ARTICLE IN PRESS

The Electricity Journal xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

The Electricity Journal

journal homepage: www.elsevier.com/locate/tej

Response to Jacobson and Delucchi's rebuttal of my critique

ABSTRACT

This paper provides further arguments why Jacobson and Delucchi's (JD) critiques of my paper are misplaced. It also provides additional references to work that reached different conclusions than Jacobson et al. Work by JD and others is useful in identifying the plethora of assumptions required to conclude that intermittent renewables can now be economically substituted for all current uses of fossil fuels throughout the entire economy.

My paper titled "100% Renewables Study Has Limited Relevance for Carbon Policy" (Paper),[1] which Jacobson and Delucchi's (JD, hereafter)[2] offered a rebuttal, essentially focused on comparing the work in reference 4 at [1] to integrated resource planning (IRP) as that is practiced in Oregon, and at the regional level across the Pacific Northwest (PNW). In comparison to IRP, conclusions from the work by Jacobson et al. requires heroic assumptions that (a) no transaction costs exists to transform power systems and processes, (b) there are no environmental costs of renewables, (c) generation located anywhere can serve loads everywhere, and (d) system reliability can be maintained using storage strategies.

The debate here is not whether there is a role for such macro analysis. Such analysis can provide useful insights. That being said, when it comes to evaluating modifications to the existing power system, let alone the overall economy, the type of work that Jacobson and colleagues offer will not pass muster. Those assumptions may be reasonable if he had framed his analysis as a "what if" designed to investigate how various technologies behave (e.g., interact) under different operating conditions. City and county staff, state and federal legislators, have neither the time, nor in many cases, the skills, to parse that work. Rather, as we have seen – and which I note in [1] - that kind of work is latched on to by well-meaning people who do not understand what they're dealing with. While the Trump Administration exits the Paris Climate Accord and sets aside the Clean Power Plan, doubling-down on work such as Jacobson's in response, while understandable, compounds the problem. Or as the saying goes, "two don't make a right." What follows is my reply to JD's critique of my Paper. First, one of their comments appears as rebuttal. That is followed by my response, which be surrebuttal in a contested hearing process.

Rebuttal 1:

"Much of his criticism centers on his claims that these studies are not near-term utility planning documents and don't evaluate costs associated with sub-hourly fluctuations between load and generation, variations in capacity factor, curtailment, and storage."

Surrebuttal 1:

My criticism is not that their work fails to address the near-term. Both IRP and the regional power planning performed by the Northwest Power Planning Council (NWPPC) tht appears in [1] are long-term methodologies. They both use a 20-year horizon to arrive at a near-term action plan. They use a long-run analysis to account for the fact that utility capital investments are long lived. As such, my Paper compares the assumptions used in [18] and reference 4 in [1] to findings contained in Portland General Electric (PGE) 2016 IRP.[3] Two other IRP's, one by PacifiCorp[4] and one by Idaho Power[5] have also been submitted to the Oregon Public Utility Commission (Commission). All three IRP's are required to meet the same design criteria.[6] These IRP's all rely on multiple complex models with numerous simplifying assumptions that are only an approximation of actual real-time operation of each utility's system, and the broader Western Interconnection. However, as the guidelines at [6] illustrate, in each case the analysis begins with the extant power system. NWPPC performs electricity system planning for the four northwest states (Idaho, western Montana, Oregon, and Washington) that make up the PNW.[7] While the NWPPC modeling and analytics are at the regional level, their development, operation, and interpretation proceeds through a rigorous multi-year process that JD may find illuminating.

In the power planning conducted under the guidance of the Commission, and that performed by the NWPPC, the levelized cost of energy (LCOE) of competing generation technologies is an input to calculating the net present value of revenue requirements (NPVRR). In turn, NPVRR, in addition to various risk metrics, are used to identify a preferred system expansion portfolio.

DOI of original article: http://dx.doi.org/10.1016/j.tej.2017.11.011

[1] "100% Renewables Study Has Limited Relevance for Carbon Policy," by Robert J. Procter, The Electricity Journal < DOI: 10.1016/j.tej.2017.11.010 >

[2] 100% clean, renewable energy studies provide scientific solution that policymakers can rely on, Jacobson, M.Z. The Electricity Journal < DOI: 10.1016/j.tej.2017.11.011 >.

[3] "Portland General Electric 2016 Integrated Resource Plan," Portland General Electric. November 2016. See: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning.

[4] "2017 Integrated Resource Plan," PacifiCorp, April 4, 2017. See: http://pacificorp.com/irp.

[5] "2017 IRP," Idaho Power, June 2017. See: https://www.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/IRP.pdf.

