National Grid's Technical Reference Manual

for the

Benefit-Cost Analysis

of

Non-Pipeline Alternatives

in

Rhode Island

For use by and prepared by

The Narragansett Electric Company d/b/a National Grid

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NATIONAL GRID's RHODE ISLAND NON-PIPES ALTERNATIVES BENEFIT-COST ANALYSIS TECHNICAL REFERENCE MANUAL

1. Introduction

National Grid's[1] Rhode Island Non-Pipeline Alternatives Benefit-Cost Analysis Technical Reference Manual (RI NPA BCA TRM) details how the Company assesses cost-effectiveness of Non-Pipeline Alternative (NPA) opportunities planned in Rhode Island through the Rhode Island Non-Pipeline Alternative Benefit-Cost Analysis Model (RI NPA BCA Model). This cost-effective assessment is in alignment with the Rhode Island Benefit Cost Test (RI Test) as detailed in the Docket 4600 Benefit-Cost Framework[2] and in accordance with Sections 1.3(B) and 1.3(C) of the Least-Cost Procurement Standards (LCP Standards) as detailed in Docket 5015[3], with both dockets respectively approved by the Rhode Island Public Utilities Commission (PUC)[4]. Although the LCP Standards were originally developed for the Company's Energy Efficiency (EE) program, the same principles have been applied to other benefit-cost analyses (BCA) conducted by the Company at the request of the PUC, including the RI NPA BCA Model.

The following RI NPA BCA Model approach was based on the LCP Standards:

I. Assess the cost-effectiveness of the NPA portfolio per a benefit-cost test that builds on the Total Resource Cost Test (TRC Test) approved by the Public Utilities Commission (PUC) in Docket 4443[5], but that more fully reflects the policy objectives of the State with regard to energy, its costs, benefits, and environmental and societal impacts. Based on the Company's EE Program Plans, in consultation with the EERMC, it was determined that these benefits should include resource impacts, non-energy impacts, distribution system impacts, economic development impacts, and the value of greenhouse gas (GHG) reductions, as described below.

II. Apply the following principles when developing the RI Test:

   a. **Efficiency and Conservation as a Resource.** EE improvements and energy conservation are some of the many resources that can be deployed to meet customers' needs. It should, therefore, be compared with both supply-side and demand-side alternative energy resources in a consistent and comprehensive manner.

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[1] The Narragansett Electric Company d/b/a National Grid (National Grid or Company).

[2] "Docket No. 4600 and Docket No. 4600-A." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, Rhode Island Public Utilities Commission, 2 Nov. 2018, www.ripuc.ri.gov/eventsactions/docket/4600page.html.

[3] "Least Cost Procurement Standards." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, Energy Efficiency and Resource Management Council, 21 Aug. 2020, http://www.ripuc.ri.gov/eventsactions/docket/5015_LCP_Standards_05_28_2020_8.21.2020%20Clean%20Copy%20FINAL.pdf.

[4] "RIPUC." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, State of Rhode Island, www.ripuc.ri.gov/.

[5] "Docket No. 4443." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, Energy Efficiency and Resource Management Council, 17 Sept. 2013, www.ripuc.ri.gov/eventsactions/docket/4443page.html.

b. **Energy Policy Goals.** Rhode Island's cost-effectiveness test should account for its applicable policy goals, as articulated in legislation (e.g., Resilient Rhode Island Act[6]), PUC orders, regulations, guidelines, and other policy directives.
c. **Hard-to-Quantify Impacts.** BCA practices should account for all relevant, important impacts, even those that are difficult to quantify and monetize.
d. **Symmetry.** BCA practices should be symmetrical, for example, by including both costs and benefits for each relevant type of impact.
e. **Forward Looking**. Analysis of the impacts of the investments should be forward-looking, capturing the difference between costs and benefits that would occur over the life of the NPA investment with those that would occur absent the investments (i.e., "Reference Case"). Sunk costs and benefits are not relevant to a cost-effectiveness analysis.
f. **Transparency.** BCA practices should be completely transparent, and should fully document and reveal all relevant inputs, assumptions, methodologies, and results.

III. With respect to the value of greenhouse gas reductions, the RI Test shall include the costs of carbon dioxide (CO_2) mitigation as they are imposed and are projected to be imposed by the Regional Greenhouse Gas Initiative (RGGI)[7]. The RI Test shall also include any other utility system costs associated with reasonably anticipated future greenhouse gas reduction requirements at the state, regional, or federal level for both electric and gas programs. The RI Test may include the value of greenhouse gas reduction not embedded in any of the above (e.g., non-embedded or societal CO_2 costs). The RI Test may also include the costs and benefits of other emissions and their generation or reduction through LCP (e.g., nitrogen oxides (NOx), sulfur dioxide (SO_2)).

IV. Benefits and costs that are projected to occur over the project life of the individual NPA projects shall be stated in present value terms in the RI Test calculation using a discount rate that appropriately reflects the risks and opportunity cost of the investment.

[6] "Resilient Rhode Island Act of 2014 - Climate Change Coordinating Council." *Chapter 42-6.2*, State of Rhode Island and Providence Plantations, 2014, http://webserver.rilin.state.ri.us/Statutes/TITLE42/42-6.2/INDEX.HTM.

[7] "State Statutes & Regulations - Rhode Island." *The Regional Greenhouse Gas Initiative*, RGGI, Inc., www.rggi.org/program-overview-and-design/state-regulations.

2. Overview of the Rhode Island Test

The RI Test compares the present value of a stream of **total benefits** to the **total costs** of the investment, **over the life** of that investment necessary to implement and realize the **net benefits**. The RI Test captures the value produced by the investment installed over the useful life of the investment. The investment life is based on the individual NPA contract timeframe and thus is expected to change on a per project basis.

