March 8, 2016

We support SB 921 with amendment

(A Primer on the Risks and Costs of 25% Renewables)

We believe that Maryland Legislators should base policy decisions on fact; mandating intermittent renewables (wind/solar) without whole system engineering design is unwise. To help with the homework, this monograph provides an engineering assessment of the risk and costs of intermittent renewables. Risks are real and decision makers need to understand the total cost of the whole system even if the bulk of these costs are indirect such as taxes or increased prices on other goods and services.

Maryland's Greenhouse Gas Reduction Act (GGRA) requires a zero carbon grid. The GGRA mandates an 80-95% reduction in greenhouse gas emissions by 2050. A zero carbon grid is essential for large emission reduction because it enables emission reduction through electrification of other energy sectors (e.g. transportation, space heating). Some energy sectors will be difficult and expensive to decarbonize (jet fuel, manufacturing, chemical processing…) and will comprise the bulk of carbon emissions. The GGRA goal implies an electric grid requirement of zero carbon, not low carbon.

It is impractical to build a reliable zero carbon system based solely on intermittent renewables. Zero carbon <u>generators</u> are not the same as reliable zero carbon <u>systems</u>; there is no competent engineering study to explain how a 100% wind, water, solar system would be reliable [Note A]. Mandating intermittent renewables commits the rest of the grid to provide dispatchable (on demand) backup and fossil fuel is currently the only practical/economic backup option. Fossil fuel generators and wind installations are not interchangeable. Something needs to provide power when there is no wind/sun. An intermittent renewables system implies that 20-30% residual fossil fuel is acceptable. If zero carbon is essential, the only options are to avoid the intermittent generators, or view them as a halfway step to be replaced.

Storage technology is unlikely to cure intermittency. Existing storage technology can offset rapidly changing wind/solar production. Given development, storage may become practical for leveling daily load variation. But the difficult and serious intermittency problem is seasonal and annual. We see <u>NO</u> practical technology for storing that much energy.

Cost/performance of immature technologies is uncertain. Optimism is common when estimating the cost and performance of unproven technologies. It has been common to assume a 30 year life with no performance degradation and no maintenance, but new lessons are being learned every day. After 15 years, 54% of onshore wind turbines in the UK are not functional[1]. Wind turbines in cold regions or high altitudes will require deicing system development[2]. In large wind installations, wind turbines need to be spaced further apart than originally expected[3]. Decision makers should view cost/performance estimates with skepticism, especially with unproven technologies unsupported by physical data.

Deicing wind turbine blades

Weather is uncertain. A system with generation dependent on the whims of weather introduces new risks. What does Maryland do for power if weather produces sequential years with low wind/sunlight?

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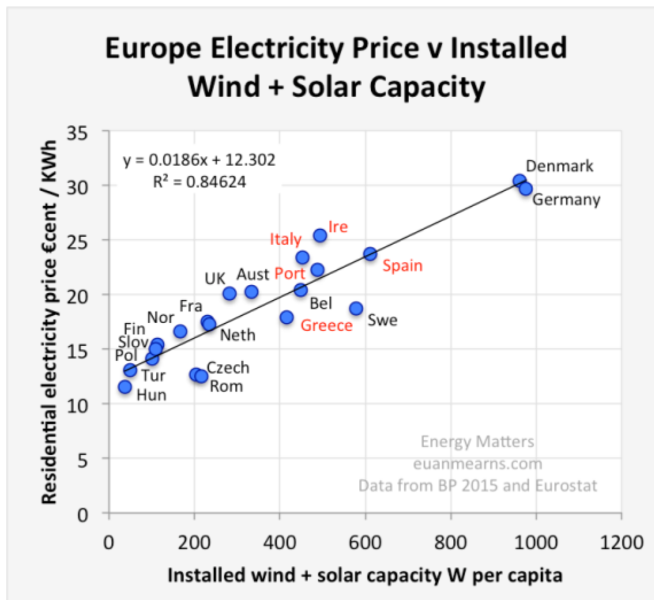
The consequence of poor choices is stranded investment. In their current form, intermittent renewables cannot satisfy the GGRA mandates. Without an unforeseen revolutionary breakthrough it may be necessary to scrap the renewables and build another source of power.

