RHODE ISLAND RENEWABLE THERMAL MARKET DEVELOPMENT STRATEGY

Prepared for Rhode Island Office of Energy Resources

January 2017

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ACKNOWLEDGEMENTS

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The Project Team and the Rhode Island Office of Energy Resources would like to thank the members of the stakeholder working group for their guidance and support throughout this project. See Appendix 3 for the complete list of working group members. The authors would also like to thank staff members from the Office of Energy Resources, National Grid, and Rhode Island Department of Labor and Training for reviewing the report, and William Sloan (Meister Consultants Group) for his editorial support.

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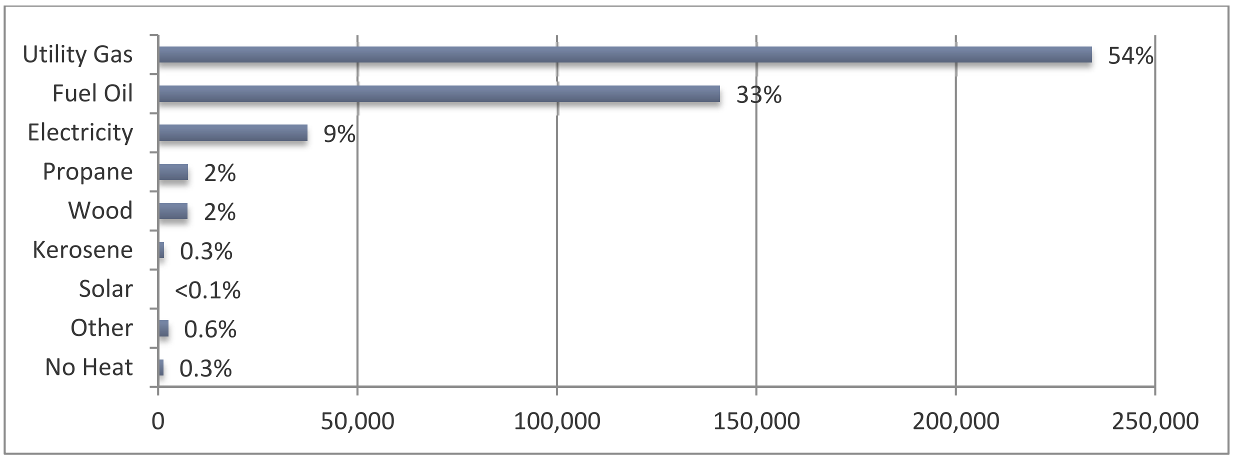
EXECUTIVE SUMMARY

The State of Thermal Energy in Rhode Island

Renewable thermal (RT) represents a key opportunity to achieve climate and energy objectives in Rhode Island. Approximately one third of Rhode Island's total energy use (63 trillion Btus of energy) is used each year in the thermal sector. This includes residential, commercial, and industrial applications for space heating, space cooling, domestic hot water, and process heat.[1]

Currently, almost all of Rhode Island's thermal energy load is served by fossil fuels like heating oil, propane or natural gas. Renewable thermal technologies like cold climate air source heat pumps (ASHPs), ground source heat pumps (GSHPs), solar thermal, biodiesel, or high efficiency biomass heating technologies currently serve only a very small percentage of statewide thermal load.

The majority of Rhode Island's heating load is served by fossil fuels.



Rhode Island's fossil-based thermal energy industry is a major contributor to greenhouse gas (GHG) emissions in the state – accounting for approximately 35% of the state's GHG emissions. In addition, because Rhode Island has no in-state natural gas or petroleum resources, a large portion of the approximately $1.1 billion in annual expenditure on heating fuels flows directly out of the state.

Benefits and Impacts of Scaling Renewable Thermal in Rhode Island

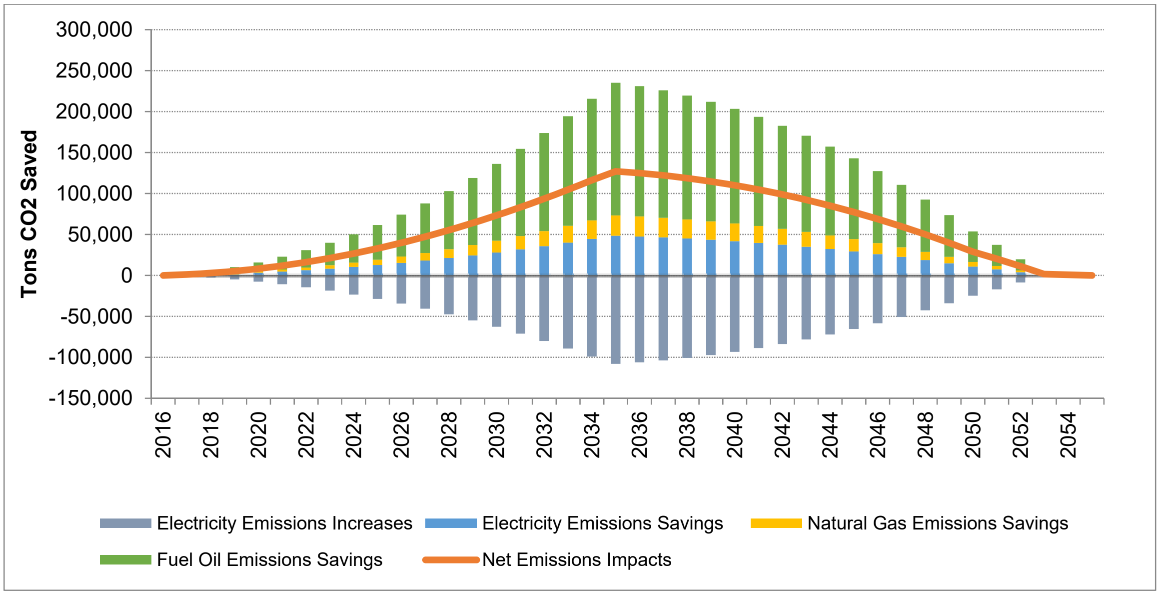
There is a significant opportunity for Rhode Island to diversify the thermal energy economy and scale RT to reduce GHG emissions and generate economic development benefits. In fact, scenario modeling results for this study indicate that if Rhode Island increases RT to 5%, the State can generate over $193 million in

[1] This study largely excludes process heat consumption. Additionally, as discussed in Section 6, the quantification of program impacts focuses primarily on heating rather than cooling energy.

lifetime net benefits. Such a program would have substantial benefits in terms of employment and environmental impact, with minimal impacts to the energy bills of Rhode Island homes and businesses:

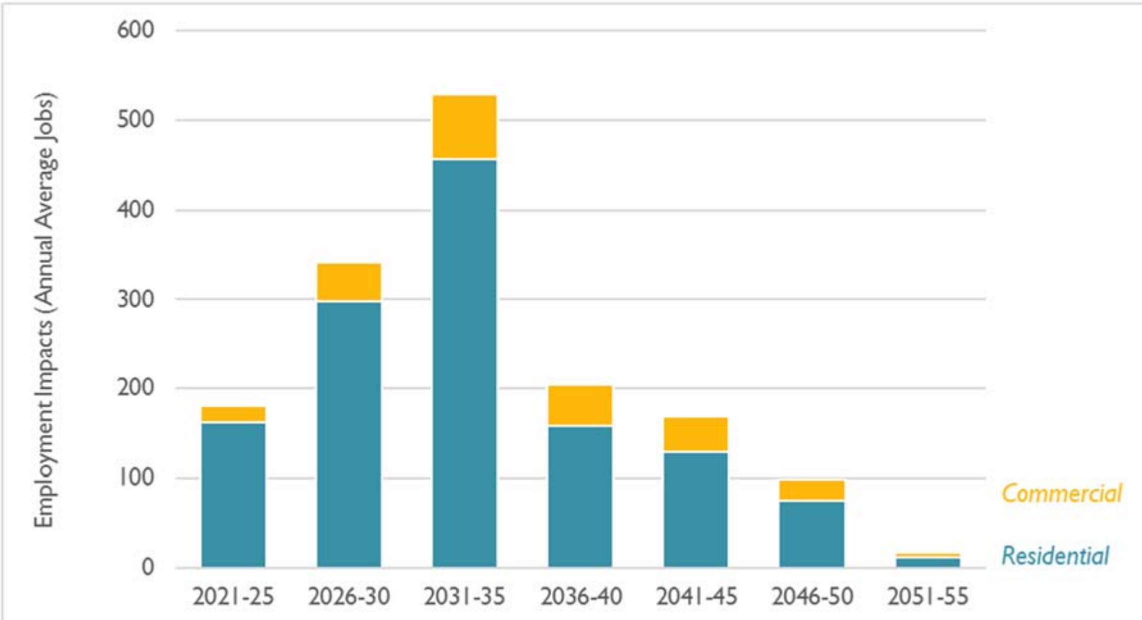
Environmental Benefits. A renewable thermal scale-up would lead to significant emissions benefits in Rhode Island, avoiding 2.2 million tons CO2e over the life of a program that meets 5% of the state's RT load, or an average of more than 60 thousand tons per year over the life of the measures.

Annual Emissions Impacts by Year



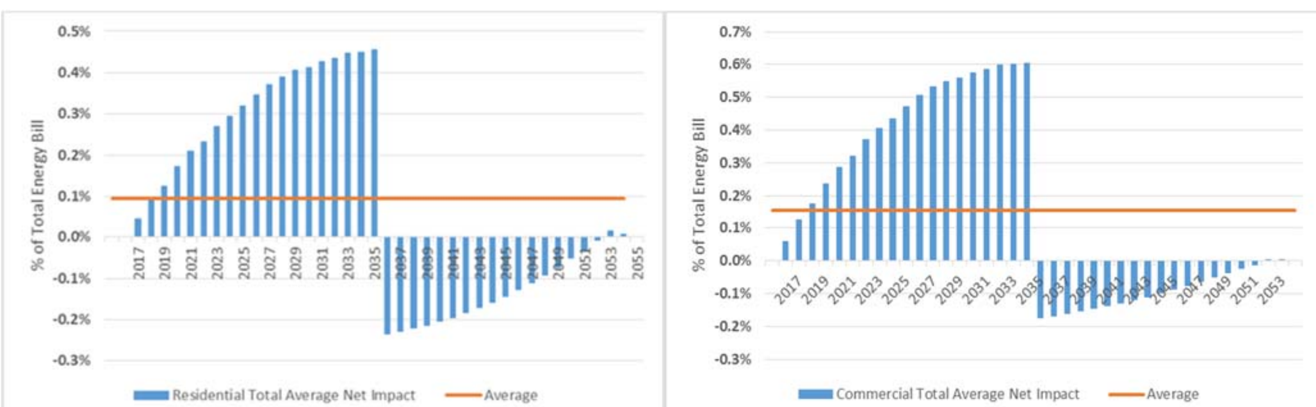
Employment Benefits. Such a program would drive a strong increase in Rhode Island jobs, leading to a net increase of 165 jobs on average from 2017 to 2055. At the program's peak, it would have an impact of more than 500 jobs.

Average annual job impacts by 5-year period (2021-2055)



Ratepayer Impacts. Impacts on non-participating customers – which would be driven primarily by the need to recover program administration and incentive costs – are project to be marginal, as cost increases would be mitigated by the downward pressure on rates from increased electricity sales that result from ASHP and GSHP installation. Overall, the combined ratepayer impact is expected to amount to a 0.1 percent increase in energy costs for residential customers, and a 0.15 percent increase for commercial customers.

Combined Electric and Natural Gas Impacts for Residential (left) and Commercial (right) Customers



Enabling Renewable Thermal Market Growth Through Policy Action

There is a clear need to develop targeted policies and programs to scale up Rhode Island's renewable thermal market. This report assessed U.S. and international best practices for RT market development. In consultation with local experts and advisors, 19 policies and market development strategies were identified for Rhode Island, which can reduce major barriers and drive RT market development.

A number of market barriers inhibit the development of the RT market.

High system costs
RT systems typically have higher upfront costs and face greater financing challenges

Lack of policy support
RT receives less robust policy support than other renewable energy technologies

Low public awareness
Consumers have low awareness of and confidence in RT technologies

Gaps in workforce development
There are gaps in local RT supply chain and a lack of adequately-trained personnel

Unclear regulatory/metering protocols
Standards for certifying RT technologies & installers, and measuring output are unclear

Lack of bioenergy infrastructure
RI has inadequate infrastructure for ramping up biodiesel and biomass

High priority policies and market development strategies include:

- **Establish statewide renewable thermal market development targets.** State efforts to establish targets are important to foster development of RT markets. Notably, establishing statewide targets—and the attendant market development policies—provides clear signals to encourage private investment. In Rhode Island, policymakers should consider establishing statewide renewable thermal market development targets that are both achievable and aligned with the technology deployment necessary to meet the State's interim and long-term GHG reduction targets (i.e. a 45% reduction below 1990 levels by 2035 and 80% by 2050).
- **Establish stable, long-term incentives for renewable thermal technologies.** Because Rhode Island's renewable thermal industry is a small, niche market, it is subject to high costs. Though some market segments are currently cost-competitive with conventional fossil fuels, well-designed incentives will be necessary to improve cost-competitiveness of RT technologies for most market segments. Rhode Island may consider developing a long-term, stable incentive for RT technologies across the residential, commercial and industrial sectors. Notably, while other states in the region have incentives in place for residential RT technologies, incentives for commercial and industrial (C&I) applications are more limited and have been slower to emerge. The C&I sector could present an opportunity for Rhode Island to take leadership in the region.
- **Integrate renewable thermal recommendations into Executive Order 15-17 ("Leading by Example").** Building owners and consumers in Rhode Island are largely unfamiliar with RT technologies and their potential benefits. By demonstrating use of RT technologies in publicly-owned buildings, Rhode Island can raise the profile of the sector, send a clear signal to the market, and gather crucial performance data on commercial-scale renewable thermal technologies that could inform future building code and policy developments for the RT sector. Accordingly, Rhode Island may consider integrating RT into the Governor's Executive Order 15-17 "Leading by Example" program. Currently, E.O. 15-17 mandates numerous energy- and GHG-related goals and actions for State agencies, though RT is not among

them. By requiring a certain percentage of thermal energy used in State facilities from RT technologies by a certain date, Rhode Island can take near-term steps to jumpstart the RT market.

- **Expand access to low-cost financing for renewable thermal technologies.** Most RT technologies have high first costs (relative to fossil fuel technologies). Low-cost financing can be offered to reduce the upfront cost burden of RT and drive higher rates of customer adoption. Several public and private financing models for renewable thermal and other energy projects have been piloted across the U.S. In many cases, publicly-supported equipment loan programs—like the HEAT loan that is currently offered to energy efficiency customers in Rhode Island—offer more favorable terms than those available in the private sector. To increase residential customer adoption of renewable thermal, OER could work with the Energy Efficiency Resource Management Council (EERMC) and National Grid to expand the HEAT Loan to encompass all RT technologies. In addition, OER could work with the Rhode Island Infrastructure Bank (RIIB) to explore the potential for clarifying the position of RT in RIIB's EBF and C-PACE programs and conducting outreach to property owners and government entities on including RT in the implementation of comprehensive building efficiency measures.

- **Implement community outreach, education, and bulk procurement programs.** Customers tend to be relatively unfamiliar with RT technologies. As a result, contractors experience high customer acquisition and other soft costs due to the amount of time needed to educate consumers about the technology and make a sale. The "Solarize" model is a grassroots community education and outreach campaign model that has successfully increased adoption of small-scale solar photovoltaics (PV) by providing system discounts driven by reductions in customer acquisition costs to an aggregated customer base. It offers a promising model that could be adapted to the RT sector to increase consumer confidence in RT and ultimately help reduce customer acquisition costs for installers. Rhode Island could consider developing a community-based bulk procurement program like Solarize RI (which has already reached one third of the state's 39 municipalities and driven 3.4 MW of new installed capacity as of October 2016) to drive outreach and adoption of RT technologies across the state.

This roadmap represents the first step in the creation and implementation of a comprehensive strategy and policy platform to break down market barriers and drive RT investment in Rhode Island. The report lays the foundation for Rhode Island policymakers and industry leaders to develop policies and programs that can scale up the market. It also illustrates the costs and benefits associated with the scale up of Rhode Island's RT market, especially as it relates to the state's goals to reduce GHG emissions, cost-effectively deploy clean energy technologies, and create net economic benefits across the state.

SECTION 1 INTRODUCTION

The thermal energy sector[2] is a significant consumer of energy in Rhode Island, accounting for approximately one third of Rhode Island's total energy use (RI Division of Planning, 2015). Consequently, it is a major source of greenhouse gas (GHG) emissions in the state, generating nearly four million tons of carbon dioxide emissions annually or approximately 35 percent of the state's total emissions (RI Division of Planning, 2015). By diversifying the thermal energy sector to increase use of heating and cooling technologies that can utilize renewable energy sources—including technologies such as cold climate air source heat pumps, ground source heat pumps, high efficiency (and low emission) wood pellet heating, solar thermal, and biofuels—Rhode Island can make significant strides towards achieving its GHG emissions reduction goals.

Diversifying the thermal sector also represents a significant opportunity to create new economic benefits in the state. Notably, Rhode Island has no in-state natural gas or petroleum resources. As a result, a significant portion of the approximately $1.1 billion in annual expenditure on heating fuels flows directly out of the state (RI Division of Planning, 2015). By incorporating a greater share of renewable energy sources in the thermal energy sector, policymakers can give the local economy a boost and create jobs in Rhode Island.

To date, however, virtually all clean energy policies and programs in Rhode Island have focused on the electric sector. There has been little to no activity focused on cultivating the development of a renewable thermal (RT) market. As a result, the RT industry has historically been relatively small and slow growing in Rhode Island, and RT technologies account for a negligible portion of the total thermal energy load in the state.

By implementing targeted policies and programs to grow the RT market, Rhode Island policymakers can realize a variety of consumer, economic, and environmental benefits for its businesses and residents (see Box 1). With these objectives in mind, this report analyzes the market challenges and opportunities facing Rhode Island's RT market today (see SECTION 4). The report describes policy options that could be deployed in the near-term to catalyze development of Rhode Island's RT market (see SECTION 5). The report also discusses the results of a detailed market impact analysis (see Section 6), which includes analyses

[2] Broadly, the thermal sector comprises of energy consumed in residential and commercial buildings primarily for space heating and cooling, water heating, and industrial sector fuel consumption to generate process heat. In the Rhode Island State Energy Plan, only space, water, and process heating applications of thermal energy is considered. This report considers technologies that serve space heating, space cooling, and water heating end uses, though the discussion of quantitative impacts focuses primarily on space and water heating end uses.

of the financial, employment, and emissions impacts of a state investment in growing the renewable thermal market.[3]

To achieve significant emissions reduction from the thermal sector, it will be necessary for state policymakers, industry leaders, consumer groups, building owners, and a variety of other stakeholders to collaborate, leveraging public and private sector resources to scale up the renewable thermal market. This study lays the foundation for such collaboration, describing near-term market development initiatives that Rhode Island can implement to address its greenhouse gas, economic development, and clean energy priorities.

Box 1. Renewable thermal and Rhode Island's Energy Priorities

Energy 2035: Rhode Island State Energy Plan (RISEP) laid out a comprehensive vision for transforming the state's energy economy into a "secure, cost-effective, and sustainable" energy system (RI Division of Planning, 2015). In addition to providing an assessment of energy supply and consumption in the state, *Energy 2035* outlined a number of goals for the state's energy system, broken down into three key themes: security, cost-effectiveness, and sustainability. Development of robust renewable thermal markets can help Rhode Island achieve a number of goals across these themes.

- Security. Increasing the use of RT technologies will lead to an increase in fuel diversity across the thermal energy sector, helping to reduce Rhode Island's vulnerability to disruptions in energy infrastructure, increase consumer choice, and synergize with the increasing deployment of distributed renewable electricity generation (e.g. electric heat pumps). Notably, as average global temperatures rise as a result of climate change, the demand on Rhode Island's infrastructure to provide cooling is also anticipated to increase. Highly-efficient RT technologies will be essential to provide a reliable source of cooling to the roughly 30% of New England homes that now lack air conditioning (U.S. Energy Information Administration, 2009b).
- Cost-effectiveness. Increased deployment of RT is anticipated to provide net benefits across the economy. As discussed in SECTION 6, a major investment in RT will provide a net benefit to the state as a whole with near-zero impacts on energy affordability while contributing to economic growth and job creation. Growing the RT market will also help to drive the technology cost reductions needed to provide energy savings to consumers and provide greater energy price stability through reduced reliance on volatile national and global fossil fuel markets.
- Sustainability. Thermal energy accounts for nearly 35% of statewide emissions—over 30% greater than emissions from the electricity sector. Scaling up the renewable thermal technology deployment will contribute to the emissions reductions necessary to reach Rhode Island's

[3] In conjunction with the development of this report, OER developed a separate Fuel Dealer Clean Energy Action Plan, which identifies market barriers, opportunities, and next steps for more broadly enabling delivered fuel (i.e. oil and propane) dealers to integrate RT technologies and energy efficiency and weatherization services into their product offerings.

ambitious GHG emissions reduction targets of 45% below 1990 levels by 2035 and 80% below 1990 levels by 2050.

1.1 REPORT STRUCTURE

The report is structured as follows:

- Section 2 – Renewable Thermal Technology Overview. This section provides an overview of the renewable thermal technologies that are the focus of this study, as well as the regional and global renewable thermal policy context.
- Section 3 – Rhode Island Thermal Energy Market. This section provides an overview of the current state of the thermal energy sector, including the status of renewable thermal technology deployment and the in-state supply chain.
- Section 4 – Market Barriers and Opportunities for Renewable Thermal. This section analyzes high-level and technology-specific market barriers identified through research and engagement of experts and key industry and government stakeholders.
- Section 5 – Rhode Island Policies and Market Development Strategy. This section discusses a range of policy opportunities Rhode Island could pursue to catalyze development of the renewable thermal market with a focus on five high-priority, high-impact policy opportunities identified by key stakeholders that Rhode Island could implement in the near term.
- Section 6 – Renewable Thermal Market Impacts. This section discusses analyses conducted to model the financial, employment, and emissions impacts of a state investment in a renewable thermal scale-up.
- Section 7 – Conclusion. This section summarizes the key findings from the report and identifies key next steps Rhode Island could pursue in order to begin scaling-up renewable thermal technology deployment.
- Appendices. Additional appendices provide (1) detailed information on policy recommendations, (2) the inputs and assumptions used in the quantitative impact analysis, and (3) a list of working group participants.

SECTION 2 RENEWABLE THERMAL TECHNOLOGY OVERVIEW

2.1 RENEWABLE THERMAL TECHNOLOGIES

The term "renewable thermal" (or "renewable heating and cooling") has been defined differently across a number of policy settings. For purposes of this market development assessment, renewable thermal is defined as a technology that can utilize renewable energy resources to provide space heating/cooling, water heating, and process heating. This study focuses primarily on the six RT technologies and fuels identified in the RISEP as high-potential, having already achieved cost-competitiveness with some conventional heating fuels:[4]

- Air Source Heat Pumps (ASHP), which are assumed to meet the standards of the Northeast Energy Efficiency Partnerships' Cold Climate Air Source Heat Pump (ccASHP) standard;
- Ground Source Heat Pumps (GSHP), which are assumed to satisfy US EPA ENERGY STAR guidelines;
- Biomass Boilers, which are assumed to be high-efficiency, low-emissions models similar to those eligible for the Massachusetts Clean Energy Center biomass rebate programs, and which include thermal storage;
- Solar Hot Water (SHW) Installations, which are assumed to meet Solar Rating and Certification Corporation (SRCC) standards; and
- Biodiesel blending in home heating oil, which is assumed to come from sources that can provide substantial lifetime GHG reductions.
- Biogas blending in utility natural gas, which is assumed to be produced primarily by anaerobic digestion or thermal gasification.

These technologies are discussed throughout this report.[5] In the quantitative market impacts discussion of this report (Section 6), the first four technologies are prioritized in the discussion of costs and benefits.

[4] This analysis focuses on these technologies with the exception of biogas, which differs from the other technologies in requiring blending and injection into existing commercial natural gas infrastructure.

[5] Detailed policy recommendations for biogas are not explored in this report, as biogas blending would be primarily centralized in a single authority (National Grid), and stakeholders with expertise in anaerobic digestion and thermal gasification were not represented in the stakeholder working group. Biogas was also not included in the renewable thermal deployment scenario for purposes of impact analyses, as National Grid recently completed a report on biogas potential and impacts in MA, NH, NY, and RI.

Potential impacts of biofuel blends are discussed separately in this section. A brief discussion of these primary technologies is provided below, with an additional focus in this section on biodiesel.[6]

2.1.1 AIR SOURCE HEAT PUMPS (ASHP)

Air source heat pumps use a compressor, expansion valve, refrigerant, and electric heat exchangers to transfer heat in and out of a building to provide space heating and cooling.[7] ASHPs use the outdoor air as a reservoir for extracting heat (to provide space heating) and rejecting heat (to provide space cooling). ASHPs are often considered a renewable thermal technology because they source thermal energy from the natural environment rather than from fossil fuels. While grid electricity is used to operate the pump itself, ASHPs are able to achieve efficiencies that exceed 100% (with typical COPs that reaching 1.75 or greater) as grid electricity is used only to pump, rather than generate, thermal energy. It is expected that electricity used to power heat pumps will increasingly be sourced from renewable energy sources (as required by Rhode Island's Renewable Energy Standard of 38.5% by 2035).

Although ASHPs have traditionally been used in warmer climates, new cold-climate heat pumps can provide useful heating in temperatures as low as -15°F; however, at such temperatures, both capacity and efficiency are significantly reduced. This means that in most typical buildings, ASHPs will require use of a backup heating source (e.g. electric resistance baseboards or the existing heating system).[8] The Northeast Energy Efficiency Partnerships (NEEP) has developed a set of technical specifications to certify Cold Climate Air Source Heat Pumps (ccASHPs). In particular, NEEP's certification requires that ccASHPs are able to achieve a coefficient of performance (COP) of 1.75 at 5°F (i.e. 75% more efficient than electric resistance heat) (NEEP, 2017). ASHPs are installed either as ductless systems where one or more indoor units are typically mounted on walls, or as ducted systems that use the building's existing forced air duct system to distribute heat throughout the building.

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[6] Biodiesel was not included in the renewable thermal deployment scenario for purposes of impacts analyses: biodiesel's status as a premium heating oil adder means that it cannot be assessed on the basis of system-wide or consumer costs and benefits. Nonetheless, there are important environmental benefits associated with displacing oil purchases, which are discussed in greater depth in Box 6 in Section 6.4. Policy opportunities that would enable an expansion of the biodiesel sales in Rhode Island are discussed in further detail in Appendix 1: Detailed Policy Recommendations.

[7] Similar technologies are available for domestic hot water – typically referred to as heat pump water heaters. This study focuses on the space heating/cooling applications of air source heat pumps.

[8] In some high-performance buildings (e.g. built to zero-net energy or Passive House standards), ASHPs can serve as a whole home heating source. However, the vast majority of homes lack sufficient weatherization and will require a backup heating source.

Additional resources on air source heat pumps:

- **The U.S. Department of Energy** provides detailed information on ASHP and ductless minisplit ASHP.
- **The Northeast Energy Efficiency Partnerships** facilitates the Northeast/Mid-Atlantic Air-Source Heat Pump Working Group to develop a Cold Climate ASHP (ccASHP) specification to certify high-efficiency heat pumps that are optimized for cold climates. The NEEP website provides a range of ASHP resources, including the ccASHP specification, a regularly-updated list of all certified ASHPs, and summaries of regional ASHP incentives and policies.

2.1.2 GROUND SOURCE HEAT PUMPS (GSHP)

Ground source heat pumps (often referred to as geothermal heat pumps) use an indoor heat pump unit and a heat exchanging ground "loop" buried underground (or underwater) to transfer heat in and out of a building. While air temperatures can vary drastically depending on latitude, altitude, season, and day-to-day weather changes, the variation in subsurface and/or groundwater temperatures remain relatively consistent from season-to-season—typically between 45°F and 75°F, depending on climate and latitude (DOE, 2011). GSHPs can extract more heat with typically greater efficiency than ASHPs in colder weather, enabling GSHPs to provide sufficient heating to serve the whole seasonal building load (though some systems are sized below peak heating load and installed with backup electric resistance heat to reduce installed costs). However, due to the drilling requirements and ground loop components, the installed cost of GSHPs are significantly higher than ASHPs on a per-ton basis. Similar to ASHPs, GSHPs are considered to be renewable thermal technologies because they source thermal energy from the environment (in this case, taking advantage of relatively stable below-ground temperatures) rather than directly generating heat with fossil fuels. GSHPs are able to achieve COPs of 3.0 or greater.

There is significant variation in how the ground loop component is designed and installed. Common configurations are detailed below:

- In **closed-loop systems**, a ground loop (typically made of polyethylene or PVC) circulates water and/or antifreeze to exchange heat with the ground or groundwater source. For closed-loop residential and smaller commercial systems, horizontal "slinky" configurations are often used, while vertical column wells of up to 400 feet deep are often used for larger commercial systems. Closed-loop systems can also be submerged in bodies of water.
- **Open-loop systems** can circulate groundwater sources themselves for heat extraction and rejection – which can reduce the installed cost due to less piping. While heat exchange efficiency is higher than in closed-loop systems due to the even more stable temperature of groundwater sources, open-loop systems will consume relatively greater electricity due to added pumping power required to circulate the groundwater itself.
- GSHPs can also be designed as **direct exchange systems**, which circulate a refrigerant through a copper pipe instead of a typical ground loop. While these systems are highly efficient at heat

extraction and rejection, the high global warming potential of refrigerants means that a leak could compromise GHG emissions reductions gained from the system's efficiency.

Additional resources on ground source heat pumps:

- **The U.S. Department of Energy** provides detailed information on GSHP systems.
- **The International Ground Source Heat Pump Association (IGSHPA)** is a non-profit GSHP industry group headquartered at the campus of Oklahoma State University. The IGSHPA website serves as a clearing house for educational resources, research, and publications on GSHP technologies.
- **The New England Geothermal Professional Association (NEGPA)** is a non-profit New England regional industry group that provides a range of educational and training resources on GSHP.

2.1.3 SOLAR THERMAL

Solar thermal systems harness thermal energy from sunlight in order to generate heat for domestic hot water (DHW) and space heating. When both DHW and space heating uses are deployed, the system is referred to as a solar combi-system. The majority of solar thermal installations internationally and in the northeast are currently designed and sized to serve DHW only (referred to as solar water heating [SWH] or solar hot water [SHW]). Similar to solar photovoltaic systems, the loss of solar insolation during the winter significantly affects production; thus, a backup water heating source will be needed to continue providing hot water during the winter. Solar thermal systems are considered renewable thermal technologies because they use heat captured directly from the sun. Some electricity may be required for pumps and controls, as well as to provide backup heat when solar insolation is inadequate.

