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Leaders of the Pack: ACEEE's Third National Review of Exemplary Energy Efficiency Programs

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RAP Energy solutions for a changing world

Residential Efficiency Retrofits:

A Roadmap for the Future

May 2011

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A Roadmap for the Future

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Contents

List of Acronyms

ACEEE American Council for an Energy-Efficient Economy
BPI Building Performance Institute
BPIE Buildings Performance Institute Europe
CERT Carbon Emissions Reduction Target
CO_2 Carbon Dioxide
CO_2e Carbon Dioxide Equivalent
G8 Group of Eight
GHG Greenhouse Gas
HVAC Heating, Ventilating, and Air Conditioning
KfW Kreditanstalt für Wiederaufbau
kWh Kilowatt Hour(s)
kWh/m^2 Kilowatt Hour(s) per Square Meter
PACE Property-Assessed Clean Energy
PV Photovoltaic

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Finally, we pay special tribute to Blair Hamilton, our co-author. More than 20 years after being initially diagnosed with cancer, Blair died on April 8, 2011. Anyone who met Blair could not help but be affected by his visionary thinking, indomitable spirit, and unparalleled passion for his work promoting energy efficiency. As his co-authorship of this paper illustrates, he actively served that mission until the very end. The energy efficiency community will sorely miss him. Those of us who were fortunate enough to call him a friend will miss him even more. We dedicate this paper to his memory. We hope it inspires new and better ideas on this critically important topic, just as Blair always did for us.

Chris Neme, Energy Futures Group
Meg Gottstein, Regulatory Assistance Project

Executive Summary

Science tells us that global emissions of carbon dioxide and other greenhouse gases (GHG) must be reduced at an unprecedented rate to avert the potentially catastrophic effects of global climate change. To address this imperative, many nations and regions have committed to achieving economy-wide emission reductions on the order of 80% by 2050, and have adopted policies and near-term emission reduction targets to put these on course.

Roughly half of all efficiency and/or carbon emission reduction potential in North American and European buildings is associated with retrofit improvements to existing homes.

Success in meeting this unprecedented challenge will require fundamental changes in the way energy is produced and used throughout the global economy. Notably, studies in both North America and Europe point to the transformation required in the power sector—nearly full decarbonization by the 2030s as well as the likely need for mass electrification of space heating, water heating, and personal transportation. Universally, energy efficiency is recognized as playing a pivotal role in both transforming the power sector and achieving GHG reduction requirements at least-cost to our global economy.

Buildings can represent on the order of 40% of energy requirements in the economy, depending on the region, and are therefore of strategic importance in reducing GHG emissions. Retrofit improvements to the heating and cooling systems of existing homes and their thermal envelope (e.g. by increasing insulation levels and reducing air leakage) present major opportunities for cost-effective investments in efficiency. Indeed, roughly half of all efficiency and/or carbon emission reduction potential in North American and European buildings is associated with retrofit improvements to existing homes.

Achieving carbon reduction targets at affordable costs requires an aggressive strategy for tapping the efficiency potential in existing homes. To put this level of ambition in perspective, studies suggest that the optimal level of home retrofit efficiency savings given 2050 climate goals is likely to be above 50%, about twice what the leading retrofit programs are achieving today. Achieving that level of savings will require a comprehensive, "whole house" approach in which, at a minimum, efficiency upgrades are made to multiple components of the home in an integrated way. The imperative to reach a sufficiently broad range of homes will also be challenging to meet. Studies suggest the least-cost path to meeting climate goals requires averaging a least 5% annual market penetration of whole-house residential retrofits, yet no jurisdiction is currently reaching even 2% per year.

The nature of the challenge discussed here demands a new way of thinking about a strategy for achieving mass-scale, deep residential efficiency retrofits. While it is essential that the strategy effectively engage current (and future) homeowners, it must begin to do so in a way that treats the building itself as the long-term client. Just as important, a successful retrofit strategy for the future needs to view buildings collectively as a critical component of the energy system infrastructure required to decarbonize the economy. To this end, the strategy should be designed to evaluate and pursue such improvements, much in the way that other infrastructure upgrade needs (such as highways, gas pipelines, electric grids) are evaluated and pursued: for the long-term benefit of all users.

