NMR Group, Inc.

MEMORANDUM

To: Scott Dimetrosky, EEB Evaluation Consultant

From: Zack Tyler, Matt Rusteika, Rob Baker, and Lisa Wilson-Wright, NMR Group

Date: December 15th, 2014

Re: R48: HES Additional Measure Review

The 2014-2016 EEB Program Evaluation Plan calls for the completion of a "Market Assessment/Literature Review/Performance Evaluation for Incorporation of High Performance Measures into HES/Res Programs". This memo presents the findings of secondary research that was conducted in order to examine market drivers and barriers associated with four measures that were not incentivized by Connecticut Light and Power or the United Illuminating Company at the time this study was developed. These measures may provide future energy savings opportunities for the State of Connecticut.

1 Summary of Results

The evaluation team conducted secondary research for four measures that were not incentivized by either Connecticut Light and Power or the United Illuminating Company (from here on referred to as "The Companies") at the time this study was planned and may present an opportunity for additional energy savings. Market drivers and barriers were identified for Wi-Fi thermostats, foundation wall insulation, water heater tank wrap insulation, and solar-assisted hot water (solar thermal) systems. Program experiences from other states have been summarized where applicable.

Below is a high-level summary of each measure along with a recommendation for the EEB. Additional details can be found in the body of the memo.

1.1 Wi-Fi Thermostats

The primary purpose of Wi-Fi thermostats (sometimes referred to as "smart" thermostats) is to allow occupants to adjust their thermostat setpoints remotely. This technology has the ability to empower homeowners to change their behavior in ways that could potentially lower energy consumption. Wi-Fi thermostats offer a wide range of additional features that tend to vary from product to product (see Section 4.2).

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The most significant market barrier for Wi-Fi thermostats appears to be the high upfront cost associated with most products; the average Wi-Fi enabled thermostat costs around $200.[1] A recent evaluation of a Wi-Fi thermostat pilot program in New Hampshire recommended that the utility offer a rebate between $50 and $150 depending on percentage of customers that the local utility hoped to convert to Wi-Fi thermostats.[2,3]

Current Status: The Companies are reportedly in the process of adding Wi-Fi thermostats to their list of incentivized measures for their residential programs.

Recommendation: The Companies should consider offering a mail-in rebate for Wi-Fi thermostats that does not exceed $100. Offering Wi-Fi thermostat incentives in the form of a mail-in rebate, as opposed to directly installing them through the HES and HES-IE programs, would limit the overall costs to the Companies as the HES and HES-IE vendors would not be responsible for installing the measure; this is the approach currently used in Massachusetts and Rhode Island and it allows homeowners to install the thermostats themselves if they choose. Pilot studies in Massachusetts and New Hampshire both showed savings from Wi-Fi thermostats and both states currently offer $100 incentives for Wi-Fi thermostats.[4] Similarly, Rhode Island currently offers a $50 mail-in rebate for Wi-Fi thermostats. Finally, the Team recommends that the Companies evaluate the costs and savings of Wi-Fi thermostats after a year of implementation; this measure was not included in the Connecticut Single-Family Potential Study[5] (the Potential Study) and therefore has not been screened for cost-effectiveness by the evaluators.

1.2 Foundation Wall Insulation

The recent Single-Family Weatherization Baseline Assessment[6] shows that 34% of Connecticut homes with foundation walls in conditioned space[7] have uninsulated foundation walls. This indicates a significant opportunity for foundation wall insulation improvements in existing single-family homes in the state.

Insulating foundation walls results in decreased energy consumption and provides homeowners with flexibility for their basement space, as it brings the space into the "thermal envelope" of the home. It also often reduces distribution losses, since basement ductwork and/or heating pipes are moved into the conditioned space of the building.

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[1] http://www.homedepot.com/b/Heating-Venting-Cooling-Thermostats-WiFi-Thermostats/N-5yc1vZc5kl
[2] Cadmus. *Wi-Fi Programmable Thermostat Pilot Program Evaluation*. Prepared for Liberty Utilities on July, 2013.
[3] This recommendation was based on surveys in which participants indicated what they were willing to pay for Wi-Fi thermostats and what their recommended incentive level was.
[4] New Hampshire requires the thermostats be installed by a licensed HVAC contractor or plumber.
[5] NMR Group, Inc. *Single-Family Potential Study: Review Draft*. Submitted to Connecticut Energy Efficiency Fund, CL&P, and UI on July 3, 2014.
[6] NMR Group, Inc. *Single-Family Weatherization Baseline Assessment*. Submitted to Connecticut Energy Efficiency Fund, CL&P, and UI on May 30, 2014.
[7] The Team defined *conditioned space* using RESNET's formal interpretation, which can be found here: http://www.resnet.us/standards/Floor_Area_Interpretation.pdf

Up-front cost and moisture problems are the primary barriers to the installation of foundation wall insulation and may deter certain homeowners from pursuing such retrofits (see Section 4.3 for additional details).

