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CC: EC4 STAB Members

Re: STAB Consultant Team Technical Questions 1.0, 2025.07.28

1 Introduction

The STAB Consultant Team has been asked to provide an initial technical review of several documents related to the development of Rhode Island's Climate Action Strategy. This memo captures questions related to:

- Inputs and Assumptions Workbook for the **PATHWAYS model**
- Modeling **scenario definition** slide

The following two sections of this memo provide specific questions the Consultant Team has formulated regarding each of these materials. We have also included a final section requesting information related to additional models and methodologies from E3 outside of these areas.

While we have sought to develop a thorough list of questions at this time, we note that this represents an *initial* list of questions related to a large and complex modeling effort, and we expect there will be additional rounds of questions that may relate to these topics in the future, either as we begin to receive answers to this initial round, or during the process of reviewing additional study models, materials, measures and modeling results.

This information is needed by the STAB to perform a thorough scientific and technical review of Rhode Island's Climate Strategy.

2 PATHWAYS Model

Overarching

- Has E3 demonstrated correlation between the PATHWAYS model's three key drivers and each of the stock rollover subsectors? How is the selection and use of these drivers justified for each subsector?
- We agree with other stakeholder feedback which flags the need to update population and housing growth rates from the current 2013 forecasts.
- For each input in the PATHWAYS model, please identify where inputs currently used are: general (i.e., baseline assumptions in the Pathways model), carried forward from a recent study in another jurisdiction; carried forward from E3's work on the Future of

Gas Docket in Rhode Island; or updated directly for this project to reflect up-to-date Rhode Island-specific context, policies and data.

- Please identify all inputs and assumptions that are significantly driven by professional judgement from E3 staff. This could be areas where there is limited data available, where specific values were selected from secondary sources with recognition of significant uncertainty, or other areas. For example, in the Future of Gas Docket, several key modeling assumptions were based on professional judgement, including but not limited to:
    - The annual rate of energy efficiency savings available in the industrial sector (1%) and the shares of different industrial loads that could be electrified (100%, 50%, or 0%)
    - The share of gas pipeline investments that could be avoided through electrification (50%)
    - The future costs of renewable fuels such as RNG, SNG, and renewable biodiesel (high uncertainty)
    - The decision to model only stock rollover for energy efficiency, rather than consider early retirement or mandatory changes such as regulatory action
- Demand and market adoption are "user-defined" in the model. Please provide a detailed description of how E3 will strike a balance between realistic and ambitious values and trajectories for these inputs.
- Please provide a list of existing Rhode Island measures and policies that E3 has incorporated into the model inputs and assumptions to date, with a general explanation and specific details of how and where each has been integrated.
- Please elaborate on the process for projecting measure/policy impacts for energy- and emissions-only sub-sectors, since these have fewer underlying inputs to "tweak" and appear less well-defined.
- How are interactions between equipment in the Pathways Model and demand response (DR) potential in the expansion model accounted for?
- In what specific ways does the model currently integrate considerations and modeling parameters, inputs, timelines and costs specific to low-income and environmental justice communities?
- Many devices are assumed to have no change in capital costs or annual maintenance costs for the entirety of the modeling period. Is this realistic? Is this based on third-party forecasts or other external data sources?
- Roughly two-thirds of devices are assumed to have no change between the average efficiency of base year stock and the average efficiency of new sales in 2052 (i.e., efficiency is constant from 2022 to 2052). Is this realistic? Is this based on third-party forecasts or other external data sources?
- Does E3 plan to include a high-level sensitivity analysis of key inputs once draft results are presented? Which inputs does E3 anticipate being most "sensitive", considering how the model is designed?

