Impact of State Subsidies To Support Zero-Carbon Resources At Levels Consistent With The Social Cost of Carbon

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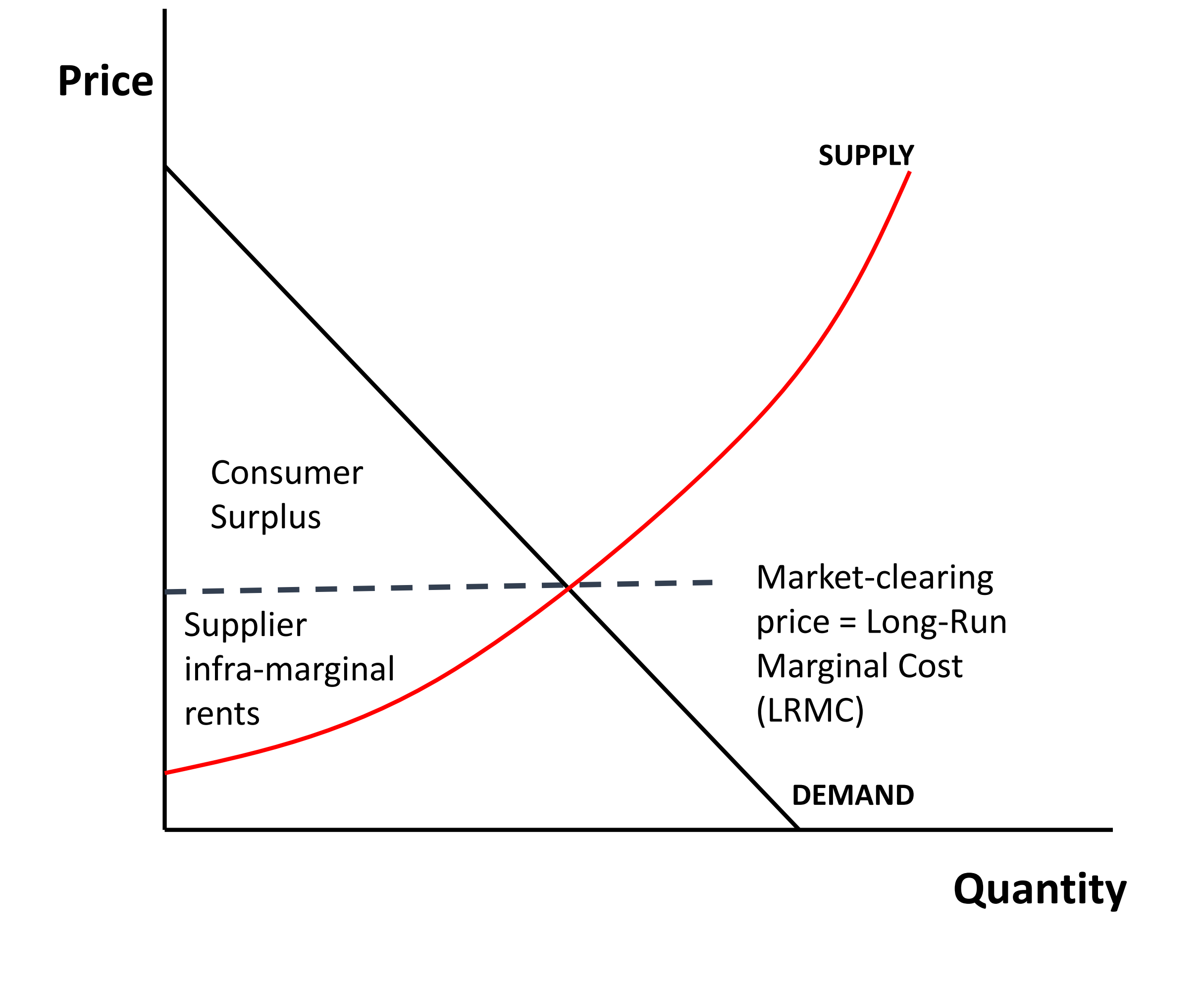
MOPR should be applied to resources receiving out-of-market support payments that are designed to result, or can be expected to result, in the entry of new capacity resources or the preservation of existing capacity resources that would not be part of the generation mix in an economically efficient competitive market outcome.