[6] "Investigation into Integrated Resource Planning, DISPOSITION: GUIDELINES ADOPTED; RULEMAKING AND INVESTIGATION OPENED," Order 07-002, BEFORE THE PUBLIC UTILITY COMMISSION OF OREGON UM 1056, January 8, 2007. Note: also see Order 07-047 errata to this Order. See: http://apps.puc.state.or.us/orders/2007ords/07-002.pdf.

[7] "Seventh Northwest Power Plan," Northwest Power Planning Council, Adopted Feb. 10, 2016. See: https://www.nwcouncil.org/energy/powerplan/7/plan/.

https://doi.org/10.1016/j.tej.2017.11.012

Rebuttal 2:

"…we suggest that Proctor has the relationship between energy/climate policymaking and utility planning backwards: the former guide the latter, not the other way around."

Surrebuttal 2:

My Paper was not designed to argue that utility policy guides energy/climate policy, or vice-versa. Real-world utility policy development and implementation is much more dynamic, rather than linear. An example from Oregon may help illuminate the importance of understanding utility operations when attempting to use climate policy to drive utility policy. SB1547,[8] otherwise known as Clean Energy and Coal Transition Act (Act), was signed into law in March 2016. It was the product of discussions between advocates of renewable generation, the environmental community, consumer advocates, utility representatives, and the governor's office. What brought these parties to the bargaining table was a series of citizen ballot initiatives aimed at removing coal from retail delivery in Oregon. This might fit JD's argument that climate policy drives utility policy. However, while the Act, and by extension Oregon, have been heralded as an example of the first state to ban coal-fired electricity from retail delivery,[9] such is not the case.[10]

Such is not the case because the resulting utility policy does not remove coal from retail deliveries in Oregon by 2035, or any date thereafter, for the reasons discussed in [10]. The process used to gain passage of SB1547, most especially sidelining the Commission from the early negotiations,[11] removed an independent voice with the skill set to identify the limitations of SB1547, and possibly offer solutions that might have produced a utility policy that could help achieve climate policy goals.

As is also described in [10], the cost per unit of CO_2 removed by increasing Renewable Performance Stanedards (RPS) requirements (increased by the Act) is the most expensive approach to cut CO_2 emissions.[12] Comments submitted by me to the Commission on PacifiCorp's 2017 IRP provide further support for solid utility-level analysis of alternative climate policies.[13]

Rebuttal 3:

"… Procter apparently is not aware of related work that we have done that directly addresses his claims that we have not adequately accounted for variation between load and generation, capacity factors, and so on… we have two separate studies… that simulate matching demand with supply and storage down to 30 s resolution for multiple years… "

Surrebuttal 3:

One paper that JD is likely referring to, one by Jacobson, Delucchi, Cameron, and Frew (hereafter, JDCF), appears as reference 20 at [1]. In addition, in preparing my Paper, I read his reply comments to other papers that called his analysis into question. My Paper was not focused on providing an exhaustive review and critique of research countering his work and his reply to those papers.

The reader may compare JDCF's analysis to that contained in any of the aforementioned IRP's or the regional planning of the NWPPC. Here again, reference [1] includes excerpts from PGE's IRP to illustrate the complexity involved in evaluating if a proposed system expansion leads to reliability impacts. In contrast to IRP, JD's methodology can only address that issue at a very high level of abstraction. Further, while JD's argue that their grid integration study demonstrates that the various storage technologies can economically maintain reliability, the types of storage used are not economic either for PGE or for the PNW generally.

Rebuttal 4:

"...at least 28 other peer-reviewed papers have found, ... that demand can match supply with 100% or near-100% renewable energy systems of different sizes."

Surrebuttal 4:

I invite JD and their collaborators to become versed in the economics and operation of the electricity sector such as it exists today. Such an investigation may bear fruit with respect to how modeling is performed by utilities, various oversight bodies, be they state or federal. Clack's work[14], which was released while I was developing my Paper, represents a serious investigation of their analysis while keeping two feet firmly planted in the "real world".

Rebuttal 5:

"Procter claims we do not discuss externalities associated with wind, water, and solar (WWS) resource extraction, fabrication, shipping, construction, operation, and decommissioning. This statement is not true. Section S10.1 of Ref. [2] states,"

Surrebuttal 5:

To reach conclusions about the social costs and benefits of competing generation technologies for the U.S. and/or 139 countries, their analysis must address the environmental impacts of renewable technologies with the same level of rigor. There are many sources of information on the environmental impacts of using renewables from extraction to disposal.[15]

[8] "Senate Bill 1547, Clean Energy and Coal Transition Act" 78th OREGON LEGISLATIVE ASSEMBLY–2016 Regular Session. See: https://olis.leg.state.or.us/liz/2016R1/Downloads/MeasureDocument/SB1547.

