Categorizing Questions and Comments

1. Scenarios
2. Modeling run prioritization criteria and run requests
3. Analysis Framework
4. Inputs and Assumptions
5. Modeling Rules/Constraints
6. Outputs

Scenarios (could be basis for additional modeling runs)

- Decarbonize the grid much sooner than 2040. (A. Christodoulou)
- Model (from a clean slate) a PNM fully decarbonized grid with wind, solar, a 1500 MW/70-hour duration PSH, minimal transmission incremental build, and separate/distinct fast-response grid stability resources such as BESS. From any sort of “end case” optimized model (such as the one suggested immediately above), then determine the interim steps that get you to the desired end state in an efficient manner from a cost, reliability, and emissions standpoint. (T. Conroy)

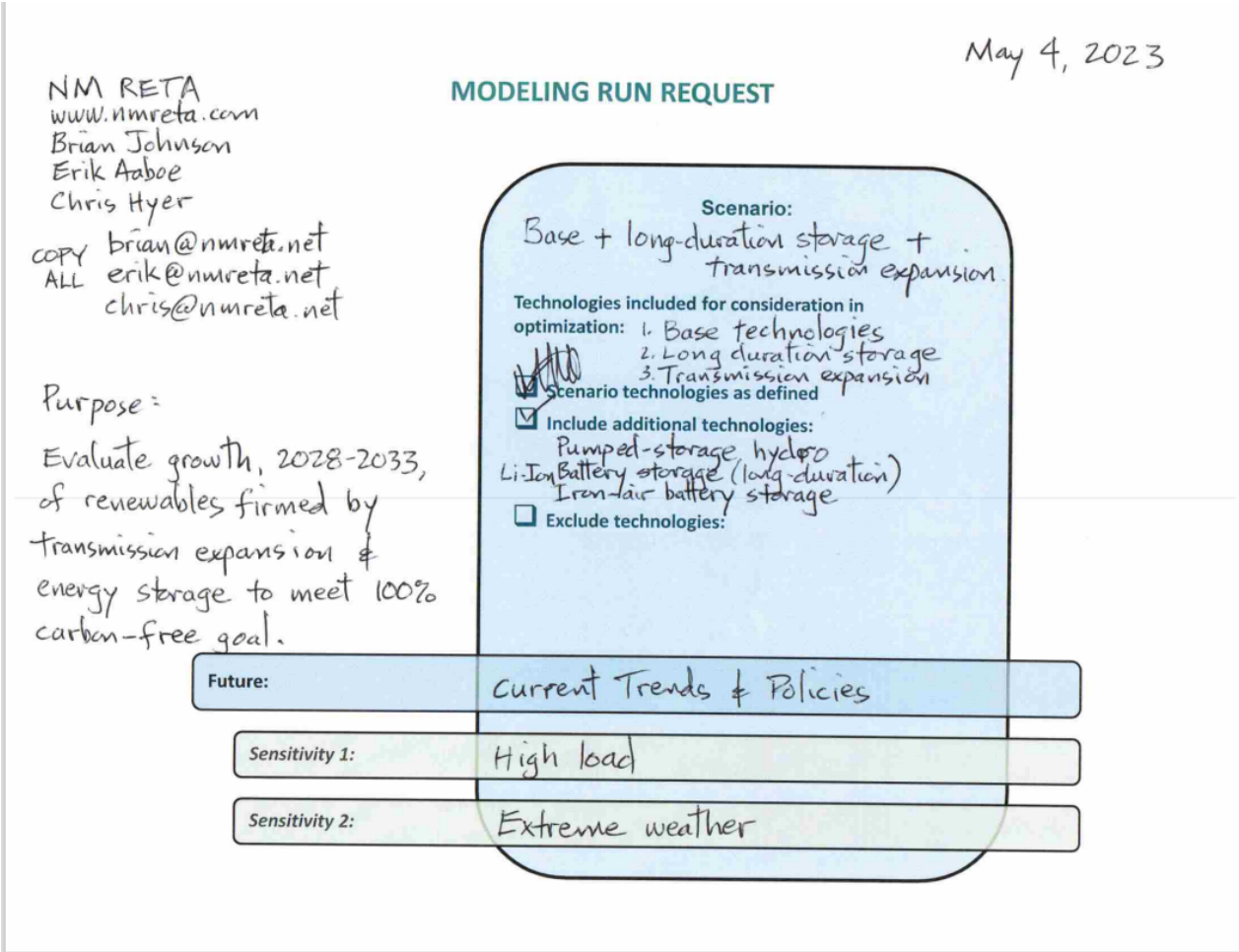
Modeling Run Prioritization Criteria and Run Requests

