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Alex Pavlak

Comments on 5/4/23 Early Results of the 100% Study

The DNR PPRP program was tasked to compare two policies, 100% RPS vs 100% CARES which it did. Main comments on the early results presentation are:

- Neither policy is an effective decarbonization strategy. Both policies generated more electricity from in-State natural gas in 2040 than in 2020.
- There is no market model for import/export prices. If all the neighbors are doing the same thing, everyone wants to buy/sell at the same time and there is no market. Assuming equal import/export prices discounts baseload and strongly biases cost analysis in favor of intermittent generation.

Additional comments:

- There are inconsistencies in the early results. Both policies appeared to show 43% clean not 100%.
- It is not clear how the technological mix is determined. A rational analysis would begin with minimum cost which would have few technologies. Policy choices would then expand the mix at higher cost.
- The analysis is a cost analysis, and a presented Early Result was retail rate impact. Conversion from cost to retail price involves substantial subjective assumptions which are not specified.
- We still see no classical end-to-end model validation. The Taylor diagram presented as a reply to the last time the validation question was asked should properly be called verification (the science is consistent), not validation (quantitative system performance).
- The DNR 100% Study has been a low budget, part-time, policy comparison. Fact based policy first requires a sound understanding of how wind, PV, nuclear, and storage fit together to deliver reliable, affordable, zero carbon electricity. This is a much larger professional system engineering effort.
- Additional scenario recommendations. A no-cost import/export assumption precludes a rational cost analysis. Closed boundary scenarios are recommended for the remaining scenarios.

Neither 100% RPS or 100% CARES is 100% clean

The 100% Study is tasked as a comparison of two policies, 100% RPS vs 100% CARES. Both policies require that Maryland produce enough electrical energy (TWh) from qualified sources that is equal to the annual average Maryland load, (68 TWh in 2040). The policies can be easily met by building enough qualified generation to produce on average 68 TWh, maximizing out-of-State intermittent generation, then building enough natural gas generation to keep the lights on, exporting over-generation. The main difficulty with this strategy is that it is not zero carbon.

The threat is climate change. To avoid exporting problems to the neighbors, the goal should be ZERO (not net-zero) greenhouse gas emissions. The low-risk engineering approach is to first quantify how wind, PV, nuclear, and storage fit together to deliver reliable, affordable, zero carbon electric power. This initial analysis should be unconstrained by existing policy, market structure, governance, and legacy infrastructure (all new construction). Rational planning first requires a destination which serves as the basis for deriving interim goals, technology choices, schedule, and roadmap. After policymakers choose a path, THEN they can rationally balance risk and cost to choose interim goals and schedule.

Dr. Alex Pavlak; 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

Inconsistencies

2040 predictions (TWH)			
Scenario	Load	Qualified	
BAU	68	29	43%
100% RPS	68	29	43%
100% CARES	68	43	63%

The adjacent table was scaled from Early Results, the 2040 bar in the 3 Generation-in-Maryland scenario charts. In all scenarios the 2040 load was 68 /TWh/yr, a very reasonable 0.8% load growth over the 20-year period. Note that there is no difference in the amount of electricity generated from qualified sources for BAU (business as usual) and RPS scenarios, and none of the 100% scenarios generates enough in-State electricity from qualified generators to equal the 68 TWh average load.

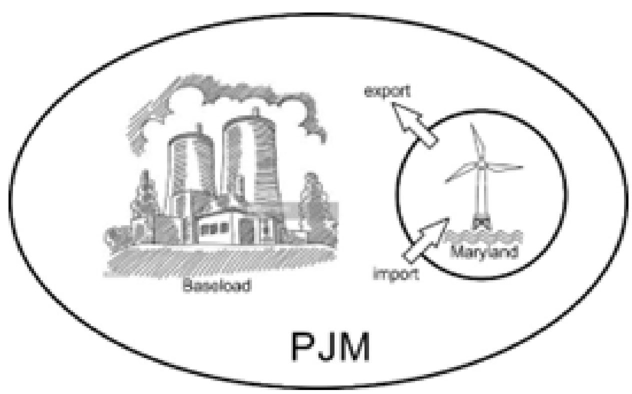
None of the scenarios presented are zero carbon, in-State natural gas generation in 2040 is >2.5x the amount generated from natural gas in 2020. One of the scenarios presented is labeled 100% clean. It is 100% CARES, not 100% clean. 55% of in State generation is from natural gas.

