COMMENT

A Minimal Problem of Marginal Emissions

by Ryan Thomas Trahan

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I. Introduction

Prof. Richard L. Revesz and Dr. Burcin Unel provide a useful, albeit no longer current, review of electric energy storage in *Managing the Future of the Electricity Grid: Energy Storage and Greenhouse Gas Emissions (Managing)*.[1] *Managing* was released in draft during the Federal Energy Regulatory Commission (FERC) comment period on revised rules for energy storage technologies. That rulemaking process culminated early last year in Final Order 841,[2] directing regional electricity grids operators to remove barriers to the participation of electric storage resources in wholesale markets.[3] *Managing* remains relevant today as the process of implementing Final Order 841 carries on, and as state and local policymakers design incentive programs for accelerating the deployment of energy storage technologies.

Separate from the 841 rulemaking process, the energy storage market has continued its rapid technical and manufacturing evolution. Those advances may reasonably be expected to impact today's regulatory aims and frameworks, just as prior technological progress influenced administrative goals and processes. One current issue is whether interim technological progress has already affected the policy recommendations in *Managing*.

Central to the analysis in *Managing* is the proposition that deploying energy storage may actually increase greenhouse gas (GHG) emissions.[4] Its recommendations each follow from that base, i.e., internalize emissions externalities, eliminate barriers to entry, and implement rules to guarantee accurate price signals.[5] These policy directives intuitively feel right, resembling as they do first principles of economics. Where theory intersects with administrative process, however, concessions are often made, and so it is here. Taking the prescription reviewed in this brief comment, *Managing* describes the path toward internalizing emissions externalities (vis-à-vis carbon tax or otherwise integrating with wholesale electricity market prices) as long and uncertain. As such, the actual recommendation to policymakers is to perform cost-benefit analysis.

Cost-benefit analysis is a familiar framework for decisionmaking, although *Managing* forwards two suggestions that may reasonably be viewed as less typical. It takes the position that its recommendations should be achieved prior to energy storage incentive programs being implemented, so as to avoid the specter of inadvertently causing higher emissions. Second, it encourages policymakers to engage in comprehensive analysis of all available energy storage technologies, and all manner of possible generation combinations as substitutes for deploying energy storage.[6] These suggestions are addressed in reverse order.

II. Risks of "Comprehensive" Analysis

Managing does not seek to "pick winners" in energy storage and presents each major storage technology on equal terms, relying on data from Lazard's first study in 2015.[7] When viewed today that presentation implies a false equivalency. Due to interim technical progress, "energy storage" in 2019 is an analog for battery energy storage, primarily in the form of lithium-ion batteries, a result achieved in the open market.[8]

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[1] Richard L Revesz & Burcin Unel, *Managing the Future of the Electricity Grid: Energy Storage and Greenhouse Gas Emissions*, 42 Harv. Envtl. Rev. 139 (2018) [hereinafter *Managing*].

[2] Federal Energy Regulatory Comission, RM16-23-001; AD16-20-001, Order No. 841-A (2019)

[3] Rather than being pedantic, it is suggested that the difference in usage between "grid," singular, and "grids," plural, affects analytical effort by focusing attention toward solutions for a single theoretical system rather than the diverse category of systems that actually exist and can be expected to proliferate.

[4] *Managing* at 143.

[5] *Id.* at 179-96.

[6] *Id.* at 180-84.

[7] *See* Lazard, Lazard's Levelized Cost of Storage Analysis Version 1.0 (2015).

[8] *See generally* U.S. Department of Energy, Global Energy Storage Database Projects (last accessed Jan. 19, 2019). To date, lithium-ion technology exhibits technical, social, and cost attributes more competitive than other energy storage technologies, e.g., it is highly efficient in charge-to-discharge roundtrips, it is modular and flexible in both deployments and applications, and costs are broadly equivalent to or lower than the lowest cost substitute. Crucially, battery technology is in the midst of a cycle of substantial improvement.

Comprehensive cost-benefit analysis of substitute technologies is generally held to be most useful where market outcomes remain fluid, or are skewed. By contrast, applying such analysis at the end of a relatively transparent and open market competition risks harmful delay. Introducing such analysis to energy storage technologies, at present, might perversely provide an opening for bias and outcome shaping by reshuffling a dealt deck.

Another risk of comprehensive cost-benefit analysis in this context is potentially more pernicious. *Managing* implies that substitutes for energy storage exist by gesturing to time-worn concepts: theoretical generation sources, brute generation build-out, and efficiency improvements through generation types. An adequate exposition of these approaches is not provided in *Managing* and none is warranted here; suffice to state that these approaches are all well studied and do not constitute actual substitutes for energy storage.[9] Policymakers would likely be better served to focus on the deployment of current battery storage technology so as to capture its demonstrated benefits.