The benefits calculated in the RI Test are primarily avoided resource (e.g., natural gas energy) supply and distribution costs, valued at marginal cost for the periods when there is a load reduction; and the monetized value of non-resource savings including avoided costs compared to a Reference Case (e.g., avoided utility capital and operations and maintenance (O&M) costs). The costs calculated in the RI Test are those borne by both the utility and by participants plus the increase in supply costs for any period when load is increased. All capital expenditure (CAPEX) (e.g., equipment, installation) and operational expenditure (OPEX) (e.g., evaluation and administration) are included.

All savings included in the value calculations are net savings. The expected net savings are typically an engineering estimate of savings modified to reflect the actual realization of savings based on evaluation studies, when available. The expected net savings also reflect market effects due to the program (*e.g.*, Demand Reduction Induced Price Effects (DRIPE)).

In accordance with Section 1.3.B of the revised Standards, National Grid adheres to the RI Test for all NPA investment proposals. National Grid has developed the RI NPA BCA Model, which is a derivative of the RI Test and utilizes the same Docket 4600 Benefit-Cost Framework, to more accurately assess NPA opportunities benefits and costs. The benefit categories and formulas in the RI NPA BCA Model are detailed in Section 3.

3. Description of Program Benefits and Costs

Table 1 summarizes the benefits and costs included in the RI Test and how they are treated in the Company's NPA BCA. Note that an "X" indicates that the category is quantified while an "O" indicates the category is unquantified, as applicable for RI NPAs. The "Docket 4600 Category" column in the table below references the categories and their respective details listed within Appendix A of Docket 4600.[8]

Table 1. Summary of RI Test Benefits and Costs and Treatment

RI Test Category	Docket 4600 Category	NPA	Notes
Electric Energy Benefits	Energy Supply & Transmission Operating Value of Energy Provided or Saved (Power System Level)	O	(1)
	Retail Supplier Risk Premium (Power System Level)	O	
	Criteria Air Pollutant and Other	O	
	Distribution System Performance (Power System Level)	O	
Renewable Portfolio Standards (RPS) and Clean Energy Policies Compliance Benefits	REC Value (Power System Level)	O	(1)
	GHG Compliance Costs (Power System Level)	O	
	Environmental Externality Costs (Power System Level)	O	
Demand Reduction Induced Price Effects	Energy DRIPE (Power System Level)	X	
Electric Generation Capacity Benefits	Forward Commitment Capacity Value (Power System Level)	O	(1)
Electric Transmission Capacity Benefits	Electric Transmission Capacity Value (Power System Level)	O	(1)
	Electric Transmission Infrastructure Costs for Site-Specific Resources	O	
Electric Distribution Capacity Benefits	Distribution Capacity Costs (Power System Level)	O	(1)
Natural Gas Benefits	Participant non-energy benefits: oil, gas, water, wastewater (Customer Level)	X	
Delivered Fuel Benefits		X	
Water and Sewer Benefits		O	(2)
Value of Improved Reliability	Distribution System and Customer Reliability/Resilience Impacts (Power System Level)	X	
Non-Energy Impacts	Distribution Delivery Costs (Power System Level)	O	(3)
	Distribution system safety loss/gain (Power System Level)	O	
	Customer empowerment and choice (Customer Level)	O	

[8] "Docket No. 4600-A." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, Rhode Island Public Utilities Commission, 3 Aug. 2017, www.ripuc.ri.gov/eventsactions/docket/4600A-PUC-GuidanceDocument-Notice_8-3-17.pdf. Appendix A.

RI Test Category	Docket 4600 Category	NPA	Notes
	Utility low income (Power System Level)	O	
	Non-participant rate and bill impacts (Customer Level)	O	
Non-Embedded GHG Reduction Benefits	GHG Externality Cost (Societal Level)	X	
Non-Embedded NOx Reduction Benefits	Criteria Air Pollutant and Other Environmental Externality Costs (Societal Level)	X	
Non-Embedded SO_2 Reduction Benefits	Public Health (Societal Level)	X	
Economic Development Benefits	Non-energy benefits: Economic Development (Societal Level)	O	(4)
Utility Costs	Utility / Third Party Developer Renewable Energy, Efficiency, or Distributed Energy Resources costs	X	
Participant Costs	Program participant / prosumer benefits / costs (Customer Level)	X	

Notes
An "X" indicates that the category is quantified while an "O" indicates the category is unquantified, as applicable for RI NPAs in the SRP program.
(1) Electric-specific benefits/cost categories are captured in the RI NWA BCA Model and are not applicable to the RI NPA BCA Model.
(2) These non-electric utility benefits are expected to be negligible for a site-specific targeted need (i.e., NWAs).
(3) Currently do not have data to claim benefits for a targeted need case.
(4) Sensitivity analysis is currently under development. This benefit is negligible unless sensitivity analysis determines otherwise.

The following additional Docket 4600 Benefit Categories require further analysis to determine the appropriate methodology and magnitude of quantitative or qualitative impacts:

- Low-income participant benefits (Customer Level)
- Forward commitment avoided ancillary services value (Power System Level)
- Net Risk Benefits to Utility System Operations from Distributed Energy Resource (DER) Flexibility & Diversity (Power System Level)
- Option value of individual resources (Power System Level)
- Investment under uncertainty: real options value (Power System Level)
- Innovation and learning by doing (Power System Level)
- Conservation and community benefits (Societal Level)
- Innovation and knowledge spillover - related to demo projects and other Research, Design, and Development (RD&D) (Societal Level)
- Societal low-income impacts (Societal Level)
- National security and US international influence (Societal Level)

All quantified NPA benefits are directly associated with the development of non-pipes compared to a Reference Case with no NPA options. The source for many of the avoided cost value components is the "Avoided Energy Supply Components in New England: 2021 Report" (AESC 2021 Study) prepared by Synapse Energy Economics for AESC 2021 Study Group in May, 2021.[9] This report was sponsored by the electric and gas EE program administrators of National Grid in New England and is designed to be used for cost-effectiveness screening in 2019 through 2021.

