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Commonwealth Accelerated Renewable Thermal Strategy

Final Report

Prepared for:
Massachusetts Department of Energy Resources

DOER
Massachusetts Department of Energy Resources

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List of Acronyms

BAU – Business as Usual
BF – Biofuels
BG – Biogas
BMCH – Biomass Chips
BMP – Biomass Pellets
CARTS – Commonwealth Accelerated Renewable Thermal Strategy
CBECS – Commercial Building Energy Consumption Survey (EIA)
ccASHP – Cold-Climate Air Source Heat Pump
DOER – Department of Energy Resources
EEA – Executive Office of Energy and Environmental Affairs
EIA – Energy Information Administration
EU – European Union
FIT – Feed-in Tariff
FO – Fuel Oil
GHG – Green House Gas
GSHP – Geothermal Heat Pump
GWSA – Global Warming Solutions Act
HSS – High State Support
LPG – Liquefied Petroleum Gas (Propane)
MA – Massachusetts
MassCEC – Massachusetts Clean Energy Center
MCG – Meister Consultants Group
NCI – Navigant Consulting Inc.
RECS – Residential Energy Consumption Survey (EIA)
RT – Renewable Thermal
SAG – Stakeholder Advisory Group
ST – Solar Thermal

Executive Summary

The Massachusetts Department of Energy Resources (DOER) is a state agency whose mission is to analyze and develop policies and programs to ensure Massachusetts' citizens have adequate and diverse energy supplies, at a reasonable cost, with minimal impact on the environment. DOER initiated the Commonwealth Accelerated Renewable Thermal Strategy (CARTS) program and retained a team consisting of Navigant Consulting Inc. (Navigant) and Meister Consultants Group (MCG) to identify the best strategies to rapidly spur renewable thermal (RT) market growth in Massachusetts. This team was tasked with analyzing the impacts of accelerated market growth on the Commonwealth; researching best-practices from other jurisdictions; and developing a strategy to guide DOER's market development efforts. The CARTS program covered the following high-efficiency technologies: cold climate air-source heat pumps, biomass pellet\chip boilers and furnaces (chips were only considered for use in larger building applications), ground-source heat pumps, solar thermal systems, biofuels, and biogas. Through prior analysis, DOER identified the main opportunities as being in heat pumps, biomass, and solar thermal, with a secondary role for biofuels and biogas.

The primary objectives of the CARTS program were to identify ways to reduce GHG emissions, expand economic development opportunities, and reduce heating and cooling costs for consumers. GHG emissions reductions are driven by the Massachusetts *Global Warming Solutions Act* (GWSA) of 2008, which set statewide limits on GHG emissions for both 2020 and 2050. In 2010, the Executive Office of Energy and Environmental Affairs published the *Massachusetts Clean Energy and Climate Plan for 2020*, which laid out a broad, statewide plan to achieve both GWSA emission limits.[1] This plan includes a hard target for GHG emissions reductions attributable to solar thermal systems (0.1% below 1990 levels in 2020) and an indicative target for all RT equipment (2% below 1990 levels in 2020, inclusive of solar thermal).

The CARTS team followed a systematic approach to analyzing the heating and cooling market in Massachusetts and developing appropriate strategies to spur RT market growth. The team modeled the Massachusetts market and analyzed the energy (including consumer fuel savings), environmental (GHG emission reductions), and economic (job growth and state tax revenues) impacts of potential RT growth scenarios. In parallel, the team also reviewed successful policies from other jurisdictions and identified programs and approaches that are applicable to Massachusetts. Throughout the CARTS analysis, the team solicited feedback and guidance from a group of stakeholders.

The CARTS team identified key conclusions from modeling the Massachusetts heating and cooling market and analyzing potential RT growth scenarios, as described in detail in section 3.3 . Six of these takeaways include:

- **The net present value (NPV) of benefits from RT investment may reach 2.4X to 3.2X the NPV of costs –** Under business as usual, the net present value (NPV) of benefits to the state for investments until 2030 total $5.1 billion to $7.5 billion (including continued savings for 10 years

[1] "Massachusetts Clean Energy and Climate Plan for 2020", December 2010, Available at: www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

beyond the last year of investment). The range is due to the upper and lower range used for estimating the value of avoided GHG emissions. The NPV of the costs (including all consumer and incentive investment) in RT installations through 2030 total $3.9 billion. Under very high state support assumptions, Massachusetts could expect benefits to increase to roughly $23 billion to $31.3 billion at a cost of $9.8 billion in investment. This represents a 2.4X to 3.2X benefit to cost ratio. Even when excluding the avoided cost of GHG emissions, the benefits outweigh the investment cost by a factor of 2.3X in the high support scenario.

- **Meeting 2020 GHG goals requires aggressive state support –** Under business as usual conditions, RT technologies may not achieve significant market penetration until well after 2020. Massachusetts will only achieve the 2020 GHG emissions reduction goal through very aggressive growth, targeted at accelerating adoption of RT technologies over the next 6 years.
- **Meeting 2020 GHG targets can put MA on a trajectory to meet 30-32% of thermal energy from RT technologies by 2030 –** With aggressive support for RT technologies and business-as-usual rates of conversion to natural gas, the state may serve a maximum of 32% of thermal loads with RT (up to 15,000 MWth of capacity). This penetration will decrease if natural gas conversion rates increase.
- **Massachusetts should support a portfolio of all RT technologies –** Meeting customer's differing needs necessitates deployment of all RT technologies. While all RT technologies have merits across different applications, efficient heat pumps in residential applications and clean biomass in commercial buildings, present the highest fuel cost savings to customers. However, to most cost-effectively across the economy achieve GHG emission reduction targets, including and especially the 2050 GHG emission limit, the state should also support solar thermal market growth, as solar thermal systems reduce more GHG emissions on a per installation basis.
- **Priority customer classes for RT adoption are residences and businesses currently using heating oil or electricity for space heating and domestic hot water –** Customer classes were prioritized based on an analysis of payback times associated with the RT investments, achievable GHG emission reductions, segment size, and income level. The most important customer classes for targeting purposes are:
    - Commercial, Large Buildings, Using Fuel Oil / Electricity
    - Residential, High Income, Using Fuel Oil
    - Residential, Low Income, Using Fuel Oil / Electric

  Priority customers will likely be living in areas not served by natural gas utilities, outside of gas service areas, or a long distance from gas distribution. Currently about 1.2 million households in Massachusetts are not using natural gas for space heating.
- **Natural gas customers should be targeted, but present a cost-competitiveness challenge –** In many regions across the state, natural gas (NG) is the biggest competitor for RT technologies due to its current low price. Since it is least likely that current NG customers (particularly residential customers) will convert to RT, Massachusetts should target non-NG customers who have access to convert to NG, and convert them to RT. The team estimates that by aggressively targeting potential natural gas customers, the state can convert approximately 4,500 customers to RT technologies by 2020.

Based on energy potential modeling, the experience in other jurisdictions, and input from the stakeholder advisory group and DOER a set of appropriate strategies were identified to address the barriers and challenges facing the Massachusetts RT market. Grouped in topic area clusters

(Governance, Innovation, Financing…) the team compiled and prioritized a list of 66 unique market development strategies. From this long list, Table ES-1 lists the top seven priority strategies. These are identified to be central to growing the market at an accelerated pace. A second tier of additional strategies is included in Table ES-2.

The strategies are discussed in more detail in section 6 of this report, including how they were prioritized. This is a recommended list of strategies that does not reflect a commitment by DOER or others to implement specific strategies.

Table ES-1: Top Priority Strategies

Topic Area	Strategy
Governance	Develop statewide renewable thermal goals for each technology
Governance	Leverage, coordinate, and expand efforts across state agencies to meet short-term goals
Marketing	Launch comprehensive RT technology information campaign with MassSave
Governance	Support implementation of long-term, stable performance-based RT incentives
Governance	Integrate RT in state and public buildings via "Leading by Example" and/or other state energy programs
Governance	Integrate RT into the Stretch Energy Code and other building energy codes
Finance	Develop low-cost financing for renewable thermal through the MassSave HEAT loan program

Table ES-2: Additional Strategies

Topic Area	Strategy
Marketing	Develop "Thermalize" program, modeled after the successful Massachusetts Solarize program
Marketing	Develop comprehensive, online database with case studies and technology performance metrics
Marketing	Provide data to assist developers and installers to identify "high value" renewable thermal customers
Marketing	Create tool that helps customers self-screen for suitability of RT technologies
Innovation	Support technology exchanges with "state-of-the-art" manufacturers
Resource and Logistics	Create Renewable Thermal Industry Advisory Forum
Governance	Review market enabling guidance regarding fuel choices and associated GHG emissions

Topic Area	Strategy
Labor and Standards	Institute technical and sales training programs
Resource and Logistics	Engage heating oil and propane industry to explore RT business opportunities
Governance	Integrate renewable thermal into energy protection and assistance programs for low-income families
Labor and Standards	Integrate RT and EE into community college and vocational school curricula in MA

The 18 strategies identified above were developed as a comprehensive package of actions that address RT barriers. If the strategies are not executed in a comprehensive fashion, the potential tradeoffs of omitting any given strategy should be considered. Substantial RT market growth is more likely to be achieved by supporting all aspects of the RT industry including addressing consumer awareness, regulatory support, incentives and financing mechanisms, R&D, and installer training.

1 Introduction

1.1 Background

The Massachusetts Department of Energy Resources (DOER) is a state agency whose mandate is to analyze and develop policies and programs to ensure that Massachusetts' citizens have adequate and diverse energy supplies, at a reasonable cost, with minimal impact on the environment. To that end, DOER strives to create a clean energy future for the Commonwealth, economically and environmentally, including:

- Accelerating the deployment of cost-effective energy efficiency;
- Increasing the development of clean energy resources;
- Implementing strategies to assure reliable supplies and improve the cost of clean energy relative to fossil-fuel based generation; and
- Supporting MA clean energy companies and spurring MA clean energy employment.

The market for renewable heating and cooling and thermal energy recovery in Massachusetts is growing, but small. Increasing the market share of renewable heating and cooling technologies at an accelerated pace will enable the Commonwealth to address a series of important challenges. These include reducing the state's dependency on heating sources that are either costly (oil, propane, electricity), constrained (natural gas), or both. Renewable heating and cooling technologies can help Massachusetts meet greenhouse gas (GHG) emission reduction targets, increase energy efficiency, and improve air quality.

However, realizing the full benefits of renewable heating and cooling in time to meet the challenges described above requires a comprehensive approach to market development. As a result, DOER initiated the Commonwealth Accelerated Renewable Thermal Strategy (CARTS) program and retained a team consisting of Navigant Consulting Inc. (Navigant) and Meister Consultants Group (MCG) to identify the best strategies to spur renewable thermal (RT) market growth in Massachusetts. The team was tasked with analyzing the energy, economic, and environmental impacts of accelerated market growth on the Commonwealth; researching best-practices from other jurisdictions; and developing a strategy to help guide DOER's market development efforts. Potential strategies covered a broad scope, including:

- Financial incentives or programs to help overcome high first costs;
- Expanded consumer awareness;
- Integration of RT technologies into building codes and renovation requirements; and
- Workforce training initiatives to build capacity within the renewable thermal market.

This report documents the analysis the CARTS team conducted and presents key findings that will help inform DOER's and the Executive Office for Energy and Environmental Affairs (EEA) decision-making process. It builds on DOER's prior analysis of the RT opportunity in the state in two studies:

- "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study," March 2012, prepared by Meister Consultants Group.

- "Heating and Cooling in the Massachusetts Alternative Portfolio Standard," Report to the Legislature by DOER, December 2012, prepared with assistance from Meister Consultants Group and the Massachusetts Clean Energy Center (MassCEC).

This report will help DOER accelerate expansion of the renewable thermal market to meet the state's energy, economic, and environmental goals.

1.2 Objectives and Goals

The primary objective of the CARTS program was to develop a pathway to accelerate growth of the renewable thermal market in Massachusetts. The program focused on mechanisms to achieve three goals:

1. **Reduce GHG Emissions** – The Massachusetts *Global Warming Solutions Act* (GWSA) of 2008 set statewide limits on GHG emissions for both 2020 and 2050. In 2010, the Executive Office of Energy and Environmental Affairs published the *Massachusetts Clean Energy and Climate Plan for 2020*, which laid out a broad, statewide plan to achieve both GWSA goals.[2] The targets related to RT for 2020 include:
    a. Renewable thermal technologies can account for a 2% reduction in GHG emissions below the 1990 emissions level.
    b. Solar thermal systems should contribute a 0.1% reduction in GHG emissions below the 1990 emissions level.

    The economy-wide target for 2050, covering all sectors, is to reduce GHG emissions 80% below the 1990 emissions level.

2. **Increase Economic Development Opportunities** – Massachusetts has established itself as a leader in energy efficiency by supporting continued investment in the industry. RT technologies present a key opportunity to create in-state jobs and support businesses in Massachusetts through accelerated renewable thermal market growth. Massachusetts consumers benefit further as RT technologies and locally sourced fuel (in the case of biomass) offset fossil fuel imports.

3. **Reduce Heating and Cooling Expenditures for Consumers** – Renewable thermal technologies have the potential to reduce energy costs for Massachusetts residents and provide savings to these consumers over the long-term. Of particular importance to DOER is equitable access to these cost-saving technologies for all the state's residents and businesses.

1.3 Technologies

The main renewable thermal technologies considered by the Massachusetts state agencies are:

- High-efficiency, cold-climate **air-source heat pumps** (ccASHP) – only those high-efficiency systems that overcome electric generation and grid losses to generate net primary energy benefits.

[2] "Massachusetts Clean Energy and Climate Plan for 2020", December 2010, Available at: www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

- High-efficiency **ground-source heat pumps** (GSHP) – only those high-efficiency systems that overcome electric generation and grid losses to generate net primary energy benefits (also known as geothermal heat pumps, GHP).
- High-efficiency, sustainable **biomass thermal** (BM) – including both pellets (BMP) and chips (BMCH) from sustainably sourced wood or other solid biomass materials; chips are used in commercial applications only
- **Solar thermal** (ST) – focusing on systems serving both space and domestic water heating
- **Biofuels** (BF) – liquid advanced biofuels, defined as those that reduce lifecycle GHG emissions by 50% or more[3], primarily for blending into existing fuel oil supplies at low percentages
- **Biogas** (BG) – biogases from landfills, anaerobic digestion, or gasification, for select industrial applications or gas distribution injection

Through preceding analysis (MCG reports), DOER and MassCEC identified these as the main RT technologies with the key opportunities lying with HP, BMP and ST, and with a secondary role for BG and BF. All of the technologies have a vendor/installer base in the state. This base is small compared to traditional heating and cooling technologies, but it is growing. For a comprehensive discussion of the technologies and markets, see the "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study."[4] This report focuses on strategies designed to help Massachusetts accelerate growth of the renewable thermal market, and achieve the goals stated above.

[3] Section 211(o)(1) of the Clean Air Act, last amended by the Energy Independence and Security Act of 2007
[4] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study," March 2012, prepared by Meister Consultants Group for the Massachusetts Department of Energy Resources.

2 Approach

The team developed a multi-pronged approach to drive strategy development. Figure 2-1 shows the CARTS components and the approach for integrating them into a viable strategy. These components serve the following needs:

- **Customer class analysis** – To characterize market segments (e.g., large commercial buildings burning heating oil) and individual customer classes (i.e., one for each competing RT technology in each market segment), and to identify the priority customer classes with the greatest potential to help achieve market growth and greenhouse gas (GHG) emissions reduction goals.
- **Potential analysis** – To evaluate the energy, environmental, and economic impacts over time in Massachusetts via four different market-growth scenarios; this analysis utilized a market growth and impact analysis model to determine impacts of each scenario on key metrics.
- **Stakeholder advisory group (SAG)** – To provide strategy inputs, feedback on the potential analysis, and overall review to help ensure that strategic program outputs are optimal and viable.
- **Jurisdiction analysis** – To understand the characteristics of successful programs in other states and countries, including the market context and key success factors that would be applicable to Massachusetts.

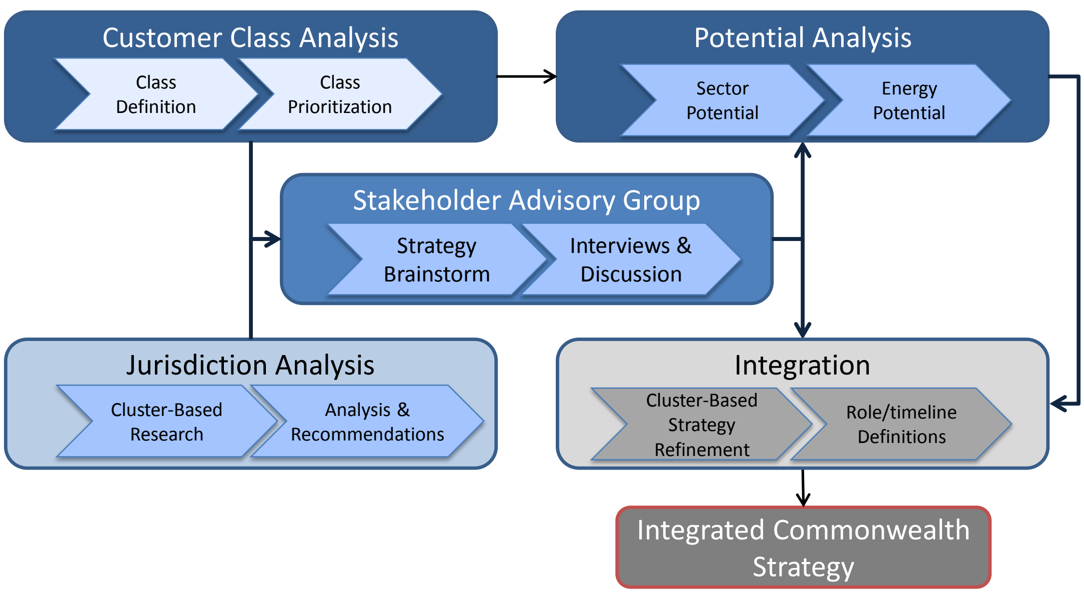

Figure 2-1: Strategy Integration Approach

The following three subsections (sections 2.1 through 2.3) describe the approach for the Customer Class Analysis, the Potential Analysis, and the Stakeholder Advisory Group. Section 2.4 describes the economic cluster-based framework used to categorize and define CARTS strategies. This framework provided the basis for strategy characterization throughout this project. Section 2.4 also describes the strategy development process used to define, develop, and prioritize the final strategies presented in section 6.

2.1 Customer Class Analysis

The team used the five characteristics listed in Table 2-1 to divide the MA market into distinct market segments and customer classes. Each market segment, or portion of building stock in the State, is defined by current thermal fuel, building sector (i.e., residential or commercial), and building size (for commercial) or income level (for residential). Appendix A lists all market segments along with relevant size and consumption data). Each market segment represents a competitive market for heating and cooling equipment, in which each potential RT technology represents a single customer class. For example, within small commercial buildings using heating oil (a market segment), there are four different RT customer classes, one for each RT technology. The market segments are valuable as a basis for discussing market development strategies, while the customer classes are used in market growth and impact modeling to understand the potential market penetration of each RT technology.

Table 2-1: Customer Class Characteristics

Key Criteria	Definition
Sector	Commercial and Residential (single- and multi-family together)
Income Level [A] / Building Size [B]	**Residential:** High/Low Income (split at $60,000 annual income) **Commercial:** Large/Small Bldgs. (split at 15,000 ft^2)
Access to Natural Gas	**All MA buildings –** split by access to natural gas distribution network Percentage Basis, Per DOER Natural Gas Distribution Data
Offsetting Fuel Type	Electric, Fuel Oil, Natural Gas, Propane (LPG)
Target Renewable Thermal Tech	**Renewable Thermal Technologies:** • High-efficiency, cold-climate air-source heat pumps (ccASHP) • Sustainable biomass pellets (BMP) • Sustainable biomass chips (large-commercial only) (BMCH) • High-efficiency ground-source heat pumps (GSHP) • Solar thermal combination space and water heating (ST) **Additional technologies for independent customer class review:** • Biofuels – for mixing with existing fuel oil supplies • Biogas – for industrial applications or injection in NG distribution network
A: Residential buildings are broken into high and low-income customers because DOER may consider providing additional assistance to low-income customers in order to assure equitable access to renewable thermal technology. Income level split based on Massachusetts Low-Income Home Energy Assistance Program (LIHEAP) eligibility requirements. The annual income cutoff for LIHEAP eligibility is roughly $60,000, for a household of four.[5] B: Commercial buildings size is split at 15,000 ft^2 feet; that is roughly the average commercial building size.[6]	

The team used the characteristics in Table 2-1 to develop 54 customer classes representing the segments of the market that DOER was interested in (See Appendix B for a complete list of customer classes and Appendix C for assumptions on each technology). These customer classes include each of the RT technologies that are competitive for customers using electricity, fuel oil, or propane, but only include two RT technologies, ccASHP and GSHP, for customers using natural gas. As part of a preliminary scoping evaluation, the team reviewed MCG's incremental lifecycle cost estimates for each technology and offsetting fuel combination. MCG concluded that commercial-scale GSHP (MCG did not analyze ccASHP for a lack of reliable cost data) were the only technologies that could achieve savings when replacing natural gas.[7] Therefore, the team determined that the heat pump technologies (GSHP and ccASHP) are currently the only RT technologies realistically capable of competing with natural gas in small or large commercial buildings. This same assumption is used for all modeling scenarios.

[5] Massachusetts Low-Income Home Energy Assistance Program (LIHEAP), details available at: www.massresources.org/liheap-eligibility.html#eligible.

[6] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey (CBECS), Available at: www.eia.gov/consumption/commercial/

[7] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

Additional research on the RT R&D pipeline could lead to new insights into realistic cost adjustments for future use in this model, but are not included at this time.

This study assumes that all residential and commercial heat pumps will provide both heating and cooling, i.e., no heat pump owners will forego the cooling capability in the summer. The study assumes that those residential users without cooling who install a GSHP or ccASHP would otherwise have installed a conventional cooling system. Therefore their payback periods are based on the incremental cost of the heat pump over a conventional heating and cooling system. Certainly, if a resident purchased a heat pump but would not otherwise have invested in a conventional cooling system, their payback period would be significantly longer since it would account solely for heating energy savings. Analysis of such customers was not considered in this study.

The team evaluated biogas and biofuel strategies qualitatively rather than including them in the customer class analysis, since these technologies are not adopted via the same pathways as the other technologies. Biofuels are typically blended with traditional heating fuels at central locations and delivered to customers using existing fuel distribution networks. Biogas is generated in landfills and through anaerobic digestion (e.g. on livestock farms or wastewater treatment plants) or through gasification, and is generally used onsite or in district heating systems. It can also be mixed with natural gas, after being cleaned up and injected in the natural gas distribution grid. The qualitative assessment of biogas and biofuels led to the inclusion of a number of specific strategies in this report (see section 6 for additional discussion).

The team developed a prioritization process to evaluate each of the 54 customer classes and identify the top priority customer classes for DOER to target. The team rated each customer class using the criteria, rating scales, and weighting factors shown in Figure 2-2 to calculate a total score for each class. All 54 customer classes were then prioritized based on these scores. The rating scales for each characteristic, except "Income Level", were established to create relatively even distributions of customer classes across the rating scales. Income level uses a binary rating scale, which only rewards residential low-income customer classes. Such a scale boosts the overall prioritization of low-income customer classes by recognizing the general need for providing equitable access to high-efficiency heating and cooling equipment to all consumers. The team developed the weighting factors and validated them through discussion with the stakeholders and DOER to ensure confidence with the prioritization framework. The weighting factors reflect the team's interest in targeting customer classes and RT technologies that most cost-effectively (low payback time) achieve a significant GHG impact across Massachusetts (segment size and GHG emission reductions).

