Capacity Market

Capacity is "*the rated and continuous load-carrying ability, expressed in megawatts (MW) or megavolt-amperes (MVA), of generation, transmission, or other electrical equipment*."[1] A capacity market, when it exists, is a part of the electricity market and is coordinated by an Independent System Operator (ISO) or a Regional Transmission Organization (RTO).[2] A capacity market is designed to provide long-term pricing signals to attract needed new investments and to maintain existing resources required to ensure resource adequacy and the reliability of an ISO/RTO region. The capacity market is used to commit capacity resources required to reliably meet forecasted demand and to provide sufficient reserve margins. It can be mandatory or voluntary with a timeframe from a few months to three years in advance (forward market). The capacity market usually has a few additional incremental auctions that are held closer to the capacity commitment period, to adjust the capacity obligation due to a load forecast increase or decrease. The capacity markets developed by different ISOs/RTOs differ with respect to:

- Demand curve (e.g., vertical versus downward-sloping)
- Auction mechanism (e.g., optimization or descending clock auction)
- Length of the forward commitment period (e.g., a few months to a few years)

Market Clearing

The capacity market uses a capacity auction mechanism to clear the market by reconciling an offer-based supply curve with a demand curve. The auction mechanism can be an optimization or descending clock auction. In both cases, the ISO/RTO defines a price cap. The price cap is imposed to avoid unreasonably large capacity prices.

The supply curve is designed by sequentially aggregating offers submitted by capacity resource owners. The capacity owners submit offers to provide a certain amount of capacity at a certain price. An ISO/RTO aggregates the offers in a capacity "offer curve." Depending on the ISO/RTO, the capacity resources may consist of:

- Generator resources (existing and planned)
- Demand resources
- Energy efficiency resources
- Qualifying transmission upgrades
- Interruptible load for reliability resources

The demand curve can be vertical or downward-sloping. The vertical demand curve is the simplest way to specify a capacity requirement (Exhibit 1.a). For example, the vertical demand curve in ISO New England is determined by using an installed capacity requirement (ICR). The ICR is based on a probability that the customers will be disconnected due to resource deficiency no more than once in ten years. The ICR is usually calculated as a sum of a forecasted demand and a planning reserve margin, that is developed based on the required reliability level (once in ten years loss of supply).

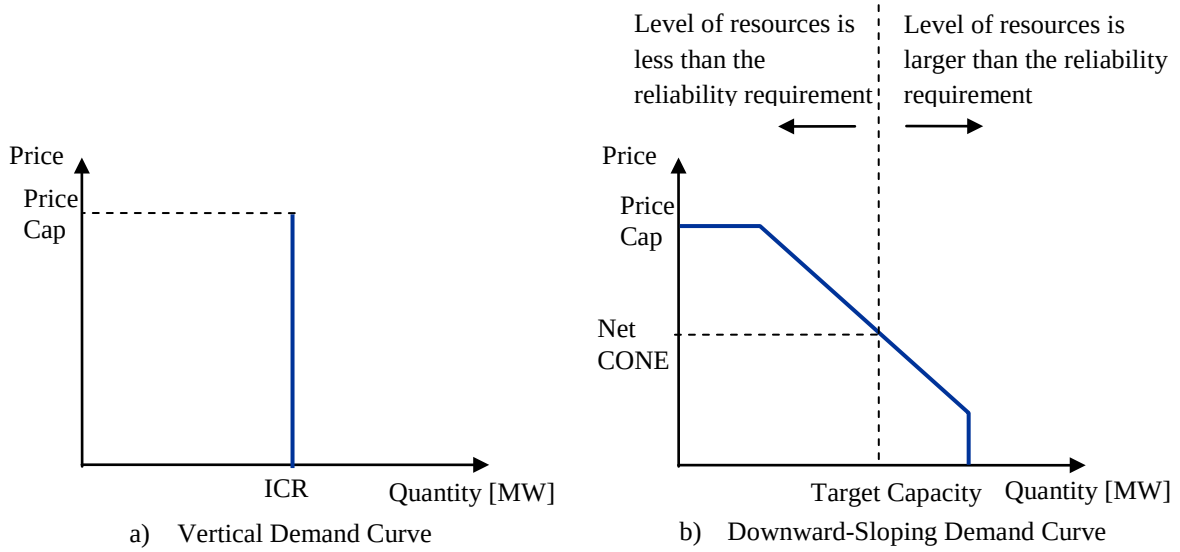
The downward-sloping demand curve is based on a variable resource requirement concept. The purpose of the resource requirement concept is to prevent overbuilding and to provide revenue to a resource when the reliability level is lower than required. The demand curve is defined by a family of price/quantity points where each level of the resources is correlated with a specified price (Exhibit 1.b). The demand prices are a function of the net cost of a new entry (CONE), and the demand quantities are a function of the reliability requirement. The net CONE is defined as a difference between investment costs and