Current Status: The companies recently added foundation wall insulation to their list of measures incentivized through the HES and HES-IE programs.

Recommendation: The Companies should carefully monitor the roll out of foundation wall insulation as an incentivized measure in the HES and HES-IE programs. Specifically, the Companies should follow-up with HES and HES-IE vendors to confirm that moisture concerns associated with foundation wall insulation are being addressed in the field and are not a significant barrier to their recommended improvements. Despite the market barriers associated with foundation wall insulation retrofits, incentivizing this type of insulation is likely to provide cost-effective energy savings (average Benefit/Cost [B/C] ratio of 1.56 in the Potential Study) and increase compliance with the current weatherization standard.

1.3 Water Heater Tank Wrap Insulation

Water heater tank wrap insulation is an after-market product that can be used to increase the efficiency of water heaters with storage tanks. A low cost retrofit, tank wrap has been shown to produce cost-effective savings for older storage tank water heaters (those manufactured prior to 2001). A review draft of the recent Potential Study suggests that water heater tank wrap is, on average, cost-effective when self-installed (average B/C ratio of 3.80) or installed by a contractor (average B/C ratio of 1.01). While these results suggest water heater tank wrap insulation is cost-effective, they do not account for the fact that many of the existing water heaters in Connecticut single-family homes are likely to be replaced in the near future based on the average age of the existing tanks.[8] Given that tanks manufactured after 2001 have higher insulation R-values (due to an increase in federal standards[9] at that time) it is unlikely that water heater tank wrap insulation will be cost-effective moving forward.

Recommendation: Due to the average age of existing storage tank hot water heaters in Connecticut (and the likelihood of older tank replacement in the near future), the upcoming increase in the minimum federal standards for storage tank hot water heaters, and the market barriers associated with tank wrap (namely voiding warranties and self-installation challenges) the evaluation team recommends that the Companies do not add water heater tank wrap insulation to their list of incentivized measures.

[8] Based on the results of the weatherization study site visits conventional storage tank water heaters had an average age of 9.3 years and indirect storage tanks had an average age of 9.0 years in 2012.
[9] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27

1.4 Solar-Assisted Hot Water Systems

Solar-assisted hot water systems (also known as solar thermal systems) use solar panels to collect the sun's thermal energy and heat water for domestic use. Connecticut currently offers financing for solar thermal installations but does not offer any additional incentives. There are federal tax credits available for solar thermal installations which reduce the costs for homeowners, though the up-front cost can still be quite expensive. While solar-assisted hot water systems are highly efficient, a recent Florida study showed that a readily available heat pump water heater outperformed two types of solar hot water systems (see Section 6.3). While these results are not directly applicable to Connecticut they do indicate that heat pump water heaters are competitive with solar-assisted hot water systems in terms of overall efficiency.

Current Status: The Companies are reportedly in the process of adding solar-assisted hot water systems to their list of incentivized measures for the HES and HES-IE programs.

Recommendation: The Companies should carefully monitor the cost-effectiveness of these systems after they have been implemented into the HES and HES-IE programs. While solar-assisted hot water systems have the potential to save a significant amount of energy, they have been outperformed by heat pump water heaters in certain studies, they are expensive compared to other high efficiency water heater technologies, and were shown to have an average B/C ratio of less than 1.0 (B/C ratio of 0.85) in the Potential Study.

2 Introduction

The evaluation team conducted secondary research for four measures that were not incentivized by the Companies at the time this study was planned. The following measures were considered for this study:

- Wi-Fi Thermostats—currently being added to the list of measures incentivized by the Companies
- Foundation wall insulation—recently added to the HES and HES-IE programs
- Water heater tank wrap insulation—not under consideration for addition to the list of measures incentivized by the Companies
- Solar-assisted hot water systems—currently being added to the list of measures incentivized by the Companies

The evaluation team selected these measures based on two considerations: the B/C ratio as determined in the Potential Study that was cited earlier and discussions with the EEB Evaluation Consultant. Foundation wall insulation (B/C ratio of 1.56) and water heater tank wrap insulation (B/C ratio of 3.80)[10] both showed average B/C ratios that were greater than 1.0 in the potential study.[11] Solar-assisted hot water systems showed an average B/C ratio of 0.85. These results, and

[10] This benefit/cost ratio assumes the tank-wrap insulation is self-installed. The benefit/cost ratio drops to 1.01 assuming a contractor installs the insulation.
[11] All of the benefit/cost ratios reported in this memo were calculated using the Total Resource Cost Test.

the fact that these measures were not incentivized by the Connecticut electric and gas utilities at the time this study was being planned, led to the decision to include these measures in this study. WiFi thermostats were not included in the single-family potential study and were added to this study at the request of the EEB Evaluation Consultant.

The remainder of this memo summarizes the market drivers, market barriers, and other program experiences (if applicable) associated with each of these four measures.

