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ENERGY MARKET DESIGN WITH CAPACITY MECHANISMS

Introduction

Governments in various EU countries have been concerned about the ability of liberalized electricity markets to provide a sufficiently stable investment climate to ensure security of supplies and, as a result, have introduced ‘capacity mechanisms’. In broad terms, prior to the introduction of these mechanisms the most common national market design in the EU was to remunerate capacity based on the energy that it produces, with no explicit reward for capacity. This design is often labelled an ‘energy-only’ market. Capacity mechanisms, such as those implemented in France, Poland, the UK, and Italy, provide additional revenue streams to all or a subset of capacity, in return for accepting an obligation to be available in periods of system stress.

While in principle an energy-only market, without regulatory intervention in the form of a capacity mechanism, can provide sufficient investment signals to secure adequate plant capacity, there could be a number of policy or market failures that mean this may not work in practice, which we explore in this chapter. Where these cannot be addressed by less intrusive reforms, a capacity mechanism could be a viable option.

However, given concerns that widespread and/or uncoordinated implementation of capacity mechanisms across the EU could distort the internal market, the EU has developed a legal framework to ensure that capacity mechanisms are only introduced where strictly required and where they conform to certain design principles.

In this chapter, we examine some of the challenges for the energy-only market, in particular with increasing shares of (subsidized) renewable plant capacity, and consider the circumstances under which intervention in the form of a capacity market may be appropriate.

This chapter is structured as follows.

- We first look at the mechanisms in the energy-only market that work in favour of security of supply and the challenges—including potential market or policy failures—that may arise without explicit remuneration of plant capacity. This section is an important base for the further discussion: Economists would only endorse policy interventions if the existing system design exhibited systematic market failures. If the claims of market failures were unfounded then so would be any proposals for policy intervention in the market.
- We then consider some of these proposals and discuss how to create efficient capacity investment incentives.
- Finally, we focus on the challenges that arise from increasing penetration of renewables and consider some of the challenges that capacity mechanisms may face in attracting new flexible technologies necessary to manage intermittency.

Energy-only market - can it be sustainable?

The underlying electricity market design philosophy in the EU, as enshrined in the Electricity Regulation[1] and its associated network codes, is that power stations (and demand-side response providers) are remunerated for the energy they produce (€/MWh), while there is no obligation also explicitly to reward capacity. As already explained in the previous chapters, this design is often labelled ‘energy-only market’, even though this can at best be a short-hand description of prevailing regimes. For simplicity, however, in the following, when referring to the term ‘energy-only’ market, we mean the comprehensive arrangements in a country which reward wholesale power mainly through a per MWh-charge, even though there may at the same time be voluntary capacity related contracts such as back-up or option contracts.

For instance, some capacity will be remunerated for their availability, including plants that provide ancillary services (voltage and frequency control, for example) to the local transmission system operator (TSO) or plants that act as back-up reserve for generators’ portfolios. Furthermore, even in today’s energy-only market, balancing arrangements oblige the sellers of power to inject and withdraw power from the grid in a balanced manner and according to schedules which they need to nominate in advance and which serve contracted load at every point in time. This means that the respective energy supply contracts, and therefore also the energy prices stipulated therein, contain at least an implicit capacity element. The regulated balancing arrangements, which can contain penal elements for imbalances can be interpreted as a regulatory intervention that implicitly supports the remuneration of capacity.

The energy-only market regime has been criticized by academics (initially mainly from the USA), practitioners (especially also in Latin America), and recently also European policy-makers. In particular, the regime is alleged to insufficiently reward the provision of reserve capacity from flexible and dispatchable plants[2] such as gas-fired power stations or electricity storage plants (e.g. pumped hydro storage plants or batteries), preventing them from operating profitably. This would lead to the premature closure of required reserve capacity and lack of investment incentives for new capacities. Such a development would ultimately and fundamentally threaten the security of electricity supply.

In order to judge whether the market design has systematic failures we explore the possible causes of market failures in several steps. First, we explore the functioning of the energy-only market and ask how plant capacity is being rewarded and if this may be sufficient? Next, we

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[1] Regulation (EU) 2019/943 of the European Parliament and of the Council on the internal market for electricity [2019] OJ L158/54 (Electricity Regulation).

2 In dispatchable plants the operator can control the output profile and increase or decrease output at his discretion. Thermal power stations such as coal and gas plants are typical examples of dispatchable plant. By contrast, in non-dispatchable plant the output profile is subject to external forces, typically climate conditions. Typical examples of non-dispatchable plant are wind or solar power generation technologies. For these technologies the operator has the discretion to reduce the output, but they cannot increase it to nameplate capacity if there is no wind or solar radiation.

explore possible market failures and ask what arguments could provide a theoretical justification for political market interventions.

Functioning of the energy-only market

In the energy-only market, plant operators will offer their production based on the variable (or short-term marginal) cost of their plants (at least in the absence of market power), while consumers or their agents (the retail suppliers) will signal their willingness to pay for electricity as buyers. The result is a wholesale market clearing for very short delivery periods (eg each individual hour or fifteen-minute period) which establishes a uniform price for all electricity traded in relation to that delivery period and for a given location. This mechanism allows producers to earn revenues above their own variable cost (and thus achieve a contribution to fixed and capital costs) in two instances, as we can observe in Figure 1.[3]

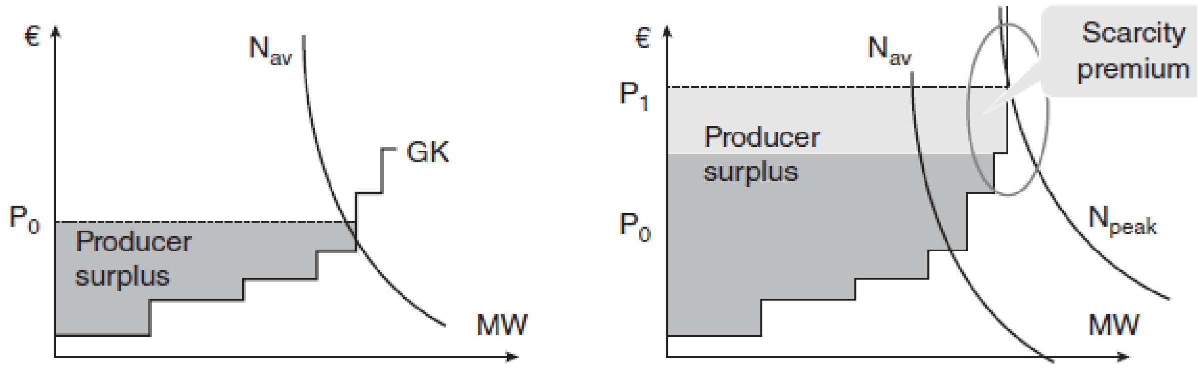
The left graph of Figure 1 shows that, in any hour, generators with power stations with lower variable cost than the last plant, which is required to meet demand, ie the price-setting plant, will earn a margin on their own variable cost as the uniform market price exceeds their own variable cost. In technical economic terms this is known as a producer surplus.