III. But What if Energy Storage Deployments Cause Higher GHG Emissions?

Where decarbonization is a policy goal, circumscribed policy review is supported by the understanding that increased deployment of energy storage corresponds with lower GHG emissions. That position is, in turn, grounded in current empirical study and common sense. Wind and solar do not incur marginal fuel costs and, therefore, intermittent generation has a fundamental marginal price advantage in charging an energy storage technology. Energy storage, in turn, expands the value and variety of applications for renewable generators and provides for crucial flexibility in dispatch. *Managing* makes reference to these benefits but relies primarily on an older study (CN Study)[10] as the basis of its premonitory counter-analysis.

A. Texas, 2007-2009

The CN study examined data sets, for the years 2007 through 2009, in the Texas market.[11] It assumed, among other things, a competitive wholesale electricity market with adequate price signals, and found that deploying bulk energy storage to the interconnection would tend to decrease peaks in consumption while increasing consumption troughs. This effect would result from an owner using an energy storage technology to engage in price arbitrage by charging during a single nighttime hour (lowest price during a consumption trough) and discharging during a single daytime hour (highest price during a consumption peak). The essential finding was that marginal GHG emissions would increase if a higher emitting generation source, like coal, were used for charging, and the stored energy was subsequently discharged during the day thereby avoiding marginal gas or solar generation. The reason being coal is dirtier than gas or solar, and inefficient storage technology amplifies the problem due to energy loss.

B. United States, 2019

Energy storage efficiency is accounted for in the CN Study. The observed result of higher GHG emissions from an increased deployment of bulk storage holds even assuming a theoretical energy storage technology with perfect efficiency. Thus, while the modern primacy of efficient lithium ion battery storage technology removes the worst-case scenarios of the CN Study, it does not affect the base finding.

Other interim developments do undermine the central proposition. The sound and explicit assumption of the CN Study was that renewables would not be the marginal sources of electricity used to charge energy storage technologies in circumstances where there was insufficient penetration. To wit, Texas only generated an average of 4.7% of its electricity from intermittent generation sources in the period studied, 2007 to 2009, and in all three of those years was among the national leaders in intermittent generation.[12]

Today, 10 states have intermittent generation of more than 20%, four have more than 30%, and two are expected to cross the 50% threshold this year. Texas no longer ranks among the top ten, even though intermittent generation now constitutes 17.4% of its overall generation mix.[13] The United States, as a whole, is expected to obtain nearly three times the percentage of intermittent genera-

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[9] The theoretical generation technologies sketch is, in essence, a curious retread of the possibility that dispatchable nuclear power will one day exist and be economic and useful when paired with other programs. The prescription to overwhelm problems of intermittency by brute installation, while valuable, is accounted in real-world installations—increased nameplate capacity is deployed to the extent it is economic but remains meaningless without energy supply. Efficiency gains in aggregate generation, e.g., from complimentary heterogenous generation sources, are a well-studied source of marginal improvement, complimentary with energy storage.

[10] *See* Richard T. Carson & Kevin Novan, *The Private and Social Economics of Bulk Electricity Storage*, 66 J. Envtl. Econ. & Mgmt. 404 (2013). *Managing* additionally cites to a more recent discussion paper which is derivative of the CN Study, *see* Joshua Linn & Jhih-Shyang Shih, *Does Electricity Storage Innovation Reduce Greenhouse Gas Emissions?*, Resources for the Future (Sept. 2016). Joseph Linn and Jhih-Shyang Shih present a stylized model to question whether lower costs for energy storage will lead to a decrease in deployment of intermittent generation sources. Sufficient empirical data exists to conclude the opposite. *Managing* separately lists concerns with increased coal usage that should be of independent concern if, at some future time, gross subsidy steering overcomes the market diseconomies of coal.

[11] The Electric Reliability Council of Texas (ERCOT) interconnection does not of course encompass all of Texas, but CN Study's terminology is used herein for consistency.

[12] *The Private and Social Economics of Bulk Electricity Storage*, *supra* note 10.