The AESC Study determines projections of marginal energy supply costs that will be avoided due to reductions in the use of electricity, natural gas, and other fuels, as well as avoided environmental compliance costs resulting from EE and other conservation programs. The AESC study is prepared every three years for the AESC Study Group, which is comprised of the Program Administrators as detailed in the AESC Study, as well as utilities throughout New England and other interested non-utility parties.

The AESC Study provides projections of avoided costs of energy in each New England state for a hypothetical future in which a myriad of EE and DER opportunities exist. The NPA BCA utilizes RI specific values where available. In some cases where RI specific values are not available, Southern New England values are used.

The RI NPA BCA methodology is technology agnostic and should be broadly applicable to all anticipated project and portfolio types, with some adjustments as necessary. Specific availability of a technology during the specified system need time may differ. This technology coincidence factor is based upon the association between the distribution system, supply, and peak demand for the specified NPA need. These generalized values are subject to change.

3.1 Electric Energy Benefits

Electric energy benefits due to NPA implementation can be a result of reduced energy usage (e.g., targeted EE or DR), a shift of usage from peak to off-peak (e.g., battery storage), or energy generation (e.g., solar). The resulting avoided electric energy costs are appropriate benefits for inclusion but are calculated and considered by using the RI NWA BCA Model. Electric energy benefits are valued using the avoided electric energy costs developed in the AESC 2021 Study, Appendix B.[10]

Electrification of end-uses is an NPA technology. Electric appliances and heating equipment can be used as an alternative to natural gas to reduce natural gas demand. To represent an increase in electric demand, the electric energy savings value should be negative.

Additional context on this benefit is included within the RI NWA Technical Reference Manual as detailed in Appendix 5 of the 2020 SRP Year-End Report as found in Docket No. 5080.[11]

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[9] "Avoided Energy Supply Components in New England: 2021 Report." *AESC 2021 Materials*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

[10] "AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report, Appendix B*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

[11] Docket No. 5080." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, The Narragansett Electric Company d/b/a National Grid, 20 Nov. 2020, www.ripuc.ri.gov/eventsactions/docket/5080page.html.

3.2 RPS and Clean Energy Policy Compliance Benefits

This benefit category captures the value of avoided embedded CO_2 and SO_2 costs separately from the "Environmental and Public Health Benefits" category and is applicable electric energy benefits only. These RPS and Clean Energy Policy compliance benefits due to NPAs are the results of the reduced energy usage as described in Section 3.1. Additional context on this benefit is included within the RI NWA Technical Reference Manual as detailed in Appendix 5 of the 2020 SRP Year-End Report as found in Docket No. 5080.[12]

3.3 Demand Reduction Induced Price Effects

DRIPE is the reduction in prices in energy and capacity markets resulting from the reduction in need for energy and/or capacity due to reduced demand from electric system investments. These gas system investments can include NPAs. These investments avoid both marginal energy production and capital investments, but also lead to structural changes in the market due to lower demand. Over a period of time, the market adjusts to lower demand, but until that time the reduced demand leads to a reduction in the market price of the energy commodity. When this price effect is a result of NPAs, it is appropriate to include the impact in the RI NPA BCA Model.

DRIPE effects are very small when expressed in terms of an impact on market prices, i.e., reductions of a fraction of a percent. However, the DRIPE impacts are significant when expressed in absolute dollar terms over all the MMBtu transacted across the market. Very small impacts on market prices, when applied to all energy and capacity being purchased in the market, translate into large absolute dollar amounts. Gas Supply and Cross DRIPE values developed for the AESC 2021 Study are used in the RI NPA BCA Model. Gas Supply DRIPE is the value of reduced natural gas demand on gas commodity prices. This has a Zone-on-Zone component differentiated by state and Zone-on-Rest-of-Region DRIPE that accounts for reductions in one zone impact on New England customers. Since RI has its own zone this calculator uses those specific Zone DRIPE benefits. 3.1AESC also provides annual Cross DRIPE values to account for electricity price effects caused by a change in natural gas pricing. Each technology then has a coincidence and rating factor that is applied based on its system need.

Loss factors are applied to the Gas Supply and Cross DRIPE values to account for lost and unaccounted for gas (LAUF) from the point of delivery to the customer's facility.

The dollar value of annual benefits is therefore calculated as:

- GasSupplyDRIPE Benefit ($/yr) = NaturalGasSavings MMBtu/yr * GasSupplyDRIPE $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 + %LAUF) * (1 + %Inflation)^(year-2021)
- CrossDRIPE Benefit ($/yr) = NaturalGasSavings MMBtu/yr * CrossDRIPE $/MMBtu * TechnologyCoincidence * TechnologyDerate* (1 + %LAUF) * (1 + %Inflation)^(year-2021)

Where:

[12] Docket No. 5080." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, The Narragansett Electric Company d/b/a National Grid, 20 Nov. 2020, www.ripuc.ri.gov/eventsactions/docket/5080page.html.