The right graph of Figure 1 illustrates that generators can earn additional rents in tight capacity situations. This is the case where less plant capacity is available than latent demand,[4] leading to scarcity prices. These prices can exceed the variable cost of the most expensive power stations. They will rather reflect the electricity price at which certain consumers are willing to reduce their demand or the long-term marginal costs of power generation including capacity costs. Through this, any generators — including the marginal generator and possibly also consumers who can offer demand flexibility (at lower cost than the marginal consumer)—will earn a margin on their variable cost. This so-called 'scarcity premium' can offer a further contribution to amortise fixed and investment cost. This is known as 'peak-load pricing theory'.

3 For further explanations of the functioning of competitive power markets see Steven Stoft, Power System Economics: Designing Markets for Electricity (2002) or Frontier Economics and FORMAET, 'Decentralised capacity obligations—a promising alternative to centralised capacity mechanisms?' Study on behalf of the German Federal Ministry of Economics and Technology (German only, English short version available upon request, May 2013).

4 By latent demand we mean aggregate demand that would prevail at (very) low prices of electricity.

Figure 1 Functioning of an energy-only electricity market (peak-load pricing theory)



Source: Frontier Economics

In such a world, an energy-only market—without regulatory intervention in the form of capacity mechanisms—can in principle provide sufficient investment signals and secure adequate plant capacity.

Current low electricity margins as a justification for capacity mechanisms?

Figure 2 plots the clean 'spark' spread and clean 'dark' spread over recent years, for Germany, as well as the EU price for carbon emissions allowances. Spark and dark spreads measure the difference between (baseload) wholesale prices and the fuel and carbon costs for a reference gas-fired and coal-fired plant, respectively. They provide an indication of gross profit margin (i.e. before considering fixed costs) from the wholesale markets, assuming baseload (i.e. continuous) operation.

Figure 2 Clean spark and dark spreads, Germany (monthly averages)

Source: Frontier Economics, based on Bloomberg data

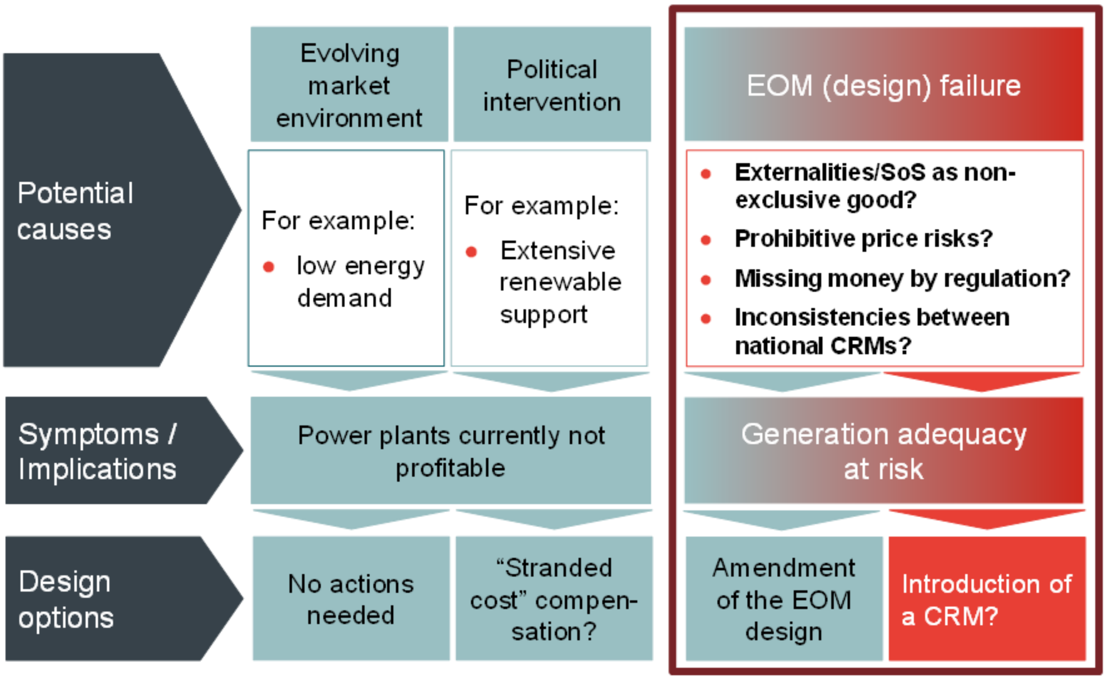
As can be seen from Figure 2, it has become increasingly challenging for conventional plants to earn profits (and even more so since the end of 2020 as carbon prices have increased substantially). That is not to say that all thermal plants are incurring substantial losses: some plants may be more efficient than the reference assumption, conditions elsewhere in Europe may be somewhat more favorable, and losses might be avoided by operating more flexibly (where possible).

However, it has been challenging for plants operating without further financial support for capacity (which include the majority of conventional plants) to recover fixed costs. This is a concern for policy-makers who intend to further increase the role of non-dispatchable renewable generation (wind, solar), in particular.

However, it is important to identify the cause of current low electricity profit margins clearly since (temporarily) low margins alone do not justify political intervention in the market. Moreover, it is expectations about future market prices (rather than current market prices) that drive investments in new capacity.

In Figure 3 we distinguish four potential reasons for the current situation:

Figure 3 Arguments discussed in favour of the introduction of capacity mechanisms



Source: Frontier Economics

Evolving market environment

Falling margins on electricity sales in the wholesale market might be the result of existing overcapacity in the market and can be readily explained by the workings of market mechanisms.