[13] *See* EIA, Electricity Generation by State, https://www.eia.gov/electricity/data/state (last visited Jan. 19, 2019).

tion this year as Texas did in the 2007-2009 time frame.[14] That remarkable change in penetration has been attendant with a fundamental cost reduction in intermittent (renewable) generation, thus increasing the absolute cost advantage of renewables in charging. The drastically reduced costs and much higher penetration of renewables, together with efficient lithium-ion energy storage, may reasonably permit policymakers to largely disregard the specter raised in *Managing*, more so in light of countervailing empirical demonstrations. It is beyond the scope of this brief comment but elsewhere I have sought to address the more fundamental policy problem of applying (particularly older) narrow marginal analysis of emissions in the context of rapidly changing technologies.[15]

Nonetheless, since *Managing*'s analysis could be applicable in outlier circumstances, policymakers may be well-served to adopt a simple policy bifurcation: move quickly (deploy, iterate, and deploy again) on energy storage incentive programs coupled to renewable generation. Projects not joined to deployment of renewable generation may require greater study, provided such analysis is properly weighed against costs of inaction, delay, and outcome shaping. Incentives are by nature clumsy and inefficient, and where time is deemed of the essence policymakers should not make the perfect the enemy of the good.[16]

IV. Step Change Framework

In certain respects, the current energy storage discussion misses the forest for the trees. The core activity of electricity procurement in the United States flipped a little more than three years ago. In the 120 years prior, the only technically and economically feasible system was a centralized power architecture, mainly resembling the following: power plant ⇨ transmission lines ⇨ substation ⇨ distribution lines ⇨ end consumer. As I have suggested,[17] both the means and ends of electricity procurement were altered when distributed generation unexpectedly achieved broad cost parity with centralized electricity delivery, with root implications for each.

Energy storage is fundamental to the evolution of electricity procurement systems, decentralized or not, thus it may be of some use to policymakers designing energy storage incentive programs to note the principles identified in *Regulating Toward (in)Security*:

- The electricity industry invests more money toward the delivery of electricity than it does to generate it in the first instance, a trend that is likely to intensify as technological advances and demographic trends continue to interact.
- Distributed generation has recently achieved rough cost parity with centralized electricity systems, and the cost of decentralized electricity systems continues to fall rapidly alongside the improving economics of battery energy storage.
- Centralized electricity grids do not generate positive networked effects and, as such, are not a technical requirement of electricity procurement.
- Electricity grids, like communication networks, generate what I have termed *negative* networked effects in the form of shared and untenable security risks which worsen with greater connectivity. The impacts of negative networked effects in centralized grid networks are seen in three primary categories: (i) natural disasters; (ii) cyber insecurity; and (iii) and physical attack. Impacts from negative networked effects have grown in economic magnitude, and are likely to continue to do so at an increasing pace.

V. Conclusion

In brief summary, policymakers committed to GHG reductions need not overthink the utility of battery energy storage incentives coupled with renewable generation deployment. Battery storage technology is efficient, and the charging sources are increasingly cleaner, and will be more so to the extent such incentives are implemented and adoption is accelerated. Additional policy analysis might instead be usefully applied to understanding the implications of recent and dramatic progress in generation and storage technology. Technical progress has opened a generational opportunity for policymakers to design more economic and resilient systems of electricity procurement for their constituencies.

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[14] *See* EIA, EIA forecasts renewables will be fastest growing source of electricity generation, https://www.eia.gov/todayinenergy/detail.php?id=38053 (last visited Jan. 19, 2019).

[15] Ryan Trahan, *Policy Problems in Economic Analysis of Decarbonization* (Vanderbilt Law Sch. Working Paper).

[16] *Managing* laments past electric vehicle charging programs as an example of uncareful policy analysis. Ironically, that position too is centrally based on a study using 2007 to 2009 data, *see* Joshua S. Graff Zivin et al., *Spatial and Temporal Heterogeneity of Marginal Emissions: Implications for Electric Cars and Other Electricity-Shifting Policies*, 107 J. Econ. Behavior & Org. 248, 249 (2014). Joshua Graff Zivin used emissions data sets to, among other things, estimate the marginal emissions of electric vehicles. The results implied that, in specific scenarios, electric vehicle emissions were higher than internal combustion engines, e.g., if charged at night in certain parts of the Upper Midwest. The Graff Zivin findings were challenged as early as 2015, *see, e.g.*, Rachael Nealer et al., *Cleaner Cars From Cradle to Grave How Electric Cars Beat Gasoline Cars on Lifetime Global Warming Emissions*, Union of Concerned Scientists (2015) (title serves as sufficient summary); and more recently definitively superannuated *see* David Reichmuth, *New Data Show Electric Vehicles Continue to Get Cleaner*, Union of Concerned Scientists (Mar. 8, 2018).

[17] *See* Ryan Trahan, *Regulating Toward (in)Security in the U.S. Electricity System*, 12 Tex. J. Oil, Gas & Energy L. 2 (2017).