February 19, 2019

Comments on the Interim Report Concerning the Maryland RPS
By the Future of Energy Initiative

Tasked to evaluate the Maryland RPS[1], the PPRP is to be complimented for its effort to come to grips with a complex, confusing and politically charged challenge. In support of the Interim Report Concerning the Maryland RPS (Report), we offer the following comments:

1. CHECK THE NUMBERS –The Interim Report's main conclusion, that PJM can produce sufficient electricity from renewable generators to cover member State RECs, conflicts with PJM metered generation from renewables by a factor of 1.77. Such a large difference needs to be reconciled.
2. RATIONAL GOALS – The RPS Study is narrowly focused and does not address the purpose of an RPS. Maryland's RPS goal conflicts with the Greenhouse Gas Reduction act (Note #1)[2]. An electric power goal compatible with the GGRA should be "a reliable power system with no GreenHouse Gas (GHG) emissions."
3. SYSTEM DESIGN - Clean electric power is fundamentally a system problem, not a technology problem. A Concept Definition Study shows how technology fits together to deliver reliable, affordable electric power when and where it is needed. Transmission is a current issue not an emerging issue. Much of the difference between the Interim Report's estimates and PJM metered data might be explained by curtailment, electricity production that is discarded due to local transmission congestion.
4. PJM CAPACITY MARKET –The PJM/FERC capacity market debate is just the beginning of a fundamental change in electricity markets.

1. CHECK THE NUMBERS

Central to the PPRP Interim Report is EXETERs estimate of "Projected Generation," that is, the amount of renewable electricity available delivered to the PJM system that qualifies for State RECs. Table III-2 of PPRPs Interim Report shows a projected non-carve out generation of 51,065 GWh for 2018. EXETERs method is complicated and involves a number of unstated assumptions and a proprietary PJM-GATS database. We offer a simple sanity check, a validation, by comparing this estimate with published 2017 PJM metered data. PJM metered data is a direct measurement involving few assumptions.

PJM 2017 generation		
		GWh
total PJM		808,230
	wind	20,714
	hydro	14,868
	waste	3,984
	solar	1,469
	biofuel	1,473
renew subtotal		42,508
Less hydro, solar		26,171

PJM Renewables

PJM publishes an annual state-of-the-market report in March. The latest available is for 2017[3]. Page 13 of that report summarized 2017 PJM generation by fuel source. The adjacent table breaks out those fuel sources classified as renewable. Subtracting large scale hydro and solar corresponds to Tier 1 non-carve- out. So from the adjacent table, the metered 2017 Tier 1 non-carve out would be about 26,171 GWh. Renewable generation on PJM grew by ~10% from 2016 to 2017. Escalating 2017 metered data by 10% suggests a 2018 "adjusted from metered generation" of about 28,788 GWh. The corresponding Interim

Report's 2018 Table III-2 non-carve out projected generation estimate (51,065 GWh) is higher than the adjusted from 2017 metered generation (28,788 GWh) by a factor of 1.77.

One key assumption in the EXETER calculation is wind Capacity Factor (CF); the amount of electricity produced over the whole year divided by the amount that would have been produced if the wind turbines were able to generate rated power 100% of the time. PJM reports a system level CF for 2017 of 27.6%[4] with a 10 year average of 27.8% and no trend (note #15 at the end of these comments). The lack of trend over the past decade shows that any turbine technology improvements over the past decade have been small compared to other (probably system) factors. The PJM CF includes turbine design, wind resource, maintenance downtime, wakes, imperfect siting, imperfect setup, aging etc. as well as system constraints and losses.

PPRP should reconcile these numbers, why does the EXETER estimate of projected renewable generation significantly exceeds the PJM metered renewable generation. We note that the EXETER approach is a theoretical technology number assuming 100% utilization and no system constraints or losses. There appears to be no validation or verification. The PJM number is a practical system measurement of the amount of renewable energy delivered to the grid.

The Maryland RPS mandates that a percentage of electricity consumed by ratepayers to come from renewable sources. Therefore, the RPS should be based on the amount of electricity delivered to ratepayers including all system constraints and losses. The major conclusion of the Interim report, "*there is sufficient non-carve-out Tier 1 renewable energy generation to meet the current (as of October 2018) requirements of state RPS policies within PJM, including Maryland, through 2030 except for small deficits from 2022 through 2025*" may be incorrect.

2. RATIONAL GOALS

Rational goal setting starts with a clear statement of purpose. A sound goal is stable, it does not change. A sound goal states a performance level, what to do, not how to do it. "We choose to go to the moon before the end of the decade..." is a superb performance goal. It says what to do, not how to do it.

