Proposed Approach Towards Defining Scenarios
for the Rhode Island Greenhouse Gas (GHG) Emissions Reduction Study

Memorandum from Study Consulting Team
June 28, 2016

Purpose

This memorandum proposes an approach for developing greenhouse gas (GHG) mitigation scenarios for the Rhode Island GHG Emissions Reduction Study. The mitigation scenarios will be composed of differing combinations and levels of GHG reduction technologies and practices. All scenarios will be principally designed to achieve Rhode Island's long-term goal of 80% GHG emissions reduction below 1990 levels by 2050. A phased approach to scenario development is proposed. A Phase I modeling effort will examine the impact of major mitigation options on an individual basis. The Phase I results will facilitate the construction of three to five scenarios for modeling in Phase II, which will represent different pathways to the state's 2050 climate mitigation target. The goals, process, and outputs of the anticipated scenario analysis are discussed herein.

Background

The vast majority of Rhode Island's GHG emissions (over 90% in 2010) are from the production and use of energy. As long-term mitigation studies for multiple states, cities, and countries have shown, shifting a carbon-intensive energy system like Rhode Island's to a low-carbon footing requires several fundamental transformations.[1] Categorized at a high level, these include:

- **Energy efficiency:** Significant improvements in energy efficiency (using less energy to provide the same outputs or services) are critical in the buildings, transportation, and industrial sectors. They can include changes in practices by consumers and businesses, such as reducing travel by single-passenger vehicles, as well as technological improvements that increase efficiency (e.g., energy-efficient appliances, "smart grid" technologies).

- **Decarbonization of electricity:** The GHG intensity of electric power can be reduced by increasing the role of renewables, no-to-low carbon energy resources (such as large hydropower), nuclear power, and carbon capture and storage. Simultaneously electrifying energy end uses (converting from fossil fuels to electricity by changing equipment and practices) maximizes the mitigation benefit of clean electricity.

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[1] See, for example, the California PATHWAYS Project (https://ethree.com/public_projects/energy_principals_study.php), the Massachusetts Clean Energy and Climate Plan (http://www.mass.gov/eea/waste-mgnt-recycling/air-quality/climate-change-adaptation/mass-clean-energy-and-climate-plan.html), and Chapter 7 (Energy Systems) of the mitigation volume of the Intergovernmental Panel on Climate Change's Fifth Assessment Report (https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter7.pdf).

- **Decarbonization of other fuels:** In addition to electricity, other fuels must be replaced by low-carbon alternatives to the extent feasible (e.g., substituting biogas for conventional natural gas or cellulosic ethanol for gasoline).

As Rhode Island charts a path to its 2050 mitigation target, these transformations will affect all parts of its energy system, including the state's leading GHG source sectors: transportation, electricity consumption, and residential and commercial heating (Table 1).

Table 1: 2010 Rhode Island GHG Emissions Inventory

Sector	Emissions [Million Metric Tonnes CO_2e]	Percent Share
Energy Supply	3.54	28.42%
Electric Power Consumption	*3.39*	*27.19%*
Natural Gas Distribution	*0.15*	*1.24%*
Residential Heating	2.28	18.31%
Commercial Heating	0.93	7.46%
Transportation	4.33	34.70%
Aviation	*0.27*	*2.17%*
Highway Vehicles	*3.70*	*29.66%*
Non-road Sources	*0.33*	*2.68%*
Lubricants	*0.02*	*0.19%*
Industrial	1.07	8.55%
Industrial Heating	*0.64*	*5.10%*
Industrial Processes	*0.43*	*3.45%*
Agriculture	0.02	0.17%
Waste	0.30	2.39%
Solid Waste	*0.22*	*1.78%*
Wastewater	*0.08*	*0.62%*
TOTAL	**12.47**	**100.00%**

Substantial abatement in each of these sectors will be needed to achieve the long-term goal.

Proposed Scenario Development Process

Recognizing the scale of the transformations necessary to lower GHG emissions by 80%, we propose focusing the Study's scenario analysis on *major* mitigation options. These are options with significant technical potential to reduce emissions in the most important source sectors in Rhode Island. As outlined below, we suggest a two-phase process to identify and analyze major options and to use them to develop the study's three to five overall 80% pathway scenarios.