[1] ISO New England. (2011). *Glossary & Acronyms*. Retrieved on January 10, 2011, from http://www.iso-ne.com/support/training/glossary/index-p1.html

[2] Many of the technical terms used in this primer are defined in a companion *Glossary for Power Market Primers.*

estimated variable profits over the life of the project expressed in $/MW-day or $/kW-month. The demand price is higher than the net CONE if the level of the resources is less than the reliability requirement. The demand price is lower than the net CONE if the level of the resources is larger than the reliability requirement. The reliability requirement is a function of regional and locational target reserve margins.

Exhibit 1 Demand curve



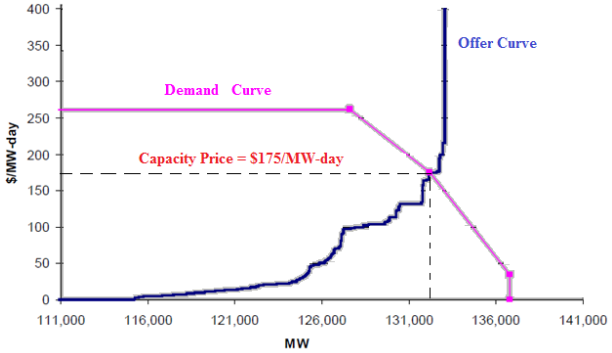
a) Vertical Demand Curve

b) Downward-Sloping Demand Curve

Image created by NETL.

An auction mechanism that is used to clear a capacity market can be an optimization or a descending clock auction. The optimization mechanism is based on determining a capacity requirement that provides the required reliability level at the minimum cost. The resource owners submit offers to provide capacity at a certain price while the load-serving entities (LSE) submit forecasted capacity requirements. The ISO/RTO aggregates the capacity offers in a capacity offer curve and uses the LSE's capacity requirements to determine a demand curve. The intersection of the capacity offer curve and the demand curve represents the capacity market price (CP) and the capacity quantity (CQ) (Exhibit 2). If the resource owner's offer is smaller than the CP price, it will be accepted and the capacity resource owner will be obligated to provide the submitted level of capacity during the operating year. If the resource owner's offer is higher than the CP price, it will not be accepted and the capacity resource owner will not be obligated to provide the submitted level of capacity during the operating year.

Exhibit 2 Illustration of an ISO/RTO capacity market clearing results

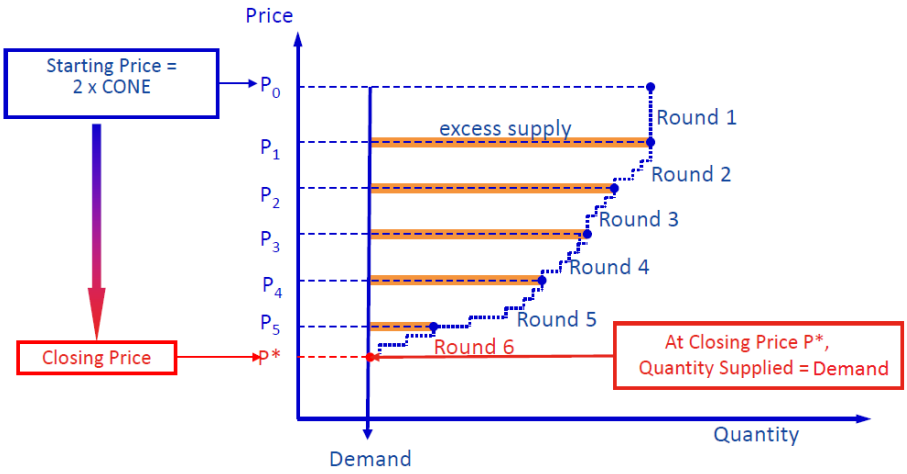


(*Adapted with permission from PJM.*[3])

[3] PJM. (2013). *2010/2011 RPM Base Residual Auction Results*. Retrieved on January 15, 2013, from http://www.pjm.com/~/media/markets-ops/rpm/rpm-auction-info/20080201-2010-2011-bra-report.ashx

The descending clock auction is a multi-round process that is used in ISO New England. The process is based on reducing the capacity market price until the quantity of available capacity resources matches the fixed capacity demand. The basic concept of the descending clock auction is that more than enough capacity resources will submit offers if the market capacity price is high. Some capacity resources will remove themselves from the auction as the capacity market price drops (Exhibit 3).

