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CAPACITY MARKETS AS A TOOL FOR PROMOTING FLEXIBILITY AND ENSURING SECURITY IN THE ELECTRICITY SYSTEM

EXECUTIVE SUMMARY

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Executive summary

THE IMPORTANCE AND NEED FOR FLEXIBILITY IN ELECTRICITY SYSTEMS

The penetration of distributed renewable resources and other factors, such as climate change, increase the need for flexibility of electricity systems

Various structural factors are significantly increasing flexibility needs in electricity systems in response to fluctuations in electricity supply and demand. As recognised by the European Commission in its 'Clean Industrial Deal' Communication of February 2025, greater electricity system flexibility is required to (i) speed up the decarbonisation of the economy, (ii) respond to new operational challenges arising from the deployment of distributed energy resources and the increased variability of electricity demand, and (iii) maintain electricity supply at high levels of quality and security that support the competitiveness of the European economy and industry.

Flexible electricity systems enable an adequate response to operational contingencies and external shocks affecting supply and demand, which are becoming increasingly common

The flexibility of the electricity system can be understood, in general terms, as its capacity to (i) respond to operational situations of a very different nature in the short and very short term, characterised by high variability in electricity consumption and generation, (ii) respond resiliently to unexpected contingencies arising from a range of factors (weather, asset failures, accidents, cyberattacks...); and (iii) adapt efficiently, in the medium and long term, to changes in electricity demand. This responsiveness must adapt to a context of continuous interaction between thousands of elements and resources relating to generation, storage, and demand.

There are numerous technologies and energy resources that can provide flexibility to the electricity system, with different capabilities, varying levels of firmness, and response speed

Flexibility resources can be classified into four main groups: (i) dispatchable or controllable generation, (ii) demand response and active demand management, (iii) storage systems using different technologies (e.g., batteries or pumped storage), and (iv) electricity grids and interconnections with neighbouring electricity systems for the exchange of electricity.

Alongside these major groups, it is worth noting that devices based on digitalisation and power electronics also contribute to improving the flexibility of the electricity system in the very short term. These technologies enhance system stability, ensuring a swift and efficient response when needed.

Scenarios for the evolution of electricity systems towards net-zero emissions suggest that the short-term flexibility provided by thermal and hydroelectric power plants (on a timescale ranging from hours to a few days) will be complemented by that provided by storage facilities, such as pumped storage or batteries, and demand response mechanisms. In the very long term, by 2050, demand response (particularly well-suited to responding rapidly to system signals, including the flexible operation of electrolysers) will provide up to two-thirds of short-term flexibility requirements. The remaining third will be supplied by battery storage systems and regulatable and pumped-storage hydroelectric power stations.

In the coming years, significant investments will be required to achieve the levels of flexibility needed to ensure a reliable and resilient electricity system

The flexibility requirements of an electricity system also depend on its specific physical characteristics, determined by existing assets, grid configuration, interconnections with other systems, the progress of the electrification of demand, and the penetration of renewable energy. Depending on all these factors, it may be optimal to provide flexibility using different technology mixes (e.g., various combinations of batteries, pumped storage or other technologies, with different operational and flexible response capabilities).

In Europe, flexibility requirements will double by 2030 in order to properly integrate renewable energy and respond to more volatile consumption patterns. Compared to 2021 levels, daily flexibility demand will increase by a factor of 2.4 (which can be met through demand response, sector coupling, and storage technologies). On the other hand, weekly flexibility demand will double (with large-scale storage systems), and seasonal or annual flexibility will increase by a factor of 1.3 (with a greater role for hydropower plants and, if the hydrogen value chain is developed, electrolysers).

In the Spanish electricity system, the greater share of non-dispatchable renewables (wind and solar) and the greater variability of demand (due to greater sensitivity to temperature changes) result in residual demand curves (duck curves) that show very sharp changes in the very short term (within a few hours). This implies the need to ensure the availability of several thousand MW of flexible resources, capable of adjusting their generation or consumption profiles upward or downward.

European regulation allows for the introduction of capacity remuneration mechanisms to ensure investment in flexible technologies and the availability of flexible resources

The recent reform of the European electricity market design establishes capacity remuneration mechanisms (or capacity mechanisms, CRM) as a structural element of the market, with the aim of facilitating the necessary investments in non-fossil technologies (storage and demand response) and supporting other technologies, such as natural gas combined cycle plants, which offer backup and flexibility to the system across different time horizons. Capacity mechanisms for conventional technologies, such as combined-cycle plants, must also comply with state-aid rules set out in guidelines such as the CEEAG (Climate, Environment and Energy State Aid Guidelines) or the recently approved CISAF (Clean Industrial Deal State Aid Framework).

The main objective of CRMs is to ensure an adequate level of available capacity in the system to meet demand (i.e., resource adequacy) and to respond to system needs from the very short term to the seasonal or annual horizon. These resources may include generation or storage assets and demand response mechanisms.

One of the main reasons for implementing CRMs in electricity markets is that ‘energy-only’ market designs often suffer from problems such as the difficulty for generators (and other assets, such as batteries) to recover all their costs (i.e., the so-called ‘missing money problem’), particularly in scenarios with increasing penetration of intermittent renewable energy sources with very low or zero marginal costs.

There is a wide range of CRM types, including different types of market instruments and mechanisms, implemented in Europe and other regions

The range of CRM types is varied and can be classified into volume-based or price-based. Within the former category, we can identify mechanisms with a specific focus (targeted CRM), such as strategic reserves, and market mechanisms with universal scope (market-wide CRM), such as capacity obligations, capacity auctions, or reliability options.

