ARE RENEWABLES REALLY INEXPENSIVE?

Many advocates for wind and solar power claim that those resources are the most cost-effective option for new power supply, but such claims typically only look at a portion of the cost of adding renewables to the grid—the direct cost of building and operating the facility. Rarely do they address the costs imposed on the system to integrate renewables or the infrastructure improvements required to maintain system reliability. These costs might not be paid directly by the owner of the wind or solar facilities, but they are actual costs incurred in delivering electricity to consumers who must ultimately pay for them. We believe that utilities and states that are considering the replacement of existing generation with new renewable projects should closely examine the full cost of the renewables—not just their direct construction and operating costs, but the imposed costs and infrastructure costs as well.

BACKGROUND

Even though electricity demand in the United States has been relatively flat over the past decade, wind and solar power have seen substantial growth in recent years. In 2010, there were 40.3 gigawatts (GW) of wind turbines and just 1.1 GW of utility-scale solar power in the U.S. By 2018, this had grown to 96 GW of wind generation and 33 GW of solar power amounting to 8.8% and 3.0% of total generating capacity, respectively.[i] While it has led to profound changes in how we produce electricity this rapid expansion of renewable generation, with an increase of nearly 140% for wind and 2800% for solar in eight years, was not prompted by a need to meet increased electricity demand. Over that same period of time, electricity demand in the United States has actually only required 0.6% more electricity in 2018 than was generated in 2010.[ii]

The increase in wind and solar generating capacity has been driven instead by policy preferences put in place at both the federal and state levels. Two main examples of these policy preferences include federal investment and production tax credits that served to artificially lower the cost of this power to consumers, and renewable portfolio standards (RPS) at the state level that required utilities to procure renewable power. Through 2018, these policies have resulted in over $100 billion in federal tax incentives and other subsidies that have driven the growth of renewable power.[iii] While these programs currently amount to a $6.10 per megawatt-hour (MWh) subsidy to new wind projects and a $11.10/MWh subsidy to new solar (14% and 23% of total direct costs, respectively), the more than $100 billion in financial support enjoyed by the renewable industry has succeeded in artificially lowering the cost of renewable energy development and served to distort energy markets.[iv]

Cost projections for new wind and solar projects vary substantially from one study to the next. Some claim new renewables are now cheap enough to replace existing generation on purely economic grounds.[v] Other studies cast doubt on the viability of renewables without mandates and subsidies.[vi] Clearly, any significant movement away from conventional generation and toward wind and solar power demands further investigation of the costs.

DIRECT COSTS FOR RENEWABLES

One common way to compare the economics of power plants is to calculate the average cost of generating electricity over the lifetime of a plant on a per-MWh basis. This measure is known as the levelized cost of electricity (LCOE), and includes all costs directly associated with building and operating a new power plant—capital, financing, maintenance, fuel, and other variable costs (as we shall see later, these are not the only costs that need to be considered for renewables). Typically, levelized costs are calculated by summing all of the costs associated with an electricity source over its lifetime and dividing those costs (in dollars) by the electric generation the source is expected to produce (in megawatt hours). In general, generating sources with lower LCOE are preferable to sources with higher LCOE.

Many groups publish LCOE estimates; the figure below shows several commonly cited results for new renewables. These LCOE estimates vary due to significantly different financial and operating assumptions. These assumptions include capital and fixed costs, financing terms, project life, and capacity factor.

Levelized Cost of Electricity for New Renewables, $/MWh (Direct Costs only)[vii]

Study	New Solar PV	New Wind
America's Power/IER	$67.7	$66.4
NREL (High)	$58.8	$143.0
NREL (Low)	$33.0	$30.3
Lazard (High)	$44.0	$56.0
Lazard (Low)	$36.0	$29.0
EIA	$48.8	$42.8

Calculating LCOE for existing generating resources finds existing conventional generators to have lower LCOEs than those of any new generator (see table below). These values will be lower because they do not include the capital cost of building new capacity. It should be noted that these represent national average values. As these costs can vary due to conditions in different regions, each case should be examined closely to determine the total cost of generating projects.