Exhibit 3 Descending clock auction mechanics



(*Adapted with permission from ISO New England.*[4])

In each round the auctioneer announces a start of round price, the end of round price, and excess supply at the end of the prior round, and participants submit offers at prices within the announced price range. The descending clock clearing mechanism can be illustrated using a simple example.

Example 1 – A Descending Clock Auction An ISO NE auctioneer conducts a descending clock auction to provide enough capacity resources to meet the future demand. The auctioneer forecasts that the installed capacity requirement is 25,000 MW, existing capability is 23,000 MW, participating new capacity is 5,000 MW and CONE = $5/kW-month. The auctioneer announced $10/kW-month as the start of round 1 price and $8/kW-month as the end of the round price. The resource owners offer all available capacity (28,000 MW) and the auctioneer calculates 3,000 MW of excess capacity. The auctioneer then announces $7.99/kW-month as the start price and $6/kW-month as the end price for round 2. Some owners decide to remove their offers from the auction because the new price is not profitable for them. The new capacity offer is 26,000 MW. The auctioneer determines that there is still 1,000 MW of the excess capacity. New start and end of the round 3 prices are $5.99/kW-month and $4.00/kW-month, respectively. The resource offer is 25,500 MW, which leads to -500 MW of excess capacity. The auctioneer stops the auction and determines the closing price as the intersection between the demand curve and offer curve. The closing price will be between 5.99/kW-month and $4.00/kW-month.

Zonal or Locational Capacity Price

The forward-capacity auction begins with a single system-wide price. However, making sure that there is enough capacity in the ISO/RTO area does not mean that capacity is deliverable to specific locations. ISOs/RTOs introduce zonal or locational capacity prices to overcome this obstacle.

[4] ISO NE. (2013). *Introduction to Wholesale Electricity Market (WEM 101) – Overview of Forward Capacity Market (FCM)*. Retrieved on January 15, 2013, from http://www.iso-ne.com/support/training/courses/wem101/21_overview_of_fcm.pdf

An ISO/RTO determines the locational capacity price using a similar approach as described above. The only difference is that it will use zonal/local demand, capacity resources, and CONE. A zonal capacity price will be different than the region capacity price if the location is import-constrained. The difference between these two prices should attract capacity resources in locations where they are needed the most. The New York ISO was the first market to introduce a locational capacity market. It has three different zones: New York City, Long Island, and New York Control Area. For each of the zones, the New York ISO determines different net CONE values that are used to develop a local demand curve and to set the locational capacity price (Exhibit 4).

Exhibit 4 CONE – New York ISO (2010/2011 capability period)[5]

Zone	New York City	Long Island	New York Control Area
CONE [$/kW-year]	219	194	107
Capacity price [$/kW-month]	9.22	1.67	1.47
Capacity price [$/kW-year]	110.64	20.04	17.64

Similarly, PJM has defined five zones with different CONE prices. ISO New England was directed by the Federal Energy Regulatory Commission to model eight capacity zones corresponding to its eight load zones.

Types of Capacity Markets in the U.S.

Different ISOs/RTOs in the U.S. coordinate capacity markets over different time frames. Capacity markets can be a few months to a few years in advance. Each capacity market has its own characteristics (these were not explained in this primer because some of the capacity rules in different ISOs/RTOs are still changing). More details about the capacity markets in different ISOs/RTOs can be found in the primer *Comparison of Different ISO/RTO Capacity Market Structures.*

Exhibit 5 summarizes the existing U. S. energy markets by ISO/RTO.

Exhibit 5 Simple electric energy market

ISO/RTO	Capacity Market	
	Forward (years)	Forward (months)
California ISO	No	No
ERCOT	No	No
Midwest ISO (voluntary)	No	Yes
ISO New England	Yes	No
New York ISO	No	Yes
PJM	Yes	No
Southwest Power Pool	No	No

More details about the different markets can be found in the primers *Energy Market, Ancillary Services* and *Capacity Market.* More details about the different ISOs/RTOs can be found in the ISO/RTO primers *California Independent System Operator, ERCOT Independent System Operator, MISO Regional Transmission Organization, ISO New England Regional Transmission Organization, New York ISO Regional Transmission Organization, PJM Regional Transmission Organization* and *Southwest Power Pool, Inc*.

[5] Potomac Economics. (2011). *New York ISO - 2010 State of the Market, July 2011*. Retrieved on January 10, 2011, from http://www.potomaceconomics.com/markets_monitored/new_york_iso