Economically efficient market outcomes will not occur unless appropriate market conditions are present

- An economic theorem proves that ***under the proper conditions***, effective competition in the marketplace will produce the optimal economic result of economic efficiency.
- Conditions needed to enable effective competition include:
  - Enough rival buyers and sellers to prevent the exercise of market power
  - Available and accessible information
  - Employment of the available cost-effective state of technology that exhibits decreasing returns to variable inputs in the production process
  - Free entry and exist
  - A technology neutral, level competitive playing field in the marketplace
  - Internalization of all relevant costs in cost-based competition

An economically optimal market outcome maximizes the total gains from trade, equal to the consumer surplus plus the supplier infra-marginal rents



Economically efficient market outcomes are necessary to drive a cost-effective electric supply portfolio

An efficient market outcome creates price signals that shape the investment decisions of market participants including:

- **New supply entry—**at cost-effective levels and timing in response to market-clearing prices equal to the long-run marginal cost of supply (LRMC).

- **Existing resource retirement**—based on the cost of replacement. An existing supplier will cost-effectively retire when the going-forward cost of the existing supplier exceeds the LRMC-based market-clearing price that reflects the cost of replacement supply.

- **Production efficiency—**the LRMC-based market-clearing price produces infra-marginal rents that drive employment of the most efficient mix of available technologies in the production process.

When the proper conditions do not exist, predictable market distortions and associated economic inefficiencies result.

Market distortions exist in the PJM market

- **Economic inefficiencies result from the unresolved missing money market problem.** Underlying conditions in electric energy markets prevent the energy market-clearing price alone from reflecting the long-run marginal cost when electricity demand and supply are in long-run balance with the desired level of reliability. For many possible reasons, the PJM capacity market chronically clears at a price below the level expected in an efficient market outcome that is needed to augment energy prices and provide the LRMC-based price signal.
- **Economic inefficiencies result when Short-Run Marginal Costs do not internalize all relevant costs.** Currently, rival generators in the PJM marketplace do not fully internalize the cost of CO_2 emissions. William Nordhaus won the Nobel Prize in economics in 2018 for his work quantifying the uncompensated cost imposed on others by incremental anthropogenic CO_2 emissions, known as the social cost of carbon (SCC). The current US EPA mid-range estimate of the SCC is around 50 dollars (2020) per metric tonne with much higher values at the upper range of estimates.

Interventions to counter market distortions should attempt to replicate efficient competitive market outcomes

- Alfred Kahn wrote the textbook on government regulation and established the principle that government involvement in the marketplace needs to enable effective competition. Kahn asserts:

    - The main body of microeconomic theory can be interpreted as describing how, under proper conditions, an unregulated economy will produce optimum economic results.
    - That for one or another of many possible reasons, competition simply does not work well in some case.
    - The single most widely accepted rule for the governance of the regulated industries is regulate them in such a way as to produce the same results as would be produced by effective competition, if it were feasible.

Alfred E. Kahn, The Economics of Regulation: Principles and Institutions, vol. 1, MIT Press, Cambridge, Massachusetts, 1998 (original publication 1970), pp. 11 and 17.

The PJM capacity market and MOPR can be analyzed as an "Interventions" for countering the missing money distortion in the PJM energy market

- The PJM capacity market aims to fill the missing money gap between the SRMC-based energy market-clearing price and the LRMC. To do this, PJM's capacity market is designed to produce a market-clearing capacity price [at the targeted reliability level] reflecting the total cost of new entry minus the contribution from the energy market revenues—the "Net CONE" — for the lowest cost capacity resource, i.e., the "peaker" technology. The MOPR is a market intervention aimed at enabling an efficient capacity market outcome.