Candidate Prioritization Criteria (anonymous input)

1) Rank as determined by vote of modeling working group members
2) Alignment with Statement of Need
3) Delineation from existing scenarios
4) Runs that impact short term (within 10-year horizon) implementation rather than the long term interpretation (currently doing?)...This contradicts input from others that suggests at least one 20-year horizon scenario and resiliency analysis be conducted.

Run Requests

- We would like to see a run with base technologies, current policy trends & high penetration of EVs and electrification of space heating, given the incentives from Congress that we are going to be administering and adding to our own state programs. (J. Waite)
- Scenario with significant increase in demand response (several stakeholders).
- My early research results point to higher costs for wind generation resources due to likely long term wind "droughts" not anticipated in PNM's models. That motivates a desire for running scenarios or sensitivities with alternate treatment of wind resources either through their ELCC input to capacity expansion modeling or through the extreme weather data used as inputs for both Capacity Expansion and PCM models. (G. Wilke)



May 4, 2023

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MODELING RUN REQUEST

Purpose:

Evaluate growth, 2028-2033, of renewables firmed by transmission expansion & energy storage to meet 100% carbon-free goal.

Scenario:
Base + long-duration storage + transmission expansion

Technologies included for consideration in optimization:
1. Base technologies
2. Long duration storage
3. Transmission expansion

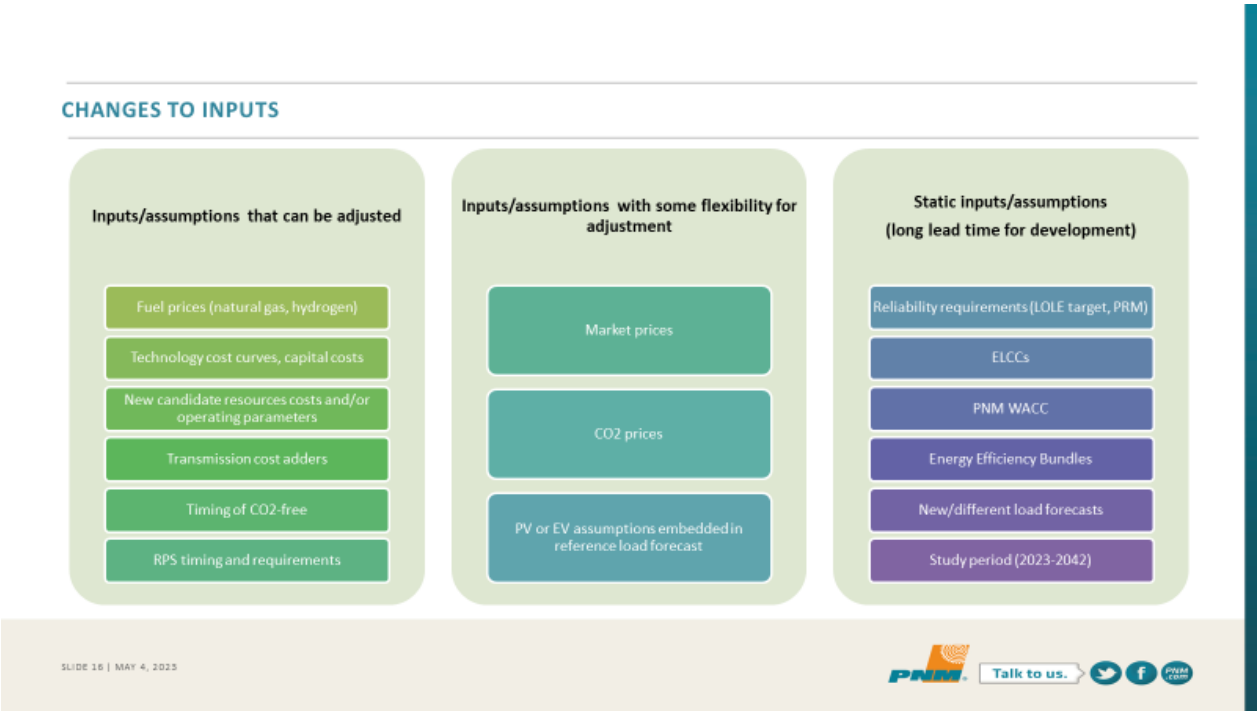
☒ Scenario technologies as defined
☑ Include additional technologies:
Pumped-storage hydro
Li-Ion Battery storage (long-duration)
Iron-air battery storage
☐ Exclude technologies:

Future: Current Trends & Policies
Sensitivity 1: High load
Sensitivity 2: Extreme weather

Analysis Framework

- Need a process for forecasting complete replacement of the grid vs forecasting the implementation of incremental dispatchable resources onto an existing system. (T. Conroy)
- Consideration of assets that are owned by 3rd parties instead of utility-owned. (T. Conroy)

Inputs and Assumptions



- Review ELCCs for solar, wind, storage and combinations (C. Mitchell) and reflect synergies among them (C. Leger). Suggested reference on this offered by E. Aaboe: https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/integrated-resource-plan-and-long-term-procurement-plan-irp-ltpp/20230210_irp_e3_astrape_updated_incremental_elcc_study.pdf
- Be explicit regarding Demand Response and Energy Efficiency , and consider a model run with significant increases in both (several stakeholders)
- Use of LCOE for resource costs (instead of what? Capital costs?) (C. Mitchell)
- Review reliability of fossil resources as in the past, they were modeled as more reliable than warranted. (C. Leger)
- Market availability and transmission interconnections must be adequately considered. (C. Leger)

Questions and Comments

From J. Waite, EMNRD, 5/8/23

- How is long-duration v. short duration storage modelled? For example, we are trying to understand if there costs associated with deferring long-duration storage now and having the short-duration storage (batteries) left as stranded assets later?
- What types of energy security events or impacts are modeled and cost out with LOLE? Are any cascading impacts to human health and economic function embedded in the model? Does the modeling include potential for sabotage (physical attacks) or cyberattacks?

From C. Beadles, WRA, 5/13/2023

- Should other types of gas plants should be considered in the modeling and not just aeroderivative. I'm wondering whether the emissions and operational performance of existing gas could be improved cost-effectively to avoid new gas that should be depreciated faster to avoid or reduce stranded investment risk in the future. Response captured by A. Gould based on 5/11/2023 meeting… Aeroderivative is used as a generic asset in the IRP as it is the combustion technology most likely to meet the portfolio needs; such as size, start time, ramp time, etc. When an RFP is issued for actual resources, technology other that aeroderivative can be submitted and will be considered, at which point (in CCN/PPA filings) intervenors can question issues such as potential stranded investment risk of new investment vs. existing generation assets.

From T. Conroy, 5/8/23, regarding seasonal duration storage

1. For all seasonal duration energy storage technologies except PSH, there are technology, cost, and commercial risks which must be considered and projected.
2. PSH has permitting timeline, construction timeline, and construction cost risks, but as a 100-year-old technology does not have meaningful technology or commercial risks.
3. Approx. 50% of PSH project capital costs will be spent locally, as compared to the approx. 5% to 10% spent locally on solar, wind, and BESS technology projects. It is unclear if these local construction jobs impact should be included in any analysis. For the Carrizo PSH project at $3.6 billion capital in 2020$, the local construction spending is estimated at $1.8 billion. Construction jobs are estimated at 673 direct/2,196 total jobs for a 5-year period.
4. Note that PSH projects are expected to remain in service for more than 100 years. The first PSH project in the U.S. (Rocky River Plant) was built 96 years ago and remains in service at 29MW nameplate.
5. Note that the Carrizo project is located on Navajo lands and is therefore expected to qualify for a 50% ITC remuneration level.
6. There is a great deal of uncertainty in projecting PSH construction/capital expenses since no plants have been built in the U.S. for decades. The attached whitepaper which Kinetic power wrote to NREL to inform their future technologies and costs projections defines the cost estimation process used for the Carrizo project. We feel that our empirical based, adjusted to 2020$ approach is the most accurate possible approach to PSH cost estimations today.
7. PNM IRP timeline and interest rate projections:
    a. The Carrizo project license (pre-construction) timeline is expected to be 3 to 4 years.
    b. The (subsequent) construction timeline to COD is expected to be 4 to 5 years.