- NaturalGasSavings(MMBtu/yr) = Estimated annual natural gas savings based on Engineering models
- GasSupplyDRIPE ($/MMBtu) = Projected annual values (AESC 2021, Appendix C, "Zone-on-Zone Gas Supply DRIPE")
- CrossDRIPE ($/MMBtu) = Projected annual values (AESC 2021, Appendix C, "Zone-on-Zone G-E cross DRIPE")
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)[13]
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.4 Electric Capacity Benefits

Electric capacity benefits due to NPAs are a result of load reductions or increases in electric demand as result of the NPA implementation (i.e., electrification). The resulting electric capacity benefits are appropriate for inclusion but are calculated and considered by using the RI NWA BCA Model. Electric energy benefits are valued using the avoided electric capacity costs developed in the AESC 2021 Study, Appendix B.[14] Additional context on this benefit is included within the RI NWA Technical Reference Manual as detailed in Appendix 5 of the 2020 SRP Year-End Report as found in Docket No. 5080.[15]

3.5 Natural Gas Benefits

An avoided resource benefit is produced when an NPA reduces natural gas usage. Natural gas energy and capacity benefits are considered and included in the RI NPA BCA Model calculations.

3.5.1 Natural Gas Energy Benefits

Natural gas energy benefits due to NPA implementation can be a result of reduced energy usage (e.g., EE) or the elimination of natural gas usage (e.g., electrification). The resulting avoided natural gas energy costs are appropriate benefits for inclusion in the RI NPA BCA Model. Natural gas energy benefits are valued by end use and developed in the AESC 2021 Study, Appendix C.[11]

Avoided costs may be viewed as a proxy for market costs. However, avoided costs may be different from wholesale market spot costs because avoided costs are based on simulation of market conditions, as opposed to real-time conditions. They may be different from standard offer commodity costs because of time lags and differing opinions on certain key assumptions, such as short-term fuel costs.

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[13] "Gas Distribution, Gas Gathering, Gas Transmission, Hazardous Liquids, Liquefied Natural Gas (LNG), and Underground Natural Gas Storage (UNGS) Annual Report Data." *PHMSA*, https://www.phmsa.dot.gov/data-and-statistics/pipeline/gas-distribution-gas-gathering-gas-transmission-hazardous-liquids.

[14] "AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report, Appendix B*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

[15] Docket No. 5080." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, The Narragansett Electric Company d/b/a National Grid, 20 Nov. 2020, www.ripuc.ri.gov/eventsactions/docket/5080page.html.

In the RI NPA BCA benefits calculation, energy savings are grossed up using a lost and unaccounted for gas (LAUF) factor, because a reduction in energy use at the end user means that amount of energy does not have to generated, plus the extra generation that is needed to cover the losses that occur in the delivery.

AESC's avoided cost of gas at a retail customer's meter has two components: (1) the avoided cost of gas delivered to the local distribution company (LDC) and (2) the avoided cost of delivering gas on the LDC system. The retail costs of natural gas energy in the AESC 2021 Study are provided by end-use categories. Net energy savings are apportioned into these categories in the value calculation. The end-use categories are defined as follows:

- Non-Heating: Year-round end-uses generally constant gas usage throughout the year
- Hot Water: Year-round hot water end-uses generally constant gas usage throughout the year
- Heating: Space heating end-uses in which gas use is high during winter months
- All: Inclusive of heating and non-heating gas usage throughout the year

In cases where an energy use transfer occurs, energy reductions and increases could occur across fuel types (e.g., demand response). Each solution is considered by end-use category and then added together resulting in a net monetized energy reduction value. Furthermore, a derate factor is applied to solutions where customer behavior plays a role in the demand reduction achieved. This factor is used to scale the projected demand reduction to ensure the benefits of the solution are being characterized appropriately.

Natural gas energy savings created through NPAs are valued using the avoided cost of gas to retail customers by end-use from the 2021 AESC, Appendix C.[16] The values are then grossed up to account for distribution losses. Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2021 real dollar values to nominal values. Natural gas energy savings are specific to a measure and the end-use of natural gas they impact.

The dollar value of annual benefits is therefore calculated as:

- Natural Gas Energy Benefit ($/yr) = NaturalGasEnergySavings MMBtu/yr * $RetailCost_{EndUse}$ $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 + %LAUF) * (1 + %Inflation)^(year-2021)

Where:

- NaturalGasEnergySavings (MMBtu/yr) = Estimated annual natural gas energy savings based on Engineering models
- $RetailCost_{EndUse}$ ($/MMBtu) = Retail value to customers by end-use (AESC 2021, Appendix C, "Avoided cost of gas to retail customers for Southern New England (SNE) assuming no avoidable retail margin")
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type

[16] "AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report, Appendix C*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.5.2 Natural Gas Capacity Benefits

At the supply level, natural gas supply capacity benefits due to NPAs are a result of load reductions at winter peak. At the distribution and supply infrastructure site-specific level, natural gas capacity benefits are a result of the deferred system upgrade. This value is an avoided cost based on a time-deferred expected project cost of the system upgrade.

3.5.2.1 Natural Gas Supply Capacity Benefits

When additional natural gas capacity does not have to be procured because of NPAs, an avoided natural gas capacity benefit is created. An LDC builds its natural gas system and procures natural gas supply to maintain system pressures and conditions during peak demand. In New England, the system peak occurs in the winter during the coldest days of the year as natural gas is widely used for space heating today. Supply capacity benefits accrue when winter peak demand is reduced. To convert annual natural gas demand to peak load demand, a factor of 1.25% is used. This value is a company assumption derived from distribution design.

Supply capacity savings created through NPAs are valued using the avoided natural gas costs from the 2021 AESC, Appendix C.[17] The values are then grossed up to account for distribution losses. Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2021 real dollar values to nominal values. Capacity savings are specific to a measure and costing period based on how the program is designed. The highest monetary value and benefit is produced by a measure that can deliver during the peak times, which is in the winter during the coldest days of the year.