SWH systems use a collector to capture solar thermal energy, designed as flat plates or evacuated tubes. A heat exchange liquid is circulated with a pump to capture heat from the collector when the collector temperature exceeds the hot water storage tank. A heat exchanger is then used to transfer heat from the heat exchange liquid to heat the hot water tank. In climates where temperatures drop below freezing, freeze protection is required to prevent the risk of freeze damage. Typically, freeze protection entails using an antifreeze mixture in a pressurized, closed-loop system or an unpressurized "drainback" system, which allows the water or antifreeze to automatically drain from the collector when pumping ceases. A pump is also required to circulate the heat exchange fluid, which consumes a small amount of electricity over the course of the year.

Additional resources on solar thermal:

- **The U.S. Department of Energy** provides detailed information on solar water heating systems.
- **The Solar Rating & Certification Corporation (SRCC)** provides performance certifications and standards for solar thermal products. SRCC ratings are the established industry standard and are often used to set incentive levels in state SHW programs.

2.1.4 WOOD PELLETS/CHIPS

Pellets and chips (often referred to collectively as biomass thermal when used for heat) are wood-based fuels manufactured for use in heating appliances—typically in high-efficiency central pellet and chip boilers and in pellet stoves for space heating. Pellets and chips themselves are typically sourced from harvested woody biomass. These sources are supplemented by waste wood from mills, furniture manufacturing, and other processing facilities dealing in forest products. Wood pellets are more efficient and refined and are typically used in residential or smaller commercial building applications, whereas wood chips are more commonly used in larger commercial or industrial buildings and large-scale combined heat and power facilities due to lower cost.

Biomass fuels are often treated as carbon neutral fuels (e.g. by the Regional Greenhouse Gas Initiative), though there is significant debate regarding the life-cycle emissions of biomass fuels, given the wide range of production methods utilized and energy used in harvesting and processing the fuels. Nonetheless, sustainably-harvested wood fuels can serve as low-emissions fuels that can offer significant GHG reductions over fossil fuels.

Moreover, some policymakers have expressed concerns about particulate matter (PM) emissions from wood heating systems. Biomass heating typically generates greater PM emissions per unit of heat than equivalent fossil fuel sources (Russell & Burkhard, 2011). As such, the EPA recently released new guidelines mandating that all biomass heaters achieve a maximum PM emissions limit of 0.32 lb/MMBtu of heat output by 2015, reaching 0.10 lb/mmBtu output by 2020 (EPA, 2015). Some states such as Massachusetts and New York, have integrated more stringent emissions requirements (0.08 lb/mmBtu), into their wood pellet heating rebate programs in an effort to reduce PM emissions from wood heating appliances.[9] These states have also implemented requirements for thermal storage, which can potentially reduce PM emissions and improve system performance (Kunde et al., 2013).

It is worth noting that there is currently no in-state production of biomass chips and pellets in Rhode Island. Developing a biomass heating sector in Rhode Island will likely require investments in in-state wood fuel production, as the added cost of importing wood fuels from other New England states increases challenges with cost-competitiveness with fossil fuels.

Additional resources on wood pellets/chips:

- **The U.S. Department of Energy** provides detailed information on wood and pellet heating systems.
- **The Biomass Thermal Energy Council (BTEC)** is a biomass industry association that engages in research, education, and advocacy for biomass thermal energy. The BTEC website provides a

[9] For specific emissions standards used in Massachusetts rebate programs, see: http://files.masscec.com/get-clean-energy/business/clean-heating-cooling/BiomassProgramManualSmallScale.pdf. For emissions standards used in New York, see: https://www.nyserda.ny.gov/All-Programs/Programs/Renewable-Heat-NY.

wide range of educational resources, as well as databases on state and federal incentives and policies on biomass heating.

2.1.5 BIODIESEL

Biodiesel is a replacement or supplement for conventional petroleum-based fuel oil, and can be produced from a range of sources such as plant oils, animal fats, and organic waste oils. Pure biodiesel is manufactured separately and added to conventional No. 2 distillate fuel oil to create a blended fuel capable of being used in most standard oil boilers and furnaces. Biodiesel is considered a renewable fuel as it uses harvested or waste organic matter for production. Depending on the method used and the fuel source, biodiesel can offer GHG emissions reductions of up to 66% or greater when replacing conventional heating oil (Huo et al., 2008). Biodiesel blends are named based on the amount of biodiesel present in the fuel – for example, a B5 blend contains 5% biodiesel, while a B99 blend contains 99% biodiesel.

One distinct and significant advantage of biodiesel over other renewable thermal technologies is that use of a biodiesel blend does not require an additional investment in equipment by the consumer: lower-level blends can be burned by standard boilers without damaging the equipment. As such, biodiesel can directly displace gallons of heating oil on a one-to-one basis, which can yield significant GHG emissions reductions and other environmental benefits. Given that roughly one third of residences and nearly half of businesses use heating oil and other delivered fuels (see Section 3.1), increasing the share of biodiesel in heating oil can have a valuable role in a comprehensive renewable thermal strategy for Rhode Island. With significant in-state production of biodiesel, as well as the potential to produce additional biodiesel from locally-sourced feedstock, an increase in biodiesel sales could provide significant economic and employment benefits to Rhode Island. The various stakeholder groups that may be impacted by greater investment in biodiesel are discussed in Box 2.

Box 2. Impacted stakeholders from a biodiesel scale-up

Increased use of biodiesel can be beneficial step towards achieving Rhode Island's climate goals. A variety of stakeholders could be impacted by such a scale up, including, but not limited to: local biodiesel producers, fuel oil dealers, and customers.

- **Local biodiesel producers.** Rhode Island has robust in-state biodiesel production, primarily relying on use of waste vegetable oil. As discussed throughout this section, there are some barriers to increasing sales of biodiesel and higher-blend heating oil. Direct policy intervention to increase biodiesel usage would be beneficial to the local biodiesel industry.
- **Fuel dealers.** Fuel dealers already sell biodiesel as required by RI standards, though some fuel dealers have reported selling blends directly to smaller subsets of customers ranging from B20 to B99. Fuel dealers engaged through this study generally saw biodiesel as an opportunity to offer a more environmentally-friendly product to their customers, as industry research has noted that biodiesel may discourage homeowners interested in converting to natural gas from

conversion. However, dealers have significant concerns about liability issues resulting from damage to customer equipment due to high blends of biodiesel and thus expressed interest in ensuring that biodiesel blends purchased from distributors are more consistent.

- **Customers.** Rhode Island heating oil customers have a positive view of biodiesel, with customers reporting their interest in using a cleaner, more environmentally-friendly, locally-produced fuel that does not require any modification of their current heating system. However, the vast majority of these customers are not familiar with biodiesel and are not aware of the Rhode Island mandate (Warm Thoughts Communications, 2015). A scale-up of biodiesel might expose customers to risks of equipment malfunctions if blending consistency cannot be improved. Moreover, the price premium of biodiesel will increase with higher blends in lieu of a more robust incentive.

2.1.6 BIOGAS

Biogas refers to a mixture of methane and carbon dioxide produced by the decomposition of organic matter. Raw biogas is composed primarily of methane (roughly 50-60%) and carbon dioxide (40 to 50%). While biogas is typically flared (to convert methane to CO_2 to reduce GHG impact) or used for electricity generation, biogas can also be processed into a pipeline-quality gas that can be directly injected into natural gas transmission infrastructure and used as a heating fuel. Biogas is typically produced through two methods that are applicable to a wide range of feedstocks:

- Anaerobic digestion (AD) refers to the decomposition of organic matter in anaerobic conditions (in absence of oxygen) by microorganisms. This process uses multiple types of bacteria to convert organic matter into methane and CO_2. AD is generally used for high moisture content feedstocks, including some municipal solid waste, wastewater, and animal manure (California Energy Commission, 2016; National Grid, 2010). AD in landfills creates landfill gas, which can also be refined to pipeline-quality gas.
- Thermal gasification (TG) refers to a process by which methane, CO_2, and other gases are produced through the complete thermal breakdown of organic matter in an enclosed reactor. TG is typically used for low-moisture feedstocks, including wood and agricultural residues and energy crops.

A 2010 report by National Grid found that a maximum technical potential of approximately 12.5 billion cubic feet of biogas could be produced in Rhode Island, primarily from AD and TG of municipal solid waste, wood residues, and landfill gas. This production would account for 15% of RI's overall natural gas demand and 35% of gas demand not used for electricity generation and could lead to an annual GHG reduction of roughly 700,000 tons of CO_2/year and create 100 – 400 jobs (National Grid, 2010).

National Grid noted that a capital investment of roughly $400 million in Rhode Island would be needed to achieve this technical potential, and argued that a renewable portfolio standard mechanism for biogas blending (e.g. 3% or more by 2030) could be an effective and reasonable policy mechanism for driving biogas investment.

2.2 GLOBAL AND REGIONAL POLICY CONTEXT

2.2.1 RENEWABLE THERMAL POLICY IN RHODE ISLAND

Rhode Island has already taken several initial steps to support RT markets. Perhaps the most significant of these is Rhode Island's biodiesel blending requirement, which requires a minimum biodiesel blend of B5 by 2017. While other states have considered such minimum requirements, this is to date the only statewide biodiesel mandate for heating fuels in place in the Northeast (on a municipal level, New York City recently expanded its mandate to B5 by October 2017 and B20 by 2034) (New York City Council, 2016).

Incentives are also in place for RT technologies in Rhode Island. Solar thermal projects are eligible for grant funds through the Rhode Island Renewable Energy Fund, and ASHPs are eligible for a rebate through the energy efficiency incentive program administered by National Grid, Rhode Island's sole investor-owned utility.

In addition, the Rhode Island Office of Energy Resources is in the midst of a planning process to determine the appropriate path forward for renewable thermal policy support. Two early steps in this process were to specifically include thermal load in the 2015 Rhode Island State Energy Plan and to convene a range of stakeholders to develop a Rhode Island Thermal Working Group report in 2015 (RI Division of Planning, 2015; RI OER, 2015). The market development strategy included in this report builds on these efforts, and solicited the involvement of many of the state's thermal working group participants as a stakeholder advisory board.

2.2.2 RENEWABLE THERMAL POLICY IN OTHER JURISDICTIONS

Renewable thermal policies and programs in other Northeastern states

Beyond Rhode Island, other states in the Northeast have put in place a range of renewable thermal policies. Table 1 summarizes the policy and planning steps taken by these states, and specific activities are detailed further in Table 2 below.[10] Notably, while all states in the Northeast have passed ambitious GHG reduction targets, policy approaches to renewable thermal across these states have been more limited.

[10] Note: The regional renewable thermal policy landscape is emerging with the scopes of various policies and programs constantly changing. This information represents the best publicly-available information as of October 2016.

Table 1. Renewable thermal policy context in the Northeast

● Policy/program in place ◑ Limited policy/program[11] in place or policy currently in development

	CT	MA	ME	NH	NY	VT	RI
Statewide GHG reduction targets	●	●	●	●	●	●	●
State RT strategy	◑	●			◑		◑
RT integration into state RPS		◑		●			
Residential RT incentives	◑	●	◑	●	◑	●	◑
Commercial RT Incentives	◑	●	◑	◑	◑	◑	◑
Low-cost financing program for RT	◑	◑	◑	◑	◑	◑	◑
Biodiesel mandate		◑					●
Biodiesel incentives	●	●	●		●	●	●

[11] E.g. program/policy covers limited renewable thermal technologies, limited to residential or commercial

Table 2. Specific State-by-state Activities

State	Summary of state renewable thermal context
Connecticut	⦿ Development of Connecticut renewable thermal feasibility and market development strategy ongoing ⦿ Range of residential financing programs and CPACE available for some RT technologies through Energize CT and CT Green Bank ⦿ Available incentives through Energize CT focus only on heat pumps (C-PACE, 2016; EnergizeCT, 2015; Yale Center for Business and the Environment, 2015)
Maine	⦿ Wide range of incentives and low-interest loan programs for RT available through Efficiency Maine ⦿ Nearly three-quarters of Mainers use delivered fuels (heating oil and propane) for home heating ⦿ In 2011, the Maine legislature established targets to reduce state oil consumption by 30% below 2007 levels by 2030 and 50% below 2007 levels by 2050 (Efficiency Maine, 2016; Maine State Legislature, 2011; Maine State Housing Authority, 2016)
Massachusetts	⦿ Developed the Commonwealth Accelerated Renewable Thermal Strategy (CARTS) in 2014 ⦿ MassCEC Clean Heating and Cooling Program and Commonwealth Solar Hot Water Program will provide a combined $40 million in residential and commercial RT incentives through 2020 ⦿ MA Dept. of Energy Resources is currently developing regulations to integrate RT into the state Alternative Portfolio Standard (MA EEA & DOER, 2016; MassCEC, 2015; Navigant Consulting & MCG, 2014)
New Hampshire	⦿ Developed first-in-the-nation carve-out for RT in the state renewable portfolio standard in 2012 ⦿ RPS carve-out for RT resulted in development of first state regulations on heat metering in 2014 ⦿ Limited utility incentives for heat pumps, residential and commercial incentives for SHW and biomass boilers (NH PUC, 2016a, 2016b; NHSaves, 2016)
New York	⦿ Currently engaged in developing a broader framework for driving RT market development ⦿ NYSERDA provides rebates for residential and commercial biomass as well as residential financing options for biomass and ASHP/GSHP (NYSERDA, 2015, 2016)
Vermont	⦿ Broad RT residential and commercial incentives available through Efficiency Vermont and the VT Small Scale Renewable Energy Incentive Program ⦿ Vermont and the State of Upper Austria signed an agreement in 2013 to collaborate on promoting biomass heating (Efficiency Vermont, 2016; Renewable Energy Vermont, 2013; VT RERC, 2015)

Renewable thermal policies and programs in Europe

Renewable thermal markets are more well-developed in Europe, where renewable thermal policies and targets are more widespread and have generally been in place for longer than in U.S. jurisdictions. Table 3 discusses some of the major renewable thermal policies, programs, and targets that are in place in European jurisdictions

It is worth noting that, while there are some valuable, transferrable lessons learned and policy best practices from various European models—some of which are discussed in detail in this report (e.g. see Section 5.3.2.2 for additional discussion on the UK Renewable Heat Incentive)—the European thermal energy context is different than that of the United States. In particular, the prominence of district heating in many jurisdictions—reaching 63%, 50%, and 45% market share in Denmark, Sweden, and Finland respectively (Euroheat & Power, 2015; Froning, 2013; Skoldberg & Ryden, 2014; Vainio et al., 2015)—and the ability to utilize centralized, large-scale sources of renewable thermal energy (e.g. biomass CHP, district-scale heat pumps, large-scale solar thermal) in district heating networks has been important to scale up the market in those jurisdictions. Additionally, the binding European GHG reduction targets and cap and trade system, combined with generally higher energy prices across the region,[12] has provided additional impetus for renewable thermal policy action and made renewable thermal deployment more cost-effective.

[12] For example, while the average residential price of natural gas in Rhode Island in 2015 was approximately $1.38 per therm (nearly 40% greater than the US average) (EIA, 2016), the average price across the EU as a whole was 2,08€ ($2.31) per therm with jurisdictions like Sweden averaging 3,43€ ($3.81) per therm (Eurostat, 2016).

Table 3. European Renewable Thermal Policies

Jurisdiction	European RT Market Development Targets & Policies
Austria	Target: 33% RT by 2020 • Grants and direct subsidies (e.g., % of system cost, or fixed amounts per system type, USD/kW, esp. for biomass and solar thermal) • Stable long-term incentives through rebate program created in the 1980s • Strong cluster development • Strong manufacturing base and export market (International Energy Agency, 2014)
Denmark	Target: 40% RT by 2020 • Large district heating network serves majority of population • Integrating biomass, SHW, and heat pumps into district heating • Tax policies level playing field between renewables and fossil fuels • Soft-cost reduction programs (e.g., training and certification, permit streamlining, etc.) (International Energy Agency, 2013)
Germany	Target: 15.5% RT by 2020 • National renewable heating mandate for certain buildings • SHW rebate program with mix of “bonus” incentives for innovation and efficiency (largest SHW market in Europe and largest consumer of bioenergy) • Soft-cost reduction programs (International Energy Agency, 2015)
United Kingdom	Target: 12% RT by 2020 • Performance-based incentives (RT production incentives, USD/kWh) • Developed first feed-in tariff for heat (Renewable Heating Incentive) • Developed detailed heat metering requirements • Strong emerging market for renewable thermal (International Energy Agency, 2016)

SECTION 3 RHODE ISLAND THERMAL ENERGY MARKET

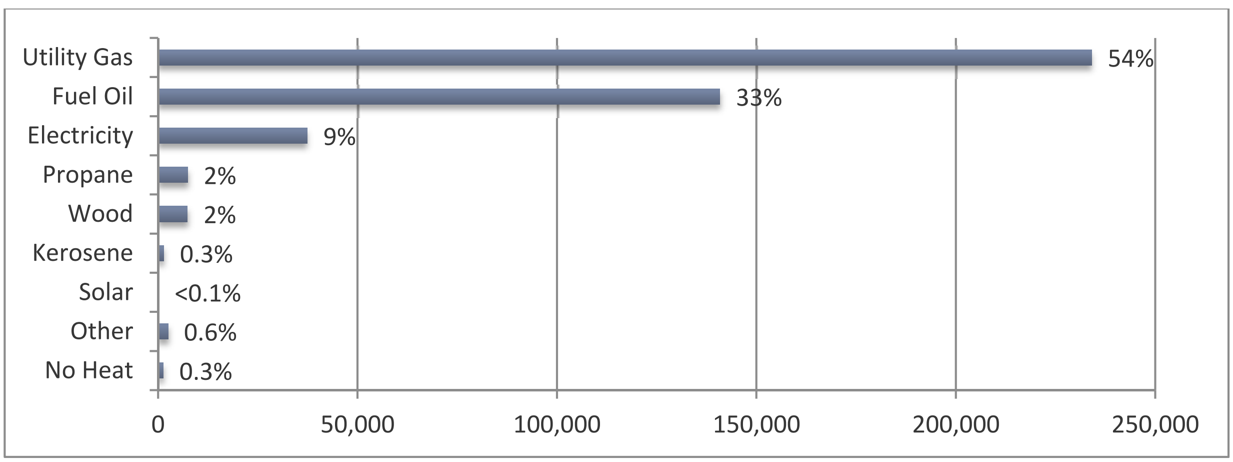
3.1 CURRENT STATE OF THERMAL ENERGY IN RHODE ISLAND

Thermal energy is a significant contributor to Rhode Island's overall energy use. In the 2015 Rhode Island State Energy Plan, it was estimated that the state's annual thermal energy consumption amounts to 63 trillion Btu/year across all sectors in 2010.

3.1.1 RESIDENTIAL THERMAL ENERGY

Overall, thermal energy use is dominated by utility gas and distillate fuel oil. An estimated 54% of Rhode Island residences are heated by natural gas, 33% by fuel oil, 9% by electricity (likely to be primarily electric resistance heating), and 5% by other sources (such as propane, kerosene, or wood (RI OER, 2015).

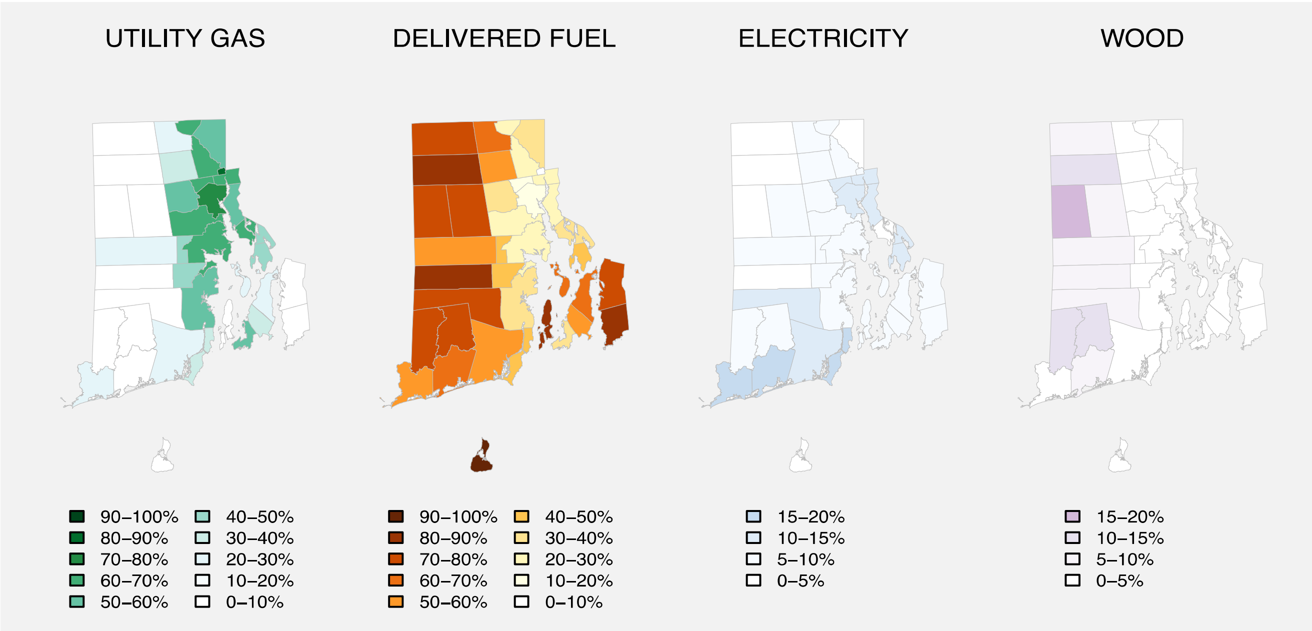
Figure 1. RI Heating Fuel Breakdown



The use of thermal fuels in Rhode Island is heavily associated with geography and population density. As illustrated in

Figure 2 below, in the heavily populated area around Providence and in Newport, natural gas is the dominant thermal energy source, while in the less dense areas in the western part of the state, the remainder of Newport County, and on Block Island, a majority of homes are heated with delivered fuel oil.[13]

Figure 2. Rhode Island Thermal Fuel Use by Geography



Home heating fuel is also associated with demographics. While, single-family residences are more or less evenly divided between natural gas and fuel oil use, multifamily homes are dominated by gas-heated dwellings, with both fuel oil and electric heat making up substantial portions of the remainder. Additionally, across the board, rented units are slightly more likely to have electric heat than owner-occupied units.[14]

[13] Geographic data collected from the US Census American Community Survey, 2010-2014 5-Year Estimates.

[14] Demographic data collected from the US Census American Community Survey, 2010-2014 5-Year Estimates.

Table 4. Residential Fuel Use by Housing Sector

Sector	Occupancy	Estimated Households		Percent of Group Using Each Fuel Category						
		Count	%	Utility Gas	Delivered Fuel	Electricity	Wood	Solar	Other	No Heat
Single Family	Owned	227,521	53%	46%	47%	3%	3%	0%	1%	0%
Single Family	Rented	32,185	7%	47%	42%	8%	1%	0%	0%	0%
Multifamily	Owned	31,575	7%	69%	22%	10%	0%	0%	0%	0%
Multifamily	Rented	141,424	33%	66%	16%	17%	0%	0%	0%	1%
Total Households		**432,705**	**100%**	**234,143**	**149,781**	**37,410**	**7,357**	**198**	**2,498**	**1,319**
Percent of Total				**54%**	**35%**	**9%**	**2%**	**0.05%**	**0.58%**	**0.30%**

Homes heated by utility gas and delivered fuels most frequently use boiler-based heating systems, though a large minority use central furnaces as well. Homes heated with electricity predominantly use electric resistance heat.[15]

Table 5. Estimated Number of Rhode Island Households by Heating Fuel and Heating System

	Utility Gas	Delivered Fuel	Electricity	Wood	Solar	Other/ None	Total	% of Total
Steam or Forced Hot Water System	120,749	89,323	3,715	316	-	-	**214,105**	**49%**
Central Warm-Air Furnace	99,997	52,719	4,169	1,270	-	-	**158,156**	**37%**
Built-In Room Heater	9,626	6,554	-	-	-	-	**16,180**	**4%**
Built-In Electric Units	-	521	25,912	-	-	-	**26,432**	**6%**
Floor or Wall Pipeless Furnace	1,258	332	574	-	-	-	**2,164**	**0.5%**
Room Heaters	-	332	1,973	-	-	-	**2,305**	**0.5%**
Stove/Fireplace	556	-	-	5,450	-	-	**6,007**	**1.4%**
Heat Pump	-	-	695	-	-	-	**695**	**0.2%**
Solar Thermal	-	-	-	-	198	-	**198**	**0.0%**
Other Equipment	1,955	-	372	320	-	3,817	**6,464**	**1.5%**
Total	**234,143**	**149,781**	**37,410**	**7,357**	**198**	**3,817**	**432,705**	**100%**

[15] The percentage of homes in each fuel category that use a given heating technology was calculated using the US Energy Information Administration's Residential Energy Consumption Survey (RECS) database. RECS data is not available at a more granular level than the New England region as a whole, however, so these figures reflect regional trends in heating technology.

3.1.2 NON-RESIDENTIAL THERMAL ENERGY

While data on non-residential energy consumption is not available at as granular a level as residential thermal consumption, regional data is available and was used for this report.[16]

As indicated in Table 6 below, delivered fuels are the most popular fuel source among commercial buildings, acting as the primary heating source for 48% of commercial buildings. However, because utility gas is the most common heating source among large (>20,000 sq.ft.) commercial buildings, natural gas heats more commercial floor space (47%) than any other fuel.

Table 6. Commercial Heating Fuel Breakdown

Fuel	Buildings			Heated Square Footage		
	Small Commercial	Large Commercial	Total	Small Commercial	Large Commercial	Total
Delivered Fuel	43%	5%	48%	14%	15%	29%
Utility Gas	19%	9%	28%	9%	38%	47%
Electricity	13%	2%	14%	6%	5%	11%
Wood	6%	1%	6%	2%	1%	2%
District Energy	1%	1%	3%	1%	8%	9%
Other	1%	0%	1%	0%	1%	1%
Total	**82%**	**18%**	**100%**	**32%**	**68%**	**100%**

Commercial buildings use a variety of thermal distribution systems, the two most common being boilers and packaged heating systems.[17] Additionally, a number of small commercial buildings utilize electric resistance heat.[18]

[16] Data is from the EIA Commercial Buildings Energy Consumption Survey (CBECS). As with the EIA RECS database, EIA CBECS database is only available at the regional (New England) level, and no companion dataset allows for the identification of specific building counts utilizing a given heating fuel among commercial buildings in Rhode Island (as the Census ACS data does for residential buildings).

[17] Packaged heating systems refer to thermal systems where all heating components are combined into a single exterior unit. While packaged units may utilize a variety of heating fuels and technologies, CBECS does not provide more granular data.

[18] These are categorized as "Space Heater" buildings in CBECS and may include other heating technologies as well.

Table 7. Commercial Thermal Distribution Systems

Fuel	Buildings			Heated Square Footage		
	Small Commercial	Large Commercial	Total	Small Commercial	Large Commercial	Total
Packaged System	30%	6%	37%	12%	22%	34%
Boiler	22%	7%	28%	9%	30%	39%
Electric Resistance	17%	2%	19%	5%	3%	8%
Furnace	7%	1%	8%	2%	2%	5%
Heat Pump	4%	0%	4%	3%	2%	5%
District Heat	1%	1%	3%	1%	8%	9%
Other	1%	0%	1%	0%	0%	0%
Total	**82%**	**18%**	**100%**	**32%**	**68%**	**100%**

3.1.3 IMPORTANCE FOR RENEWABLE THERMAL PROGRAMMING

The state of the Rhode Island thermal energy landscape has important implications for renewable thermal programming in the state. From the analysis above, several conclusions may be drawn:

- Renewable thermal projects can be expected to primarily replace oil heat, at least in the short term. This is because of the low fuel prices for natural gas in the current market, and the limited supply of electric-heated homes in the state.
- Opportunities for oil heat conversion may be disproportionately present in the western and southeastern portions of the state, where oil heat is more common.
- Opportunities for oil heat conversion may be disproportionately present in the single family housing sector, where oil heat is more common.
- The very low portion of multifamily rental units that utilize oil heat may present barriers to making renewable thermal technologies available to low-income populations.
- Among commercial buildings, while oil heat is the most common heating fuel, it is disproportionately common in smaller facilities (indicating that small commercial facilities may have greater opportunities for renewable thermal installations)

3.2 BENCHMARKING POTENTIAL INDUSTRY SIZE IN CURRENT MARKET SITUATION

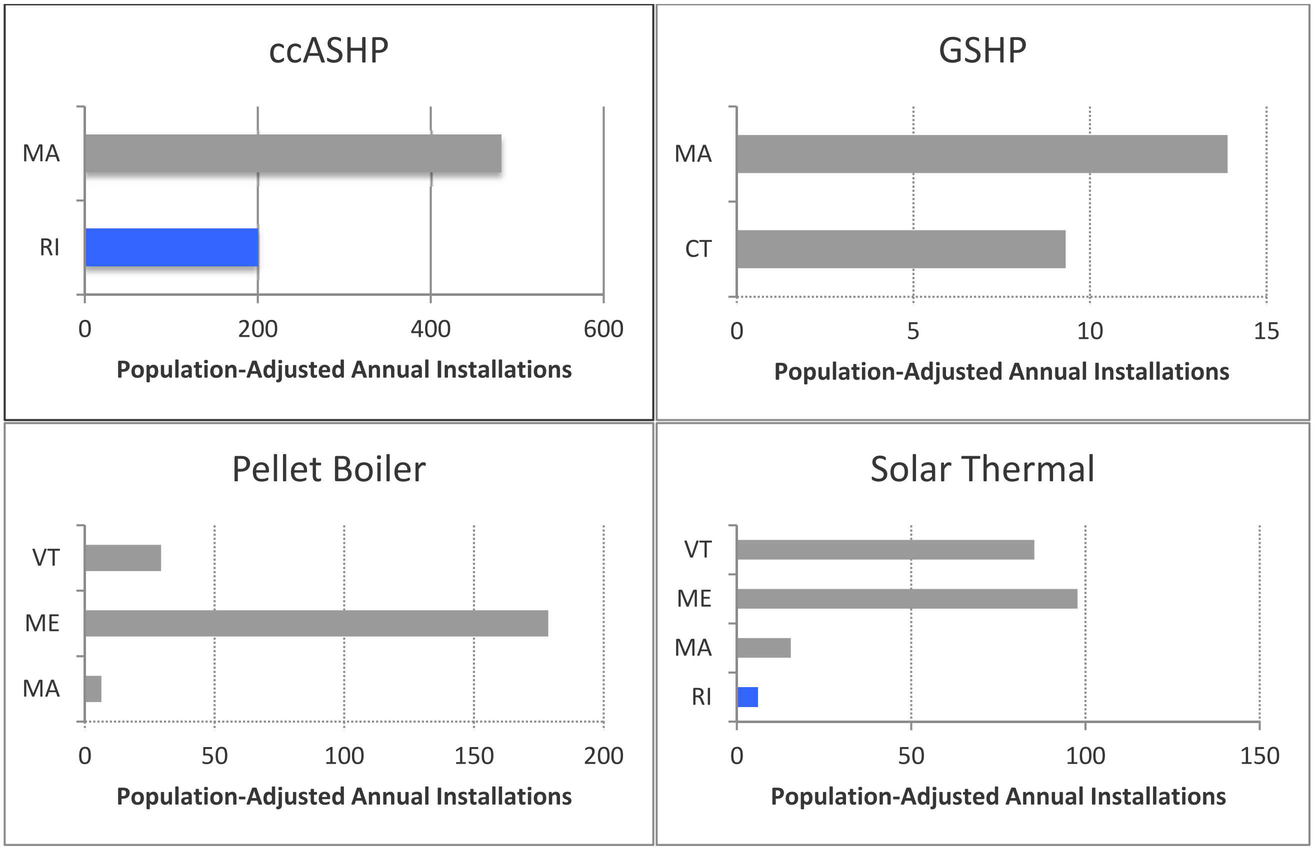
Exact statistics on renewable thermal market size in Rhode Island or the broader New England region are unknown. Estimates of the size of regional markets may be obtained through the various incentive programs in place in Rhode Island and other New England states, which were used to establish rough benchmarks on the current capacity of the regional renewable thermal industry.