Low energy and electricity demand in Europe during the early 2010s (when the first wave of capacity mechanisms was introduced in the EU) were a result of the earlier economic crisis and structural changes that it induced. Some overcapacity in conventional plant was inherited from the pre-liberalized (and in some cases also post-liberalized) era. Furthermore, the economic crisis after 2008 led to low prices for CO_2-certificates worsening the commercial viability especially of gas-fired power plants (as compared to more CO_2-intense coal plants). The longer-term impact of the Covid-19 crisis (and subsequent economic recovery) on electricity demand is yet to be established.

These developments reflect market risks and should not be seen as an economic justification for the introduction of a capacity mechanism. Certain risks should be accepted by market operators.

Political intervention

Secondly, market investors may have been ‘tricked’ by certain changes in the policy environment.

For example, policy decisions may have contributed to excess capacity. Member States have subsidised the expansion of renewable capacity (not only in non-dispatchable technologies but also in biofuels etc) and cogeneration facilities. Furthermore, an investment boom was triggered in conventional plant in connection with the introduction of the European Emissions Trading Scheme (EU ETS) that initially (until 2012) saw generous rules for the free allocation of emission permits in the early phase in some Member States. As could be expected, these overcapacities result in low electricity wholesale prices. More recently, a tightening of EU greenhouse gas emissions reduction targets has led to an increase in the price of CO_2 certificates (see Figure 2) putting pressure on lignite and coal-fired generation in particular, which have also been subjected to more stringent restrictions on air quality.

This alone is not an indication of any market failure per se. Power generators claiming for a compensation are really asking for ‘stranded cost’ payments to compensate for a specific and historic policy decision. Such circumstances do not, however, justify the introduction of capacity mechanisms.

Design flaws

Thirdly, deficiencies within the specific design of energy-only markets in individual countries (rather than deficiencies in the functioning of energy-only markets per se) may imply that the market does not meet its role of ensuring security of supply through sufficient capacity—at least not in the most efficient way. A number of deficiencies have been discussed in practice.

Some countries (for example, Bulgaria and Greece) have (until recently) had explicit caps on either wholesale prices or balancing prices, set at far below the value of lost load (the value that customers place on reliability, or their own cost of interruption). In other countries, the inefficiency in price signals may be less apparent. For example, in Germany, imbalance prices were calculated on the basis of average bids rather than marginal bids. This has implied that market players who did not keep a balance between their injection into and their withdrawal from the grid faced no penalty and might have even benefited from being out of balance. Such a setting clearly does not provide clear incentives for market players to back their contracted sale with capacity as it could be commercially advantageous to simply top up the imbalance from power on the grid. If all players behaved in this way and the reserve margin became slimmer, the likelihood of outages would rise over time.

By and large, EU internal market legislation for electricity (in particular the network codes for electricity balancing and capacity allocation and congestion management) aims to ensure an efficiently functioning energy-only market. For example, it requires balancing energy price signals to be based on marginal bids and asymmetric prices for shortfalls and excess supplies, and for Member States to set imbalance settlement prices in situations on scarcity that reflect the very high valuation of power by consumers that are actually or potentially interrupted. Member States have less discretion now to set price caps in the day-ahead and intra-day markets. For the most part, renewable and low-carbon capacity must be balance responsible. The EU Electricity Regulation aims to reinforce these requirements, obliging Member States seeking to introduce a capacity mechanism to produce an implementation plan, setting out market reforms to address any potential deficiencies in the energy market design and a clear timetable for implementing them.

Where it is feasible to resolve the failures within the current regime, the introduction of more far-reaching capacity mechanisms is not required. We return to the options to enhance the current energy-only market design in the third section of this chapter.

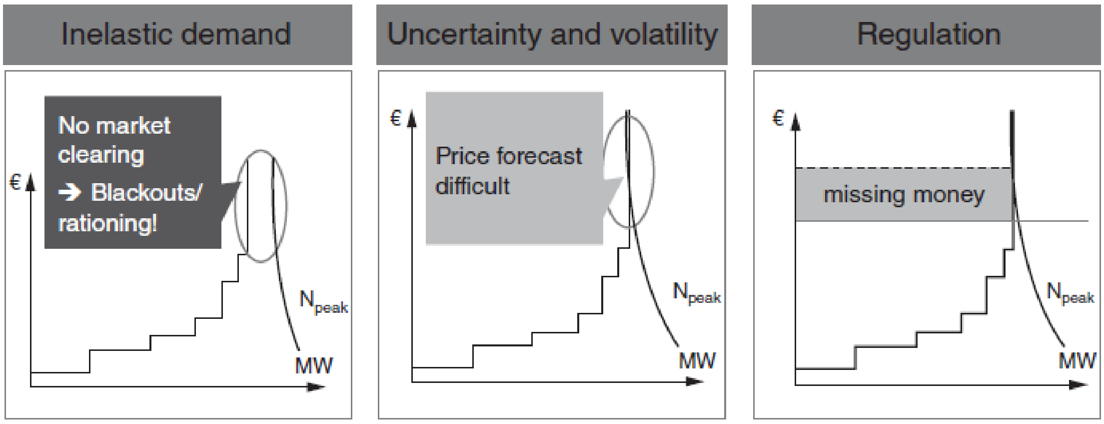
Market failures

Fourthly, there could be genuine and structural failures of how energy-only markets work. If such failures exist, and these failures cannot be healed by less intrusive means, then the introduction of certain capacity mechanisms becomes a viable option. We discuss these potential fundamental failures in the following section.

Possible fundamental market failures

The academic literature[5] and the practical debate have identified several possible fundamental causes of market failures, broadly in the three categories of externalities/public goods nature of security of supply given inelastic demand, volatility which may create prohibitive prices risk, and the threat of or the actual political intervention in price formation (missing money) which are presented in Figure 4.[6]

Figure 4 Potential fundamental market failures in an energy-only market



Source: Frontier Economics

In essence, all these problems may cause plant capacity to be insufficiently remunerated. This in turn would lead to underinvestment and an inefficiently low level of security of supply.

Some authors also raise concern about the use or abuse of market power in capacity constrained markets. The issue here, however, is not that of an insufficient remuneration of plant, but of excessive remuneration. However, abuse of market power may lead to political intervention in price formation and therefore indirectly to the 'missing money' problem stated earlier.