- Although an efficient capacity market-clearing price reflects the fixed costs of the peaker technology, not all capacity resource investment will involve peakers. Once enough cost-effective peakers enter the market, additional entrants will invest in generating technologies with additional fixed costs to achieve lower heat rates or lower carbon intensity compared to the peaker technology because the expected infra-marginal rents can cover the additional costs of greater production efficiency or lower carbon intensity. However, these cost-effective technology investments can only result when rival energy market participants internalize all relevant costs in their short-run marginal cost-based energy market supply bids. Otherwise, the infra-marginal rents end up below the level expected in an efficient market, and consequently there will be underinvestment in cost-effective production efficiency or lower carbon intensity results in the supply portfolio.

State policy support and subsidies of zero CO_2 emission resources is an intervention aimed at countering the CO_2 emission externality cost market distortion

- An SCC-based zero-emission credit is a market intervention aimed to offset energy market cash flow shortfalls realized by zero CO_2 emitting suppliers due to the failure to fully internalize the SCC in short-run marginal cost-based competition. This intervention aims to counteract the market distortion that leads to economically inefficient premature retirements of lower-than-rival carbon intensive generating resources.
- State policy-driven deployment of relatively low carbon intensive supply resources with implicit costs of carbon removal (the difference between the cost of the lower carbon intensive resource minus the cost of the higher carbon intensive resource expected in the distorted market new entry, divided by the difference in CO_2 emission levels) that is below the SCC are market interventions that will have the effect of offsetting the energy market cash flow shortfalls that cause an underinvestment in these economically efficient supply resources in the generation portfolio mix.

An effective MOPR intervention should exempt resources with implicit cost of carbon removal or zero-emission credits that are consistent with a market internalization of the SCC

- PJM would be correct in recognizing that there is no basis to apply the MOPR to a resource because it receives a zero-emission credit that is consistent with reasonable estimate of the SCC. In fact, doing so would increase economic inefficiencies if the MOPR requires an existing generator receiving the zero-emission credit to bid into the capacity market without incorporating the zero-emission subsidy that offsets the infra-marginal rent shortfall associated with the lack of carbon pricing in the energy market.
- Similarly, PJM would be correct in recognizing that there is no basis to apply MOPR to state policy-driven zero CO_2 emitting resource deployment with an implicit cost of carbon removal less than or equal to the SCC. In fact, doing so would increase economic inefficiencies due to the predictable incentive to underinvest in these cost-effective low carbon resources in the supply portfolio mix.
- Because zero-emission credits and policy-driven deployment of resources with implicit cost of carbon removal less than or equal to the SCC result in a *more* cost-effective resource mix than the market outcome that would occur without these interventions, therefore the stakeholder process should ensure that the MOPR is not applied in such cases.

Appendix

Simple illustration of an economically efficient versus distorted electricity market outcome and appropriate market interventions

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Technology specific cost and performance profiles

Technology	Capital cost	Heat rate	Secure fuel cost	Variable O&M
	$/kW	Btus/kWh	$/MMBtu	$/MWh
Natural gas-fired combustion turbine	700	10,000	3.00	4
Natural gas-fired combined cycle	1,000	6,500	3.00	2
Wind and battery	3,011	NA	NA	NA

Common cost and performance profiles

- Annual levelized capital cost rate of 7 percent
- Natural gas: 117 pounds of CO_2/MMBtu and 2,205 pounds per metric tonne yields carbon intensity of fuel equal to 0.0635 tonnes CO_2/MMBtu
- 50 $/Tonne CO_2 value for the social cost of carbon, selected purely for illustrative purposes. There is a range of potential values for the social cost of carbon employing different assumptions and valuation methodologies that may be considered by policy makers.