Customer Class Characteristics	Residential	Commercial	Rating Scales
Income Level / Building Size	High/Low Income	Large/Small Bldgs.	5 = Residential Low-Income 0 = All Other Classes
Cost Benefit	Simple Payback Period, without incentives		5 = < 2 years 4 = < 3.5 years 3 = < 6 years 2 = < 9 years 1 = > 9 years
GHG Emissions Reductions	Low/Med/High reductions calculated based on technology and offsetting fuel, using data from MCG Heating and Cooling Opportunities and Impacts Study		**Residential:** High = > 15 Tons/Yr ΔCO_2e Med = 6-15 Tons/Yr ΔCO_2e Low = < 6 Tons/Yr ΔCO_2e **Commercial:** High = > 120 Tons/Yr ΔCO_2e Med = 50-120 Tons/Yr ΔCO_2e Low = < 50 Tons/Yr ΔCO_2e
Segment Size	Total primary thermal energy consumption (MMBtu) of all buildings in the market segment		5= > 35 MM 4= >12 MM 3= >3 MM 2= >700,000 1= <700,000

Prioritization Criteria	Wgt
Cost Benefit: Payback Analysis	40%
GHG Emissions Reductions	30%
Segment Size (MMBtu)	20%
Income Level	10%

The Top Priority Customer Classes

Figure 2-2: Customer Class Prioritization Metrics and Weighting Criteria

In gathering data for each customer class, the team built on Meister Consultants Group's (MCG) previous work on renewable thermal technologies for DOER. The payback periods for each renewable thermal technology were calculated based on cost and performance data published by MCG, and the GHG emission calculations were built off GHG emissions reduction factors provided by MCG.[8, 9] See Appendix C for detailed tables. The statewide market segment size data for residential and commercial customer classes was extracted from the Residential Energy Consumption Survey (RECS) and the Commercial Buildings Energy Consumption Survey (CBECS) respectively. [10, 11] Appendix A shows all relevant RECS and CBECS data used in this analysis.

[8] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

[9] "Heating and Cooling in the Massachusetts Alternative Portfolio Standard", Massachusetts Department of Energy Resources, with assistance from Massachusetts Clean energy Center and Meister Consultants Group, December 2012, Available at: www.mass.gov/eea/docs/doer/pub-info/heating-and-cooling-in-aps.pdf

[10] U.S. Energy Information Administration, Residential Energy Consumption Survey (RECS), Available at: www.eia.gov/consumption/residential/

[11] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey (CBECS), Available at: www.eia.gov/consumption/commercial/

2.2 *Potential Analysis*

2.2.1 Model Background

To determine the future impacts in Massachusetts from expanding the RT market, the team modeled the growth of RT technologies in the state between now and 2030. The model is a Fisher-Pry-based technology adoption model that calculates the market growth of RT technologies. It uses a lowest-cost approach (to consumers) to develop expected market growth curves based on maximum achievable market penetration and market saturation time, as defined below.[12]

- **Market Penetration –** The percentage of a market that purchases or adopts a specific product or technology. The Fisher-Pry model estimates the achievable market penetration based on the simple payback period of the technology.
- **Market Saturation Time –** The duration (in years) for a technology to increase market penetration from 10% to 90%.

The Fisher-Pry model estimates market saturation time based on 12 different market input factors; those with the most substantial impact include:

- **Payback Period –** Years required for the cumulative cost savings to equal or surpass the incremental first cost of equipment.
- **Market Risk –** Risk associated with uncertainty and instability in the marketplace, which can be due to uncertainty over costs, industry viability, or even customer awareness, confidence, or brand reputation. An example of a high market risk environment is a jurisdiction lacking long-term, stable guarantees for incentives.
- **Technology Risk –** Measures how well-proven and readily available the technology is. For example, technologies which are completely new to the industry are higher risk, whereas technologies that are only new to a specific market (or application) and have been proven elsewhere would be lower risk.
- **Government Regulation –** Measure of government involvement in the market. A government stated goal is an example of low government involvement, whereas a government mandated minimum efficiency requirement is an example of high involvement, having a significant impact on the market.

The model uses these factors to determine market growth instead of relying on individual assumptions about annual market growth for each technology or various supply and/or demand curves that may sometimes be used in market penetration modeling. With this approach, the model does not account for other more qualitative limiting market factors, such as the ability to train quality installers or manufacture equipment at a sufficient rate to meet the growth rates.

The model is an imitative model that uses equations developed from historical penetration rates of real products. It has been validated in this industry via comparison to historical data for solar photovoltaics. The Fisher-Pry market growth curves have been developed and refined over time based on empirical adoption data for a wide range of technologies. Some of the original technologies used to develop the

[12] Michelfelder and Morrin, "Overview of New Product Diffusion Sales Forecasting Models" provides a summary of product diffusion models, including Fisher-Pry. Available: law.unh.edu/assets/images/uploads/pages/ipmanagement-new-product-diffusion-sales-forecasting-models.pdf

Fisher-Pry model include: water-based versus oil-based paints, plastic versus metal in cars, synthetic rubber for natural rubber, organic versus inorganic insecticides, and jet-engine aircraft for piston-engine aircraft.[13] Figure 2-3 shows four example market growth curves from the model, each with different market saturation times (5, 10, 15, & 20 years) and increasing achievable market penetration. Although increased market penetration (reduced payback period) can go hand-in-hand with reduced saturation time, these plots are intended to illustrate that to reach near-term goals, reducing market saturation time is more important than maximizing the long-term achievable market penetration. However, with increased long-term maximum achievable penetration, it may be possible to achieve the same near-term market growth goals with a longer (and less burdensome) market saturation time.

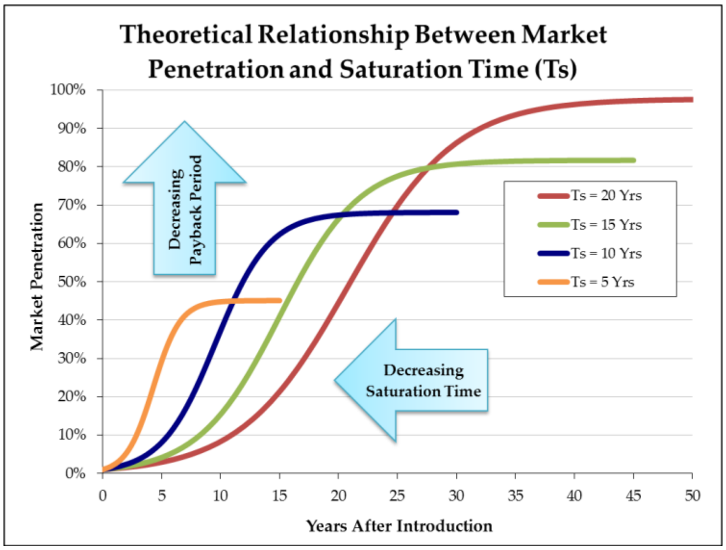

Figure 2-3: Fisher-Pry Market Penetration Dynamics

Decreasing saturation time requires different activities than increasing the maximum achievable penetration, which is influenced primarily by the payback period. Reducing market saturation time can be done by changing one or more of the 12 market saturation factors in the model. For example, to reduce technology risk, the state could fund or otherwise support demonstration projects to help validate the technology to industry and potential buyers. Alternatively, the state could fund an information campaign to reduce market risk by increasing awareness and helping to dispel any myths or incorrect perceptions that could hurt the growth of the technology. Note that these activities will not (in any substantial fashion) reduce payback times to help drive up the max achievable penetration, but are still very important in developing a viable market and accelerating growth.

The model is designed to analyze the adoption of a single technology entering a market, but this analysis had to account for multiple technologies competing for each market segment. Accordingly, the team calculated the market penetration for every customer class, ignoring competition from other technologies. Then, to account for competition among technologies within a market segment (e.g., solar thermal and biomass in low-income households with electric heating), the team first assumed that the technology that achieves the highest market penetration in each market segment would roughly

[13] Fisher, J. C. and R. H. Pry, "A Simple Substitution Model of Technological Change", Technological Forecasting and Social Change, 3 (March 1971), 75-88.

approximate the maximum achievable market penetration for all RT technologies. To estimate the penetration of each individual technology in each market segment, the team divided the market penetration of that highest penetrating technology among all of the competing customer classes based on the relative payback period of each customer class. Customer classes with shorter payback periods therefore received proportionally larger shares of the market.

Because the model ties penetration to each technology's payback period, it does not reflect any given policy unless that policy specifically drives one of the key input factors (see below). For example, specific levels of investment in marketing and communications are not reflected directly by the model, but are instead reflected qualitatively in a reduction in market risk. Further, if a given distribution is desired between RT technologies, for example, as a policy decision, that must be achieved by adjusting the payback period or other input factors to the model.

Figure 2-4 outlines the process used to analyze the market growth of each customer class.

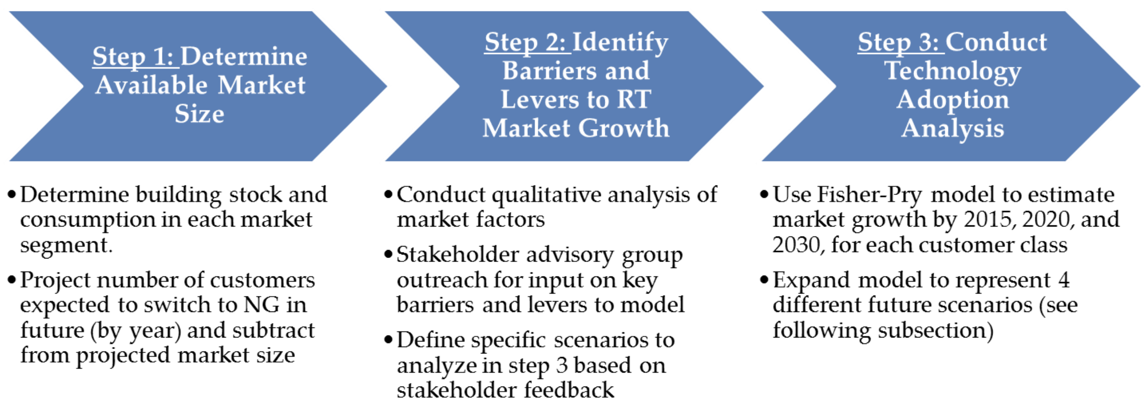

Figure 2-4: Sector Potential Analysis Process

The team used building survey data (see Appendix A) and natural gas market growth projections to estimate the sizes of each market segment by year.[14] The team developed these natural gas market growth projections based on historical natural gas distribution data provided by DOER.

2.2.2 Scenario Analysis

In coordination with stakeholders, four scenarios were developed for future technology penetration. The scenarios differ in their level of state support and their treatment of natural gas customers, and are defined by the various levers that agencies have to influence the penetration of renewable thermal technologies. These scenarios do not attempt to modify any federal programs or incentive levels, although in the High State Support (HSS) scenario, federal incentives are assumed to be extended past their scheduled expiration date.

[14] Residential Energy Consumption Survey (RECS) data available from: www.eia.gov/consumption/residential/ and Commercial Building Energy Consumption Survey (CBECS) data available from: www.eia.gov/consumption/commercial/

The Business as Usual (BAU) scenario represents a projection of market growth based on current levels of support, and represents a baseline for this study. The other scenarios show what impact may occur by emphasizing different types and levels of state support. For example, the HSS scenario represents one combination of levels and types of support that will achieve the 2020 GHG emissions reductions goals. HSS was developed on an iterative basis whereby incentive levels were increased and market saturation variables adjusted in order to achieve the 2020 goals. These scenarios do not consider the political environment and make no claim about the viability of obtaining the necessary funding, training quality installers at a sufficient rate, or overcoming other potential market constraints. The team assumes that as part of the comprehensive strategy, such barriers can be addressed. Table 2-2 outlines the four analysis scenarios. See Appendix D for an overview of current incentives.

Table 2-2: Potential-Analysis Scenarios

Scenario	Description
Business as Usual (BAU)	**Objective:** Determine a baseline set of impacts on the state due to existing policies and programs **Characterization:** • Continuation of today's policies and existing levels of market support **Assumptions:** • Incentive discontinuation on current schedule • Federal renewable energy tax credits expire in 2016 as scheduled • Annual growth of NG segment for residential and commercial customers continuing at current pace (applies only to population within NG service territory)[15]
High State Support (HSS)	**Objective:** Determine what level/type of support is required **to reach 2020 GHG goals** **Characterization:** • Strong state support for prioritized customer classes • Encourages aggressive market development across sectors • Incentive levels set to ensure that 2020 GHG goals are met, with the same level of support continuing to 2030 • Represents shortest payback time (to consumers) approach to meeting 2020 goals **Assumptions:** • Continuation of all current incentives (federal and state) • Market development activities (e.g., marketing campaigns, installer training, financing support) will reduce the market saturation time for prioritized customer classes from 20 years to 10 years • Adds additional 25% incentive on top of existing incentives (on total installed cost) to reduce up-front cost for prioritized customer classes • NG market segment growth consistent with BAU

[15] Data for natural gas conversions up to 2025 provided by Sussex Economic Advisors, November 2013. Extrapolation to 2030 by Navigant.

Scenario	Description
Accelerated NG Expansion & HSS (NG-HSS)	**Objective:** determine the impact on the RT market of a simultaneous push to expand NG in the state **Characterization:** • Based on HSS scenario level of support for RT • Market size decreases over time as portion of available market converts to NG **Assumptions:** • Accelerated annual growth of NG segment for residential and commercial customers up to 2025 (assuming equipment incentives for conversion to gas and regulatory approval of main expansion policies). BAU growth of the NG segment following 2025 up to 2030 (applies only to population within NG service territory)[16] • NG growth in each market sector scaled based on historical NG conversion rates (i.e. commercial sector growth expected to be much slower than residential growth)
Cusp-Customer Targeting and BAU (CC-BAU)	**Objective:** Determine the potential impact of directly targeting customers who may be on the cusp of converting to NG [17] **Characterization:** • Based on BAU scenario level of support for RT • Base market size does not decrease over time (due to customers converting to NG) by accounting for aggressive targeting of natural gas cusp-customers **Assumptions:** • 0% annual conversion to NG – equal across market segments

In each of these different scenarios, the team calculated impacts on GHG emissions, job creation, and state tax revenues. The detailed assumptions for each scenario are outlined below in Table E-1 through Table E-4 in Appendix E.

2.3 *Stakeholder Advisory Group*

The team assembled a Stakeholder Advisory Group (SAG) made up of a broad range of stakeholders. The SAG served multiple purposes:

» Support development of a robust and actionable roadmap in order to significantly accelerate development of renewable thermal in Massachusetts
» Provide feedback on market development, energy and customer class projections and underlying assumptions based on current market experience and information
» Prioritize RT market barriers and propose recommendations to support development of Massachusetts renewable thermal policies and programs
» Identify collaborative opportunities for RT market development with Mass DOER, other state agencies, industry, environmental, and other stakeholder groups

[16] Ibid.
[17] NG cusp-customers are those customers who do not use NG as their primary heating fuel but are located on-main, either with or without a service line. These customers generally face relatively low costs to convert to NG and are therefore the most likely customers to convert.

Table 2-3 shows the schedule and purposes for the four SAG meetings.

Table 2-3: Stakeholder Advisory Group Meetings

Meeting Date	Purpose
July 8, 2013 (in-person)	Introductions, review of objectives, role of stakeholder advisory group, and presentation of modeling methodology and overall program approach
July 29, 2013 (webinar)	Review of strategy options as leveraged in other jurisdictions (and applicability to the MA market) and brainstorming on additional strategies to consider
Aug 28, 2013 (in person)	Review of draft action plan summarizing each recommended strategy
September 13 (in person)	Review of draft implementation plan summarizing steps, roles/responsibilities, milestones, objectives, etc. of each recommended strategy

Members of the CARTS SAG included renewable thermal trade group representatives, manufacturers, project developers, policymakers, low-income housing groups, as well as environmental non-profit and advocacy groups. Appendix F contains the full list of stakeholders that contributed to the CARTS project.

2.4 Cluster Development and Strategy Prioritization Framework

The Navigant team formulated strategy definitions using an economic cluster development framework. Clusters are geographic groupings of interconnected companies in a related industry or field. In discussing policy, clusters provide a valuable framework to understand the interconnected components of an industry, including manufacturers, supply chains, vendors, installers, marketing and communication firms, research organizations, and training organizations. All strategies were categorized, as Figure 2-5 shows, in six different economic cluster categories.

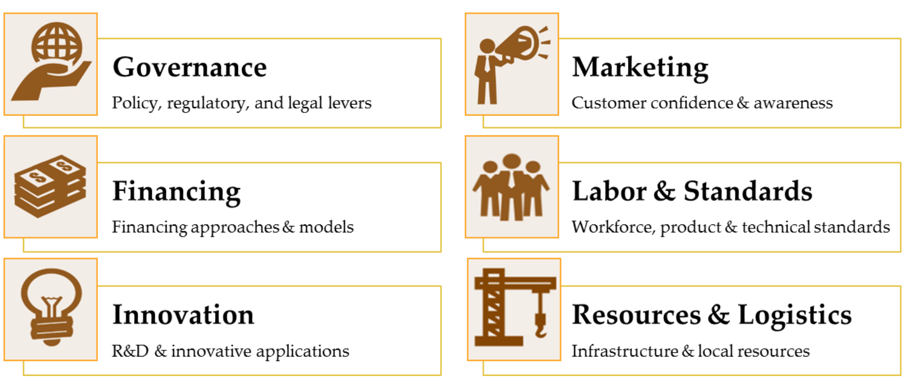

Figure 2-5: Economic Cluster Areas for Strategy Development

The team developed the initial strategies through a combination of different activities:

- **Individual stakeholder discussions –** One-on-one discussions with various members of the SAG to aggregate opinions and perspectives on how the state may be able to help specific industry areas or the RT industry as a whole.
- **Group stakeholder dialogue –** Facilitated dialogue during each of the stakeholder meetings (see section 2.3, above) to capture feedback on key barriers to focus on, the top cluster areas to address, and the level of consensus around various brainstormed ideas.
- **Internal research –** Literature review and brainstorming by team members to leverage past experience in development and review of successful strategies for expansion of renewable and energy efficiency technologies.
- **Jurisdiction analysis –** Lessons learned from detailed analysis of successful renewable thermal programs in other jurisdictions, including an applicability cross-check, to ensure appropriateness of such strategies in Massachusetts (see section 4).
- **DOER input –** Feedback and commentary from key DOER policymakers who have specialized knowledge of available policy avenues and other levers by which the state can drive RT growth.
- **Modeling results/conclusions –** key qualitative conclusions shaped many aspects of the strategy recommendations. Quantitative conclusions will guide DOER in comparing impacts of expansion in RT and NG industries and in determining appropriate levels of support, including incentives.

The team characterized each strategy in detail and validated this content at each step via review with DOER and the SAG members, both individually and as a group. Each strategy definition is grounded in practical input from many of those organizations that may ultimately be responsible for implementation. The relevant details articulated in each strategy include an objective, applicable barrier(s), background, pathway, specific steps with dates, milestones, and identification of lead and supporting organizations.

In total, the team defined an inventory of 66 unique strategies. Weighted scores were calculated for each of these strategies for prioritization purposes. The weighted scores built on four different metrics:

- **Time to Impact** – expected duration from initiation to realization of benefits;
- **Expected Impact Level –** relative ability of the strategy to accelerate MA market penetration;
- **Minimum Resources Required –** the approximate minimum financial investment needed from all contributors to have an impact; and
- **Expected Stakeholder Support –** the expected level of interest from industry leaders and their willingness to step up and play an active role in implementation.

Table 2-4 shows the definitions and weights for each of the metrics. The metrics and weights were defined based on discussions between DOER and the Navigant Team, and were refined through discussions with the SAG. Each column contains a different metric that was scored on a scale of 1 to 5. The scores for each column were then weighted according to the percentages listed in the final row of each column.

Table 2-4: Strategy Prioritization Metric Definitions

		Time to Impact	Expected Impact Level*	Min. Resources Required	Expected Stakeholder Support
Score	5	Immediate (<1.5 years)	Very High – Large impacts on 2 factors or impacts 3+ factors (must impact cost-effectiveness)	$50,000	Very High
Score	4	Short (1.5-3 yrs)	High – Impacts two factors (must impact cost-effectiveness)	$150,000	High
Score	3	Med (3-5 yrs)	Med – Impacts one or more factors	$500,000	Med
Score	2	Med-Long (5-8 yrs)	Low – Small impact on one factor	$1MM	Low
Score	1	Long (>8 yrs)	Very Low or None	$2MM	Very Low or None
Weight		**35%**	**35%**	**20%**	**10%**

*Impact level factors include: cost effectiveness, market risk, technology risk, government regulation

The team presented the top preliminary strategies to the SAG during the third meeting and then a more detailed and updated version of the top recommended strategies, which incorporated SAG feedback, in the fourth meeting (see Section 2.3 above for the meeting schedule). Section 6 presents the recommended strategic pathway in detail, including 18 individual strategies.

3 Customer Class Analysis Results

3.1 Customer Classes Prioritization

Using the customer class characterization and prioritization process described in section 2.1 the team developed the prioritized list of the top 15 customer classes in Table 3-1, used for all scenarios. The prioritization does not change between scenarios because the ultimate goal for GHG reductions in 2020 remains the same and the prioritization framework remains a valuable and relevant approach in any scenario. Table 3-2 shows the top six solar thermal customer classes. The customer classes listed in these two tables represent the priority market segments and technologies for an accelerated market expansion of RT and SHW respectively. The team focused on targeting these customer classes throughout the modeling and strategy development stages of the study

Table 3-1: Top 15 Customer Classes

Offsetting Fuel	Building Sector	Income Level / Bldg. Size	Target Renewable Thermal Tech	Payback Score BAU (0 - 5)	GHG Emissions Reductions (Low/Med/Hi)	Final Score (0 - 5)
Electric	Residential	Low Income	GSHP	5	High	4.6
Electric	Residential	Low Income	ccASHP	5	High	4.6
Electric	Commercial	Large Bldgs	BMP	5	High	4.3
Fuel Oil	Residential	Low Income	GSHP	5	Med	4.3
Electric	Commercial	Small Bldgs	BMP	5	High	4.1
Electric	Residential	High Income	ccASHP	5	High	4.1
Electric	Residential	High Income	GSHP	5	High	4.1
Fuel Oil	Commercial	Large Bldgs	BMP	5	Med	4.0
Fuel Oil	Residential	High Income	GSHP	5	Med	4.0
Electric	Commercial	Large Bldgs	BMCH	4	High	3.9
Electric	Residential	Low Income	BMP	3	High	3.8
Fuel Oil	Commercial	Small Bldgs	BMP	5	Med	3.8
Electric	Commercial	Large Bldgs	GSHP	3	High	3.5
Electric	Commercial	Large Bldgs	Solar Thermal	3	High	3.5
Electric	Residential	Low Income	Solar Thermal	2	High	3.4

Table 3-2: Top 6 Solar Thermal Customer Classes

Offsetting Fuel	Building Sector	Income Level / Bldg. Size	Target Renewable Thermal Tech	Payback Score BAU (0 - 5)	GHG Emissions Reductions (Low/Med/Hi)	Final Score (0 - 5)
Electric	Commercial	Large Bldgs	Solar Thermal	3	High	3.5
Electric	Residential	Low Income	Solar Thermal	2	High	3.4
Electric	Commercial	Small Bldgs	Solar Thermal	3	High	3.3
Electric	Residential	High Income	Solar Thermal	2	High	2.9
Fuel Oil	Commercial	Large Bldgs	Solar Thermal	2	Med	2.8
Fuel Oil	Residential	Low Income	Solar Thermal	1	Med	2.7

3.2 Potential Analysis Results

Using the Fisher-Pry technology adoption model (see section 2.2.1, above), the team projected market growth of the RT market in Massachusetts between 2015 and 2030. Table 3-3 summarizes the overall impacts of RT market growth in Massachusetts under the HSS Scenario, which meets state GHG emissions reduction goals for 2020. The CARTS model, which optimizes outputs based on the lowest cost to consumers, requires 144,000 cumulative installations by 2020, which amounts to 3,000 MWth, with a total investment (i.e., total value of all projects) of $4.5 billion. Detailed data are not currently available on current installations of RT technologies in Massachusetts. The publicly available MassCEC data for the Commonwealth Solar Hot Water Program shows that 314 residences over 1.5 years received awards under this program, 44 (14%) of which were identified as combination heat and hot water systems.[18] Installations of other RT technologies in the state are expected to be on the same order of magnitude as those for solar thermal.

For comparison, Table 3-3 shows an example of an alternate CARTS scenario that also meets 2020 goals for GHG emissions reductions, but relies more heavily on solar thermal, with less than half of the total installed capacity and 17% less overall investment. SHW delivers higher GHG emission reductions per installation than heat pumps, which explains why the overall number of installations and the total investment volume is lower. However, the total funding required by the state is higher in this alternate scenario because solar thermal has generally higher first-costs than other RT technologies.

[18] Residential data available at: www.masscec.com/content/commonwealth-solar-hot-water-residential-awarded-projects-database. The systems come online over the course of approximately 1.5 years. Commercial data available at: www.masscec.com/content/commonwealth-solar-hot-water-commercial-awarded-projects-database

Table 3-3: Installation and Investment Summary for Two Scenarios in 2020

CARTS Scenario	Distribution of Installed Capacity by Sector (% Residential/ %Commercial)	Cumulative Installations	Cumulative Installed Capacity (MWTh)	Cumulative Investment Value (Millions $2013)	
				Total	Funded by State
HSS Scenario	**57%/43%**	**144,000**	**3,000**	**$4,500**	**$1,100 (24%)**
HSS w/Solar Emphasis*	**57%/43%**	**95,000**	**1,400**	**$3,700**	**$1,300 (35%)**

*This scenario is only one of many alternate results which could ultimately meet the State's GHG emission reduction goals. The HSS w/Solar Emphasis Scenario (row 1) is not detailed in the remainder of this report.

