Capacity mechanism – some properties of its design and remuneration

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***Abstract**: The instant paper deals with the mechanism for capacity provision, which is instrumental for the operation of the capacity market. The latter belongs to the wholesale electricity market and complements the energy only one. The capacity market is tasked with securing reliable power generation under the conditions of imbalance and stress for the energy system. Capacity and energy only markets interact in a consistent manner, thus their proper operation becomes crucial. The capacity market, however, seems to be expensive and few energy systems throughout the EU rely on it. Therefore, it is important to draw a line between different capacity mechanisms already set up and operated in terms of their most important features such as physical volume and clearing price setting. This analysis seems relevant for policy-makers' decision to adopt or to dismiss the mechanism for capacity in Bulgaria.*
***Keywords**: CAPACITY MARKET, CAPACITY MECHANISM, ENERGY ONLY MARKET, TAXONOMY, RELIABILITY OPTIONS, OBLIGATIONS FOR CAPACITY*

1. Introduction

Energy-only markets reward electricity that is actually produced. Like other goods/services, electrical power has been provided on the wholesale and retail markets. The market for capacity belongs to the wholesale one but does not supply electricity as usual. It supplies the mere ability to provide the latter in terms of installed assets that are ready to be (re)activated in order to generate electrical power in case of emergency and shortage. Bad weather conditions, natural disaster and/or industrial accidents may cause electricity imbalance economy-wide. Thus, the demand for is greater than the supply of power leading to peak wholesale prices (since it is still expensive to store energy and defer its consumption). The peak prices of electricity are neither politically nor socially acceptable. The trade-off between *efficiency and equity* is well-known issue in public economics [1]. If the price per megawatt hour of power rises, albeit efficient, it becomes unaffordable for low-income people who are at risk of poverty. If the electricity price is set (artificially) low, the revenue from power sales is not sufficient to cover even the operating costs of enterprises. Then, albeit equitable, the price is inefficient. Such a market constellation raises the "*missing money*" phenomenon within the energy sector [2]. Capital as a production factor becomes scarce for additional investments in electricity generation. The "missing money" problem and the political/social unacceptability of high prices lead to insufficient capacity for energy generation, while its consumption rises. In order to cope with such an imbalance, a capacity market and its remuneration mechanism are established and implemented. The capacity market operates parallel to the energy-only one. The purpose of the former is to reduce the intensity and the level of peak energy prices [3].

Capacity for electricity generation has been supplied not only by companies from the energy sector. Several big end consumers from many different industries may also contribute to the capacity market by modifying their energy consuming "behavior" any time the national/regional energy system requires it. Large industrial consumers track and know very well their own electricity consumption profile and accept restricting the latter within a given timeframe when and if an imbalance occurs. In exchange for their *demand-side response and flexibility*, government programs remunerate generously big non-energy companies. They are paid for their efforts to mitigate the (regional/national) electricity grid stress/shortage by limiting and/or deferring their electrical power consumption. Demand-side response providers are considered as "an increasingly valuable resource option whose …potential impacts are expanded by grid modernization efforts" [16].

Despite the differences between the energy only market and the capacity one, they consistently interact. Under the turbulent conditions of ever-rising energy prices, impulses of interaction may become more visible. In terms of illustration, by reaching a predetermined high level, the electricity wholesale price per unit may trigger the (re)activation of power plants' production assets on the capacity market. The latter influences vice versa the energy only market. The rising wholesale price, which is an indication for power generation and grid stress, makes investments into additional assets on the energy only market more profitable.

The design of the capacity mechanisms wherever they are adopted and implemented varies due to a set of factors. They determine the environment, where *energy only and capacity markets* operate in parallel and the historically established relation "government-market" intervention within the economy. Last, but no least, cost effectiveness is an important factor for the adoption and operation of capacity mechanism in the particular economy.

The statistics provides data for non-negligible public expenditures remunerating companies that take part on the capacity market. In 2019 and 2020 the amounts paid to them were approximately €2,6 billion, while almost doubling in 2021 (~€4,9 billion). Costs of capacity mechanism operation are going to rise slightly - for 2022 they are estimated at €5,2 billion [5], which is due to the adoption and implementation of capacity mechanisms in Poland and Italy.

2. Taxonomy for capacity mechanisms

By the time of its liberalization, an important property of the electrical power market EU wide was the "strong faith in energy only markets" [6]. Though, the increasing share of renewable sources in the EU energy mix marked a turning point in its reliance on energy only market. The variable green energy leads to fewer operating hours for the conventional power plants. Though, they remain crucial, however, in case of peak demand (and prices). The first capacity mechanism was designed and implemented in Spain in 1997 [15, 6].

An important property for the already liberalized EU energy market today is its diversity. Some countries rely on the capacity markets, while many others still consider introducing them.

Under *the strategic reserve* design, the capacity needed to cover any imbalance of electricity generation and consumption is set in a centralized manner, i.e. by a public institution (power grid operator and/or public regulatory authority, which supervises the energy sector).