In Rhode Island, data sources include the ASHP rebate database maintained by National Grid (which primarily markets ASHP use for cooling applications) and Rhode Island Renewable Energy Fund grants for solar hot water. In 2015, National Grid rebated over 1,000 ASHPs, 200 of which met the NEEP criteria of a cold-climate ASHP (the standard being considered in this analysis). The Rhode Island Renewable Energy Fund has had limited participation, rebating only twelve SHW systems over a two-year period.

Data from incentive programs run in other states can be used to provide an indication of the regional renewable thermal market more broadly. These include incentive programs operated by the Massachusetts Clean Energy Center, Efficiency Maine Trust, Energize Connecticut and the Connecticut Green Bank, and Efficiency Vermont. For these states, annual installation counts were derived from the last full year for which data is available for each program. These counts were then normalized by population to show a corresponding number of installations that would occur annually in Rhode Island at these market penetration rates.

The resulting annual installation rates (adjusted for the population of Rhode Island) are shown in the figures below.

Figure 3. Annual Installations of Renewable Thermal Technologies in New England[19]



As is made clear by the current installation rates, the market for ccASHPs is significantly larger in New England than for other technologies, even when restricted to products that meet the NEEP ccASHP standard. While many regional ASHP incentive programs base eligibility on SEER or HSPF ratings, the Massachusetts Clean Energy Center requires that participating products additional cold climate performance standards, including being certified by the NEEP ccASHP standard. In Rhode Island, National Grid's incentive program does not require products to meet the NEEP ccASHP standard, though National Grid does track the number of products that qualify for the standard. As noted above, in 2015, 200 of the 1,028 ASHPs rebated by National Grid met the NEEP ccASHP standard.

There are far fewer rebated installations for GSHPs than ASHPs in Massachusetts and Connecticut, though stakeholder group participants noted that they believed the actual market was significantly larger than reflected in state rebate program statistics.

[19] No Rhode Island-specific data is available for pellet boilers and ground source heat pumps.

There is a wide variety of installation rates among pellet boilers in states that offer an incentive and track installations. Stakeholder group participants have noted that the regional biomass industry is stronger in northern New England states, where wood heating is more common.[20]

Finally, among solar thermal installations, the number of projects rebated through Rhode Island's Renewable Energy Fund has been outpaced by incentive programs in place in Maine, Massachusetts, and Vermont.

3.3 RHODE ISLAND RENEWABLE THERMAL SUPPLY CHAIN ASSESSMENT

One important element for growing Rhode Island renewable thermal sector is to assess the strength of the supply chain. This report provides a rough assessment of the number of firms active along the supply chain for each of the RT technologies.

Firms active in Rhode Island in each technology were identified by consulting industry trade organization lists, RT incentive databases maintained by state agencies in Rhode Island and neighboring states,[21] and published rosters of installer and distributor partners of major manufacturers. This analysis is not intended to be an exhaustive census of renewable thermal firms, but is intended to provide a rough indication of the strength or weaknesses of different linkages on the renewable thermal supply chain. It is possible that a portion of the state's RT service providers may be located outside of the state. Table 8 below provides a summary of findings.

Table 8. RI Service Providers by Supply Chain Stage

Technology/Fuel	Installation/Maintenance	Distribution	Manufacturing
ASHP	30+	30+	0
GSHP	10-20	2-5	0
Solar Thermal	5-10	0	0
Biomass	2-5	0	1
Biodiesel	N/A	N/A	1
Wood Pellets	2-5		
Thermal Storage (Biomass Boilers)	1		

[20] More than 10% of residences in Maine and Vermont use wood heat as a primary heating source, compared to less than 2% of Rhode Island residences (U.S. Census Bureau, 2015).

[21] These include incentive databases maintained by the Rhode Island Renewable Energy Fund, the Massachusetts Clean Energy Center, and the Connecticut Green Bank.

This current service provider landscape has some clear strengths and weaknesses:

- Air Source Heat Pumps: Rhode Island has a decent presence of in-state ASHP firms active in installation and distribution. As noted above, National Grid currently offers incentives for ASHP installations that displace electric heat and rebates approximately 1,000 heat pumps per year. There is no known ASHP manufacturing capacity in-state.
- Ground Source Heat Pumps: The in-state GSHP industry is smaller than the in-state ASHP industry, but is still active. There are numerous in-state installers, but few known distributors located in-state, and no manufacturing capacity.
- Solar Thermal: There is little known activity in the solar thermal sector in Rhode Island. The Rhode Island Renewable Energy Fund has offered grants for solar hot water systems for several years, but as of March 2016 had only rebated twelve systems installed by three firms (all occurring between October 2013 and November 2014). Many of the solar thermal contractors identified are primarily solar photovoltaic installers that also offer solar thermal installations.
- Biomass: There is very limited biomass industry activity in Rhode Island (defined here as firms installing or servicing central wood pellet or chip boilers). Several firms were identified that install central wood boilers as a small part of a larger business, but no specialized wood pellet or chip installers were identified in Rhode Island. One in-state manufacturer offers wood pellet boilers as one item in a large portfolio of manufactured products.
- Biodiesel: There is a single manufacturer of biodiesel active in Rhode Island, which supplies biodiesel for use in both transportation and heating. All home heating fuel suppliers are required to utilize a minimum blend of biodiesel, which is generally mixed at the terminal, though a small number of fuel oil suppliers also offer higher blends of biodiesel to customers as an optional product.

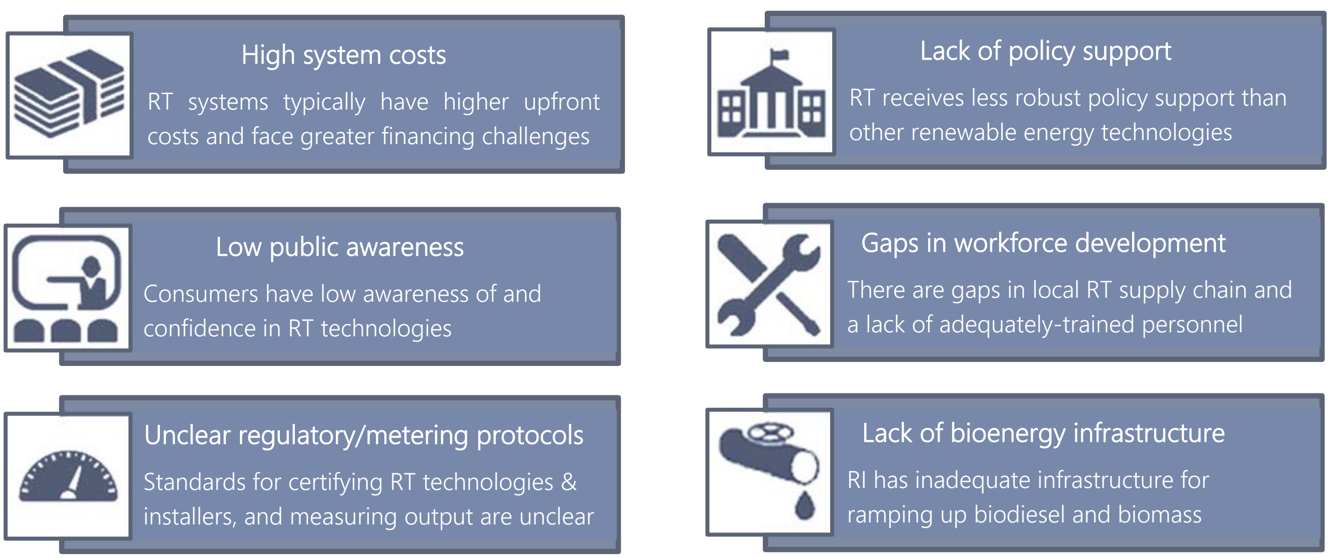
SECTION 4 RENEWABLE THERMAL MARKET BARRIERS

4.1 OVERVIEW OF MARKET BARRIERS

Renewable thermal market barriers have been well documented across a number of U.S. and international studies (Navigant Consulting & Meister Consultants Group, 2014; Veilleux et al., 2012; Veilleux & Rickerson, 2015). Using this literature as a starting point, Rhode Island OER convened industry and market experts to assess the renewable thermal barriers in Rhode Island's unique market context.

Figure 4 below illustrates the major barriers impacting Rhode Island's renewable thermal market. The following section describes how each of these barriers play out broadly across the state. Section 4.2 provides additional detail on key barriers and opportunities for each of the renewable thermal technologies (i.e. solar thermal, ASHP, GSHP, etc.)

Figure 4. Summary of Rhode Island renewable thermal market barriers



Major market barriers in Rhode Island include:

- High system costs and/or inadequate return on investment. RT systems generally have higher upfront costs than conventional fossil fuel systems. In addition, RT systems often do not provide a sufficient return on investment for building owners. This is a particular challenge given the current low prices of natural gas and oil. Additionally, RT technologies often face a number of financing barriers, in part driven by the lack of established protocols to measure heat production and thus monetize the investment on a performance basis.

- Lack of policy support. RT technologies tend to receive significantly less public policy support relative to renewable electricity (e.g. solar photovoltaics). Few jurisdictions in the United States (or globally) have comprehensive strategies and policy frameworks to encourage RT technology adoption across key building sectors. Within Rhode Island, stakeholders described challenges to developing the necessary political and institutional support for RT policies. As such, few RT technologies have received significant, sustained incentive and other policy support in Rhode Island. Similarly, manufacturers noted that little direct state and federal investment has been provided to support R&D for RT technologies.
- Low public awareness. There is a general lack of awareness regarding the economic, greenhouse gas, and societal benefits of RT technologies as well as the types and applications of these technologies among consumers, businesses, and policymakers. Stakeholders noted that consumers typically have a lack of confidence in the reliability and performance of RT technologies even when economics are favorable. In addition, stakeholders indicated that broad-based outreach and education programs are needed, which target both consumers and industry groups (e.g. general contractors, plumbers, oil heat dealers, etc.) to increase awareness and drive technology deployment.
- Gaps in workforce development. Rhode Island stakeholders reported challenges in hiring adequately-trained personnel. Contractors and oil heat dealers specifically noted that the licenses and certifications required to install some RT technologies present a significant barrier for bringing new skilled labor into the market, particularly when compared to neighboring states. For example, oil dealers pointed out that installing residential air source heat pumps in RI requires a journeyman refrigeration license and the requisite 240 hours of schooling and two years of apprenticeship. Massachusetts, on the other hand, only requires the completion of a written exam to install residential systems.
- Unclear regulatory and metering protocols. Stakeholders noted that regulatory and metering standards are unclear for many RT technologies. This creates confusion in the marketplace regarding best practices for installation and system performance. However, in recent years, some new standards have emerged to certify heating performance for RT technologies in cold climates (e.g. Northeast Energy Efficiency Partnerships Cold Climate Air-Source Heat Pump Specification), though individual states across the Northeast are applying differing performance standards and requirements for rebate program eligibility. Manufacturers note that adapting to ongoing changes in these standards can be challenging without a two-year timeline to update products to address tightening performance requirements. In addition, stakeholders and policymakers indicated that while better data is needed to adequately measure the performance of RT technologies, there are no commonly accepted metering standards for RT technologies. While states like New Hampshire and Massachusetts have developed—or are developing—protocols to govern metering for RT technologies, there is still not

widespread agreement across industries on heat metering requirements.[22] There was notable disagreement among stakeholders as to the complexity of metering various RT technologies.

- Lack of bioenergy infrastructure. Some stakeholders reported that biodiesel and biomass fuels face significant infrastructure development barriers that affect the supply chain. Biodiesel fuel manufacturers and oil heat dealers discussed a number of challenges related to lack of infrastructure at the terminal and distribution levels that have made it challenging to increase and regulate the share of biodiesel in heating oil blends. With respect to biomass, stakeholders noted that there is no in-state production of wood pellets, chips, and other biomass fuels despite potentially adequate in-state resources to support fuel production.

4.2 TECHNOLOGY SPECIFIC BARRIERS

Stakeholders also identified a number of technology specific barriers and opportunities across the renewable thermal sector. The following table details specific concerns for air-source heat pumps, ground source heat pumps, solar water heating, biodiesel, and wood heating.

Table 9. Barriers to Integrating Specific Technologies

Technology	Technology-specific barriers
Air-source heat pumps	⦿ **Cold-climate performance.** While significant progress has been made in the last five years to improve the performance of ASHPs, performance and efficiency at extremely low temperatures remain challenging. As such, for most typical buildings (i.e. built to code or with some envelope improvements), ASHPs require a backup heating source during the coldest days of the year (NEEP, 2014) ⦿ **Installation challenges.** Numerous studies regarding real-world residential ASHP performance in the Northeast have been conducted over the past several years. These studies have provided a wide range of measured efficiencies for ASHPs ranging from seasonal coefficients of performance (COPs) of 1.1 to 3.0 (NEEP, 2014; Williamson & Aldrich, 2015). This wide range suggests there are still challenges to overcome at the installation level that can significantly affect the performance of ASHP systems.
Ground-source heat pumps	⦿ **High upfront costs.** While GSHPs can provide the highest efficiency heating and cooling of all RT technologies, GSHPs installed costs are significantly higher than other technologies (DOE, 2016b). In addition, at the end of 2016, the 30% federal investment tax credits are being eliminated (for homes) and reduced to 10% (for businesses), which will further increase the cost burden of GSHPs to consumers (DOE, 2016a, 2016c). ⦿ **Installation challenges.** GSHP wells can be a significant source of installation problems reported by consumers. Many installers subcontract out well drilling work to other firms. Additionally, managing

[22] ASTM International formed a subcommittee in 2012 to develop a heat metering standard for hydronic applications under the Technical Committee E44 on Solar, Geothermal, and Other Alternative Energy Sources. While the development of the standard is ongoing, it is worth noting that it does not address operational requirements, which can influence the accuracy of metering outputs.

	risk from loop fields and wells can be a significant challenge to standardizing and developing financing mechanisms and products.
Solar water heating	⦿ **Affordable competing technologies.** Solar water heating is one of the most well-established, mature renewable energy technologies. However, despite existing incentives (e.g. from the RI Renewable Energy Fund), the industry has not experienced significant increase in market volume and installed costs remain high. Moreover, uptake has slowed significantly in many Northeastern jurisdictions as solar photovoltaics and electric heat pump water heaters have become more affordable.[23] ⦿ **Seasonal performance.** While solar water heating systems are often able to provide sufficient thermal energy in the summer to match domestic loads, they provide significantly less thermal energy during the winter, requiring the use of a backup system to meet demand (Aldrich & Vijayakumar, n.d.).
Biodiesel	⦿ **Inadequate infrastructure and mixing regulations.** While biodiesel mixing is supported by a statewide mandate, industry stakeholders and oil dealers noted there is inadequate infrastructure at the terminal and distribution level for storing biodiesel and mixing it into heating oil. Due in part to lack of infrastructure and regulation, the biodiesel content in blends is inconsistent, with oil dealers reporting that some blends marketed as B5 have been shown through testing to be over B20. ⦿ **Inadequate equipment for higher blends.** Oil dealers noted that both aging consumer equipment and distribution equipment (e.g. pumps, seals, nozzles) are not designed and warrantied for use for biofuel blends higher than B10 (or in some cases, B5). As such, increasing biofuel blends beyond the 5% required by the bioheat mandate may be challenging without support to replace and develop new equipment.
Wood heating	⦿ **No in-state fuel production.** Stakeholders from the biomass industry noted that there is no production of high-quality wood chips or pellets in Rhode Island (or in Massachusetts). As such, biomass fuels would need to be imported from New Hampshire, Vermont, and Maine if demand were to rise. ⦿ **Challenges with PM emissions.** The burning of biomass fuels, particularly in smaller appliances, can release greater amounts of particulate matter (PM) emissions than fossil fuels (Russell & Burkhard, 2011). Significant scale-up of wood-based heating systems could create localized air pollution issues. The EPA has recently passed PM emissions regulations for wood heating, though some Northeastern states have opted to go beyond these regulations with more stringent requirements for rebate eligibility (e.g. by tightening the allowable PM emissions, or implementing thermal efficiency and thermal storage requirements) (MassCEC, 2016; NYSERDA, 2015).

[23] For example, the Vermont Small Scale Renewable Energy Incentive Program reported a decline in solar water heating rebates provided from 353 in FY2012 to 61 in FY15. Efficiency Maine reported a greater than 50% decline in solar thermal rebates compared to an increase of nearly 300% in solar PV rebates between FY2010 and FY2013.

SECTION 5 RHODE ISLAND POLICIES AND MARKET DEVELOPMENT STRATEGY

5.1 INTRODUCTION

This section describes the policy and market development strategies that Rhode Island can implement to drive deployment of renewable thermal. As illustrated in Table 10, 19 policies and market development strategies have been identified, which are grouped around four major categories: (1) planning, targets, and mandates, (2) financing and incentives, (3) soft cost reductions, and (4) standards and workforce development.

Table 10. Overview of renewable thermal policies and market development strategies for Rhode Island

Market development category	Description and Proposed RI Renewable Thermal Policies
Planning, targets & mandates	**Definition:** Government efforts to develop plans, establish targets, and enact mandates are important to foster development of renewable thermal markets. Establishing statewide targets and long-term plans for renewable thermal can provide clear signals to encourage private investment. Mandates require development of renewable thermal in key sectors (e.g. RH&C mandate for public buildings), which can drive forward market development. **Proposed RT Policies for RI:** ⦿ Establish statewide renewable thermal market development targets ⦿ Integrate specific goals and recommendations for renewable thermal into Executive Order 15-17 ("Leading by Example") ⦿ Establish biofuel mixing guidelines ⦿ Explore opportunities to expand the biodiesel mandate
Financing & incentives	**Definition:** Incentives and low-cost financing are critical for overcoming economic barriers. Well-designed incentives can improve cost-competitiveness of renewable thermal technologies (relative to conventional fossil fuels). Accessible low-cost financing can increase adoption by reducing impacts of high upfront costs of renewable thermal technologies. Other government grant and loan programs can provide necessary support to drive R&D and fund business development and infrastructure critical to growing the renewable thermal market. **Proposed RT Policies for RI:** ⦿ Establish stable, long-term incentives for renewable thermal technologies ⦿ Expand access to low-cost financing for renewable thermal technologies ⦿ Establish a renewable thermal business development grant program

	⦿ Provide grants and incentives for improving bioenergy infrastructure ⦿ Fund EM&V projects and/or multifamily demonstration projects for renewable thermal technologies ⦿ Explore opportunities to modify biodiesel tax exemption
Soft cost reductions	**Definition:** "Soft costs" include costs related to labor, engineering, customer acquisition, financing, permitting, transaction, and other indirect and administrative costs. Such costs comprise a significant proportion of renewable thermal technology installed costs. State governments can reduce soft costs by, for example, (1) providing support for marketing, education, and customer awareness programs, which help reduce customer acquisition and transaction costs, or (2) streamlining state or local permitting and other regulations to reduce permitting and other transaction costs. **Proposed RT Policies for RI:** ⦿ Implement community outreach, education, and bulk procurement programs ⦿ Market renewable thermal technologies through utility efficiency programs ⦿ Reduce renewable thermal soft costs by revising state and local policies and regulations ⦿ Engage educational institutions to serve as champions for renewable thermal technologies ⦿ Support standardization and aggregation of renewable thermal assets ⦿ Develop a consumer education and decision-making program for renewable thermal technologies
Standards & workforce development	**Definition:** Establishing programs that support workforce development can help to increase the pipeline of skilled workers, accelerate growth in the renewable thermal industry, and improve the quality of renewable thermal installations. Developing standards can also address inconsistency and uncertainty with technology performance and regulations. Harmonizing these standards and regulations across the Northeastern region could increase ease of compliance and reduce costs for the industry. **Proposed RT Policies for RI:** ⦿ Develop certification schemes and training programs for renewable thermal technologies and installers ⦿ Support development of renewable thermal vocational training programs ⦿ Support regional development of renewable thermal technology performance standards, certification, and R&D

Building on this policy framework, OER asked industry leaders, market experts, as well as their internal policy experts to assess each policy in order to determine its relative level of importance to jumpstart the state's RT market. Stakeholders ranked policies against the criteria described in Table 11.

Table 11. Policy opportunity assessment criteria

Criteria	Rating criteria		
Size of impact: The potential for the policy to significantly impact the market	Low	Medium	High
Time to impact: The estimated time from implementation to expected significant impacts on the market.	Near-term (<3 years)	Medium-term (3-6 years)	Long-term (>6 years)
Estimated cost: The estimated cost of implementing the policy to the relevant implementing authority[24]	Low (<$1 million)	Medium ($1-5 million)	High (>$5 million)
Implementation timeline: The potential for the policy to be implemented in the near, medium, and long term	Near-term (<3 years)	Medium-term (3-6 years)	Long-term (>6 years)

Stakeholders identified five high priority policies, which are briefly illustrated in Table 12 below. The following sections provide additional detail regarding the implementation pathway for each of the high priority policies. For information on all 19 market development policies, interested readers should consult Appendix 1.

Table 12. Stakeholder Priority Policies

Planning, targets & mandates	Establish statewide renewable thermal market development targets
Financing & incentives	Establish stable, long-term incentives for renewable thermal technologies
Planning, targets & mandates	Integrate specific recommendations for renewable thermal into Executive Order 15-17 (“Leading by Example”)
Financing & incentives	Expand access to low-cost financing for renewable thermal technologies

[24] Note that this category does not assess the cost to consumers for purchasing RT technologies, but rather assesses the cost of supporting the policy to the relevant implementing authority (e.g. the State of Rhode Island, National Grid, etc.).

Soft cost reductions	Implement community outreach, education, and bulk procurement programs

5.2 ESTABLISH STATEWIDE RENEWABLE THERMAL TARGETS

Table 13. Policy Summary – Statewide Renewable Thermal Targets

Policy category	Planning, targets, & mandates
Time to Impact	Long
Size of Impact	High
Estimated Cost	Low

Barriers addressed	Lack of policy support Low public awareness
Technologies included	Air source heat pumps Ground source heat pumps Solar thermal Biomass heating Biodiesel
Implementation timeline	Near

5.2.1 BACKGROUND

Rhode Island has established goals for GHG emissions reductions (in the Resilient Rhode Island Act) and renewable electricity generation (via the state Renewable Energy Standard); however, the state has not established a target for RT technologies. By establishing a statewide target, Rhode Island can demonstrate commitment to developing the RT market, which would improve private sector confidence and drive increase investment in the space. Establishing a statewide target for RT should be considered a first step towards driving long-term scale-up in the RI RT market. It is worth noting that, in practice, such a target would be developed in tandem with an incentive mechanism to drive market development (see Section 5.3).

As discussed further in SECTION 6, three RT deployment scenarios were analyzed for their financial, employment, and emissions impacts (Table 14). Policymakers may consider these analyses as reference points in determining an appropriate target for a statewide RT target.

Table 14. Renewable thermal deployment scenarios and summary of impacts.

Scenario		Low	Medium	High
By 2035	**% of Thermal Load Served by RT***	**2%**	**5%**	**10%**
	Equivalent % of Electricity Sales Converted**	3%	7%	13%
	RT share of annual Res SF Heating Installations***	9%	20%	42%
	RT Installations/Year*****	1,199	2,856	5,946

* Reference point: The UK targets 12% by 2020, many EU nations have gone well beyond this, but also have much strong markets and starting points

** Reference point: RI Renewable Energy Standard targets 14.5% by 2019

*** Assuming that 4% of homes replace heating systems each year, per RECS

**** Reference point: MassCEC rebated 3,180 jobs in 2015, which corresponds to 520 jobs in RI scaled on a per-customer basis

5.2.2 POLICY & PROGRAM OPTIONS FOR STATEWIDE TARGETS

Rhode Island policymakers may consider the following factors when developing a statewide RT targets:

- **Align RT goal with state emissions targets.** Policymakers could consider goals that are both achievable and aligned with the technology deployment necessary to meet the state's interim and long-term GHG reduction targets. Thermal energy accounts for roughly 35% of all statewide emissions, and achieving the state's emissions targets will necessitate a significant increase in deployment of RT.
- **Broad range of technologies.** Stakeholders reported that policymakers should not prioritize one type of RT technology over another. Accordingly, Rhode Island may establish market development goals based on a common metric (e.g. capacity targets, number of installations, market value, % of state thermal energy load, % of square footage heated by RT), which can be applied across all RT technologies discussed in this report.
- **Updates to the biodiesel mandate.** Rhode Island has already specified a clear development target for biodiesel via the legislatively required bioheat blending mandate. The mandate provides a boost to the biodiesel industry by requiring every gallon of heating oil to contain at least two percent biodiesel, increasing to five percent by 2017. However, as discussed in Box 3, the state faces a number of challenges if it is to increase the blending mandate in the future. To address these challenges, policymakers may need to consider tackling infrastructure upgrades at the terminal level as well as making changes to the biodiesel tax exemption in order to scale up its bioheat blending mandate.

Box 3. Challenges and opportunities for biodiesel mandates in Rhode Island

Rhode Island is currently the only state in the Northeast to have implemented a statewide mandate for biodiesel blending in heating fuels.[25] Other states have considered the possibility of establishing a mandate but have stopped short of implementation: Massachusetts for example, ultimately decided to establish a voluntary biodiesel blending program instead of a mandate in 2010 (MA DOER, 2010). Under Rhode Island's mandate, the share of biodiesel in heating oil must reach 5% by 2017. While there is an opportunity to expand this mandate (e.g. to B20 by 2035), stakeholders have identified a number of issues related to biodiesel blending that may need to be addressed in order to scale up the biodiesel market.

- **Blending practices.** Blending of biodiesel is typically accomplished at the terminal level through a practice of "splash blending." While straightforward, splash blending can be imprecise and lead to inconsistent blends: fuel dealers have reported seeing blends as high as B24 when testing batches of ostensibly-B5 oil. As disclosure is required for biodiesel blends of B20 or higher, inconsistent blending can expose fuel dealers to liabilities for damages resulting from equipment malfunctions and spills.
- **Equipment limitations on fuel mix.** At higher blend levels, biodiesel can act as a solvent, potentially causing damage to pumps, gaskets, and other boiler components. Although the National Biodiesel Board has identified tanks and systems that are capable of burning up to B20, oil dealers have reported that manufacturers of some equipment used at the distribution level for fuel delivery do not cover greater than B5 in their warranties.
- **Gel point.** Biodiesel tends to "gel" up at a higher temperature than standard heating oil. Thus, in the winter, higher blends of biodiesel may clog filters, pumps, tanks, and other equipment at higher temperatures than No. 2 heating oil. Anti-gel additives can improve flow in cold weather, though fuel dealers have reported problems with such additives in particularly cold temperatures.

A potential approach to addressing some of these issues is to drive investment in infrastructure upgrades at the terminal level. There is currently no infrastructure at the terminal level (e.g. equipment to hold B99 and to enable injection blending at greater than B5 blends) that allows for direct sales of higher blends. Industry stakeholders have estimated the cost of such equipment at roughly $1 million at the terminal level, though it is unlikely that terminal owners will invest in such equipment without an expanded legislative mandate or an incentive. Additional discussion about infrastructure needs and possible approaches for driving such upgrades is provided in Appendix 1: Detailed Policy Recommendations

Additionally, a biodiesel tax exemption is available at the state level, which exempts biodiesel produced in Rhode Island from the state fuel excise tax of $0.32/gallon. However, industry stakeholders have noted

[25] Notably, New York City passed an ordinance that expanded a previous B2 blending mandate to achieve B5 by October 2017, stepping up to B20 by 2034 incrementally. Other states have implemented biofuel blending mandates specifically for transportation fuels.

that monetizing this tax exemption is difficult: oil distributors must track the gallons of biodiesel sold, file for the tax exemption, and pass the savings onto the consumer. Due to the complexity of tracking the gallons of biodiesel sold to consumers at the distribution level (due in part to inconsistent blending) and the fact that the tax credit ultimately amounts to an impact of under $0.02/gallon for a B5 blend, distributors are reluctant to file the necessary paperwork to access the tax exemption. Additional discussion on how the tax exemption might be modified (e.g. by implementing a direct upstream incentive at the production level) is provided in Section 5.3.

5.3 ESTABLISH STABLE, LONG-TERM INCENTIVES FOR RENEWABLE THERMAL TECHNOLOGIES

Table 15. Policy Summary – Long Term Incentives

Policy category	Financing & incentives
Time to Impact	Near and Medium[26]
Size of Impact	High
Estimated Cost	High

Barriers addressed	High system costs Lack of policy support
Technologies included	Air source heat pumps Ground source heat pumps Solar thermal Biomass heating Biodiesel
Implementation timeline	Near-medium

5.3.1 BACKGROUND

There are few existing policy incentives supporting RT market development in Rhode Island. In fact, only ASHPs and solar thermal technologies have benefited from utility and Renewable Energy Fund rebates in Rhode Island, and even these programs have seen mixed use to date. In recent years, several states in the New England region have established robust incentives for RT, primarily funded by a mix of ratepayer charges, forward capacity market revenues, and RGGI revenues.[27] In order to increase the cost-

[26] This recommendation discusses two broad categories of incentive programs discussed under this recommendation. The rebate program is more well-suited for near-term implementation.