3 Wi-Fi Thermostats

Wi-Fi thermostats (also known as smart thermostats) have become readily available in recent years and offer significant flexibility to occupants when compared to traditional manual or programmable thermostats. In addition to retail and contractor availability, these thermostats are now offered as an option with a number of different home security and home energy management systems. The flexibility created by Wi-Fi thermostats has the potential to cause changes in behavior that decreases energy consumption. Specifically, Wi-Fi thermostats allow users to program temperature setpoints for different days and times, similar to traditional programmable thermostats. The difference between programmable thermostats and Wi-Fi thermostats is that Wi-Fi thermostats can be controlled remotely through smart phones applications, web-sites, or other means and technologies to provide additional setpoint flexibility. Wi-Fi thermostats also offer many add-on capabilities (e.g., notifications and alerts, weather updates) increasing their potential value to occupants.

3.1 Market Drivers

The evaluation team identified the following market drivers for Wi-Fi thermostats.

Alerts and Other Features

Wi-Fi thermostats offer homeowners benefits beyond the ability to adjust thermostat setpoints remotely. Other benefits associated with Wi-Fi thermostats include the following:

- Monitoring heating and cooling system run-time
- Notifying occupants when setpoints exceed or fall below the programmed levels
- Alerting homeowners if the heating or cooling system fails
- Sending text messages to the thermostat console for household members to see
- Presenting of weather forecasts on the thermostat console
- Alerting homeowners when to change filters
- Integration with utility-based smart grid technologies[12]
- Reporting features which allow homeowners more insight into their consumption habits and cost savings opportunities

[12] http://honeywell.com/News/Pages/New-Honeywell-Wi-Fi-Thermostat-Helps-Utilities-Keep-The-Lights-On-And-Save-Customers-Money.aspx

Self-Adjusting Ability

Some thermostats, such as the Nest[13] thermostat, have the ability to self-adjust. These thermostats learn the behavior of occupants and program themselves over time. Occupants must teach the thermostat how to work for about a week, and at that point the thermostat begins to self-regulate itself. This type of thermostat makes it so that occupants do not have to regulate their own thermostats and ultimately can result in increased energy savings and increased comfort.

Smart Grid Integration

"Smart grid"–a current buzz word in the energy efficiency industry–"generally refers to a class of technology people are using to bring utility electricity delivery systems into the 21st century, using computer-based remote control and automation," according to the Department of Energy.[14] One feature of the smart grid is its ability to connect homeowners' thermostats directly to utilities. This is beneficial for the utilities, as they can implement demand response mechanisms by controlling homeowners' thermostats during peak demand events and adjusting the temperature setpoint to reduce the peak demand (with the permission of the customer). Kansas City Power & Light (KCP&L) currently runs a program in which they provide homeowners and businesses with smart thermostats so that they (KCP&L) have the flexibility to control said thermostats during peak demand periods.[15]

3.2 Market Barriers

The evaluation team identified the following market barriers for Wi-Fi thermostats.

Cost

As is the case with many emerging technologies, Wi-Fi thermostats come at a cost that some consumers may consider prohibitive. The average Wi-Fi enabled thermostat costs around $200.[16] In comparison, traditional programmable thermostats can be purchased for as little as $20.[17]

Wi-Fi thermostats, as indicated in the name of the technology, require access to wireless networks to be fully functional. This fact, in conjunction with the relatively high up-front costs associated with these thermostats, could lead to some markets being excluded from access to Wi-Fi thermostats because of financial and technological constraints.

Installation

Many thermostats can be self-installed, including Wi-Fi thermostats. However, some homes may not have all of the necessary wiring to install these thermostats as they require more connections

[13] https://nest.com/thermostat/life-with-nest-thermostat/
[14] http://energy.gov/oe/services/technology-development/smart-grid
[15] http://www.kcplsmartgrid.com/smartgrid-products-and-services/mysmart-thermostat
[16] http://www.homedepot.com/b/Heating-Venting-Cooling-Thermostats-WiFi-Thermostats/N-5yc1vZc5kl
[17] http://www.homedepot.com/b/Heating-Venting-Cooling-Thermostats-Programmable-Thermostats/N-5yc1vZc4kcZ12ky?NCNI-5

than older thermostat technologies. As a result, some occupants may need to hire a contractor to install a Wi-Fi thermostat, which increases the cost of installation.

Security and Privacy Concerns

Given that these thermostats are connected to wireless networks, some occupants may have misgivings about security. Recently, some consumers have expressed reservations about whether it is possible to hack Wi-Fi thermostats.[18] A Wi-Fi thermostat that has been hacked could provide hackers with information about when a homeowner is or is not at home. Whether a Wi-Fi thermostat can be compromised remotely has not yet been proven, however.

3.3 Pilot Program Experiences

The Team reviewed two local Wi-Fi thermostat pilot program experiences to assess how other utilities have fared when incorporating these technologies into their list of incentivized measures.

