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Capacity mechanisms: needs, solutions and state of affairs

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CAPACITY MECHANISMS: NEEDS, SOLUTIONS AND STATE OF AFFAIRS

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EXECUTIVE SUMMARY

The viability of energy-only markets and the potential need for additional payment for capacity have been discussed since the introduction of the first power markets in the early 1990's. No convincing theoretical argument has come up to prove that energy-only markets work in practice, and neither has the necessicity of additional remuneration mechanisms for capacity been scientifically proven. For a decade or so, discussions about power markets were dominated by other issues like integration of renewables, congestion management and market integration. However, more recently the discussion about Capacity Mechanisms (CMs) has recurred, mainly driven by the growth of renewable generation with zero marginal cost (wind, solar PV). Together with the aftermath of the financial crisis, this development has significantly reduced prices in Europe, removing the incentives to invest in new (non-subsidized) capacity and challenging the profitability of existing capacity. This development may start to threaten security of supply, and consequently the discussion about capacity remuneration has reemerged, especially in Europe.

This report deals with CMs– if and why there is a need for them, and what solutions have been proposed and taken in use. We define a Capacity Mechanism as:

> A CM is a mechanism to value generation or demand response capacity, generally but not always leading to a revenue stream to owners of such capacity in addition to revenues from the energy marklet.

In the "default" energy-only market solution, generators only receive the price of electricity and no additional payments for the availability of generation capacity. Already in the 1980's it was shown that under ideal conditions, electricity spot markets provide efficient outcomes in both the short and the long term, meaning that they lead to optimal investment in generation capacity. The discussion since has been about if the theory holds in practice. Several market failures have been observed as counter arguments:

- Lack of demand response
- Price restrictions
- Imperfect information
- Regulatory uncertainty
- Regulatory restrictions to investment
- Risk-averse behavior by investors
- Investment cycles

These issues are often used as arguments for the need for CMs. Counter arguments to this include:

- The complexity of CMs
- Reduced incentives for demand response
- Complex cross-border effects that may hamper market integration
- Risk of overinvestment

Generic market designs

CMs are often divided into volume based and price based mechanisms. The present work takes a different approach, classifying the models according to three basic questions:

1. What is the product?:
    - Physical capacity; or
    - A financial instrument
2. How is the required volume determined?:
    - Through the market's response to a price set by a Central Authority;
    - Ex ante by a Central Authority through a top-down approach;
    - Through a bottom-up approach with ex post verification by Central Authority; or
    - By individual customers
3. Who is responsible for procurement?:
    - A Central Authority; or
    - Individual entities

From a classification based on these questions, the following CM groupings and terminology are recognized:

TABLE 0.1 COMMON GROUPINGS AND TERMINOLOGY

	What is the product	How is the required volume determined	Who is responsible for procurement
Strategic Reserve	Physical Capacity (sub-set of generation only)	Central Authority sets volume	Central Authority (sub-set of generation only)
Ex Ante Capacity Obligation	Physical Capacity	Central Authority sets volume	LSEs or other individual entities
Ex Post Capacity Obligation	Physical Capacity	LSEs determined volume with *ex post* verification by Central Authority based on predetermined procedure and parameters	LSEs or other individual entities
Capacity Auction	Physical Capacity	Central Authority sets volume	Central Authority
Reliability Options	Financial Instrument	Central Authority sets volume	Central Authority
Capacity Payment	Physical Capacity	Central Authority sets price, volume determined by market	Central Authority
Capacity Subscription	Physical Capacity	Customers determine volume based on their preferences for uninterrupted supply and the price of capacity	Customers, directly and through intermediaries

Note that the term "capacity market" is not used for any specific CM design. The reason is that "capacity market" does not describe one specific model. Rather, it is specifically used for a market where parties with a capacity deficit (in the context of the relevant model) can buy from parties with a surplus. A capacity market can occur in several of the models, depending on the actual market design.

A brief description of each CM grouping is given below:

A **Strategic Reserve** mechanism is implemented alongside an energy-only market. In this model, the system operator directly contracts with a small proportion of capacity to provide an additional reserve that should only be dispatched when all other available capacity in the market is already operating. The majority of capacity investment is still driven by energy-only market signals, since most providers in the market do not receive explicit capacity revenue.