   Construction and technology inflation and interest rate assumptions will presumably be crucial to make consistent for PNM asset choices to be deployed in future years.

From T. Conroy, 5/19/2023

1. Is the PNM 8760 hourly load data (for 2022 or 2021) now classified as "PNM confidential"?
2. I'm not precisely sure what "respondents to PNM RFPs" means, but I will presume that Kinetic Power falls into this category. Does it mean currently open RFP's, past RFP's, future expected RFP's, does it include RFI's, etc.

From K. Gould, NM AREA, 5/8/23

- Has Gridworks facilitated IRPs for other utilities? I am curious because maybe your expertise can help in navigating how the modeling inputs should be presented for a transparent review by stakeholders. It is my understanding that in other jurisdictions the third party modelers (Ascend and Astrape in this case) present a table of sorts an the outset, stating all the assumptions they have used and what the sensitives in the models are aka which assumptions really drive the modeling. It would be extremely helpful in deciding what to ask PNM to model to have these assumptions at the outset. For starters, can we get:
  (1) What are the key assumptions PNM has changed in this IRP from 2020?
  (2) What are the cost assumptions PNM is using for all the technologies and how did it derive these cost assumptions? MLT REFERRED HER TO https://gridworks.org/wp-content/uploads/2023/05/2023.05.12-Candidate-resources.pdf.
  (3) Are there any artificial MW limits to any of the technologies or MW grouping, like wind has to be added in 400MW bundles ect?
  (4)What is the import limit during the highest need hours?
  (5)What is PNM modeling to be the high need hours /months or its coincident peak? Is PNM using 3S1W or modified 3S1W or something else?
  (6) How is PNM treating the expiration of Reeves and Valencia in the models?
  (7) What is PNM modeling for the forced outage rates of PNM's existing plants and how did it derive those figures?
  (8) How is PNM modeling interruptible load?
  (9) How is PNM modeling the ETA carbon limit - is it assuming this number is an annual number?
  (10) How many MW of battery/ solar/ wind is PNM modeling in its base case?
  (11)What is PNM's current mix of resources that has been approved by the Commission?
  (12) Has PNM modeled any coordination with regional utilities to pool planning reserves?
  (12) Can PNM model a possible scenario of PNM joining an RTO with either CalISO or SPP?
  (13) Can PNM run models with averages of actual costs from its RFPs?

NM AREA is not likely going to run its own models this year but would still like to know how long it would take for PNM to set up a VM or to give us access to the models with all the input information. MLT REPLIED THAT VM WILL NOT BE AVAILABLE DURING THIS IRP CYCLE.

From M. Ballantine (5/11/2023)

- Curious about LOLE (%) vs cost of resource options.

From H. Gopalakrishnan (5/11/2023)

- Why not run 8760 MIP in Capacity Expansion (i.e.: fitted chronology) with either 1 year steps with no overlap or 2 year steps with 1 year overlap. This helps avoid the uncertainties associated with ELCC methodology.

From R. Wilson (5/11/2023)

- There are additional tax credits that PNM might take advantage of, including those relating to % of domestic content and projects cited in Energy Communities. Will those be modeled for different technologies?" (R. Wilson)

From G. Wilke (5/11/2023)

- How would the capacity expansion model incorporate feedback from PCM regarding likely long-term outages of Li-Ion units?
- Regarding purchase of hydrogen does the carbon intensity law limit PNM to 100% green hydrogen while restricted to 0 carbon intensity.