New Hampshire Wi-Fi Programmable Thermostat Pilot Program[19]

Liberty Utilities in New Hampshire created a pilot program for its natural gas customers to replace existing programmable thermostats with new Wi-Fi thermostats. Specifically, the program installed the Venstar ColorTouch T5800 thermostat at 29 participating homes.

Based on a billing analysis, the study found that the average home that participated in the program saw savings of 69 therms during the 2012-2013 heating season. The 69 therms of savings were equivalent to 8% of the baseline natural gas consumption.

Of the 29 homes that were included in the study, 23 were included in the billing analysis. The billing analysis showed that three of the 23 participants (13%) actually increased their gas consumption after installing the thermostat. These participants may have changed their behavior due to the flexibility that Wi-Fi thermostats offer, in turn increasing their energy consumption instead of decreasing it.

The majority of participants (88%) found installation of the thermostats to be "very easy," "easy," or "neutral." None of the participants reported difficulty programming their thermostats.

Participants suggested that the utility offer a rebate of $50-$100 for a $200 Wi-Fi thermostat to encourage adoption. The evaluation contractor suggested the utility offer rebates as high as $150 as that is what participants' "willingness to pay" responses suggested would be necessary in some cases.

Current Status: Liberty Utilities and Unitil currently offer a mail-in rebate of $100 per Wi-Fi thermostat (not to exceed two thermostats) for their natural gas customers.[20] Customers are

[18] http://venturebeat.com/2014/08/10/hello-dave-i-control-your-thermostat-googles-nest-gets-hacked/
[19] Cadmus. *Wi-Fi Programmable Thermostat Pilot Program Evaluation*. Prepared for Liberty Utilities on July, 2013.
[20] http://www.nhsaves.com/save-home/save-more/heating-cooling-water-heating-systems/

required to have their thermostat installed by a licensed HVAC contractor or plumber to receive the rebates in New Hampshire.

Massachusetts & Rhode Island Wi-Fi Programmable Controllable Thermostat Pilot Program[21]

In 2011, National Grid (of Massachusetts and Rhode Island) created a Wi-Fi thermostat pilot program which offered free Wi-Fi thermostats to 86 households (69 in Massachusetts and 17 in Rhode Island). The program provided participants with the Ecobee Wi-Fi thermostat.

Through a billing analysis, the program found that households with one thermostat installation showed gas savings of 11% per thermostat over the average annual pre-installation gas usage, while households with two thermostat installations showed gas savings of 8% per thermostat over the average annual pre-installation gas usage. The program also found that Wi-Fi thermostats that replaced non-programmable thermostats showed higher gas savings (10% per thermostat replacement) than Wi-Fi thermostats replacing programmable thermostats (8% per thermostat replacement).

The program found that savings from Wi-Fi thermostats can vary widely from household to household as the savings are largely a function of occupant behavior. In some cases, the program found that energy savings from Wi-Fi thermostats were similar to those of a standard programmable thermostat.

Current Status: Massachusetts currently offers a $100 mail-in rebate per Wi-Fi thermostat (not to exceed two thermostats) for natural gas customers.[22] Similarly, National Grid in Rhode Island currently offers a $50 mail-in rebate per Wi-Fi thermostat (again, not to exceed two thermostats) to customers that heat with natural gas and/or customers that have central air conditioning systems.[23]

[21] Cadmus. *Wi-Fi Programmable Controllable Thermostat Pilot Program Evaluation*. Prepared for the Electric and Gas Program Administrators of Massachusetts on September, 2012.
[22] http://www.masssave.com/residential/offers/thermostats
[23] https://www.smartenergy-zone.com/nationalgrid/pdf/GLD-W.pdf

Comparison of Pilot Study Impacts

Table 1 presents a comparison of the Wi-Fi thermostat pilot programs discussed above.

Table 1: Comparison of Wi-Fi Thermostat Pilot Program Impacts

State	# of Participants	Savings per Thermostat (therms or kWh)	Installation Method	Proposed Incentive Level	Current Incentive Level per Unit*
New Hampshire	23	66	Mix of direct install and self install	Between $50 and $150 per thermostat	$100
Massachusetts/Rhode Island-Natural Gas	66	82	Direct install	N/A	$100
Massachusetts/Rhode Island-Electric	11	104	Direct install	N/A	$50

*Each state has incorporated a Wi-Fi thermostat incentive program since the pilot programs completed.

4 Foundation Wall Insulation

Foundation wall insulation can be installed on either the interior or exterior of the foundation walls, but exterior foundation insulation is typically only installed during the construction process, as foundation walls are generally located below grade and buried during construction. As a result, retrofit-based foundation wall insulation is likely to be placed on the interior of foundation walls.