[27] For example: the MassCEC Clean Heating and Cooling Program (http://www.masscec.com/get-clean-energy/residential/clean-heating-and-cooling), Efficiency Maine Home Energy Savings Program (http://www.efficiencymaine.com/at-home/home-energy-savings-program/), and the Efficiency Vermont Residential Heating Systems rebate program

competitiveness of RT technologies – and provide consumers with a strong signal of State support for the sector – Rhode Island could develop a robust incentive program for RT technologies across the residential, commercial and industrial sectors. Notably, while other states in the region have incentives in place for residential RT technologies, incentives for commercial and industrial (C&I) applications are more limited and have been slower to emerge, which could present an opportunity for Rhode Island to take leadership.[28] Regardless, such an incentive program should be specifically designed to enable the state to meet proposed RT development targets (see Section 5.2).

5.3.2 POLICY & PROGRAM OPTIONS FOR LONG-TERM INCENTIVES

There are two main options to Rhode Island policymakers when designing an incentive program: (1) a capacity-based (rebate) program or (2) a performance-based incentive. In the near term, it may be most effective to implement a straightforward rebate program, providing a streamlined and simple incentive to jumpstart the market. Over time, performance-based incentives may be more suitable to encourage high performance technologies in the medium and long term. In addition, as described in Box 4, a long-term, identification of a stable funding source to support incentive programs would provide industry leaders the certainty necessary to make investments in the RT market. Key issues for each of these options are described in greater detail in the following sections.

Box 4. Funding RT incentive programs

To develop a long-term sustainable RT market, it is necessary to identify a reliable funding mechanism that ensures policy stability and minimizes market disruptions caused by a "stop-and-go" incentive. RT program funding options may include: (i) a systems benefit charge (SBC) imposed on sales of electricity, gas, and/or delivered fuels (e.g. as is done for renewable electric programs), (ii) revenues from RGGI and FCM, (iii) gross receipts taxes on delivered fuels, or (iv) revenues from statewide carbon pricing.

The pros and cons of each funding source vary and depends largely on the political climate as well as existing statutory limitations.

While a detailed assessment of incentive funding was not performed for Rhode Island, experience in other New England jurisdictions like Massachusetts and New Hampshire suggest that the most straightforward approach is to integrate RT into existing programs. For example, Massachusetts utilized funding from the existing MassCEC Renewable Energy Trust (funded by a systems benefit charge of $0.0005/kWh) to provide rebate funding for the Clean Heating and Cooling program. In addition, both

(https://www.efficiencyvermont.com/Media/Default/docs/rebates/forms/efficiency-vermont-residential-heating-systems-rebate-form.pdf).

[28] While the residential sector accounts for a majority of thermal energy usage in Rhode Island, thermal energy usage in the commercial and industrial sectors account for over 40% of thermal energy usage and roughly 15% of all GHG emissions in the state (derived from RI 2035 Energy Plan).

New Hampshire and Massachusetts have integrated RT into existing portfolio standard programs. As such, Rhode Island may consider adjusting its existing Renewable Energy Fund rules to integrate RT technologies into the state incentive program.

5.3.2.1 Upfront RT Rebate

Rebates offer a number of benefits, which can help jumpstart early-stage markets. Compared to performance-based incentives, rebates are relatively straightforward to implement and simple for customers or installers to monetize. In addition, they do not necessarily require complex modeling or metering to calculate. Rhode Island also has a track record of providing some (limited) rebates for RT technologies, such as the National Grid rebate for ASHPs and the Renewable Energy Fund's rebate for solar hot water systems. An expanded RT rebate program could build off of these existing programs.

While rebates offer a number of advantages to a nascent market, rebate programs do have some drawbacks. In particular, rebate programs can place a significant administrative burden on the authority overseeing the program (e.g. utility, state agency, third-party organization). For example, as discussed in Section 6.2.1, it is estimated that the non-incentive costs to National Grid to administer its electric and gas efficiency programs are approximately 44% of the total cost of these programs (e.g. admin, sales, marketing, technical assistance, etc.). Rebates also typically reward installers or customers for installations and not necessarily system efficiency or performance. This can contribute to the installation of poorly designed or performing systems. Thus, a well-designed rebate program is in best cases accompanied by basic performance requirements and a robust EM&V program to ensure systems are performing efficiently and providing customers with the expected energy savings.

Ultimately, rebates can be structured in a number of different ways, and Rhode Island policymakers should carefully consider design issues if they develop a RT rebate. Key factors may include:

- **Rebate calculation.** States may calculate rebates based on a variety of factors, including size (or capacity), efficiency of a system, or expected performance of the system. For example, most utilities provide ASHP rebates for residential systems of a certain size and efficiency rating (e.g. heating seasonal performance factor and/or seasonal energy efficiency ratio). Alternately, some state programs (e.g. MassCEC Clean Heating and Cooling Program rebates for SHW, California Solar Incentive Thermal Program) calculate rebates based on the expected performance of the system.[29]
- **Rebate adders.** A number of states provide rebate adders to encourage certain actions or to encourage stakeholders to participate in the market. For example, Massachusetts provides a number of rebate adders (on top of a base rebate of $ per heating ton) for its GSHP rebate, including: (1) an efficiency adder for additional rated coefficient of performance (COP) above the minimum of 3.6; (2) rebate adders for households below 80% and 120% of the state median income;

[29] Under the CSI-Thermal Program in California, participants receive an upfront payment based on the expected fuel (e.g. electricity, propane, and gas) displaced in the first year (based on the SRCC Standard 300 ratings). The Massachusetts SHW rebate through the Clean Heating and Cooling program is calculated based on the SRCC OG-100 rating and the number of collectors.

and (3) adders for installations in affordable housing and public/non-profit buildings (MassCEC, 2016a). The Massachusetts SHW rebate also provides adders if installers use components manufactured in the state and if the SHW system is co-located with a solar PV system (MassCEC 2016).

- **Timing and recipient of payment.** Rebates may also vary based upon the time of payment and/or the recipient of the rebate payment. In Massachusetts, for example, rebates are paid out to the installer or customer after the installation is completed. By contrast, ASHP rebates in Vermont are applied at time of sale from the distributor. This means that when installers purchase qualifying equipment from participating distributors, an $800 rebate is immediately applied on the price of purchase, reducing the administrative burden on installers to file individual rebates with the state. Stakeholders suggested Rhode Island consider exploring the opportunity to provide incentives further upstream. Such an approach has been successful, for example, in Connecticut, where Energize CT changed a mail-in rebate for heat pump water heaters to an instant rebate, thereby helping drive an over 500% increase in installations between 2013 and 2014 while reducing administrative costs for both HVAC installers and program administrators (Pernia, 2015).

  In particular, this approach could be ideal for a biodiesel incentive program, where an existing tax exemption that must be claimed at the distributor level and passed on to customers (see Section 2.1.5) has been underutilized. An upstream biodiesel incentive program could take the form of a production rebate or tax credit (e.g. $ per gallon sold), which would enable producers to sell biodiesel to distributors at the same cost as heating oil.
- **Quality assurance program.** As with any program, policymakers should carefully consider the quality assurance program that accompanies a rebate program. This may include, for example, requiring schematic drawings, inspections, or other EM&V requirements to ensure that high quality installations are incented through the rebate program.

5.3.2.2 Performance-based incentives and portfolio standards

Unlike upfront incentives, performance-based incentives[30] compensate RT systems for the heat generated (or saved) by the system (e.g. $/therm or $\$/kWh_{th}$) during a certain period of time (e.g. 10 years). Performance-based incentives can help to maximize the quality of installations by compensating actual production (Veilleux & Rickerson, 2015). In the U.S., performance-based incentives are often integrated into a utility mandate such as a renewable energy standard (RES). In such cases, regulators use the RES to mandate that utilities purchase a certain percentage of their load from renewable resources each year. The regulator establishes a performance-based incentive (e.g. in the form of a renewable energy credit (REC) market) to incentivize production from renewable generators. In such cases, the utility will pay eligible generators for each kWh of renewable energy, and the regulators will use REC procurements as a means to track utility compliance. Accordingly, policymakers will often use performance-based incentives like RECs as a tool to achieve state renewable energy goals or targets (see Section 5.2).

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[30] E.g. feed-in tariffs, tradeable credits, net metering, competitive tenders

It is possible to apply performance-based incentives to the RT market. Within the U.S., Massachusetts and New Hampshire have integrated RT into their alternative portfolio standard and renewable portfolio standard, respectively. In the United Kingdom, the renewable heat incentive (RHI) is structured similar to a feed-in tariff (the preferred renewable energy incentive mechanism used throughout Europe), providing an administratively set tariff to consumers for every unit of renewable heat generated on a pence per kWh basis.[31]

There are some drawbacks to performance-based incentives, which Rhode Island policymakers should consider. Notably, within Rhode Island, some stakeholders expressed concerns about integrating RT technologies into the state RES, due to the fact that the RES was designed to drive increases in renewable electricity sales and because RT technologies will typically replace non-electric fuels like oil, propane, or natural gas. Moreover, metering RT installations can be complicated, which can make managing a performance-based incentive more challenging.

Performance-based incentives can be structured in many ways, and Rhode Island policymakers should carefully consider a number of design factors. The following subsections lay out three considerations related to: (1) establishing heat metering requirements; (2) integrating RT into Rhode Island's Renewable Energy Standard; and (3) integrating RT into a thermal tariff program.

Heat metering

Implementing a performance-based incentive will require metering clear metering standards. While there are a number of different options available for metering different RT technologies, there is currently no standardized approach to metering in the U.S. Both New Hampshire and Massachusetts, as well as the UK Renewable Heat Incentive, can provide a helpful starting point for establishing metering guidelines in Rhode Island.[32] In addition, policymakers may also wish to review status of the U.S. Heat Metering Standard, which is being jointly developed by ASTM International and the International Association of Plumbing and Mechanical Code Officials (IAPMO). The proposed standard will define the general performance (accuracy) and operational characteristics for hydronic heat meter instrumentation, which is an important first step towards greater standardization of metering requirements (EPA, 2016).

Notably, while metering is possible (and often required) for larger installations, the added cost of a meter will increase the already high system cost challenges for residential and smaller commercial installations.

[31] The amount paid to each installation is based on a tariff rate that takes into account the size of the system and the type of technology. Tariff support is delivered in the form of payments made every three months over a contract period that generally lasts 20 years.

[32] New Hampshire RPS thermal metering provisions are available at:

http://www.puc.state.nh.us/sustainable%20energy/Draft%20Large%20System%20Thermal%20Application.pdf; Massachusetts draft metering guidelines are available at:

http://www.mass.gov/eea/docs/doer/renewables/thermal/guideline-on-metering-and-calculationspart-2.pdf; UK Non-Domestic Renewable Heat Incentive "Easy guide to metering requirements" is available at: https://www.ofgem.gov.uk/system/files/docs/2016/07/es957_easyguide_to_metering_2016.pdf.

As such, in many of the performance-based incentives discussed below, metering is not required for small installations. In such cases, less accurate forms of 'performance monitoring' or modeling are used to estimate or validate performance of the system. Alternately, incentive programs can provide rebate adders to cover the additional cost of metering: for example, MassCEC currently provides a rebate adder for SHW systems that covers the cost of metering the installation (MassCEC, 2016).

Integrating RT into the Renewable Energy Standard

Integrating RT into existing state renewable portfolio standards (RPS) has been the approach pursued by New Hampshire and Massachusetts. Through these programs, RT systems of all sizes can receive the relevant renewable energy certificates (e.g. T-RECs in NH and AECs in MA) and associated payments based on their expected or metered production.

- In 2013, New Hampshire established the first carve-out for RT technologies in the nation (2% by 2025) by integrating RT into the total Class I requirement of its RPS. New Hampshire then established a separate schedule of Alternative Compliance Payments (ACP) for thermal energy. The alternative compliance payment for thermal RECs (or T-RECS) was set to slightly less than half of the Class I rate ($25.33/MWh of thermal energy in 2016). This enables utilities to meet their RPS requirement at less expense. The NH thermal RPS covers GSHPs, solar thermal, and biomass thermal. Systems larger than 200,000 Btu/hr must be metered, while smaller systems receive T-RECS based on pre-defined formulas that allow NH PUC to assume the level of production (NH PUC, 2016b).
- In 2014, the Massachusetts Department of Energy Resources was directed to develop a rule to integrate RT into the state's Alternative Portfolio Standard mandate (5% by 2020, which is separate from the state's RPS), which to date has primarily been met through use of eligible combined heat and power systems. The draft rule is currently in public comment period. The proposed MA approach would differ from the NH approach in a number of ways, including: (i) "pre-minting" ten years' worth of credits for smaller systems (to serve effectively as an upfront rebate rather than a steady stream of payments); (ii) including residential and commercial-scale ASHP technologies, biogas, and liquid biofuels; and (iii) providing differing metering requirements and levels of payments on a per AEC basis for each technology and size.

Building on the New Hampshire and Massachusetts Models, OER could work with the Legislature to integrate RT technologies into the RES. This may be accomplished by either (1) establishing a carve-out for RT technologies in the RI RES or (2) by setting up a separate portfolio standard for thermal energy. In either approach, an increasing proportion of thermal energy production from customer-sited sources would need to be derived from RT technologies. Stakeholders have expressed some reservations to establishing a carve-out in the RI RES, articulating interest in preserving the simplicity of the RES relative to other similar state mechanisms. Setting up a separate compliance mechanism could address concerns about adding complexity to the RES, though some stakeholders commented that an alternate approach to using a compliance mechanism could be more straightforward.

Establishing renewable thermal tariffs

While renewable portfolio standards have been the mechanism of choice for driving the deployment of renewable electricity generation in the United States, alternative mechanisms such as feed-in tariffs have also seen success in various state and national markets. Just as jurisdictions are seeking to integrate RT into their RPS programs, there may be opportunities to adapt other incentive schemes that have been successful in the electricity sector to the thermal sector. In particular, the UK's Renewable Heat Incentive offers a model that could be adapted to Rhode Island's needs.

- Renewable Heat Incentive (UK). The UK RHI provides an inflation-indexed tariff for thermal energy generated from RT sources, with different tariff rates and regulations residential (7-year tariff) and non-residential systems (20-year tariff). The RHI rewards generators of biomass technologies, heat pumps, solar thermal, and biogas for heat production, paying consumers a tariff for every unit of renewable heat generated on a pence per kWh basis. Regulators set tariffs in consultation with industry and other stakeholders, designing tariffs to provide system owners with an average internal rate of return (IRR) of 12%. These tariffs may also be reduced (either through "degression" triggers or at the discretion of regulators) over time as progress towards the UK's renewable heating goal (12% of thermal energy from RT by 2020) is made.

  The RHI has been responsible for incentivizing deployment of nearly 25,000 new residential installations since the launch of the residential program in mid-2014 and over 5,000 non-residential installations with nearly 1 GW of heating capacity since the launch of the non-residential program at the end of 2011. Similar to the NH and MA (proposed) portfolio standard rules, metering is required for commercial-scale systems but not for domestic systems. Participating in the residential RHI requires the completion of an energy audit (and issuance of an Energy Performance Certificate), which provides an official figure for expected heat demand in order to calculate tariff payments (Ofgem, 2015a, 2015b).

Within Rhode Island, policymakers could adapt the framework provided by the existing Renewable Energy Growth Program to support RT development. Currently, the Renewable Energy Growth Program aims to achieve a total deployment goal of 160 MW of distributed renewable electricity generation by 2019 through fixed-price, performance-based incentives (15- or 20-year tariffs) for renewable energy projects (National Grid, n.d.). The tariff program currently supports deployment of solar PV, wind, hydroelectric, and anaerobic digestion projects, and the tariff is set annually based on the level necessary to meet the year's goal. Policymakers could adapt this program—or create a parallel but separate initiative—to drive deployment of RT technologies, establishing a $/kWh tariff for homeowners and businesses that generate heating or cooling from RT technologies.

Some stakeholders noted that this option may be more straightforward than establishing an RES compliance mechanism. Others expressed concerns with the potential for a centralized competitive procurement mechanism, noting that many of the smaller contracting firms that currently install RT technologies (especially residential scale) would not be able to effectively compete against larger firms.

5.4 INTEGRATE RENEWABLE THERMAL RECOMMENDATIONS INTO EXECUTIVE ORDER 15-17 (LEAD BY EXAMPLE)

Table 16. Policy Summary – Lead By Example

Policy category	Planning, targets, & mandates
Time to Impact	Long
Size of Impact	Medium
Estimated Cost	High

Barriers addressed	Lack of policy support Low public awareness
Technologies included	Air source heat pumps Ground source heat pumps Solar thermal Biomass heating Biodiesel
Implementation timeline	Near

5.4.1 BACKGROUND

On December 8, 2015, Governor Gina Raimondo signed Executive Order 15-17 "State Agencies to Lead by Example in Energy Efficiency and Clean Energy." The Executive Order mandates numerous energy- and GHG-related goals and actions for State agencies, including, but not limited to: (i) a 100% renewable electricity by 2025 mandate; (ii) a 10% reduction in energy consumption below 2014 levels by 2019; (iii) a 25% zero emissions procurement requirement for new light-duty vehicles by 2025; and (iv) a directive to develop a stretch building code for high performance buildings by 2017 (Raimondo, 2015).

To build upon the Governor's strong leadership on adopting clean energy solutions for state government, OER and its agency partners may consider integrating robust, but achievable RT recommendations into E.O. 15-17. By doing so, Rhode Island can take immediate steps to raise the profile of RT, send a clear signal to the market, and gather crucial performance data on commercial-scale RT technologies that could inform future building code and policy developments for the RT sector.

5.4.2 POLICY OPTIONS FOR A RENEWABLE THERMAL "LEAD BY EXAMPLE" PROGRAM

To implement a Lead by Example program for RT, OER and its State agency partners should articulate clear targets for RT. These may include:

- Completing the ongoing inventory of thermal energy usage across State facilities. RI state agency staff have indicated that a complete inventory of the thermal energy usage of and heating technologies installed at State facilities is currently underway. This inventory should be completed as a preliminary step to integrating RT into a "Lead by Example" program

- Establishing renewable thermal targets. Set a goal of achieving a certain percentage of thermal energy used in State facilities from RT technologies by a certain date. The State would have to design the target to encourage compliance strategies that emphasize adoption of RT over gas conversions or procurement of high-efficiency gas technologies. Alternately, if setting a distinct target for RT in State facilities is not feasible, OER could work with relevant state agencies to issue guidance to all State agencies regarding the role of RT in achieving compliance with EO 15-17. This could include, for example, guidance on how RT can help State agencies in achieving the mandate of at least 10% reduction in energy consumption by FY 2019 (Item 4) and other interim or future goals, as well as providing specific recommendations for RT technologies alongside the emissions reductions measures identified in Item 11.[33]
- Integrating renewable thermal into Stretch Code. As OER coordinates the effort to develop a stretch building code (Item 8), OER should consider integrating RT requirements into the final version of the stretch code (see Appendix for more information), and facilitating State agency adoption of the stretch code during major renovations or new construction.

It is worth noting that, while there is a legally established definition of renewable energy resources (§ 39-26-5) that has been used to guide the development of renewable electric technologies, it does not include any RT technologies.[34] As such, if the State is interesting in pursuing this recommendation, it will be necessary for the State to issue guidance as to the definition of a RT technology – or alternately, work with the legislature to amend the relevant statute to include thermal technologies. There is not currently a commonly-recognized definition for RT across the region. In addition, the State should list all accepted RT technologies into the suggested GHG mitigation activities listed in item 11.

Finally, the State may also consider requiring RT technologies installed in its facilities to be metered (see Section 5.3.2.2 for more information on metering). Data from these installations could be integrated into existing reporting requirements for compliance with State energy/GHG targets.

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[33] Item 11 of E.O. 15-17 identifies a number of GHG mitigation activities for state agencies to consider, including installing renewable energy sources, using more efficient lighting, purchasing ENERGY STAR appliances, installing electric vehicle charging stations, committing to energy targets for new construction, and reducing emissions from employee travel.

[34] § 39-26-5 defines renewable energy resources as "generation units." While solar thermal would be considered a renewable energy technology due to using "direct solar radiation," it would be limited only to concentrated solar thermal generation.

5.5 EXPAND ACCESS TO LOW-COST FINANCING FOR RENEWABLE THERMAL TECHNOLOGIES

Table 17. Policy Summary – Access to Low-Cost Financing

Policy category	Financing & incentives	Barriers addressed	High system costs
Time to Impact	Near-Medium	Technologies included	Air source heat pumps Ground source heat pumps Solar thermal Biomass heating
Size of Impact	High		
Estimated Cost	High	Implementation timeline	Near

5.5.1 BACKGROUND

The high upfront costs of RT systems (relative to fossil fuels) remain a key barrier to deployment. Low-interest financing programs can be offered to reduce the upfront cost burden of RT and drive higher rates of customer adoption.

A number of public and private financing models for RT and other energy projects have been piloted across the U.S. In many cases, publicly-supported equipment loan programs offer more favorable terms than those available in the private sector. Some programs have created revolving loan funds. Others have used credit enhancements to attract financial institutions private investors to the RT market.

For example, Massachusetts offers end-users a 0% interest HEAT Loan (of up to $25,000 over a 7-year term) through the Mass Save program, which helps residential consumers finance high costs of energy efficiency upgrades and was recently expanded to include all residential RT technology installations.[35] This loan program, in conjunction with other incentive programs, is seen as critical to driving uptake of some RT technologies.

Within Rhode Island, National Grid offers a 0% interest HEAT Loan; however, only ASHP, GSHP, and SHW systems are eligible technologies, and they are subject to a number of restrictions. ASHPs and GSHPs, for example, can only be financed if they are replacing existing electric heating systems. As only 9% of residential buildings in Rhode Island use electric heating, this requirement significantly limits the use of the

[35] i.e. ASHP, GSHP (during heating system replacement only), SHW, and pellet boilers

HEAT Loan as a financing tool (National Grid, 2015). Commercial installations are also not eligible for the HEAT Loan, though there are some other financing programs for commercial and government/quasi-government agency buildings. The Rhode Island Infrastructure Bank (RIIB) administers and sponsors a number of statewide infrastructure and facility revolving funds and loan programs for both public and private sector entities (i.e. Efficient Buildings Fund [EBF] and Commercial Property Assessed Clean Energy [C-PACE] program), which could be leveraged more broadly to support RT.

To increase residential customer adoption of RT, OER could work with the Energy Efficiency Resource Management Council (EERMC) and National Grid to remove restrictions and expand the HEAT Loan to encompass all RT technologies. Chief among the changes would be to enable fuel switching opportunities that currently constrain financing of ASHPs and other technologies. In addition, OER could work with the Rhode Island Infrastructure Bank (RIIB) to explore the potential for clarifying the position of RT in RIIB's EBF and C-PACE programs and conducting outreach to property owners and government entities on including RT in the implementation of comprehensive building efficiency measures.

5.5.2 POLICY & PROGRAM OPTIONS FOR FINANCING PROGRAMS

To expand access to low-interest financing for RT, OER and its state agency partners may consider the following options:

- Expand Access to the HEAT loan. OER and EERMC could work with National Grid to expand the HEAT Loan to encompass all RT technologies and consider enabling broader fuel switching opportunities. In such a case, OER may need to work with National Grid to explore the need to broaden the pool of funding used to cover the cost of the HEAT Loan. As the costs of some residential RT technologies may exceed the scope of an expanded HEAT Loan, the launch of a residential PACE program may be needed to cover such projects.
- Integrate renewable thermal into the Efficient Buildings Fund (EBF). The EBF is an energy revolving loan fund that finances cost-effective energy efficiency and renewable energy projects for municipally-owned and quasi-governmental agency buildings. In 2015, the EBF provided $17.2 million in loans to six RI communities (RIIB, 2016). The eligibility of RT projects under the EBF—provided they are able to demonstrate cost-effectiveness—is currently unclear, though RIIB representatives have noted that OER serves as the originating authority for determining eligibility of energy efficiency or renewable energy measures (RI OER, 2015a, 2015b). OER could thus direct RIIB to include cost-effective RT installations as eligible improvements under EBF (e.g. by specifically calling out RT as an eligible energy efficiency project application in the rules and regulations). Additionally, OER could work with RIIB to conduct outreach to eligible entities to encourage including RT as part of a suite of comprehensive building energy efficiency and renewable energy measures.
- Integrate renewable thermal into C-PACE program and outreach. C-PACE is a financing tool that enables commercial real estate owners to finance energy efficiency and renewable energy projects through an assessment on the building's property tax bill. Launched in Rhode Island 2016, C-PACE

is designed to be a broadly applicable commercial financing program with few limits on eligible measures and no savings-to-investment ratio requirement. RIIB representatives have noted that RT measures would qualify under C-PACE—either as eligible measures or as ineligible measures that could be completed alongside other eligible measures (RIIB, 2016a). As with EBF, OER could work with RIIB to specifically call out the eligibility of RT projects. Additionally, RIIB conducts quarterly vendor training sessions and regular outreach to property owners, particularly regarding the adoption of comprehensive building measures. OER could also work with RIIB to integrate RT into such outreach to property owners, contractors, and vendors.

5.6 IMPLEMENT COMMUNITY OUTREACH, EDUCATION & BULK PROCUREMENT PROGRAMS

Table 18. Policy Summary – Community Programs

Policy category	Soft cost reductions	Barriers addressed	High system costs Low public awareness
Time to Impact	Near-Medium	Technologies included	Air source heat pumps Ground source heat pumps Solar thermal Biomass heating
Size of Impact	Medium		
Estimated Cost	Low	Implementation timeline	Near-Medium

5.6.1 BACKGROUND

RT systems are relatively unknown by most customers. As a result, contractors are subject to high "soft costs" due to the amount of time needed to educate consumers about the technology and make a sale. The Solarize model is a grassroots community education and outreach campaign model that has successfully increased adoption of small-scale solar PV by providing system discounts driven by reductions in customer acquisition costs to an aggregated customer base.[36] It offers a promising model that could be adapted to RT sector in order to increase consumer confidence in RT and ultimately help reduce customer

[36] OER is currently providing support for the Solarize RI program, which successfully drove installations of 3.4 MW of new capacity as of October 2016.

acquisition costs for installers. As described in Box 5, a number of communities have already begun to deploy this approach for the RT sector.

Box 5. Adapting the "Solarize" model for renewable heat

In 2015, OER established Solarize Rhode Island as a partnership with Commerce RI and SmartPower to provide grants to support communities interested in implementing community bulk purchasing programs for solar PV. OER has the opportunity to adapt the Solarize model to include RT technologies, applying lessons learned from Solarize RI and other communities that have piloted similar RT campaigns.

A number of community groups in the U.S. have piloted – or are launching – bulk procurement models for RT technologies in neighboring states:

- **MA Dept. of Energy Resources.** Through its Renewable Thermal Business Investment Grant Program, DOER funded development of an online and technical assistance platform and two pilot campaigns for air source heat pumps in the Western MA and Greater Boston regions from 2015-2016. These campaigns primarily focused on engaging oil heat dealers that also offered air source heat pumps to customers.
- **HeatSmart Tompkins.** Residents of Tompkins County, NY established Solar Tompkins in 2013 to serve as a local community non-profit to drive adoption of solar PV. After two successful rounds of Solarize campaigns, Solar Tompkins implemented HeatSmart Tompkins between fall 2015 and spring 2016 to educate and promote the adoption of energy efficiency measures and heat pumps for space and water heating.
- **Renewable Thermal Solutions in New England.** In fall of 2016, a group of five New England cities (Boston, Providence, Somerville, Northampton, and Portland) were awarded a grant through the Carbon Neutral Cities Alliance (CNCA) Innovation Fund to design and implement RT-related outreach and procurement campaigns in their respective cities. These campaigns will be proceeded by in-depth market segmentation analyses and are expected to be launched in Q2 and Q3 of 2017.

5.6.2 POLICY & PROGRAM OPTIONS FOR EDUCATION & OUTREACH INITIATIVES

Rhode Island could consider developing a community-based bulk procurement program similar to Solarize RI to drive outreach and adoption of RT technologies across the state. OER could fund pilots with different campaign designs in a few jurisdictions, building on lessons learned from the Providence CNCA pilot and campaigns in other states. Rhode Island may consider the following recommendations for implementing such a program:

- Contractor education on consumer outreach programs. Outreach to local contractors in advance of any pilot program launches should be conducted, as many HVAC contractors are unfamiliar with the Solarize model and may not understand the goals of the outreach programs, how best to position themselves to be selected by a community, or how to maximize outreach and number of lead conversions. This approach has been utilized with success in some Solarize-style campaigns, including in New York State through Community Solar NY.

- Additional contractor considerations. Solarize campaigns are frequently designed to solicit one installer that can provide the best pricing and customer service to the community. As such, Solarize campaigns across the Northeast (and in RI) have on many occasions been served by larger national installation firms that can offer more favorable pricing due to scale.[37] By comparison, the HVAC contractor industry is typically composed of smaller, more localized firms that may be more sensitive to competition from larger external firms; may perceive selecting an exclusive installer to serve a state-supported community campaign as favoritism; and may face challenges in meeting significantly greater demand from a campaign. It may be worth considering using multiple local installers for some of the pilot campaigns – though using multiple installers in a campaign can come with other tradeoffs, including reduced opportunities for discounts and greater consumer challenges in evaluating different quotes from different installation companies. Each community will need to evaluate the appropriate contractor arrangement for their context, and it may be beneficial to be less prescriptive and provide greater flexibility to communities in terms of campaign design in the initial pilots.
- Test different campaign design options. While Solarize campaigns are typically based on a well-established model, the optimal approach for RT campaign design has not yet been established and likely will vary significantly based on the community. Campaign organizers will have to make a number of different decisions with respect to campaign design, including the technologies and offer to be provided through the campaign (e.g. a single RT technology, multiple technologies, combinations with energy efficiency upgrades, etc.), the number and type of contractors to engage. If OER is interested in implementing a similar statewide program to Solarize RI for heat, OER could consider testing significantly different approaches to designing each of the pilot campaigns before further scale-up.
- Conduct market analyses prior to campaign implementation. As discussed throughout this report, RT technologies are less well-known than solar PV and face significant cost-effectiveness challenges relative to natural gas. Given the significant differences between evaluating building configurations for RT technologies (relative to roof configurations for solar PV), it can be more challenging to increase the value of high-quality leads. As such, in order to maximize the value of the leads provided to contractors (and thus the potential savings that can be passed on to consumers), OER could consider working with pilot communities to conduct market segmentation analyses to identify ideal candidates for the RT technology to be deployed.

[37] 25 of the 51 Solarize Mass campaigns between 2011 and 2015, as well as the 2015 Mass Solar Connect were served by either RGS Energy or Direct Energy Solar (MassCEC, n.d.).