- Phase I
    - Finalize list of major mitigation options
    - Define and model a high-investment/penetration scenario for each major option

- Phase II
    - Analyze potential combinations of major mitigation options and evaluate trade-offs, constraints, and dependencies
    - Devise overall pathway scenarios that combine major options to reach the 2050 goal

Phase I

The purpose of Phase I is to develop building blocks for the pathway scenarios by analyzing major mitigation options for Rhode Island in depth. A high-investment or penetration scenario will be created for each option and compared to the study's baseline to illuminate impacts when the option is implemented on an individual basis at an aggressive level. The first step in the phase is to confirm the list of major options that will be evaluated. We recommend 10 major mitigation options that focus on the principal GHG source sectors in Rhode Island, rely on commercially available (or nearly commercially available) technologies, and could substantially reduce GHG emissions if widely deployed:

1. Electric and natural gas energy efficiency (extending all cost-effective efficiency program beyond 2024)
2. Reduction of on-road vehicle miles traveled
3. Utility-scale renewable electricity[2]
4. Distributed renewable electricity
5. Additional imports of low-carbon electricity
6. Nuclear electricity (license renewal for existing plants)
7. Electric heat in buildings
8. Biofuels/biomass heat in buildings
9. Electric vehicles
10. Advanced biofuels for transportation

The final list of major options will be determined in consultation with the State Team, Technical Committee, and stakeholders.

Analytical work in Phase I will center on modeling high-penetration scenarios for the major mitigation options. Fundamentally, these will seek to quantify the maximum

[2] The analysis of the scenarios for utility-scale and distributed renewable electricity would also include an assessment of the role that grid-connected energy storage could play in facilitating renewables penetration.

implementation potential that can reasonably be imagined for each option. This potential will likely be less than the theoretically possible technical potential but greater than what is currently considered cost-effective. We will consult both stakeholders and the literature (e.g., the California PATHWAYS study) to develop implementation assumptions and will localize them for Rhode Island by considering state-specific stocks and turnover rates of capital equipment. In some cases, high penetration of low-carbon technologies may be enabled by accelerated retirement of capital equipment, which could be incentivized by state policy.

Although the Phase I scenarios will represent maximal penetration of the major options, we will program them in the project's Long-range Energy Alternatives Planning (LEAP) model so the penetration rate can be varied between this upper bound and the background rate in the baseline scenario. This design will facilitate combining major options at different levels when devising 80% pathway scenarios in Phase II. Once the high-penetration scenarios are implemented in LEAP, the tool can be used to produce a range of outputs for each, including projections of emissions, costs and benefits, and energy use and production in total and compared to the baseline.

Information from Phase I will help inform decisions in Phase II on bundling the major mitigation options at varying penetration levels within an 80% reduction scenario. The results of Phase I will support a better understanding of the ultimate drivers behind Phase II scenario results, including the specific mitigation options that might be contributing to economic and environmental outcomes as well as tradeoffs and interdependencies between various options.

The Phase I modeling will proceed along the following anticipated timeline:

- During the June 29th meeting, Technical Committee members and stakeholders will be presented with the phased approach to scenario design described in this memo.
- Phase I modeling will occur in July and August by SEI and the NESCAUM team.
- During July, before the initiation of the modeling, assumptions on high-investment/penetration levels for the major mitigation options will be circulated to the Technical Committee and stakeholders for review and input via email.

Phase II

Phase II will focus on developing three to five 80% pathway scenarios using the resources and information produced in Phase I. The consulting team will support the State Team and Technical Committee in exploring trade-offs between the major mitigation options and combining the options in ways that attain the 2050 goal. The exploration will be seeded with some illustrative combinations of the major options—e.g., electric vehicles and heat with nuclear electricity vs. with renewable electricity. The objective will be to devise a set of scenarios that shed light on important alternatives for Rhode Island decision makers as well as potential commonalities among 80% reduction pathways.

If time permits and the necessary assumptions and data are readily available, the Phase II modeling may also comprise quantification of some non-major mitigation options. These options could then be added to the pathway scenarios. We will determine which non-major options to model, if any, in collaboration with the State Team and Technical Committee.

Phase II will likewise include an examination of the sensitivity of mitigation pathways to key modeling inputs. We propose considering the following inputs in the sensitivity analysis (but would like stakeholder feedback on this list):

- Fuel prices
- Technology costs
- Discount rate
- Biofuel emission factors
- Population growth
- Economic (GDP) growth

As with the Phase I scenarios, the overall pathway scenarios will be implemented in the study LEAP model. LEAP can then be used to generate a variety of outputs such as emission, cost-benefit, and energy supply and demand projections.[3]

The Phase II modeling will proceed along the following anticipated timeline:

- The Technical Committee and stakeholders will be presented with Phase I results and straw Phase II scenarios for consideration in late-September/early-October.
- Phase II modeling will occur during October.
- Outputs from the Phase II modeling will be presented to the Technical Committee and stakeholders for review and comment in November. Additional/revised pathway scenarios will be developed as needed based on the Committee's feedback.
- Findings will be included in the project report and discussed with the State Team, Technical Committee and stakeholders.

[3] We welcome stakeholder requests for specific outputs and will make every effort to accommodate them.