The recent Single-Family Weatherization Baseline Assessment[24] shows that 34% of Connecticut homes with foundation walls in conditioned space[25] (or 18% of all Connecticut single-family homes) have uninsulated foundation walls. This indicates a significant opportunity for foundation wall insulation improvements in existing single-family homes in the state.

4.1 Potential Study Findings

In the Potential Study, the models assumed foundation wall upgrades to R-13 cavity insulation in homes that had conditioned basements but had insulation with an R-value less than R-13 for cavity insulation or R-10 for continuous insulation. The Team found that foundation wall insulation upgrades to this level resulted in an average B/C ratio of 1.56 using the Total Resource Cost (TRC) test. [26] In total, upgrades were applied to models for 91 sites, and 45 of those sites (49%) had a B/C ratio greater than 1.0 using the TRC test.

[24] NMR Group, Inc. *Single-Family Weatherization Baseline Assessment*. Submitted to Connecticut Energy Efficiency Fund, CL&P, and UI on May 30, 2014.
[25] The Team defined *conditioned space* using RESNET's formal interpretation, which can be found here: http://www.resnet.us/standards/Floor_Area_Interpretation.pdf
[26] Costs associated with foundation insulation upgrades were based on data collected as part of a NEEP incremental cost study (http://www.neep.org/incremental-cost-study-phase-1-report).

4.2 Market Drivers

The evaluation team identified the following market drivers for foundation wall insulation.

Various Insulation Material and Installation Options

One benefit of insulating foundation walls in basements is that there are a variety of options as to which insulating material to use and how to install it.[27] In existing homes, interior foundation wall insulation is typically the only solution for insulating the foundation. For homeowners that do not intend to finish the basement, it may make sense to install rigid foam insulation (e.g., foil-face polyisocyanurate board), which is fastened directly the foundation walls. This insulation is typically easy to install, as there are not many obstructions (e.g., plumbing fixtures or electrical wires) on foundation walls. Alternatively, if homeowners intend to finish their basement, they may want to build stud walls and insulate the cavities in between the studs. This method allows homeowners to put up drywall and finish the space.

Building Science Corporation has detailed a variety of foundation wall insulation options on their website.[28] The proper insulation approach depends on a variety of factors including—but not limited to—future use of the space, cost, moisture control, and energy savings.

More Comfortable Space

Insulating the foundation walls of a basement can provide a homeowner with more usable space. Installing foundation wall insulation brings the basement into the "thermal envelope" of the home. This keeps the basement warmer in the winter, which can be a major benefit in cold climates as it can prevent pipes from freezing.[29] Insulating the foundation walls also allows homeowners to make the basement a more comfortable and more usable space, either by finishing it or by better capturing the HVAC system distribution losses to indirectly heat the basement space, thereby making it more comfortable.

4.3 Market Barriers

The evaluation team identified the following market barriers for foundation wall insulation.

Moisture Problems

One issue with foundation wall insulation is that it can create or magnify moisture problems associated with basements. Foundation walls are most often located at least partially below grade and are in contact with moist ground. For this reason, it is imperative that insulation contractors account for potential moisture problems before installing foundation wall insulation. Some insulation materials (specifically, fiberglass) are not suitable for direct contact with the foundation wall because they will absorb moisture and create mold/mildew problems. Moisture is a very real concern, and could scare some homeowners away from installing foundation wall

[27] http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_basement_insul.pdf
[28] http://www.buildingscience.com/doctypes/enclosures-that-work/high-r-value-foundation-assemblies
[29] http://apps1.eere.energy.gov/buildings/publications/pdfs/building_america/measure_guide_basement_insul.pdf

insulation. That said, there are a variety of foundation wall insulation options that do account for moisture concerns.[30]

Cost

Northeast Energy Efficiency Partnership (NEEP) recently conducted an incremental cost study which showed that insulating a previously uninsulated foundation wall to R-16 is associated with a total installed cost of $2.93 per square foot.[31] That cost is higher than the average cost of insulating other building shell components typically associated with higher energy savings, such as attics or above grade walls (both of which cost $2.02 per square foot to insulate from R-0 to R-19). These results, in combination with the fact that above grade wall and ceiling insulation are likely to yield a quicker payback, may create a barrier for certain homeowners when deciding which retrofit opportunities to pursue.

4.4 Program Experience

Not many efficiency programs appear to currently offer incentives for foundation wall insulation. This could be partially due to the fact that foundation wall insulation is often associated with moisture control issues, or that it may not be cost-effective in all applications. Moisture control concerns have the potential to be a liability for utilities offering incentives for foundation wall insulation.

Efficiency Maine

In the Northeast, Efficiency Maine's Home Energy Savings Program offers a $500 incentive for basement wall insulation that is increased to R-15 or 2" of thick continuous foam and is compliant with the fire code.[32] The Home Energy Savings Program is designed to provide homeowners with a whole-house energy assessment and encourage the adoption of comprehensive energy upgrades; this program is similar to the HES and HES-IE programs in Connecticut.