Buildings

- Building average shell costs and energy demand reductions appear to be specific to single-family homes only, since they are based on the EnergyWise Single Family Program.
    - Does the model account for differences in costs and demand for multi-family homes compared to single-family homes?
    - Do these costs and demand projections account for differences in the age of the home/year it was built and general efficiency/construction trends?
    - It appears that the counter-factual for this data was an assumption of natural gas heating across all homes, which would not be representative of current homes. Please advise.
- It appears that only a "basic retrofit" is being considered for building shells for both residential and commercial buildings. Was a deeper retrofit package considered, or does the model account for deeper retrofits in another way? What is included in the definition of a "basic retrofit"?
- The Space Heating Service Demand Change and Air Conditioning Service Demand Change are identical for residential retrofits and commercial retrofits. It appears that the RI EnergyWise SingleFamily program is the source for both. Is this appropriate? Please elaborate. We would recommend that modeling account for differences in building sector (i.e., residential vs. commercial, and even small-scale commercial vs. large-scale commercial), building size (for residential – instead of consistent demand or $/building) and age.
- Are all building shell inputs (demand, incremental costs) held constant for the entire study period (i.e., 2022 to 2052)? This does not seem realistic.
- Is there any supporting data/study that supports the assumption that 100% of air source heat pumps will have supplemental heat? Are cold-climate heat pumps being considered, and do these impact/factor into the anticipated penetration of heat pump supplemental heating?
- Please go into further detail about how the "early retirement function" was used to account for early retirements of existing furnaces and boilers in favor of heat pumps.
- We note that E3 uses the forecast of heating degree days and cooling degree days for New England from the EIA AEO to scale annual heating and cooling demands up or down. Which EIA AEO dataset? Was this compared to climate projections in other sources, and does this align with climate projections used in the parallel climate risk and vulnerability assessment and resilience planning?

- Does the model account for differences in the global warming potential (GWP) and resulting emissions of refrigerants used in various technologies (e.g., standard vs. low-GWP heat pumps, commercial refrigeration, etc.) over time?
- How is the interdependency of envelope improvements, heating fuel, and gas/electrical infrastructure costs handled?

Transportation

- Please provide a detailed explanation of how mode-switching (away from personal vehicles to transit and active transportation) has been modeled and integrated in the model.
- What inputs (e.g., policies, programs, actions) has E3 considered to model reductions in overall vehicle miles traveled?
- How were market share inputs for EVs (various technologies) vs. ICE vehicles (various fuels) derived?
- What assumptions, costs, and deployment trajectories have been modeled regarding charging infrastructure needs to ensure adequate charging to support modeled EV adoption levels? How have demand and grid impacts been modeled? Does modeling account for demand and cost impacts from technologies such as EV energy management systems?

Industry

- Please provide detailed data and documentation regarding the industrial sector assumptions, inputs, and modeling methodology. For example, please explain or provide supporting data for the decision to model flat growth for all industrial energy only subsectors based on "recent historical trends in the state"
- Does modeling include a breakdown by process temperature? Electrification opportunities are significantly different for different temperatures (e.g., available technologies, costs, efficiencies…).

Table 2: Stock rollover default data sources

- Pathways currently uses the EIA 2020 RECS survey/study. The 2024 Residential Energy Consumption Survey household data collection concluded on April 9, 2025 and EIA plans to release initial household characteristics results in early 2026. While the current timeline likely means using the 2020 survey for now, can E3 set up the model in such a way as to streamline and facilitate RECS input updates, in acknowledgment of the fact that the RECS study has a significant impact on the model?
- Residential cooking: The Sweeney et al. study is from 2014 (10+ years). What value(s) are being used from this study?
- NREL ResStock and ComStock: Which datasets specifically are being used?

- Heat pump cost data: Please provide more detail regarding the data used from the Clean Heat Rhode Island program (e.g., what year, how large a dataset, what kinds of HPs).
- EIA CBECS: A new study on changes in office energy following the pandemic was released: https://www.eia.gov/consumption/commercial/reports/2024/covid/. Has this been reviewed and relevant findings integrated into the model?
- EIA AEO: The EIA released the 2025 Annual Energy Outlook in 2025. Future year ICE values referencing the 2023 study should be updated to reference this study.
- The Edmunds source for near-term vehicle prices appears informal.