[9] Here is one example of how the law is miss-understood: "Great News, Oregon Votes Out Coal by 2035," Eco Watch, March 3, 2017. See: https://www.ecowatch.com/oregon-passes-historic-bill-to-phase-out-coal-and-double-down-on-renew-1882185757.html.

[10] "Cutting Carbon from Electricity generation," by Robert J. Procter, The Electricity Journal, Volume 30, Issue 2, March 2017, Pages 41–46. See: http://www.sciencedirect.com/science/article/pii/S1040619017300118.

[11] "State utility regulators were silenced by governor on big energy bill," by Ted Sicklinger, The Oregonian, Updated on February 22, 2016 at 4:25 PM Posted on Feb. 17, 2016 at 6:00 AM. See: http://www.oregonlive.com/politics/index.ssf/2016/02/state_utility_regulators_were.html.

[12] For a more detailed analysis of competing CO2 reduction policies, see the NWPPC power plan at reference No. 7.

[13] "BEFORE THE PUBLIC UTILITY COMMISSION – Revised OF OREGON LC 67, by Robert J. Procter, Ph.D. Procter Economics, Submitted Oct. 14, 2017. See: http://edocs.puc.state.or.us/efdocs/HAC/lc67hac84635.pdf.

[14] Christopher T. M. Clacka, Staffan A. Qvist, Jay Apt, Morgan Bazilian, Adam R. Brandt, Ken Caldeira, Steven J. Davis, Victor Diakov, Mark A. Handschy, Paul D. H. Hines, Paulina Jaramillo, Daniel M. Kammen, Jane C. S. Long, M. Granger Morgan, Adam Reed, Varun Sivaram, James Sweeney, George R. Tynan, David G. Victor, John P. Weyant and Jay F. Whitacre, "Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar," Proceedings of the National Academy of Sciences, June 27, 2017.See: http://www.pnas.org/content/early/2017/06/16/1610381114.full.pdf?withds=yes.

[15] There is a great deal of information available on the environmental impacts of using renewables to generate electricity and in transportation. Here are but a few (no rank ordering): "GHG Emissions from the Production of Lithium-Io. See: http://large.stanford.edu/courses/2014/ph240/lambilliotte2/n; Electric Vehicles in China," by Han Hao, Zhexuan Mu, Shuhua Jiang, Zongwei Liu and Fuquan Zhao, Sustainability 2017, 9, 504; doi:10.3390/su9040504; "Effects of Mining Lithium," Ohio State University College of Engineering, (no date or author identified). See: https://u.osu.edu/2367group3/environmental-concerns/effects-of-mining-lithium/"How Green are Electric Cars?," by Louis Lambilliotte, June 11, 2015. See: http://large.stanford.edu/courses/2014/ph240/lambilliotte2/; "Application of Life- Cycle Assessment to Nanoscale Technology: Lithium-ion Batteries for Electric Vehicles," U.S. Environmental Protection Agency, EPA 744-R-12-001, April 24, 2013. See: https://www.epa.gov/sites/production/files/2014-01/documents/lithium_batteries_lca.pdf, "The Social-Environmental Impacts Of Renewable Energy Expansion In Scotland," by E. Ariel Bergmann, Sergio Colombo and Nick Hanley, Presented at The Agricultural Economics Society's 81st Annual Conference, University of Reading, UK, April 2–4, 2007. See: https://ageconsearch.umn.edu/bitstream/7964/1/cp07be01.pdf, "Chapter 5, Environmental Impacts of Renewable Electricity Generation," in Electricity from Renewable Resources: Status, Prospects, and Impediments, The National Academies Press, (2010); "Social, economical and environmental impacts of renewable energy systems," A.K. Akella, *, R.P. Saini, M.P. Sharma, Renewable Energy, 34 (2009) 390–396. See: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.4230&rep=rep1&type=pdf; "Positive and Negative Impacts of Renewable Energy Sources," by Stanislav Vezmar J. J. Strossmayer, Anton Spajić, J. J. Strossmayer, Danijel Topic, J. J. Strossmayer, Damir Sljivac, J. J. Strossmayer, Kneza Trpimira, Lajos Jozsa, J. J. Strossmayer, and Kneza Trpimira, International Journal of Electrical and Computer Engineering Systems, Vol. 5 No. 2., 2014, pp. 15–23. See: https://bib.irb.hr/datoteka/755710.05-02-14-03.pdf; "How do batteries affect the environment?," World Economic Forum, by Caleb Goods, June 8, 2015. See: https://www.weforum.org/agenda/2015/06/how-do-batteries-affect-the-environment/; "Chapter 4 Environmental Impacts of Renewable Electricity Generation," in The Power of Renewables: Opportunities and Challenges for China and the United States, The National Academies Press, pp. 89–112, 2010. See: https://www.nap.edu/read/12987/.