SECTION 6 RENEWABLE THERMAL MARKET IMPACTS

6.1 INTRODUCTION AND OVERVIEW

This analysis investigates the impacts of a large-scale investment in Renewable Thermal (RT) technologies in Rhode Island, including:

- An evaluation of the net statewide economic costs and benefits of a large-scale RT program, as evaluated through the Rhode Island Total Resource Cost Test;
- A financial evaluation of RT technologies and applications from the program participant perspective;
- An evaluation of the financial impact of a RT program on non-participating state ratepayers; and
- An investigation of the employment impacts of a large-scale RT program.

This arrangement of policy metrics is designed to provide state policymakers and industry stakeholders with information regarding the impacts of making a strong policy investment in RT in Rhode Island. Additionally, this analysis is designed to show how the economic impacts of RT technologies may change depending on several key scenarios of interest (such as changes in fuel prices or technology installation costs).

6.1.1 EVALUATION FRAMEWORK: MULTI-STAKEHOLDER PERSPECTIVES

Demand-side energy programs can have financial impacts for program participants, statewide ratepayers, and the net state economy. Depending on the perspective used to evaluate a RT program, different costs and benefits will be considered. Program financial impacts often vary across perspectives: A particular installation may provide net economic benefits for the state of Rhode Island as a whole, but still may not provide an attractive payback for an end customer. Therefore, this study incorporates a multi-stakeholder approach, which separately evaluated costs and benefits from multiple perspectives and presents output metrics that are relevant to each.

This analysis considers the costs and benefits of a RT program from the following perspectives:

- The Statewide Economic Perspective. The statewide perspective provides a general accounting of the costs and benefits expected to accrue to the state as whole. Rather than evaluating whether a given RT installation provides an adequate return or payback for a given customer, the statewide perspective evaluates whether the lifetime benefits that will accrue to the state of Rhode Island (i.e.

wholesale energy cost savings, price suppression effects, and non-energy benefits) outweigh the lifetime costs of a large-scale RT program (i.e. incremental installation costs, program administrative costs, and any added energy expenditures).

In this analysis, the statewide economic perspective is assessed using the Rhode Island Total Resource Cost Test[38] – which is presently used to evaluate energy efficiency demand-side management programs in the state. This consistency allows the costs and benefits of RT in Rhode Island to be contextualized and compared to the costs and benefits of the state's existing energy efficiency programs. Results are presented in terms of the ratio of lifetime net present value benefits to lifetime net present value costs. If lifetime benefits outweigh lifetime costs, the program presents a net economic benefit to the state of Rhode Island.

- The Participant Perspective. The participant perspective evaluates the lifetime financial benefits that RT installations are expected to provide to program participants – with benefits based strictly on expected energy savings and ignoring non-energy benefits.[39]
- The Program Administrator Perspective. Also frequently described as the Utility Perspective, this perspective evaluates whether the value of the wholesale benefits included in the statewide economic perspective exceed the program incentive and administrative costs that would be incurred by a state or utility program administrator.
- The Ratepayer Perspective. RT programs may impact non-participating gas and electricity ratepayers throughout the state. There will be two primary factors that impact state ratepayers: (1) changes to total utility gas and electricity sales caused by RT adoption could impact the retail rate necessary to maintain utility revenue requirements, and (2) program incentive and administrative costs must be recovered. [40]

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[38] Where possible, this analysis conformed to the methodology and data sources used in the Rhode Island Total Resource Cost Test, which is used to evaluate electricity and natural gas energy efficiency programs in Rhode Island. This includes incorporating Demand Reduction Induced Price Effects (DRIPE) and non-energy benefits (such as improved safety, thermal comfort, property value increase, etc). Inputs and methodology are based on the 2016 Rhode Island Technical Reference Manual, the 2015 New England Avoided Energy Supply Costs report and the 2016 National Grid Rhode Island Energy Efficiency Program Plan.

[39] As Rhode Island does not conduct a Participant Cost Test as a formal part of the evaluation of energy efficiency programs in the state, this analysis followed the methodology of the Participant Cost Test as laid out in the California Standard Practice Manual, which is the methodological basis for most demand-side management program evaluation frameworks in the United States, including the Rhode Island TRC.

[40] This analysis assumes that necessary program incentive and administrative costs would be funded through an added charge on Rhode Island state electricity rates. Numerous other funding mechanisms may be considered for RT programming – such as an added charge on utility gas rates, an added charge on all home energy consumption (including electricity, gas, and delivered fuels), or a non-rate-based funding source (such as tax revenue). This analysis assumes an added charge on electricity rates both for modelling simplicity and because this approach has been used to fund RT incentive programs in the region (i.e. the Massachusetts Clean Energy Center's Clean Heating and Cooling incentive programs). Additionally, the assumption that costs would be recovered via a charge on electricity rates rather than natural gas rates would equitably spread the costs of a program across all Rhode Island utility customers, rather than the specific subset of Rhode Island homes and businesses that use natural gas heat (and who would be expected to have minimal participation in RT programming).

The ratepayer impact portion of this analysis evaluates the direction and magnitude of any financial impacts on non-participating ratepayers that would result from a large-scale RT program.

6.1.2 EVALUATION MEASURES: TECHNOLOGIES AND APPLICATIONS

This analysis evaluates impacts of four of the most common installed RT technologies: ASHPs, GSHPs, Solar Hot Water, and central biomass boilers.[41]

This analysis evaluates **residential single family**, **multifamily**, and **commercial** installations for each of the above technologies.[42] In developing a portfolio of projects to evaluate, this analysis assumed that the vast majority of installations would occur in the residential single-family sector.[43]

Measures were also differentiated based on the current heating fuel and technology. This analysis considered the economics of converting buildings heated by electricity resistance heat, natural gas-fired furnaces or boilers, and oil-fired furnaces or boilers.

Participation counts were allocated across current heating technologies based on the presence of different home heating technologies in Rhode Island[44] and the economics of RT installations replacing different current heat fuels. Accordingly, it was assumed that the roughly three quarters of RT installations would displace home heating oil.

Consistent with Rhode Island's targets of addressing thermal heating load, this analysis only considers impacts on space and water heating load, and specifically excludes cooling impacts. The decision to exclude cooling impacts was based on uncertainty regarding existing cooling equipment. If a home or business currently has whole-building cooling, an air or ground source heat pump will provide additional energy and cost savings due to improved cooling efficiencies compared to most standard cooling equipment. If a building does not presently have cooling, an ASHP or GSHP installation will lead to increased cooling energy consumption and costs, but will also provide participants with a substantial non-financial benefit

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[41] This analysis focuses on RT technologies that entail physical installations at a customer site. Increased biofuel blending in home heating oil delivered supply is an additional means of achieving state RT goals, and is considered in the full pending *Renewable Thermal Market Development Strategy*, but is not included in this analysis.

[42] It is assumed that residential biomass boiler systems would consume wood pellets, while commercial biomass boiler systems would consume wood chips.

[43] Specifically, it was assumed that 85% of installations would occur in the single family residential sector, 10% would occur in the multifamily sector, and 5% would occur in the commercial sector. This arrangement reflected the large focus on residential renewable thermal applications in regional incentive programs to date, the relatively low barriers to single-family project development compared to other sectors, and the increased certainty regarding measure inputs in the single family sector compared to the multifamily and commercial sectors.

[44] Determined using Census Bureau American Community Survey (ACS) data for residential buildings and Energy Information Administration Commercial Building Energy Consumption Survey (CBECS) data for commercial buildings.

(that is, space cooling). Given this ambiguity and the focus on renewable heating energy, cooling impacts are not considered in the below financial analysis.

6.1.3 EVALUATION SCENARIOS: SATURATION PERCENTAGES AND MARKET ASSUMPTIONS

This analysis evaluates the impacts of a RT scale-up at several penetration levels, considered as a percentage of the state's overall thermal load to be achieved by the year 2035, the final year included in the Rhode Island State Energy Plan (RISEP).[45]

The base scenario considered in this analysis is one where renewable heat accounts for 5% of the statewide thermal load by the year 2035.[46] To provide high and low estimates of potential impacts, additional scenarios were modelled to evaluate impacts of RT programs accounting for 2% and 10% of statewide thermal load by 2035.[47] For the purposes of this analysis, it was assumed that all ASHP installations would require an incentive, and this analysis does not model cost reductions over time. In reality, it is reasonable to assume that costs will decrease over time as the market grows, reducing the need for RT incentives.

In addition, this evaluation includes sensitivity analyses on two key determinants of RT program cost-effectiveness: thermal energy prices and technology installation costs. The former considered an increase in fossil fuel costs, and was modeled by utilizing the natural gas and home heating oil avoided energy prices applicable in 2013 (prior to the recent decline in global oil prices).[48] The latter considered a decrease in RT installation costs, and was modeled by assuming an across-the-board 20% reduction in RT installation costs, assumed to be achieved by either hard or soft cost reductions. Additionally, a final sensitivity analysis scenario was conducted that evaluated both a reversion to higher 2013 energy prices and a 20% decrease in installation costs.

6.1.4 MODEL DATA SOURCES AND ASSUMPTIONS

Additional data sources and assumptions are provided in Appendix A to this report.

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[45] Thermal load was determined from the RISEP, and excludes the industrial sector. As the RISEP does not identify the share of electricity consumption used for space heat load, this was estimated from the US Energy Information Administration's Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Survey (CBECS).

[46] This scenario was selected through conversations with OER staff and would amount to an aggressive scale-up in RT installations that is in a similar range as other regional policy targets.

[47] The 10% high-penetration scenario, while aggressive by American standards, is in line with or below renewable thermal targets in Europe. The United Kingdom, for example, targets 12% renewable heat by 2020. The 2% low-penetration scenario would still amount to a substantial increase in the rate of RT installations in Rhode Island, and would require Rhode Island to achieve an average installation rate through 2035 that is approximately double the per-capita rate of RT installations currently occurring in Massachusetts through the Massachusetts Clean Energy Center incentive programs.

[48] For this sensitivity analysis, the 2013 New England Annual Energy Supply Costs study was used. The 2015 version of this study was used for the base version of the analysis.

6.2 FINANCIAL IMPACTS

6.2.1 TOTAL RESOURCE COST (TRC) ANALYSIS

The Total Resource Cost (TRC) Test evaluates statewide costs and benefits that can be expected to result from a large-scale investment in RT in Rhode Island. The primary benefit considered in a TRC test is the avoided cost of non-consumed energy.[49] In Rhode Island, the TRC test also includes Demand Reduction Induced Price Effects (DRIPE)[50] and also goes beyond strict financial impacts to monetize and evaluate non-energy benefits (such as improved home comfort, increased property values, etc.).

TRC costs include the incremental cost of installed RT equipment (where appropriate),[51] administrative costs of managing a RT incentive program,[52] the added fuel costs of RT technologies,[53] as well as any DRIPE associated with these added fuel costs.

Typically, results are expressed as a ratio of lifetime net present value benefits to lifetime net present value costs. If lifetime benefits outweigh lifetime costs, the portfolio is considered to yield net economic benefits to the state of Rhode Island.

Portfolio-Level Cost-Benefit Results:

Table 19 demonstrates the portfolio-level results of the base scenario (5% of thermal load) as well as the low- and high-impact scenarios (2% and 10% of thermal load). Under the base scenario, an RT portfolio that aims to account for 5% of Rhode Island's thermal load by 2035 is expected to yield $200 million in lifetime net benefits for the state, at a benefit-cost ratio of 1.18.

[49] The TRC values energy savings at the system-level avoided costs rather than end-customer retail rates as retail rates are considered a transfer payment between actors within the state, and are not net costs or benefits to the state. Avoided electricity capacity costs are not included in this analysis because the Rhode Island TRC does not currently value winter peak reductions (as Rhode Island has a summer electricity peak).

[50] DRIPE refers to the price-suppression effect that decreased electricity or natural gas purchases will have on the wholesale energy prices. As demand will decrease, prices are expected to decline slightly for all ratepayers. It was assumed that there would be no price suppression effect on the price of fuel oil, given the global nature of the market.

[51] This depends on whether (1) a customer would have purchased standard heating equipment if they had not installed RT equipment (such as a situation when current heating equipment failed, or in the case of new construction), in which case only the incremental cost of an RT installation is considered, or if (2) a customer would not have purchased new heating equipment if RT equipment were not installed, in which case the full measure cost is considered. In this analysis, it was assumed that the full cost of all SHW installations and ASHP installations supported by existing heating equipment would be considered, while all other installations would occur in replace-on-burnout settings where only the incremental cost should be considered.

[52] The costs of incentives themselves are not considered in a TRC test, as these are also considered a transfer payment between actors within the state.

[53] For example, if an oil-heated customer installed an ASHP, that customer would pay increased electricity costs.

Table 19. TRC Portfolio Results by Impact level

Targeted Impact	Lifetime Benefits	Lifetime Costs	Lifetime Net Benefits	Benefit-Cost Ratio
Low-Impact Scenario (2%)	$499,184,227	$452,110,071	$47,074,156	1.10
Base Scenario (5%)	**$1,239,572,340**	**$1,046,388,849**	**$193,183,491**	**1.18**
High-Impact Scenario (10%)	$2,487,223,364	$2,043,708,932	$443,514,432	1.22

Cost-Benefit Impacts by Cost Component:

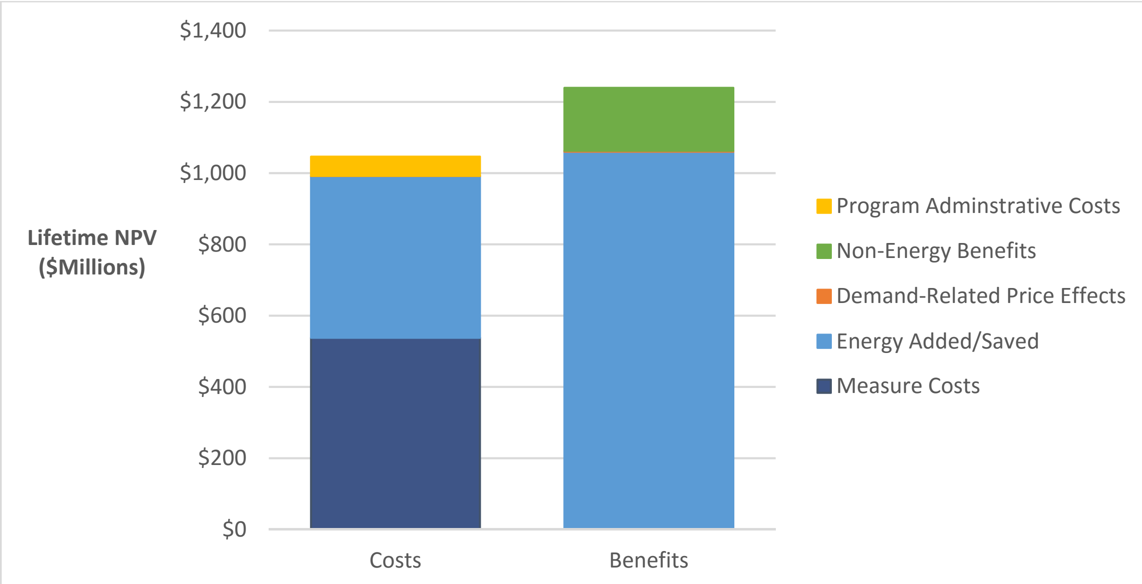
Figure 5 below shows the breakdown of the different cost components discussed above in the base (5% of thermal load) scenario. TRC costs are split nearly evenly between measure installation costs and added energy costs (primarily heat pump electricity consumption with some wood pellet or chip consumption included), with administrative costs accounting for the small remainder. TRC benefits are made up mainly by avoided energy costs, with quantified non-energy benefits providing most of the remainder.[54]

Specific non-energy benefits included in this analysis (and quantified in the evaluation of National Grid Rhode Island efficiency programs) include: improved home comfort and durability, improved safety, reduced equipment maintenance costs, health benefits, increased property value and commercial rents, and national security benefits from reduced fossil fuel imports. Environmental and employment impacts are not quantified in the Rhode Island TRC and are not included here (though they are discussed separately in the sections below).

While non-energy benefits account for approximately 14% of all TRC lifetime benefits, it is important to note that the base TRC scenario would still be cost-effective even if these were not counted. The value of avoided energy costs alone (with a $106 million lifetime NPV) are enough to exceed lifetime costs and provide $14 million in lifetime benefits to the state of Rhode Island.

[54] DRIPE accounts for only a very small amount of both net TRC costs and benefits. This is because the 2015 NE AESC assumed a significant decrease in the overall value of DRIPE impacts, particularly after the year 2018.

Figure 5. Stacked TRC Costs and Benefits in the Base Scenario (5% thermal load served by RT by 2035)



Policy Cost and Investment

Such an investment in RT projects would require a significant investment by the state of Rhode Island, both in the form of measure incentives (assumed incentive levels are discussed in the Participant Cost Analysis section below) and administrative costs.[55]

Administrative costs are estimated based on the ratio of administrative to incentive spending planned by National Grid in its 2016 Rhode Island Energy Efficiency Program Plan. In the 2016 Plan, National Grid budgets for non-incentive cost expenditures that are 44% of the value of the program incentives provided, and it is assumed that a RT program in Rhode Island would experience a similar rate of non-incentive spending.

In the base scenario targeting 5% of thermal load, program implementers are expected to incur roughly $134 million in incentive expenditures through 2035 based on the incentive levels and participation rates assumed in this analysis. Based on the current rate of National Grid administrative cost spending, it is assumed that program implementers would experience an additional cost of roughly $59 million through 2035 for a total undiscounted program cost of $193 million.

Sensitivity Analysis

As noted above, this evaluation includes a sensitivity analysis that considers how results may change in several potential scenarios:

[55] The calculation of statewide costs and benefits accounts for administrative costs. Incentive payments are not directly included in the Rhode Island TRC, but the full incremental cost of RT installations (which is greater than assumed incentive levels) is included as a TRC cost category.

- A reversion to 2013 fossil fuel prices. The price of fuel oil and natural gas are primary drivers of the economic viability of RT technologies. This is particularly notable for fuel oil which, as a more expensive fuel than natural gas, presents a better financial opportunity for conversion to RT. In recent years, the price of fuel oil has declined substantially, limiting the cost-effectiveness of RT technologies. This scenario considers cost-effectiveness of RT if the recent price decrease in fossil fuels were reversed by utilizing 2013 fossil fuel prices (which entails an increase in the price of fuel oil by roughly 50%).
- A 20% reduction in RT installation costs. Another key driver of RT cost effectiveness is a reduction in the installed costs of RT technologies, either as a natural result of market growth or as driven by policy intervention. This scenario considers a hypothetical installed cost reduction of 20%.
- The interaction of the two above effects.

Table 20 compares the results of each of these to the base model (assuming a targeted thermal load impact of 5% for all scenarios). Each of these scenarios represents an improvement in the cost-benefit picture compared to the base model, though the greater impact would be a return to 2013 fossil fuel prices. This reflects the central role that oil prices have in determining the opportunities for and cost-effectiveness of RT market growth in Rhode Island.

If the recent decline in oil prices were to be reversed, and RT installation costs were also to decline 20% either through hard or soft cost reductions, the overall benefit-cost ratio of the portfolio of RT installations would increase to 1.80, and the state's net lifetime benefits would increase to over $740 million.

Table 20. TRC Portfolio Results by Model Scenario (Assumes "5% of Thermal Load" Impact Level)

Sensitivity Scenario	Lifetime Benefits	Lifetime Costs	Lifetime Net Benefits	Cost-Benefit Ratio
Base Model	$1,239,572,340	$1,046,388,849	$193,183,491	1.18
2013 Fossil Fuel Prices	$1,670,366,899	$1,046,389,287	$623,977,611	1.60
Reduced RT Costs	$1,239,572,340	$926,494,420	$313,077,920	1.34
Interaction of Effects	$1,670,366,899	$926,494,858	$743,872,040	1.80

Measure-Level Results

The results above refer to a portfolio of RT installations, with installation rates among different technologies and sectors determined by combination of market segmentation, measure cost-effectiveness, and current market size in Rhode Island and other regional markets. The cost-effectiveness of specific RT measures varies significantly both across RT technologies and based on factors such as customer sector and current heating fuel and technology.

Below, Table 21 shows measure-level TRC results for each measure included in this study (for the base scenario). These results do not account for administrative costs, which are considered only at the portfolio level.

Generally, ASHPs offer the greatest opportunities for cost-effective installations from the TRC perspective, while GSHPs, biomass boilers, and SHW installations are only cost-effective in specific circumstances. Across the board, there are very few opportunities to cost-effectively displace natural gas, which is a more affordable than electric or oil heat on per-MMBtu basis. Fuels such as propane and wood, which each serve roughly two percent of the Rhode Island households, are not included as baseline heating fuels in this analysis (U.S. Census Bureau, 2015).

Table 21. Measure-Level TRC Cost-Benefit Ratios (Base Model)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	1.39	0.83	0.83	1.55	1.55
	GSHP	0.62	0.40	0.42	0.83	0.88
	Pellet Boiler			0.41		0.87
Residential MF	ASHP	1.46	0.79	0.79	1.66	1.66
	GSHP	0.71	0.42	0.44	0.97	1.01
	Pellet Boiler			0.38		0.86
Commercial	ASHP	3.26	0.66		1.42	
	GSHP	1.99	0.41		0.87	
	Wood Chip Boiler		0.48		1.05	
Water Heat		Electric	Gas		Oil	
Residential SF	Solar Hot Water	0.58	0.38		0.96	
Residential MF	Solar Hot Water	0.83	0.53		1.38	
Commercial	Solar Hot Water	1.72	0.37		1.17	

The cost-effectiveness of specific measures can change dramatically, however, with changes in fossil fuel prices and technology installation costs. Table 22 shows how measure-level benefit-cost ratios would change in a scenario where fossil fuel prices revert to 2013 levels and technology costs decrease. In this scenario, every RT technology would be a cost-effective replacement for oil heat, and opportunities for cost-effective replacements of other technologies would also increase.

Table 22. Measure-Level TRC Cost-Benefit Ratios (Interaction of Fossil Fuel & Technology Cost Adjustments)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	1.59	0.98	0.98	2.47	2.47
	GSHP	0.75	0.50	0.53	1.46	1.56
	Pellet Boiler			0.47		1.35
Residential MF	ASHP	1.65	0.92	0.92	2.68	2.68
	GSHP	0.85	0.53	0.56	1.73	1.84
	Pellet Boiler			0.43		1.36
Commercial	ASHP	3.68	0.78		2.41	
	GSHP	2.49	0.53		1.63	
	Wood Chip Boiler		0.56		1.75	
Water Heat		**Electric**	**Gas**		**Oil**	
Residential SF	Solar Hot Water	0.72	0.46		1.75	
Residential MF	Solar Hot Water	1.03	0.64		2.52	
Commercial	Solar Hot Water	2.15	0.49		2.20	

6.2.2 PARTICIPANT COST ANALYSIS

The Participant Cost Test (PCT) evaluates the cost-effectiveness of a given measure from the perspective of a program participant. From the participant perspective, costs include the incremental cost of installing a given RT measure as well as the energy costs of the installed RT equipment.[56] Participant benefits include retail energy costs saved by not utilizing the baseline heating system, as well as the value of any incentives. This analysis does not include non-energy benefits in the calculation of participant cost-effectiveness, and bases the analysis solely on the comparison of installation costs and energy savings.

As an RT incentive program has not been put into place in Rhode Island, this analysis hypothetically assumed that incentive levels be put into place that are equivalent to those currently offered in Massachusetts by the Massachusetts Clean Energy Center. The specific incentives included in this analysis are:

- ASHPs: $625 per single-head system
- GSHPs: $1,500 per ton

[56] In the Participant Cost Test, only retail energy savings are considered.

- **Biomass Boilers:** 45% of project cost up to $10,000.
- **SHW**: Calculated value multiplying $100 by the Solar Rating & Certification Commission OG-100 product rating, multiplied by the number of collectors, up to 40% of project cost.

As with the TRC test, PCT results are frequently reported as the ratio of lifetime benefits to lifetime costs.

Measure-Level Results

Table 23 details the PCT cost-benefit results for each individual measure.

Generally, even with incentives in place, there are limited opportunities for cost-effective measure installations for participants – reflecting the difficult economics that have confronted the RT sector at a time when oil prices have declined. Most cost-effective installation opportunities that do exist target electric resistance heat, though some opportunities for cost-effective installations targeting conversion from oil heat do exist as well.[57]

As this analysis does not take into account cooling loads or non-energy benefits, it ignores the real possibility that a number of Rhode Island residents and business will choose to install RT technologies in based on benefits that are not captured in this analysis. However, scaling the market may require larger incentive levels or larger macro-level changes in fuel prices and installations costs.

Table 23. Measure-Level PCT Cost-Benefit Ratios (Base Model)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	1.30	0.53	0.53	0.75	0.75
	GSHP	0.78	0.41	0.43	0.59	0.62
	Pellet Boiler			0.61		0.86
Residential MF	ASHP	1.52	0.61	0.61	0.87	0.87
	GSHP	0.95	0.47	0.49	0.68	0.72
	Pellet Boiler			0.62		0.89
Commercial	ASHP	1.53	0.63		0.88	
	GSHP	1.13	0.54		0.71	
	Wood Chip Boiler		0.88		1.14	

[57] Generally, the TRC test presents more cost-effective options for RT installations than the PCT test. A primary reason for this is the difference in discounts rates incorporated in the analysis. Following the approach detailed by National Grid in its 2016 Energy Efficiency Program Plan, the TRC analysis uses a real discount rate of 0.44% based on the 20-year US Treasury Note to reflect the low-risk nature and long-term benefits of RT resources. However, the PCT analysis uses a much higher discount rate of 8% to represent the payback requirements that program participants may expect from RT installations.

Water Heat		Electric	Gas	Oil
Residential SF	Solar Hot Water	0.97	0.68	0.87
Residential MF	Solar Hot Water	1.22	0.80	1.08
Commercial	Solar Hot Water	1.13	0.78	1.03

As with measure-level TRC results, participant cost-benefit results change dramatically in the scenario analysis. In a scenario where fossil fuel prices have increased and technology costs have decreased, nearly all RT applications that replace electricity and fuel oil are cost-effective. This underscores both the substantial impact of global oil prices on the RT industry as well as the potential benefits of any policy or technology efforts to lower the installation costs of RT installations.

Table 24. Measure-Level PCT Cost-Benefit Ratios (Interaction of Fossil Fuel & Technology Cost Adjustments)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	1.49	0.62	0.62	1.24	1.24
	GSHP	0.94	0.51	0.54	0.99	1.05
	Pellet Boiler			0.65		1.26
Residential MF	ASHP	1.71	0.70	0.70	1.43	1.43
	GSHP	1.13	0.58	0.61	1.16	1.23
	Pellet Boiler			0.66		1.32
Commercial	ASHP	1.72	0.72		1.45	
	GSHP	1.41	0.69		1.22	
	Wood Chip Boiler		0.98		1.76	
Water Heat		**Electric**	**Gas**		**Oil**	
Residential SF	Solar Hot Water	1.21	0.86		1.38	
Residential MF	Solar Hot Water	1.52	1.01		1.78	
Commercial	Solar Hot Water	1.42	0.99		1.69	

6.2.3 PROGRAM ADMINISTRATOR COST ANALYSIS

The Program Administrator Cost Test (PACT) (sometimes called the Utility Cost Test) evaluates program cost-effectiveness from the perspective of the utility or other program implementer who is responsible for administering a program. For program administrators, the key consideration is whether the benefits of avoided energy cost savings (also used in the TRC analysis) outweigh the costs of administering a program (that is, incentive costs plus administrative costs). For a utility program implementer, a cost-effective program will lead to an overall reduction in the costs of serving customer energy needs.

This analysis assesses the PACT according to the methodology established in the California Standard Practice Manual. As this is a fuel-switching program, avoided costs from multiple fuels (including fuel oil, for which energy savings would not impact a utility implementer) are included in the calculation of Program Administrator benefits. This analysis includes energy savings from unregulated fuels (such as fuel oil) in the calculation of the PACT, consistent with the intent of determining the most cost-effective means of meeting end-use customer energy needs.

PACT results are presented on a measure-by-measure basis, and also at the portfolio level.

Measure-Level Results

Table 25 details the PACT cost-benefit results for each individual measure. As with the TRC measure-level results presented above, the measure benefit-cost ratios below do not account for administrative costs, which are considered at the portfolio level.

At the assumed incentive levels, ASHP and GSHP heat pumps provide clear lifetime wholesale cost reductions in applications that replace electric or oil heat, as well as solar hot water that replaces oil heat. Wood pellet boilers and most measures that replace gas heat do not pass the PACT under the base case.

Table 25. Measure-Level PACT Cost-Benefit Ratios (Base Model)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	2.11	0.98	0.98	2.25	2.25
	GSHP	1.28	0.60	0.60	1.39	1.39
	Pellet Boiler			0.28		0.63
Residential MF	ASHP	2.32	1.08	1.08	2.47	2.47
	GSHP	1.56	0.73	0.73	1.69	1.69
	Pellet Boiler			0.31		0.70
Commercial	ASHP	2.38	0.98		2.44	
	GSHP	1.61	0.67		1.67	
	Wood Chip Boiler		0.38		0.95	
Water Heat		**Electric**	**Gas**		**Oil**	
Residential SF	Solar Hot Water	0.69	0.41		1.11	
Residential MF	Solar Hot Water	1.00	0.59		1.61	

Commercial	Solar Hot Water	0.93	0.48	1.50

As with the TRC and PCT impacts, PACT measure cost-effectiveness was also considered in a scenario that assumes both a return to 2013 oil prices and a 20% reduction in installed costs. In this scenario, wood pellet boilers become cost effective from the PACT perspective, but most measures replacing gas heat do not.

Table 26. Measure-Level PACT Cost-Benefit Ratios (Interaction of Fossil Fuel & Technology Cost Adjustments)

Space Heat		Electric	Gas		Oil	
			Furnace	Boiler	Furnace	Boiler
Residential SF	ASHP	2.11	1.01	1.01	3.41	3.41
	GSHP	1.28	0.62	0.62	2.10	2.10
	Pellet Boiler			0.31		1.04
Residential MF	ASHP	2.32	1.11	1.11	3.75	3.75
	GSHP	1.56	0.76	0.76	2.56	2.56
	Pellet Boiler			0.34		1.14
Commercial	ASHP	2.38	1.02		3.69	
	GSHP	1.61	0.70		2.54	
	Wood Chip Boiler		0.43		1.55	
Water Heat		**Electric**	**Gas**		**Oil**	
Residential SF	Solar Hot Water	0.69	0.38		1.68	
Residential MF	Solar Hot Water	1.00	0.56		2.44	
Commercial	Solar Hot Water	0.93	0.50		2.28	

Portfolio-Level Cost-Benefit Results:

Table 27 shows the portfolio-level results of the Program Administrator Cost Test under the 2%, 5%, and 10% thermal load scenarios. Additionally, portfolio results are shown for a scenario that assumes both a return to 2013 fossil fuel prices and a 20% installed cost reduction (and an impact equal to 5% of thermal load).