Table 4: Energy only default data sources

- Several sources are outdated and should be updated to ensure alignment with current costs. For example:
    - Schiller et al. 2020: based on 2012 – 2017 data, so underlying data is ~10 years old.
    - NETL 2024: This source for carbon capture cost is 10+ years old and should be updated given the pace of technology and market evolution.

Table 5: Emissions only subsectors in Pathways

- Urea fertilization: It appear that only CO2 is being considered, but application of urea also releases N2O – especially during use on agricultural soils. Will this be included as well?

3 Scenario Definitions

Overarching & Scenario Definition Decision-Making

- Why are there only three scenarios in scope for this study? The Future of Gas Dhad a reference scenario alongside six additional decarbonization scenarios.
    - Please explain the rationale for significantly deviating from the number, and nature, of those scenarios.
    - Particularly, why is there only a single 'Act on Climate' scenario?
    - Given the extensive effort put into the Future of Gas Docket, why has E3 not recommended targeted, low-cost updates to key scenarios from that analysis?
- Please explain the rationale for isolating ACCII/ACT in the comparison of the first and second scenarios.
    - Didn't the analysis for the Future of Gas Docket provide this information? i.e., the baseline scenario for that study did not include ACCII/ACT, and all other scenarios did include it.

        - There was even a sensitivity conducted around (non)compliance with this policy in that study. Consequently, the question naturally arises: is this really the most high-impact aspect of RI's decarbonization pathway to isolate using the limited scenario design space?
        - Have there been significant changes to the likely impacts of this policy if implemented since the Future of Gas docket that required new analysis of the impact of this policy? This question is not asking about likelihood of implementation – we are wondering specifically about changes to the anticipated impacts if the policy is in place.
- Has E3 modeled scenario sets with similar characteristics for other recent studies? If so, please comment on the relative importance of the different sectors and key modeling inputs in each scenario, using quantitative results from those other studies where possible.

Industrial sector

- Please provide detailed data and documentation regarding the industrial sector assumptions, inputs, and modeling methodology.
- What is 'modest' and 'optimistic' electrification? Are there specific underlying data sources, technological assumptions, or models supporting specific values for this sector in each scenario?
- Is the only assumption that will vary across scenarios for the industrial sector related to electrification? Are there efficiency or other assumptions that are also changing across scenarios?
- Has E3 engaged in a sector-specific review of RI's industrial base, and the decarbonization opportunities present there? If so, please provide associated data and documentation.

Electric sector

- Please describe in more detail the assumptions underlying the statement 'electricity sales reach zero emissions by 2033'. How does this compliance come about?
    - Have any scenarios been considered that do not rely in large part (or entirely) on presumed procurement of RECs from ISO-NE to meet this statutory obligation, as was assumed in the Future of Gas Docket?
        - If not, this may be a missed opportunity to broaden the analytical space covered by this study compared to the Future of Gas study
    - How are PLEXOS modeling efforts informing this compliance pathway? What are the expected costs? Are all PLEXOS inputs drawn from the same sources, vintage, and region as PATHWAYS inputs for the same sector(s)? What PATHWAYS inputs will be impacted by the outcomes of the PLEXOS modeling effort? Please clearly identify these, as it would be helpful to know which current input values are expected to change.
    - Has E3 considered that, as long as REC procurement is the compliance pathway for the electric sector, incremental DG and EE within RI will, in fact, produce tangible reductions in emissions? How has this been modeled (i.e., does the model accurately recognize the actual emissions intensity of electricity on the grid

in RI, and appropriately value incremental DG and EE accordingly, separately from the RECs compliance pathway? If so, please clearly describe this methodology, and provide data sources and values for the modeled incremental value of these electric system resources, both in terms of GHG emissions and avoided costs)

- How does the model account for declining supply, and/or rising cost, of RECs, if other states in the northeast also pursue ambitious state-level decarbonization goals? In the longer term, how does E3's model respond to REC supply dropping to (close to) zero as we approach 2050, if other states elect to retire RECs produced in-state to meet their own statutory decarbonization goals? Has E3 considered the compliance/cost risk for Rhode Island if other states raise their alternative compliance payment values?