From these data, it is clear that meeting the 2020 goals will be a challenge and will require aggressive RT support. The HSS scenario represents ramping up to approximately 45,300 RT system installations per year in 2020, or 38,000 more per year than the BAU scenario (7,300 per year). By comparison, the team estimates that in total between 130,000 and 170,000 heating systems are replaced in the state each year.[19] Of these, approximately 46%, or 70,000 are for non-natural gas systems each year.[20]

Figure 3-1 shows the market growth of all renewable thermal technologies in Massachusetts under each of the four scenarios. This figure presents market penetration in terms of the percentage of the total thermal load in the state. The HSS and Accelerated NG Expansion & HSS scenarios both meet MA GHG goals for 2020 (see section 3.2.3 for detailed GHG emissions results). The model assumed continuation of policies without changes after 2020, which produces continued rapid market growth through 2030. However, it is conceivable that many policies or market factors could change, producing very different energy, economic, and environmental impacts. Some of these potential changes include:

- Reductions in installed cost via economies of scale, contractor experience, or technical innovations.
- Reductions in incentive levels, depending on state policies in 2020 and progress towards future goals. If such reductions are combined with cost reductions, consumers could still see the same costs. Cost dynamics will likely affect each RT technology differently.
- Increases in RT technology awareness and development of an RT brand that can drive sales by capitalizing on non-energy benefits and leveraging a sustainability image.

[19] Estimated assuming roughly 2,590,000 residential households and commercial buildings in MA (based on RECS and CBECS data), using conventional heating systems with an average useable life of 15-20 years; note that EIA data show some boilers may last as long at 20-30 years, meaning fewer annual installations and slower turnover of the installed stock of boilers (data available: www.eia.gov/analysis/studies/buildings/equipcosts/pdf/appendix-a.pdf)
[20] Split based on number of buildings in MA from CBECS and RECS. See Appendix A.

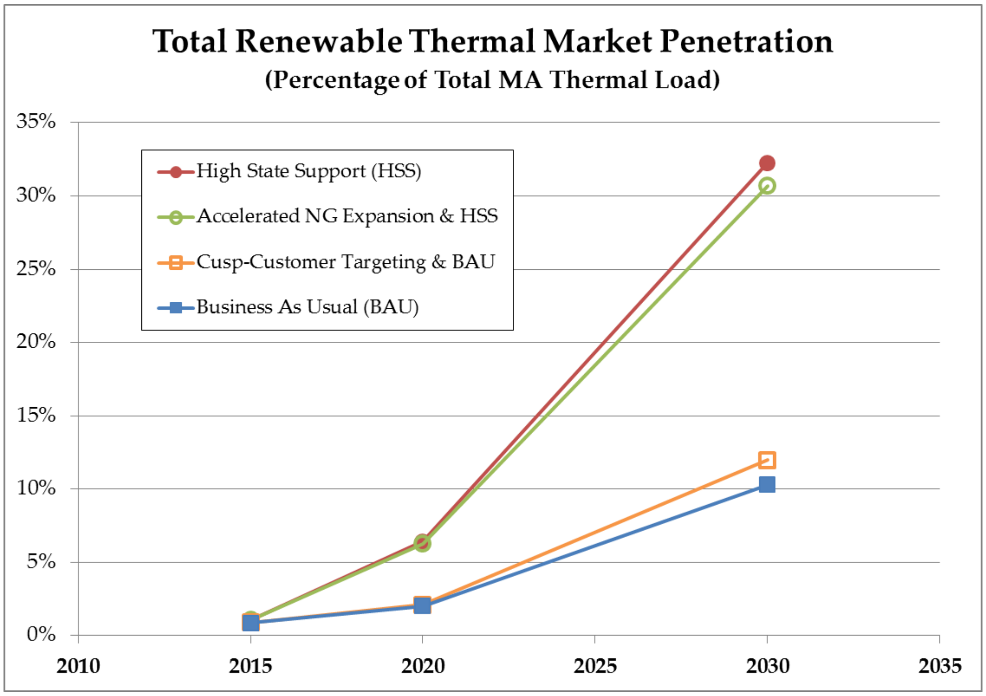

Figure 3-1: Total Market Penetration of Renewable Thermal Technologies by Scenario

The team analyzed the impact of renewable thermal market growth on the state economy, government, environment, and utilities. The results of this analysis are presented in sections 3.2.1 through 3.2.3 Appendix G describes the methodologies used for each analysis.

3.2.1 Energy Impact

Renewable thermal market growth is expected to reduce the demand for fossil fuels for heating and cooling in the state. Figure 3-2 shows the estimated statewide reduction in fossil fuel demand (fuel oil, natural gas, propane, and electricity via power generation) due to renewable thermal technologies under each scenario. Additionally, this figure shows the net reductions in fossil fuel expenditures by consumers (data labels). Under the High State Support scenario, RT technologies will reduce MA residents' expenditures on fossil fuel by roughly $560 million per year by 2020, while BAU will reduce expenditures by roughly $99 million per year. For the equipment installed by 2030, including the additional benefits accrued for an additional 10 years of equipment operation, the HSS scenario produces a present value reduction in expenditures of $22 billion compared to $4.8 billion under BAU.[21] This analysis assumes a site-to-source electricity conversion (due to generation and transmission losses) of 3.1 for the duration of the study, thereby assuming that the electricity generation fuel mix remains constant through 2030.[22]

[21] Net Present Value calculation assumes a 7% nominal discount rate and 2.5% inflation.

[22] Site-to-source conversion based on EIA nation-wide assumption of 3.1; conversion factor varies due to fuel mix. See buildingsdatabook.eren.doe.gov/TableView.aspx?table=3.1.4

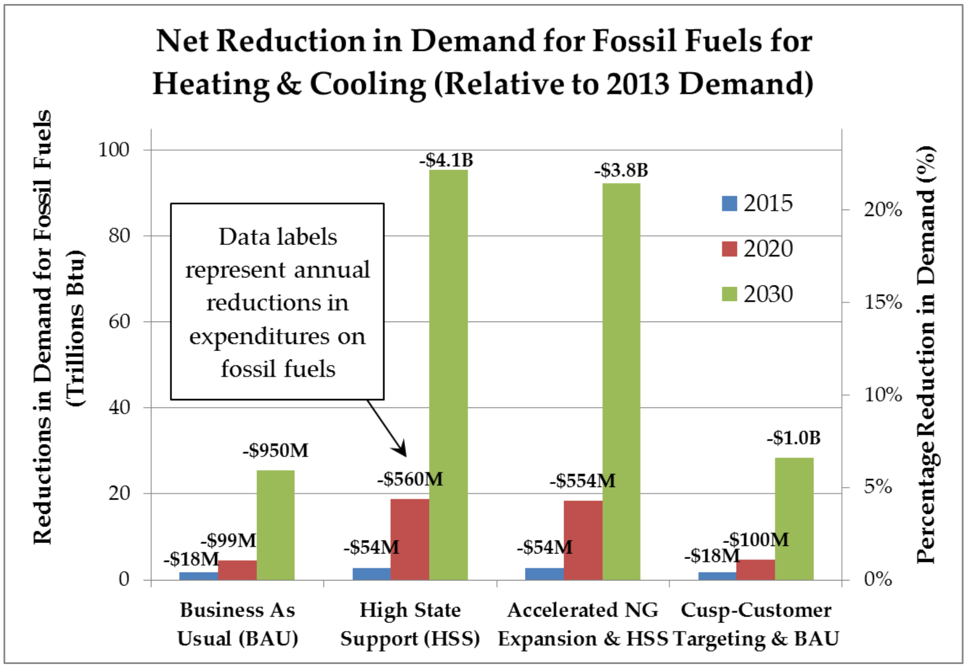

Figure 3-2: Impact on Demand for Fossil Fuels by Scenario due to RT Expansion

3.2.2 Economic Impact

To reach the market growth rates and GHG emissions targets, the HSS scenario requires a cumulative $1.2 billion state investment between now and 2020, which represents a net present value of $900 million (or a net present value by 2030 of $2.4 billion).[23] Figure 3-3 shows the annual state (public sector) investment levels over time for both the BAU scenario, which does not meet GHG emissions goals, and for the HSS scenario. These investments account for costs of offsetting high first costs via incentives but does not account for the other required market development activities (e.g., contractor training or marketing) whose costs are less clear. While the example investment is a rebate to directly offset the costs to the consumer, the investments could come in other forms, such as research and development funding to reduce equipment costs at an equivalent level to a rebate.

[23] Net Present Value calculation assumes a 7% nominal discount rate and 2.5% inflation.

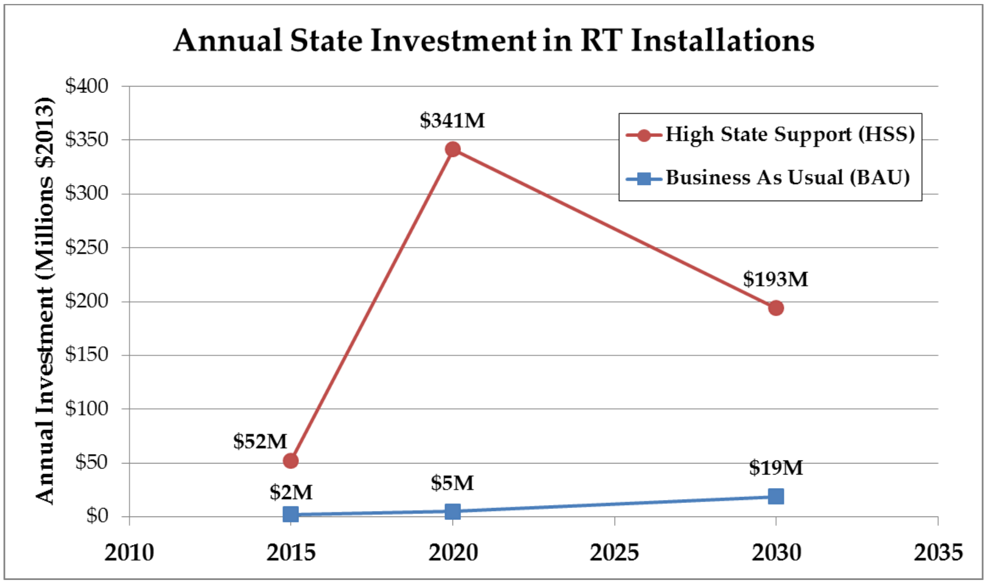

Figure 3-3: Annual State (Public Sector) Investment in RT Installations

In each of the scenarios, the team analyzed the impact of renewable thermal market growth on the state economy, in terms of increased job creation (Figure 3-4), and on the state government, in terms of changes in state tax revenue (Figure 3-5). In 2020, under the HSS scenario, the state investment in RT industry growth should create (or maintain) nearly 14,000 full-time-equivalent jobs (FTE) and generate over $35 million in additional tax revenues annually (compared to BAU). The jobs include those for installation and maintenance of equipment, as well as those in the related fuel industries and other indirect and induced jobs that are produced as a result of increased cash flows in the economy. See Appendix G (section G.3) for detailed discussion of job creation methodology.

In both the "High State Support" (HSS) and "Accelerated NG Expansion & HSS" scenarios, the RT growth rate slows from 2020 to 2030. This is a direct result of the top customer classes' accelerated market saturation time (10 years in HSS versus 20 years for BAU, where market saturation time is defined as the duration between 10% and 90% penetration in a select market segment). Therefore, by 2030 each technology will have attained more than half of its achievable market penetration and the annual growth rate for these technologies will begin to decrease. This effect is exhibited in the annual state investment, job creation, and tax revenue analyses, which are heavily based on the number of installations per year. The trend of slowing growth by 2030 may be reversed if strong state support continues through 2030 and drives a greater-than-expected equipment-cost reduction (either by increased incentives or through equipment/industry maturation). If cost reductions accelerate, the payback period will decrease, and the peak achievable market penetration will increase, ultimately pushing the plateauing portion of the market penetration curve into the future, and at a higher penetration level. (See theoretical penetration curves in Figure 2-3 for reference.)

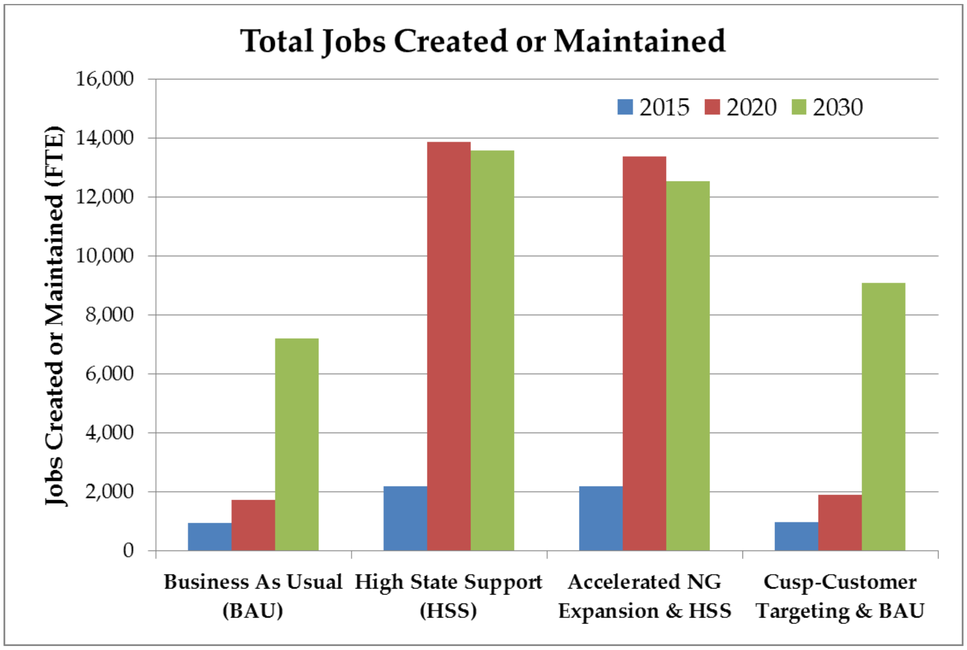

Figure 3-4: Impact on Job Creation (direct, indirect, and induced) in Each Scenario

The state tax revenue analysis accounts for the impact of renewable thermal market growth on state sales tax revenue (from sales of RT equipment), state personal income tax revenue (due to RT market related job growth), and state personal tax credits (for residential solar thermal). Since this analysis is comprised of multiple factors, some of which have a negative impact on state tax revenues, the results are not as directly linked to market penetration as the results of the job creation analysis. Yet it is clear that in the "High State Support" and "Accelerated NG Expansion & HSS" scenarios the 2030 results are substantially impacted by the reduced annual growth of RT technologies as the technologies surpass 50% of the achievable penetration in a given market segment and growth begins to slow accordingly. Note also that sales taxes are directly impacted by the cost of the equipment and the average equipment cost differs between scenarios. The BAU equipment costs are higher because of the relatively high volumes of solar thermal, while the HSS scenario sees greater volumes of the lower-cost technologies due to the lowest-cost optimizing nature of the Fisher-Pry model.

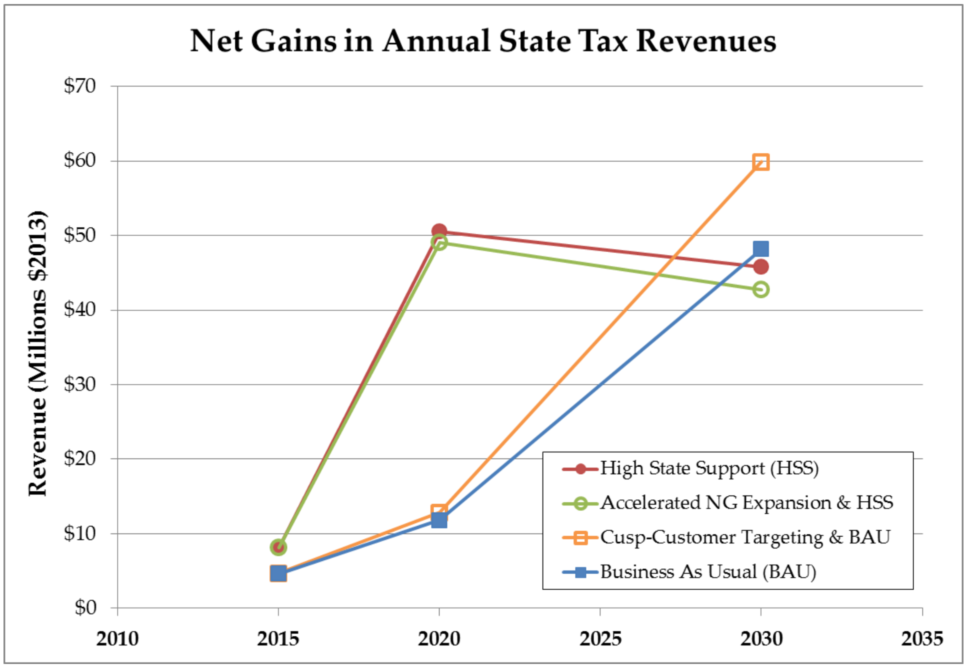

Figure 3-5: Impact on State Tax Revenues by Scenario

The tax revenue increases represent a small portion of the benefits to the state; as shown in Figure 3-2 above, RT technologies also reduce annual fuel costs for state residents. On an individual consumer basis, RT technologies can have substantial impacts on annual heating and cooling expenditures. The range of savings varies significantly depending on the consumer's current thermal fuel and the desired RT technology. Table 3-4 and Table 3-5 show the annual fuel savings for each fuel and technology combination. Note that the savings estimates in these tables only reflect fuel costs and do not include maintenance costs. In both commercial and residential applications, the saving among RT technologies is highest for heat pumps. Biomass produces lower savings due to lower efficiencies and absence of savings for space cooling. Solar thermal produces lower savings because, unlike the other systems, the team assumes that it only provides 40% of the total building thermal load. This assumption is consistent with past DOER analysis.[24]

[24] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study," March 2012, prepared by Meister Consultants Group for the Massachusetts Department of Energy Resources.

Table 3-4: Annual Fuel Cost Savings per Installation for Various Residential Technology Conversions

Residential	Annual Fuel Cost Savings by RT Technology				
	Biomass	ccASHP	GSHP	Solar Thermal	Natural Gas
Fuel Oil	$1,649	$1,934	$2,464	$1,215	$1,698
Electricity	$2,883	$3,168	$3,698	$1,680	$2,932
LPG	$921	$1,206	$1,736	$941	$970
Natural Gas	-$49	$236	$766	$576	N/A

Table 3-5: Annual Fuel Cost Savings per Installation for Various Commercial Technology Conversions

Commercial	Annual Fuel Cost Savings by RT Technology				
	Biomass	ccASHP	GSHP	Solar Thermal	Natural Gas
Fuel Oil	$9,850	$12,641	$16,341	$8,778	$12,090
Electricity	$19,356	$22,146	$25,847	$12,606	$21,596
LPG	$4,953	$7,744	$11,445	$6,806	$7,194
Natural Gas	-$2,240	$550	$4,251	$3,909	N/A

See Appendix C for data on installed costs and other assumptions for each technology.

3.2.3 Environmental Impact

In the environmental impact analysis the team estimated the reduction in statewide GHG emissions attributable to renewable thermal market growth. Massachusetts has identified two GHG emissions reduction targets in the *Massachusetts Clean Energy and Climate Plan for 2020*. These targets include: (1) Renewable thermal technologies could all together account for a 2% reduction in GHG emissions below the 1990 emissions level, and (2) Solar thermal systems should contribute at least a 0.1% reduction in GHG emissions below the 1990 level (see discussion in section 1.2).[25] Figure 3-6 below presents GHG reduction estimates and costs of avoided CO_2 emissions for all renewable thermal technologies, and Figure 3-7 shows estimates for solar thermal systems alone.

In both analyses the state will not achieve the 2020 GHG emissions targets under the "BAU" scenario. In order to achieve these goals the state will need to provide substantial support for all renewable thermal technologies, as reflected in the performance of the "High State Support" scenario.

[25] "Massachusetts Clean Energy and Climate Plan for 2020", December 2010, Available at: www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

Figure 3-6 also shows that if the state decided to provide both high state support for RT technologies and support for accelerated expansion of natural gas the state would still reach its 2020 GHG emissions targets. However, by 2030 the state would achieve roughly 2% fewer reductions in GHG emissions due to the expansion of natural gas competing with RT market growth.

The team estimated the value of avoided CO_2 emissions based on the discussion of the additional cost of CO_2-emissions in the 2013 Avoided Energy Supply Cost report by Synapse. Given the ongoing discussion about the exact valuation of avoided GHG emissions, a range of CO_2-values is used in the CARTS analysis. The "RGGI-only" scenario in the Synapse report provides a lower bound of the CO_2-values. The Long Term Marginal Abatement Cost identified by Synapse serves here as an upper bound. See the values in Table 3-6. For the years following 2030 the values were kept constant at their 2030 levels.

Table 3-6: Value of Avoided CO_2 emissions (2013$/Ton)[26]

Year	2015	2020	2030
RGGI Only scenario	**$5.28**	**$10.55**	**$10.55**
Long Term Marginal Abatement Cost	**$100**	**$100**	**$100**

Using the values outlined above, the Net Present Value (NPV) of the cumulative benefits from avoided GHG emissions was calculated[27], taking into account the RT equipment installed between 2015 and 2030, and 10 years of continued operation after 2030. For the HSS scenario this results in an avoided cost of CO_2 NPV between $944 million (RGGI values) and $8.99 billion (marginal abatement cost). Under BAU the NPV of the avoided CO_2-emissions is between $283 million and $2.71 billion respectively.

[26] "Avoided Energy Supply Costs in New England: 2013 Report", Synapse Energy Economics Inc., July 2013

[27] Net Present Value calculation assumes a 7% nominal discount rate and 2.5% inflation.

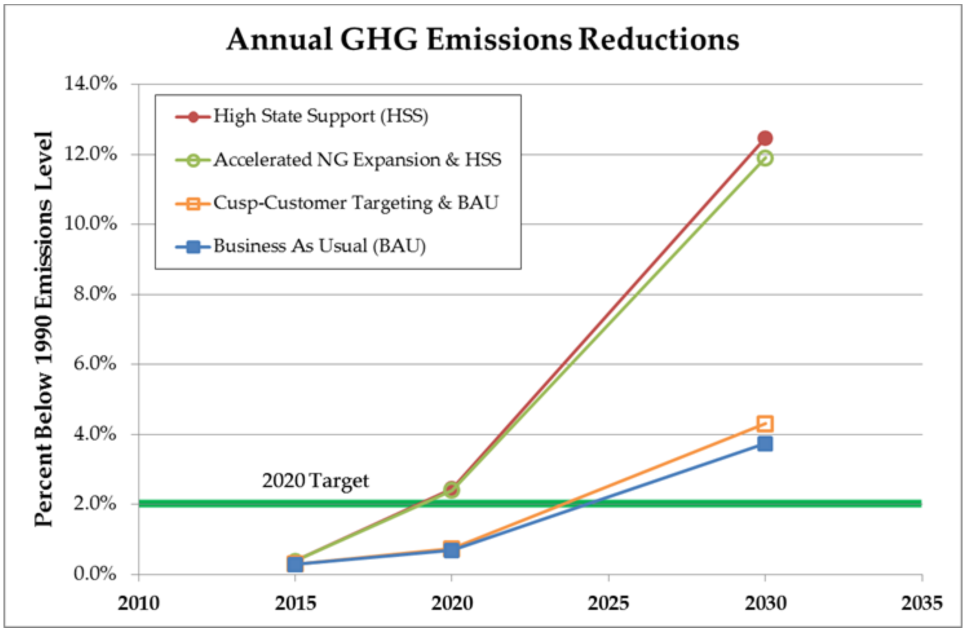

Figure 3-6: Impact on GHG Emissions

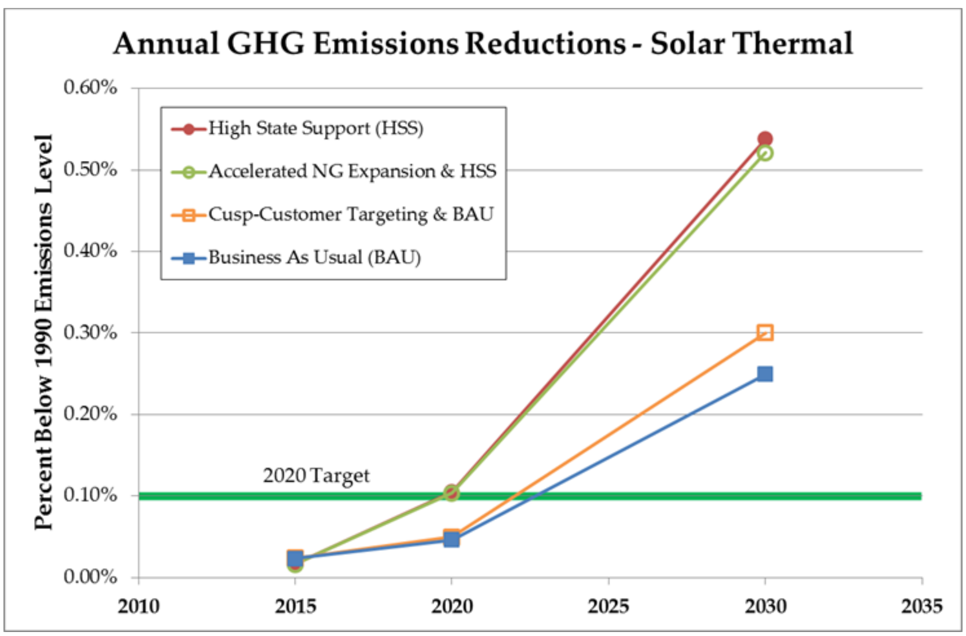

Figure 3-7: Impact on GHG Emissions – Solar Thermal

3.3 *Analysis Conclusions*

Strategies should focus on the 2020 GHG targets, which present the most immediate challenge given the short timeline, but long-term challenges should also be addressed in order to foster a strong industry.