Avoided natural gas costs in the AESC 2021 Study are provided in six different costing periods. Net energy savings are apportioned into these periods in the value calculation. The six costing periods throughout the year are defined as follows:

- Highest 10 Days: Gas requirements that only occur on the coldest 10 days of the year
- Highest 30 Days: Gas requirements that only occur on the coldest 30 days of the year
- Highest 90 Days: Gas requirements that occur only during the coldest 90 days of the year
- Winter: November through March
- Winter/Shoulder: All months except June through August
- Baseload: Load that is constant throughout the year, all months

NPA system needs have a targeted demand reduction during a specific costing period. Each system need will therefore have a specific cost period to focus a solution to deliver demand reduction during specific times of the year. Natural gas supply capacity savings for NPAs are allocated to specific times of the year

[17] "AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report, Appendix C*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

and multiplied by the appropriate avoided capacity value. Generally, the system need is occurring during the winter season when natural gas demand is the highest.

The dollar value of annual benefits is therefore calculated as:

- Natural Gas Supply Capacity Benefit ($/yr) = CumulativeAnnualPeakSavings MMBtu * $\text{CapacityValue}_{\text{CostPeriod}}$ $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 +%LAUF) * (1 + %Inflation)^(year-2021)

Where:

- CumulativeAnnualPeakSavings (MMBtu) = Estimated peak natural gas capacity savings based on Engineering models
- $\text{CapacityValue}_{\text{CostPeriod}}$ ($/MMBtu) = Projected annual value associated with a specific costing period (AESC 2021, Appendix C, "Avoided natural gas costs by costs period – Southern New England")
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.5.2.2 Natural Gas Distribution Capacity Benefits

Distribution Capacity benefit is based on the direct deferred distribution infrastructure due to the implementation of the NPA. This value includes such inputs as deferred capital expenditure, deferred O&M, and deferred taxes over the expected contract timeframe of the NPA.

3.5.2.3 Natural Gas Supply Infrastructure Site-Specific Benefits

Supply Infrastructure Site-Specific benefit is based on the direct deferred supply infrastructure due to the implementation of the NPA. This benefit category applies to supply infrastructure located on the distribution system that would be installed and operated by an LDC. This value includes such inputs as deferred capital expenditure, deferred O&M, and deferred taxes over the expected contract timeframe of the NPA. This value will typically be null for demand-side NPAs.

3.6 Delivered Fuel Benefits

Customers use a variety of fuels and energy sources to meet their energy needs. To consider fuels other than natural gas, the demand for alternative fuels is included in the RI NPA BCA models. Fuel oil delivered fuel is currently included and the RI NPA BCA model can be expanded to include additional fuel types as appropriate.

3.6.1 Fuel Oil Delivered Fuel Benefits

Fuel oil is often used as an alternative fuel to natural gas to reduce natural gas peak demand during peak times. Fuel oil when used in place of natural gas generates a fuel oil delivered fuel value. To represent an increase in fuel oil usage, the fuel oil savings value should be negative.

Fuel oil delivered fuel benefits created through NPAs are valued using the avoided costs of fuels from the 2021 AESC, Appendix D.[18] Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2021 real dollar values to nominal values. Furthermore, a derate factor is applied to solutions where customer behavior plays a role in the demand reduction achieved. This factor is used to scale the projected increase in alternative fuel consumption.

The dollar value of annual benefits is therefore calculated as:

- Fuel Oil Energy Benefit ($/yr) = FuelOilEnergySavings MMBtu/yr * $RetailCost_{DistFuelOil}$ $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 + %Inflation)^(year-2021)

Where:

- FuelOilEnergySavings (MMBtu/yr) = Estimated annual fuel oil energy savings based on the need to offset natural gas use
- $RetailCost_{DistFuelOil}$ ($/MMBtu) = Retail value to customers by sector (AESC 2021, Appendix D, "Avoided cost of petroleum fuels and other fuels by sector")
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.7 Water and Sewer Benefits

An avoided resource benefit is produced when a project, in which customers have invested to save fuel or electricity, also reduces water consumption. Examples of reduced water consumption can include a cooling tower project that reduces makeup water usage or need. Water and sewer benefits are negligible for NPAs, so they are not included in the RI NPA BCA Model calculations.

3.8 Value of Improved Reliability

Due to the site-specific nature of these solutions, a reliability benefit should also be localized. The reliability benefit is currently difficult to quantify due to the new nature of the technologies that NPAs typically utilize. This benefit will be developed and applied as more projects are implemented and technology-specific reliability values are determined.

3.9 Non-Energy Impacts

Non-Energy Impacts (NEIs) can be produced as a direct result of NPA investments and are therefore appropriate for inclusion in the RI NPA BCA Model. Non-energy impacts may include but are not limited to: labor, material, facility use, health and safety, materials handling, national security, property values, and transportation. For income-eligible measures, NEIs also include the impacts of lower energy bills, such as reduced arrearages or avoided utility shut-off costs. The Company plans to conduct future bill

[18] "AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report, Appendix D*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials

impact studies should non-participant rate and bill impacts be included in future. These benefits are currently seen to be negligible for NPAs.

3.10 Environmental and Public Health Impacts

Environmental benefits due to NPAs are a result of reduced energy use from the implemented solution. The resulting avoided environmental costs are appropriate benefits for inclusion in the RI NPA BCA Model. Reduction in the use of natural gas procured provides environmental benefits to Rhode Island and the region, including reduced greenhouse gas emissions and improved air quality. This BCA does account for net environmental impacts. Thus, in cases where the reduction in natural gas would be offset by increases in electricity or alternative fuel sources, a net environmental impact will be derived.