In relatively small and insular markets (e.g. Ireland), there may be a further concern about the effects of lumpy investment. While market prices may be sufficiently high before a new

[5] See eg Peter Cramton and Steven Stoft, 'The convergence of market designs for adequate generating capacity—with special attention to the CAISO's resource adequacy problem', A White Paper for California's Electricity Oversight Board (April 2006); Dominique Finon and Virginie Pignon, 'Electricity and long-term capacity adequacy: the quest for regulatory mechanism compatible with electricity market' (2008); William W Hogan, 'On an "energy only" electricity market design for resource adequacy' Harvard University Center for Business and Government Working Paper (2005), https://scholar.harvard.edu/whogan/files/hogan_energy_only_092305.pdf. Pablo Rodilla and Carlos Batlle, 'Security of electricity supply at the generation level: problem analysis' (2012).

6 See also Frontier Economics, Formaet Services, 'Electricity market in Germany: does the current market design provide security of supply?' Study for the BMWi (September 2014).

investment, the efficient scale of a new investment may be so large that for some time it depresses the market price. The effect may be that no single player is ever prepared to invest.

Security of supply as ‘public good’

The academic literature takes particular concern with the combination of two features: First, consumers cannot or do not express their willingness to pay through the market, and therefore respond insufficiently to price signals (consumers are price-inelastic). Secondly, in situations with actual generation shortage and partial power disruption in defined parts of the grid areas (brownouts), producers located in the affected area cannot earn any revenues or margins. Furthermore, in a situation with partial disruption (brownout) the prevailing energy price may not reflect the social value of electricity to consumers as some demand may be curtailed and the market price has to be defined administratively. This in turn has two consequences:

First, power generators, which are available to produce in a brownout situation may only benefit from electricity prices administratively defined for the hours in which demand is technically curtailed. If these prices turn out not to reflect scarcity prices, producers will reflect this lower valuation in their investment (and disinvestment) decisions. As a result of this externality, less generation capacity may be held on the system than is economically and socially desirable. The provision of (reserve) capacity has characteristics of a public good.

Secondly, vis-à-vis consumers there may be inefficient rationing of demand in case of power supply failures. When demand responds insufficiently to high electricity prices in periods of a capacity shortage, random rationing of demand can occur (blackouts or brownouts). Some consumers, who value reliable power supply more than other customers, will not have the opportunity to effectively signal their higher valuation, and they may be interrupted along with other consumers in their network area.

This inability of customers to signal their desired level of reliability through prices may be caused by a number of factors. Institutional barriers may limit the implementation of time-of-use or real-time electricity tariffs. For example, in some countries, while smart metering technologies exist that allow for real-time pricing, respective tariffs may not have been approved by authorities and can therefore not be applied. Furthermore, technical and commercial conditions (such as high cost of the required consumption metering technology or inadequate consumer interest in required tariffs and metering technologies) may limit the demand response by consumers. These circumstances could potentially justify a policy intervention in the market design to achieve the socially desirable level of capacity on the system. However, the measures should be selected very carefully. These could range from weak interventions such as defining rules for price determination and settlement for hours in which demand is technically partly curtailed to the implementation of comprehensive and complex capacity mechanisms.

Underinvestment due to prohibitive price risk (uncertainty for investors)

If plant investors depend on scarcity rents to amortize their investment cost, they will consider investments as particularly risky. If, on the other hand, there is uncertainty about the frequency and level of price spikes, risk averse investors will become more cautious and will require higher risk premia, either to invest or to continue operation. In both cases, this will eventually lead to higher prices for consumers. This situation can become particularly relevant as the volatility of electricity wholesale prices rises with the increasing penetration of wind and solar generation.

The basic argument here is one of a market failure in financial markets (to fund the continued operation of power stations) and not one of a failure in the electricity market itself. The issue may be exacerbated by policy-driven uncertainty (which we discuss further below), but we focus just on the issue of market driven volatility for now.

Under certain circumstances this may justify policy intervention in the market by mandating capacity mechanisms. This may be the case if the social benefit of risk reallocation (where part of the risk is shifted from plant investors to the collective of consumers) outweighed the detrimental effects of the intervention, e.g. less reliance on dynamic and market-based solutions, increased regulatory and policy risk.

However, it should be noted that capacity mechanisms are not the only way to handle some of the aforementioned risks. The electricity market offers opportunities to limit or reallocate risks via forward and option contracts, some of them already prevailing today (albeit not always over the durations required to support investment decisions). Moreover, the signal of increased market risk may be an important one. As a result of increasing renewable generation the fundamental risks[7] in the electricity market are increasing and therefore it may be economically efficient for investors to consider them in their investment decisions by increasing risk premia and return requirements. In this sense it is questionable whether the increase in market risk alone justifies policy intervention in the market design by setting up capacity mechanisms.

The threat of exercise of market power in peaking periods

The next market failure consists not in energy prices being too low to reward risky plant investment, but rather in prices being too high. The scarcer plant capacity is, the easier it can be for dominant firms to exploit their market power by raising prices in scarcity situations to the detriment of consumers and overall welfare. An effective capacity mechanism should lead to additional plant capacity and fewer scarcity situations and as such, mitigate the risk of

[7] The term fundamental risk refers to risk which is related to certain underlying and often physical factors in the market, such as the level of demand, the availability of wind and solar radiation, or fuel prices. Wind and solar availabilities are fundamental factors that have in many countries only achieved significance over the last decade.

market power. Moreover, capacity mechanisms can be designed to explicitly limit the price at which generators with a capacity contract can offer their output in the market.

However, we would like to note again that the introduction of a capacity mechanism is not the only remedy that may be considered here. Effective antitrust enforcement in case of market abuses may yield equal (or higher) benefits. Furthermore, market power can also exist in capacity mechanisms. Antitrust enforcement in case of market abuses may be even easier in an energy market than in a capacity mechanism since the economic rational of investment and disinvestment decisions may be more difficult to assess by cartel authorities in a capacity mechanism. Relatively high energy prices may also be desirable to induce new investment and attract new entrants, although there may be a temporary risk of high producers' rents and higher than optimal prices for consumers as a side effect.