In the base 5% impact scenario, the RT portfolio would accrue discounted lifetime benefits of roughly $250 million from the program administrator perspective (in the form of avoided energy costs) and costs of roughly $175 million (in the form of program administrative and incentive costs and increased electricity supply costs from heat pump consumption). The portfolio is cost-effective with a benefit-cost ratio of 1.42.

Under the interaction scenario that assumes both 2013 fossil fuel prices and a 20% cost reduction, the ratio of NPV benefits to NPV costs grows to 2.01.

Table 27. PACT Portfolio Results by Impact level (Base Model)

Targeted Impact	Lifetime Benefits	Lifetime Costs	Lifetime Net Benefits	Benefit-Cost Ratio
Low-Impact Scenario (2%)	$97,850,797	$83,216,502	$14,634,295	1.18
Base Scenario (5%)	**$248,868,996**	**$175,665,096**	**$73,203,901**	**1.42**
High-Impact Scenario (10%)	$488,226,624	$323,575,423	$164,651,201	1.51
FF Prices & Cost Reduction Interaction Scenario (5%)	**$348,805,001**	**$173,878,221**	**$174,926,780**	**2.01**

6.2.4 RATEPAYER IMPACT ANALYSIS

A third perspective of interested is that of state utility ratepayers, who will be impacted by RT programs both because of changes in statewide electricity and natural gas sales and because of the need to recover program incentive and administrative costs. This analysis is based on the base scenario described above, that of a portfolio of RT installations amounting to 5% of statewide thermal load by 2035.

Increased adoption of renewable energy thermal systems will result in customers switching from one heating fuel to another, mainly from fossil fuel-based heating systems, such as boilers and furnaces using oil and natural gas, and inefficient electric resistance heating systems. As most of the installations included in this portfolio are ASHP measures but relatively few installations replace electric resistance heat, this portfolio leads to increased electricity consumption but reductions in natural gas and oil consumption. The impacts on rates are summarized below:

Electricity. While electricity system costs are expected to increase to serve more electric customers and higher electricity usage,[58] the increases in electricity sales will likely put downward pressure on electricity rates. This is because the rate-reducing impact from allocating revenue requirements over greater electricity sales are expected to outweigh the rate-increasing impact of increased system costs (taking both supply and distribution costs into account). However, if the program costs for increasing the adoption of renewable energy thermal systems are recovered through system benefit-like charges placed on residential

[58] This analysis takes into account the cost increase at the wholesale energy market, but does not explicitly include any impact from the delivery system cost changes. It assumed that the renewable thermal portfolio will not increase electricity delivery costs or, if it did, that the cost increase would be negligible as the state's electricity system peak is in the summer, when impacts from RT installations will be very small.

and commercial ratepayers,[59] this would put upward pressure on rates. For this analysis, we found that these two effects absorb each other, for a little to no net impact on total electricity rates.[60]

Gas. While a relatively small number of RT projects are expected to involve conversions from natural gas, natural gas consumption is still expected to decline slightly as a result of the RT portfolio of installations, as a small number of homes and business convert from gas heat to RT sources. This reduction in natural gas use would lead to a decrease in utility revenue compared to a counterfactual case with no additional RT conversions, and therefore also lead to an increase in rates to recover the revenue shortfall during the useful life of the RT installations.

Fuel Oil. As most RT projects are expected to involve conversion from fuel oil, there will be a decline in oil consumption related to the RT installations. However, because oil prices are set in a global oil market and any sales impact from Rhode Island's change in consumption will have little impact on the global oil market, this analysis assumes that any sales reductions will not affect the local price of oil.

Rate Impact Approach

This analysis is based on a business-as-usual (BAU) revenue forecast, which is developed using estimates of future BAU sales and total retail rates.[61] BAU sales are forecasted through 2055 based on the most recent historical sales data and U.S. Energy Information Administration's annual growth rate projection for the New England region.[62] Retail rates are forecasted by escalating the current full retail rates by the projected avoided energy cost escalation rates. The avoided retail energy costs consist of (a) avoided energy supply costs based on the 2015 Avoided Energy Supply Cost study, and (b) avoided delivery costs based on National Grid's current tariffs for electricity and natural gas, conservatively estimated to increase at a rate of 1%/year.

This BAU forecast of natural gas and electricity sales was then adjusted to account for the sales increases and decreases of various fuels associated with the RT portfolio of installation, and the expected recovery of program costs through an added ratepayer charge on a customer's electricity consumption. This analysis also assumes that the additional surcharge for RT technologies is set at the same level in terms of cents per kWh for residential and commercial customers.

Finally, average rates for all affected customers were estimated by dividing revenue by the sales forecasts in the scenario assuming RT installations. Average rate impacts were determined by comparing these calculated rates to the expected BAU rate levels.

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[59] As noted above, this analysis assumed that program costs would be recovered on electricity rates for modeling simplicity and for consistency with other regional approaches. No policy decision has been made on this topic in Rhode Island.

[60] Includes energy supply, transmission, distribution rates and other surcharges.

[61] Revenue data used in this analysis represent all electricity revenue including electricity supply, transmission and distribution.

[62] EIA provides sales forecast through 2040. After 2040, we escalated sales based on the average annual sales growth rate in the last five years of the EIA forecast.

Bill Impact Approach

Additionally, to demonstrate the full magnitude of the impact of rate increases on customers, a bill impact analysis was conducted for participating and non-participating ratepayers. This analysis considers both changes in rates and changes in customer's consumption patterns, which provides a better indication of how customers are impacted by a new policy. Non-participant bill impacts take into account all of the expected rate impacts discussed in the preceding section. Participants are also impacted equally by the rate impacts, but have adjusted their consumption levels due to the installations of renewable heating systems, and so results are provided separately for participants and non-participants.

Non-participant average annual energy bills were estimated for all customers by sector. Average annual bills were estimated based on the expected average energy use by customer by sector, and the estimated rates in the BAU and policy cases. The average energy use by sector was estimated by dividing the BAU sales forecast by the BAU customer forecast. BAU sales are forecasted based on the most recent historical sales data and U.S. Energy Information Administration's annual growth rate projection for the New England region. The BAU customers are forecasted using the most recent customer data based on EIA statistics and projecting it using the average growth rate in customers from the previous five years.

Rate Impacts

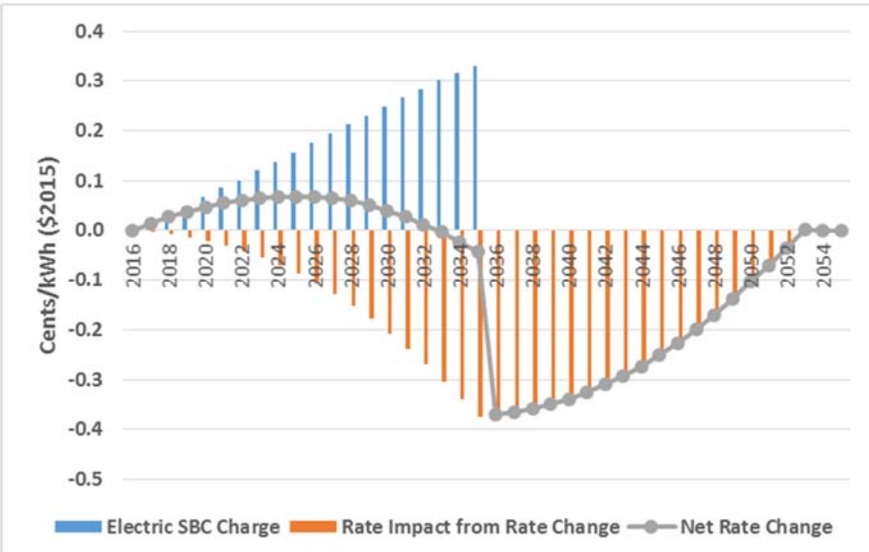
Overall, estimated changes in electricity and natural gas rates are marginal. Natural gas residential rate impacts start at a very small scale and peak at 1.1 percent in 2035 with the long-term average impact of about 0.5 percent. At different time periods, the impacts range from less than 0.2 cents per therm (or 0.1%) in the first 10 years to about 1.3 cents per therm (or 0.7%) in the second 10 years (see Table 28). The natural gas rate impacts on commercial customers are significantly smaller because the commercial program scale is very small. Natural gas commercial rate impacts peak at about 0.1 percent in 2035 and range from less than 0.1 cents per therm (or 0.01%) in the first 10 years to about 0.12 cents per therm (or 0.08%) in the second 10 years (Table 28). The long-term average rate impact for commercial gas customers is about 0.1 percent.

Table 28. Natural Gas Rate Impact Results

	Residential		Commercial	
	Cents/Therm ($2015)	% change	Cents/Therm ($2015)	% change
First 10 Years	0.18	0.11%	0.01	0.01%
Second 10 Years	1.34	0.72%	0.12	0.08%
Remaining Years	1.35	0.62%	0.17	0.06%
All Years	1.01	0.51%	0.08	0.05%

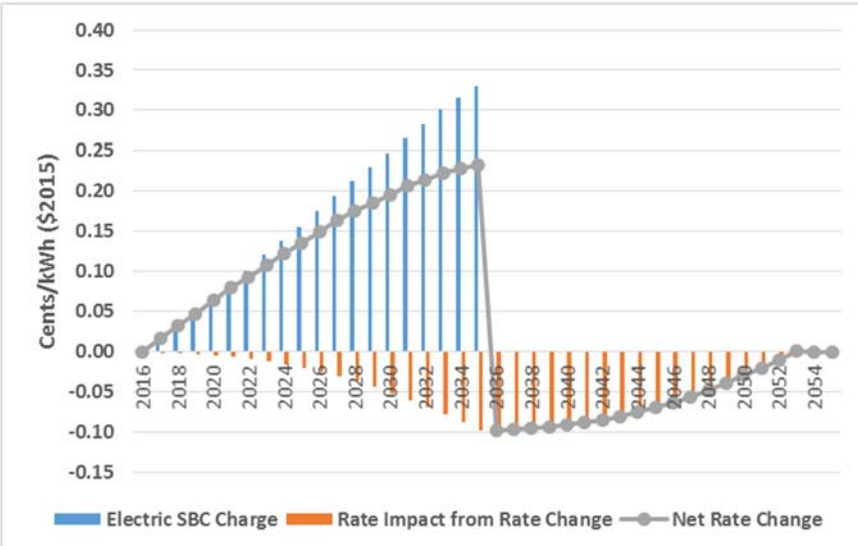
Residential electric rate impacts are shown in Figure 6 below. Program costs are assumed to be recovered via an added systems benefit charge (SBC) placed on both residential and non-residential electric customers, which gradually increases from zero in 2017 to about 0.3 cents per kWh (or about 1.3 percent relative to a business-as-usual rate) in 2035, the year in which new installations are assumed to end. The downward pressure on rates from increased electricity sales is expected to peak in 2035, before gradually decreasing through 2055. This reduction in rates will absorb about half of the SBC's upward pressure, keeping the maximum net rate impact at about 0.07 cents per kWh. Throughout the entire study period, the average net electric rate impact for residential customer is -0.07 cents per kWh or a 0.3% decrease.

Figure 6. Residential Electric Rate Impacts



Commercial electric rate impacts are shown in Figure 7 below. Overall, the impact for the commercial customers is greater than the impact for the residential customers, primarily because electricity sales increases due to the commercial program are significantly smaller for the commercial customers while commercial SBCs are essentially the same as residential SBCs. The figure shows that the maximum SBC charge is about 0.33 cents per kWh in 2035 while the maximum downward pressure on rates from increases sales is just about -0.1 cents per kWh. Throughout the entire study period, the average net electric rate impact for commercial customers is slightly positive, at about 0.05 cents per kWh or a 0.2 percent increase.

Figure 7. Commercial Electric Rate Impacts



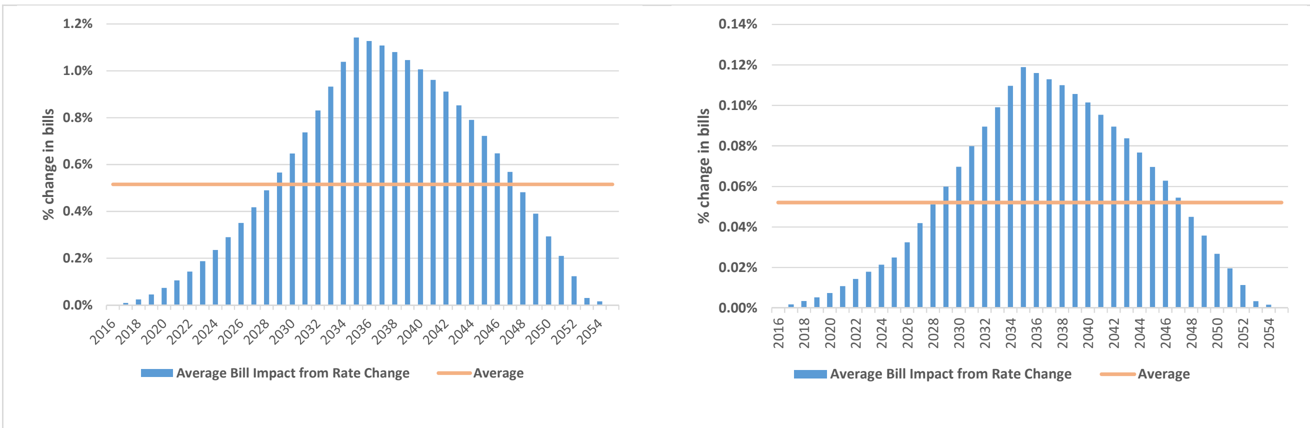
Non-Participant Bill Impacts

Non-participant bill impacts for natural gas and electricity can be calculated using the rate impacts identified above and data on average monthly energy consumption.

Along with gas rates, natural gas non-participant bill impacts are expected to increase gradually through 2035, as shown in Figure 8.[63] For residential customers, the average bill impact peaks in 2035 with about a 1.1 percent increase in average natural gas bills (or about $15 per year). Throughout the study period, the average bill impact for residential non-participant natural gas customers is about a 0.5 percent bill increase (or about $7 per year). For commercial customers, the average bill impact peaks in 2035 with a 0.12 percent increase in average natural gas bills (or about $9 per year). Throughout the study period, the average bill impact for commercial non-participant natural gas customers is about a 0.05 percent bill increase (or about $4 per year).

[63] For this analysis, natural gas and electric bill impacts are shown separately to better illustrate the impacts on the two different fuels on customer's bills. However, these separate bill impacts are for informational purposes only, because the majority of customers in Rhode Island are both electric and natural gas customers with National Grid. Subsequently, combined bill impacts for both natural gas and electric bills are also shown. These combined bill impacts should provide the most appropriate energy bill impacts for utility customers who use both electricity and natural gas. However, for customers who use fuel oil or wood chips, separate electric bill impact results are relevant and important.

Figure 8. Natural Gas Bill Impacts for Residential (left) and Commercial (right) Customers



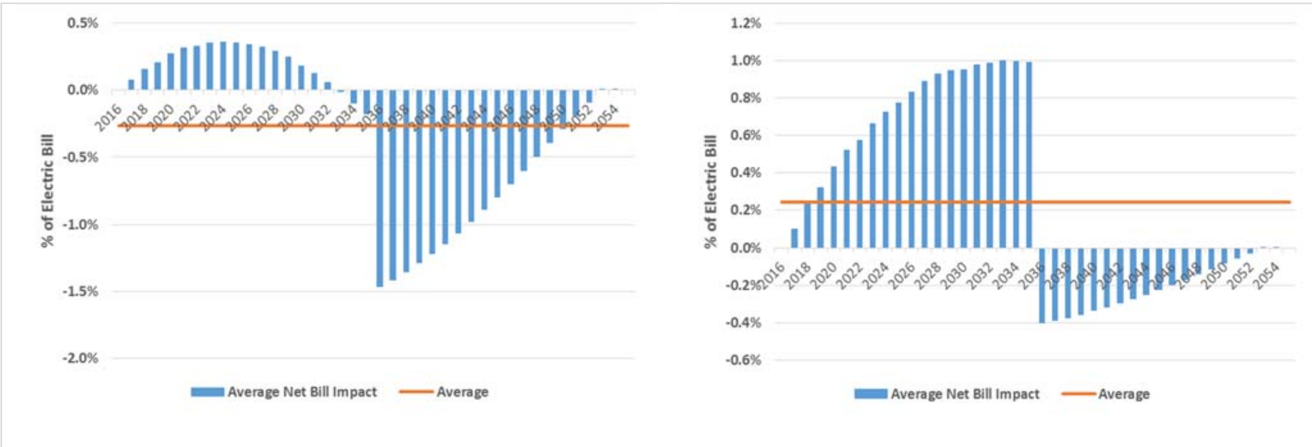
Average electric non-participant bill impacts are shown in Figure 9 below. For both residential and commercial customers, bills are expected to increase gradually until 2028, at which point they start to decline as the rate reduction impacts from increased electricity sales influence the customer's net bills. Starting in 2036, average electric bills decrease as program costs are no longer collected through rates.

For residential customers, bill impacts peak around 2024 with just about 0.4 percent increase (or about $4 per year) relative to a BAU electric bill, and decrease by 1.5 percent (or about $22 per year) by 2036. Throughout the study period, the average change in bills for residential non-participant electric customers is negligible with an overall bill decrease of about 0.03 percent (or about $4 per year). For commercial customers, average bills peak around 2035 with about a 1 percent bill increase (or $98 per year), and decrease to a bill reduction of 0.4 percent (or about $40 in bill savings) in 2036. Throughout the study period, the average change in bills for commercial non-participant electric customers is about a 0.3 percent increase (or about $24 per year).

Following the end of new installations in 2035 (and therefore the end of system benefit charges for this set of installations), bill impacts will be negative due to the downward pressure of increased electrification on rates. Impacts would slowly diminish through the end of the study period as installations reach the end of their expected useful lives.

These electric bill impacts also represent the total bill impact for customers who use oil for space heating because there are no gas rate impacts on customers that use oil.

Figure 9. Electric Bill Impacts for Residential (left) and Commercial (right) Customers



The combination of the natural gas and electric bill impacts for customers who use both natural gas and electricity represent the complete bill impact, as shown below in Figure 10 for residential customers and Figure 11 for commercial customers. The largest expected average bill impact for residential customers is about a 0.45 percent increase in bills (or about $13) in 2035, and the lowest average impact is about a 0.2 percent decrease in bills (or about $7) in 2036. Throughout the study period, the average combined bill impact for non-participant residential customers is negligible with about a 0.1 percent increase (or about $3). For commercial customers, the average net bill impacts are expected to peak in 2035 with a 0.6 percent increase (or about $100), and the lowest average impact is about a 0.15 percent decrease (or a savings of $31). Throughout the study period, the average combined bill impact for non-participant commercial customers is 0.15 percent (or about $25).

Figure 10. Combined Electric and Natural Gas Impacts for Residential Customers

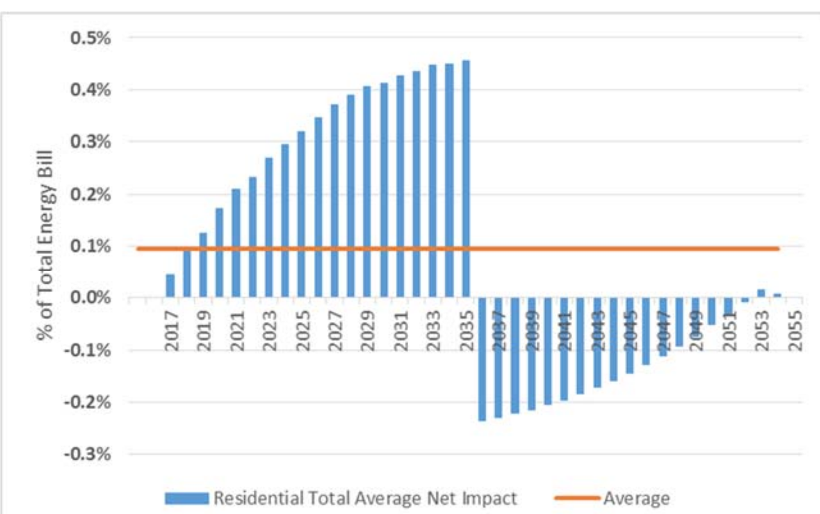
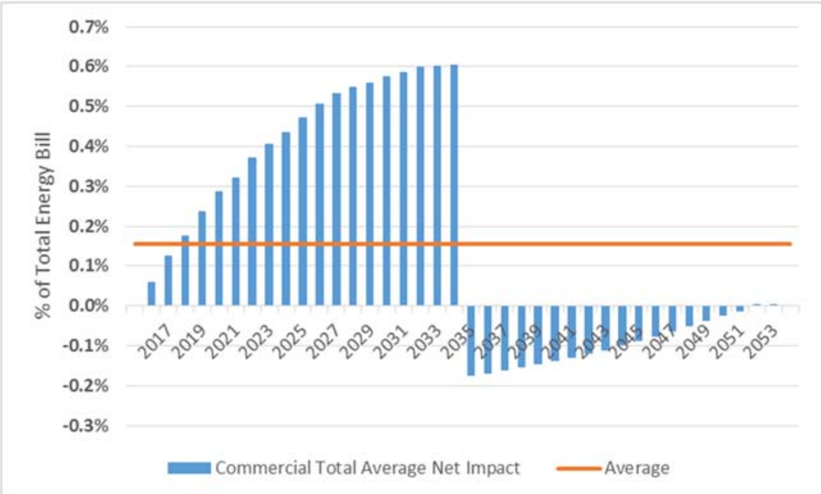


Figure 11. Combined Electric and Natural Gas Impacts for Commercial Customers



Participant Bill Impacts

Table 29 below presents the energy bill reduction impacts for residential single-family participants and commercial participants who switch from either natural gas, fuel oil, or electric resistance heating systems to an ASHP or GSHP (averaging the total projected impacts of participants in each rate class).[64] The expected bill savings are smallest for customers who are currently using natural gas, largely because the price of natural gas is relatively low compared to other fuels. The expected bill savings for customers who are currently using electric resistance heating is potentially significant given that ASHP and GSHP systems are substantially more efficient than electric resistance heating systems.

Table 29. Summary of Average Bill Savings for Program Participants switching to ASHP or GSHP

	Residential Single Family		Commercial	
Current Fuel	Annual Savings	Percentage	Annual Savings	Percentage
Natural Gas	$180	7%	$2,090	5%
Fuel Oil	$650	24%	$5,600	12%
Electric Resistance	$1,780	39%	$14,670	26%

6.3 EMPLOYMENT IMPACT ANALYSIS

[64] Bill savings represent average bill savings from customers who install ASHP or GSHP in 2016 through 2035. These bill savings do not include the negligible bill increases or decreases discussed above in this section.

The economic impact analysis captures the changes in activity in the state of Rhode Island due to RT programs under the base impact scenario targeting 5% of Rhode Island thermal load. These impacts are generated by:

- *Installation and servicing of new measures*: The equipment and labor required for air source heat pumps (ASHP), geothermal heat pumps (GSHP), wood pellet boilers, and solar thermal hot water systems.
- *Avoided installations of standard measures*: The lost economic activity from boilers and furnaces that would have been installed but-for the RT program.
- *Heating fuel consumption*: Both positive impacts (e.g., more jobs for wood pellet delivery) and negative impacts (e.g., less jobs for oil fuel delivery) from changes in heating fuel use.
- *Customer spending*: The impact of customers re-spending their savings in the state economy.
- *Program administration*: Jobs associated with running the RT program.

Employment Impact Approach

Employment impacts were conducted based on projected cost inputs, the bill impact analysis, and the IMPLAN model.[65] These inputs were translated into job impacts in Rhode Island using this information and state-specific data from the IMPLAN model. The measure-specific spending was used to estimate "direct impacts," which represent the new jobs at the site of the RT measure installation. These impacts represent the increased labor from installing the RT measures minus the reduction in labor from standard measures that were not installed due to the RT program.

The IMPLAN model was used to estimate the spin-off activity from both RT and standard equipment installations, including (1) "indirect impacts," which comprise equipment and services needed to support the installation but that are not directly related to installation labor and (2) "induced impacts," which emerge when contractors re-spend their wages and customers re-spend their savings. Where contractors and consumers spend these dollars determines the impacts on the state. For instance, installation of air source heat pumps generates activity both where the heat pumps are made (indirect impacts) and at local stores where the installing contractors spend their wages (induced impacts). In order to estimate these effects, the IMPLAN model combines:

- Detailed economic data for Rhode Island,
- Commuting flows between the state and the rest of the United States,
- Flows of goods in and out of the state, and
- Inter-industry relationships.

[65] IMPLAN is a standard input-output model that is used in assessing economic impacts across the United States.

The interplay of these factors determines the amount of indirect and induced impacts generated by the RE thermal program in Rhode Island.

A breakdown of labor and equipment costs for standard measures that would have been installed absent the RT case (e.g., gas furnaces) was developed by drawing on cost data for RT and standard measures, and on a breakdown of labor and equipment costs for RT measures. Net labor spending (new labor spending minus avoided labor spending on standard installations) was used to calculate direct job impacts for installation, assuming the average wages from relevant industries.[66] Labor income was also modeled to capture the impacts of contractors re-spending their income in Rhode Island. The net spending on equipment (new RT equipment minus avoided spending on standard equipment) was assigned to specific IMPLAN industries in order to capture the impacts of equipment purchases in Rhode Island.[67]

The analysis also took into account the shifts in fuel spending caused by the program, but determined that changes in electricity and natural gas demand would have little to no effect on Rhode Island jobs for several reasons. First, Rhode Island has no natural gas production and, second, jobs associated with the distribution of natural gas and electricity do not fluctuate with volume distributed. However, changes in demand for fuel oil and wood pellets would have an effect on jobs because each delivery requires more labor.[68] Workers are needed to load the trucks, drive them, and deliver the fuel to customers. Therefore, this analysis assumed that jobs changed commensurately with increases or decreases in volume of these fuels.[69] Fuel oil jobs lost were based on the historical jobs per million gallons delivered in Rhode Island multiplied by the fuel oil savings attributed to the program.[70] This analysis also assumed that oil and wood delivery jobs were equivalent on a weight basis.[71] These two activities have a slightly negative net impact on the state's economy because the program creates a large reduction in oil delivery but only a small amount of new demand for wood pellets.

Job impacts are also based on shifts in customer spending due to the program. By estimating economic impacts from customer savings using a bill impact analysis along with an estimate of the out-of-pocket

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[66] Average income values were derived from the following IMPLAN industries: "maintenance and repair construction of residential structures" for residential installations, and "maintenance and repair construction of nonresidential structures" for commercial installations.

[67] The IMPLAN industry "heating equipment (except warm air furnaces) manufacturing" was used for boiler and solar hot water equipment. For furnace, ground-source heat pump, and air-source heat pump equipment, the IMPLAN industry "air conditioning, refrigeration, and warm air heating equipment manufacturing" was used.

[68] It was assumed that neither wood pellets nor fuel oil were produced or refined in Rhode Island. However, it was assumed all distribution of these fuels was handled in-state.

[69] The "truck transportation" IMPLAN industry was used to estimate the income required for fuel delivery.

[70] US County Business Patterns data (http://censtats.census.gov/cgi-bin/cbpnaic/cbpdetl.pl) provided the number of fuel oil delivery jobs, and the Energy Information Administration (EIA) form 821 databases (https://www.eia.gov/dnav/pet/pet_cons_821use_dcu_SRI_a.htm) provided fuel oil volume. The jobs factor was based on the 5.65 jobs per million gallons delivered in the 2014 and 2015.

[71] The weight of fuel oil is 7 pounds per gallon. Along with the 5.65 delivery jobs per gallon, this leads to a factor of 1.61 jobs per thousand tons.

costs for participants, the IMPLAN model captured the full costs paid by customers. The analysis assumed that the difference in total customer costs with and without the policy is re-spent when there are savings. If there were net costs, we assumed that customers spend less than they would have otherwise. Commercial customers' savings was assumed to be split between profits and re-investment. All residential customers' savings was assumed to be re-spent on typical household goods and services.

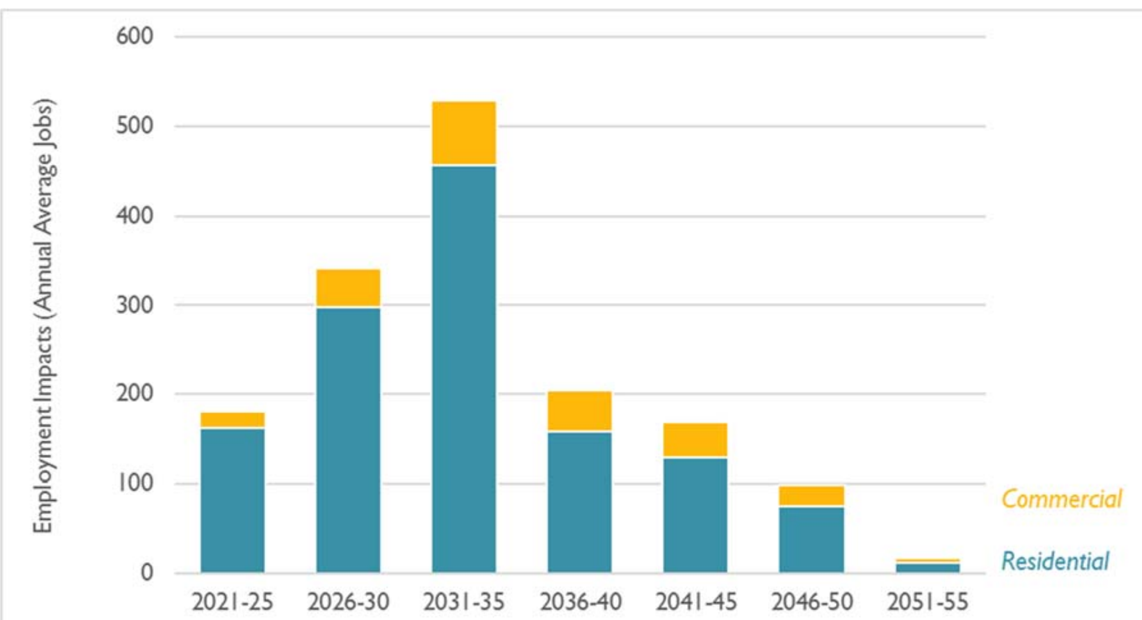
Finally, based on the share of program costs dedicated to administration of the program,[72] direct job impacts in Rhode Island associated with running the program were estimated and the total impact from these jobs in the state was modeled.