Professional boundary condition management

A model boundary with imports/exports is rational only if the boundary is well defined. While Exeter/VCE seem to define physical transmission, the study is silent on market models across this boundary. The effect of equal price imports/exports is to strongly bias the cost analysis modeling against baseload capacity, in favor of intermittent generation.

A best practice in system engineering is a well-defined boundary. The simple assumption is closed, no imports/exports. A closed boundary around Maryland assures that the model will capture all costs, particularly the high cost of managing intermittency. After total costs are defined, the boundary condition can be relaxed to explore the opportunity for synergy with Maryland's neighbors. If everybody is pursuing decarbonization, synergy is unlikely.

The adjacent Venn diagram illustrates the difficulty. Consider a constant load PJM as a closed system with Maryland as fraction of total PJM load. Consider Maryland to be powered by wind turbines sized to meet average Maryland load, and PJM to be powered by baseload sized to equal PJM load including Maryland. All costs are fixed cost, no variable cost. PJM has the capacity to deliver full power to Maryland when there is no wind. This appears to be the way Exeter/VCE size their model.



PJM Venn diagram

But now consider how the economics and markets operate. If Maryland relies on PJM for firm capacity, other PJM members are holding more generation capacity than they need, and they will want Maryland to pay higher import prices to recover that cost. There is no incentive for them to purchase Maryland exports at any price. From Maryland's perspective, imports would cost just as much as they would pay if they had no wind turbines, and they were unable to export. So why does Maryland have wind? These import/export dynamics play out in the real world:

1. Denmark currently claims 43% wind generation but has the highest electricity prices in Europe ($0.58/kWh US). The reason electricity in Denmark is expensive is import/export to UCTE (the European grid). When Denmark wants to sell, nobody wants to buy so the price they get is low. When Denmark wants to buy, nobody wants to sell unless the price is high.
2. In 2015 Georgetown Texas tried to use average wind to cut ties to the grid and lost millions keeping the lights on.
3. Ontario Canada currently exports over-generation at 10 cents on the dollar to the US.

In a world where everybody is decarbonizing, a 100% clean closed boundary PJM will have cost components like a 100% clean closed boundary Maryland.

Additional scenario recommendations

The current 100% Study has the resources to run additional scenarios. Any cost analysis with an open Maryland import/export boundary is meaningless. A relatively simple next step would be to close the MD boundary and model a stand-alone Maryland system. Focus this next step on the cost-optimal balance between wind, PV, nuclear and storage independent of: current policy, legacy infrastructure (all new construction), existing markets (cost only), delivery dates, and roadmaps. Reference scenario: 100% combined cycle natural gas turbines

1. 100% renewables: 100% OSW + PV + backup. What is the cost optimal balance?
2. Nuclear + green fueled combustion turbines. What is the cost-optimal balance? (probably 3:1)
3. Nuclear + 8.5 GW OSW (2:1)

Beyond the current 100-% study: develop a Clean Energy Systems Center

Policymakers need access to competent system analysis and development skills supported by expert red team consultants, to educate legislators, answer questions, provide factual constraints for investment, policy development and risk management. System tasks in need of prioritization and planning are:

- Identify robust zero carbon generation technology balance, optimal generation
- Develop, license, acquire, multiple models
- Setup reference scenarios, validations, verifications
- Technology cost sensitivity analysis.
- Transmission architectures, n-I reliability assessments, load management
- Overall system failure analysis and loss-of-load reliability assessments
- Load profile analysis, impact of electrification
- Extreme event management
- Policy evaluations and fiscal analysis
- Dispatch options and strategies
- Spinning reserves and reliability assessments
- Black start procedures simulations
- System resilience assessments
- Development sequence and schedules
- Technology requirements development
- Governance assessments, changes in roles and responsibilities
- Interface with PJM and other States
- Market reform, compare alternative wholesale/retail market structure

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