Levelized Cost of Electricity, $/MWh (Direct Costs only)[viii]

Study	Existing Nuclear	Existing CCGT	Existing Coal	New CCGT	New Solar PV	New Wind
America's Power/IER	$33.3	$35.9	$40.9	$50.0	$67.7	$66.4
NREL (avg.)	*N/A*	*N/A*	*N/A*	$48.3	$45.3	$54.8
Lazard (avg.)	$27.5	N/A	$36.0	$57.5	$40.0	$42.5
EIA	*N/A*	*N/A*	*N/A*	$42.8	$48.8	$42.8

LCOE OF NEW RENEWABLES COMPARED TO EXISTING COAL

America's Power's 2019 LCOE study was commissioned to evaluate whether it makes sense to continue operating existing power plants—coal, nuclear and natural gas combined cycle (NGCC)—rather than replace them with new electricity sources. The study shows that existing nuclear, coal-fired and NGCC power plants have lower levelized costs, on average, than new NGCC, new wind and new solar. The sources from this study included Lazard (2018), EIA (2019), NREL (2018), EVA (2018), IHS Markit (2017) and America's Power/IER (2019).

For **existing coal**, this analysis specifically looked at four studies for a total of six different LCOE's:

- Lazard (low end of range) $27/MWh
- America's Power $41 MWh
- Lazard (high end of range) $45/MWh
- **Average of six LCOE's** **$38/MWh**

For **new wind**, this analysis specifically looked at six studies for a total of 10 different LCOE's:

- Lazard (low end of range) $29/MWh
- America's Power $66-$90/MWh
- NREL (high end of range) $143/MWh
- **Average of 10 LCOE's** **$68/MWh**

Again, it is important to highlight that most LCOE data is based on national averages derived from publicly available data and that levelized costs will be different for each existing plant and each new one. While these simple averages should not be assumed to include every factor that could impact a specific facility or unit's LCOE, they do demonstrate that on average new wind and solar have higher levelized costs than are generally recognized, especially compared to existing generation sources.

IMPOSED COSTS FOR RENEWABLES

It is important to understand, however, that direct costs to produce electricity are not the only costs that must be considered with renewables. The value of electricity produced depends on its ability to serve demand, and wind and solar power are only available when the wind blows and the sun shines. They cannot be scheduled to operate when most needed, as can conventional power plant alternatives. According to the International Energy Agency:

Whenever technologies differ in the when, where and how of their generation, a comparison based on LCOE is no longer sufficient and can be misleading. A comparison based only on LCOE implicitly assumes that the electricity generated from different sources has the same value.[ix]

But wind and solar power do not have the same value as conventional generation. In addition to not operating on-demand, they provide little of the installed capacity value that is needed to maintain reserve margins,[x] and cannot be relied on to provide the "essential reliability services" the grid needs for real-time reliability.[xi] Instead, they rely on other generators to perform the services they cannot, "imposing" the cost of doing so on those generators and the grid. In order to properly compare the cost of new renewable capacity to the conventional coal or natural gas capacity it is intended to replace, these imposed costs must be attributed back to the renewables.

The imposed cost of new renewables will vary by location, and depends on the existing resource mix and amount of renewables already on the system. As wind and solar capacity increases, so do the imposed costs of "integrating" it into a system.[xii] Small amounts of wind and solar can often be integrated with low imposed costs, placing little burden on the existing resources of the grid. As the amount of wind and solar on the system increases, other generators are called on to operate in more expensive and inefficient ways than their original intent. This can range from running expensive "peaker" gas turbines much more often in order to follow the variations in wind and solar generation, to paying for power plants that will seldom operate but must be maintained to ensure reliability. If enough renewables are added to a system, new dispatchable generation may ultimately be required in order to integrate them.

A study in the journal *Renewable Energy* showed that most estimates of renewable integration costs were at or below $8/MWh—if renewables make up less than 20% of generation. At 30%-40% of generation, their models showed these costs rising to $22-$27/MWh.[xiii] Modeling conducted by America's Power and IER found that when enough renewables are added to a system that additional gas generation must be added for backup generation, the imposed costs of integration are $23.6/MWh for wind and $21/MWh for solar power.[xiv]

In vertically integrated utility systems, imposed costs are simply another element of system costs. Deregulated power markets, however, require market mechanisms to compensate conventional generators for the imposed cost of renewables. If those payments aren't sufficient, existing generators may opt to retire instead of operating at a loss, regardless of the value they provide the grid. The recent heat wave in Texas provides a useful example of this dynamic. In the last ten years, wind capacity has grown from 10% to 26% of capacity in the Texas power market (ERCOT).[xv] The low marginal cost of subsidized wind power depressed market prices which, when coupled with the absence of a capacity market in ERCOT that would pay generators to remain available, led to the retirement of 5,000 MW of coal capacity in 2018. With this capacity no longer available, ERCOT was forced to enact emergency procedures to avoid blackouts as demand reached record levels this August.