Components of annual dollar per MWh cost at varied plant factors

1. Annual output = plant factor * 8760 hours in a year
2. Annual capital cost = Annual levelized capital carrying charge rate * Capital cost per MW
3. Annual capital cost per MWh = Annual capital cost / output
4. Fuel cost per MWh= heat rate per MWh * fuel price
5. CO_2 emission cost per MWh = heat rate per MWh * carbon intensity of fuel

Total annual dollar per MWh cost at a given plant factor

Total cost per MWh = Annual capital cost per MWh + fuel cost per MWh + VOM + CO_2 emission cost per MWh

The economically efficient capacity and energy market outcome

- The efficient market outcome produces a market-clearing capacity price of $134/MW/day reflecting the annualized levelized cost of the least cost peaking technology and market-clearing energy prices that reflect short-run marginal costs including a CO_2 cost of 50 $/Tonne CO_2 emissions.
- The efficient market outcome creates a cost-effective electric supply portfolio reflecting economic trade-offs between capital costs and operating costs. The efficient market-clearing price of capacity reflects the fixed costs of the peaker technology and the market-clearing energy prices reflect short-run marginal cost-based bids. Entry and exit in response to the efficient market capacity and energy price signals produces a cost-effective generation mix. The outcome involves CTs being the economic peaker technology and incentivizing the entry of CTs to meet the segments of load expected 10 percent or less of the time. CT entry into the marketplace results in the SRMC of CTs clearing the marketplace and creating potential infra-marginal rents for combined cycle technology resource entry. The potential infra-marginal rents available from serving loads expected more than 10 percent of the time are large enough to cover the additional capital cost of the combined cycle resource entry. With the entry of cost-effective combined cycle technologies, the potential infra-marginal rents market-clearing prices reflecting the SRMC of CT and combined cycle technologies incentivize entry from available wind resources with battery storage if this dispatchable renewable resource can operate for forty percent or more of the hours in the year when CTs and CCs are setting market-clearing energy prices.

The distorted energy market outcome

- If the costs of CO_2 emissions are not internalized by rival suppliers, then the market result is distorted from the efficient market outcome. Under these conditions, the CT technology is still the lowest cost peaker technology and the market-clearing capacity price still reflects the fixed costs of the CT technology. However, entry of these peaking resources does not create enough infra-marginal rents to incentivize combined cycle entry until enough CTs are installed to meet the segments of load expected 20 percent or less of the time. Similarly, the available infra-marginal rents do not incentivize the entry of available wind resources with battery storage until CTs and CCs are setting the market-clearing energy prices more than eighty percent of the time. The bottom line is that the failure to fully internalize the CO_2 cost into the market predictably results in uneconomic investment in more carbon intensive electric supply resources.
- In the efficient market outcome, entry of a wind resource with battery storage capable of operating at a 40 percent plant factor is at an entry cost parity with a combined cycle technology. However, the wind resource with battery storage capable of operating at a 40 percent plant factor appears to cost around 18.67 $/MWh more than the combined cycle alternative if the cost of carbon is not internalized into the market (At 40 percent plant factors, the annual dollar per MWh cost of the wind plus battery technology is 60.15 and the natural gas-fired combined cycle cost (excluding the CO_2 emission cost) is 41.48. The difference in cost equals 18.67). Therefore, a mandate to add this lower carbon intensive supply option in the distorted marketplace forces those who must meet the mandate to internalize the additional costs of the wind with battery storage resource without compensation of the higher cost from the capacity or energy market. As a result, the mandate also results in an uncompensated benefit of an CO_2 emission offset. The added costs of the lower carbon intensive resource divided by the associated emissions offset indicates an implicit cost of CO_2 emission reduction of around the 50 $/tonne level.

Market interventions to move from the distorted to the efficient market outcome

The differences between the efficient and distorted market outcomes indicate that market interventions can move a distorted electricity market result toward the efficient market outcome. Intervening in a distorted energy market with a CO_2 emission credit or renewable energy credit for zero-emission output does not change the fixed costs of a peaker, and therefore would not alter an efficient capacity market outcome. Moreover, these energy market interventions counter the price suppression and infra-marginal rent suppression for zero-emission resources and therefore counter the uneconomic underinvestment in lower carbon intensive supply resources. If these interventions reflect the social cost of carbon, then the expected impact is to move the market outcome toward the efficient market outcome.