Missing money problem due to threat of regulatory intervention

That said, in regulatory practice, it is difficult to distinguish between an appropriate price spike necessary to signal scarcity and a high price as a result of abuse of market power. If price caps or bidding restrictions are mistakenly introduced (or investors worry that they might be), this will lead to lower revenues (or expectations thereof). This is known as the missing money problem, which might justify the introduction of a capacity mechanism in order to compensate for such lost revenues.

Politically driven uncertainty

In any electricity market, volatility and uncertainty in relation to market prices create significant risks for investors. As explained above, investors should be willing and able to take on and manage these risks when markets are allowed to operate free of political intervention. Investors are, however, less able to manage risks associated with politically driven policies. For example:

- Risks associated with the pace and extent of renewables deployment, typically driven by discrete political subsidy decisions.
- Risks associated with technology compliance (such as whether more restrictive air quality standards might be introduced, whether certain plants might be able to obtain exemptions from them and the resulting impact on plant closure decisions). Politically mandated phase out of certain plant technologies and uncertainties around exact timelines for such decommission also fall into this category.
- Risks associated with broader environmental policy. For example, under the current European Commission, the EU's greenhouse gas emissions reduction target for 2030 has been increased from 40 per cent to 55 per cent. The impacts of future policy changes will have unknown effects on the economics of different types of capacity.
- This is not to argue for capacity mechanisms as a way of compensating investors for adverse policy shifts—as discussed above, there may be more appropriate mechanisms

for doing so; most notably avoiding abrupt policy changes. But it should be recognized that uncertainties regarding when and how policy will change make it difficult both for

- existing plant owners to make efficient closure decisions (which could result in uncoordinated and excessive closure); and
- investors in new capacity to determine what type of capacity will be needed, how much, and when.

What are the policy options - and how would they perform?

Reform without capacity mechanism

As described earlier, an analysis of the energy-only market suggests that some deficiencies may prevail in the current market designs in some countries. Before embarking on the design of capacity mechanisms it is therefore reasonable to consider the root cause of these flaws in the design. We explore three potential causes and corresponding remedies.

First, enhancing the flexibility of demand and integrating demand response in the electricity market would help remedy an important shortcoming in the current regime. Sophisticated metering and billing systems are available and would be required to mobilize demand response (and they have already been installed in some Member States). For this to be effective it would not even be required to cover the entire market demand. Initially, it would be sufficient to focus on large consumers such as industry and commerce. However, enhancing the flexibility of demand and integrating demand response into the electricity market may also imply additional fixed and variable costs which have to be taken into account when assessing such options. Especially for energy users for whom the procurement of energy and the management of energy demand is not part of its core business, not enough management attention may be available to exploit opportunities to make demand more flexible. Informational support (from regulators or TSOs) may contribute to overcoming this failure.

Secondly, stability of the policy framework is another ingredient to a well-functioning market. This requires a clear policy commitment of how policy-makers and authorities will respond to high electricity prices in scarcity situations, as well as clarity over whether capacity mechanisms will be implemented. Uncertainty over the introduction of capacity mechanisms in the future may reduce investment incentives today. Furthermore, keeping renewable support to announced renewable expansion targets falls into this category.

Thirdly, ensuring market liquidity is important. In markets where liquidity has not matured and therefore where a market lacks reliable medium-term price signals and market prices respond very strongly to policy events, measures may be sought to enhance market liquidity. This could involve structural changes such as increasing cross-border capacities or softer behavioural remedies such as obliging key players to act as market-makers.

Which capacity mechanisms are debated?

The next level of escalating policy intervention in the market would be to consider explicit capacity support mechanisms. Several distinct options have emerged in the international debate, including strategic reserve, capacity auctions, capacity obligations, reliability options, and capacity payments, and we refer the reader to Annex 1 for an overview of these types.[8]

All capacity mechanisms imply additional costs to the system. As well as transaction costs, which are associated with any change in design, there might be additional costs resulting from (a) design flaws and (b) policy failures.[9]

With respect to design flaws (a), even a well-intended design is likely to exhibit deficiencies. These may ultimately be evened out over time as experience with the performance of a particular design grows. The practical experience in implementing capacity mechanisms shows that these models take years if not decades to converge on a stable design. For example, some designs have experienced volatile capacity prices and have been ineffective at triggering the required capacities.[10] Regarding policy failures (b), policy-makers may want to use (or misuse) capacity mechanisms for objectives other than those originally intended. For example, for political reasons they may favour certain technologies or types of players over others. Any such policy failures will raise the cost of the design, and may distort intra-EU trade.

For these reasons, the Electricity Regulation sets certain constraints on capacity mechanism design, including that capacity mechanisms shall

- be temporary;
- select capacity providers (and determine the price) through a transparent, non-discriminatory and competitive process; and
- be technology neutral (including being open to cross-border participation).

There are both targeted and market-wide mechanisms that meet these criteria.

8 See Frontier Economics and Consentec, 'Impact assessment of capacity mechanisms' Study on behalf of the German Federal Ministry of Economics and Technology (English short version, May 2013). The list of possible design options is not exhaustive, and each option can have further variants. For instance, Öko-Institut, LBD, and Raue have developed a variant for Germany where only part of the capacity requirement is procured by a central agency (eg a TSO). This 'partial' capacity mechanism is guided by the distributional consideration of limiting generators' profits. In this model, capacity payments are paid out only to those plants that would not operate without such payments. All plants continue to participate in the energy market. Please note that, in contrast to other types of capacity mechanisms discussed in this chapter, this particular model has never been implemented in practice. See Öko-Institut, LBD, and Raue, 'Fokussierte Kapazitätsmärkte. Ein neues Marktdesign für den Übergang zu einem neuen Energiesystem', Study on behalf of WWF Deutschland (in German only, October 2012).

9 For examples see Fernando Barrera, Matthias Janssen, and Christoph Riechmann, 'Kapazitätsmärkte: aus der internationalen Praxis lernen?' (2011).