In an **Ex Ante Capacity Obligation** model, a Central Authority determines the volume of physical capacity that is required. The obligation to procure the capacity is passed onto LSEs, based on the load that each LSE has served before, establishing the obligation before the actual realization i.e. ex ante. LSEs satisfy their obligations via a wide range of possibilities including self-supply, bilateral contracts, demand response or capacity markets (if these are established).

In an **Ex Post Capacity Obligation** model, the responsibility to procure capacity is passed to the LSEs. The final obligation will only be known *ex post*, and will then be verified by a Central Authority. The measured realized load forms the basis for the calculation of the obligation. The final obligation is established based on a predetermined methodology with parameters that are set *ex ante* by the Central Authority. Typically, the methodology is used to adjust for weather conditions and ensure that the LSEs would have sufficient capacity in (predetermined) extreme conditions. The total (country/region level) obligation will be the sum of the obligations of the LSEs, but plays no direct role in the model.

In a **Capacity Auction** model, a Central Authority determines the volume of physical capacity required, and centrally procures that volume from the market. An elastic demand curve, where the price depends on the volume, may be used as an alternative to a fixed demand. An auction or tender process may be used, or some other central procurement process.

Reliability Options involve delivery of a physical volume when the security of supply is at risk. The product is structured as a financial instrument (option). Models in operation at present typically involve a Central Authority setting the volume to be procured, and then applies a central procurement process of the options. The option strike price is set as a measure of the security of supply and in effect sets a price cap in the market, while the generator's volatile revenue stream through high prices is substituted with the more long term and foreseeable option premium. When the security of supply is at risk, the option is exercised (market price > option strike price) and the generator must physically deliver the agreed amount otherwise it will be face a financial exposure to the spot price at the spot market. In some cases an additional penalty for non-performance may apply.

Under a **Capacity Payment** mechanism, an ongoing fixed payment is determined or negotiated when a capacity provider enters the market, and provided by the system operator to that provider for the term of that agreement.

In a **Capacity Subscription** model, customers themselves determine the amount of capacity they wish to procure, based upon their anticipated demand requirements, and the price at which capacity is offered. Customers then procure that capacity from providers through a capacity market that will have price elastic demand and supply. Demand is dynamically capped at the procured capacity level.

The full report describes each of the models and discusses the advantages and disadvantages of each.

Besides the choice of basic CM, and depending on the type of mechanism, many design parameters have to be determined, among these:

- The amount of capacity to procure;

- The form of the auction mechanisms, if relevant: Sealed-bid, Descending-clock, Hybrid, Sequential, Combinatorial and Two-sided;
- Contract durations;
- Lead times;
- Self-supply;
- Penalties for non-delivery;
- Price caps;
- Determination of credits; and
- Locational requirements

Survey

A survey was performed in order to get an up-to-date overview of CMs all over the world. This includes the status and description of currently implemented CMs as well as planned implementations in the future. Responses were received from 31 countries spread over the globe. Information was gathered about the power system and power market including general market design parameters, level of regulation and qualitative information about the profitability of market participants. In order to get more insight on the particular need for CMs, questions with respect to the system reliability were added. Finally, information on the actual CMs were collected.

The power systems surveyed present a range of characteristics. There was a large spread in the size of the systems, ranging from a few 1000 MW to more than 160 GW annual peak load in countries with different fuel supply mixes – ranging from single-fuel to multi-fuel (coal, nuclear, hydro), different market structures and consumption patterns ranging from peak to energy-constrained systems. By capturing these characteristics, the survey could then empirically check a possible relation between these variables and the use of CMs.

Twenty-six out of the 31 jurisdictions indicated their market as "liberalized", with a wide variation of market solutions. Early 2014, twelve of these markets had implemented or planned to implement a CM as shown in Figure 0.1.

