A Primer on Wind and Solar Value Deflation

The economic value of additional wind and solar capacity decreases as their penetration rises.

Key takeaways:

- Value deflation is driven not only by the weather-dependent variability of wind and solar but also by the lower revenues earned for their highest-output hours and their low output during high-priced hours
- Studies of deep decarbonization do not find single technology pathways (e.g., 100% renewables) to be least cost, in part due to value deflation
- Metrics like the levelized cost of electricity (LCOE) neglect decreasing value and increasing system costs
- Despite these effects, wind and solar deployment will increase moving forward, but how much varies by region and how uncertainties (e.g., cost, policy) unfold

Variable renewable energy like wind and solar are becoming increasingly economical as their costs fall. Although wind and solar are expected to play key roles in decarbonizing electric generation, the economic potential of wind and solar is a moving target that depends both on **declining marginal value and cost**.

Declining value (sometimes called "value deflation" or "decreasing returns") refers to how the **marginal value of additional renewables drops as their penetration rises** on a particular grid. The profile value of wind and solar declines with increasing penetration due to the declining covariance between their output and the marginal cost of serving load, especially since the output of renewables is correlated across successive installations. Essentially, wind and solar lower wholesale electricity prices during hours when their output is highest. Figure 1 shows how the temporal variability of wind can lead to challenges at higher levels.

Value deflation limits economic returns for wind and solar at higher deployment, as the revenue per installed capacity has diminishing value in a given region. This effect is different from ancillary system costs rising with higher wind and solar shares (e.g., higher operating reserve costs), which is linked with value deflation.

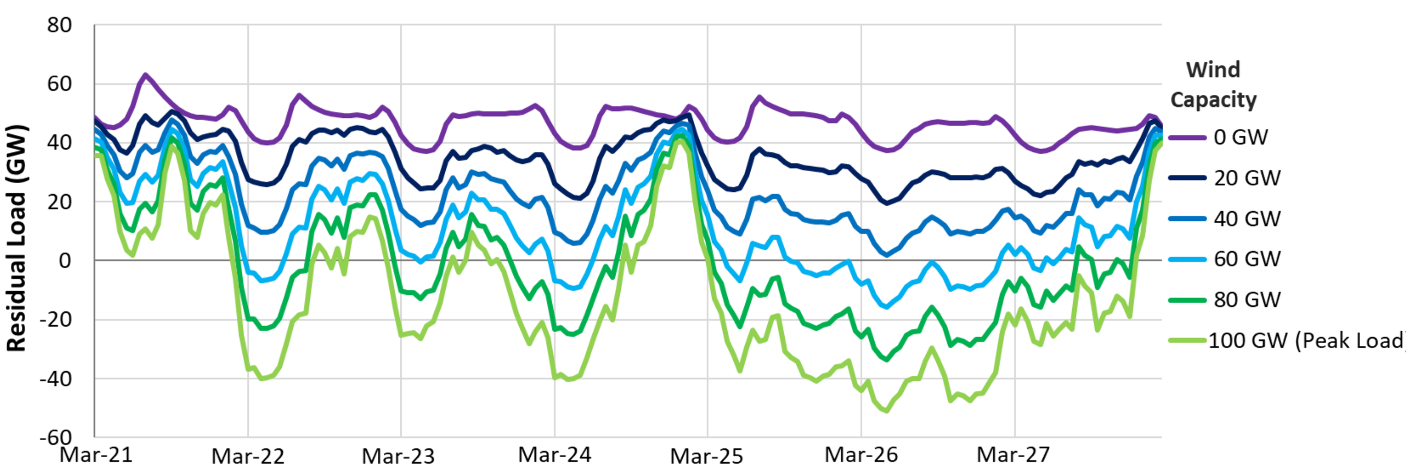
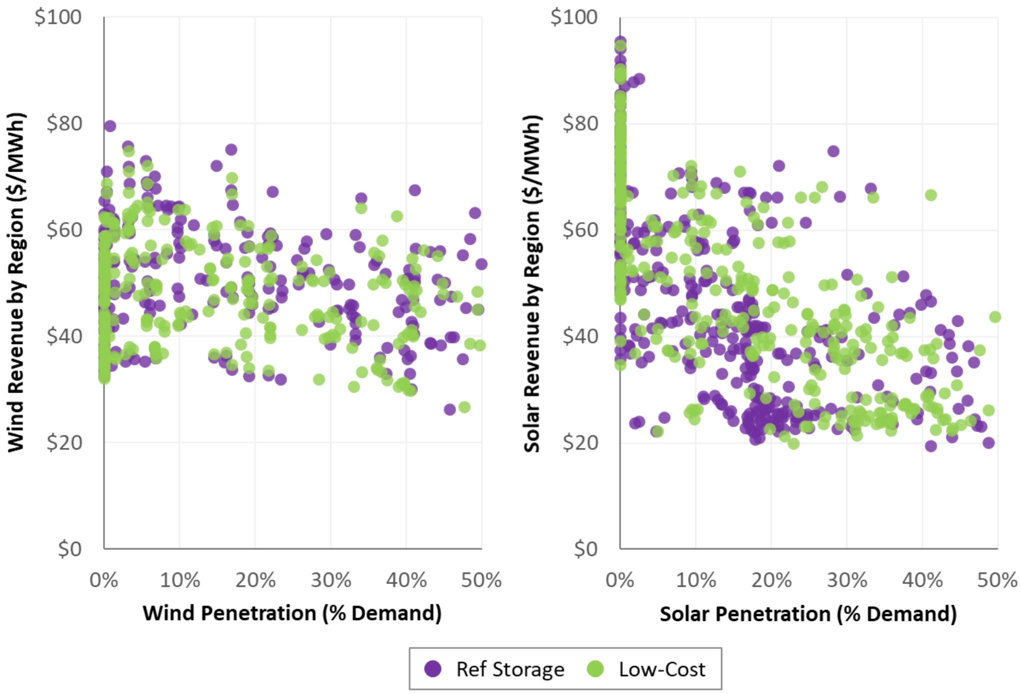