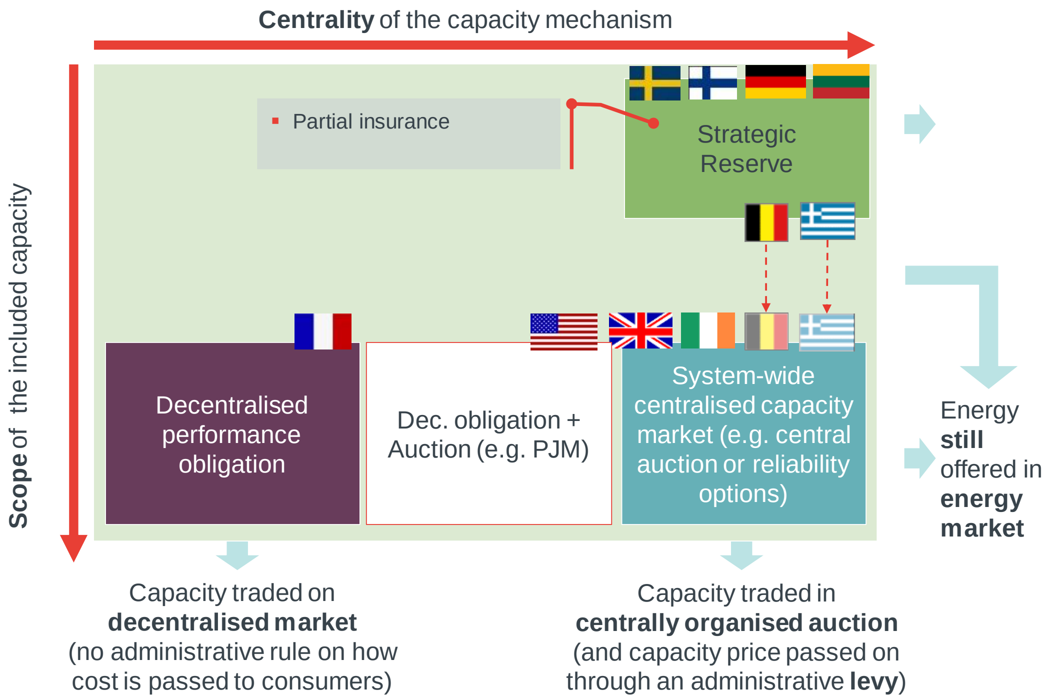
10 For instance, the Capacity Credit Market as operated in the PJM region of the US between 1999 and 2007 led to highly volatile capacity prices, especially due to an inelastic demand for capacity credits. This design was replaced from 2007 by the reliability pricing model which incorporated an artificial demand curve (known as variable resource requirement) that mimicked some demand flexibility. Early capacity market designs in PJM also implied that capacity was not always available when needed.

An example of a targeted mechanism is a strategic reserve, in which contracted plants are purposely excluded from the energy market, and are only to be used as a 'last resort' in the event the system is stressed (to help ensure the reliability standard is met).

Regarding market-wide mechanisms, we can distinguish between whether capacity is procured by central agents (eg the TSO or a state authority in the case of reliability options) or by decentralized agents (eg in the case of capacity obligations on retail suppliers). In terms of reach and scope of the mechanism, we can distinguish whether all capacity on the system benefits from payments from a capacity mechanism (eg in the case of reliability options or capacity obligations) or only certain qualifying plant. Under reliability options, in case the electricity spot price exceeds the strike price in the option contract, electricity committed under this contract is offered at the strike price. If all or most capacities are covered by such option contracts, the strike prices in these contracts may effectively cap the electricity spot price in the energy market in many periods. The implicit price cap would be exceeded only in periods of very high demand, for instance when expensive demand side options are called at very high prices.

Figure 5 maps the design options illustrated in Annex 1 in the dimension of centralization and scope/reach.

Figure 5 Classification of capacity mechanisms

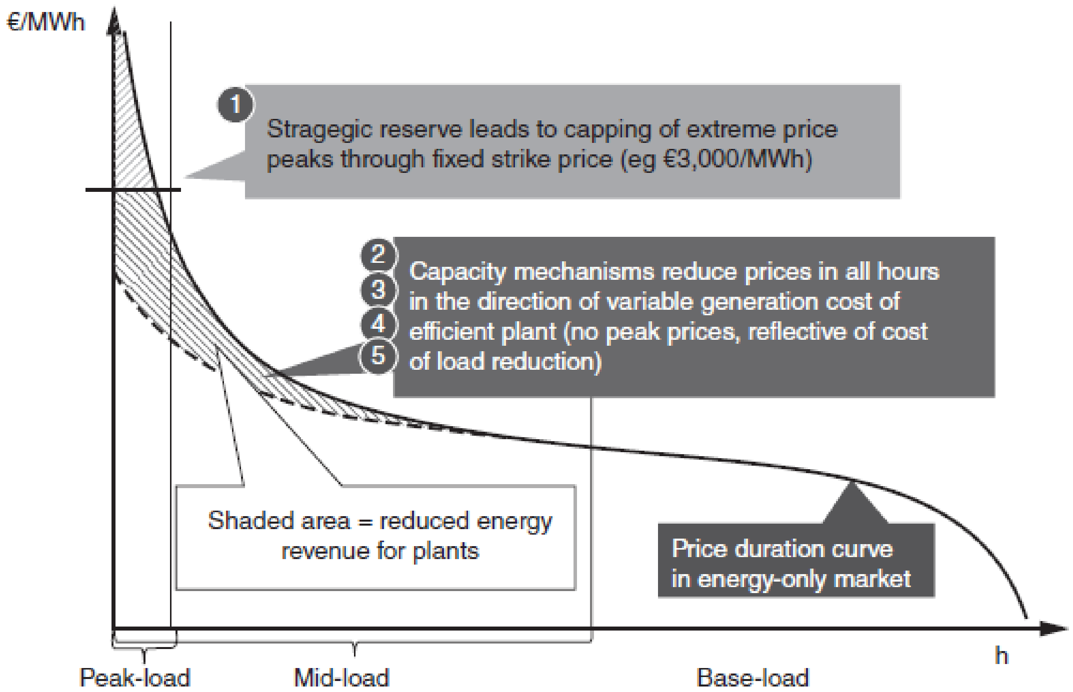


Source: Frontier Economics

Which design options address which market failures?

When deciding on an appropriate capacity mechanism for any country, those models that allow achieving the required level of security of supply, and at the same time limit the degree of policy intervention into the market would be preferred. Depending on the design choice, the introduction of a capacity mechanism can have significant repercussions on the energy market and revenue prospects of power plants from this market. For example, the impact of a well-designed strategic reserve on the energy market will be limited (if any impact exists) to the few hours per year when scarcity prices trigger its activation (see no 1 in Figure 6), depending on the rule by which electricity wholesale prices are set in these specific hours.[11]

Figure 6 Impact of capacity mechanisms on the energy market (schematic illustration)



Source: Frontier Economics

Note: Note that prices are shown as a price duration curve, ie hourly prices are ordered by their level starting from high to low prices.