5 Water Heater Tank Wrap Insulation

Water heater tank wrap insulation is an after-market product that can be used to increase the efficiency of storage tank water heaters. Tank wrap insulation can be added to any water heater storage tank, regardless of the fuel type, as long as care is taken during the installation process.

5.1 Potential Study Findings

In the Potential Study, R-10 water heater tank wrap was modeled for all storage tank water heaters that did not already have an exterior tank wrap. A cost-effectiveness screening analysis

[30] http://www.buildingscience.com/doctypes/enclosures-that-work/high-r-value-foundation-assemblies
[31] http://www.neep.org/sites/default/files/products/Incremental%20Cost_study_FINAL_REPORT_2011Sep23.pdf
[32] http://www.efficiencymaine.com/at-home/home-energy-savings-program/hesp-menu-incentives/

showed that water heater tank wrap, when self-installed, has an average benefit/cost ratio of 3.80 using the TRC test. The average benefit/cost ratio drops to 1.01 if one assumes that the tank wrap is installed by a certified contractor.

5.2 Market Drivers

The evaluation team identified the following market drivers for water heater tank wrap insulation.

Cost

Water heater tank wrap insulation is easy to procure, relatively cheap, and can be found in most hardware stores for a cost of approximately $25. In addition to low material cost, water heater tank wrap can be self-installed, eliminating labor installation costs.

5.3 Market Barriers

The following market barriers were identified for water heater tank wrap insulation.

Increasing R-value of New Storage Tanks

Newer water heaters with storage tanks have a higher R-value of insulation surrounding the tanks than older water heaters have. Specifically, water heaters manufactured in 2001 or later are likely to have higher insulation R-values than tanks built in 2000 due to the fact that the federal government increased the efficiency requirements of domestic hot water systems on January 17, 2001.[33,34] As a result, using water heater tank wrap insulation is likely not cost-effective on newer storage tanks. According to the Department of Energy, the average lifetime for natural gas, electric, and oil-fired storage tank hot water heaters is 13 years.[35] This means that, on average, most Connecticut homeowners are likely to have a water heater that was manufactured after 2001; this is based on findings from the Weatherization study which indicated that, in 2012, the average age of conventional storage tank hot water heaters was 9.3 and the average age of indirect water heater storage tanks was 9.0.

Self-Installation Challenges

While water heater tank wrap insulation can be self-installed, this may present challenges under certain circumstances; many homeowners install water heater tank wrap insulation incorrectly. Common self-installation errors include:

- Covering the thermostat
- Blocking combustion air intake at the base of a gas or propane fired tank
- Blocking of the burner area

[33] http://www1.eere.energy.gov/buildings/appliance_standards/product.aspx/productid/27#historicalinformation
[34] These standards are set to increase again on April 16, 2015.
[35] http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0005

- Installing the wrap too close to the flue, increasing the risk of fire

Warranty Issues

Some manufacturers will void the warranty associated with their water heaters if external tank wraps are added to the tank. Most storage tank water heater warranties last somewhere between six and twelve years. As a result, installing tank wrap on water heater tanks that are still under warranty is not recommended in most circumstances.

5.4 California Experience

In California, the Title 24 standards currently require R-12 tank wrap insulation on unfired tanks (i.e., indirect water heater tanks) and gas storage tanks with an energy factor equal to or less than the federal minimum standards.[36,37] The California Codes and Standards Initiative recently investigated whether or not installing water heater tank wrap insulation is cost-effective.[38] The study found that installing tank wrap is cost-effective when the internal insulation is less than 2 inches thick, which is the case in many existing water heater tanks. Conversely, the study found that installing tank wrap on new water heater tanks is typically not cost-effective, because new DOE standards require a minimum of 2 inches of internal insulation.

6 Solar-Assisted Hot Water Systems

According to the Massachusetts Clean Energy Center (MassCEC), "A solar hot water system captures heat from sunlight and circulates the thermal energy to your water tank. Solar hot water systems reduce the usage of traditional water heating fuels (such as oil, electricity, or natural gas) and thereby reduce the amount you spend purchasing these fuels. These systems do not fully replace conventional water heaters, but can provide up to 80% of a building's total hot water needs."[39]

6.1 Potential Study Findings

The Single-Family Potential Study found that solar-assisted hot water systems have an average benefit/cost ratio of 0.85 using the TRC test. This measure was modeled as an upgrade at 108 out of the 180 sites considered in the study, and had a benefit/cost ratio greater than or equal to 1.0 at 48% of the sites. It is important to note that the Team did not assess the feasibility of solar hot water during the onsite inspections that were part of the Weatherization Baseline Assessment. As

[36] http://www.energy.ca.gov/2012publications/CEC-400-2012-004/CEC-400-2012-004-CMF-REV2.pdf
[37] Note that the federal minimum standards will increase on April 16, 2015.
[38]http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Residential/Water_Heating/2013_CASE_WH2.WH5_WaterHeaterReady-10.28.2011.pdf
[39] http://www.masscec.com/technology/solar-hot-water

a result, we randomly selected 60% of the sites and applied the solar-assisted hot water heater upgrade.[40]

6.2 Market Drivers

Market drivers for solar-assisted hot water heaters are detailed below.

