *Working Paper* RSC 2025/44, Robert Schuman Centre for Advanced Studies, available at <https://hdl.handle.net/1814/93923>
- Newbery, D. and M. Grubb (2014) 'The final hurdle? Security of supply, the capacity mechanism and the role of interconnectors', *Cambridge Working Papers in Economics* 1433, Faculty of Economics, University of Cambridge, available at <https://www.econ.cam.ac.uk/publications/cwpe/1433>
- Rodilla, P., P. Mastropietro and P. Brito-Pereira (2023) 'The Challenge of Integrating Demand Response in Capacity Remuneration Mechanisms: Providing a Comprehensive Theoretical Framework', *IEEE Power and Energy Magazine* 21(4): 64-71, available at <https://doi.org/10.1109/MPE.2023.3269551>
- Roques, F. (2008) 'Capacity Mechanisms and Institutional Context: Healing Symptoms or Causes?' *Utilities Policy* 16(3): 171-183, available at <https://doi.org/10.1016/j.jup.2008.01.008>
- Roques, F. (2019) 'Counting on the neighbours: challenges and practical approaches for cross-border participation in capacity mechanisms', *Oxford Review of Economic Policy* 35(2): 332-349, available at <https://doi.org/10.1093/oxrep/grz008>
- Roques, F. and D. Finon (2017) 'Adapting electricity markets to decarbonisation and security of supply objectives: Toward a hybrid regime?' *Energy Policy* 105: 584-596, available at <https://doi.org/10.1016/j.enpol.2017.02.035>
- Roques, F. and C. Verhaeghe (2022) 'Different approaches for capacity mechanisms in Europe: Rationale and potential for coordination?' in L. Hancher, A. de Houtelocque and M. Sadowska (eds) *Capacity Mechanisms in the EU Energy Market: Law, Policy, and Economics*, Oxford University Press
- Roques, F., C. Verhaeghe and C. Cartry (2025b) *Accelerating the deployment of clean power technologies to reliably decarbonise Europe through enhanced planning and contracting mechanisms*, Compass Lexecon, available at <https://cdn.catf.us/wp-content/uploads/2025/06/24081828/clean-power-tech-decarbonise-europe-planning-contracting.pdf>

- Roques, F., C. Verhaeghe, F. Bourcier, A. Lorne and S. Malleret (2025a) *Electricity market design to support the development of flexibility in EU power systems - an analysis of best international practices*, Compass Lexecon, available at <https://www.compasslexecon.com/cases/report-on-electricity-market-design-to-support-the-development-of-flexibility-in-eu-power-systems-an-analysis-of-best-international-practices>
- Rose, J., S. Muthiah, F. Brock, J. Karp and T. Sakya (2014) 'Polar Vortex Energy Pricing Implications—Commercial Opportunities and System Reliability', White Paper—Addendum, ICF International Inc, available at https://www.pserc.cornell.edu/empire/YAGTP4723_Addendum%20ICF%20Polar%20Vortex%20White%20Paper%2017Jan2014.pdf
- Stiewe, C., A.L. Xu, A. Eicke and L. Hirth (2025) 'Cross-border cannibalization: Spillover effects of wind and solar energy on interconnected European electricity markets', *Energy Economics* 143: 108251, available at <https://doi.org/10.1016/j.eneco.2025.108251>
- Zachmann, G., C. Batlle, F. Beaudé, C. Maurer, M. Morawiecka and F. Roques (2024) 'Unity in power, power in unity: why the EU needs more integrated electricity markets', *Policy Brief* 2024/03, Bruegel, available at <https://www.bruegel.org/system/files/2024-04/PB%2003%202024.pdf>

Bruegel, Rue de la Charité 33,
B-1210 Brussels
(+32) 2 227 4210
info@bruegel.org
www.bruegel.org

REPUBLISHING AND REFERENCING POLICY

© Bruegel 2025. Bruegel publications can be freely republished and quoted according to the Creative Commons licence CC BY-ND 4.0. Please provide a full reference, clearly stating the relevant author(s) and including a prominent hyperlink to the original publication on Bruegel's website. You may do so in any reasonable manner, but not in any way that suggests the author(s) or Bruegel endorse you or your use. Any reproduction must be unaltered and in the original language. For any alteration (for example, translation), please contact us at press@bruegel.org. Publication of altered content (for example, translated content) is allowed only with Bruegel's explicit written approval. Bruegel takes no institutional standpoint. All views expressed are the researchers' own.