11 Apart from that, the strategic reserve can deprive the energy market of certain capacity if it includes plants which otherwise would not have been decommissioned but would be dispatched in the energy market at least for some hours. Excluding this capacity could lead to higher prices in the energy market; however, we expect that this effect is negligible as long as the strategic reserve corresponds to a small percentage of peak demand.

While the Electricity Regulation is clear that strategic reserves should only be used when all other sources of supply have been exhausted,[12] there is relatively little precedent in relation to the use of energy in strategic reserves. Investors/owners in plants in the wholesale market may still fear that the government/regulators would want to avoid very high price spikes, and dispatch the reserve to dampen market prices, reducing revenues for all plants outside of the reserve. If this were the case, while the strategic reserve can provide stable revenues for plants in the reserve, it can in theory adversely affect revenues (or increase perceived revenue risk) for plants outside of the reserve.

This means that strategic reserves are more suited to addressing short-term issues (for example related to managing the exit of existing plants), they are less suited to addressing structural issues where new investment may be required. One such transitional motivation may also be to use the strategic reserve as a safety net in a situation of significant structural change in the sector (eg the mandated phase-out of CO_2-intense plants). The reserve could be used to step in if the energy market does not clear due to lack of capacity. Calling up the reserve would indicate that in the specific circumstance the energy only market is not able—on its own—to cope with the speed of change in the sector.

By contrast, capacity mechanisms with a broader scope/reach will also impact on energy prices in mid-merit and possibly even base-load periods. This is because all capacity benefiting from capacity payments is also allowed to participate in the energy market. If the capacity mechanism is effective in securing additional plant capacity, then more capacity will be available and some of this may be new and so more efficient than older plant, thereby exerting a downward pressure on the energy price.

The interdependency between the capacity mechanism and the energy market may also result in a ‘waterbed effect’. This can arise if power plants generate extra revenue through capacity mechanisms, but lose revenue in the energy market (see the shaded area in Figure 6) as a consequence. While in the aggregate plants may tend to have higher overall revenues, some plants may end up with lower revenues.

Therefore, it is important that any decision about the introduction and choice of capacity mechanism is accompanied by an assessment of the nature of the market failures that may apply (which may involve a degree of judgement, given that many market failures might be resolved through market reforms, as noted above):

- If a market failure (in relation to security of supply) is diagnosed with certainty and it is persistent in nature, the introduction of a capacity mechanism broad in scope, like reliability options or capacity obligations, may be justified.
- To the contrary, if the market failure is uncertain, temporary, or limited in scope, a bridging measure in the form of a partial capacity mechanism might be sufficient.

12 The Electricity Regulation (n 1) is clear that, during such periods, imbalances should be priced up to the value of lost load (VoLL) or the intra-day market technical price limit, whichever is higher, ensuring that market prices, in turn, reflect the scarcity on the system (art 22(2)).

- In case of a more severe but still transitory failure, a more comprehensive mechanism may be required. Nevertheless, in such case, the mechanism should also be transitory (sunset clause) or reversible, to keep intervention at minimum.

Challenges for capacity market design in the transition towards net zero

Energy policy in many EU countries has recently focused on the expansion of renewable energy sources (RES). Non-dispatchable technologies[13] of wind and solar play a particular role in this. Therefore, RES expansion can raise particular issues in relation to future security of supply especially in relation to (a) volatility of generation and (b) inaccuracies of production forecast.

In relation to (a), volatile and fluctuating generation from wind and solar requires the availability of secured back-up capacities. In a decarbonized energy system, the role of conventional generation will be increasingly limited, so back-up capacity must come from either storage or demand flexibility that can step in for these renewables. The question is whether market mechanisms alone can deliver these capacities. In relation to (b) inaccuracies in production forecast, the availability of wind and solar radiation can only be predicted with limited accuracy. The availability of respective plants is only known with high certainty shortly (a few hours or less) before real-time dispatch. This holds even though there have been significant improvements in forecasting accuracy in recent years. This uncertainty about actual production requires back-up capacity that needs to be dispatchable at short notice.

Therefore, even absent the potential wider market failures discussed above, the question arises whether the development of RES raises further issues for security of supply on the system.

Historically, there have been concerns that exempting RES from balancing obligations may inefficiently increase the need for capacity reserves. In addition, purchasing the required short-term flexibility to deal with forecasting errors may have been challenging, given the required markets were often underdeveloped. As explained above, the development of EU internal market legislation for electricity means that these issues are becoming increasingly less relevant.

However, the need to restrict unabated coal and gas-fired power generation to meet decarbonation ambitions, combined with the increasing competitiveness of RES (and resulting withdrawal of subsidies), may create new challenges going forward for the design of capacity markets (as well as for reserve products).

Authorities typically ensure that capacity providers are remunerated according to their expected ability to deliver (if required to do so) during system stress events, measured using a ‘de-rating factor’.

[13] Generation from respective technologies can be regulated down, but not up (unless the technologies have already been instructed to regulate downwards).

For conventional generation, de-rating factors are relatively straightforward to calculate. Assuming a reasonable degree of foresight regarding market conditions, the main reason a conventional plant will not be available at peak is due to an unplanned (ie forced) outage. Forced outage rates for conventional plant types can be easily observed from historical data.[14]

However, as the importance of conventional generation reduces, capacity markets will become dominated by other forms of capacity, including RES, demand-side response and (new forms of) storage. For such technologies, calculating 'availability' is much more complex:

- There may (initially) be less data available regarding historical outage rates for new technologies (although over time, this may become less of an issue).
- Measuring the potential contribution of demand-side response requires the establishment of a 'baseline' consumption level. Defining this is not a perfect science, and complex, especially noting that for energy users the cost of offering flexibility can drastically change with the duration that this service is called.[15]
- The expected contribution of storage and (intermittent) RES at peak will depend on expectations regarding their future deployment. For example, the more storage capacity is expected to be already on the system, the less will be the incremental contribution of new storage. Similar considerations apply to intermittent RES. The expected contribution of storage may also depend on the volume of energy that can be stored, which will in turn affect the duration at which storage can dispatch at full capacity.