For clean energy, a rational overall performance goal is already stated by Maryland's Greenhouse Gas Reduction Act of 2016[5]:

An 80%-95% overall reduction in GreenHouse Gas (GHG) emissions by 2050

The difficulty is that this goal is buried in §2-1025.c.2.2.3. This goal correctly states the primary purpose of Maryland's clean energy transition and should be up front and central to any planning effort. Rational goal setting derives interim goals from the ultimate goal. An important allocated goal is:

Reliable, affordable, zero GHG electric power systems by 2050

A clean grid is essential for electrification strategies (electric vehicles) to be effective. A primary value of sound goals is that they clarify what to avoid, specifically anything that interferes with the eventual achievement of zero GHG emissions. The next step is to present stakeholders with trustworthy set of whole system comparisons: renewables vs nuclear vs sequestration vs mix. In the engineering world we

Dr. Alex Pavlak; Chairman, Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net

call this a Concept Definition Study[6]. Based on facts stakeholders can and choose a technology path and a pace and make compromises if necessary (such as zero GHG really means <5 grams (CO_2)/kWh).

In contrast a RPS is a technology mandate; a guess that is uninformed by any system requirement. The RPS fails to recognize that a system is necessary to deliver reliable affordable power and that variable renewable generation changes system architecture. Guessing at solutions is not how mature societies build infrastructure. The costs are too high, the consequences of mistakes too severe. The quickest way to 80-95% overall GHG reduction is to minimize the risk of serious mistakes through classical engineering.

3. SYSTEM DESIGN

The development of clean electric power systems is fundamentally a system design problem, not a technology problem. The challenge is to figure out how to configure technologies to form systems that deliver reliable affordable electric power when and where it is needed.

Jenkins[7] reviewed 40 system studies published since 2014 and found *"...strong agreement in the literature that reaching near-zero emissions is much more challenging – and requires a different set of resources – than comparatively modest emission reductions (e.g. CO2 reductions of 50-70%)"*. What this means is that the lowest cost zero GHG solution may be to discard the technologies that were chosen to get the first 30% or add additional technologies like carbon sequestration.

The source of the complexity is variable generation which affects the grid architecture in two fundamental ways. First, the availability of power from each generator type depends on weather conditions. Second, there is a tendency to lose all the power on the system from one generator type at the same time. There is no solar at night and there is a tendency to lose all wind during peak load (on occasion the reason that the load peaks is because the temperature is extreme because there is no wind). None of this is important today with PJM wind at 2.6% and solar <1% with ample fossil fuel backup.

The next rational step is for Maryland to identify alternative system concepts that can deliver reliable affordable zero GHG emission electric power when and where it is needed, a Concept Definition Study.

4. PJM CAPCITY MARKET

The Interim report identified PJMs FERC filing as an emerging issue. "*FERC found that PJM's existing Minimum Offer Price Rule (MOPR) does not adequately address the price suppressive effect of resources receiving out-of-market payments (RECs) to ensure a just and reasonable rate."* This filing is just the beginning of important changes that have yet to play out.

Note #5, the Evolution of Clean Energy Markets in The Big Picture Perspective[8] points to fundamental changes underway in electricity markets. This change is driven by two forces: a) Generators are shifting from high variable cost fossil fuel generators to high fixed cost clean generators; and b) variable renewable generators have little or no capacity credit at high penetration levels.

Dr. Alex Pavlak; Chairman, Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net

Fair markets align price with cost. Wind turbines are not interchangeable with fossil fuel plants. Therefore fair electricity markets need to be based on whole system cost, not just generator cost. When a wind turbine is added to a system, the system can throttle back on fossil fuel consumption whenever the wind blows but it cannot eliminate the fossil fuel plant.[a] It is necessary for the system to retain the fossil fuel plant to keep the lights on when the system has no wind. This means that a fair market would compete the capital cost of the wind turbine with the variable cost of the fossil fuel plant.

While today's markets are based on buying and selling energy (kWh), future systems will place a higher emphasis on capacity (kW), the ability to meet peak load. Variable generators will not do well in capacity markets.

[a] An argument can be made that at very low wind penetration (<5%) wind can be viewed as a statistical generator and provide the system with capacity credit. This is not true at higher penetration as evidenced by the fact that standalone wind is not a reliable system.

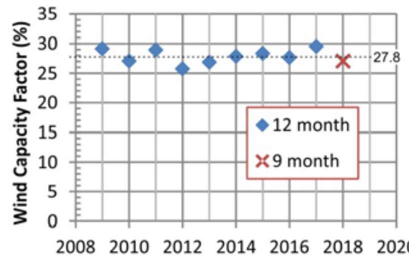
Dr. Alex Pavlak; Chairman, Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net

February 19, 2019

#15 PJM Wind Capacity Factors

Capacity Factor (CF) is an important wind generator performance measure relating wind turbine investment to electricity production. For this Note, CF is the actual output of all wind farms on the PJM system for a period of one year as a percentage of the potential output had all wind turbines been running at full nameplate capacity (maximum power rating) during that year.