The capacity markets currently in place in Europe generate efficient economic signals to encourage investment in flexibility resources and ensure their availability

There are currently eight capacity mechanisms in the European Union. Three of these (Germany, Finland, and Sweden) are based on a strategic reserve model, whilst five are market-wide mechanisms, of which four are based on a centralised procurement system (Belgium, Ireland, Italy, and Poland) and one (France) is based on decentralised capacity contracting obligations. In France (2027) and Germany (possibly in 2028), new CRM designs based on market mechanisms will be implemented, in line with those currently in place in Belgium, Ireland, Italy, and Poland.

The main conclusion of the analysis is that capacity mechanisms can help ensure the required levels of flexibility in many electricity systems

Although the operational circumstances of each electricity system differ, market mechanisms—and, in particular, market-wide capacity markets—avoid certain problems associated with other mechanisms such as strategic reserves (which can distort price signals) or capacity payments (which do not necessarily reflect the cost of maintaining the desired levels of reserve margin and flexibility). Furthermore, they are usually designed so that all technologies (including cross-border resources) can participate in competitive auctions, offering firm capacity or flexibility in an efficient manner.

RECOMMENDATIONS REGARDING THE SPANISH ELECTRICITY SYSTEM

The development of a capacity market is one of the ways to ensure an adequate reserve margin and strengthen the security of electricity supply

The Spanish electricity system faces supply risks due to insufficient levels of demand coverage. According to the latest analysis of demand coverage in the Spanish peninsular electricity system, carried out by Red Eléctrica in September 2025, there are significant risks to demand coverage in the short (2026) and medium term (2030). Furthermore, Red Eléctrica notes that the economic viability of a significant share of the generation units providing system back-up services may not be ensured in the short and medium term in the absence of additional incentives. The development of a capacity market is one way to ensure an adequate reserve margin in the Spanish electricity system, while supporting the economic viability of the generation assets required to meet demand.

Operational flexibility in the short to medium term can be promoted by strengthening interconnections, deploying storage technologies, and enabling the participation of all resources in the provision of balancing, frequency, and voltage control services

Analyses by Red Eléctrica indicate that, to maintain adequate voltage and frequency control, as well as inertia in the electricity system, greater flexibility and responsive capacity are desirable. This can be achieved by strengthening international interconnections and deploying storage technologies, such as batteries and pumped storage, with different response characteristics. Furthermore, the participation of all resources, including renewable generation, storage, and demand response, in providing balancing services and frequency and voltage control should be facilitated.

The proposed design for the capacity market could be improved in certain respects that may introduce risks of distortions and inefficiency in the market's operation

The capacity market proposed by the Spanish Government in December 2024, which is pending approval in Brussels, is a universal centralised market, similar to those existing in other EU Member States. The capacity service is defined as a service providing availability of firm capacity during times of system stress. This new market will allocate, through 'pay-as-bid' auctions, payments for capacity services provided by eligible entities (under economic, legal, and technical criteria) to participate in the auction with certified energy resources (i.e., firm capacity, defined according to firmness parameters set ex ante for the various technologies) to provide a capacity service. Participation in the auctions is open to all technologies (generation, storage, and demand response), demand aggregators (including suppliers), and other entities acting as representatives of third parties.

Although the proposed capacity market in Spain is aligned with existing market designs in Europe, the following areas for improvement can be identified:

- Stress hours, as defined in the proposal, should be aligned with periods of shortage of generation in the system.
- The definition of 'effective service provision' should be revised, as defining it as an average across all stress hours weakens the incentive for the availability of capacity at specific moments when the system needs more power.
- The flexibility coefficient must be defined in such a way as to avoid discriminating against certain technologies (e.g., nuclear generation, which does not participate in manual activation balancing markets but provides firm capacity during periods of generation shortage).
- The suitability of the chosen auction mechanism (sealed-bid auctions and payments based on bids, or pay-as-bid) should be assessed, as this may not be the most efficient design, according to multiple academic studies.
- An explicit frequency for auctions and predetermined lead times should be defined to avoid creating uncertainty amongst investors and companies operating generation assets.
- The possibility of holding transitional auctions linked to multi-year contracts should be enabled, to avoid discouraging necessary investment in combined-cycle plants or allocating the total investment value to bids for a single year.
- The scheme should guarantee exit rights, allowing facilities that are not awarded the service and whose economic viability is compromised to cease operations.
- The mechanism should avoid double compensation (e.g., ERDF aid for storage projects) in order to prevent distortions in the capacity market.
- The number of key parameters dependent on regulatory decisions not subject to transparent methodologies (e.g., price caps, confidential reserve prices, technology-specific firmness ratios, etc.) should be limited, as these generate uncertainty and regulatory risk that negatively affect investment decisions and auction outcomes.

In parallel with the launch of the capacity market, coordination and consistency should be ensured across the set of measures aimed at increasing the system's flexibility, resilience, and security of supply

The objectives of the new capacity market include ensuring demand coverage across different time horizons ensuring that sufficient flexibility resources are available to respond to a wide variety of operational scenarios and contingencies, ranging from the very short term (seconds, minutes, a few hours) to the short term (hours, the following day, subsequent days), the medium term (days to weeks) and the long term (months, seasons and years).

In recent months, a number of regulatory measures have been approved to ensure adequate demand coverage and flexibility, creating incentives for investment in a mix of efficient flexibility technologies and for the provision of flexibility and resilience services for the electricity system as a whole.

Whilst all these regulations are aimed at promoting the development of flexibility resources within the electricity system, it should be ensured that they do not interfere with the design of the future capacity market, whose key parameters must ensure the availability of sufficient flexible generation, storage and demand-side management resources to meet the needs for demand coverage across different time horizons (real time, short, medium and long term).

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