Comments from FirstEnergy received on September 3rd

PPRP's response follows each question below.

1) What is the available output of the model for the following:

    a. Generation buildout and retirements?
    Generator buildout and retirements are available for each investment period from 3-km resolution to state-level resolution.
    b. Production costs, total system cost?
    Available at each investment period, defined as a year for this project.
    c. Pricing (wholesale energy, capacity, retail)?
    Available at each investment period.
    d. Transmission constraints?
    Model outputs transmission buildout, utilization rate at each investment period.

2) Are the wind profiles static, or are they stochastic?

Wind profiles are 5-min time resolution and 3-km horizontal resolution derived from weather data from the National Oceanic Atmospheric Administration's High Resolution Rapid Refresh weather forecast model. That data is converted to power accounting for swept rotor area and air density and adjusted to reflect wind turbulence, and the effect of severe weather conditions such as icing. See VCE's model documentation beginning on p. 75.

3) Is there any feedback for changing fuel prices, or are they static?

EIA's fuel price projections from their *Annual Energy Outlook* are utilized. Fuel prices respond to demand both from the electricity sector and rest of the economy. The price elasticity affects both intra-year and inter-year prices.

4) What is the objective function of the model; long-term lowest system (capacity + energy) or 1 year?

The objective function is to minimize the total system cost for a given construct of constraints and sectoral coupling for a minimum of a calendar year.

VCE defines as including: amortized generator capital expenditures, fuel costs, start-up and shutdown costs, amortized transmission capital expenditures, amortized storage capital expenditures, variable operation and maintenance (O&M) expenditures, fixed O&M expenditures, amortized natural gas transport expenditures, transmission wheeling charges, transmission access charges, interconnection expenditures, demand-side management and demand response expenditures, distribution costs and access charges, curtailment charges, reserve costs, retirement costs, and international trading costs. See Section 1.3 on p. 5 in VCE's manual for more information.

5) Are the wind/solar profiles correlated?

No.

6) How does the model handle shifting LCC? Specifically, currently a tracking solar array has about a 45% load carrying capability, but that is only because the peak hours happen in summer from about 1-6pm. That same solar array only has a 20% LCC if the peak happens 4 hours later, theoretically you would need to build twice the resources for peaking, and the units would be getting half the capacity revenues.

   VCE calculates the equivalent load carrying capability (ELCC) as a post-processing output. Within the model, the capacity value of a VRE generator is determined taking into account actual generation/load profiles over the year.[1] The impact of additional capacity on the ELCC of a particular technology depends on correlation with load. The more correlated with load, the higher the ELCC. For instance, in a study VCE did in Montana, the ELCC of solar in the 100% RPS and 100% decarbonization case is quite low, as load peaks in the summer and winter either before solar production ramps up or after solar generation begins to ramp down. In contrast, the ELCC of wind increased in this same study because wind generation was more correlated with load. See the discussion on p. 49 at https://www.vibrantcleanenergy.com/wp-content/uploads/2021/05/VCE-MT-WISdomP_Final.pdf.

7) With increased EV penetrations, does the model consider those EVs as dispatchable batteries?

A portion of EV load is available in the model for demand flexibility. However, use of them as dispatchable batteries won't be considered in the three cases discussed at our August 25th meeting but could be considered in a future scenario, such as an electrification scenario.

8) How does the model handle natural gas basis and new pipeline build (basis changes with new infrastructure)?

   The model builds any additional NG infrastructure needed to meet growing NG demand (if there is any). NG prices then respond to this growing demand, as described in question 6.

9) On page 43, CCS is $2328/kw and SMR/MSR are $6288/kw. Are those prices increasing with inflation through the study period, or assumed to drop in price over time? Also, are there limits set on the amount of new resource types available in the footprint?

   These costs are in real dollars and are held constant over time. There are limits on the amount of capacity of technologies that are at a more nascent stage of commercial development. Capacity for carbon capture and storage, small modular reactors and molten salt reactors is limited to 40 percent of what would expected if the technologies were commercially mature. Initial installations are delayed into the future

10) How is RGGI handled in the model? Theoretically as you get to 100% RGGI should become

[1] https://www.esig.energy/download/redefining-resource-adequacy-for-modern-power-systems/

moot.

RGGI requirements are included in the model.

11) How does the model address the potential for a federal emission product / subsidy?

We can address this in a sensitivity case should Congress enact pending legislation.

FirstEnergy followed up on with scenario recommendations in the following "priority" order received September 27th

1. Low wind resource
    a. What happens if wind speeds drop by x percent, or resources are unavailable due to extreme cold
    b. It appears that the reference case is BAU
2. High peak load shift
    a. what happens when the peak load shifts to later and later hours as more der shaves day time peak or EV charging happens later in the day
    b. As the shift moves away from the mid-day peak, solar resources would have lower peak load contributions and you would need increasing amounts of wind to meet demand
3. High electrification
    a. New EV (with coordinated charging), heating load, forklift, industrial equip, etc.)High/Low cost storage (low/high storage build)
4. High/Low cost storage (low/high storage build)
5. High offshore Wind/Low Onshore
6. Very low CCS and/or SMR costs and/or high efficient CC (4-5 heat rate)
    a. Most likely, the assumption is that those costs are increasing with inflation, but the n-th of its kind SMR could have a significantly lower cost.
7. High gas price scenario
    a. Currently using the AEO HRT, which is a pretty low gas price