The remuneration per unit of electrical energy is determined throughout an auction or by a bilateral bargaining. In the strategic reserve as a form of capacity mechanism, different energy producers take part despite their technology and primary source of electrical power generation. Under the strategic reserve design, all of the producers are (re)activated any time the national/regional energy system is prone to stress due to bad weather, natural disaster and/or any other unforeseen circumstances. The capacity providers reserve and maintain their production assets *outside* the energy only market. In exchange for securing the electricity supply, providers receive two kinds of cash flows. The first one is fixed and is calculated in advance, while the second one is variable. The fixed and secure cash flows are payments that reward capacity providers, which are ready to be (re)activated in case of emergency for the energy system. The variable ones reward the power already generated and dispatched by the capacity provider.

The strategic reserve seems simple for design and implemention. Entities participating usually reserve their production assets outside the energy only market and do not compete there. In addition, the mechanism of strategic reserve may be useful in preventing long established energy companies, exposed to financial difficulty, from possible market exit. According to contracts they conclude as capacity providers, the latter receive regular revenue in exchange for guaranteeing the energy supply in case of emergency. If it does not occur, energy companies in charge of reserved capacity may not need to produce power at all. Therefore, companies on the capacity market are in a position to generate windfall (easy to make) profit since they do not incur operating costs, while receiving fixed (generous) payments from the public institutions [12, 5].

Keeping production assets ready for (re)activation and/or "rescuing" enterprises in financial difficulty (due to obsolete technology or primary source with high greenhouse gas emission level) raise the issue of low efficiency inherent to the capacity mechanism in terms of strategic reserve.

Obligation for capacity provision is an alternative design of the mechanism for capacity, where providers of the latter conclude contracts in a *decentralized manner.* As a result, the level of market prices is discovered, at which demand for almost balances supply of capacity, which is ready for power production. Under the *obligation for capacity design,* contracts have been concluded with a mid-term time horizon of delivery (i.e. for three years). The latter is in line with the mid-term position of the capacity mechanism between the long-term power purchase agreements and the short-term energy only markets [6].

The public entity (the energy system operator, ESO and/or the public regulator) may intervene via two possible routes in order to curb the capacity mechanism. Firstly, the public institution provides in detail the requirements for adequate electricity supply (i.e. the maximum hours per year without power, which are acceptable for the community). With reference to the latter, any provider of capacity calculates and determines its individual contribution in order to satisfy the centrally established requirements and parameters for adequate operation of the energy system.

Alternatively, the public institution (ESO/the regulator) estimates in a central manner the cumulative obligation for capacity provision economy-wide. The applied methodology is set to precisely predict the total (in megawatts), which is consistent with the adequacy level of the national/regional electricity system. Moreover, ESO/the regulator establishes some reserve margins for the capacity volume needed to guarantee the adequacy requirement [6]. The prospective capacity providers usually need to undergo a certification procedure three to four years prior to delivery, while the validity of their certificates is revisited annually. The design of *the obligation to provide capacity* extends the set of participants. In addition to energy producing firms, large end consumers coming from energy-intensive businesses are also allowed to acquire obligation for capacity. These businesses are capable to flexibly managing their electrical power consumption. Some of the demand-side responding operators may deploy energy storage technology.

The capacity auctions is another mechanism design, under which the particular amount of capacity for energy generation and supply is determined in a central manner for the upcoming years. The national grid operator (ESO) and/or the public regulator of the energy (utilities) sector intervene in order to properly determine the correct capacity (in quantitative terms). The other important parameter – the remuneration - has been discovered throughout auctions that hold regularly. They are in charge of price "discovery", which is the most transparent and market-conform procedure. After the clearing price is "discovered", it becomes valid for all participants: incumbent and newly established ones, despite their technology and primary energy source for generation of electrical power. Therefore, capacity auctions firmly adhere to the concept of *non-discrimination* in its most relevant aspects – companies' "age", energy source, technology of generation, residency (domestic or abroad).

Drawing a parallel between the highly regulated energy and stock markets, some scholars highlight the role national institutions may play in securing their smooth operation [16]. No doubt, institutional capacity matters for making the mechanism of (energy) capacity operational. Though, this issue remains outside the subject of the instant paper.

While under the other so far discussed forms of capacity mechanisms the object of delivery are physical assets for production and supply of electricity (the physical capacity), under the *reliability options (RO)* there is an additional one. The options constitute a financial instrument. ROs are most suitable in case a long-term and persistent risk of insufficient energy supply has been identified throughout the given energy system [8]. Initially, the contours of such a capacity mechanism and the derivatives on it can be traced to Colombia, Italy and Ireland [9, 12, 14].

Like other financial derivatives, the reliability options constitute a contract between two parties. The buyer is the national grid operator, resp. the regulator of the utilities sector. The public authority acts for the sake of public interest, which is a relevant difference to the rest of financial derivatives. The buyer (the public institution/authority) and the seller conclude the option contract at a fixed price, i.e. *the strike one*. The national grid operator, resp. the energy sector regulator use it as a *hedging* instrument against the price volatility on the energy market. There, the buyer of RO acts as a *monopsony representing the society.* The sellers of the reliability option, on their turn, are different capacity providers, interested in receiving secure income (premium) from the option contract [7].