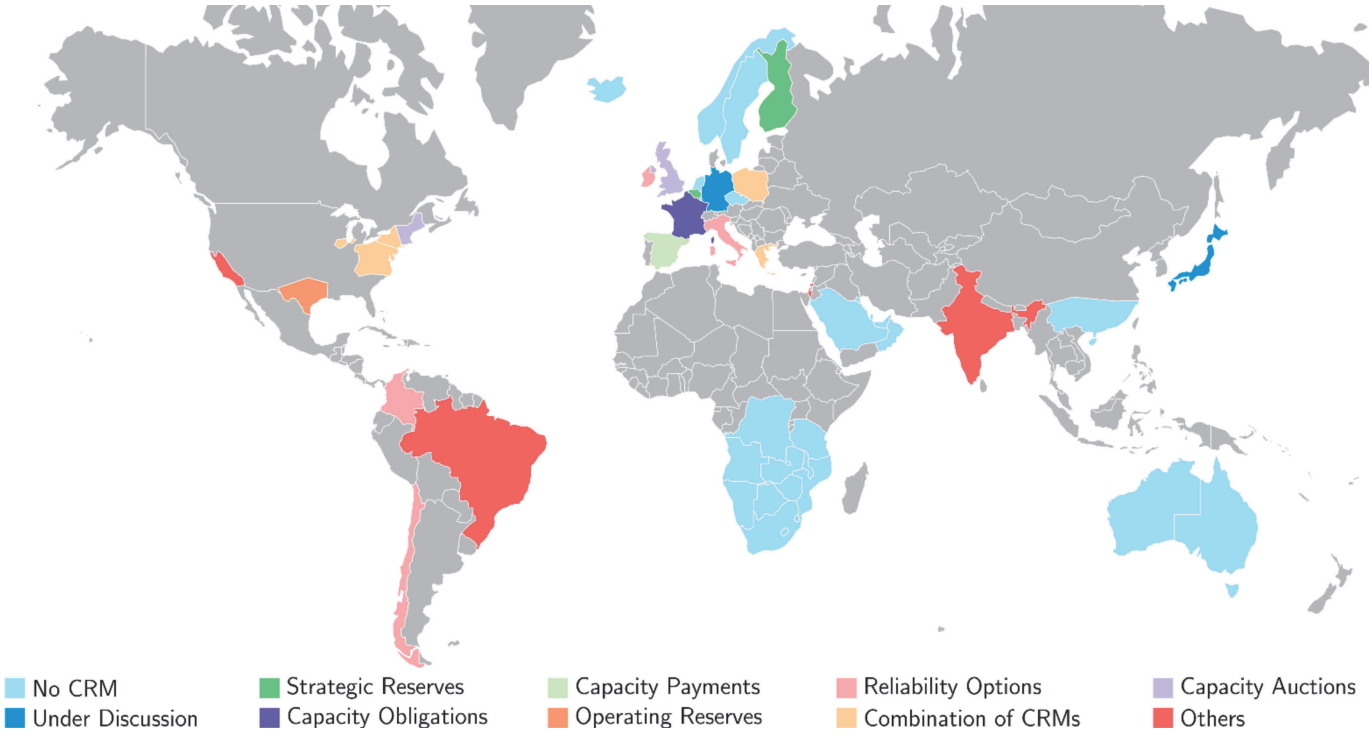

Figure 0.1: Market areas expected to have Capacity Mechanisms around 2020, based on 2014 survey

The survey highlights present and expected profitability of generation investments. Furthermore, it turns out that a number of countries are concerned about system reliability with most of these concerns related to generation adequacy. CMs in use include Strategic Reserves, Capacity Payments, Capacity Auctions and Reliability Options. Countries that use CMs reside on all continents.

Three of the countries that do not have a CM today have decided to introduce one or are currently implementing one. Two other countries have serious discussions about CMs. An additional four countries are changing their designs. This shows that market design is dynamic and continuously evolving.

Thanks to the 31 received contributions, the survey gives a good landscape of currently existing and developed CMs around the world. The integration of CMs in the market design is independent from the market/system size. CMs are identified in both very large (PJM) and very small (Ireland) systems. CMs occur more often in system with large seasonal differences and where respondents indicate doubts about the generation adequacy in the long run. The large variety and combination of CMs in place indicates that country specific characteristics lead to individual designs. Based on the survey however, it was not possible to identify objective power system characteristics that distinguish between the need or not for a CM.