The following key findings are a result of the customer class modeling. These findings directly informed the Navigant Team's strategy development:

- **RT must be part of the equation to meet GHG targets –** To achieve the MA GHG emissions reduction targets for buildings without RT technologies, the state would have to convert approximately 20% of the customers using fuel oil (FO) or electricity for heating in the state to natural gas by 2020. This is believed to be an unrealistic target due to the high cost of extending gas mains to this number of customers. Such expansion is not achievable without substantial expansion of gas mains to less densely populated areas. As NG begins to saturate the high-density neighborhoods/towns in the state, expansion of gas mains becomes more costly per potential conversion. RT technologies provide much greater reduction in GHG emissions per installation, thereby requiring fewer installations to reach GHG targets than for the equivalent impacts from NG fired-equipment.
- **The net present value (NPV) of benefits from RT investment may reach 2.4X to 3.2X the NPV of costs –** Under BAU, the net present value (NPV) of benefits to the state for investments until 2030 total \$5.1 billion to \$7.5 billion; this includes customer fuel savings and the state's avoided cost of CO_2 emissions through 2040 (assuming savings continue for 10 years beyond the last year of investment). The NPV of the costs (including all consumer and incentive investment) in RT installations through 2030 total \$3.9 billion in BAU. Under the HSS scenario, Massachusetts could expect benefits to increase to roughly \$23 billion to \$31 billion at a cost of \$9.8 billion in investment. This represents a 2.4X to 3.2X benefit to cost ratio. Table 3-7 summarizes the costs and benefits of investments in RT technologies under both the BAU and HSS scenarios. Note that even when excluding the avoided cost of GHG emissions, the benefits outweigh the investment cost by a factor of 2.3X in the HSS scenario.

Table 3-7: Investment Cost and Benefit Summary

	Annual Total Investment, MM 2013$			Annual State Investment, MM 2013$ (% of total)			Annual Number of Installations		
Year	**2015**	**2020**	**2030**	**2015**	**2020**	**2030**	**2015**	**2020**	**2030**
BAU	100	222	875	2 (2%)	5 (2%)	19 (2%)	3,150	7,300	27,500
HSS	217	1,361	855	52 (24%)	341 (25%)	194 (23%)	7,150	45,300	28,350
	NPV Total Cost, MM 2013$		**NPV Total Benefit, MM 2013$**		**NPV CO2 Avoided, MM 2013$**		**CO2 cost assumption**		
Year	**2015 - 2030**		**2015 - 2040**		**2015 - 2040**				
BAU	3,900		5,100		283		RGGI CO_2 cost		
			7,529		2,712		Marginal abatement CO_2 cost		
HSS	9,800		23,250		944		RGGI CO_2 cost		
			31,300		8,994		Marginal abatement CO_2 cost		

- **Meeting 2020 GHG goals would require the aggressive support shown in the "High State Support" scenario –** Under the BAU scenario, RT technologies do not achieve significant market penetration until well after 2020. The HSS scenario meets the 2% GHG emissions reduction goal by 2020, and it does so through aggressive growth in the next 6 years. The HSS scenario requires approximately 45,300 installations per year in 2020, roughly a six-fold increase over the number of installations in 2020 under the BAU scenario (7,300 per year). Such growth will clearly require significant investment from the Commonwealth both in terms of incentives and market development activities. To achieve the 2020 GHG goals, the HSS scenario requires a 25% incentive for RT technologies, in addition to existing incentives. The HSS scenario also requires support for market development activities (e.g., marketing campaigns, installer training, and financing support) targeted at substantially reducing market saturation time for RT technologies. Without market development support, such rapid growth can be stalled due to lack of experienced, trained installers and contractors and limited availability of supply chains for equipment, parts, and fuel in the case of biomass.

- **Meeting 2020 GHG targets can put MA on a potential trajectory to meet 30-32% of thermal energy from RT technology by 2030 – Under the HSS scenario** (i.e., aggressive support for RT technologies, and business-as-usual rates of conversion to natural gas), the state may be able to serve up to 32% of thermal loads with RT technology (up to 15,000 MWth of capacity) by 2030. As shown in the Accelerated NG & HSS scenario, the load served by RT will be reduced by up to 2% if natural gas conversion rates increase. The European jurisdictions described in Section 4, have RT targets ranging from 12% to 39% in 2020.
- **Market development based on lowest overall investment does not equate to the lowest cost to customers –** As shown in Table 3-3, above, by projecting RT market growth based on the lowest cost opportunity for customers, the resulting total investment required to meet GHG goals (i.e., HSS scenario) is higher than a scenario in which total cost is optimized. By emphasizing solar thermal development, for example, the state could potentially achieve market growth targets with less total investment, but with higher cost to individual consumers and/or higher total investment by the state (due to higher required incentive levels).
- **Accelerated penetration is more important than increasing peak achievable penetration –** Accelerating penetration (via reduced saturation time) has a more significant impact on increasing near-term market penetration than does increasing the long-term achievable peak penetration (reducing payback period). For example, reducing the payback period by 25% for all customer classes in the BAU scenario results in a 6% increase in the cumulative number of RT installations by 2020. However, reducing the saturation time by 25% (independently of the payback period) for all customer classes in the BAU scenario results in a 50% increase in the cumulative number of RT installations by 2020. Therefore, reducing market saturation time has a larger impact on near-term market penetration than strictly reducing payback period. Although, payback period does impact saturation time, saturation time can also be reduced by other market factors as well, as described in section 2.2 above. It should also be noted that the cost of reducing market saturation time is difficult to project and is not equivalent to the cost of reducing payback period.
- **Key growth acceleration levers can reduce market saturation time –** The following are the four key market factors that have the greatest impact on saturation time and for which DOER or other stakeholders can influence (in descending order – see definitions in section 2.2, above):
    1. **Payback Period**
    2. **Market Risk**
    3. **Technology Risk**

4. **Government Regulation**

- **The state should balance industry development and reaching GHG targets –** Strategies should balance the need to reach 2020 GHG targets with the desire to build a long-lasting and healthy renewable thermal market that can achieve 2050 targets. Market development strategies will help accelerate adoption and contribute towards reaching the 2020 goals. In order to achieve the 2050 goals, the state will also need to support strategies focused on cost reduction, to increase the maximum achievable market penetration of RT technologies. Cost reduction in particular will help foster organic growth of the RT market which will be crucial in reducing the market's reliance on state funding and establishing a robust industry capable of long-term growth. Strategies that focus solely on large customers that can provide a high impact through few installations will not help build as strong of an industry as strategies that target high volumes of customers (e.g., residential or small commercial). Further, strategies that help develop the industry will support greater job growth and more equitable access to RT technology.
- **Massachusetts should support a portfolio of all RT technologies –** Massachusetts has set a GHG emissions goal specifically for solar thermal, of 0.1% reduction in emissions below 1990 emissions level by 2020. Solar thermal systems provide the best GHG emissions reductions on a per installation basis out of all of the RT technologies. However, the economics for solar thermal are weaker than for biomass and heat pumps, which could achieve higher market penetration. To help reach the overall GHG goals for 2020, other RT technologies that provide lower first costs should be supported. Biomass (both pellets and chips) will be particularly beneficial in commercial applications, while heat pumps present the highest priority opportunity in residential applications. (Refer to Table 3-1 and Table 3-2, above, for the prioritized customer classes.)
- **RT (particularly solar) innovations (technical and other) should be supported** – RT technologies, especially solar, have opportunities for cost reductions that can improve cost competitiveness. In particular, advances in low-cost collectors, thermal storage systems (and/or integrated high-efficiency backups), and PV-driven heat pumps, may enable solar to penetrate key sectors where it has been limited in the past. By allocating near-term funds towards reducing RT first-costs through technological innovations and R&D initiatives, state investments for incentives can potentially be reduced in the medium term (i.e., 2020-2030 and beyond). Such an approach reduces the longer-term burden for up-front incentives and could mitigate the burden of trying to achieve such drastic reductions in saturation time (i.e., acceleration of equipment turnover/conversion). As discussed in section 2.2 , if the state can increase the maximum achievable market penetration of RT technologies (primarily achieved through first-cost reduction) then it may be possible to capture the necessary market share (to reach the 2020 GHG goals) with a slightly longer market saturation time. Investment in R&D will help aggressive growth beyond 2020. As shown in section 3.2.2 above, current projections show a tapering of growth by 2030 as the RT market starts approaching the top of the market penetration S-curve, leading to reduced annual market growth. This reduction in growth is most evident in the 2030 results of the potential analyses, which are based on annual installation volumes (such as job creation and state tax revenue).

  RT R&D initiatives should focus on equipment and technology innovation, soft cost reductions (costs associated with acquisition, installation, financing, and permitting), and new applications for RT systems. To contribute to the 2020 goal, innovations must be commercialized and available for sale to the public in the next 3-5 years. For example, in August of 2012, the National Renewable Energy Laboratory (NREL) identified a few key opportunity areas for additional innovations for solar thermal, including: polymer heat exchangers, storage tanks, and piping; integrated valve packages; lower-cost mounting methods; and reduced installation costs through lighter components and greater use of plug-and-play configurations.[28] Such advances will help the industry to develop strong organic growth and increase the long-term achievable penetration.

- **Natural gas customers should be targeted but present a cost-competitiveness challenge –** Massachusetts home/building owners heating with fuel oil, electricity, or propane are priority targets due to the greater cost effectiveness of installing RT in their buildings relative to those using natural gas. However, natural gas is the most widely used heating fuel in Massachusetts, and excluding those customers reduces the potential market for RT. A larger pool of potential customers attracts investment in the RT industry and provides a longer and wider pipeline of opportunities for achieving favorable returns on the investment. Converting natural gas heating to RT shields these customers against potential natural gas price increases in the future, and is consistent with reaching the Commonwealth's longer term GHG target of -80% by 2050. Non-energy benefits of RT technologies such as improved ventilation or energy resilience can help drive early adoption by natural gas customers, especially among high-income residential customers.
    1. **Cusp natural gas customers –** If Massachusetts can aggressively target fuel oil, electric, and propane heating customers on the cusp of converting to natural gas (i.e., those who have access to a natural gas main, but who currently do not use the fuel for heating or at all), and convert them to renewable thermal rather than natural gas, we expect the market penetration of RT to increase by ~0.1% over the BAU scenario (adding ~4,500 new customers) by 2020. This increase in penetration would result in an additional 0.04% reduction in GHG emissions.
    2. **Existing natural gas customers –** The best RT options for competing with existing natural gas customer classes are commercial scale ccASHP and GSHP due to their ability to serve cooling needs as well as heating needs. However, even for heat pumps, as they are burdened with a high first cost, it will be difficult to achieve significant market penetration without strong state support, so non-energy benefits should be highlighted for marketing/sales purposes (including high level of comfort with consistent temperatures throughout, and lower GHG emissions). In the BAU scenario, by 2020, we estimate that 300 large and small commercial natural gas customers will convert to RT (representing ~0.01% of the building stock statewide). If MA were to provide high state support for these customer classes we would expect conversation to RT by 1,400 customers (representing ~0.06% of the building stock statewide. Based on these findings we recommend that DOER first target the cusp natural gas customers (lower hanging fruit) but also support careful targeting of current natural gas customers.
- **Natural gas expansion will impact RT growth –** Expansion of natural gas distribution as modeled will lessen the GHG emissions reductions attributable to RT technologies (i.e., less progress towards reduction goals). The team modeled the impact on GHG emissions for both

[28] K. Hudon et. Al. "Low-Cost Solar Water Heating Research and Development Roadmap," August 2012, available at: www.nrel.gov/docs/fy12osti/54793.pdf

the High State Support scenario, and the Accelerated NG Expansion & HSS scenario. Based on the difference in results for both scenarios, accelerated NG expansion will decrease the impact on GHG emissions in the High State Support scenario by up to 2% in 2020 and 5% in 2030. Relative to 1990 GHG emissions levels, this corresponds to a difference of 0.05% for 2020 and a 0.57% difference in 2030 (analysis does not account for GHG emissions reductions due to NG conversions). While these data indicate that natural gas expansion undercuts investments and gains in GHG emissions reductions through RT expansion, the impacts are geographically limited. For example, gas expansion will not occur in rural areas where the population density is insufficient to support expansion of gas mains; gas distribution expansion is expected to focus primarily on areas with existing gas mains. RT markets on the other hand are not limited by population density.

- **Top market segments** – The most important market segments for targeting purposes (aside from existing natural gas customer classes) are:
    - Commercial, Large, Fuel Oil / Electric
    - Residential, High Income, Fuel Oil
    - Residential, Low Income, Fuel Oil / Electric

  This is based on the following indicators:
    - The largest market segments by primary energy consumption are (see Figure 3-8):
        1. Commercial, Large, Fuel Oil
        2. Residential, High Income, Fuel Oil
        3. Commercial, Large, Electric
        4. Residential, Low Income, Fuel Oil

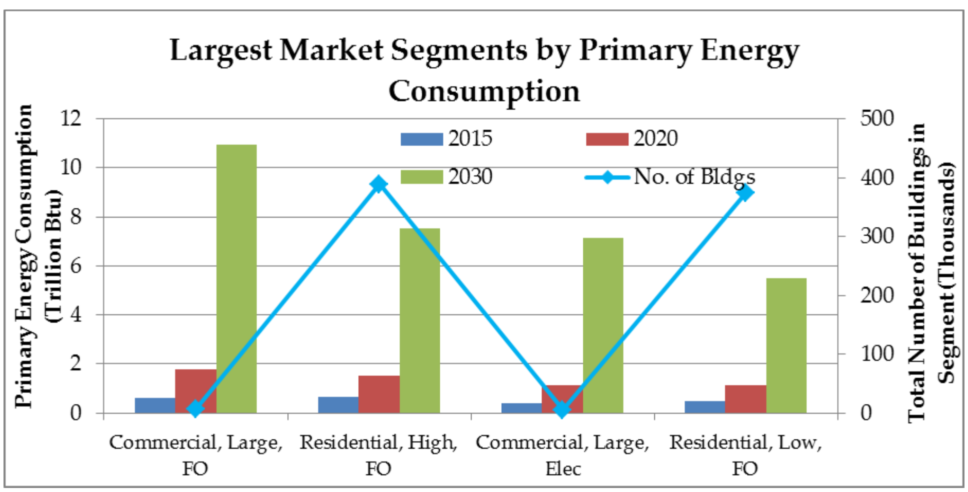

Figure 3-8: Largest Market Segments by Primary Energy Consumption

    - The market segments with the highest potential impact on GHG emissions are (see Figure 3-9):
        1. Commercial, Large, Electric
        2. Commercial, Large, Fuel Oil
        3. Residential, High Income, Fuel Oil
        4. Residential, Low Income, Electric

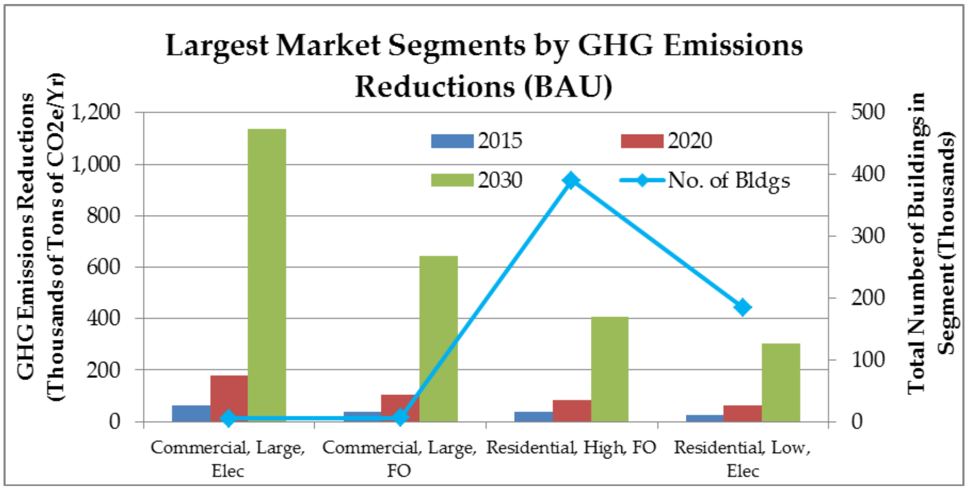

Figure 3-9: Largest Market Segments by GHG Emissions Reductions

- The market segments with the highest potential impact on job creation are (see Figure 3-10):
    1. Commercial, Large, Fuel Oil
    2. Residential, High Income, Fuel Oil
    3. Commercial, Large, Electric
    4. Residential, Low Income, Fuel Oil

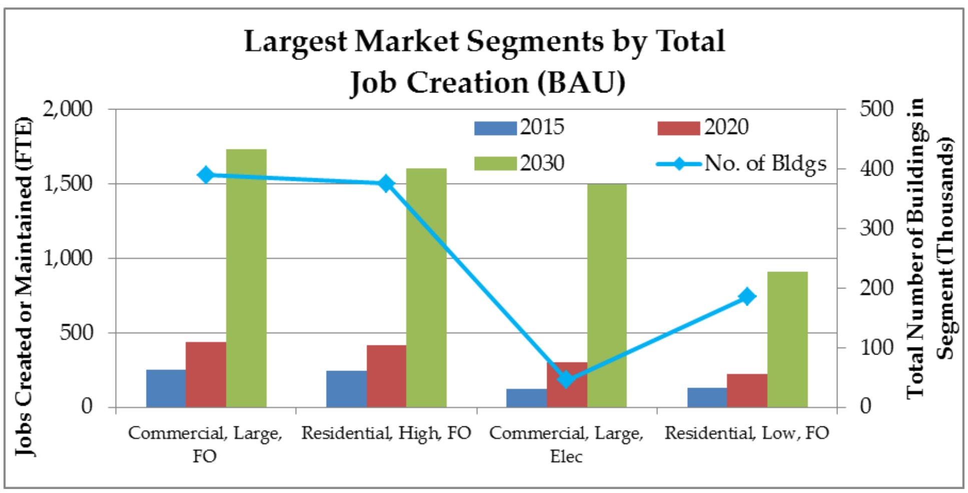

Figure 3-10: Largest Market Segments by Total Job Creation (direct, indirect, and induced)

4 Analysis of Strategies in Other Jurisdictions

To inform renewable thermal market development strategies in the Commonwealth, the CARTS team assessed international best practices across four key jurisdictions. Three of the jurisdictions assessed – Upper Austria, Denmark, and Germany – have strong, well-established renewable heating and cooling markets. The fourth jurisdiction – the United Kingdom – represents an emerging market, with robust renewable thermal policies in place, and strong growth expected in the future.

All of the international jurisdictions analyzed are located in the European Union, and as such, are subject to European Union (EU)-wide energy, climate, and building requirements. The EU established the so-called "20-20-20" targets, which aim to reduce greenhouse gases by 20%, increase renewable energy use to 20%, and create a 20% improvement in energy efficiency across all member states by 2020.

To meet the 20-20-20 targets, each of the member states has taken on binding targets for raising their share of renewable energy and reducing their greenhouse gas emissions. Country targets are set based upon the relative wealth of EU countries and, in the case of renewable energy, each countries' initial starting point. For example, Sweden has a target of 49% renewable energy generation by 2020, whereas Malta is expected only to achieve 10% renewable generation. Energy efficiency requirements are also established for each of the member states.

Member states are given a certain degree of flexibility in determining how to reach their respective country targets. To this end, each of the member states submits a National Renewable Energy Action Plan (NREAP) to the EU Commission, which details their renewable energy plan. Depending upon their resources and priorities, member states focus to a greater or lesser extent on developing renewables in the electricity, heating, or transportation sectors. Thus, while EU member countries are not required to establish binding renewable thermal targets, renewable heating and cooling plays a significant role in the national energy policy strategy. Figure 4-1 illustrates renewable energy goals developed as part of the NREAP process and submitted to the European Commission by Austria, Germany, the United Kingdom, and Denmark.

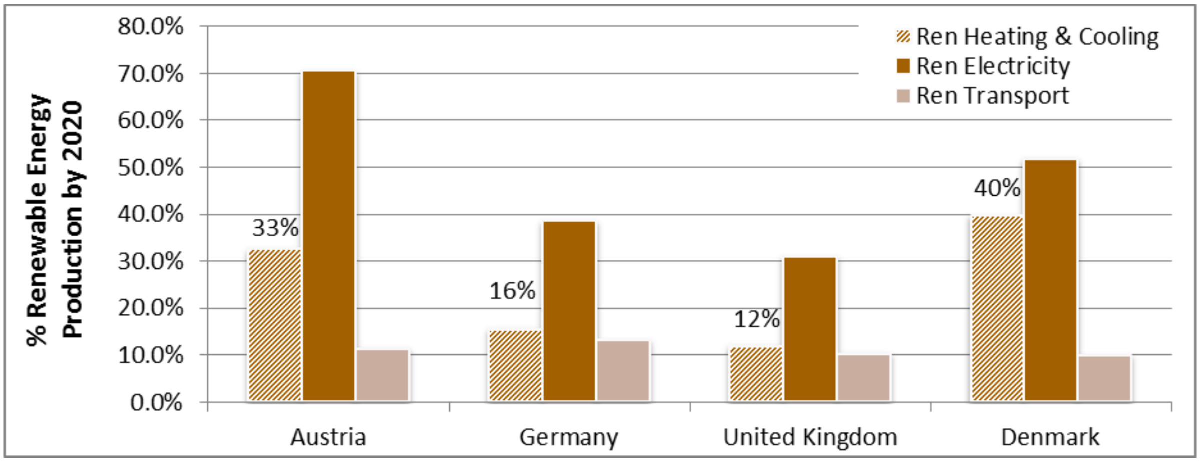

Figure 4-1: Key European Renewable Energy Targets

Additionally, EU energy efficiency legislation (the Energy Performance of Buildings Directive) has significantly tightened energy efficiency requirements for buildings over the years and links building energy performance to heating, cooling and power production. Member states must ensure that new construction and major building renovations are "nearly zero-energy." Accordingly, new construction and building renovations must consider integration of renewable heating and cooling technologies among other alternative energy or advanced energy efficiency technologies.

Finally, EU member countries also have wide latitude to develop policies and market development programs to respond to local resources available, industry needs, as well as political realities. As described in Table 4-1, EU jurisdictions have deployed a wide range of market development goals and approaches, customized to the needs and requirements of local markets.