Federal Tax Credits

Because solar-assisted hot water heaters are considered a renewable energy resource, they are currently backed by the federal government in the form of a tax credit. The federal government currently provides a tax credit of 30% on qualified expenditures for a solar hot water system that provides at least half of the water heating energy for a property.[41]

State-Level Incentives

Many states have implemented their own Renewable Portfolio Standards, which drive the market for solar-assisted hot water systems. For example, Massachusetts offers the Commonwealth Solar Hot Water Program, which provides rebates for solar hot water systems. The Massachusetts Clean Energy Center has reserved $10 million of funding for the program, which is expected to last until the end of 2016.[42] Similarly, NYSERDA offers incentives up to $4,000 per site for residential systems and $25,000 per site for non-residential application to New York State residents and businesses.[43]

6.3 Market Barriers

Market barriers for solar-assisted hot water heaters are detailed below.

Costs

A variety of sources indicate that a typical solar hot water installation can cost anywhere from $5,000 to $11,000 depending on a number of factors (e.g., size of system, condition of the roof, length of pipe runs, etc.).[44,45,46] These costs are substantially higher than the costs associated with other efficient water heating technologies such as heat pump water heaters (approximately $1,600 installed[47]) and natural gas tankless hot water heaters (approximately $3,500 installed[48]).

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[40] The Team arrived at this 60% figure after interviews with several solar contractors in Connecticut suggested that about that proportion of single-family homes in the state could feasibly support the installation of a solar array without incurring the substantial extra costs associated with roof reinforcement, electrical system upgrade, or trimming or removing trees.

[41] http://energy.gov/savings/residential-renewable-energy-tax-credit

[42] http://www.masscec.com/programs/commonwealth-solar-hot-water

[43] http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Renewables/Solar-Technologies/Solar-Hot-Water/Solar-Hot-Water-Incentive.aspx

[44] http://www.nrel.gov/docs/fy11osti/48986.pdf

[45] http://www.aceee.org/consumer/water-heating

[46] http://www.revermont.org/main/go-renewable/solar-hot-water/

[47] http://www.regulations.gov/#!documentDetail;D=EERE-2006-STD-0129-0170, ch.8, p. 8-25.

[48] http://www.neep.org/incremental-cost-study-phase-1

The high upfront cost of solar-assisted hot water systems could deter certain homeowners from pursuing them as a domestic hot water option.

Lack of Awareness

While there are many benefits associated with solar-assisted hot water systems, many homeowners are still unaware of the technology, which creates a barrier to increasing market penetration. The New York City Economic Development Corporation (NYCEDC) recently conducted a study to address barriers to the installation of solar thermal technologies.[49] The NYCEDC cited consumer lack of awareness as one of three major barriers to solar thermal installations.[50] They attributed this lack of awareness to the fact that reliable performance data is difficult to find for solar thermal installations.

Competitive High Efficiency Water Heaters

Relatively newer water heating technologies such as on-demand tankless gas water heaters and heat pump water heaters have emerged as attainable high-efficiency alternatives in the water heating market over the last few years. A 2013 study by the Florida Solar Energy Center showed a heat pump water heater outperforming two different solar hot water systems (2.75 kWh/day consumption vs. 3.0 kWh/day and 3.4 kWh/day consumption, respectively).[51] While these findings are not directly applicable to Connecticut homes due to their having been gathered in a much sunnier climate, they do indicate that heat pump water heaters are competitively efficient with solar-assisted hot water systems. Moreover, the cost of a heat pump water heater is significantly less than that of a solar-assisted hot water heater, as indicated in the "Costs" section above. Finally, the Companies already offer a $400 rebate for heat pump water heaters, lowering their total installed cost even more.

6.4 Program Experience

Solar hot water heater programs have been implemented in multiple states; summaries of a few are presented below. Connecticut currently offers financing options for solar hot water installations but they do not offer rebates.[52]

NYSERDA

NYSERDA launched a solar thermal program in December 2010. The program provides incentives for solar hot water systems that displace electrically-heated domestic hot water.[53] As mentioned in Section 6.2, NYSERDA offers incentives up to $4,000 per site for residential

[49]http://www.nycedc.com/sites/default/files/filemanager/Resources/Studies/Solar_Study/SolarThermalUpdateOp.pdf
[50] The other two barriers listed in the NYCEDC study were lack of incentives and lack of financing.
[51] http://www.fsec.ucf.edu/en/publications/pdf/FSEC-RR-386-12.pdf
[52] http://www.energizect.com/residents/programs/residential-solar-hot-water
[53] http://www.nyserda.ny.gov/Publications/Program-Planning-Status-and-Evaluation-Reports/Renewable-Portfolio-Standard-Reports.aspx

systems and $25,000 per site for non-residential application to New York State residents and businesses.[54]