Some suggest that costs imposed on the grid by wind and solar generation can be reduced by pairing the renewables with utility-scale battery storage systems, with the combination able to overcome the deficiencies of wind and solar and deliver reliable power to the grid. However, the cost of doing so is currently prohibitively high. In its most recent study of the cost of energy storage systems, Lazard Ltd. found the levelized cost of batteries used in this manner to be between $108/MWh and $140/MWh (not including the cost of the paired solar generator), with each such project they studied having a negative net present value.[xvi]

INFRASTRUCTURE COSTS

Wind and solar generators are built in areas where the wind is strongest and the sun brightest, and where land is available to develop. Typically, these areas are far from load centers and often from existing electric transmission infrastructure. New transmission projects must be built to transport this power to customers, and to reduce strains this new flow of electricity may have on other parts of the system. These costs will be substantial and should be attributed to the renewables that require them, yet they are usually not included in estimates of direct wind and solar power costs.[xvii]

An estimate of these costs was offered in a report by the Brattle Group that examined recent transmission studies by utilities and grid operators. They found transmission investment required by renewables to range from $300/kW to $700/kW, with an average cost of $500/kW of renewable capacity.[xviii] If these costs were properly considered along with construction costs, the capital cost of new renewable generation would be as much as 40 percent higher. A more realistic analysis that incorporates that 40 percent increase in capital costs for new renewable generation would amount to an increase in the LCOE of wind by at least 12%-28% and an increase in the LCOE of solar by at least 13%-30%.[xix]

Building new transmission to integrate renewables has dwarfed all other transmission expenses in recent years. The Edison Electric Institute, which represents investor-owned utilities, reported that its member planned to spend more than $60.6 billion on transmission upgrades between 2014 and 2024, of which $46.1 billion (76 percent) was explicitly for integrating renewables into the grid.[xx] Some representative transmission projects to integrate renewables that highlight these expenditures include:

- Texas's Competitive Renewable Energy Zone (2013, $7 billion cost)[xxi]
- California's Tehachapi Renewable Transmission Project (2016, $3.2 billion)[xxii]
- Midwest ISO's CapX2020 Transmission Project (2017, $2 billion)[xxiii]

Integrating wind and solar generation not only requires power plants for backup, it requires that there be fuel available to accommodate rapid swings in demand. Existing natural gas pipeline and storage infrastructure may not be sufficient to accommodate such large and rapid changes in demand by generators in support of renewables. In 2011, the Interstate Natural Gas Association of America studied the issue and found that between $2 billion and $15 billion of new natural gas infrastructure will be needed just to meet the firming requirements of intermittent renewables.[xxiv] While this is an area that has not received as much attention as perhaps is necessary, an investment of upwards of $15 billion in new natural gas infrastructure solely to support renewable generation highlights the importance of examining the full costs associated with increased renewable generation.

RENEWABLE MANDATES AND ELECTRCITY RATES

Determining the total of direct, imposed, and infrastructure costs that can be attributed to renewable generation can be a challenging exercise for system planners and modelers, but we do not need to run a model to see evidence of these costs. Each of these costs are real and must eventually be recovered from the electricity ratepayer, so if adding renewables to the electricity grid increases system costs, we will see it in higher retail electricity prices.

Lawrence Berkeley Laboratory estimates that the cost of RPS programs to ratepayers was $4.1 billion in 2017.[xxv] This is a conservative estimate, as the study did not include renewable integration costs imposed on the system. Similarly, a study from the Energy Policy Institute at the University of Chicago examined the impact RPS programs had on electricity rates across the country, and also concluded they led to higher electricity rates. Rates increased by 11% when the share of renewable generation increased by 1.8%, and by 17% when the renewable share increased by 4.2%. According to the study, "These cost estimates significantly exceed the marginal operational costs of renewables and likely reflect costs that renewables impose on the generation system, including those associated with their intermittency, higher transmission costs, and any stranded asset costs assigned to ratepayers."[xxvi]

CONCLUSION

Although the cost of building and operating new wind and solar power has declined in recent years, these resources are still more expensive on average than existing coal, natural gas, and nuclear power plants. This is especially the case when the costs imposed on the grid, the cost paid by taxpayers through subsides, and the cost of required infrastructure improvements, be it additional transmission or gas infrastructure to support intermittent renewables, are also considered. We urge policy makers that are considering the replacement of existing coal generators with new wind and solar resources to more closely examine the total cost of those renewable projects, which is substantially higher than just their initial construction and operating costs. Additionally, policy makers should review the market distorting impacts of renewable subsidies and mandates.