Table 4-1: Summary of Market Development Approaches by Jurisdiction

Jurisdiction	Market Development Approaches
State of Upper Austria (Austria)	• **Goal: 100% renewable heating and electricity by 2030** • Stable long-term incentives (rebates) in place since 1980s • Strong cluster development approach (Oekoenergie cluster), developed to develop new (biomass) markets for local farmers • Strong manufacturing base and export market

Jurisdiction	Market Development Approaches
Denmark	• **Goal: 39% renewable heat by 2020** • Large district heating network serves majority of population (especially around Copenhagen) • Heating grid was historically dependent upon oil and fossil fuels and subject to significant disruptions during 1970's oil crisis. Tax policies since 1980s leveled playing field between renewables and fossil fuels. • In 2012, Denmark became the first country in the world to ban oil and gas-fired heating systems. By 2016, Denmark will prohibit installation of new oil heating in existing buildings if district heating is available. • Integration of biomass, SHW, and heat pumps into district heating (as well as natural gas) limits volatility of oil on heating prices
Germany	• **Goal: 14% renewable heating by 2020** • Largest SHW market in Europe and largest consumer of bioenergy • Legislatively mandated renewable heating and cooling target • Rebate program has a mix of "bonus" incentives to encourage innovation and efficiency for renewable thermal
United Kingdom	• **Goal: 12% renewable heat by 2020** • Historically has had a small renewable heating market • Developed first feed-in tariff for heat (Renewable Heat Incentive) in order to quickly scale innovation and deployment of renewable heating technologies • Developed detailed heat metering requirements to monitor performance • Strong emerging market for renewable thermal

While policy and program mechanisms across the jurisdictions varied (e.g. deploying rebates vs. feed-in tariffs), several best practices are observed across the jurisdictions. These include:

- Development of renewable heating and cooling action plans and/or targets
- Implementation of stable, long-term incentive programs to improve cost-effectiveness
- Creation of industry-led marketing programs to increase public awareness (often co-financed with public and private sector funds)
- Integration of renewable heating and cooling with energy efficiency marketing, outreach, and financing programs
- Integration of renewable heating and cooling technologies into building codes
- Development of performance monitoring requirements, either via regular inspections or metering/monitoring technologies

A comprehensive assessment of market development strategies implemented across the four international jurisdictions is provided in Appendix H (Slides from second stakeholder meeting).

5 Market Barriers

This report focuses on strategies designed to help Massachusetts accelerate growth of the renewable thermal market, and achieve the Commonwealth's 2020 GHG emissions goals. It builds on two previous Massachusetts market and technology reports, which assessed the barriers, opportunities, technical requirements, and economics of renewable heating and cooling technologies.[29, 30] The CARTS study, like past market assessments, was developed in close collaboration with regional stakeholders, including broad input from manufacturers and developers, trade groups, environmental advocates, building managers, government agencies, and technical experts, among others.

In evaluating the current state of the market, CARTS stakeholders confirmed past findings and reported that five major barriers impact renewable thermal market growth in Massachusetts:

- High capital costs: relative to conventional fossil fuel systems, renewable thermal technologies tend to have significantly higher upfront costs.
- Lack of policy support: renewable thermal technologies tend not to receive public policy support relative to renewable electricity or renewable transport fuels.
- Poor public awareness: there tends to be poor awareness of the economic (lifecycle), GHG, and societal benefits of renewable thermal systems among policymakers and the general public. Similarly, there tends to be a lack of consumer confidence in renewable thermal technologies.
- Opaque regulatory standards: renewable thermal technologies tend to face confusing or unclear regulatory standards.
- Workforce development: many renewable thermal industry stakeholders report challenges hiring adequately trained personnel.

Stakeholders reported that high capital costs, lack of policy support, and poor public awareness represent the most significant barriers to market development. Accordingly, stakeholders emphasized the need to develop strong governance, marketing, and financing strategies (see "Cluster Development Framework" in Section 2.4) to address these barriers. This feedback formed the basis for developing the "cornerstone strategies" detailed in Section 6.

Detailed renewable thermal market development strategies, which were shaped by stakeholders throughout the CARTS process, are described in Section 6. Additionally, it is worth noting that stakeholders provided important feedback on the development and implementation of the renewable thermal market models, including the customer class, sector potential, and energy potential analyses. Appendix G describes the modeling methodologies, which were developed in close collaboration with the stakeholder advisory group.

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[29] Meister Consultants Group. (2012). *Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study.* Prepared for Massachusetts Department of Energy Resources and Massachusetts Clean Energy Center. Retrieved from www.masscec.com.

[30] Executive Office of Energy and Environmental Affairs, Department of Energy Resources. (2012). *Heating and Cooling in the Massachusetts Alternative Portfolio Standard.* Prepared for the Massachusetts Legislature. Prepared with assistance from Massachusetts Department of Energy Resources and Meister Consultants Group. Retrieved from www.mass.gov.

6 Recommended Strategy Pathway for Massachusetts

As discussed in Section 2.4, the Navigant team developed the set of 66 strategies discussed below through a combination of avenues, including stakeholder discussions (individual and group meetings), internal research, jurisdiction analysis, DOER input, and results of the modeling analysis (see section 3). Appendix I lists the complete set of strategies. Through the prioritization process described in Section 2.4, the team identified:

- 1 keystone strategy;
- 6 cornerstone strategies;
- 11 building block strategies; and
- 48 other strategies that remain of interest and may continue to support targeted actions by DOER or others.

Figure 6-1 lists the recommended keystone and cornerstone strategies for use in expanding the RT industry in the state and helping achieve the 2020 GHG emission reduction targets (see section 1.2. The keystone strategy is a key underlying strategy that ties together the efforts of all other strategies, while the cornerstone strategies provide a solid footing in key cluster areas on which the state can build a comprehensive RT program.

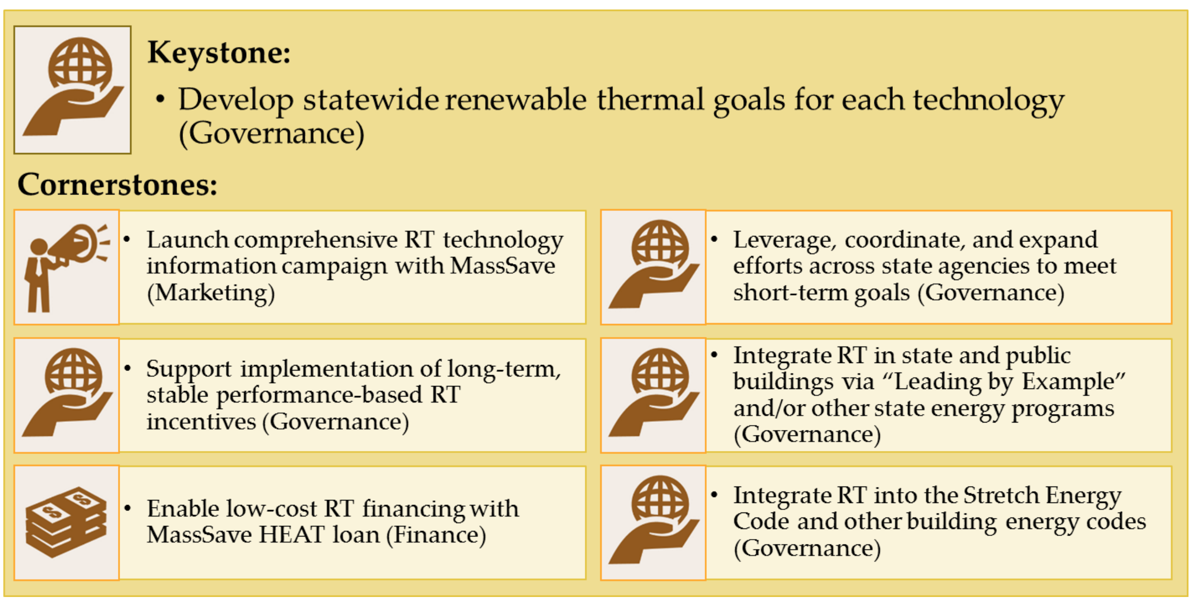

Figure 6-1: Keystone and Cornerstone Strategy Recommendations

The team's 11 recommended building-block strategies can support the primary objectives and build on the cornerstone strategies. These building blocks are not an a la carte selection of options, but rather a comprehensive set of strategies that the Navigant team has identified for execution to ensure that the state reaches its 2020 GHG targets. These strategies do not represent a commitment by DOER and are instead a recommendation to DOER developed through the process described in section 2.4. If for any reason the strategies are not to be executed in a comprehensive fashion, care should be taken in understanding the tradeoffs of omitting any given strategy. Figure 6-2 lists each of the building block strategies.

Marketing
- Develop "Thermalize" program, modeled after Solarize Mass
- Develop comprehensive database with case studies and technology performance metrics
- Provide data to assist developers and installers identify "high value" renewable thermal customers
- Create tool that helps customers self-screen for suitability of RT technologies

Governance
- Review market enabling guidance regarding fuel choices and associated GHG emissions impacts
- Integrate renewable thermal into energy protection and assistance programs for low-income families

Resources & Logistics
- Create Renewable Thermal Industry Advisory Forum
- Engage heating oil and propane industry to explore RT business opportunities

Innovation
- Encourage exchanges with foreign manufacturers to deploy state-of-the-art technology

Labor & Standards
- Institute technical and sales training programs
- Integrate RT and EE into community college and vocational school curricula in MA

Figure 6-2: Building-Block Strategies by Cluster Area

The subsections below describe each of the strategies in detail.

6.1 Keystone Strategy: Develop Statewide Renewable Thermal Goals

Table 6-1: Strategy #1 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Dec 2013 **End:** Ongoing reporting	**Proposed Lead Organization:** DOER **Additional Participants:** Executive Office EEA, MassDEP, MassCEC, trade groups, consultants

Objective: Clearly communicate Massachusetts' commitment to drive renewable thermal market growth

Background: Stakeholders have repeatedly mentioned the value of statewide goals in helping to drive investment and resources in renewable energy and energy efficiency. Goals provide long-term indications to investors that the state has concrete targets and, if done in a simple fashion, help to convey realistic estimates of the financial size of the opportunity in the state. Targets can also work as a marketing tool to help promote the industry in the state and increase awareness among consumers. For example, goal setting in the PV industry in Massachusetts, along with the support necessary to meet those goals, has helped to accelerate the state past its goals nearly four years early and become the seventh highest ranked state in the nation for installed solar capacity.[31]

Pathway: DOER should establish market development goals (i.e., capacity (MWth) or market value ($) by 2020) for each renewable thermal technology. Goals should account for key policy drivers and customer class analysis insights and should be based on the renewable thermal GHG emission reductions targets in the Massachusetts Clean Energy and Climate Plan for 2020[32]. Goals should be adjusted over time in order to respond to market conditions.

Table 6-2: Strategy #1 Implementation Steps

Steps	Deliverable/Milestone
1. Estimate GHG reductions and associated dollar-value of projects for typical residential and commercial installations for each technology 2. Review key policy underlying policy goals and achievable impacts from available incentive funds 3. Propose 2020 high/low technology (MWth) and market ($) goals for RT technologies (e.g. between 100 and 200 MWth installed by 2020) and review with market leaders 4. Publicly communicate state's commitment to achieving RT goals 5. Monitor, report, and update market growth goals over time (see strategy #2)	1. Dec 2013: estimate market growth and GHG emission reduction potential for each technology 2. Dec 2013: establish statewide goals 3. Mar 2014: launch quarterly reporting program (see strategy #2)

6.2 *Cornerstone Strategies*

6.2.1 Leverage, coordinate, and expand efforts across state agencies to meet short-term goals

Table 6-3: Strategy #2 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Dec 2013 **End:** Ongoing	**Proposed Lead Organization**: DOER **Additional Participants**: MassDEP, MassCEC, DCAMM, Utility PAs

Objective: Coordinate implementation of state agency programs to accelerate RT technology deployment in the short-term.

[31] For additional updates on PV goals, see the Northeast Sustainable Energy Association (NESEA) website at: www.nesea.org/renewable-energy/massachusetts-rockets-past-solar-goals-patrick-shoots-for-the-sky/

[32] 2% reduction in GHG emissions below the 1990 emissions level for all renewable thermal technologies, including at least a 0.1% reduction in GHG emissions levels for solar thermal technologies; see section 1.2, above, for additional discussion of GHG targets. "Massachusetts Clean Energy and Climate Plan for 2020", December 2010, Available at: www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

Background: Presently the state has many different incentive and market development programs hosted by different agencies, including MassCEC, Mass DOER, MassDEP, as well as MassSave. It is important to understand the aggregate effect of these different programs on the development of the renewable thermal markets. Coordination among key actors in Massachusetts can provide valuable benefits. As part of coordination, additional analysis is needed to understand the sensitivity to various incentive levels and to determine levels needed to reach specific target customer groups.

Pathway: Key agency leaders at DOER, MassDEP, MassCEC, as well as the utility Program Administrators (PA) should meet on a monthly basis to track progress toward statewide renewable thermal goals, coordinate implementation of market development programs (e.g. incentive levels and structures, regulation, performance requirements, marketing, etc.), and adjust programs as necessary to achieve goals. The group could also address industry research needs, such as thermal energy metering assessment and technology validation (e.g. ccASHP performance testing).

Table 6-4: Strategy #2 Implementation Steps

Steps	Deliverable/Milestone
1. Establish monthly meetings for state agencies 2. Analyze impacts of existing state incentives and regulations and adjust programs to achieve near-term goals 3. Implement quarterly market progress reports, assessing market development metrics for each technology (e.g. # of installations, installed costs, expected payback, incentives awarded, performance monitoring results, etc.) 4. Manage/adjust agency programs to respond to market needs	1. Dec 2013: start monthly meetings 2. Mar 2014: launch quarterly reporting program

6.2.2 Launch comprehensive RT technology information campaign with MassSave

Table 6-5: Strategy #3 Summary

Cluster Area	Time	Responsibilities
Marketing	**Start:** Dec 2013 **End:** Review May 2015	**Proposed Lead Organization:** DOER, Utility PAs **Additional Participants:** DPU, Trade groups, Environmental groups

Objective: Expand awareness of RT technologies by leveraging existing customer outreach/information programs like MassSave

Background: Customers lack awareness of renewable thermal technologies and, as a result, tend not to ask energy auditors or HVAC contractors how or if they can install these technologies for their home or business. Developing demand among consumers by helping them understand the benefits is important in promoting organic industry growth. As discussed in section 2.2.1, above, customer education is essential to reduce market risk and accelerate RT market growth. The modeling results and the fundamental theory of the Fisher-Pry market penetration model emphasize the need for all such activities which shorten the market saturation time. (See additional discussion of market risk and market saturation time in section 3.3.)

Pathway: Develop a communication campaign with MassSave to increase awareness of renewable thermal technologies. This should include approaches that increase widespread consumer awareness by integrating RT into MassSave's wide-reaching, mass-media communications (e.g. bill stuffers and billboards) and one-on-one customer engagement (e.g. sales trainings for contractors). In all cases, communication should include expanded communication around existing RT opportunities (e.g., ASHP rebates, HEAT loans), as well as introduction of new RT opportunities.

Table 6-6: Strategy #3 Implementation Steps

Steps	Deliverable/Milestone
1. Coordinate with utility program administrators (PAs) to determine the best ways to expand MassSave marketing and auditing efforts (and strategy # 7 for financing) to include all RT. Specifically discuss funding options that address/avoid fuel switching issues. 2. Partner with other environmental and state energy organizations to collaborate on RT marketing efforts 3. Identify target markets and optimal marketing channels for each RT technology and launch new or improved marketing campaigns 4. Monitor the impact of expanded marketing efforts for RT technologies	1. Dec 2013: Concrete plans for MassSave expansion 2. Mar 2014: Industry partnerships established 3. May 2014: New or improved marketing campaigns launched 4. May 2015: 1 yr program evaluation

6.2.3 Support implementation of long-term, stable performance-based RT incentives

Table 6-7: Strategy #4 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Dec 2013 **End:** Ongoing	**Proposed Lead Organization:** DOER **Additional Participants:** Mass Renewable Thermal Coalition

Objective: Improve cost effectiveness and reward reliable performance by implementing a performance-based incentive

Background: Other jurisdictions have shown that performance-based incentives (PBI) for renewable energy technologies have been successful in increasing market adoption. PBI programs reward better performing technologies and appliances, which are important from an energy efficiency, emissions reduction, and rate/tax payer point of view. One example of a RT PBI is the United Kingdom's Renewable Heat Incentive, which is structured as a feed-in tariff (FIT, see Table 4-1, above). Leveraging lessons learned from international jurisdictions, Massachusetts policymakers should implement a PBI to drive market growth for renewable thermal technologies in the Commonwealth.

Pathway: Implement a long-term, performance-based incentive for RT technologies to help improve cost effectiveness and increase market penetration. Performance-based incentives, by definition, should promote long-term energy efficient performance that will reliably meet long-term expectations for GHG emissions reductions and do so by improving cost-effectiveness of the products. For example, senate bill (SB) 1593 "An Act relative to credit for thermal energy generated with renewable fuels" would allow renewable thermal technologies to qualify in the Alternative Portfolio Standard. Enacted in 2008, the APS currently provides support for a range of alternative electricity technologies, but not thermal energy (heat/cooling). This bill would allow renewable thermal technologies to qualify for the APS, providing a production based incentive revenue stream.

Table 6-8: Strategy #4 Implementation Steps

Steps	Deliverable/Milestone
1. Determine necessary actions to ensure that clean and energy efficient RT technologies become eligible for a performance based incentive. 2. Support political processes in legislature for SB 1593 and/or other policies encouraging performance based incentives 3. Engage with DOER on regulatory implementation efforts. 4. Evaluate the incentive levels periodically and adjust them based on market conditions to avoid over- or under-stimulating the market.	1. Dec 2013 – engage in legislative discussions and amendments 2. Schedule TBD – adoption of legislation by full legislature 3. Schedule TBD – DOER to implement regulation 4. Schedule TBD – periodic incentive level updates

6.2.4 Integrate RT in state and public buildings via "Leading by Example" and/or other state energy programs

Table 6-9: Strategy #5 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Dec 2013 **End:** TBD	**Proposed Lead Organization**: DOER, Executive Office of Energy and Environmental Affairs , Executive Office for Administration and Finance **Additional Participants**: MassDEP, DCAMM, OSD, CLF

Objective: Reduce GHG emissions from state buildings and provide a clear signal to the marketplace of state support for renewable thermal

Background: The "Leading by Example" (LBE) program sets aggressive targets for buildings and facilities owned and operated by Massachusetts state agencies regarding GHG emission reductions, energy conservation, and renewable energy. This program has been a key driver in accelerating energy efficiency and renewable energy in the state. Currently, the LBE program includes targets for renewable electricity (30% renewable electricity by 2020) and energy efficiency (35% energy consumption reductions by 2020). Targets do not currently exist for renewable thermal technologies. By incorporating renewable thermal targets into state buildings, the Commonwealth provides a clear signal to the market, gathers important operational data on RT technologies, and pilots a program that could be expanded into the building code across the state.

Pathway: The Governor's office should amend Executive Order No. 484 to include a renewable thermal target for all Massachusetts' executive agencies and public institutions of higher education (e.g. supply 30% of all heat from renewable sources by 2020). Integrate renewable thermal into the "energy measures and strategies" options for all state buildings. If political barriers prevent such actions, the state can lead by example by pushing renewable thermal in state buildings through other existing state energy programs.

Table 6-10: Strategy #5 Implementation Steps

Steps	Deliverable/Milestone
1. Draft language to establish targets and strategies for integrating renewable thermal technologies under Executive Order No. 484, building upon experience with the Accelerated Energy Program 2. Sign amendments to Executive Order No. 484 and continue to leverage existing opportunities (e.g., Accelerated Energy Program - DCAMM) for expansion of RT in public buildings 3. Develop technical resources, incentive programs, and procurement pathways to assist public building integrate renewable thermal technologies	1. Dec 2013: draft amendments to Executive Order No 484 2. Jan 2014: sign/implement amendments to Executive Order No. 484 3. Jan 2014: start developing technical resources

6.2.5 Integrate RT into the Stretch Energy Code and other building energy codes

Table 6-11: Strategy #6 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Winter 2014 **End:** Summer 2014	**Proposed Lead Organization:** DOER **Additional Participants:** MA Municipalities Association (MMA), MA Board of Building Regulations and Standards (BBRS)

Objective: Drive RT market growth by updating energy codes to include renewable thermal requirements

Background: To achieve "Green Community" status in Massachusetts, a municipality must require all new residential construction over 3,000 square feet and all new commercial and industrial real estate construction to minimize, to the extent feasible, the life-cycle cost of the facility by utilizing energy efficiency, water conservation and other renewable or alternative energy technologies. The recommended way for cities and towns to meet this requirement is by adopting the Board of Building Regulations and Standards (BBRS) Stretch Energy Code (780 CMR 115.AA), an appendix to the MA State Building Code. The MA Stretch Energy Code offers a streamlined and cost effective route to achieving approximately 20% better energy efficiency in new residential and commercial buildings than is required by the base energy code. The Stretch Energy Code is likely to be updated in the next 12 months as the baseline energy code is updated to the newest IECC in July 2014. Incorporating Renewable Thermal into code, either as an incentive or a requirement for certain building types, would encourage developers to incorporate cost-effective renewable thermal technologies into buildings. As of May 2013, 132 communities, covering more than 50% of the population, had adopted the Stretch Energy Code and adoption continues to expand.[33] DOER should explore potential for increasing energy efficiency requirements of the stretch code to encourage use of cost-effective renewable thermal technologies for new construction or major renovation in the private sector.

Pathway: New stretch energy code requirements can accelerate the integration of RT technologies either by:

A) Enabling credit for renewable thermal use, or

B) Establishing a requirement for certain buildings to use renewable thermal sources.

Seek public comment on revised stretch energy code requirements to encourage developers to use RT and EE. This can be further supported by the Green Communities program - with accompanying technical assistance, outreach, and incentives for participating communities. DOER and stakeholders should identify and integrate RT into other building energy codes such as the International Green Construction Code or the Collaboration for High Performance Schools (CHPS) code.

Table 6-12: Strategy #6 Implementation Steps

Steps	Deliverable/Milestone
1. Work with BBRS to determine options for incorporating RT into the Stretch Energy Code, evaluating technical impacts and requirements (e.g. engage consultants/researchers as needed). Additionally, evaluate options for integrating RT into the Intl Green Construction Code or CHPS. 2. Draft preliminary language for public comment period and for final code update. Review with stakeholders to ensure broad public support during comment period and acceptance in the new code. 3. Facilitate completion of code update 4. Provide support as needed to connect MMA with necessary resources and to market the new code	1. Winter 2014: participate in public comment period 2. Next steps TBD

6.2.6 Provide low-cost financing for renewable thermal through the MassSave HEAT loan program

Table 6-13: Strategy #7 Summary

Cluster Area	Time	Responsibilities
Financing	**Start:** Jan 2014 **End:** Dec 2014	**Proposed Lead Organization**: DOER, utility PAs **Additional Participants**: MassCEC, trade groups

Objective: Provide low or 0% financing for renewable heating and cooling systems

[33] Stretch Code Adoption, By Community, pdf available: www.mass.gov/eea/docs/doer/green-communities/grant-program/stretch-code-towns-adoption-by-community-map-and-list.pdf

Background: MassSave, the utility sponsored EE financing program, works with local lenders to provide zero interest or low-interest unsecured loans for SHW and other energy efficiency improvements. As part of the program, the utilities provide funds to buy down the cost of interest for the loans. The HEAT loan program has helped provide more than $125 Million in loans to state residents in the last six years and has proven to be highly effective in reducing cost barriers for the adoption of high-efficiency equipment.[34] As discussed in section 2.2.1, above (model background), and in section 3.3, above (analysis conclusions), reducing first-cost barriers is essential to increase the maximum achievable penetration of a technology, and is a vital component of a comprehensive RT strategy. Currently, SHW and heat pumps are considered eligible EE measures and customers may finance these technologies under the HEAT loan. Biomass thermal, by contrast, is viewed as renewable generation and is not currently eligible.

Pathway: DOER and stakeholders should work together to enable financing of renewable heating and cooling systems under the existing HEAT loan program. Barriers identified to date include: utility fuel-switching guidelines that prevent many renewable thermal systems from receiving financing, loan caps that prevent customers from financing renewable thermal systems in addition to EE retrofits, and poor awareness (or confusion) regarding eligibility of RT technologies. All RT technologies should be eligible for financing under both the residential and commercial HEAT loan programs.