Figure 1: Texas load profile from 2015 with hypothetical wind shares for a week in March. Residual load (vertical axis) is in-region demand minus available renewable generation, which represents load that must be met by dispatchable generators, trade, and/or energy storage.



- Figure 2 shows how the economic value of wind and solar declines as their penetration rises
- Solar output is confined to a limited number of hours, which leads to steeper value declines compared with wind
- Differences in value explain why wind might be preferred to solar in specific settings, even when the costs of the latter are lower

Figure 2: Revenues to wind (left) and solar (right) across penetration levels (% of annual energy for load). Points represent regional results across policy, gas price, and wind/solar cost scenarios in the US-REGEN model. Values are shown for scenarios without additional energy storage investments (purple) and with low-cost battery storage (green).

Value deflation has been observed in a range of market settings and quantified in modeling studies at higher levels, as shown in Figure 2. The **economic value of wind and solar varies by system, region, and assumptions about future technologies, markets, and policies**.[1] Key renewables-related drivers include:

- Levels of wind and/or solar deployment in a region
- Technological diversity, including the composition of the portfolio of renewable technologies
- Spatial distribution and geographical diversity
- Technological design of variable renewables, including hub heights for wind and tracking for solar

Technologies like energy storage can help mitigate value deflation but likely do not solve it (Figure 2), even with significant cost reductions. Like variable renewables, **storage technologies exhibit decreasing returns** themselves at higher deployment levels.[2] Other factors impacting value deflation include transmission and trade, demand flexibility, and fuel prices.

Value deflation is important for stakeholders to understand and quantify, including renewable project developers and offtakers (who are quantifying contract risk), policymakers (who are considering costs and benefits of alternate approaches to reduce emissions), owners of existing power plants (who are assessing how renewables could impact utilization and revenues), and technology developers (who are trying to use low-cost power during high-production periods or to dispatch generation options during high-priced ones).

Models of power systems should capture decreasing returns to understand the competitiveness of wind, solar, energy storage, and other system resources. Metrics like the levelized cost of electricity (LCOE) neglect value deflation and system costs, which make them poor proxies for understanding the competitiveness of different resources.

Contact Information

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[1] EPRI (2015), "Decreasing Returns to Renewable Energy," EPRI Product #3002003946

[2] Bistline (2017), "Economic and Technical Challenges of Flexible Operations Under Large-Scale Variable Renewable Deployment," *Energy Economics*

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