3.10.1 Non-Embedded Greenhouse Gas Reduction Benefits

Carbon dioxide and other GHG emissions come from a variety of sources, including the combustion of fossil fuels like natural gas, coal, gasoline, and diesel. Increase in atmospheric CO_2 concentrations contributes to an increase in global average temperature, which results in market damages, such as changes in net agricultural productivity, energy use, and property damage from increased flood risk, as well as nonmarket damages, such as those to human health and to the services that natural ecosystems provide to society.[19]

According to the AESC 2021 Study, the cost of GHG emissions reductions can be determined based on estimating either carbon damage costs or marginal abatement costs. Damage costs in the AESC are sourced from the December 2020 SCC Guidance published by the State of New York. This guidance recommended a 15 year levelized price of $128 per short ton. Due to the many uncertainties in climate damage cost estimates, the AESC study concluded that the marginal abatement cost method should be used instead. This method asserts that the value of damage avoided, at the margin, must be at least as great as the cost of the most expensive abatement technology used in a comprehensive strategy for emission reduction.[20]

The AESC 2021 Study developed three approaches for calculating the non-embedded cost of carbon based on marginal abatement costs. The first approach is an estimate for the global marginal carbon abatement cost based on carbon capture and sequestration technology, which yields a value of $92 per short ton of CO_2 equivalent and is lower than the prior AESC 2018 Study[21] value used. The second approach is based on a New England specific marginal abatement cost, where it is assumed that the marginal abatement technology is offshore wind. The third approach assumes a New England specific cost derived from multiple sectors, not just electric.

The New England specific marginal abatement costs assume a $125 per short ton of CO2 emissions. This is based on the future cost trajectories of offshore wind facilities along the east coast of the United States.

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[19] National Academies of Sciences, Engineering, and Medicine 2017. Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide. Washington, DC: The National Academies Press. https://doi.org/10.17226/24651.

[20] "Avoided Energy Supply Components in New England: 2021 Report." *AESC 2021 Materials*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/sites/default/files/AESC_2021_.pdf. Pages 171 to 182.

[21] "Avoided Energy Supply Components in New England: 2018 Report." *AESC 2018 Materials*, Synapse Energy Economics, Inc., 2018, https://www.synapse-energy.com/project/aesc-2018-materials

This aligns with New York Department of Environmental Conservation's 2020 valuation of $125 per ton. This value is used in this BCA model.

The AESC 2021 uses an assumed 117 pounds of CO2 per MMBtu for natural gas. This is derived from the U.S. Energy Information Administration's assumption of about 117 lbs/MMBtu across all sectors of natural gas use. The AESC 2021 also includes assumptions of other fuel emissions including fuel oil, gasoline, and electricity. In cases where the solution would have alternate fuel increases in the solution a net greenhouse gas reduction will be utilized.

Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2021 real dollar values to nominal values. Loss factors are applied to the natural gas supply to account for local lost and unaccounted for gas to the end-use customer. Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2018 real dollar values to nominal values.

The dollar value of annual benefits is therefore calculated as:

- GHG Reduction Benefit ($/yr) = NaturalGasEnergySavings MMBtu/yr * GHG Costs $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 + %LAUF) * (1 + %Inflation)^(year-2021)

Where:

- NaturalGasEnergySavings (MMBtu/yr) = Estimated annual natural gas energy savings based on Engineering models
- GHG Cost ($/MMBtu) = Cost of GHG emissions (AESC 2021, Table 159, "Marginal emission rates for non-electric sectors")[22]
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.10.2 Non-Embedded NOx Reduction Benefits

Nitrogen oxide (NOx) emissions come from a variety of sources including heavy duty vehicles, industrial processes, and the combustion of natural gas. NOx contributes to the formation of fine particle matter (PM) and ground-level ozone that are associated with adverse health effects including heart and lung diseases, increased airways resistance, which can aggravate asthma and other underlying health issues, and respiratory tract infections. In addition to known health impacts, PM pollution and ozone are also likely to contribute to negative climate impacts.[23]

[22] "Avoided Energy Supply Components in New England: 2021 Report." *AESC 2021 Materials*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/sites/default/files/AESC_2021_.pdf. Table 159

[23] "Our Nation's Air: Status and Trends through 2019." *Our Nation's Air: Trends Report*, United States Environmental Protection Agency, 2020, https://gispub.epa.gov/air/trendsreport/2020.

The AESC 2021 Study estimates avoided NOx emissions costs utilizing a continental U.S. average, non-embedded NOx emission wholesale cost of $14,700 per ton of NOx (2021 dollars).[24] This translates to a $0.71 per MMBtu in 2021. The RI NPA BCA model utilizes this AESC 2021.

Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2021 real dollar values to nominal values. Loss factors are applied to the natural gas supply to account for local lost and unaccounted for gas to the end-use customer. Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2018 real dollar values to nominal values.

The dollar value of annual benefits is therefore calculated as:

- NOx Reduction Benefit($/yr) = NaturalGasEnergySavings MMBtu/yr * NOxCosts $/MMBtu * TechnologyCoincidence * TechnologyDerate * (1 + %LAUF) * (1 + %Inflation)^(year-2021)

Where:

- NaturalGasEnergySavings (MMBtu/yr) = Estimated annual natural gas energy savings based on Engineering models
- NOxCosts = Projected annual values for NOx emissions (AESC 2021, Table 159, "Marginal emission rates for non-electric sectors")
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

3.10.3 Non-Embedded SO_2 Reduction Benefits

Sulfur dioxide (SO_2) emissions come from a variety of sources including industrial processes and the combustion of coal (especially high-sulfur coal) and fuel oil for electricity generation and heating. SO_2 contributes to the formation of fine PM that are associated with adverse health effects including heart and lunch diseases and increased airways resistance, which can aggravate asthma and other underlying health issues. In addition to known health impacts, PM pollution is also likely to contribute to negative climate impacts.[25]

In February, 2018, the US EPA published a Technical Support Document for estimating the benefit of reducing PM2.5 precursors from 17 sectors.[26] The EPA document estimates national average values for

[24] "Avoided Energy Supply Components in New England: 2021 Report." *AESC 2021 Materials*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/sites/default/files/AESC_2021_.pdf. Page 183

[25] "Our Nation's Air: Status and Trends through 2019." *Our Nation's Air: Trends Report*, United States Environmental Protection Agency, 2020, https://gispub.epa.gov/air/trendsreport/2020.

