View Point – The Variable Resource Requirement (VRR) Curve
How the shape saves money and increases reliability

The shape of the VRR curve has several features:

1. The **price ceiling** for the VRR curve based on the net cost of new entry (net CONE),[1] which signals to the market that if the existing resources cannot offer bids lower than the cost of entering the market, then it is cheaper to build new generation than to use existing resources. The fact that, in the 2021/2022 base residual auction (BRA), the PJM capacity market attracted 163,627.3 megawatts at a capacity-weighted average 51.1 percent *below* net CONE demonstrates the healthy level of competition in the market.
2. The installed reserve margin (IRM) is a **megawatt floor** the amount of capacity procured cannot fall below without violating the reliability requirement to maintain one in 10 year loss of load expectation (LOLE).[2] When supply tightens and approaches this floor, the curve sends a higher price signal to incent new resources to come online to avoid losing reliability.
3. After satisfying the reliability requirement, the value consumers place on the increased reliability provided by each additional megawatt decreases rapidly – creating a demand curve with a ***steep*** **downward slope**. The slope shows that consumers are only willing to pay for more megawatts if the total cost of those megawatts decreases, as shown in Table 1.

The shape of the VRR curve creates a win-win for both sides of the market: the total amount consumers pay for capacity decreases as more resources clear the market, increasing the reliability of the electric grid.

Why should consumers pay more for megawatts they don't need?

They don't. Consumers are actually paying less to procure more megawatts, which saves consumers money and improves the overall reliability of the system. This is an important feature in how the VRR curve is drawn.

Figure 1. VRR curve scaled to percentage of reserve margin

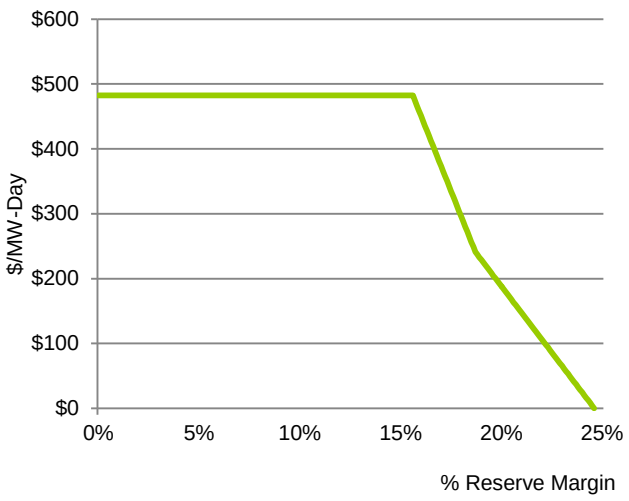
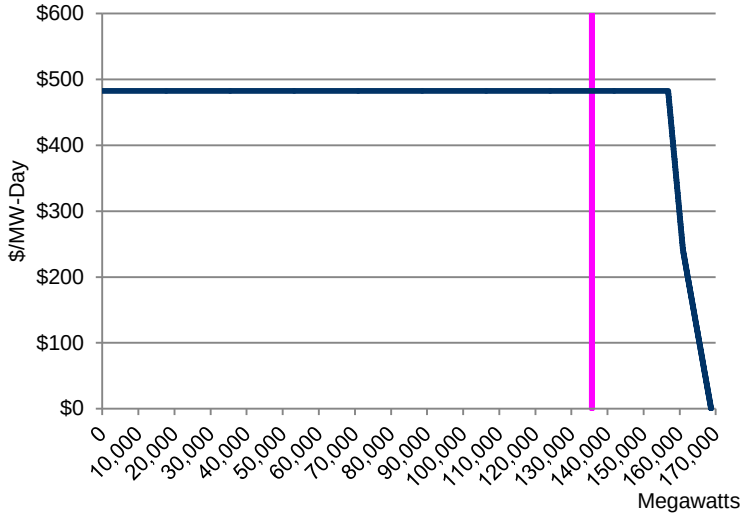


Figure 2. VRR curve showing all megawatts



Most depictions of the VRR curve show the horizontal axis beginning where the reserve margin equals zero, Figure 1, to highlight the part of the curve that is downward sloping. If, instead, the curve began at zero megawatts, it would look like Figure 2 – a long horizontal line with a steep drop at the end (the pink line indicates the origin of Figure 1). This is because the IRM that satisfies the reserve

[1] Net CONE is the total estimated costs of a new generating unit to enter the market with expected revenue from the energy and ancillary service markets netted out.

[2] The one in 10 year LOLE is an industry standard. Based on simulated models of the PJM electric grid, the IRM is the minimum amount of megawatts necessary for the probability that PJM will lose load to be no more than once in a 10-year period.

requirement is nowhere near zero megawatts. The VRR curve does not begin to slope downward until enough capacity has been procured to satisfy the IRM – after that the price for each additional megawatt of capacity falls sharply. For the 2021/2022 BRA, the IRM was 15.8 percent of the forecasted peak load, making the capacity required more than 156,800 MW.

Resources clear the capacity market at a single market clearing price, so the steep slope of the VRR curve means that the demand is price elastic and each megawatt of capacity procured beyond the IRM will ***lower*** the total cost to consumers. Table 1 depicts this relationship using the actual megawatt and associated $/MW-Day clearing prices from the 2021/2022 VRR curve for the RTO.

Table 1. Daily costs by total MW cleared

Megawatts	Clearing price $/MW-Day	Total Daily Cost
156,809	$ 482.36	$ 75,638,389
160,000	$ 294.67	$ 47,147,200
163,000	$ 176.56	$ 28,779,280
166,000	$ 83.85	$ 13,919,100

Why doesn't PJM just procure resources to satisfy the IRM?

This goes back to the first rule of economics. The law of demand states that as the price decreases, quantity demanded increases. Price elasticity now exists in the market. Markets are efficient where the marginal cost of supply equals the marginal value of demand. When demand is inelastic – i.e., if the capacity market only procured enough resources to satisfy the IRM – marginal cost can never equal marginal value because demand is no longer marginal. It's infinite. Consumers would lose the ability to influence prices and the clearing price would depend entirely on bids from the supply side of the market.

When the demand curve is elastic and thus has the ability to impact the clearing price, the amount consumers pay for capacity is commensurate with the benefit they receive from that capacity. Resources have a price signal that they need to get their costs below in order to clear the market and receive a capacity payment. As innovation leads to more cost efficient resources entering the market, the clearing price continues to decrease. Consumers and suppliers become increasingly better off.

Now suppose resources only clear the market up to the IRM megawatt quantity. Many resources that used to clear the market will not receive the revenue required to invest in improvements that keep them running. As resources come to the end of their life cycle – as all do – there won't be enough new generation coming online to replace the megawatts lost because the clearing price is too low to signal investment. Two things would happen: (1) the price of capacity skyrockets to incent investors to build new generation quickly (and likely inefficiently), and (2) the system experiences resource adequacy issues because there isn't enough capacity to satisfy the reserve requirement. The price shocks and reliability issues would be burdensome to consumers.

The shape of the VRR curve alleviates this burden by incentivizing resources to drive down costs without weakening the ability to send healthy entry and exit signals to the supply side of the market. Resources procured beyond the IRM decrease the total cost to consumers while maintaining the long-term reliability of the electric grid.