Table 6-14: Strategy #7 Implementation Steps

Steps	Deliverable/Milestone
1. Clarify existing MassSave rules for financing renewable thermal systems with utility PAs for both residential and commercial systems 2. Develop working group (see strategy #13) to identify funding sources to buy down points on loans for technologies that are not currently covered by MassSave (e.g. high efficiency, low emission biomass) and to identify any additional barriers that prevent low-cost financing for RT 3. Develop rules/guidelines with utility PAs to address barriers. 4. Fully integrate renewable thermal systems into the MassSave HEAT loan	1. Jan 2014: clarify existing MassSave rules for financing renewable thermal systems 2. Apr 2014: develop working group to identify barriers to integrating all renewable thermal technologies into HEAT loan (see strategy #13) 3. Dec 2014: issue final guidelines for HEAT loan financing for renewable thermal technologies

[34] From the website of the program's implementation contractor, Conservation Services Group: www.csgrp.com/the-mass-save-heat-loan-program-energy-efficiency-financing-case-study/

6.3 Building Block Strategies

6.3.1 Develop "Thermalize" program, modeled after the successful Massachusetts Solarize program

Table 6-15: Strategy #8 Summary

Cluster Area	Time	Responsibilities
Marketing	**Start:** Dec 2013 **End:** Review Mar 2015	**Proposed Lead Organization:** MassCEC **Additional Participants**: DOER, local communities

Objective: Increase RT awareness and reduce costs via competition and facilitation of customer acquisition

Background: The Solarize Mass program is a grassroots education campaign, driven mainly by volunteers, that increases the adoption of small-scale solar electricity in communities through a competitive tiered pricing structure. It has led to more than 900 residents and business owners signing contracts for small-scale electricity systems, while speaking with thousands more about the economic and environmental benefits of solar electricity and energy efficiency.[35] Solarize Mass for solar PV has been designed and implemented by MassCEC in collaboration with the Green Communities Division of DOER. Several solarize-style customer-aggregation pilot projects for renewable thermal technologies have been developed around the country. These programs have met with varying levels of success, providing customers' installed cost discounts ranging from 5% to 30%.[36]

Pathway: Develop a program similar to Solarize MA to increase awareness and encourage/enable adoption of solar thermal, biomass thermal, or heat pumps across the Commonwealth. Support MassCEC, and use lessons learned from the prior small, successful pilot.

[35] MassCEC webpage: www.masscec.com/solarizemass

[36] Known solarize-style pilot projects that have supported renewable thermal technologies include the Minnesota Renewable Energy Society's "Make Mine Solar Hot Water" program, the "Solar Addison County" program run by the Vermont Public Interest Research Group (VPIRG), a solar thermal pilot program in Lancaster, Mass. offered by BEAM Engineering, and the "Model Neighborhood Project" offered by the Northern Forest Center.

Table 6-16: Strategy #8 Implementation Steps

Steps	Deliverable/Milestone
1. Coordinate with Mass CEC to leverage experience and mechanisms from Solarize program to develop a plan for "Thermalize MA" program; identify initial target communities based on prevalence of oil/electric resistance heating. 2. Engage local installers and manufacturers to develop competitive procurement arrangements for RT equipment 3. Launch "Thermalize MA" program and sponsor grassroots support for RT installations via educational workshops and community outreach 4. Set up monitoring committee to evaluate the progress of the program, identify new target communities and publicize program results	1. Dec 2013: Detailed plan for launching and managing "Thermalize MA" program 2. Mar 2014: Procurement and installation contracts developed 3. Jun 2014: "Thermalize MA" program launched 4. Mar 2015: 1 year program evaluation

6.3.2 Develop comprehensive, online database with technology case studies and performance metrics

Table 6-17: Strategy #9 Summary

Cluster Area	Time	Responsibilities
Marketing	**Start:** Dec 2013 **End:** Aug 2014 (ongoing updates)	**Proposed Lead Organization**: DOER **Additional Participants**: BTEC, SEIA, NEGPA, IGSHPA, Mitsubishi, MassCEC

Objective: Improve consumer confidence in renewable thermal technology applications and performance

Background: Because many traditional HVAC installers and building owners are unfamiliar with RT technologies, they typically express skepticism regarding the operational success of RT. Providing access to case studies and state-sanctioned performance data can assist customers gain greater confidence in RT technologies.

Pathway: DOER, MassCEC, and trade groups should collect and analyze performance data of renewable thermal systems, making it publicly available to consumers, HVAC contractors, plumbers, architects, and other trades. State agencies can assist in streamlining an effective technology evaluation process (such as certification, qualification, etc.), potentially on a regional or national basis. Performance data should be accompanied by case studies, describing applications, costs, maintenance requirements, and customer experiences. Data should be accessible via mobile devices to facilitate sales by contractors with potential customers.

Table 6-18: Strategy #9 Implementation Steps

Steps	Deliverable/Milestone
1. Identify funding/resources from government and industry sources to sponsor project 2. Collect available performance data for renewable thermal systems (from MassCEC, DOER, and industry leaders) 3. Hire 3rd party vendor to aggregate data, create case studies, and develop online presence 4. Market results to consumers/trades (see strategy #3) 5. Manage and update online platform on quarterly basis	1. Dec 2013: Identify funding and resources 2. Dec 2013: Complete collection of sample data 3. Jan 2014: Issue RFP for services and select 3rd party vendor (by March) 4. Aug 2014: Launch online platform 5. Ongoing: platform updates

6.3.3 Provide data to assist developers and installers identify "high value" renewable thermal customers

Table 6-19: Strategy #10 Summary

Cluster Area	Time	Responsibilities
Marketing	**Start:** Feb 2014 **End:** Aug 2014 (periodic updates)	**Proposed Lead Organization**: MassCEC **Additional Participants:** DOER, MassDEP, MassGIS, DCAMM

Objective: Assist project developers to identify "high value" customers that are likely to adopt renewable thermal technologies

Background: Project developers report significant challenges in identifying "high-value" customers, or those likely to adopt renewable thermal technologies. This is a particular challenge for biomass thermal customers in new regions where a so-called 'hub and spoke' distribution model for pellet/chip distribution has not yet been established. Recent studies of renewable energy technologies indicate that customer acquisition costs are a significant cost center for businesses. High-value customers vary based upon technology requirements, though they generally include customers that face high heating costs and do not have easy access to natural gas. This may be, in many ways, considered training for project developers.

Pathway: MassCEC should develop GIS tools to help stakeholders (communities, developers, building owners, etc.) identify opportunities for renewable thermal installations. For each renewable thermal technology, the GIS tool should screen buildings for key technical and development requirements, including accessibility of natural gas, distance to fuel producers (for biomass chips/pellets), and space requirements, among others. Tool outputs should include estimates of project size, energy production, and cost-effectiveness.

Table 6-20: Strategy #10 Implementation Steps

Steps	Deliverable/Milestone
1. Identify funding/resources from government and industry sources to sponsor project 2. Hire 3rd party vendor to aggregate data, develop methodology, and create tool 3. Integrate tool into Thermalize program (see strategy #8), training programs (see strategy #15 and #18), and information campaigns (see strategy #3)	1. Feb 2014: issue RFP for services 2. Apr 2014: select 3rd party vendor 3. Aug 2014: launch online GIS tool

6.3.4 Create tool that helps customers self-screen for suitability of RT technologies

Table 6-21: Strategy #11 Summary

Cluster Area	Time	Responsibilities
Marketing	**Start:** Dec 2013 **End:** Jul 2014 (ongoing updates)	**Proposed Lead Organization:** DOER **Additional Participants:** MassCEC

Objective: Reduce acquisition costs through self-screening and help connect consumers and contractors

Background: Customers lack knowledge about renewable heating technologies, and thus selecting the appropriate technology is hard. Solar PV sites such as Geostellar provide recommendations to customers for solar PV systems based on their building characteristics. A similar process or questionnaire could be developed to match renewable heating technologies.

Pathway: The DOER could develop a questionnaire with basic questions tailored to major end-user categories (residential, commercial, industrial). Based on answers, customers could be directed to appropriate renewable heating and cooling resources, and information on local installers and rebates.

Table 6-22: Strategy #11 Implementation Steps

Steps	Deliverable/Milestone
1. Collaborate with stakeholders and industry experts to develop framework for screening tool and identify key inputs, outputs and underlying algorithm 2. Contract software developer or university to build web-based, publically available software tool enabling simple self-screening of RT technologies 3. Share beta copy of tool with stakeholders and refine based on feedback 4. Validate program, and release to public 5. Support and promote screening tool with public awareness campaigns (see strategy #3) and establish a monitoring team to continually update and validate the tool as new technologies arise.	1. Dec 2013: Tool framework 2. Jan 2014: Software development contract awarded 3. Mar 2014: Beta copy distributed to stakeholders 4. Jul 2014: Validated tool released to public 5. Ongoing: Tool support and promotion

6.3.5 Support technology exchanges with "state-of-the-art" manufacturers

Table 6-23: Strategy #12 Summary

Cluster Area	Time	Responsibilities
Innovation	**Start:** Jan 2014 **End:** Jul 2014 (ongoing support)	**Proposed Lead Organization**: MassCEC and trade groups **Additional Participants**: DOER, MassDEP, international partners, Barr Foundation, MA Office of International Trade and Investment (MOITI)

Objective: Increase customer access to state-of-the-art, high efficiency, and low-emissions renewable thermal systems

Background: Due to large home markets and tighter emission and efficiency regulations, many European and Asian manufacturers can provide high efficiency, low-emission and cost-effective renewable thermal systems to U.S. customers. A number of foreign manufacturers are already distributing products in Massachusetts and across New England. This includes high efficiency, low emission biomass heating systems, or solar cooling systems, as well as high efficiency heat pumps. Upper Austria has proven the benefit of a cluster development approach (Oekoenergie cluster) to drive innovation; Massachusetts can leverage this expertise and help build a new innovation cluster (see section 4).

Pathway: Encourage exchanges and partnerships between regional U.S. installers and European and Asian manufacturers in order to increase customer access to state-of-the-art systems. If the process is well guided, these exchanges can also drive innovation and economic growth in Massachusetts through partnerships between local and international manufacturers. Ensure that codes do not restrict importing of more state-of-the-art technology.

Table 6-24: Strategy #12 Implementation Steps

Steps	Deliverable/Milestone
1. Develop special incentive category to encourage use of high efficiency, low emission systems and announce renewable thermal goals (see strategy #1) 2. Identify European/Asian manufacturers interested in the U.S. market and regional U.S. installers/developers interested in offering European/Asian products 3. Provide introductions, develop events, and launch international exchange program to encourage collaboration 4. Provide technical assistance to help developers and manufacturers integrate European/Asian products into the Massachusetts market	1. Jan 2014: Establish special incentives and announce renewable thermal goals (see strategy #1) 2. Mar 2014: develop technical assistance program for international manufacturers 3. Jul 2014: Launch international exchange program 4. Ongoing: technical assistance

6.3.6 Create Renewable Thermal Industry Advisory Forum

Table 6-25: Strategy #13 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Jan 2014 **End:** Ongoing	**Proposed Lead Organization**: DOER **Additional Participants**: MassCEC, trade groups, MassDEP, CLF, international partners

Objective: Address common needs and coordinate actions across technology sectors to drive comprehensive renewable thermal market growth

Background: Similar to the support structure that trade associations can provide to a single industry, the RT industry as a whole needs joint support. While some issues and challenges are best addressed by one individual industry, many challenges that the RT sectors face are shared, and can be most effectively addressed in a joint fashion. The development of a RT stakeholder advisory group affords opportunity to address ongoing issues, including governance, marketing, workforce development, and other concerns.

Pathway: The forum should address challenges shared across renewable thermal sectors. It should assist stakeholders identify common priorities, develop working groups, and implement projects that support industry growth.

Table 6-26: Strategy #13 Implementation Steps

Steps	Deliverable/Milestone
1. Identify funding/resources and stakeholders from government, industry, and non-profits to sponsor the initiative 2. Identify common priorities and develop renewable thermal working groups 3. Implement projects/initiatives to address priorities	1. Jan 2014: identify industry and government funding to support the forum 2. Mar 2014: host kick-off meeting with key stakeholders; host monthly meetings thereafter 3. Apr 2014: identify/develop working groups to address key priorities 4. Jul 2014: launch projects to address priorities (e.g. international exchanges, see recommendation #12)

6.3.7 Review market enabling guidance regarding fuel choices and associated GHG emissions

Table 6-27: Strategy #14 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Dec 2013 **End:** Apr 2014	**Proposed Lead Organization:** DOER **Additional Participants:** DPU, EEAC, Utility PAs

Objective: Determine pathways to support fuel neutral incentives for customers who want to purchase RT equipment

Background: Energy efficiency rebates and financing from MassSave are not available to customers who would be switching thermal fuel sources by buying the incentivized equipment, also known as "fuel switching". This limits important opportunities for implementing energy efficiency as well as renewable heating and cooling technologies for Massachusetts customers, especially those using oil or propane. Potential biomass customers are among the most inhibited since biomass thermal inherently requires fuel switching.

Pathway: DOER should review its guidelines on fuel neutrality with regards to RT technology programs. Included in the review should be an evaluation of minimum required efficiencies for RT equipment for those consumers who switch fuels by upgrading to RT. The required efficiency should ensure that the switch in fuel has a net improvement in primary (source) fuel consumption and associated GHG emissions. Challenges to address include both incentive funding (see strategy #2) and marketing/communication funding (see strategy #3).

Table 6-28: Strategy #14 Implementation Steps

Steps	Deliverable/Milestone
1. Conduct outreach to key stakeholders (e.g., utilities, DPU) to identify key barriers for each RT technology. For each distinct barrier, evaluate potential impacts (GHG emissions, RT penetration, etc.) of alleviating the barrier. 2. Evaluate minimum efficiencies for each RT technology to ensure net benefit in GHG emissions for each switch (e.g., gas to electric, electric to biomass, etc.). 3. Determine pathways to alleviating key barriers that include minimum efficiency requirements. For example, identification of alternative funding sources for select fuel switching customers. 4. Implement fuel neutral financing mechanisms that address the key barriers first. Monitor effectiveness and update policies over time.	1. Dec 2013: Comprehensive understanding of barriers 2. Jan 2014: Min efficiency specs for all RT tech (e.g. matrix format) 3. April 2014: Recommendations for next steps in policy/funding 4. 2015 program year or sooner if possible: ongoing monitoring

6.3.8 Institute technical and sales training programs

Table 6-29: Strategy #15 Summary

Cluster Area	Time	Responsibilities
Labor and Standards	Start: Dec 2013 End: Ongoing	**Proposed Lead Organization:** MassCEC or Trade Groups **Additional Participants:** Manufacturers, trade associations, independent training and certification organizations, community colleges, vocational schools

Objective: Boost RT industry expertise with a particular focus on installers and on the point of transaction

Background: Installer training programs in RT are fragmented and are insufficient to be able to support accelerated RT industry growth. (See discussion of market saturation time in section 2.2.1, above.) As discussed in section 3.3, above, the modeling results highlight the need for such training in order to reduce market and technology risk. GSHP training programs have historically been difficult because there is no clear leading trade association responsible for training; GSHPA and NEGPA have helped to fill that gap. For ASHP, a number of manufacturers provide training, and in some cases, it is required for the installer to be able to offer an extended warranty (this represented the most established program due to the well-established nature of ASHP manufacturers).. The biomass industry lacks key funds to be able to invest in large-scale training programs. More outreach is needed to understand from biomass industry trade groups how the state can assist developing training programs. Further, the industry needs to educate architects, developers, energy auditors, installation contractors, and other key building players on RT technologies in order to increase awareness and options.

Pathway: Support training on RT technologies for two constituencies:

A) Technical designers & installers – technical design/installation skills to ensure reliable, efficient, and as-expected operation. As appropriate, tie-in with installer certification and inspector training.
B) RT salespeople, architects, developers, auditors, appraisers – boost business development expertise for salespeople and other industry players who may impact brand perceptions, costs, and marketability.

Coordinate with manufacturer-based installer trainings and trade association trainings; develop additional training avenues in areas where such training support is lacking or nonexistent.

Table 6-30: Strategy #15 Implementation Steps

Steps	Deliverable/Milestone
1. Reach out to manufacturers, trade organizations, and other independent training organizations to determine scope of existing programs 2. Identify target RT audiences and associated needs (key training objectives) 3. Determine need for new programs or if existing programs can be expanded 4. Bring in instructors, develop course/seminar content, identify optimal format 5. Initiate training programs and update/refine programs to ensure high quality, appropriate content and impact	1. Dec 2013: Understanding of existing training landscape 2. Jan 2014: Complete characterization of training needs and objectives 3. Jun 2014: Complete training materials and plan 4. Jan 2015 and ongoing: Training begins and updated periodically

6.3.9 Engage heating oil and propane industry to explore RT business opportunities

Table 6-31: Strategy #16 Summary

Cluster Area	Time	Responsibilities
Resources and Logistics	**Start:** Dec 2013 **End:** Fall 2014	**Proposed Lead Organization:** DOER **Additional Participants:** MEMA, PGANE, Interested companies, New England Fuel Institute (NEFI)

Objective: Leverage the energy experience and skilled labor force in the oil heat and propane industry to help develop the RT industry.

Background: Previously, the state has had some success in working with oil heat companies (e.g., Sandri) to integrate SHW and biomass thermal into their product offerings. In Vermont, some oil companies have integrated heat pumps into their product portfolios. Oil heat distributors and installers represent key sectors in the Commonwealth and could play an important role in supporting RT market growth. RT can also represent an important new market opportunity for oil heat businesses. Installers of oil heating equipment have a substantial knowledge of HVAC equipment, building systems, the supply chain for fuel distribution, as well as an established customer base. Oil dealers have expressed an interest in supporting blending biofuels with heating oil.

Pathway: Evaluate potential for future collaboration with propane and oil heat distribution companies as an avenue for increasing biomass installation and fuel distribution infrastructure. Investigate opportunities, challenges, and needs of oil heat companies interested in expanding product offerings to include renewable thermal. Key starting points may include focused dialogue, market opportunity analyses, as well as incentives (grants) to support purchase of biomass fuel distribution trucks and other infrastructure.

Table 6-32: Strategy #16 Implementation Steps

Steps	Deliverable/Milestone
1. Engage with key players in the oil and propane distribution and equipment industries to gauge interest in RT technologies and explore key pathways. 2. Develop a plan for oil heat and propane industry participation, including identification of key partners for marketing, education/training, etc. 3. In parallel, leverage existing marketing channels (see Strategy #3) to promote RT technologies and support training (see Strategy #15). 4. Expand participation beyond key partners to encourage participation by a broader portion of the industry	1. Dec 2013: Knowledge of viability and pathways for oil/propane-industry participation 2. Mar 2014: Complete RT plan for oil/propane industry 3. Jun 2014: Active oil-heat/propane industry participation in training & marketing 4. Fall 2014: Increased participation from other industry players

6.3.10 Integrate renewable thermal into energy protection and assistance programs for low-income families

Table 6-33: Strategy #17 Summary

Cluster Area	Time	Responsibilities
Governance	**Start:** Jan 2014 **End:** Sept 2015	**Proposed Lead Organization**: DOER **Additional Participants**: LIHEAP program, Good Neighbor Energy Fund, Local Emergency Fuel Assistance Program, Citizens Energy Heat Assistance Program, LEAN, Dept. of Housing and Community Dev. (DHCD)

Objective: Provide energy protection and assistance for low-income consumers using non-regulated heating fuels like biodiesel or biomass chips and pellets.

Background: Regulated fuels, like electricity and gas, cannot be cut off in times of need and do not require action on the part of the consumer to bring them into the home. Unregulated fuels, such as heating oil, can be cut off during the heating season if families cannot afford to pay for fuel delivery.

Accelerating the market for renewable thermal conversions necessitates taking into account how this may affect low-income family's fuel certainty. This will depend on the fuel displaced and the RT technologies utilized. Some technologies may enhance fuel certainty, whereas others may introduce different fuel risks. For example, heat pumps use electricity for heating, which comes with the protection of that regulated fuel. A family converting from oil to heat pumps should see their energy protection increase. Adding solar hot water to supplement existing heating systems will reduce the amount of oil that families would have to buy, but would not change the risk of supply disruption. Finally, families that convert to biomass would shift from oil supply risk or the protection of electric heating to risks related to wood delivery. Since RT technology programs would be designed to generate savings, however, families that adopt RT technologies would be more able to pay for their fuel supply overall, thereby decreasing their fuel risk.

Pathway: DOER should work with existing energy protection and assistance programs in order to include unregulated renewable thermal technologies and fuels. This may include working with LIHEAP, the Good Neighbor Energy Fund, the Local Emergency Fuel Assistance, or Citizens Energy Heat Assistance Programs to allocate funding to support customers using renewable thermal technologies.

Table 6-34: Strategy #17 Implementation Steps

Steps	Deliverable/Milestone
1. Identify and reach out to energy protection and assistance funding program managers in Massachusetts 2. Analyze barriers and opportunities for extending these programs to include renewable heating and cooling technologies and fuels 3. Create recommendations and pathways for extending programs to renewable thermal technologies 4. Implement pilot programs 5. Evaluate program results and expand pilot programs	1. Jan 2014: reach out to energy protection and assistance program managers 2. May 2014: analyze barriers and opportunities and develop recommendations 3. Sept 2014: implement recommendations and run pilot programs 4. May 2015: evaluate results of pilot programs 5. Sept 2015: expand pilot programs

6.3.11 Integrate RT and EE into community college and vocational school curricula

Table 6-35: Strategy #18 Summary

Cluster Area	Time	Responsibilities
Labor and Standards	**Start:** Dec 2013 **End:** Sept 2014	**Proposed Lead Organization:** Trade associations or DOER **Additional Participants:** DOER, manufacturers, independent training and certification organizations, community colleges, vocational schools,

Objective: Support long-term industry development through training college and vocational school students in energy efficient and renewable technologies

Background: While training of existing contractors and installers is the top priority, training for students is important for long-term development of the industry. Such a program can tie into the "Clean Heat 101" program. There may be natural connection for such an effort in coordination with the “Pathways Out of Poverty Program” that provides grant funding for job training programs for low-income individuals in the clean energy sector. The State already has other efforts underway in this area that could be leveraged. For example, in 2009, MassCEC awarded 6 grants for development of training programs for high school students, college students, educators, and workforce professionals. These grants resulted in development of more than 30 lesson plans, certificates and training programs.[37]
Pathway: Support organizations that develop curricula specifically for energy efficiency and renewable heating and cooling technologies. Develop relationships with community colleges and vocational schools to identify optimal approaches for integration of RT curricula. Conduct ongoing updates and refinements to programs to ensure content covers state-of-the-art and most comprehensively prepares graduates for a variety of career paths in RT technology.

Table 6-36: Strategy #18 Implementation Steps

Steps	Deliverable/Milestone
1. Identify candidate schools that are well positioned for new curricula in sustainable energy technologies 2. Support development of new curricula and training programs in energy efficiency techniques and renewable heating and cooling technologies 3. Help schools setup partnerships with renewable energy industry groups, manufactures, and installers to encourage employment of these students in the industry	1. Dec 2013: Candidate schools identified 2. May 2014: Initiate development of new curricula 3. Sept 2014: Industry partnerships established

[37] MassCEC Clean Energy Workforce Training Capacity Building Curricula, information available: www.masscec.com/content/clean-energy-workforce-training-capacity-building-curricula

Appendix A MA Market Segment Data

Table A-1 and Table A-2 lists the relevant CBECS and RECS data used in this analysis for each of 16 defined market segments.[38, 39] RECS data was available specifically for MA; however, CBECS data were available only for New England as a whole. The team scaled the CBECS data for New England based on the population of Massachusetts relative to the population of New England.[40]

Table A-1: Massachusetts Building Stock Data by Market Segment – Residential Buildings

Market Segment Attributes			Annual Market Segment Data			
Building Sector	Thermal Fuel	Income Level / Bldg Size	Households[A]	Avg. Primary Thermal Energy Use (MMBtu/Bldg)	Total Primary Thermal Energy Use (MMBtu)	% of Total MA Primary Thermal Energy Use per year
Residential	Electricity	Low-Income	185,356	58	10,763,001	2.5%
		High-Income	71,286	76	5,442,778	1.3%
	Fuel Oil	Low-Income	375,134	91	34,197,607	7.9%
		High-Income	389,531	116	45,224,862	10.4%
	Propane	Low-Income	50,536	49	2,482,183	0.6%
		High-Income	10,513	75	786,601	0.2%
	Natural Gas	Low-Income	793,852	84	66,941,600	15.5%
		High-Income	543,354	101	54,873,900	12.6%
		Total:	**2,419,562**	**N/A**	**220,712,532**	**51%**

Note A: Massachusetts residential households are split roughly 50/50 between single family homes and apartments in multi-family buildings (RECS).

[38] U.S. Energy Information Administration, Residential Energy Consumption Survey (RECS), Available at: www.eia.gov/consumption/residential/

[39] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey (CBECS), Available at: www.eia.gov/consumption/commercial/

[40] Rhode Island Department of Labor and Training, Labor Market Information, Available at: www.dlt.ri.gov/lmi/census/pop/neweng.htm

Table A-2: Massachusetts Building Stock Data by Market Segment – Commercial Buildings

Market Segment Attributes			Annual Market Segment Data			
Building Sector	Thermal Fuel	Income Level / Bldg. Size	Number of Comm Buildings	Avg. Primary Thermal Energy Use (MMBtu/Bldg)	Total Primary Thermal Energy Use (MMBtu)	% of Total MA Primary Thermal Energy Use per year
Commercial	Electricity	Small Bldg.	17,867	333	5,945,377	1.4%
		Large Bldg.	5,287	6,342	33,531,201	7.7%
	Fuel Oil	Small Bldg.	46,264	471	21,798,230	5.0%
		Large Bldg.	6,128	8,102	49,651,083	11.5%
	Propane	Small Bldg.	2,469	233	574,480	0.1%
		Large Bldg.	2,166	6,557	14,205,789	3.3%
	Natural Gas	Small Bldg.	26,709	421	11,248,553	2.6%
		Large Bldg.	6,775	11,127	75,389,400	17.4%
		Total:	**113,665**	**N/A**	**212,344,113**	**49%**

Appendix B MA Customer Classes

Table B-1 lists all of the 54 customer classes characterized as part of the CARTS modeling process.