[26] "Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors (February 2018)." *US EPA Benefits Mapping and Analysis Program (BenMAP)*, United States Environmental Protection Agency, Feb. 2018, www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-17-sectors.

mortality and morbidity per ton of directly-emitted SO_2 reduced for 2016, 2020, 2025, and 2030 based on the results from two other studies.[27,28] Using the average of the results from the two studies, the RI NWA BCA Model estimates the SO_2 emissions cost to be $69,000 per ton of SO_2 in 2020 (2015 dollars) increasing to $79,500 per ton of SO_2 in 2030 (2015 dollars). The EPA released its Natural Gas Combustion report in 2020.[29] This report stated that SO_2 emissions from natural gas typically has extremely low sulfur levels of 2,000 grains per million cubic feet (MCF). However, sulfur-containing odorants are added to natural gas leading to small amounts of SO_2 emissions. This results in a small SOx impact in natural gas of approximately 0.0006 lbs/MMBtu and a $0.02 impact per MMBtu. For cases where the solution includes distillate fuel used as a natural gas replacement the net emissions savings will include emissions from the distillate fuel.

Loss factors are applied to the emissions factor to account for lost and unaccounted for gas from supply to the end-use customer. Nominal annual benefits are then calculated using an average inflation rate to convert AESC's 2018 real dollar values to nominal values.

The dollar value of annual benefits is therefore calculated as:

- SO_2 Reduction Benefit ($/yr) = NaturalGasEnergySavings MMBtu/yr * SO_2EmissionsRate lb/MMBtu * SO_2Value $/ton* TechnologyCoincidence * TechnologyDerate * (1 + %LAUF) * (1 + %Inflation)^(year-2015)

Where:

- NaturalGasEnergySavings (MMBtu/yr) = Estimated annual natural gas savings based on Engineering models
- SO_2EmissionsRate (lb/MMBtu) = 0.00059 lb SO_2/MMBtu (EPA 1.4 Natural Gas Combustion, Table 1.4-2 "Emission Factors for Criteria Pollutants and Greenhouse Gases from Natural Gas Combustion" SO_2Value ($/ton) = $69,000-$79,500/ton (US EPA 2019, Tables 5-10, average of SO_2 from "Electricity Generation Units", 2015 dollars)
- TechnologyCoincidence = Coincidence factor applied based on the solution technology type
- TechnologyDerate = Derating factor applied based on solution technology type
- %LAUF = 2.7% (National Grid RI, Gas Distribution Annual Report for DOT Pipeline and Hazardous Materials Safety Administration, 2021)
- %Inflation = 2% (AESC 2021, Appendix E, Page 327)

[27] Krewski, Daniel, et al. "Extended Follow-up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality." Health Effects Institute, Health Effects Institute, 26 May 2021, https://www.healtheffects.org/publication/extended-follow-and-spatial-analysis-american-cancer-society-study-linking-particulate.

[28] Lepeule, Johanna, et al. "Chronic Exposure to Fine Particles and Mortality: An Extended Follow-up of the Harvard Six Cities Study from 1974 to 2009." National Institute of Environmental Health Sciences, U.S. Department of Health and Human Services, 1 July 2012, https://ehp.niehs.nih.gov/doi/10.1289/ehp.1104660.

[29] "1.4 Natural Gas Combustion Final Section - Supplement D, July 1998." *EPA*, Environmental Protection Agency, https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-fifth-edition-volume-i-chapter-1-external-0.

Note that the AESC 2021 Study does not include estimates for avoided SO_2 emissions costs due to the Study's assertion that most of the available emission data is considered old and the impacts are very small.[30]

3.11 Economic Development Benefits

The Docket 4600 Framework includes consideration of societal economic development benefits and notes that such benefits can be reflected via a qualitative assessment or, alternatively, can be quantified through detailed economic modelling. Therefore, economic development impacts (e.g., economic growth, job creation) can be quantified using the Regional Economic Models, Inc. (REMI) model of the Rhode Island economy, which estimates the increased economic activity resulting from investments. The overall societal impact is measured by net Rhode Island gross domestic product (GDP), which encompasses job years, incomes, state tax revenues and the increased competitiveness of Rhode Island business firms.

National Grid agrees with Docket 4600 that economic development benefits are important. However, including these benefits in the base case BCA results can be problematic due to the relatively high uncertainty associated with these benefits, which can discredit other more precise components of the BCA. Additionally, because the benefits can be large, they create a "masking" effect. For these reasons, the RI NPA BCA Model did not consider economic development benefits in its BCA.

3.12 Contract/Solution Costs

The contract or solution cost is the direct cost for the NPA. This could be a payment schedule to a third party or for paid customer participation (e.g., targeted energy efficiency or demand response). These cost schedules are typically based on an annual, semi-annual, or monthly cadence. Additionally, these cost schedules may involve an annual escalator. In cases with a known, irregular cost schedule these costs can be entered manually in their respective years.

3.13 Administrative Costs

Administrative costs are related to the ongoing support of the NPA. Administrative costs can include evaluation, measurement, and verification (EM&V) costs, ongoing communications and information technology fees, or additional costs related to the post-implementation costs to keep the NPA viable. For each solution an annual expected administrative cost will be applied. In cases with a known, irregular admin cost schedule these costs can be entered manually in their respective years.