6.3.1 RESULTS

Employment Impacts

Figure 12 shows the results of the employment impact analysis, indicating that both residential and commercial RT programs increase employment in Rhode Island. Between 2017 and 2055, residential programs have the greater impact with 165 average annual jobs. Commercial programs generate 32 average annual jobs.

Figure 12. Average annual job impacts by 5-year period (2021-2055)



Job impacts peak in the mid to late 2030s--toward the end of the program period—as an increasing amount of measures are installed through 2035. After 2035, there are no new measure installations but

[72] For program administration, the "environmental and other technical consulting services" IMPLAN sector was used.

impacts persist as consumers re-spend their savings in the state economy. These savings impacts diminish through the end of the analysis period as the measures installed earlier expire.

6.4 EMISSIONS IMPACT ANALYSIS

Emissions Impact Approach

Carbon emissions impacts were modeled for the portfolio of RT projects by deriving technology-specific carbon emissions factors associated with both baseline and RT equipment.

Electricity impacts were modeled using the EPA AVoided Emissions and geneRation Tool (AVERT) (EPA, 2016a). AVERT models the expected change in electricity consumption occurring in each hour of the year and compares this to the emissions rate of the marginal generating plant active in the region in that hour (based on a regional dispatch schedule included in the model and specific to the Northeast). Natural gas and fuel oil emissions impacts were calculating using EIA emissions factors (EIA, 2016b).

Electricity, natural gas, and fuel oil emissions impacts were calculated separately. Additionally, electricity impacts were separated into emissions increases (installation of ASHPs and GSHPs) and emissions reductions (conversion from electric resistance heat).[73] Given the wide degree of variability in emissions from bioenergy projects (discussed in Box 6 below), biomass installations were not included in this emissions analysis.

These avoided emissions are estimated based on static hourly electricity avoided emission rates in 2015 from AVERT. As it expected that the emissions per unit of electricity consumption will decrease over time as Rhode Island and other regional states pursue renewable energy targets, future electricity emissions will likely be less than the outputs of the AVERT model. Therefore, this emissions impact analysis yields a conservative result, as the future emissions of ASHP and GSHP units that lead to a net increase in electricity consumption will likely be less than what is projected by the AVERT model today.

Emissions Impacts

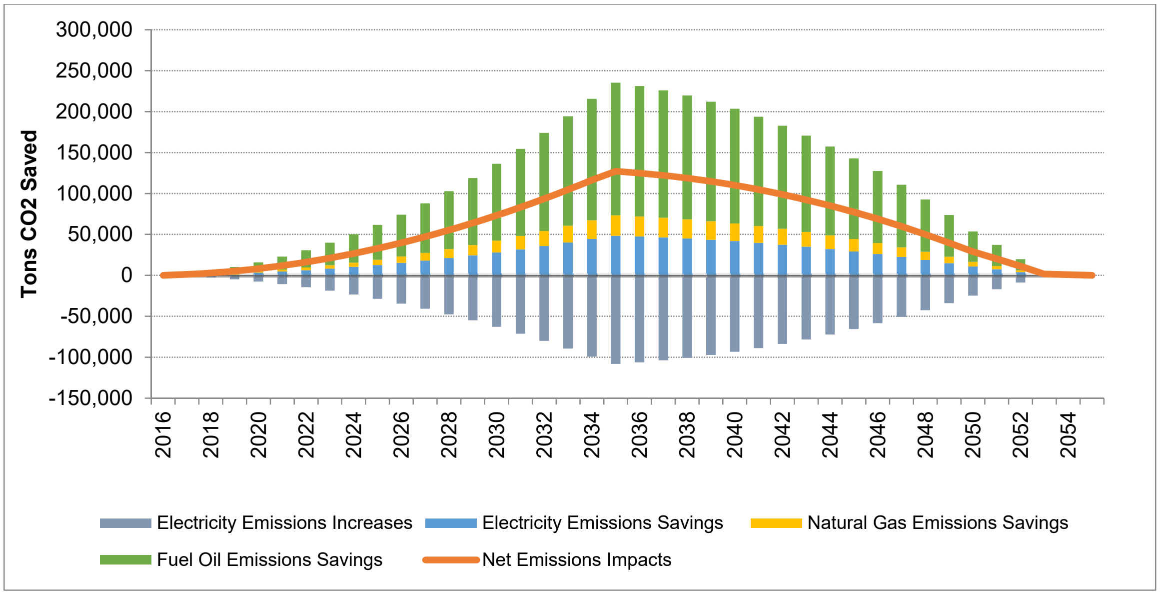
Over the lifetime of the measures included in the base model (target 5% of thermal load), RT installations would result in a CO2 emissions reduction of 2.2 million tons, or an average of just less than 60 thousand tons per year from 2017 to 2054. Emissions reductions would peak in 2035, with a reduction of 127 thousand tons of CO2.

Over the life of the program, 4.19 million tons of CO2 would be avoided from converting away from fuel oil equipment, 860 thousand tons of emissions would be avoided via conversion from electric resistance

[73] Emissions impacts related to biomass installations were not modeled due to the wide variety of emissions impact categories and the difficulty of accurately measuring emissions impacts. It is expected the contribution of biomass conversions to overall emissions impacts would be minor given the small number of wood boilers included in the RT project portfolio in this analysis. This analysis also did not take into account emissions changes in greenhouse gases other than CO2, and did not account for potential GHG emissions associated with losses in the natural gas distribution system.

heat, and 444 thousand tons would be avoided through reductions in natural gas consumption. These emissions reductions would be partially offset through 1.925 million tons of added emissions from increased electricity consumption from newly installed heat pumps over the life of the project portfolio.

Figure 13. Annual Emissions Impacts by Year



Box 6. Potential emissions reductions and challenges from an expanded biodiesel mandate

While the emissions impacts of electricity and fossil fuels are well-established, the methodology behind the emissions impacts of various forms of biofuels is unclear and controversial: while some GHG emissions reduction programs (e.g. the Regional Greenhouse Gas Initiative) treat forms of bioenergy as carbon neutral, a number of studies have challenged this assumption (Clean Air Task Force, 2016; Walker et al., 2010). In general, it is critical to assess the lifecycle emission impacts of biofuels, given the variability in supply chain ranging from waste oil (or fuel feedstock) recovery through production to delivery to end users. Given the greater emphasis of use of biofuels in transportation (e.g. through soybean-derived fuels), there are relatively few studies that assess the lifecycle emissions of biodiesel when used to displace heating oil – particularly for biodiesel derived from using from recovered waste oil as in Rhode Island.

A 2008 study conducted by Argonne National Laboratory estimated a lifecycle GHG emissions reduction for biodiesel relative to petroleum fuel of 66% (Huo et al., 2008). Though the study focuses on soybean-derived biodiesel and displacement of transportation fuels, it provides a conservative benchmark relative to a lifecycle GHG emissions reduction estimate of 80% from a 2003 study completed for the Massachusetts Oil Heat Council and National Oilheat Research Alliance. Assuming an expanded Rhode Island biodiesel mandate that reaches a B20 requirement in 2035, GHG emissions from heating oil in 2035 in RI could be reduced by between roughly 119,000 tons (10.2%) and 144,000 tons (14.3%).

It is worth noting that a significant increase of the biodiesel mandate and other policies that encourage the use of low-GHG sources of biodiesel could ultimately exceed the capacity to use only waste oil for production.

This could lead to requiring the use of feedstock-derived oils, the scale-up of which could have significant added environmental externalities.

6.4.1 CONCLUSION

Overall, the base portfolio of RT projects, which targets a 5% reduction in thermal load by 2035, would have a variety of impacts on the state of Rhode Island, program participants, and energy ratepayers.

Statewide, the 5% impact portfolio would be expected to accrue nearly $200 million in lifetime NPV economic benefits to the state of Rhode Island, as measured by the Rhode Island TRC. In a scenario where RT technology costs were to decline by 20% through hard or soft cost reductions, the lifetime net economic benefit to the state would increase by 62% to $313 million. In a scenario where the global fossil fuel prices were to recover from the recent collapse, net statewide economic benefits would increase by 323% to $624 million.

Despite these statewide economic benefits, there are presently few cost-effective opportunities for RT installations from the participant perspective without technology cost reductions or fossil fuel price increases, even accounting for incentive levels seen elsewhere in the region. This reflects the need for a clear market development strategy that encourages growth in RT industries and thereby contributes to the reduction of RT installation costs.

In the base analysis, such a portfolio of RT projects would require $193 million in statewide funding (cumulative, undiscounted) through 2035 for program incentives and non-incentive costs (which are accounted for in the calculation of net state economic benefits). This analysis assumes these costs would be provided through a systems benefit charge for statewide energy ratepayers.

Financial impacts on non-participating ratepayers would be minimized, however, by the electricity load-building nature of the RT portfolio, which include large amount of ASHP and GSHP installations. Through the combination of an added systems benefit charge to recover program costs, downward pressure on electricity rates due to increased electricity load, and upward pressure of natural gas rates due to decreased natural gas load, residential energy costs for combined electricity-natural gas ratepayers not participating in the RT program would increase by an average of 0.1% during the program impact period.

Outside of direct financial impacts, this portfolio of RT installations is expected to contribute to state job creation efforts. It is estimated that such an investment in RT in Rhode Island would lead to an average net increase of 197 jobs in the state during the program impact period.

Finally, such a portfolio of RT installations would lead to a net reduction of 2.2 million tons of CO2 emissions during the program impact period, or an average reduction of 60 thousand tons per year.

SECTION 7 CONCLUSION

Thermal energy tends to be an overlooked aspect of the clean energy policy landscape. While renewable thermal technology and policy has attracted much attention abroad, particularly in Europe, it has played only a small role in the policy conversation in the United States. Still, several RT technologies provide viable options to help states reduce the use on fossil fuels for thermal energy, a necessary element of a comprehensive clean energy policy approach.

The RT market in Rhode Island is small, but there is significant potential for expansion given the large amount of oil heat in the state, the policy actions taken to date in Rhode Island, and the additional policy activity being undertaken in other states in the Northeast. Recognizing the potential that the RT sector has to address statewide energy and environmental targets, the Rhode Island Office of Energy Resources has sponsored this Renewable Thermal Market Development Strategy.

As is demonstrated in the quantitative analysis in this report, there are opportunities to cost-effectively scale the RT market in Rhode Island (from a Total Resource Cost perspective) and provide strong economic benefits in the form of job growth. However, in many cases RT is not cost-competitive for homeowners and business that would install these technologies under current market conditions.

This difficult economics of RT installations reflects several significant market barriers that confront the RT industry, including:

- High system costs;
- Low public awareness;
- Unclear regulatory and metering protocols;
- A lack of policy support;
- Gaps in workforce development; and
- A lack of infrastructure (particularly for biomass and biodiesel).

This report recommends several key policy actions that could be taken to encourage growth in the RT sector in the near and long-term. Key policy opportunities for the state of Rhode Island include:

- Identifying statewide renewable thermal targets;
- Establishing stable, long-term incentives for renewable thermal technologies;
- Enhancing "Lead by Example" by integrating renewable thermal targets across State facilities;
- Expanding low-interest financing options for energy efficiency projects to renewable thermal technologies; and
- Implementing community-focused outreach and aggregated procurement programs.

REFERENCES

Aldrich, R., & Vijayakumar, G. (n.d.). *Cost, Design and Performance of Solar Hot Water in Cold-Climate Homes*. Steven Winter Associates, prepared for the U.S. Department of Energy. Retrieved from http://www1.eere.energy.gov/buildings/publications/pdfs/building_america/solar_hot_water_cold_climate.pdf

California Energy Commission. (2016). Anaerobic Digestion. Retrieved November 18, 2016, from http://www.energy.ca.gov/biomass/anaerobic.html

Center for Biological Diversity, Clean Air Task Force, Partnership for Policy Integrity. (2016). *Clean Air Task Force Joint Comments*. Center for Biological Diversity, Clean Air Task Force, Partnership for Policy Integrity. Retrieved from https://www.rggi.org/docs/ProgramReview/2016/02-02-16/Comments/Clean_Air_Task_Force_Joint_Comments.pdf

City of Providence. (2012). *City of Providence: Guide to Permitting*. City of Providence. Retrieved from http://www.providenceri.com/efile/107

City of Warwick. City of Warwick Schedule of Permit Fees (2015). Retrieved from http://www.warwickri.gov/sites/warwickri/files/uploads/buidling_permit_fees_2015.pdf

Commonwealth of Massachusetts Executive Office of Energy & Environmental Affairs, Department of Energy Resources. (2016). *Alternative Energy Portfolio Standard Guideline on Metering and Calculating the Useful Thermal Output of Eligible Renewable Thermal Generation Units, Part 2*. Commonwealth of Massachusetts Executive Office of Energy & Environmental Affairs, Department of Energy Resources. Retrieved from http://www.mass.gov/eea/docs/doer/renewables/thermal/guideline-on-metering-and-calculationspart-2.pdf

C-PACE. (2016). Eligible Measures. Retrieved November 18, 2016, from http://www.cpace.com/building-owners/eligible-measures

Efficiency Maine. (2016). Home Energy Savings Program - Maine Energy Rebates & Loans for Homeowners. Retrieved November 18, 2016, from http://www.efficiencymaine.com/at-home/home-energy-savings-program/

Efficiency Vermont. (2016). *Residential Heating Systems Rebate Form*. Efficiency Vermont. Retrieved from https://www.efficiencyvermont.com/Media/Default/docs/rebates/forms/efficiency-vermont-residential-heating-systems-rebate-form.pdf

EnergizeCT. (2015, September 21). Solutions/Programs. Retrieved November 18, 2016, from http://www.energizect.com/your-home/solutions-list

Euroheat & Power. (2015, March 1). District Energy in Denmark. Retrieved November 18, 2016, from https://www.euroheat.org/knowledge-centre/district-energy-denmark/

Eurostat. (2016, July). Energy Price Statistics. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_price_statistics

Froning, S. (2013, February). *Low Carbon District Heating and CHP in the Future Energy Market: State of the Art and Perspectives in the Light of Current Policies*. Presented at the Euroheat & Power. Retrieved from http://www.iea.org/media/workshops/2013/chp/sabine.pdf

Governor's Workforce Board. (n.d.). Grants and Awards. Retrieved from http://www.gwb.ri.gov/grants.htm

Huo, H., Wang, M., Bloyd, C., & Putsche, V. (2008). *Life-Cycle Assessment of Energy and Greenhouse Gas Effects of Soybean-Derived Biodiesel and Renewable Fuels* (No. ANL/ESD/08-2). Argonne National Laboratory, Energy Systems Division. Retrieved from https://greet.es.anl.gov/files/e5b5zeb7

International Energy Agency. (2013, July 5). National Renewable Energy Action Plan - Denmark. Retrieved November 18, 2016, from https://www.iea.org/policiesandmeasures/pams/denmark/name-39469-en.php

International Energy Agency. (2014, May 12). National Renewable Energy Action Plan - Austria. Retrieved November 18, 2016, from http://www.iea.org/policiesandmeasures/pams/austria/name-40136-en.php

International Energy Agency. (2015, July 30). National Renewable Energy Action Plan - Germany. Retrieved November 18, 2016, from https://www.iea.org/policiesandmeasures/pams/germany/name-39470-en.php

International Energy Agency. (2016, September 28). National Renewable Energy Action Plan - United Kingdom. Retrieved November 18, 2016, from https://www.iea.org/policiesandmeasures/pams/unitedkingdom/name-39191-en.php

International Renewable Energy Agency. (2016). *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance*. International Renewable Energy Agency. Retrieved from http://www.irena.org/DocumentDownloads/Publications/IRENA_Risk_Mitigation_2016.pdf

Kunde, R., Adeili, M., & Kuckelkorn, J. (2013). Konzeptverbesserung bei der Systemtechnik von Biomasse-Kleinfeuerungsanlagen. ZAE Bayern. Retrieved from http://www.zae-bayern.de/fileadmin/web_data/downloads/BMU_FKZ_03KB026_Pellet-KFA_Schlussbericht.pdf

Maine State Legislature. An Act to Improve Maine's Energy Security, Pub. L. No. 400§ 1-3 (2011). Retrieved from http://www.mainelegislature.org/legis/bills/bills_125th/chappdfs/PUBLIC400.pdf

MaineHousing - Maine State Housing Authority. (2016). *Maine's Energy Usage & the Low-Income Home Energy Assistance Program*. Maine State Housing Authority. Retrieved from http://www.mainehousing.org/docs/default-source/policy-research/Research-Reports/Housing-Profiles/mainehousing-energy-usage-the-liheap-program-profile--march2016.pdf?sfvrsn=12

Massachusetts Clean Energy Center. (2015, August 13). MassCEC Announces $30 Million in Funding for Clean Heating and Cooling Rebates. Retrieved November 18, 2016, from http://www.masscec.com/about-masscec/news/masscec-announces-30-million-funding-clean-heating-and-cooling-rebates

Massachusetts Clean Energy Center. (2016). *Residential and Small-Scale Ground-Source Heat Pump Program, Program Manual*. Massachusetts Clean Energy Center. Retrieved from http://files.masscec.com/get-clean-energy/govt-np/clean-heating-cooling/GSHPProgramManualResidentalSmallScale.pdf

Massachusetts Clean Energy Center. (2016). *Residential- and Small-Scale Solar Hot Water Program Manual*. Massachusetts Clean Energy Center. Retrieved from http://files.masscec.com/get-clean-energy/residential/commonwealth-solar-hot-water/SHW_Program_Manual_Small_Scale.pdf

Massachusetts Clean Energy Center. (2016, July 18). MassCEC Residential and Small-Scale Biomass Heating Program, Program Manual. Retrieved from http://files.masscec.com/get-clean-energy/business/clean-heating-cooling/BiomassProgramManualSmallScale.pdf

Massachusetts Clean Energy Center. (n.d.). *Solarize Massachusetts Information Sheet*. Massachusetts Clean Energy Center. Retrieved from http://files.masscec.com/uploads/attachments/Solarize_Massachusetts_Information_Sheet_Website.pdf

Massachusetts Department of Energy Resources. (2010). *Massachusetts Advanced Biofuels Mandate, Program Announcement*. Massachusetts Department of Energy Resources. Retrieved from http://www.mass.gov/eea/docs/doer/renewables/biofuels-mandate-announcement-jun302010.pdf

Massachusetts Oilheat Council and National Oilheat Research Alliance, prepared by Energy Research Center, Inc. (2003). *Combustion Testing of a Biodiesel Fuel Oil Blend in Residential Oil Burning Equipment - 20030801_htg-002.pdf*. Retrieved from http://biodiesel.org/reports/20030801_htg-002.pdf

National Grid. (2010). *Renewable Gas - Vision for a Sustainable Gas Network*. National Grid. Retrieved from https://www9.nationalgridus.com/non_html/ng_renewable_wp.pdf

National Grid. (2015). *0% Financing: Steps to Participate & Enrollment Form*. National Grid. Retrieved from https://www.nationalgridus.com/media/pdfs/resi-ways-to-save/ee5158-1-14_ri_financing_form.pdf

National Grid. (n.d.). Rhode Island Renewable Energy Growth Program. Retrieved November 21, 2016, from https://www9.nationalgridus.com/narragansett/business/energyeff/4_dist_gen.asp

Navigant Consulting & Meister Consultants Group. (2014). *Commonwealth Accelerated Renewable Thermal Strategy* (Final Report No. RFQQ-ENE-2013-101) (p. 99). Burlington, MA: Massachusetts Department of Energy Resources. Retrieved from http://www.mass.gov/eea/docs/doer/renewables/thermal/carts-report.pdf

New Hampshire Public Utilities Commission. (2016a). Renewable Energy Rebates. Retrieved November 18, 2016, from https://www.puc.nh.gov/Sustainable%20Energy/RenewableEnergyRebates.html

New Hampshire Public Utilities Commission. (2016b, September 15). Class I Thermal Renewable Energy Certificate Program. Retrieved November 21, 2016, from http://www.puc.state.nh.us/sustainable%20energy/Class%20I%20Thermal%20Renewable%20Energy.html

New York City Council. Int. No. 642-A (2016). Retrieved from http://www.nyc.gov/html/dcas/downloads/pdf/misc/nyc_fleet_newsletter_bioheat_law.pdf

New York State Energy Research and Development Authority. (2015, August 10). PON 3010 Renewable Heat NY Biomass Boiler Program. Retrieved November 18, 2016, from https://www.nyserda.ny.gov/Funding-Opportunities/Current-Funding-Opportunities/PON-3010-Renewable-Heat-NY-Biomass-Boiler-Program

NHSaves. (2016). Heating, Cooling & Water Heating Systems. Retrieved November 18, 2016, from http://www.nhsaves.com/save-home/save-more/heating-cooling-water-heating-systems/

Northeast Energy Efficiency Partnerships. (2014). *Ductless Heat Pump Meta Study*. Retrieved from http://www.neep.org/file/2123/download?token=UTQseZkX

Northeast Energy Efficiency Partnerships. (2017). Cold Climate Air-Source Heat Pump Specification (Version 2.0). Retrieved from http://www.neep.org/sites/default/files/resources/Cold%20Climate%20Air-source%20Heat%20Pump%20Specification-Version%202.0_0.pdf

NYSERDA. (2015). Renewable Heat NY - NYSERDA. Retrieved June 19, 2015, from http://www.nyserda.ny.gov/All-Programs/Programs/Renewable-Heat-NY

NYSERDA. (2016). Residential Financing Options. Retrieved November 18, 2016, from https://www.nyserda.ny.gov/All-Programs/Programs/Residential-Financing-Options

Ofgem. (2015a). Domestic Renewable Heat Incentive. Retrieved July 23, 2015, from https://www.ofgem.gov.uk/environmental-programmes/domestic-renewable-heat-incentive

Ofgem. (2015b). Non-Domestic Renewable Heat Incentive (RHI). Retrieved July 23, 2015, from https://www.ofgem.gov.uk/environmental-programmes/non-domestic-renewable-heat-incentive-rhi

Pernia, J. (2015, October). *CT Upstream Heat Pump Water Heater (HPWH) Program*. Presented at the Energize Connecticut. Retrieved from https://www.energystar.gov/sites/default/files/asset/document/1_Jesus%20Pernia_MythBusters%20Water%20Heater%20Edition_FINAL.pdf

Raimondo, G. M. (2015). *Executive Order 15-17, State Agencies to Lead by Example in Energy Efficiency and Clean Energy* (No. Executive Order 15-17). State of Rhode Island and Providence Plantations. Retrieved from http://www.governor.ri.gov/documents/orders/ExecOrder15-17.pdf

Renewable Energy Vermont. (2013, October 28). Vermont and Upper Austria Create Partnership to Promote Biomass Heating. Retrieved November 18, 2016, from http://vtdigger.org/2013/10/28/vermont-upper-austria-create-partnership-promote-biomass-heating/

Rhode Island Commerce Corporation. (2016). *Innovation Voucher Award Fact Sheet*. Rhode Island Commerce Corporation. Retrieved from http://commerceri.com/wp-content/uploads/2016/03/Innovation-Voucher_Summaries_20160125.pdf

Rhode Island Department of Labor and Training. (n.d.). Rhode Island Tax Credits. Retrieved from http://www.dlt.ri.gov/bwc/taxcredits.htm#JTTC

Rhode Island Division of Planning. (2015). *Energy 2035: Rhode Island State Energy Plan*. Rhode Island Division of Planning. Retrieved from http://www.planning.ri.gov/documents/LU/energy/energy15.pdf

Rhode Island General Laws. Renewable Energy Standard, § 39-26-5 (2004). Retrieved from http://webserver.rilin.state.ri.us/Statutes/TITLE39/39-26/39-26-5.HTM

Rhode Island Infrastructure Bank. (2016a). *Commercial Property Assessed Clean Energy Program: Program Guidelines*. Rhode Island Infrastructure Bank. Retrieved from http://ri-cpace.com/wp-content/uploads/RI_C-PACE_Program_Guide.pdf

Rhode Island Infrastructure Bank. (2016b). *Press Release, RI Infrastructure Bank Announces Opening of Efficient Buildings Fund Application Period, Free Energy Audits* (Press Release). Retrieved from http://www.ricwfa.com/wp-content/uploads/2016/09/FOR-IMMEDIATE-RELEASE.pdf

Rhode Island Office of Energy Resources. (2015a). *Rhode Island Efficient Buildings Fund: Frequently asked Questions, Version 3*. Rhode Island Office of Energy Resources. Retrieved from http://www.energy.ri.gov/documents/RIEBF/Efficient%20Buildings%20Fund%20FAQ%20(v3).pdf

Rhode Island Office of Energy Resources. (2015b). *Rules and Regulations for the Efficient Buildings Fund Project Priority List*. Rhode Island Office of Energy Resources. Retrieved from http://www.energy.ri.gov/documents/RIEBF/Rules%20and%20Regulations%20-%20Efficient%20Buildings%20Fund%20PPL.pdf

Rhode Island Office of Energy Resources. (2015c, July). Rhode Island Thermal Working Group Report. Retrieved from http://www.energy.ri.gov/documents/Efficiency/Rhode_Island_Thermal_Working_Group_Report.pdf

Ruggiero, Regunberg, Marshall, Blazejewski, & Tanzi. An act relating to public utilities and carriers - renewable energy programs, Pub. L. No. 8354 (2016).

Russell, N., & Burkhard, E. (2011, January). Getting There: High-Efficiency and Low-Emissions Wood Heating. *Air & Waste Management Association: Environmental Manager*, 19–22.

Skoldberg, H., & Ryden, B. (2014). *The Heating Market in Sweden: An Overall View*. Profu. Retrieved from http://www.varmemarknad.se/pdf/The_heating_market_in_Sweden_141030.pdf

The Renewable Energy Resource Center. (2015). The Renewable Energy Resource Center. Retrieved November 18, 2016, from http://www.rerc-vt.org/

U.S. Census Bureau. (2015). American Community Survey - 2010-2014 5-year Estimates. Retrieved from https://www.census.gov/programs-surveys/acs/data.html

U.S. Department of Energy. (2011). Geothermal Heat Pumps. Retrieved November 18, 2016, from http://energy.gov/energysaver/geothermal-heat-pumps

U.S. Department of Energy. (2016a). Business Energy Investment Tax Credit (ITC). Retrieved November 18, 2016, from http://energy.gov/savings/business-energy-investment-tax-credit-itc

U.S. Department of Energy. (2016b). Choosing and Installing Geothermal Heat Pumps. Retrieved November 18, 2016, from http://energy.gov/energysaver/choosing-and-installing-geothermal-heat-pumps

U.S. Department of Energy. (2016c). Residential Renewable Energy Tax Credit. Retrieved November 18, 2016, from http://energy.gov/savings/residential-renewable-energy-tax-credit

U.S. Energy Information Administration. (2009a). Residential Energy Consumption Survey. Retrieved from https://www.eia.gov/consumption/residential/data/2009/

U.S. Energy Information Administration. (2009b). Residential Energy Consumption Survey: Table HC7.8 - Air Conditioning in Homes in the Northeast Region, Divisions, and States. Retrieved November 18, 2016, from https://www.eia.gov/consumption/residential/data/2009/hc/hc7.8.xls

U.S. Energy Information Administration. (2012). Commercial Building Energy Consumption Survey. Retrieved from http://www.eia.gov/consumption/commercial/

U.S. Energy Information Administration. (2016a). Natural Gas Prices. Retrieved from http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_nus_m.htm

U.S. Energy Information Administration. (2016b, February 29). How much carbon dioxide is produced per kilowatthour when generating electricity with fossil fuels? Retrieved November 21, 2016, from https://www.eia.gov/tools/faqs/faq.cfm?id=74&t=11

U.S. Environmental Protection Agency. (2015, February 4). Fact Sheet: Summary of Requirements for Wood-fired Hydronic Heaters. Retrieved November 18, 2016, from https://www.epa.gov/residential-wood-heaters/fact-sheet-summary-requirements-wood-fired-hydronic-heaters

U.S. Environmental Protection Agency. (2016a, April 26). AVoided Emissions and geneRation Tool (AVERT). Retrieved November 21, 2016, from https://www.epa.gov/statelocalclimate/avoided-emissions-and-generation-tool-avert

U.S. Environmental Protection Agency. (2016b, May 5). Renewable Heating and Cooling: The Thermal Energy Advantage. Retrieved November 21, 2016, from https://www.epa.gov/rhc/us-heat-metering-standard

Vainio, T., Lindroos, T., Pursiheimo, E., Vesanen, T., Sipilä, K., Airaksinen, M., & Rehunen, A. (2015). *High-Efficiency CHP and Efficient District Heating and District Cooling in Finland 2010-2015* (No. VTT-R-04071-15). VTT Technical Research Centre of Finland. Retrieved from https://ec.europa.eu/energy/sites/ener/files/documents/Art%2014%20report%20ENFinland.pdf

Veilleux, N., Crowe, J., Belden, A., & Rickerson, W. (2012). *Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study*. Boston, MA: Meister Consultants Group. Prepared for Massachusetts Department of Energy Resources and Massachusetts Clean Energy Center. Retrieved from http://www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

Veilleux, N., & Rickerson, W. (2015). *Waking the Sleeping Giant: Next Generation Policy Instruments for Renewable Heating & Cooling in Commercial Buildings (RES-H-NEXT)*. Utrecht, The Netherlands: IEA Implementing Agreement for Renewable Energy Technology Deployment (IEA-RETD). Retrieved from http://iea-retd.org/wp-content/uploads/2015/02/RES-H-NEXT.pdf

Walker, T., Cardellichio, P., Colnes, A., Gunn, J., Kittler, B., Perschel, B., … Initiative, N. C. (2010). Biomass sustainability and carbon policy study. *Manomet Center for Conservation Sciences*. Retrieved from http://docs.nrdc.org/energy/files/ene_13041701a.pdf

Warm Thoughts Communications. (2015, September). *2015 Oil Heat Consumer Research Study*. Powerpoint. Retrieved from https://www.warmthoughts.com/wp-content/uploads/2015-oilheat-consumer-research-study.pptx

Williamson, J., & Aldrich, R. (2015). *Field Performance of Inverter-Driven Heat Pumps in Cold Climates* (No. DOE/GO-102015-4642). Consortium of Advanced Residential Buildings, Prepared for The National Renewable Energy Laboratory on behalf of the U.S. Department of Energy. Retrieved from https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/inverter-driven-heat-pumps-cold.pdf

Wolf Davis, K. (2015, November 5). In-Depth on National Grid's Home Energy Report Program. Retrieved November 21, 2016, from http://mobileutilitysummit.energycentral.com/in-depth-on-national-grids-home-energy-report-program/

Yale Center for Business and the Environment. (2015, September 30). Feasibility of Renewable Thermal Technologies in Connecticut. Retrieved November 18, 2016, from http://cbey.yale.edu/programs-research/feasibility-of-renewable-thermal-technologies-in-connecticut