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[i] S&P Global Market Intelligence service, queried August 12, 2019.

[ii] Total net electricity generation in 2018 was 4,177,810 GWh, compared to 4,125,060 GWh in 2010. *EIA Electricity Data Browser*, https://www.eia.gov/electricity/data/browser/, queried August 12, 2019.

[iii] Renewable subsidy data is in 2018 dollars and covers 1979-2018. Data comes from the Congressional Research Service (CRS):

CRS, *Energy Tax Policy: Historical Perspectives on and Current Status of Energy Tax Expenditures*, Report for Congress R41227, May 2, 2011.

CRS, *Energy Tax Incentives: Measuring Value Across Different Types of Energy Resources*, Report for Congress R41953, March 19, 2015.

CRS, *Energy Tax Policy: Issues in the 114th Congress*, Report for Congress R43206, June 15, 2016.

CRS, *The Value of Energy Tax Incentives for Different Types of Energy Resources: In Brief*, Report for Congress R44852, May 18, 2017.

CRS, *The Value of Energy Tax Incentives for Different Types of Energy Resources*, Report for Congress R44852, Updated March 19, 2019.

[iv] EIA, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019*, February 26, 2019. Calculations are based on Table 1a.

[v] For example, see Energy Innovation Policy and Technology LLC, *The Coal Cost Crossover: Economic Viability of Existing Coal Compared to New Local Wind and Solar Farms*, March 2019.

[vi] Frazier, W., C. Marcy, and W. Cole. "Wind and solar PV deployment after tax credits expire: A view from the standard scenarios and the annual energy outlook," *The Electricity Journal* 32(8), October 2019.
[vii] Stacy, T. and G. Taylor, *The Levelized Cost of Electricity from Existing Generation Resources*, June 2019.
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Lazard Ltd. *Lazard's Levelized Cost of Energy Analysis Version 12.0*. November 2018.
NREL (National Renewable Energy Laboratory), *2019 Annual Technology Baseline*, https://atb.nrel.gov/electricity/2019/.
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[ix] International Energy Agency, *Next Generation Wind and Solar Power From Cost to Value*, 2016.
[x] North American Electric Reliability Corporation (NERC), *2017 Long-Term Reliability Assessment*, March 2018, Fig. 22.
[xi] NERC Essential Reliability Service Task Force, *A Concept Paper on Essential Reliability Services that Characterizes Bulk Power System Reliability*, October 2014.
[xii] Milligan et al., *Review and Status of Wind Integration and Transmission in the United States: Key Issues and Lessons Learned*, National Renewables Energy Laboratory, March 2015.
[xiii] Hirth, L., F. Ueckerdt, and O. Edenhofer, "Integration Costs Revisited, An Economic Framework for Wind and Solar Variability," *Renewable Energy* 74, p. 925-939. Cost estimates were reported in euro (25-35€).
[xiv] Stacy, T. and G. Taylor, *The Levelized Cost of Electricity from Existing Generation Resources*, June 2019.
http://www.americaspower.org/issue/the-levelized-cost-of-electricity-from-existing-generation-resources/
[xv] S&P Global Market Intelligence service, queried August 22, 2019.
[xvi] Lazard Ltd., *Lazard's Levelized Cost of Storage Analysis Version 4.0*, November 2018.
https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf.
[xvii] For example, see EIA, *Capital Cost Estimates for Utility Scale Electricity Generating Plants*, November 2016. The report notes that the portion of new unit costs for electrical interconnections "…includes an allowance for the plant switchyard and a subsequent interconnection to an 'adjacent' (e.g. within a mile) of the plant [sic], but does not include significant transmission system upgrades."
[xviii] The Brattle Group, *The Coming Electrification of the North American Economy: Why We Need a Robust Transmission Grid*, prepared for The WIRES Group, February 28, 2019.
[xix] EIA calculates capital costs to comprise 65% of the LCOE of wind generation and 74% of solar generation. EIA, *Levelized Cost and Levelized Avoided Cost of New Generation Resources in the Annual Energy Outlook 2019*, February 2019.
[xx] Edison Electric Institute, *Transmission Projects: At a Glance*, March 2014.
[xxi] T. Casey, "Texas Cranks Up $7 Billion CREZ Wind Power Project," *CleanTechnica*, Oct. 18, 2013, https://cleantechnica.com/2013/10/18/texas-wind-power-gets-boost-from-new-crez-lines/.
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