Massachusetts

The Massachusetts Clean Energy Center currently has $10 million reserved for the Commonwealth Solar Hot Water program.[55] The funding is expected to last through at least 2016. Prior to the development of the Commonwealth Solar Hot Water Program, the state had funded two separate solar hot water pilots that resulted in 300 residential and commercial solar hot water installations. The Commonwealth Solar Hot Water program will offer incentives to residential, multi-family, and commercial-scale buildings. Rebates vary based on the number of collectors installed, the performance rating of the collectors, and whether the system qualifies for additional incentives. Residential rebates are capped at the lesser of $4,500 or 40% of the installed cost, while commercial rebates are capped at $100,000.

Maryland

Maryland has an RPS that requires that 20% of the energy sold in Maryland come from qualified renewable energy sources by 2022, with 2% coming from qualified solar resources.[56] The Maryland Energy Administration currently offers an incentive of $500 per project with between 10 and 100 square feet of solar hot water panels.[57]

7 Conclusions

The evaluation team conducted secondary research for Wi-Fi thermostats, foundation wall insulation, water heater tank wrap insulation, and solar-assisted hot water systems, none of which were incentivized by the Companies at the time this study was planned. Specifically, market drivers, market barriers, and applicable program experiences were investigated for these measures. After conducting a thorough review of secondary literature the Team recommends that the following:

- Wi-Fi thermostats: The Companies should consider offering a mail-in rebate for Wi-Fi thermostats that does not exceed $100. In addition, the Companies should evaluate the costs and savings of Wi-Fi thermostats after a year of implementation; this measure was not included in the Connecticut Single-Family Potential Study[58] (the Potential Study) and therefore has not been screened for cost-effectiveness in Connecticut.

[54] http://www.nyserda.ny.gov/Energy-Efficiency-and-Renewable-Programs/Renewables/Solar-Technologies/Solar-Hot-Water/Solar-Hot-Water-Incentive.aspx
[55] http://www.masscec.com/news/new-multi-year-incentive-program-solar-hot-water
[56] https://data.maryland.gov/goals/renewable-energy
[57] http://energy.maryland.gov/Residential/cleanenergygrants/index.html
[58] NMR Group, Inc. *Single-Family Potential Study: Review Draft*. Submitted to Connecticut Energy Efficiency Fund, CL&P, and UI on July 3, 2014.

- Foundation wall insulation: The Companies should carefully monitor the roll out of foundation wall insulation as an incentivized measure in the HES and HES-IE programs. Specifically, the Companies should follow-up with HES and HES-IE vendors to confirm that moisture concerns associated with foundation wall insulation are being addressed in the field and are not a significant barrier to their recommended improvements.
- Water heater tank wrap insulation: Due to the average age of existing storage tank hot water heaters in Connecticut (and the likelihood of older tank replacement in the near future), the upcoming increase in the minimum federal standards for storage tank hot water heaters, and the market barriers associated with tank wrap (namely voiding warranties and self-installation challenges) the evaluation team recommends that the Companies do not add water heater tank wrap insulation to their list of incentivized measures.
- Solar-assisted hot water systems: The Companies should carefully monitor the cost-effectiveness of these systems after they have been implemented into their list of incentivized measures.

A Appendix A: Cost-Effectiveness Inputs

Table 2 details the cost-effectiveness inputs that were used to calculate the benefit/cost ratios cited in this report. The actual cost-effectiveness screening files associated with these measures have been provided to the evaluation consultant. These files provide additional information including the savings associated with the benefit/cost ratios.

Table 2: Cost-Effectiveness Inputs

Measure	Upgrade Detail	Cost	Measure Life
Foundation Wall Insulation	Uninsulated to R-13	$2.95 per s.f.[1]	25 years[2]
	Existing Insulation to R-13	$1.75 + ($1.20 - (ExistingR*$.09)) per s.f.[1]	
Solar-Assisted Hot Water Systems	Add 66 sq. ft. of solar thermal collectors	$7,000 per house[3]	20 years[2]
Water Heater Tank Wrap Insulation	Add R-10 tank wrap	Self-installed: $21.57 per unit[4]	5 years[2]
		Contractor-installed: $81.57 per unit[5]	

[1] http://www.neep.org/incremental-cost-study-phase-1

[2] http://www.ctenergyinfo.com/2013%20Program%20Savings%20Documentation%20-%20Final.pdf

[3] http://www.nrel.gov/docs/fy11osti/48986.pdf, p.13

[4] Internet based market research, R-10 fiberglass blankets

[5] Internet based market research, R-10 fiberglass blankets, plus a $60 certified plumber fee (http://cga.ct.gov/2010/rpt/2010-R-0432.htm)