Gas Sector

- Please comment on E3's plan for addressing the gas sector, which is not referenced in detail in any of the scenarios other than the Act on Climate scenario.
  - Please describe in detail how this modeling effort will leverage, update, or deviate from the analysis of the gas sector E3 conducted in the Future of Gas docket in Rhode Island.
  - Please provide clarity on the rationale, data sources, assumptions, and trajectory that will be modeled for 'optimistic renewable fuel blending' in the Act on Climate Scenario.
  - Please define what will be assumed / modeled for the gas sector and renewable fuels in the first two scenarios. Please explain the rationale for the planned approach as well.

Carbon Sinks

- This value is not changing across the scenarios, correct?
- Is the 'held constant' assertion related to the annual net sink from forests, or the total carbon stock of the forests?
- Does the model consider the potential impacts of climate change and land use change in RI on the size of carbon sinks?

Transportation

- Please provide detailed data and documentation regarding the transportation sector assumptions, inputs, and modeling methodology (PATHWAYS and beyond).
- What assumptions will be made regarding MHDV sales penetration in each scenario?
- How is E3 considering other transportation-related studies and plans, such as:
  - RIDEM Transportation Emissions Reduction Strategy
  - RIDOT modeling funded by EC4 that is currently underway
  - Moving Forward RI 2050
  - Any assessments of opportunities from land use change and mode shift
  - Other studies, policies, and programs from RIDEM

- What policies, actions, and other enabling strategies have been considered for modeling transportation decarbonization opportunities beyond ACCII and ACT? Please explain the rationale for omitting these.
- What policies or actions have been considered to reduce vehicle miles traveled, rather than just converting from ICE to electric vehicles?

Sensitivities & Key Uncertainties

- Are any sensitivity analyses expected? If so, please describe this element of the modeling approach, specifying which inputs will be varied and which scenarios would be included in the sensitivity.
  - Has a scenario that does not rely on renewable fuel blending been considered? Isn't significant reliance on renewable fuels' availability and cost-competitiveness a significant risk for overall act on climate compliance?
  - Have any scenarios been considered that accurately reflect upstream (including out of state) emissions from low-carbon/renewable fuels?
  - How have fugitive emissions, such as gas leakage, been considered? Has a sensitivity been contemplated regarding the amount of gas leakage present in RI? Have upstream gas system leakage rates been taken into account?
  - Please detail assumptions, data sources, and rationale around low-carbon fuel technical feasibility, marginal costs, and production capacity. Please separately address renewable diesel, jet fuel, natural gas, and hydrogen. Please speak to the magnitude of uncertainty around these low-carbon fuels costs, availability, and GHG impacts compared to other key uncertainties in the model.

4 Other Models, Methodologies, and Data

- E3's RESOLVE Model, including:
  - Detailed methodology documentation (similar to what was provided for Pathways)
  - Spreadsheet of inputs and assumptions, both general and Rhode Island-specific
  - Emissions/emission factors from electricity generation
- E3's Fuel Optimization Model
  - Detailed methodology documentation (similar to what was provided for Pathways)
  - Spreadsheet of inputs and assumptions, both general and Rhode Island-specific
- E3's Biofuels Model
  - Detailed methodology documentation (similar to what was provided for Pathways)
  - Spreadsheet of inputs and assumptions, both general and Rhode Island-specific
- Please provide a detailed description of the coherence between model modules and how they interact (e.g., how and where outputs from one are used in another; how limitations or uncertainties in one may impact results in another specifically; etc.).
- Results and outputs from each of the following models:

- Pathways Model
- RESOLVE Model
- Fuels Optimization Model
- Biofuels Model