The scale and size of wind for 25% renewables has significant environmental impact. Assuming 20% wind (5% solar), the RPS implies a wind installation the size of Garrett County with perhaps 975 miles of new access roads and transmission lines and a couple of acres around each turbine for installation and repair [Note B]. While some of the land can be dual-use, many residents will have wind turbines near their homes.

Maryland citizens ultimately pay the whole bill – Basing cost on the Renewable Energy Credit market price is disingenuous. Ultimately Maryland citizens pay the total cost including various and sundry subsidies, costs charged to industrial and commercial sectors, and all cost increases imposed on the rest of the grid by intermittent renewables (storage, smart grid, idle backup generators etc.). A very rough estimate for 25% renewables is 25% of the average electric bill, or about $37.50/month.

Maryland should learn from Europe - Europe provides important lessons as they are ahead of the US in implementing renewables. The chart presents the residential electricity price in Euro cts/kWh as a function of installed wind plus solar measured as watts per capita[4]. The data shows that 30% (Germany) to 40% (Denmark) may double residential electricity prices and the previous $37.50 /month estimate above could be too small.



Capital cost – Another perspective is the total capital cost of 25% renewables. Based on overnight cost estimates [no construction finance] from EIA[5] and NREL[6], our estimate of the cost of 25% renewables [20% wind, 5% solar] for Maryland is $13 billion.

OUR OPINION

Mandating solutions is risky policy. The most serious mistake that Maryland can make today is to mandate the wrong solution. Based on known technology, both intermittent renewables and nuclear fission can reduce grid emissions a little bit. But nuclear has better potential to reach the GGRA goal of 80-95% overall emission reductions. Nuclear fission is not without its problems (waste disposal, accidents, etc.), but its problems appear to have technological and regulatory fixes. Despite the claims of optimists[8], we see no practical (economic) solution to weather induced intermittency. We oppose HB1106 because it is a simple solution mandate; it does not consider all options, ultimate goals or whole systems. **We would support of HB1106 if the word "Renewable" is replaced with "Clean Energy;" any solution satisfying the ultimate GGRA goals.**

WHO WE ARE: The Future of Energy Initiative is an open source working group of scientists and engineers. We are environmentalists and technology agnostic. Our goal is to clarify the architecture of a reliable and sustainable electric power system without fossil fuel.

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NOTES

[A] The most comprehensive engineering study so far is a massive Department of Energy study[7] that concludes that 100% renewables is technically feasible if 40% of the power comes from biomass (wood). Essentially they replace fossil fuel backup with wood fired backup which we find to be environmentally unacceptable. A Stanford Group claims that 100% wind, water, solar is feasible at low cost.[8] That paper has seen significant criticism[9]. In our opinion their conclusion is academic speculation unsupported by realistic empirical data[10] using credible engineering analysis. There are numerous other studies[11,12,13] concluding that the cost of a reliable system accelerates rapidly beyond 50% penetration with 80% often cited as a practical limit.

[B] In 2014 Maryland electricity consumption was 61,684 million kWh[14]. The need for 20% wind implies sufficient wind turbines to deliver 12,337 MkWh annually. Average Maryland power over the course of an 8,760 hour year is 1,408 MW. Assuming 30% capacity factor, this requires 1,877 (2.5Mw) wind turbines. A lesson learned in recent years is that wind turbines interfere with each other if spacing is too close. The recommended density of the extraction of energy from the atmospheric boundary layer by wind turbines[3] is currently 1 MW/km^2. For 20% wind, this requires a 1,408 km^2 wind installation, roughly the size of Garrett County. With 2.5MW wind turbines, spacing is ½ mi.

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