From C. Ho (5/11/23)

- During the 5/11 meeting, Nick mentioned the possibility of using EUE in addition to LOLE in the future. How will you weight or combine multiple reliability metrics to form the basis for your decisions? Also, it would be helpful to present a definition and/or illustration of these reliability metrics (e.g., LOLE, LOLH, LOLP, EUE, NEUE) and how they will be used.
- I would like to see a table of input parameters and their uncertainty distributions. In other words, what parameters are you treating stochastically (probabilistic) vs. discretely (sensitivity)? In particular, I would like to see more information about uncertainties in generation (wind, solar), storage, and load."
- Extreme weather considerations (C. Ho, E. Roesler, T. Nguyen, and J. Ellison)
  Conclusions from Sandia National Labs (contained in SANDIA REPORT SAND2022-0583 Printed January 2022). “Results for the extreme climate-change scenario show that the projected wind power may decrease by ~13% due to projected decreases in wind speed. Projected solar power may decrease by ~4% due to decreases in irradiance and increases in temperature in NM. Uncertainty in these climate-induced changes in wind and solar resources was accommodated in probabilistic models assuming uniform distributions in the annual reductions in solar and wind resources. Uncertainty in battery storage performance was also evaluated based on increased temperature, capacity fade, and degradation in round-trip efficiency. The hourly energy balance was determined throughout the year given uncertainties in the renewable energy resources and energy storage. The loss of load expectation (LOLE) was evaluated for the 2040 No New Combustion portfolio and found to increase from 0 days/year to a median value of ~2 days/year due to potential reductions in renewable energy resources and battery storage performance and capacity. A rank-regression analyses revealed that battery round-trip efficiency was the most significant parameter that impacted LOLE, followed by solar resource, wind resource, and battery fade. An increase in battery storage capacity to ~25,000 – 30,000 MWh from a baseline value of ~14,000 MWh was required to reduce the median value of LOLE to ~0.2 days/year with consideration of potential climate impacts and battery degradation.”

From C. Mitchell and E. Rilkoff (5/19/2023)

To: Margie Tatro and Amanda Gorman, Gridworks
From: Ed Rilkoff, PRC Utility Division Director, and Cynthia Mitchell, PRC Staff Consultant
Re: Statement of Need and Modeling and Scenario Analyses Request for Information and Data
Date: May 19, 2023

Please see the following information request regarding the Statement of Need (SoN), and Modeling and Scenario Analysis discussed in the May 18th PNM Gridworks Stakeholder Meeting. This information and data necessary to work towards a consensus SoN, and to offer informed recommendations on modeling and scenario analyses. Given the May 26th due date for Model Run Requests and suggested prioritization criteria, PRC Staff requests that PNM respond as soon as possible.

1. Could PNM provide its preliminary or draft 2023 Loads and Resources Table per Outline 3.c? See PNM 2020 IRP Table 22 "Existing resource dependable capacity & incremental resource needs (Current Trends & Policy future.

2. For the Peak Demand in (1), could PNM please clarify whether this is this a single hour coincident peak?.

a. Could PNM please provide the peak demand load duration curve for the first and last year of the forecast period.

3. For solar, wind, and storage in (1), could PNM please provide a listing of the individual projects, noting additions and retirements.

4. For storage, if not already provided in (3), could PNM please indicate the storage application or use, for instance, is the storage paired with solar or wind or other applications.

5. Could PNM please provide the details regarding DR included in (1), and how this is different from its 2020 IRP.

6. Could PNM please provide in preliminary or draft form a table showing first year (and last year, if available) Installed and Effective Capacity by Resource Types, similar to PNM's 2020 Table 31.

7. For the May 11th handout outlining the 3 Phases of scenarios and modeling, could PNM please provide the following information and data:

a. The preliminary or draft detailed summary of the results of the Phase 1 Base Technology Only Scenario similar to PNM's 2020 IRP Appendix J.

b. For each of other 14 Phase 1Scenarios, the timing and amount of the additional technology added to the Base Technology Only Scenario.

c. For the 14 Phase 2 Scenarios, the timing and amount of the additional technologies added to the Base Technology Only Scenario.

8. For the May 11th handout on the capital costs, $/kW ($2022), of renewable, thermal, and storage, could PNM please provide the LCOE for each resource.