Table B-1: List of All 54 Customer Classes

Offsetting Fuel	Building Sector	Income Level / Bldg. Size	Target RT Tech
Electricity	Commercial	Large	ccASHP
Electricity	Commercial	Large	BMCH
Electricity	Commercial	Large	BMP
Electricity	Commercial	Large	GSHP
Electricity	Commercial	Large	ST
Electricity	Commercial	Small	ccASHP
Electricity	Commercial	Small	BMP
Electricity	Commercial	Small	GSHP
Electricity	Commercial	Small	ST
Electricity	Residential	High	ccASHP
Electricity	Residential	High	BMP
Electricity	Residential	High	GSHP
Electricity	Residential	High	ST
Electricity	Residential	Low	ccASHP
Electricity	Residential	Low	BMP
Electricity	Residential	Low	GSHP
Electricity	Residential	Low	ST
Fuel Oil	Commercial	Large	ccASHP
Fuel Oil	Commercial	Large	BMCH
Fuel Oil	Commercial	Large	BMP
Fuel Oil	Commercial	Large	GSHP
Fuel Oil	Commercial	Large	ST
Fuel Oil	Commercial	Small	ccASHP
Fuel Oil	Commercial	Small	BMP
Fuel Oil	Commercial	Small	GSHP
Fuel Oil	Commercial	Small	ST
Fuel Oil	Residential	High	ccASHP
Fuel Oil	Residential	High	BMP
Fuel Oil	Residential	High	GSHP
Fuel Oil	Residential	High	ST
Fuel Oil	Residential	Low	ccASHP
Fuel Oil	Residential	Low	BMP
Fuel Oil	Residential	Low	GSHP
Fuel Oil	Residential	Low	ST
LPG	Commercial	Large	ccASHP
LPG	Commercial	Large	BMP
LPG	Commercial	Large	GSHP
LPG	Commercial	Large	ST
LPG	Commercial	Small	ccASHP
LPG	Commercial	Small	BMP
LPG	Commercial	Small	GSHP
LPG	Commercial	Small	ST
LPG	Residential	High	ccASHP
LPG	Residential	High	BMP
LPG	Residential	High	GSHP
LPG	Residential	High	ST
LPG	Residential	Low	ccASHP
LPG	Residential	Low	BMP
LPG	Residential	Low	GSHP
LPG	Residential	Low	ST
Nat. Gas	Commercial	Large	ccASHP
Nat. Gas	Commercial	Large	GSHP
Nat. Gas	Commercial	Small	ccASHP
Nat. Gas	Commercial	Small	GSHP

Appendix C Technology Assumptions

Table C-1: Cost and Efficiency Assumptions[41]

Technology	Sector	Total Installed Cost (Heating and DHW)	Installed Cost (Cooling)	Efficiency	Fuel Btu Content	Fuel Cost	Fuel cost Escalator
Natural Gas	Residential	$10,275	$6,000	85% (heating) COP = 2.5 (cool)	1 MMBtu/Mcf	$13.83 per Mcf	0.97%
	Commercial	$44,000	$116,000 (heating & cooling)	85% (heating) COP = 2.5 (cool)	1 MMBtu/Mcf	$11.07 per Mcf	0.97%
Electric	Residential	$10,275	$6,000	99% (heating) COP = 2.5 (cool)	0.0034 MMBtu/kWh	$0.155 per kWh	3%
	Commercial	$44,000	$116,000 (heating & cooling)	99% (heating) COP = 2.5 (cool)	0.0034 MMBtu/kWh	$0.145 per kWh	3%
Fuel Oil	Residential	$10,275	$6,000	85% (heating) COP = 2.5 (cool)	0.1387 MMBtu/Gal	$3.94 per Gal	3.22%
	Commercial	$44,000	$116,000 (heating & cooling)	85% (heating) COP = 2.5 (cool)	0.1387 MMBtu/Gal	$3.55 per Gal	3.22%
Solar Thermal	Residential	$31,600	N/A	5,400% (accounts for pump electricity)	0.0034 MMBtu/kWh	$0.155 per kWh	3%
	Commercial	$202,200	N/A	6,800% (accounts for pump electricity)	0.0034 MMBtu/kWh	$0.145 per kWh	3%
GSHP	Residential	$27,724	Included in heating cost	COP = 4	0.0034 MMBtu/kWh	$0.155 per kWh	3%
	Commercial	$213,758	Included in heating cost	COP = 4	0.0034 MMBtu/kWh	$0.145 per kWh	3%

[41] Unless noted otherwise, all assumptions in table based on data provided by MCG from the "Heating and Cooling in the Massachusetts Alternative Portfolio Standard", Massachusetts Department of Energy Resources, with assistance from Massachusetts Clean energy Center and Meister Consultants Group, December 2012, Available at: www.mass.gov/eea/docs/doer/pub-info/heating-and-cooling-in-aps.pdf

Technology	Sector	Total Installed Cost (Heating and DHW)	Installed Cost (Cooling)	Efficiency	Fuel Btu Content	Fuel Cost	Fuel cost Escalator
ASHP	Residential	$21,255	Included in heating cost	COP = 3	0.0034 MMBtu/kWh	$0.155 per kWh	3%
	Commercial	$158,595	Included in heating cost	COP = 3	0.0034 MMBtu/kWh	$0.145 per kWh	3%
Biomass (Pellets)	Residential	$20,800	N/A	80%	16.4 MMBtu/Ton	$220 per Ton	3.22%
	Commercial	$54,450	N/A	80%	16.4 MMBtu/Ton	$220 per Ton	3.22%
Biomass (Chips)	Commercial	$120,000	N/A	75%	9.6 MMBtu/Ton[42]	$40 per Ton	3.22%

Table C-2: Installed Costs for RT Technologies[43]

	Baseline Equipment Installed Cost		Incremental Installed Cost by RT Technology vs. Baseline Equipment				
	Heating Equip	Cooling Equip	Biomass Pellets	Biomass Chips	ccASHP	GSHP	Solar Thermal
Residential	$10,275	$6,000	$10,525	N/A	$4,980	$11,449	$27,732
Commercial	$44,000	$116,000 (heating & cooling)	$10,450	$76,000	$42,595	$97,758	$184,481

[42] Heat content of biomass chips taken from the Biomass Energy Resource Center Wood –Chip Heating Systems Guide. Available at: www.biomasscenter.org/pdfs/Wood-Chip-Heating-Guide.pdf

[43] All assumptions in table based on data provided by MCG from the "Heating and Cooling in the Massachusetts Alternative Portfolio Standard", Massachusetts Department of Energy Resources, with assistance from Massachusetts Clean energy Center and Meister Consultants Group, December 2012, Available at: www.mass.gov/eea/docs/doer/pub-info/heating-and-cooling-in-aps.pdf

Table C-3: GHG Emissions Reduction Factors[44, 45]

Offsetting Fuel	GHG Emissions Reduction Factors (Tons CO_2e/MMBtu)			
	Biomass	ccASHP	GSHP	Solar Thermal
Electric (Heating)	**0.169**	**0.153**	**0.172**	**0.225**
Electric (Cooling)	**N/A**	**0.015**	**0.034**	**N/A**
Fuel Oil (Heating)	**0.067**	**0.050**	**0.069**	**0.122**
Natural Gas (Heating)	**0.034**	**0.018**	**0.037**	**0.090**

[44] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

[45] "Heating and Cooling in the Massachusetts Alternative Portfolio Standard", Massachusetts Department of Energy Resources, with assistance from Massachusetts Clean energy Center and Meister Consultants Group, December 2012, Available at: www.mass.gov/eea/docs/doer/pub-info/heating-and-cooling-in-aps.pdf

Appendix D Existing RT Support Programs and Activities

Table D-1, Table D-2, and Table D-3 list the existing incentive programs and grant activities that are relevant for Massachusetts's homes and businesses. Additionally the DOER and MassCEC are running pilot programs for biomass, heat pump and district heating installations in residential and commercial buildings. While significant in volume, they are not listed here as they are limited in time.

Table D-1: Existing Federal Financing Programs and Incentives

Program/Incentive	RT Technologies	Notes
REAP Loan Guarantees	Solar, Biomass, GSHP	(Non-residential)
DOE Loan Guarantees	Solar, Biomass, GSHP	
Qualified Energy Conservation Bonds (QECB)	Solar, Biomass, GSHP, Biogas	
Energy Efficient Residential Mortgages (FHA)	Solar	
Residential Renewable Energy Tax Credit	Solar, GSHP	30% (Residential)
Business Energy Investment Tax Credit (ITC)	Solar, GSHP	10% GSHP, 30% ST (Non-residential)

Table D-2: Existing Massachusetts Residential Programs and Other Activities

Program/Incentive	RT Technologies	Notes
Renewable Energy Equipment Sales Tax Exemption	Solar, GSHP	100% Exemption
Personal Tax Credit	Solar	15% or $1,000 Max
Commonwealth Solar Hot Water Rebate	Solar	25% or $3,500 Max
Renewable Energy Property Tax Exemption	Solar	100% for 20 years
Mass Save HEAT loan	Solar, ASHP, GSHP	0% interest loan
Mass Save rebate	ASHP	Up to $500

Table D-3: Existing Massachusetts Non-Residential Programs and Other Activities

Program/Incentive	RT Technologies	Notes
Excise Tax Deduction	Solar	100% Deduction
Commonwealth Organics-to-Energy Program	Biomass	
Renewable Energy Property Tax Exemption	Solar	100% for 20 years
Commonwealth Solar Hot Water Commercial Program	Solar	

Appendix E Modeling Scenario Details

Table E-1: BAU Scenario Details

	Program Title	Residential	Commercial
State	Renewable Energy Income Tax Credit (15% or $1,000 Max)	ST	
State	Commonwealth Solar Hot Water Rebate Program (25% or $3,500 Max)	ST	
State	Mass Save Rebate ($500)	ccASHP	
State	Commonwealth Solar Hot Water Rebate Program (25% or $50,000 Max)	ST	ST
Federal	Residential Renewable Energy Tax Credit (30%)	GSHP, ST	
Federal	Business Energy Investment Tax Credit (ITC) (10% GSHP, 30% ST)		GSHP, ST

Table E-2: High State Support Scenario Details

	Program Title	Residential	Commercial
State	All BAU Incentives		
State	Additional RT Rebate (25% of installed cost) for top priority customer classes	All	All
State	RT Market Development Activities (targeted at reducing RT market saturation time from 20 years to 10 years)	All	All
Federal	All BAU Incentives (assuming federal incentives are extended through 2030)		

Table E-3: Accelerated NG Expansion & HSS Scenario Details

Program Title	Residential	Commercial
All HSS Incentives and Market Development Activities	All	All
Accelerated NG Market Growth (estimated based on historical NG distribution data provided by DOER)		

Table E-4: Cusp-Customer Targeting & BAU Scenario Details

Program Title	Residential	Commercial
All BAU Incentives	All	All
Reduced NG Market Growth (estimated based on approximate size of NG cusp-customer base and historical NG distribution data provided by DOER)		

Appendix F CARTS Stakeholder Contributors

Table F-1: Stakeholder Advisory Group Members

Name	Organization
Carrie Hitt	Solar Energy Industries Association (SEIA)
Charlie Niebling	Biomass Thermal Energy Council
Chris Beebe	BEAM Engineering
Chris Williams	Heat Spring
Darien Crimmin	Winn Development
David Lis	NEEP
David O'Conner	ML Strategies / Renewable Thermal Coalition
Joe Cefaly	Mitsubishi
John Wells	ABCD and Low-Income Energy Affordability Network (LEAN)
Katherine Stainken	Solar Energy Industries Association (SEIA)
Kathleen Arthur	NStar
Lisa Barrett	Conservation Services Group
Mike Hogan	Paradigm Partners
Sue Reid	Conservation Law Foundation

Appendix G Renewable Thermal Impact Analysis Methodology

In the final task of the customer class analysis, the team conducted economic and environmental impact analyses to determine how growth of the renewable thermal market would impact consumers, utilities, the environment, state government revenues, and the state's economy. The methodology for each of these analyses is described in greater detail in sections G.1 through G.3 below.

G.1 GHG Emissions Impact

In 2010, Massachusetts identified GHG emissions reductions goals in the *Massachusetts Clean Energy and Climate Plan for 2020*. The primary goal is to reduce the GHG emissions in the commonwealth by 25% percent below the 1990 emissions level by 2020. Within this goal, Massachusetts has set two sub targets related to renewable thermal technologies. These include: (1) Renewable thermal technologies should account for a 2% reduction in GHG emissions below the 1990 emissions level, and (2) Solar thermal systems should contribute a 0.1% reduction in GHG emissions below the 1990 level.[46] The team modeled the impact of renewable thermal market growth on reducing GHG emissions in the commonwealth, under all four scenarios and compared the results to these targets.

Figure G-1 below outlines the process used to calculate GHG emissions reductions estimates for each customer class. These estimates were based on annual energy consumption, offsetting fuel type, and GHG emissions reduction factors for each technology (in terms of tons of CO_2e/MMBtu). The GHG emissions reduction factors represent the difference between the expected GHG emissions of the renewable system and the GHG emissions of the fossil fuel system being replaced. GHG emissions factors were adopted from Meister Consultants Group's (MCG) previous work on the subject.[47] For the heat pumps and solar thermal systems, these factors were strictly based on GHG emitted, however for biomass systems, GHG emissions factors also had to take into account the carbon sequestered by sustainably managed forests, as described by MCG:

> "GHG reductions from biomass pellet heating systems are calculated by estimating GHG emissions avoided from fossil fuel systems. Emission reduction estimates for biomass heating are based on the Manomet study and ongoing regulatory development by DOER, which take into account the carbon debt and dividends of various biomass feedstock"[47]

The team used market penetration estimates for each customer class and scenario to determine the achievable market size for renewable technologies, by year. Then the team estimated the total thermal energy consumption of each customer class. Finally, approximate GHG emissions reductions were

[46] "Massachusetts Clean Energy and Climate Plan for 2020", December 2010, Available at: www.mass.gov/eea/docs/eea/energy/2020-clean-energy-plan.pdf

[47] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf - the Manomet study referred to in the quote is the "2010 Manomet Study of Woody Biomass Energy", Manomet Center for Conservation Sciences, 2010

calculated for each customer class (in terms of tons of CO_2e) by multiplying the thermal consumption of each class by the appropriate GHG emissions reduction factors introduced above.

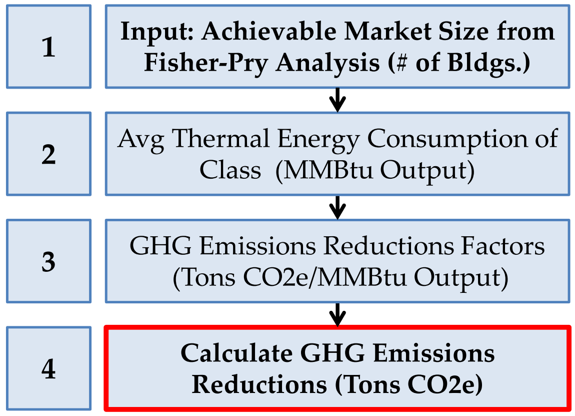

Figure G-1: GHG Emissions Reduction Analysis Process

The team compared the GHG emissions reduction projections to the GHG emissions goals set by the state by examining the GHG emissions reduction estimates as a percentage of the 1990 GHG emissions levels in the state and comparing these estimates to the 2020 targets. This data was used to aid the team in selecting priority customer classes and developing appropriate strategies to help Massachusetts reach these goals. Section 3.2.3 documents the results of this analysis.

G.2 Fossil Fuel Demand Impact

The team estimated the impact of renewable thermal technologies on the demand for fossil fuels for heating and cooling purposes using the methodology shown in Figure G-2. The results of the market penetration analysis were used to determine the achievable market size for each customer class, by year. Then the team estimated both the current and future fossil fuel consumption (in terms of MMBtu of primary thermal energy) for each customer class. The team was able to determine the relative % change in demand for fossil fuels for heating and cooling as a result of growth of the renewable thermal market by comparing the projected consumption of fossil fuel in years 2015, 2020, and 2030, to the estimated consumption today.

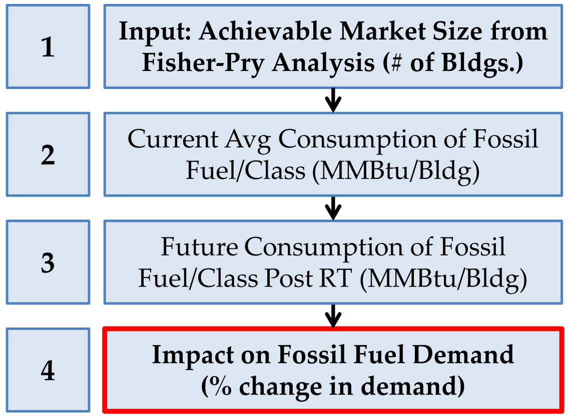

Figure G-2: Fossil Fuel Demand Impact Analysis Process

The team also accounted for fuel switching from one fossil fuel to another to ensure the analysis reflects the net impact on utilities as a result of renewable thermal market growth. For example, customers that switch from fuel oil heating to air-source heat pumps reduce the statewide demand for fuel oil, but increase the demand for electricity (used to drive the heat pump).

G.3 Jobs Impact

The team quantified the effect of a change in demand of renewable thermal energy technologies on employment in Massachusetts. The metric used to quantify industry employment was the Full-Time Equivalent (FTE), which corresponds to the number of equivalent full-time jobs created or sustained in one year from new system installations and system maintenance. This metric captures both full time and part time jobs, as well as temporary and permanent positions.

The jobs accounted for in this job impact analysis include:

- **Direct jobs**, which are created from the sale, engineering, installation, operation and maintenance of the technology. For example, an installation construction job is considered a direct job.
- **Indirect jobs**, which are created collaterally or as a result of capital invested in deployment and operation of the technology. For example, a sales agent selling a ladder used during an installation is considered to have an indirect job.
- **Induced jobs**, which are created as a result of direct/indirect job incomes that are spent and re-spent. For example, a cashier job at a grocery store near the installation is considered an induced job.

The jobs created as a result of capital invested in the renewable thermal energy industry in Massachusetts were calculated using the Regional Input-Output Modeling System (RIMS II) employment economic multipliers, obtained from the Bureau of Economic Analysis (BEA). These multipliers are both region and industry-specific and serve to estimate the local employment impact which results from a one-time or sustained increase in economic activity in a region. For a given industry and state, RIMS II gives three employment economic multipliers: one for direct jobs[48], one for indirect jobs and one for induced jobs created or sustained. The job numbers for different job 'types' were summed to get a total number of jobs created or sustained.

The calculation methodology used to estimate the total number of jobs created or sustained in a given year by customer class followed the following 4 steps:

1. **Market Projections and Costs** – Navigant first projected a technology's annual installations, under different scenarios. Navigant also determined typical installation, O&M, and fuel costs.

2. **Calculate Direct Jobs Created or Sustained**– Navigant then calculated direct employment impacts using the methodology in Figure G-3.

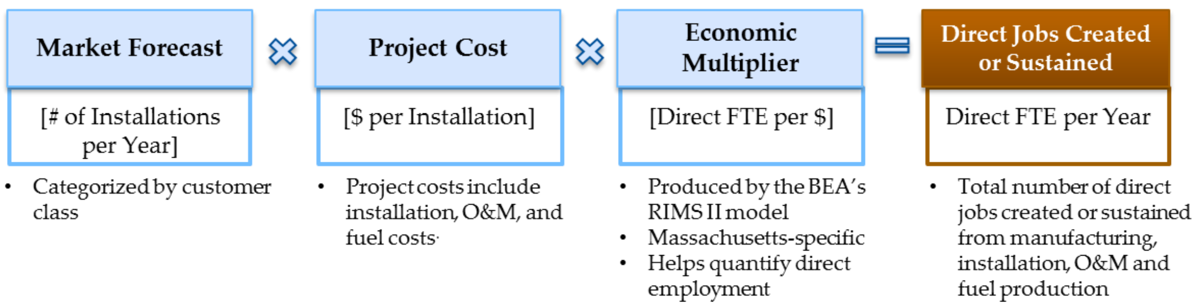

Figure G-3: Direct Jobs Calculations

3. **Calculate Indirect & Induced Jobs Created or Sustained** – Navigant calculated both indirect and induced employment impacts using a different set of RIMS II economic multipliers which are based on direct jobs. The methodology in Figure G-4 was used for calculating indirect or induced jobs.

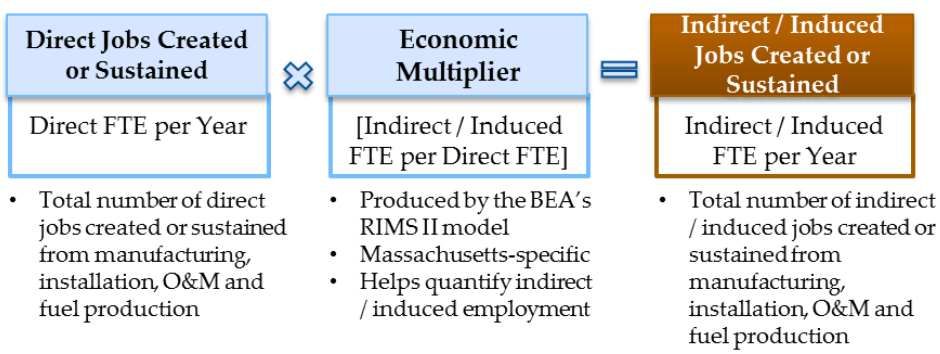

Figure G-4: Indirect and Induced Jobs Calculations

[48] A job refers to an FTE

4. **Calculate the Total Jobs Created or Sustained–** Finally, Navigant calculated the total number of jobs created from the deployment of a given renewable thermal energy technology by summing up the direct, indirect and induced jobs previously calculated.

The number of local jobs created was calculated along a technology's value chain, including manufacturing, installation, operations and maintenance. As such, jobs can be divided in four main job-sources, as Table G-1 shows, each of which has its own assumptions for each technology.

Table G-1: Job Source by Location in the Value Chain

Value Chain	Description
Manufacturing	Market research shows that the only renewable thermal technology of interest with a non-negligible manufacturing base in MA is solar thermal. Approximately one third of MA solar hot water systems have components that were manufactured in Massachusetts[49] All other renewable thermal technologies were assumed to have insignificant in-state manufacturing. Thus, manufacturing jobs created in MA were only calculated for solar.
Installation (including sales, engineering, and design)	For each technology, it was assumed that the jobs created or sustained from a technology's installation would be created in Massachusetts. An underlying assumption is that each technology's Massachusetts' installer base would expand to meet market demand in-state.
Fuel Production	This is primarily relevant for, and was only calculated for, biomass pellets and chips. Although wood pellet/chip production is an important industry in the Northeast (driven by operations in NH, NY, and PA, as illustrated in Figure G-5) currently MA does not have wood pellet/chip production operations. Thus, the biomass production jobs (from logging, transportation, etc.) were calculated for the Northeast.
Operations & Maintenance	For each technology, it was assumed that the jobs created or sustained from a technology's O&M requirements would be created in Massachusetts.