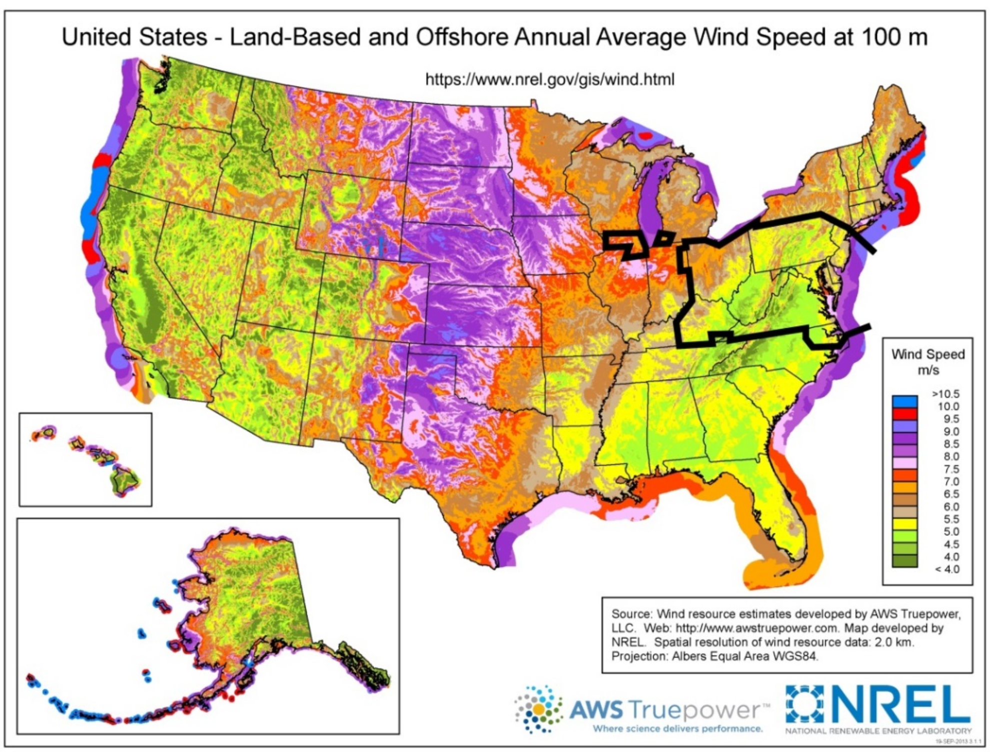
Since 2009, PJM published annual wind generator performance in its State of the Market Report. Aggregated annual wind CF data is presented in the adjacent figure. As of the date of this writing, data was available for only the first 9 months of 2018. Average CF over the 10 year period was 27.8%. It is important to emphasize that this is real world operational data; no models, approximations or assumptions.



PJM wind capacity factors

Over the past 10 years, PJM wind nameplate capacity increased by a factor of 2.4 to 8,633 MW. Yet the PJM data shows no significant wind turbine technology improvement trend. Berkeley Lab reports that modern turbines have a higher CF than older turbines mainly due to larger rotor size. For historical PJM data this appears to have been offset by a decline in CF by as much as 20% with turbine age (p. 42). For low wind resources Berkley suggests a CF technology potential of 36% but this is sill subject to ageing, and for large penetration to suboptimal sites, wakes, curtailment, maintenance, imperfect setup ...

The PJM RTO, outlined by the heavy black line, has low wind resources; so does Maryland with the potential exception of offshore wind.



Dr. Alex Pavlak; Chairman, Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net

February 19, 2019

REFERENCES

[1] Chapter 393 of the Acts of the Maryland General Assembly of 2017

[2] Note #1 – What is the purpose of the RPS? In The Big Picture Perspective, Notes from the Future of Energy Initiative, 2018, available at: http://dnr.maryland.gov/pprp/Documents/The-Big-Picture-Perspective.pdf

[3] 2017 State of the Market Report for PJM, Monitoring Analytics, March 22, 2018. https://www.pjm.com/-/media/committees-groups/committees/mc/20180322-state-of-market-report-review/20180322-2017-state-of-the-market-report-review.ashx

[4] 2017 State of the Market report, p. 14.

[5] Maryland Greenhouse Gas Reduction Act of 2016, available at: http://mgaleg.maryland.gov/2016RS/Chapters_noln/CH_11_sb0323t.pdf

[6] PJM Concept Definition Study, Future of Energy Initiative, 2018, available at: http://www.futureofenergyinitiative.org/Pubs/MEArecommendation.pdf

[7] Jenkins, J. D., et al, Getting to Zero Carbon Emissions in the Electric Power Sector, Joule 2, pp. 2487-2510, December 2018, available at: https://www.cell.com/action/showPdf?pii=S2542-4351%2818%2930562-2

[8] Future of Energy Initiative, The Evolution of Clean Electric Power Markets, Note #5 in in the Big Picture Perspective, November 2018, available at: http://www.futureofenergyinitiative.org/Pubs/RPSmemoranda.pdf

Dr. Alex Pavlak; Chairman, Future of Energy Initiative; www.pavlak.net; www.FutureOfEnergyInitiative.org
315 Dunham Ct., Severna Park, MD 21146; (410) 647-7334; (443) 603-3279(c); alex@pavlak.net