The final issue above is perhaps the most challenging to solve. As the capacity mechanism starts to be increasingly dominated by technologies whose de-rating factor does not principally depend on exogenous factors, administrative decisions regarding de-rating factors may themselves affect the technology mix. For example, the lower the assumed de-rating factor for storage, the more difficult it will be for storage to compete against other technologies.

One way of avoiding the problem might be to avoid setting de-rating factors administratively in the first place. This would be fine if policy-makers were confident that capacity mechanism penalties for non-delivery fully reflected the cost (to society) of non-delivery. Capacity could be required to declare their own ability, and make use of secondary trading where necessary to fulfil their obligations.

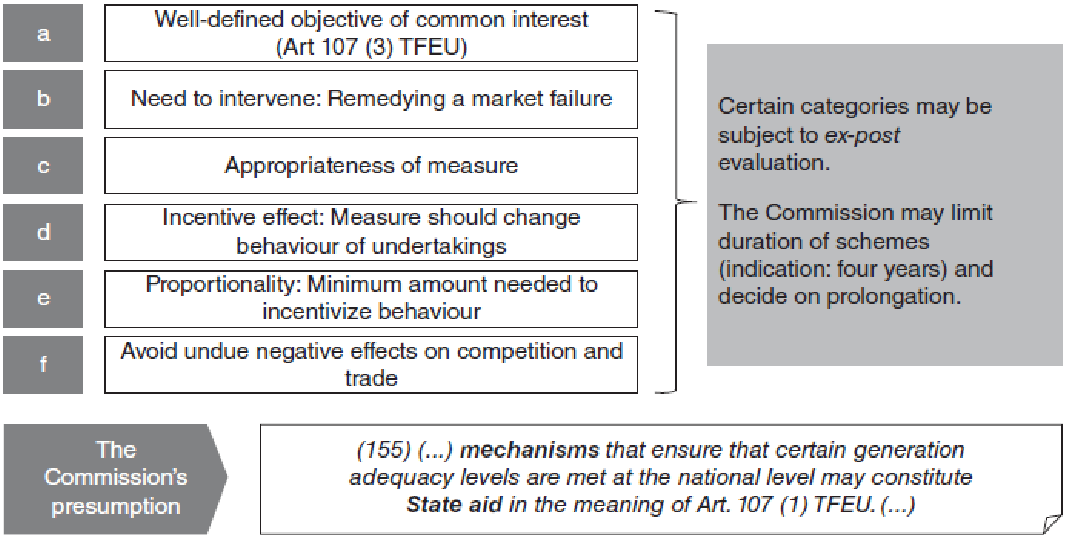
In practice, however, penalty regimes may not be 100 per cent cost-reflective (for example, because of caps on liability). And even where they are, policy-makers may want more certainty that the capacity mechanism will bring forward the right amount of physical (de-rated) capacity. Hence, it may be difficult to avoid setting de-rating factors administratively. Member States (and the Commission as part of the approval process) will need to assess whether this risk

[14] In principle, it would also be appropriate to account for the risk that dispatchable capacity do not, during periods of stress, have access to fuel supplies, which would be particularly relevant for gas-fired plants, although few CRMs do this in practice.

15 For example, it may be relatively straightforward to reduce the electrical load for a cooling installation for a 15-minute period, but it may be very costly to offer the same service for multiple hours (eg if this causes cooled products to perish).

can be minimised sufficiently for the benefits of capacity mechanisms (in terms of addressing any market failure) outweigh the potential costs (in terms of potential regulatory failure arising from the inability to implement full technological neutrality).

Figure 7 The Commission's guidance on capacity mechanisms



Source: Frontier Economics based on the Commission's EEAG 2014–2020 (n 20)

Summary - When to use which capacity mechanisms?

Our discussion shows that security of supply may be addressed through various reform measures which may lie within the current energy-only market design or which may expand the design by capacity mechanisms. The remedy—and with it the intensity of market intervention—should be adapted to the cause diagnosed through logical analysis. From an economic perspective, less interventionist measures are preferred provided they suffice to cure the issue. Therefore, reforms of the existing market design should be exploited first before embarking on the introduction of more extensive mechanisms in the form of capacity mechanisms.

Reforms of the existing market design

The current market design already offers some option for reform. For example, demand flexibility could be strengthened so that in a situation of scarce generation capacity consumers can adjust their demand depending on their willingness to pay for electricity. This helps to overcome some of the potential market failures identified in the literature and it thereby reduces the risk of unplanned and partial or complete power failures.

Reforms with capacity mechanisms

Where policy-makers do not trust that the previously discussed reforms within the current energy-only regime are sufficient, they have options of employing capacity mechanisms as an additional insurance. This insurance should be designed such that it does not unnecessarily interfere with the functioning of the market. Even if this principle is respected, and the capacity mechanism is well designed, its implementation will nevertheless imply some additional (capacity) cost.

Depending on how much trust policy-makers place on the sustainable functioning of electricity markets we distinguish several scenarios: In a scenario where policy-makers do not trust the sustainability of a reformed energy-only market, policy-makers may opt for a comprehensive capacity mechanism covering all required capacity (e.g. capacity obligations or reliability options). In a scenario in which policy-makers trust the (reformed) energy-only market in principle, but see a certain risk that their positive expectation may be disappointed or they see a temporary issue, policy-makers require an insurance or a reserve that can be deployed if capacity adequacy is temporarily distorted or until a full comprehensive capacity mechanism can be implemented in case the energy-only market ultimately proves not to be sustainable. Provided that their concerns about the market not performing are small, a mechanism limited in scope is best able to address this. In case the perceived issue was more significant, then a more comprehensive capacity mechanism would be required. If the issue was perceived to be transitory then it would also be important to design the mechanism such that it would be reversible at a later stage. In a scenario in which policy-makers have full trust in a (reformed) energy-only market no explicit capacity mechanisms would be required.

In many countries, the assessment of market failures and the costs and benefits of introducing capacity mechanisms to cure identified market is still pending. At any rate, policy-makers should also consider that the introduction of capacity mechanisms comes with a risk of design flaws and policy failures, which could become increasingly difficult to avoid. This could imply that the cost of the implementation of a capacity mechanism could exceed its benefit, especially if the market rules are poorly designed.