3.14 Utility Interconnection Costs

The interconnection cost is the cost for physically and digitally linking the solution to the gas system. Interconnection costs will be determined on a case-by-case basis regarding the specific system need and its respective targeted NPA. This cost will generally be a capital expenditure, initially borne by the utility, prior to the commercially viable date of the NPA solution.

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[30] "Avoided Energy Supply Components in New England: 2021 Report." *AESC 2021 Materials*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/sites/default/files/AESC_2021_.pdf Page 56.

4. Benefit-Cost Calculations

The RI NPA BCA Model is a comparison tool to be utilized to analyze multiple solutions with respective technologies to assess their cost-effectiveness. Currently two technology types are assessed: Energy Efficiency and Demand Response. The RI NPA BCA Model will be expanded as new technologies or solutions evolve. The RI NPA BCA Model is structured to allow for any given solution to utilize any, all, or a combination of these technologies on a per solution basis.

As prescribed by the Standards, the RI NPA BCA Model uses a "discount rate that appropriately reflects the risks of the investment". The Company maintains that the most reasonable rate at which to discount future year costs and benefits is the Company's after-tax Weighted Average Cost of Capital (WACC) (currently 6.97%)[31] since the NPA investments are utility investments, and after-tax WACC is the Company's effective discount rate.

The total benefits will equal the sum of the net present value (NPV) of each annual benefit component:

- [Electric Benefits + DRIPE Benefits + Natural Gas Energy Benefits + Natural Gas Supply Capacity Benefits + Natural Gas Distribution Capacity Benefits + Natural Gas Supply Infrastructure + Natural Gas Supply Infrastructure Site-Specific Benefits + Delivered Fuel Oil Benefits + Water & Sewer Benefits + Value of Improved Reliability + Non-Energy Impacts + Non-Embedded GHG Reduction Benefits + Non-Embedded NOx Reduction Benefits + Non-Embedded SO_2 Reduction Benefits + Economic Development Benefits]

The total costs will equal the sum of the NPV of each annual cost component:

- [Contract/Participant Costs + Program Administrative Costs + Utility Interconnection Costs]

The RI Test benefit-cost ratio (BCR) will then equal:

- Total NPV Benefits ÷ Total NPV Costs

The BCA can then financially compare multiple solutions, regardless of technology type.

The NPA investment will be considered cost-effective if the BCR for the resource is greater than 1.0.

[31] "Docket No. 4770." *State of Rhode Island Public Utilities Commission and Division of Public Utilities and Carriers*, The Narragansett Electric Company d/b/a National Grid, 29 Nov. 2017, www.ripuc.ri.gov/eventsactions/docket/4770page.html.

5. Appendices

Appendix 1	AESC 2021 Materials Source Reference
Appendix 2	Table of Terms

Appendix 1: AESC 2021 Materials Source Reference

Please refer to the following citation for the Appendix B, C and D data tables of the AESC 2021 Study materials.

"AESC 2021 Materials." *Avoided Energy Supply Components in New England: 2021 Report*, Synapse Energy Economics, Inc., 2021, https://www.synapse-energy.com/project/aesc-2021-materials.

Appendix 2: Table of Terms

Term	Definition
AESC	Avoided Energy Supply Components
AESC 2021 Study	Avoided Energy Supply Components in New England: 2021 Report
BCA	Benefit-Cost Analysis
BCR	Benefit-Cost Ratio
Capex	Capital expenditure
CO_2	Carbon dioxide
DER	Distributed Energy Resource
DR	Demand Response
DRIPE	Demand Reduction Induced Price Effect(s)
EE	Energy Efficiency
EE Plan	Energy Efficiency Program Plan
EEP	Energy Efficiency Program
EERMC	Energy Efficiency and Resource Management Council
EM&V	Evaluation, Measurement, and Verification
EPA	Environmental Protection Agency
ESS	Energy Storage System
FERC	Federal Energy Regulatory Commission
GAME	Gas Asset Management and Engineering
GDP	Gross Domestic Product
GHG	Greenhouse gas
ISO	Independent Systems Operator
LAUF	Lost and Unaccounted for Gas
LCP	Least-Cost Procurement
LCP Standards	Least-Cost Procurement Standards
LDC	Local Distribution Company
LMU	Locational Marginal Unit
MMBtu	Million British Thermal Unit
MW	Megawatt
MWh	Megawatt-hour
NERC	North American Energy Reliability Corporation
NOx	Nitrogen oxides (NO, NO_2)
NPV	Net Present Value
NPA	Non-Pipeline Alternative

Term	Definition
NWA	Non-Wires Alternative
O&M	Operations and Maintenance
Opex	Operational expenditure
PM	Particulate Matter
PTF	Pool Transmission Facilities
PTL	Pool Transmission Losses
PUC	Public Utilities Commission
RD&D	Research, Design, and Development
REC	Renewable Energy Credit
REMI	Regional Economic Models, Inc.
RGGI	Regional Greenhouse Gas Initiative
RI	Rhode Island
RI NPA BCA Model	Rhode Island Non-Pipeline Alternative Benefit-Cost Analysis Model
RI NWA BCA Model	Rhode Island Non-Wires Alternative Benefit-Cost Analysis Model
RI NWA BCA TRM	Rhode Island Non-Pipeline Alternative Benefit-Cost Analysis Technical Reference Manual
RI NWA BCA TRM	Rhode Island Non-Wires Alternative Benefit-Cost Analysis Technical Reference Manual
RI Test	Rhode Island Benefit-Cost Test
ROP	Rest of Pool
RPS	Renewable Portfolio Standards
SO_2	Sulfur dioxide
T&D	Transmission and Distribution
TRC Test	Total Resource Cost Test
TRM	Technical Reference Manual
US	United States of America
WACC	Weighted Average Cost of Capital