From C. Ho (5/23/2023)

PNM IRP Modeling Input Parameters, suggested summary

Sample inputs and tables

Climate/weather/environment

Category	Input parameter	Value	Notes
Weather	Irradiance	Fixed vs. stochastic	Distribution type or scenario
Weather	Wind	Fixed vs. stochastic	Distribution type or scenario
Wildfires	Smoke impact on irradiance	Fixed vs. stochastic	Distribution type or scenario (e.g., temporal to accommodate wildfire season)
Drought	Water availability	?	Impact on pumped hydro?
Extreme heat	Temperature	Fixed vs. stochastic vs. temporal	Impact on load (e.g., air conditioning)

Supply/Resources (relative to installed nameplate capacity)

Category	Input parameter	Value	Notes
Weather	Irradiance	Fixed vs. stochastic	Distribution type or scenario
Weather	Wind	Fixed vs. stochastic	Distribution type or scenario
Solar	Capacity factor	Fixed vs. stochastic	Distribution type or scenario
Solar	Degradation	Fixed vs. stochastic	Distribution type or scenario
Wind	Capacity factor	Fixed vs. stochastic	Distribution type or scenario
Wind	Degradation	Fixed vs. stochastic	Distribution type or scenario
Resource X	Etc.	Etc.	Etc.
Resource Y	Etc.	Etc.	Etc.
Other generation	Etc.	Etc.	Etc.

resources?			
Storage	Battery round-trip efficiency	Fixed vs. stochastic	Distribution type or scenario
Storage	Battery capacity fade	Fixed vs. stochastic	Distribution type or scenario
Storage	Other storage technologies	?	?

Demand

Category	Input parameter	Value	Notes
Demand	Load	Fixed vs. stochastic vs. temporal	Distribution type or scenario; accommodation of increased electrification from heat pumps, EVs
Demand	Demand response	Fixed vs. stochastic	Distribution type or scenario
Demand	Efficiency	Fixed vs. stochastic	Distribution type or scenario

From K. Raman and R. Wilson, Form Energy (5/25/2023)

Scenario Requests

- Scenario Request: Model a “no combustion” scenario which retires all existing combustion resources by 2040 to meet PNM’s decarbonization goals
    - Candidate Technologies:
        - Technologies Included: Solar, Wind, Li-ion storage, Long duration storage, wind expansion, geothermal
        - Technologies Excluded: Retirement of all existing natural gas combined cycle and combustion turbine resources by 2040. Retrofit of combustion resources with green hydrogen or CCS is excluded from selection.
    - Future: Current Trends and Policy
    - Sensitivities:
        - Evaluate two different retirement schedules for existing combustion resources:
            - Require combustion plants to retire at the end of their depreciation schedule
            - Require model to retire all combustion plants by 2040, but allow for endogenous retirement of combustion plants in preceding years based on economics
    - Rationale for scenario request:

- IRP should consider a future in which all fossil fuel combustion turbines are retired to meet PNM's 2040 goal of 100% emissions-free energy
  - Technologies such as green hydrogen and carbon capture have yet to be deployed at commercial scale, which results in a high degree of cost uncertainty
  - In particular, green hydrogen also requires buildout of infrastructure for producing, storing, and transporting hydrogen fuel, which may not exist in 2040
- Combustion resources of all types have air quality impacts on local communities
  - Criteria pollutants, such as NOx, are generated by combustion resources regardless of whether they are operated using natural gas or green hydrogen
  - These criteria pollutants can be linked to occurrence of chronic respiratory illness in local communities

Criteria for Scenario Prioritization:

- Expose key uncertainties in PNM's decarbonization strategy
  - Prioritized scenarios should highlight critical uncertainties that are most likely to impact PNM's ability to achieve 100% emissions-free energy by 2040
- Uncover new strategic pathways for resource procurement
  - Prioritize scenarios which may uncover alternative resource procurement pathways that are directionally distinct from PNM's existing IRP
  - Deprioritize scenarios which are likely to result in marginal modifications to the existing IRP
- Be completed in a reasonable amount of time with reasonable effort
  - Certain scenarios may require an inordinate amount of time to be set up and/or run through the models. Time versus value should be considered when prioritizing scenarios.

From M. Ballantine and G. Wilke (5/26/2023)

Glen,

I would not worry too much about gaining access to PNMs data, as understanding them in even a week would be a herculean task (I presume, as I myself have not studied their datasets).

Regarding the timeline, I assume that it is non-negotiable at this point, and so would spend time formulating a general modeling request rather than a specific one. What you write in your bullets 1. and 2. is probably plenty sufficient to make a request to PNM, something along the lines of "perform sensitivity studies on resource lifetimes and capital costs of exotic resources". I would enumerate the exotic resources of interest and specify the range (of lifetimes and capital costs) that you would like to see, as this will ensure that the modeling outputs address your concerns.