[49] "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

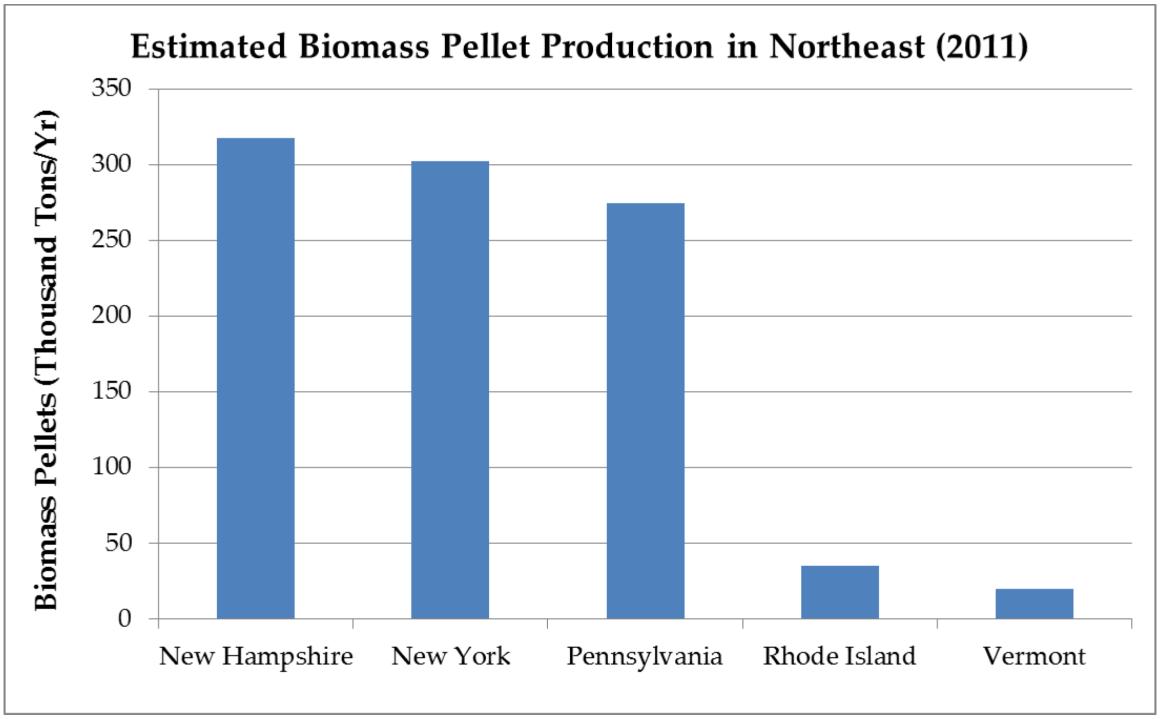

Figure G-5: Biomass Pellet Production Capabilities in the Northeast[50]

Using the methodology described above, jobs created and sustained from the deployment of thermal energy technologies were calculated by customer class for three different years: 2015, 2020 and 2030. Under alternative scenarios, the job numbers from different segments of a technology's value chain were aggregated so as to report a single job number per customer class. The job number given on a per year basis represents the total number of jobs created or sustained in that year as a result of the deployment of a technology in given customer class. It includes both temporary positions, resulting from the installation of renewable thermal technologies, and permanent positions, resulting from the O&M or fuel requirements once a technology is installed.

[50] Data extracted from "Massachusetts Renewable Heating and Cooling: Opportunities and Impacts Study, Meister Consultants Group, March 2012, Available at: www.mass.gov/eea/docs/doer/renewables/renewable-thermal-study.pdf

G.4 Tax Revenue Impact

The team explored the effect of growing the renewable thermal market on state tax revenues, including both positive and negative impacts on state tax revenues via three primary tax mechanisms:

1. **Sales Tax** – Massachusetts currently offers a 100% sales tax exemption for the purchase of residential solar thermal or GSHP equipment, representing lost tax revenues for the state.[51] However, the state will also gain sales tax revenue through the purchase of other renewable thermal equipment, for which the exemption does not exist. Figure G-6 illustrates the methodology that the team used to model the impact of renewable thermal market growth on sales tax revenue. The team first determined the total taxable revenue for each customer class by multiplying the achievable market size times the average equipment cost for each class. Then this revenue was multiplied by the Massachusetts state sales tax rate (6.25%), except for those classes which have the sales tax exemption, in which case we used a negative sales tax rate, to determine the net impact on sales tax revenue for the state.[52]

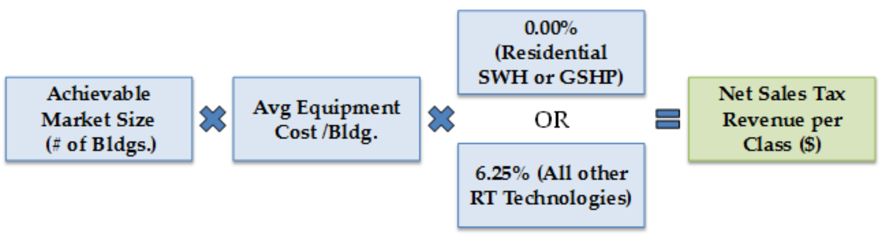

Figure G-6: Impact on State Sales Tax Revenue Methodology

2. **Additional Income Tax Revenues (due to new jobs)** – Growth of the renewable thermal market is expected to spur job creation in Massachusetts (see section G.3 below). As a result, the team anticipates the state will gain income tax revenue from the additional in-state jobs that are created. Figure G-7 shows the methodology that was used to calculate the additional income tax revenue that the state would receive from increased job growth. The team started with the estimates for the total number of jobs created for each customer class (see section G.3 below). The total number of jobs was then multiplied by the average salary for each new job and the personal income tax rate for Massachusetts (5.25%) to determine the total tax revenue attributable to each customer class.[53] The team assumed an average salary of $48,380 which represents the average salary for a construction worker in Massachusetts.[54]

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[51] Data available at: www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA05F&re=1&ee=1
[52] Data available at: www.mass.gov/dor/all-taxes/sales-and-use/
[53] Data Available at: www.taxadmin.org/fta/rate/ind_inc.pdf
[54] Data available at: www.bls.gov/oes/current/oes472061.htm

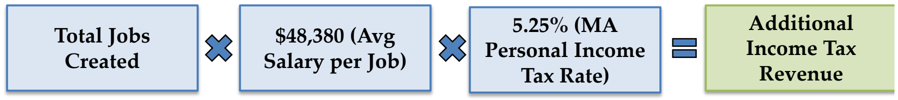


Figure G-7: Impact on State Income Tax Revenue Methodology

3. **Personal Income Tax Credits –** The commonwealth provides personal tax credits to residential customers who install solar thermal systems on their primary residence. The tax credit is worth 15% of the net expenditure for the installation of the solar thermal system, up to $1,000.[55] The team incorporated this tax credit in the analysis, as shown in Figure G-8. For the analysis the team assumed that all solar thermal customers would receive the maximum $1,000 dollar credit. For those customer classes which are eligible for the tax credit (residential solar thermal), $1,000 was subtracted from the additional income tax revenues gained by additional job creation to account for lost revenues due to this tax credit.

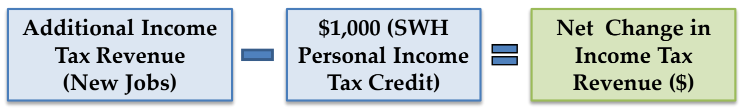
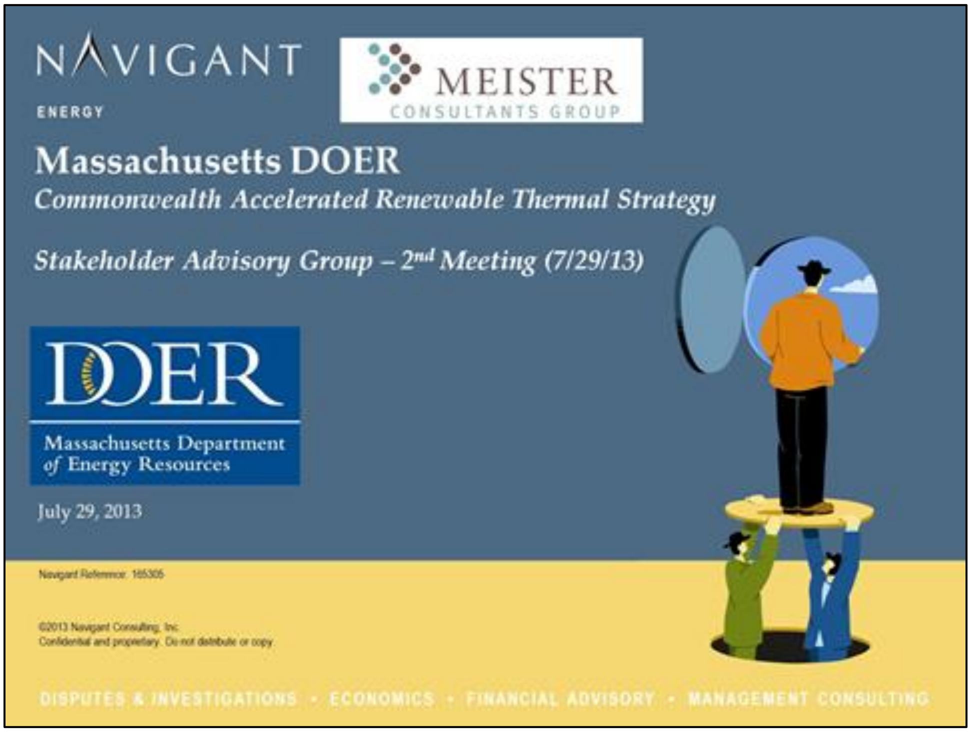


Figure G-8: Personal Income Tax Credit Impact Methodology

The team analyzed each of the above tax mechanisms for all 54 customer classes. Finally, the impacts from all three of the analyses above were aggregated to determine the net change in state tax revenues that is attributable to the growth of the renewable thermal market in Massachusetts.

[55] Data available at: www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MA06F&re=1&ee=1

Appendix H Slides from Second Stakeholder Meeting



Introduction: Selected Case Study Jurisdictions

State of Upper Austria

- **Goal**: 100% renewable heating and electricity by 2030
- Stable long-term incentives
- Strong cluster development approach (Oekoenergie cluster)
- Strong manufacturing base and export market

Germany

- **Goal:** 14% renewable heating by 2020
- Largest SHW market in Europe and largest consumer of bioenergy
- Rebate program with mix of "bonus" incentives for innovation and efficiency
- National renewable heating mandate

Introduction: Selected Case Study Jurisdictions

United Kingdom

- **Goal**: 12% renewable heat by 2020
- Developed first feed-in tariff for heat (Renewable Heating Incentive)
- Developed detailed heat metering requirements
- Strong emerging market for renewable thermal

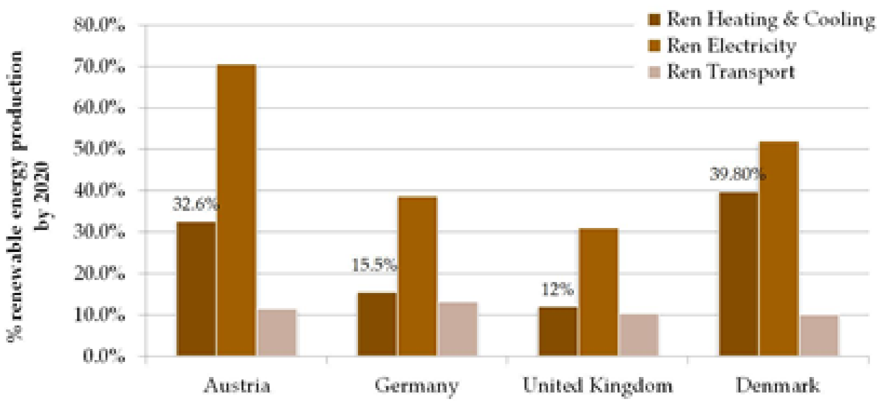
Denmark

- **Goal**: 39% renewable heat 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

Introduction

Introduction: National Renewable Energy Action Plans (NREAP)

As part of EU energy planning process, federal govts establish renewable energy goals for key sectors: heating, electricity, and transport



Note:
- Austrian goal presented here is federal target – and differs from the state of Upper Austria
- German goal presented here is greater than federal mandate of 14%.

4

Introduction

Introduction: Massachusetts Renewable Thermal Market Barriers

Past market studies have identified five major barriers to Renewable Thermal (RT) market development in Massachusetts:

» **High capital costs:** RT systems tend to have significantly higher upfront costs than fossil fuel systems

» **Lack of Policy Support:** RT tends not to receive comparable public policy support to other renewable energy or renewable fuels

» **Poor public awareness:** poor awareness of the economic (lifecycle), GHG, and societal benefits of RT systems among consumers; lack of consumer confidence

» **Opaque regulatory standards:** renewable thermal technologies tend to face opaque or unclear regulatory standards

» **Workforce Development:** RT stakeholders additionally report challenges hiring adequately trained personnel.

5

Introduction

Introduction: Building a Strong Renewable Thermal Cluster

The jurisdiction analysis describes international best practices that address market barriers using a common **cluster development framework.**

- **Governance** – Policy, regulatory, and legal levers
- **Marketing** – Customer confidence & awareness
- **Financing** – Financing approaches & models
- **Labor & Standards** – Workforce, product & technical standards
- **Innovation** – R&D & innovative applications
- **Resources & Logistics** – Infrastructure & local resources

International Best Practices

Governance – Policy, regulatory, and legal levers

Policies and regulations improve economics and increase market demand, leveling the playing field between RT and fossil fuel technologies.

» **Energy standards for buildings**: RT market development is closely tied to EU-wide EE and building standards
  - EU-wide Energy Performance of Buildings Directive (EPBD) requires new buildings/renovations to achieve "nearly zero-energy" building requirements by 2020 (2018 for public buildings)
  - Deep efficiency retrofits and RT technologies used to meet EPBD requirements
  - Germany's legislation: 14% renewable heat requirement by 2020 built on EPDB mandate

» **Energy and CO_2 taxes:** tax policies level playing field for RT technologies
  - By internalizing externalities (CO2, SOx and NOx emissions), many RT technologies are currently cheaper than fossil fuels in Denmark
  - However, across broader spectrum of countries, RT technologies continue to face cost barriers and significant competition with gas

International Best Practices

Governance
Policy, regulatory, and legal levers

Policies and regulations improve economics and increase market demand, leveling the playing field between RT and fossil fuel technologies.

» **Rebate programs:** rebates have been deployed across case study countries to support heat pumps, biomass thermal, and solar thermal
  - Upper Austria has the longest running RT rebate program (since 1980s), providing stability for home market and its manufacturing base
  - Germany's rebate program has suffered from cost constraints and "start/stop" funding history, creating challenges to scaling up market over time

» **Heat-based feed-in tariff:** UK's Renewable Heating Incentive (RHI) is world's first feed-in tariff for renewable heat
  - RHI is expected to encourage significant investment from private equity and debt providers
  - Program rolled out for commercial sector first – with extensive stakeholder input on program design and requirements
  - Requires detailed metering and system monitoring to ensure only "used and useful" heat is incentivized

International Best Practices

Financing
Financing approaches and models

Financing programs enable customers to overcome the high first costs of RT technologies.

» **3rd Party ownership:** Third party ownership (TPO) models are not widely deployed in Europe for RT technologies
  - Upper Austria developed an Energy Contracting Program to support development of TPO for biomass heating. The model has been slow to take off –only 150 biomass projects developed over several years.
  - Many RT projects are challenging for TPO due to small deal size, system complexity, and customer credit-worthiness concerns.

» **Low interest (soft) loans:** soft loan programs are widely used to finance RT systems
  - KfW, Germany's state Green bank, provides low interest loans and repayment subsidies for RT projects
  - Many countries incorporate both RT and EE into loan programs

» **On-bill financing:** UK is incorporating RT into its on-bill financing program
  - All RHI payments are conditional on thermal efficiency improvements to eliminate "wasted" heat
  - Golden rule: financial savings must be equal to or greater than repayment costs attached to energy bill
  - Generally, only part of RT or RE project is eligible for on-bill financing in order to achieve "golden rule" requirements.

International Best Practices

Innovation

R&D and innovative applications

Technology innovation can play an important role in market development, driving down costs, creating new market, and improving energy/environmental performance.

» **R&D technology programs:** Upper Austria's strong technology export market has been driven by R&D in the private sector
  - Only modest incentive support has been provided by the government in Upper Austria to encourage R&D for high efficiency, low emission biomass heating products
  - Private sector R&D has been spurred by strong demand in home market, tightening environmental/emission regulations, and innovative manufacturers

» **Incentives encouraging innovative applications:** within Germany, the federal government provides special bonus incentives for innovative applications and technologies
  - For biomass heating, bonus incentives are available for combination biomass-solar thermal plants, high efficiency systems, and condensing biomass boilers

International Best Practices

Marketing

Customer confidence & awareness

Poor customer confidence and public awareness of RT technologies remains a persistent barrier. Outreach and engagement to stakeholders is important to raise awareness and increase confidence in RT technologies and performance.

» **Public education programs:** information campaigns increase public awareness of RT technologies
  - Government and industry co-financed solar thermal information campaigns in Germany, connecting consumers with installers and encouraging installers to invest in/market solar thermal
  - Campaigns cover broad range of media and events: workshops, pamphlets, online media, billboards, newspaper, radio, and TV

» **Competitions & Procurement:** RT competitions target key consumer groups to increase consumer confidence, procure systems, and stimulate the RT supply chain
  - UK targeted social housing stock for RT competitions, implementing educational workshops, providing technical assistance, and offering incentives
  - Competitions are time-limited to encourage near-term action and stimulate industry supply chain

» **Energy assessments:** energy assessments enable customers to evaluate RT savings potential
  - RT is integrated into EE energy assessments, educating customers and connecting them with contractors
  - In many cases, EE retrofits are required for customers to take advantage of RT incentives

International Best Practices

Labor & Standards

Workforce, product & technical standards

Technology and installation standards are needed to ensure high quality performance of RT systems. Additionally, it is important to train the workforce to operate and install RT technologies. This is especially important for markets where customer confidence may be low.

- **Manufacturer Training Programs:** manufacturer participation has been essential to train RT in Upper Austria
  - In early days, govt agency hosted half-day educational events across region to train fossil fuel installers on biomass heating
  - Manufacturers followed up with detailed trainings and continue to do so
  - Austrian biomass manufacturers have started teaming up with New England regional companies to train installers across region
- **Apprenticeship & Training Program:** govt, industry, and vocational schools partnered to train new installers on RT and EE technologies
  - Many European countries have dual-training program that combines classroom training and apprenticeships for students interested in trade positions (e.g. plumbers, electricians, etc.)
  - Govt collaborated with schools and companies to incorporate EE and RT into curriculum
  - Programs were also developed to provide classroom training to "experienced" professionals to cover design, installation, and service of RT technologies

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International Best Practices

Labor & Standards

Workforce, product & technical standards

Technology and installation standards are needed to ensure high quality performance of RT systems. Additionally, it is important to train the workforce to operate and install RT technologies. This is especially important for markets where customer confidence may be low.

- **Microgeneration Certification Scheme (MCS):** developed to assist microgeneration industry tackle non-financial barriers and ensure quality installations
  - MCS is an industry led (with federal support) quality assurance scheme to certify installation companies and products (up to 45 kW for heat)
  - Onus is on industry to tackle challenges related to quality, performance, and cost reductions
  - Government expects to streamline regulations while still ensuring customer protections
  - MCS is linked to UK government finance schemes and incentives: to access FIT, RHI, or other incentives, both the installed product and installation company must be MCS certified

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International Best Practices

Resources & Logistics

Infrastructure & local resources

To grow the market, stakeholders should leverage local resources and existing infrastructure for RT. This may encompass a variety of approaches, from creating local partnerships, integrating RT into existing infrastructure, or creating comprehensive plans for RT.

- **Integrating RT into existing industries:** agricultural cooperatives spearheaded oil-heat transformation in Upper Austria
  - Ag cooperatives provide a variety of services, including distribution of tools, feed, and heating oil in Upper Austria.
  - In support of agricultural base, cooperatives determined to invest in infrastructure to distribute wood pellets as well as heating oil for their customers. This led to a very successful transformation.
- **Integrating RT into existing infrastructure:** Denmark has made concerted effort to integrate RT technologies into district heating infrastructure
  - 430 district heating plants provide majority of heating in Denmark; traditionally, plants served by coal, oil or gas
  - Copenhagen Heat Plan lays out strategy to analyze and adapt major investments in grid – incorporating biomass, solar thermal, and heat pumps into district energy system
  - Special focus on using low-cost wind electricity to power district energy heat pumps when cost-effective

Discussion

Discussion

- Which of the cluster areas do you consider most important to Mass market development and why? (Financing, Innovation, Marketing, Labor and Standards, Resources and Logistics)
- What programs that we just reviewed together do you find most promising for Massachusetts? What are pros/cons of various approaches for Mass?
- What local resources, programs, or institutions could we leverage to launch comparable market development programs in Mass?
- Who should take key roles in implementing such a program? What roles would stakeholders be able to play?
- Are there other programs, strategies or priorities that we need to consider to grow the renewable thermal market in Mass?


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Appendix I Complete List of Strategies

Table I-1: Top Priority Strategies, including Keystone, Cornerstone, and Building Blocks

Cluster Area	Strategy #	Strategy
Governance	1	Develop statewide renewable thermal goals for each technology
Governance	2	Leverage, coordinate, and expand efforts across state agencies to meet short-term goals
Marketing	3	Launch comprehensive RT technology information campaign with MassSave
Governance	4	Support implementation of long-term, stable performance-based RT incentives
Governance	5	Lead by example via "Leading by Example" and/or through other state energy program pathways
Governance	6	Integrate RT into the Stretch Energy Code and other building energy codes
Finance	7	Provide low-cost financing for renewable thermal through the MassSave HEAT loan program
Marketing	8	Develop "Thermalize" program, modeled after the successful Massachusetts Solarize program
Marketing	9	Develop comprehensive, online database with case studies and technology performance metrics
Marketing	10	Provide data to assist developers and installers identify "high value" renewable thermal customers
Marketing	11	Create tool that helps customers self-screen for suitability of RT technologies
Innovation	12	Support technology exchanges with "state-of-the-art" manufacturers
Resource and Logistics	13	Create Renewable Thermal Industry Advisory Forum
Governance	14	Review market enabling guidance regarding fuel choices and associated GHG emissions
Labor and Standards	15	Institute technical and sales training programs
Resource and Logistics	16	Engage heating oil and propane industry to explore RT business opportunities
Governance	17	Integrate renewable thermal into energy protection and assistance programs for low-income families
Labor and Standards	18	Integrate RT and EE into community college and vocational school curricula in MA

Table I-2: Other Finance Strategies

Finance Strategies
Statewide RT financing portal
Increase incentives for combined heat and power units using renewable fuels
Explore potential for supporting 3rd party ownership market in Massachusetts
Green Bank
Enhance/Expand PACE Financing
Support installation of anaerobic digestion equipment
Support grants for biofuel blending equipment at terminals
Facilitate implementation of utility on-bill financing
Securitization of RT investments

Table I-3: Other Governance Strategies

Governance Strategies
Assess impact of local property tax policies on RT technologies
Assess potential for infrastructure development of large-scale biogas plants that inject biogas directly into the gas grid
Conduct study of RT technology inspection and permitting requirements and develop streamlined "model rule"
Reduce permitting fees and property taxes for green buildings and/or buildings that exceed state energy code standards
Support efforts to harmonize U.S. and international safety, emission, and product standards for Biomass
Support efforts to harmonize U.S. and international safety, emission, and product standards for Solar Thermal
Create coalition of stakeholders to advocate on behalf of RT during International Code Council updates
Address code requirements that inhibit adoption of high efficiency heat pumps in Massachusetts
Study potential to harmonize biomass thermal air emission requirements across New England

Table I-4: Other Innovation Strategies

Innovation Strategies
Evaluate code opportunities to require low-temp distribution in new construction and renovations
Improve installers process and project management
Develop competitive bulk purchasing (reverse) auctions - give installers access to equipment based on participation and sharing of best practices.

Innovation Strategies
Crowd-sourcing
Regional bulk purchasing
Develop a grant program for graduate students
Crowd-funding
Reduce costs through larger scale operations via a regional installer licensing scheme
Commercial demonstration sites
Evaluate options to prevent voiding of warranties by using high blends of biofuels
Develop innovation challenges
Implement tax breaks for manufacturers to locate in-state

Table I-5: Other Labor and Standards Strategies

Labor and Standards Strategies
Provide external technical review of projects as requirement for incentive
Implement Design/Installation Standards, such as ISO-13256 (pump design standard)
Metering standards: develop comprehensive metering standards for all RT systems in Massachusetts
Create an installer/product certification scheme that provides quality assurance by vetting technologies and installers.
Institute biofuel blend reporting requirements

Table I-6: Other Marketing Strategies

Marketing Strategies
Support marketing efforts emphasizing cooling benefits of heat pumps (in addition to heating benefits)
Outreach with trade groups marketing benefits of renewable technologies
Provide technical support for biomass heating education campaign
Implement Annual 'Best in Class' Awards
Support biofuel marketing/awareness efforts
Integrate RT in LEED certification for homes

Table I-7: Other Resource and Logistics Strategies

Resource and Logistics Strategies
Integrate RT technologies into existing district heating systems
Evaluate level of infrastructure needed to cover the state
Evaluate need for, and support creation of trade association

Resource and Logistics Strategies
Provide technical assistance and stakeholder engagement services to support local communities identify suitable sites for AD
Expand grant opportunities to build biomass distribution infrastructure
Sustainable Biomass Certification
Support regional development of a standard certification for advanced biofuels
National R&D effort - out of scope