Implementations of Capacity Mechanisms

An important contribution of the report consists of the description of eleven implemented or planned CMs fin nine countries. These descriptions are related to the generic designs referred before, and serve both as illustrations of realizations of the generic models and as a valuable guide of lessons-learnt. The eleven (11) implemented or planned CMs from the 9 countries are as follows[1]:

[1] In addition, a description of the Brazilian solution is included that, although targeted towards energy more than capacity, offers experiences that are relevant also when focus is on capacity.

CM classification	Country/ region	What is the product?	How is the required volume determined (procured)?	Who is responsible for procurement?
Strategic Reserves	**Poland**	Interventional Cold Reserve (ICR)	Generation adequacy analysis conducted by the TSO. Public tender (bilateral and competitive bidding)	TSO (Polskie Sieci Elektroenergetyczne Operator S.A. (PSE))
	Sweden	Peak Load Reserve	Short term temporary responsibility for Capacity Reserves (not long term security of supply) Providers enter into bilateral negotiations with TSO for inclusion	TSO (Svenska Kraftnät (SvK))
Ex ante Capacity Obligation	**PJM (USA)***	Capacity Credit Market ("CCM")	Capacity obligation allocated to each Load Serving Entity ("LSE") within PJM region based on peak load served discounted by amount of DSM and scaled to account for desired reserve margin determined by PJM	RTO (PJM Interconnection LLC)
Ex post Capacity Obligation	**France**	Capacity Certificates	Decentralised dynamic market based mechanism allowing for freedom on pricing and allocation of certificates for suppliers and end-users Adequacy studies ensure security of supply at medium and long term	Load Serving Entities (LSEs): Responsible to cover their obligation by procuring capacity certificates, by reducing their actual load or thermo sensitivity.
Capacity Auction	**Great Britian**	Capacity Market Auction (for future year delivery)	Required volume defined based on security of supply standard set against a range of demand and low carbon scenarios.	TSO (National Grid)
	PJM (USA)**	Reliability Pricing Model (with Capacity Performance)	Total capacity requirement based on load forecast for the applicable time period plus desired Installed Reserve Margin (IRM) Centralized auction held three years prior to delivery year	RTO (PJM Interconnection LLC)
Reliability Options	**Colombia**	Firm Energy Obligations	Periodic auction where regulator procures contracts with sufficiently long lead time and contract duration to hedge against regulatory and long-term market price risk according to reserve margin estimates (demand is expressed in GWh per year)	Regulatory Authority (Comisión de Regulación de Energía y Gas (CREG))

CM classification	Country/ region	What is the product?	How is the required volume determined (procured)?	Who is responsible for procurement?
	Ireland**	I-SEM Capacity Mechanism (centralised reliability options)	Auctions (backed up by the existence of physical plant or firm availability date for new capacity)	TSOs (System Operator Northern Ireland (SONI), EirGrid (Republic of Ireland))
Capacity Payment	**Spain**	Capacity Payments (previously called Long Term Supply Guarantee)	Capacity payments determined administratively based on system long term needs and made up of technology and capability specific incentives related to investment, availability and environment	TSO (Red Eléctrica de España (REE)
	Ireland*	Capacity Payment Mechanism (CPM)	Price based mechanism with set funding available annually (as determined by regulator) Capacity requirement calculated annually probabilistically from a required LOLE, demand forecast and characteristics of available plant (scheduled outages and forced outages)	Regulator Authority (Commission for Energy Regulation (CER))
	Chile	Capacity Payments (combined with Auctions)	Capacity payment regulated and calculated every six months based on fixed costs of peaking generator adjusted proportional to firm capacity Auction component is decentralized at distribution company level who must organize auctions to purchase sufficient energy and capacity at least three years in advance	Capacity Payments: Regulatory Authority (Comisión Nacional de Energía (CNE)) with TSOs (The Economic Load Dispatch Center (CDEC) for Central Interconnected System (SIC) and Norte Grande Interconnected System (SING)) Auctions: LSEs (many distribution companies)

* *Former solution*

** *Proposed solution*

Considerations and criteria for CM design

There are many considerations both for the choice between an energy-only market design and a CM as well as between specific CMs. These choices depend on so many factors, that it is not possible to give generally valid guidelines. Instead, the report provides some guidelines for the issues to consider when implementation of a CM is being considered for a particular electricity market and for the choice of CM design.