A crucial design parameter of the reliability options is the strike price that has dual tasks [7, 13]. On the one hand, it is set in order to secure stable prices on the energy markets, and on the other hand – to facilitate further investment into additional productive assets for electricity generation. In case the market constellations indicate some risk (stress) for the energy system, the spot price becomes bigger than the strike one. Under these conditions, the buyer will exercise the reliability option and the seller is obliged to provide both – the physical volume (of capacity) and the electrical power.

The difference between the spot price and the strike one burdens the seller (i.e. the capacity provider) with additional costs. Seller's company suffers a financial loss, as it is *obliged* to deliver the energy at the lower strike price set previously in the option contract. In fact, the income of the capacity providing company is a product of the quantity of electrical power dispatched multiplied by the strike price (that is lower than the spot one by the time of delivery) [7].

In order to compensate the financial loss, the seller may provide power on the spot electricity market too as the current price there guarantees plenty of revenue. Delivering power on the electricity only market is a realistic behavior in case the seller of the reliability option is capable to generate more electricity than the quantity of the latter delivered in case the option is exercised. If the seller is not capable to provide the power according to the option contract, they will also suffer a financial loss. The seller has to buy the contracted electrical power at the higher price on the energy only market.

What happens if the *spot price exceeds the strike one*? In such a constellation, the market functions as if the reliability contract was not there, with all electricity consumed being settled at the spot price [6]. In exchange for the right (but not the obligation) to exercise the reliability options, the buyer pays a pre-determined premium to the other contracting party. Thereby, the seller of the reliability option secures a cash flow in terms of fixed premium in all hours despite the spot price level [6].

From the above analysis, some conclusions about the reliability options can be drawn. Firstly, they are similar to the long call options with a buyer usually a public institution, and the seller – capacity providing companies. Secondly, in period of stress and emergency for the energy system both capacity for generation and electrical power need to be *physically* delivered. Thirdly, financial resources have been exchanged between buyer and seller of reliability options. Fourthly, end consumers in terms of households, public organizations, enterprises despite their size and economic activity do also benefit from the options, since the former are financially protected against peak prices in times of electrical power shortage.

The capacity payments constitute a separate design of the capacity mechanism. It *remunerates* a unit of capacity for electricity generation at a fixed price determined *in advance.* Crucial properties of *the capacity payments* design are the *security and adequacy* of the energy supply. Both parameters sound like synonyms, nevertheless they differ, having regard to different dimensions of the electricity system.

The adequacy of the latter requires reliable power supply in the long-term. It depends upon several important determinants such as potential for power generation – incumbent and/or new enterprises, development and deployment of (new) technologies, adoption of low carbon ones, capacity of the electrical grid and the related infrastructure. For example, smart grids attaches a new property to the energy network since the latter is capable to monitor automatically electricity flows and accordingly to react to changes in demand and supply. On its turn, *the security* of the energy system concerns reliable rebalancing of demand and supply in case sudden imbalances of electricity generation emerge. Thus, security of energy supply requires short-term solutions and governance of the currently operating capacities for power generation. The security of energy supply depends also on the current potential of the electricity grid to provide connectivity for additional (and diverse) energy producers [10, 13].

Some scholars consider *capacity payments* as the simplest design of the mechanism for capacity [6]. Bearing in mind the relation "security - adequacy" with regard to energy delivery, however, it seems too complex a task to properly define two components within the payment's structure. The first one has to remunerate the adequacy (the long-term property of supply), while the second one – to reward the short-term one. An additional complexity is the price setting per unit of the total capacity, despite differentiation of remuneration in terms of already established enterprises and newcomers. In some cases the contracted amounts of remuneration is set according to the type of load the participants provide – basic load, low emission and/or renewable one.

Table 1 shows some of the main design properties of the capacity mechanisms discussed in this paper.

Table 1: *Relevant properties of capacity mechanism design*

	Volume setting	Price (remuneration) setting	Market highlights
Strategic reserve	Set by central authority (CA);	Remuneration – set by auction/bilateral agreement	Production assets reserved for emergency/shortage. Efficiency issue raised.
Obligation for capacity provision	National volume and adequacy parameters – set by CA	Remuneration set in a decentralized manner	Individual obligation for capacity varies according to total volume, resp. to adequacy parameters
Reliability options	Set by CA	Strike price – measure of the secure supply of electricity	RO exercised if spot price > strike price and seller has to deliver both volume and electricity
Capacity Payment	Volume set by the market	Remuneration set by CA	Long and short-term dimensions interwoven
Capacity Auction	National volume – set by CA	Remuneration –set by auction and valid for all participants	Non-discrimination in most relevant dimensions

3. Conclusion

The analysis of the above mentioned properties and important parameters of different alternatives for establishing and implementing a capacity mechanism provides useful clues for deciding whether the energy system needs the energy only - and the capacity market operating simultaneously. Throughout the looming energy crisis where the electricity prices are rising to unprecedented levels, any measure or set of concerted measures to calm prices down seems worth exploring and highlighting.

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