Best Regards,

Marissa

From: Glenn Wikle <glennwikle@gmail.com>
Sent: Friday, May 26, 2023 8:34 AM
To: Ballantine, Marissa D <mdballa@sandia.gov>; Newlun, Cody Jack <cjnewlu@sandia.gov>; cliffort_ho@heinrich.senate.gov
Subject: [EXTERNAL] PNM IRP modeling feedback timeline too tight

As of this moment I do not have access to the public modeling data so do not understand the inputs well enough to formulate my requests for modeling runs by COB today.

Even if I did get access to the data today *and* could actually make sense of the data set *in the few hours available*, I don't know if the public subset of the data is sufficient to understand the full breadth of the inputs being used.

In general, this process is being rushed so much that I wonder how the most involved stakeholders can keep up with it and provide meaningful feedback. I wonder if it is time to officially ask the PRC for more time. It was their late rulemaking that put us in this situation.

I want to speak to you about my main concerns, which are about economic modeling of the more "exotic" resource types based upon what I have seen in the previous IRPs:

1. It looked like the resource lifetimes were too short (by possibly as much as 50 years) for some of the more exotic resources. I believe this skews cost effective price modeling and might skew it enough to lead to incorrect decisions. Would this be dealt with as a sensitivity study? I think NREL has published the price variances so we could use those for such a study? (Access to the Siemens price data would help me understand this better.)

2. Some resource types have very large capital price variance and I don't think PNM ran sensitivity studies to take this into account. I don't know if the Siemens price db takes this into account which is why I want to look at it before I formulate a specific request.

More clarification from G. Wilke (5/26/2023)

Here I am filling in the requested details and adding more since I found another concern while reviewing the "resource catalog" from PNM. Do I need to forward this to PNM or will you folks do that?

The "exotic" resources with high cost variance are Geothermal, PSH, and compressed air. All have large variance which depends upon the geology and terrain where they are sited. There is, in fact, one example of the huge cost variance (for geothermal) in PNM's slides. I'd like to see a sensitivity study which shows us how sensitive PNM's results are to this variance. Lacking specific input from NREL I'll suggest a few points between 30% less than Siemens' number and 30% over their number

Plant lifetimes were not given in PNM's input tables. I would like to see a run with maximum lifetimes for these three resource types. For PSH and compressed I believe 100 years is reasonable. For Geothermal I don't really know but could we run with 50 and 75 years? The main idea is to see what happens if you

don't use the standard 30-year lifetime for these types of resources.

My new concern is that PNM is using a 10-hour PSH resource. I doubt this scales up linearly (which is how the capacity expansion model would scale it). Due to economy of scale, the cost per MWh decreases as capacity of the facility increases. A proxy for understanding this would be the lower end of the cost sensitivity study requested in my first paragraph, i.e. one of the reasons for high cost variance is economy of scale.

From K. Gould (5/26/2023)

Hi all:

NM AREA is interested in the follow modeling runs:

1. A model run that models correlated outages of natural gas fired plants

2. A model run that extends Valencia PPA until 2040 and no new natural gas (looking for the costs and reliability of this scenario)

3. A model run that extends both Valencia and Reeves until 2040 an no new natural gas (looking for the costs and reliability of this scenario)

4. A model run that models PNM participation in an RTO in the next 5 to 10 years

I know these are very broad requests, but if the rest of the group is interested in the outcomes of these runs NM AREA is happy to work with the group and PNM to come up with some parameters for these runs. Thank you.

I would also like to see the base case modeled with 4 Corners. It is odd the PNM did not model 4 Corners when the NMPRC denied the abandonment. This seems like a hole in the IRP. NM AREA does not have an opinion as to whether that decision was appropriate but it was the decision of the NMPRC and it should be modeled as a system resource until the PRC approves abandonment.

From C. Ho (5/26/2023)

I would like to see the following modeling scenario:

- Base-case technologies with inclusion of extreme climate impacts by 2040 (i.e., lower irradiance and lower wind resources).
    - Potential climate impacts on solar and wind resources can reference SAND2022-0583
        - This run should also consider uncertainties in battery performance (RTE and capacity fade)