APPENDIX 1: DETAILED POLICY RECOMMENDATIONS

Table 30. Detailed policy recommendations

Policy Recommendation	Assessment Criteria
1) Establish statewide renewable thermal targets: See Section 5.2	
2) Establish stable, long-term incentives for renewable thermal technologies: See Section 5.3	
3) Integrate renewable thermal recommendations into Executive Order 15-17 (Lead by Example): See Section 5.4	
4) Expand access to low-cost financing for renewable thermal technologies: See Section 5.5	
5) Implement community outreach, education, and bulk procurement programs: See section 5.6	
6) RT marketing through utility programs: National Grid is the sole electric and gas utility active in Rhode Island with significant customer infrastructure that could be utilized for outreach and marketing. Free home energy assessments offered through the National Grid EnergyWise program have provided a valuable opportunity for educating consumers and driving adoption of cost-effective energy efficiency improvements. While home energy audits typically assess the performance of home heating systems, they do not generally include homeowner education or recommendations for renewable thermal technologies. Rhode Island could engage National Grid to design and implement a comprehensive information campaign to raise awareness of renewable thermal technologies, with options that include integrating recommendations and education for renewable thermal into home energy audits and comprehensive marketing and outreach campaigns led by National Grid. **Recommendations:** ◉ OER could work with National Grid to pursue a comprehensive RT marketing program. There are multiple approaches that could be pursued: o OER could work with National Grid to develop standard educational materials to be provided to homeowners during audits regarding the suitability of RT options, benefits, and financial impact of RT technologies. Information about RT technologies could also be included in Home Energy Reports and other homeowner outreach	**Barriers addressed:** Low public awareness **Policy category:** Soft cost reduction **Implementation timeline:** Near-medium **Size of impact:** Medium **Time to impact:** Medium **Estimated cost:** Low-Medium

materials.[74] OER could also consider working with National Grid to set up a one-stop shop for homeowners seeking additional neutral information about RT opportunities. o OER could work with National Grid to engage home energy contractors in RT training via webinars, workshops, or other educational materials. Trainings could move beyond just providing educational information about RT to also providing suggestions with respect to selling and marketing RT. • If OER is interested in pursuing this option, OER would need to address the challenge of engaging National Grid to market technologies that may result in fuel switching. An initial approach for a utility marketing initiative could entail focusing on electrification of heating through air and ground source heat pumps – though such efforts would be amplified by a broader incentive scheme for heat pumps and/or an expansion of the HEAT Loan to enable a bigger range of National Grid customers to access the loan for such technologies.	**Applicable technologies:** All (though some challenges for non-electric technologies)
7) Renewable Thermal Training and Certification: Growth in the renewable thermal industry must be balanced with consumer protection and quality assurance. Training programs and certification schemes for installers are diverse and fragmented, which present not only difficulties for ensuring quality assurance, but also barriers to entry for new entrants and conventional installers interested in including renewable thermal in their product offerings. Although third-party certification and training programs have been established for more mature technologies (e.g. NABCEP for solar PV and solar hot water), such programs do not exist for renewable thermal technologies. Instead, manufacturers have filled in the gap for some renewable thermal technologies—in some cases imposing manufacturer training requirements for accessing extended warranties for technologies. As a longer-term goal, Rhode Island could look to develop or engage third-party organizations to develop a robust certification scheme(s) for installers of various RT technologies. However, given the nascent status of the RT industry in Rhode Island, imposing a certification scheme at the present could provide additional challenges for the industry. In the near term, the State could aim to serve as a central facilitator for in-state trainings for RT, driving financial support for trainings from manufacturers, conducting outreach to HVAC contractors, and providing support to contractors interested in diversification. As the market develops, OER could begin engaging stakeholders on developing a state (or regional) certification scheme. **Recommendations:** • OER could engage RT manufacturers to facilitate the establishment of robust in-state installer trainings for RT technologies. The cost of these trainings could	**Barriers addressed:** Gaps in workforce development **Policy category:** Standards and workforce development **Implementation timeline:** Medium **Size of impact:** Medium **Time to impact:** Medium-Long **Estimated cost:** Low-medium

[74] Home Energy Reports have reached 320,000 homeowners in Rhode Island (Wolf Davis, 2015).

be reduced/eliminated to reduce barriers to entry, with much of this cost borne by the manufacturers (though some public funding may be used to drive down costs further).
• OER could conduct outreach to and incentivize HVAC contractors and oil heat dealers to participate in subsidized RT training programs with the goal of driving participants to integrate RT technologies into their product offerings.
    o Currently, the RI Dept. of Labor and Training (DLT) offers a range of tax credits, including a Jobs Training Tax Credit, which provides 50% of training expenses up to $5,000 per employee over three years (RI DLT, n.d.). The Governor's Workforce Board also provides matching grants to businesses through the Incumbent Worker Training Grant Program of up to $45,000 per year in order to support employee skills-based training (Governor's Workforce Board, n.d.). Workforce training plans were also supported by grants of up to $25,000 through the Real Jobs RI Planning Grants program. However, contractors have suggested that it is less the cost of training that serves as a barrier to engaging in training (and associated continuing education requirements), but the opportunity cost of diverting staff to training for multiple days. OER could continue to engage with DLT, GWB, and contractors to identify modifications to existing programs or new program opportunities that will increase participation rates in manufacturer trainings and continuing education.
    o Contractors and manufacturers suggested that incentives for training are insufficient to make installers who are already unlikely to attend trainings (and are often responsible for poorer-quality installations) enroll. OER could explore opportunities for requiring that installers participate in training programs in order to access any future incentive programs.
• OER could consider designing an inspection requirement in order to allow installers to participate in RT incentive programs. These inspection requirements could be streamlined for installers that have received more stringent certification from manufacturers and/or a future Rhode Island or regional RT certification. OER could consider delaying the implementation of this inspection requirement until the industry has grown to a more appropriate size.
	Applicable technologies:
	All (except biodiesel)

8) Provide funding for EM&V and/or multifamily and commercial demonstration projects for RT technologies: Awareness and installations of RT technologies in 1-4 family residential buildings have grown rapidly in other Northeastern states in recent years, with several performance studies having been completed (esp. for ASHPs in residential applications). However, policy makers have indicated a continued lack of available, third-party verified performance data for evaluating RT technologies in various applications. In particular, installations of RT technologies in multifamily and commercial buildings have been slower to materialize, and there is even less	**Barriers addressed:** Unclear regulatory/ metering protocols; low public awareness

performance data available for technologies installed in such applications. Rhode Island could fund projects that improve the availability of verified performance data, particularly from the multifamily and commercial sectors. **Recommendations:** - OER could provide funding to support the development of a small but diverse set of multifamily and commercial RT retrofit projects across the state. These projects could include a range of different RT technologies and different sizes and ages of multifamily and commercial buildings. OER could work with the building operators and contractors to disseminate performance data and lessons learned from the projects to improve awareness of RT in multifamily applications. Such an initiative could be implemented in collaboration with public housing agencies to serve low income residents. - OER could fund the installation of monitoring equipment in new installations of various RT technologies. This data could then be evaluated, peer-reviewed, and made widely available to support decision-making at the policy level across the region. If OER is interested in conducting such a program, it could consider reaching out to other state agencies and/or utilities to support a regional collaboration. - If interested in pursuing this approach, OER should pursue opportunities to harmonize RT demonstration projects with ongoing work within the State regarding energy efficiency, renewables, zero net energy buildings, and equity/access for low-medium income families. The National Grid-led Multifamily Working Group, the RI Energy Efficiency and Resource Management Council, and the LMI Solar Access working group could be potential targets for engagement.	**Policy category:** Financing and incentives **Implementation timeline:** Medium **Size of impact:** Medium **Time to impact:** Medium-Long **Estimated cost:** High **Applicable technologies:** All (except biodiesel)
9) Reduce RT soft costs through revising local and state policies: The installation of RT technologies requires municipalities to issue building permits (e.g. mechanical, electrical). While fees from permitting may be necessary to cover the costs of inspecting RT installations, the cost and time required to permit, as well as inspection and other requirements, can vary widely from municipality depending on technology and application (e.g. a $10,000 installation could cost more than twice as much to permit in Providence than in Warwick) (City of Providence, 2012; City of Warwick, 2015). There are opportunities across Rhode Island to streamline permitting processes for RT technologies and expand existing tax exemptions in order to reduce the impact of soft costs on consumers. **Recommendations:** - OER could evaluate permitting costs across Rhode Island municipalities to identify opportunities to streamline permitting processes and reduce fees associated.	**Barriers addressed:** High system costs **Policy category:** Soft cost reductions **Implementation timeline:** Medium **Size of impact:** Medium **Time to impact:** Medium

- Based on findings, evaluate pathways for streamlining inspection and permitting (e.g. incentives for adopting best practices and/or model approaches, legislatively-mandated cap on permitting costs for RT) - H.B. 8354 was enacted in June 2016, which exempted "renewable energy resources" used in residential systems from property taxes" (Ruggiero et al., 2016). However, the renewable energy resources as defined in § 39-26-5 include only "generation units," which thus is unlikely to include RT technologies. Additional clarity could be provided in § 39-26-5 to include RT technologies under renewable energy resources in order to exempt these installations from property taxes (Rhode Island General Laws, 2004).	**Estimated cost:** Low **Applicable technologies:** All
10) Support development of RT vocational training programs: While industry stakeholders have identified a pressing need for improved and more accessible training for RT technologies, industry stakeholders have also identified a need for increasing the number of skilled young workers that enter the HVAC sector. The current pipeline of young workers and career changers entering the workforce is likely to be insufficient as older HVAC workers retire. In order to support the long-term prospects of RT installations and the HVAC industry as a whole, Rhode Island could explore options for developing and implementing curricula for energy efficiency and RT technologies. **Recommendations:** - OER could work with the Dept. of Labor and Training (DLT) and the Governor's Workforce Board (GWB) to explore opportunities to develop relationships with community colleges, vocational schools, and community organizations (e.g. United Way) engaged in supporting youth and low-income workforce development to develop curricula and engage young people and career changers to enter the HVAC industry. - Alternatively, OER could develop its own courses in collaboration with and taught by experts in order to provide training for RT and energy efficiency technologies. NYSERDA currently offers a number of courses through Renewable Heat NY on wood pellet boiler system design and installation, and completion of at least one course is necessary to be eligible for the incentive program.	**Barriers addressed:** Gaps in workforce development; low public awareness **Policy category:** Standards and workforce development **Implementation timeline:** Medium **Size of impact:** Medium **Time to impact:** Long **Estimated cost:** Low-medium **Applicable technologies:** All (except biodiesel)
11) Support regional development of RT technology performance standards, certifications, and supporting research: Rhode Island currently lacks comprehensive design, installation, and performance standards for RT technologies. While there are several industry and regional certifications for various technologies that have been	**Barriers addressed:** Unclear regulatory/ metering protocols; gaps in workforce development

developed,[75] RT performance standards, the applicability of certifications, and requirements for incentive program eligibility generally vary widely across the Northeastern states. In conjunction with developing incentives and a roadmap for RT technologies, Rhode Island could consider developing a product certification scheme required for accessing incentives which governs installation, design, performance, and quality assurance standards for RT technologies. **Recommendations:** ◉ OER could collaborate with other state agencies where possible to harmonize ongoing efforts across the region and reduce burdens on the industry. A regional initiative to engage with the RT industry, International Organization for Standardization (ISO), American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), Northeast Energy Efficiency Partnerships (NEEP), Solar Rating & Certification Corporation (SRCC), U.S. Dept. of Energy (DOE), and other organizations can help develop strong regional standards for design, installation, and performance in RT. ◉ OER could establish a product certification scheme for eligible RT technologies that meet design, installation, performance, and quality assurance standards. Incentives would only be awarded to RT products and fuels that meet the product standards. ◉ OER could continue to engage with relevant stakeholders over time to strengthen performance standards required for certification. Tightening performance standards will drive innovation in the industry and ensure that RT technologies become more efficient over time. ◉ Beyond product certification, it will be important to ensure that installations are properly sized and technologies are properly applied. Industry stakeholders have indicated that best practices for technology applicability, sizing, use of thermal storage, and more have yet to be clearly determined by neutral sources. OER could explore options for partnering regionally to support additional research into RT technologies with regards to sizing and applications, including providing direct grants to researchers and providing financial support to ongoing regional research efforts. When possible, OER could integrate key findings from these efforts into incentive schemes for RT.	**Policy category:** Standards and workforce development **Implementation timeline:** Medium-Long **Size of impact:** Medium **Time to impact:** Long **Estimated cost:** Low **Applicable technologies:** All
12) Establish a RT business and infrastructure grant program: The expansion of the RT market in Rhode Island could be accompanied by investments to attract new businesses, keep heating dollars in-state, and address gaps in the RT supply chain infrastructure. Rhode Island has previously provided financial support to local businesses through the Rhode Island Commerce Corporation, most recently providing	**Barriers addressed:** Gaps in infrastructure/ supply chain

[75] There are a range of existing standards and certification schemes with varying levels of specification and applicability: Solar Rating & Certification Corporation (for solar hot water), American Society of Mechanical Engineers and EPA emissions standards (for pellet boilers), Northeast Energy Efficiency Partnerships – Cold Climate ASHP Specification (for ASHP), American Heating/Refrigeration Institute and New England Geothermal Professional Association (for GSHP)

nearly $500,000 in innovation vouchers to 11 companies across the state (RI Commerce Corporation, 2016). A similar program focused on RT technology innovation could help to jumpstart local businesses, drive growth in Rhode Island's RT sector, and create jobs. **Recommendations:** ◉ OER could explore options for driving investment in RT businesses and infrastructure: e.g. establishing an infrastructure support grant program (see MA Renewable Thermal Business Investment Grant Program for an example), implementing a production-based incentive for new RT manufacturers/producers and distributors (e.g. $/ton of pellets or $/gallon of biodiesel produced/distributed, declining over 3-5 years). ◉ OER could engage with industry stakeholders and other state agencies (e.g. Rhode Island Commerce Corporation) in order to determine the optimal targets and mechanism for providing support.	**Policy category:** Financing and incentives **Implementation timeline:** Medium **Size of impact:** Medium **Time to impact:** Medium **Estimated cost:** Medium-High **Applicable technologies:** All
13) Provide grants/incentives for improving bioenergy infrastructure: Some industry stakeholders have identified a need for additional investment in the wood pellet/chip and biofuel supply chains. In particular, there are currently no manufacturers of wood pellets located in Rhode Island. In addition, there is a need to expand and upgrade terminal and distribution infrastructure for biodiesel to meet increasing biodiesel blend mandates. Given the decentralized nature of the oil heat industry, there is insufficient capital and interest in funding such infrastructure improvements, which are necessary to help meet the state biodiesel mandate as well as ensure that blending is consistent to prevent damage to customer equipment. Infrastructure and business development grants, tax incentives, and/or production incentives can provide the financial support needed to catalyze private sector investments for such capital-intensive bioenergy infrastructure investments and drive economic development in Rhode Island. **Recommendations:** ◉ OER could explore options for grant funding or financing (e.g. in collaboration with the RI Infrastructure Bank) biodiesel infrastructure at the terminal level. This would entail supporting the installation of larger mixing and storage tanks, as well as injection blending components to ensure greater consistency in blending. ◉ An example of such a program focused on biofuel infrastructure (though focused on E85 Ethanol as opposed to biodiesel) is "The Bio-Fuel Station	**Barriers addressed:** Gaps in infrastructure/ supply chain **Policy category:** Financing and incentives **Implementation timeline:** Near **Size of impact:** Medium **Time to impact:** Near-Medium **Estimated cost:** Medium

Initiative: Driving Energy Independence for the Empire State" from NYSERDA. This approximately $1 million program provides fixed grants of $35,000 per site for new installations of equipment used for dispensing, storing, or selling biofuels to consumers. Biodiesel stakeholders cited this program as a successful initiative that led to a significant increase in the number of locations that dealers could pick up new biofuels, thus reducing associated travel costs.	**Applicable technologies:** Biodiesel Biomass
14) Engage educational institutions on renewable thermal: Engage educational institutions to install RT demonstration projects, associate RT with sustainability as part of branding and marketing, and serve as sectoral champions for RT. Adoption of RT is critical to achieving climate goals, but most consumers don't associate heating and cooling with clean or renewable energy. While most consumers are driven by non-sustainability motivations (e.g. potential savings, home comfort), a change in messaging will be needed to more strongly associate RT with sustainability. Academic institutions are high-visibility champions of sustainability and clean energy. Engaging academic institutions to install RT demonstration projects, host community educational events, and serve as champions for RT could help to raise the profile of RT. **Recommendations:** - OER could engage public and private educational institutions (primary/secondary schools and colleges & universities) to serve as champions of RT. OER could provide financial support for installing demonstration projects and hosting community education events to build awareness (which could be done in conjunction with a community aggregation pilot).	**Barriers addressed:** Low public awareness **Policy category:** Soft cost reductions **Implementation timeline:** Medium **Size of impact:** Low-Medium **Time to impact:** Near-Medium **Estimated cost:** Low-medium **Applicable technologies:** All
15) Establish biofuel mixing guidelines: Under the Biodiesel Heating Oil Act of 2013, all No. 2 heating oil sold in Rhode Island must contain 5% biodiesel by July 2017. While biodiesel blending is ongoing, fuel dealers have reported major inconsistencies in the actual biodiesel content of each batch of oil they fill up at the terminal level. In particular, biodiesel blending is typically accomplished through a practice of "splash blending," which can be challenging in cold temperatures and result in wildly inconsistent blends: dealers have reported seeing blends of up to B24 (when expecting a normal batch of B5 or less), and testing each batch of oil is both time and cost prohibitive for fuel dealers. On the distribution side, most of the equipment and infrastructure currently in use is not designed for use for blends of greater than B5 or B10. Similarly, use of high biofuel blends in aging tanks and oil boilers and furnaces can result in equipment malfunctions	**Barriers addressed:** Unclear regulatory/ metering protocols **Policy category:** Mandates **Implementation timeline:** Near-Medium

and spills. These factors can result in significant problems for fuel dealers, including exposure to liabilities due to spills or equipment malfunction and a heightened level of service calls. Given the liabilities associated with inconsistent biodiesel blends, additional regulations. In addition to funding the purchase of larger storage tanks and components that enable injection mixing (see above), Rhode Island could consider establishing guidelines for biofuel mixing to ensure greater consistency in blends at the terminal level. **Recommendation:** ◉ Rhode Island could engage fuel dealers and terminal operators to establish clear guidelines governing the mixing and testing process at the terminal level. Such guidelines should be developed alongside a program to fund or finance the purchase of the necessary equipment at the terminal level to ensure that the guidelines can be achieved and enforced.	**Size of impact:** Low-Medium **Time to impact:** Near **Estimated cost:** Low **Applicable technologies:** Biodiesel
16) Support RT standardization and aggregation initiatives: To scale up low-cost investment capital – and drive down development costs – RT projects must become more accessible to mainstream investors. Standardization of project documents and aggregation of projects are important mechanisms that would enable smaller RT projects to be pooled together. By standardizing contracts, it is possible to lower due diligence cost, better conform to investor requirements, broaden the investor pool, and diversify individual asset risks (International Renewable Energy Agency, 2016). Very little effort to date has occurred to standardize and aggregate RT assets, though a number of initiatives have been successfully implemented for solar and energy efficiency assets, which have unlocked low-cost capital that has helped the market scale. Such efforts may help to enable the creation of third-party ownership models (e.g. leasing and power purchase agreements) for renewable thermal technologies, which have been a major driver of the rapid scale-up of renewable electricity generation resources over the past several years. Notably, large-scale investors (like pension funds) require 'benchmark-size' deals greater than USD 300 million to consider investment. Asset aggregation in distinct structures permits the creation of various individual tranches to appeal to a variety of investor appetites, broadening the potential pool of capital providers. Building a replicable aggregation model for RT that can be scaled up will require strong support and commitment from governments as well as consensus on specific terms of standardization from industry stakeholders. **Recommendation:** ◉ OER could participate in ongoing initiatives led by other regional actors (e.g. NYSERDA) to engage industry, policy, and financial stakeholders in the region to help drive standardization of renewable thermal installations. Key steps in the process may include:	**Barriers addressed:** High system costs **Policy category:** Soft cost reductions **Implementation timeline:** Medium **Size of impact:** Low-Medium **Time to impact:** Near-Medium **Estimated cost:** Low-medium **Applicable technologies:** All

• Management of a working group that promotes engagement and coordination among finance and industry stakeholders; • Development of standardized toolkits (e.g. template contracts, performance metrics, transaction structures) that promote the standardization of terms necessary to aggregate projects • Demonstration of projects and provision of technical assistance to government and industry stakeholders	
17) Develop a consumer education and decision-making platform for RT: There is currently no established, consumer education platform managed by a neutral third party that provides consumers with educational information on RT technologies – or with the tools to assess their home's potential for adopting RT technologies. Customers are often skeptical of claims made by manufacturers, utilities, or contractors, and a website backed by the State that can provide unbiased educational information could help to spread awareness and drive adoption of residential RT technologies. **Recommendation:** ◉ OER could sponsor (or lead an initiative with other Northeastern states) to lead the development of a central, "one-stop shop" for providing neutral educational information to consumers on RT technologies (with potential for expansion to other renewable energy and energy efficiency technologies). Flexible, but simple tools for supporting decision-making (e.g. financial calculators, customer action recommendation tools) could be embedded in the site to facilitate decision-making, as well as up-to-date information on available rebates and eligible contractors.	**Barriers addressed:** Low public awareness **Policy category:** Soft cost reductions **Implementation timeline:** Medium **Size of impact:** Low-Medium **Time to impact:** Medium **Estimated cost:** Low **Applicable technologies:** All
18) Explore opportunities to expand the biodiesel mandate. Rhode Island's biodiesel blending mandate is the only state level blending mandate for heating oil. However, it is scheduled to reach B5 (5%) in 2017 with no current plans for expansion. Based on engagement of heating oil dealers through the fuel dealer roundtables and market survey, most dealers have already achieved this mandate (see Recommendation 15 above for fuel dealer concerns regarding blend practices and levels), with some dealers offering up to B99 based on customer demand. An expansion of the biodiesel mandate (e.g. to B15 or B20 by 2035) could provide additional GHG emissions reductions (see Box 6 in Section 6.4). **Recommendation:** ◉ OER could engage industry stakeholders and state policymakers to pursue an expansion of the state biodiesel mandate. There are some challenges	**Barriers addressed:** Lack of policy support **Policy category:** Planning, targets & mandates **Implementation timeline:** Near-Medium

associated with greater biodiesel blends, as discussed further in Section 2.1.5, including blending practices, existing equipment limitations, and gel point, which will need to be resolved through engagement with industry stakeholders to enable an expansion of the biodiesel mandate. Notably, while no other biodiesel blending mandates have been implemented at the state level for heating oil, New York City expanded its biodiesel blending mandate in September 2016 to reach B5 by October 2017 and B20 by 2034. OER could build off of NYC's experience with stakeholder engagement and policy design to address the aforementioned challenge with greater blends (e.g. mandate exemptions for boilers that have a warranty or compatibility issue with higher biodiesel blends).	**Size of impact:** Medium **Time to impact:** Medium-Long **Estimated cost:** Low **Applicable technologies:** Biodiesel
19) Explore opportunities to modify biodiesel tax exemption. Biodiesel provides GHG emissions reductions relative to conventional heating oil, but biodiesel produced in RI is generally more expensive than the heating oil it displaces. RI exempts biodiesel from the state fuel excise tax of $0.32 per gallon of B100 biodiesel, though industry stakeholders have noted that monetizing this tax exemption is difficult. In particular, oil distributors must track the gallons of biodiesel sold, file for the tax exemption, then pass the savings onto the consumer. As biodiesel blending can be inconsistent (see Recommendation 15 above for additional discussion)—and the tax credit for a B5 blend amounts to $0.016 per gallon of blended heating oil—oil distributors typically do not want to take on the additional administrative burden of filing for the tax exemption. Opportunities exist to modify the existing biodiesel tax exemption to improve the effectiveness of incentive delivery—which will be particularly important to mitigate the price premium of biodiesel if RI is interested in pursuing an expansion of the biodiesel blending mandate. OER could engage with industry stakeholders and state policymakers to explore opportunities to modify the biodiesel tax exemption. In particular, industry stakeholders have suggested that the tax exemption be moved further up the supply chain from the distribution level to the production level. This might take the form of a production tax credit—e.g. $0.32/gallon of biodiesel sold by producers to distributors filed by the producer, similar to the federal Biodiesel Production and Blending Tax Credit. Such a mechanism would enable biodiesel producers to sell biodiesel to distributors at (or below) market price for heating oil and mitigate the cost premium to customers and shift the administrative burden from the distribution level to the production level where the added burden is expected to be lower.	**Barriers addressed:** High upfront costs **Policy category:** Financing & incentives **Implementation timeline:** Near-Medium **Size of impact:** Medium **Time to impact:** Near **Estimated cost:** Medium **Applicable technologies:** Biodiesel

APPENDIX 2: FINANCIAL ANALYSIS INPUTS AND ASSUMPTIONS

Renewable Thermal Installation Assumptions

Typical single-family renewable thermal technology costs were sourced from regional rebate databases from programs implemented in Massachusetts and Connecticut, taking stakeholder group participant input into account. It was assumed that ASHP projects would serve 70% of a household's heating load and require a three-ton system. It was also assumed that pellet boilers would include thermal storage, and that solar hot water systems would have two collectors and serve 70% of a household's hot water load.

Multifamily cost estimates were determined by scaling single family cost estimates based on the economies of scale seen in regional rebate databases and cost factors noted in stakeholder interviews. Commercial space heating equipment costs were sourced from the midpoint of the ranges displayed in the 2012 Massachusetts DOER *Heating and Cooling in the Massachusetts Alternative Portfolio Standard* report, and commercial SHW costs were assumed to be equivalent to multifamily costs given the similar hot water load.

Table 31. Assumed RE Thermal Costs

Sector	Technology	Cost
Single Family	ASHP	$11,780
	GSHP	$35,000
	Pellet Boiler	$22,561
	SHW	$9,482
Multifamily	ASHP	$29,450
	GSHP	$87,500
	Pellet Boiler	$56,400
	SHW	$23,710
Commercial	ASHP	$71,900
	GSHP	$213,800
	Chip Boiler	$120,000
	SHW	$23,710

For the Participant Cost Test, incentive levels were based on those currently in place in the rebate programs offered in Massachusetts by the Massachusetts Clean Energy Center (MassCEC). Current MassCEC rebate levels are:

- ASHPs: $625 per single-head system
- GSHPs: $1,500 per ton
- Biomass Boilers: 45% of project cost up to $10,000.
- SHW: Calculated value multiplying $100 by the Solar Rating & Certification Commission OG-100 product rating, multiplied by the number of collectors, up to 40% of project cost.

As MassCEC programs primarily target single-family residential buildings, multifamily and commercial incentive levels were calculated based on residential incentive levels and assumed to scale with project cost. The specific incentive levels assumed in this analysis are in the table below.

Table 32. Incentive Levels

Sector	Technology	Cost
Single Family	ASHP	$1,875
	GSHP	$6,840
	Pellet Boiler	$10,000
	SHW	$2,740
Multifamily	ASHP	$4,690
	GSHP	$17,100
	Pellet Boiler	$25,000
	SHW	$6,850
Commercial	ASHP	$11,450
	GSHP	$41,780
	Chip Boiler	$53,190
	SHW	$6,850

Additionally, it was assumed that solar hot water projects would be eligible for a 30% federal Investment Tax Credit.

It was assumed that ccASHPs would have an average HSPF of 11, based on the equipment list approved by NEEP for certification in its ccASHP standard to date. GSHPs were assumed to have a COP of 4.1 based on the closed-loop ENERGY STAR standard. Solar hot water heaters were assumed to have a SRCC OG-100 rating of 13.7 based on the average seen in the MassCEC rebate program to date. Wood pellet boilers were assumed to have a heating efficiency of 85%, and wood chip boilers and efficiency of 80% based on stakeholder group feedback.

Per the Rhode Island Technical Reference Manual, ASHPs were assumed to have an Expected Useful Life (EUL) of 18 years, and GSHPs an EUL of 15 years. Wood boilers were assumed to have an EUL of 20 years based on the Rhode Island TRM assumptions for gas boilers (wood boiler values are not included in the TRM). Solar water heaters were assumed to have an EUL of 20 years based on the standard warranty term in the industry.

Based on current market size and economics, it was assumed that ASHPs would account for the majority of the RT project portfolio, but that the market size of other technologies would increase at a faster rate than ASHPs over time. Assumed number of installations at different stages of the program period are shown in 5-year increments in the table below.

Table 33. Assumed Number of Installations

Year	ASHP	GSHP	Wood Boiler	SHW
2020	521	74	34	94
2025	991	187	85	235
2030	1,465	298	136	376
2035	1,931	408	188	519

Building Assumptions

Buildings were separated into the residential single family, residential multifamily, and commercial sectors. Average building square footage and thermal energy consumption was determined using the EIA RECS and CBECS databases. Recognizing the difficulties of determining standard measure inputs for customer large commercial applications, this analysis only considers small commercial buildings under 20,000 square feet. Multifamily buildings are considered at the building level, rather than the apartment level, as thermal systems are often whole-building installations. Based on the EIA RECS database, it was assumed that a typical multifamily building contains 5.5 housing units.

This table below summarizes the building assumptions used in this analysis.

Table 34. Average Thermal Load per Building

Sector	Building Square Footage	Space Heating Annual MMBTU	Water Heating Annual MMBTU
Single Family	2,100	65	10
Multifamily	5,000	219	36
Commercial	15,800	535	33

Heating Fuel Prices

Where appropriate the 2015 regional *Avoided Energy Supply Costs in New England* (AESC) report was used as a source for fuel prices. This report was referenced for avoided energy costs and wholesale supply costs for electricity and natural gas. Current national grid retail tariffs were used to source the distribution components of electricity and natural gas retail rates.

The Rhode Island Office of Energy Resources maintains a database of average home heating oil prices in the state, and this database was used to create estimates of fuel oil avoided costs. Based on feedback from stakeholder working group participants, it was determined that the AESC avoided cost values for woody biomass fuel were not accurate, and alternate prices of $250/ton for wood pellets and $125/ton for wood chips were used. Both oil and wood fuel prices were escalated according to the escalation factors included in the AESC.

APPENDIX 3: WORKING GROUP PARTICIPANTS

The Rhode Island Office of Energy Resources thanks the following individuals for contributing their time and input to the development of this report.

Table 35. Working group participants

Name	Affiliation
Rick Nortz	Mitsubishi Electric
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Bruce Payton	RI Dept. of Environmental Management – Division of Forest Environment
Angela Li	National Grid
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Mark Chaffee	Taco, Inc.
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Kevin Flynn	Viessmann Manufacturing
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