Guided by this paradigm, we have prepared this *Roadmap for the Future* to assist policymakers and practitioners in both designing and implementing a residential retrofit strategy. Because a roadmap requires some key guideposts, we present eight principles for success. These are premised on the lessons learned from over two decades of international experience and the imperative to both achieve much deeper levels of savings per home and reach a much broader swath of the market than any region, nation, or state has achieved to date.

Climate change and other economic imperatives require a new paradigm that treats the building as the long-term client and views buildings collectively as part of energy system infrastructure.

A. Principles for a Successful Whole-House Retrofit Strategy

Eight principles for a whole-house retrofit strategy capable of securing aggressive GHG emission reductions and economic benefits form the core of *Roadmap for the Future*. We present these as high-level principles, recognizing that specific approaches and design details for putting them into practice will need to be tailored to local market conditions and political realities.

In developing these principles, we have identified four key areas that warrant particular attention: (a) designing a successful market development program; (b) developing complementary regulations to promote whole-house retrofits; (c) tapping the optimal savings potential of each home, and (d) designing performance-based delivery for mass-scale deep retrofits. *Roadmap for the Future* provides additional guidance and design recommendations in these areas. A summary of our observations and conclusions for the first three are included under the corresponding principles described in Section A below.

Because successful delivery of this strategy will be as important as the strategy itself, in *Roadmap for the Future* we explore in some detail the design considerations associated with a performance-based obligation. Section B presents a summary of our observations and recommendations for a successful, performance-based delivery framework.

Principle 1: The Strategy Addresses Market Complexities

There are a variety of well-documented, complex barriers to investments in home efficiency retrofits and opportunities to promote greater investment. These include, among others: inadequate access to capital for many homeowners, the split incentives associated with many rental properties (between who pays the energy bills and who owns the building), a lack of sufficient and credible information on the inefficiency of the home and the benefits associated with efficiency upgrades, and high "hassle" costs associated with getting the work done. Moreover, different building types and vintages offer different savings opportunities, and their owners may face unique barriers to investment.

History is replete with examples of single-tactic approaches to the residential retrofit market, such as the offer of free audits or the promotion of financing products, which have accomplished little. A successful strategy will need to move away from a prescriptive "one-size-fits-all" program in favor of a multi-pronged approach capable of effectively addressing market complexities. Accordingly, this "first principle" is reflected in all the subsequent principles and design considerations presented in *Roadmap for the Future*.

Principle 2: The Strategy Delivers Comprehensive Retrofits

Achieving GHG reduction targets at least cost will require a shift in thinking about "how deep to go" in treating each premise with efficiency improvements. Continued reliance on simple pay-back metrics and other short-term calculations to determine the cost-effectiveness of retrofit treatments will leave too much efficiency "on the table"—and with it, untapped economic benefits. *Roadmap for the Future* provides guidance on how to define the level of cost-effective retrofit improvements to each home that is more consistent with long-term goals for energy savings and carbon reduction.

Once all the cost-effective retrofit opportunities are identified, addressing them in a single treatment has several important advantages. A single treatment eliminates the transaction costs of multiple visits, minimizes the potential of rendering future and deeper treatments technically or economically unviable, and avoids the possibility that a homeowner is left believing the efficiency work is "done." The retrofit strategy should therefore be designed to encourage homeowners to invest at the outset in retrofit upgrades that are as comprehensive as possible.

In practice, however, many homeowners will not be prepared to make, or able to finance, the total investment required to address all cost-optimal retrofit opportunities as a single project. The level of financial subsidy and attractive financing terms that could make this investment manageable for them may also be challenging for the vast majority of jurisdictions to offer. From a practical standpoint, the residential retrofit strategy will need to be designed to minimize the potential adverse effects of partial initial treatments and to pace whole-house upgrades and associated investment in a manner that works well for the building owner.

Roadmap for the Future provides a set of design guidelines to accomplish this objective. These reflect the need to view the building itself, as well as the building owner as an ongoing client. In brief, they address the need to:

- ***Treat the house as an integrated system***
- ***Develop long-term energy retrofit plans for homes***
- ***Encourage the proper sequencing of efficiency-measure installations***
- ***Encourage bundling of measures that should ideally be pursued together***
- ***Encourage as deep a treatment as possible for each measure pursued***
- ***Encourage the installation of as many economically optimal (in the long term) measures or measure bundles as possible.***

Principle 3: The Strategy Expands Private-Sector Supply-Chain Capacity

As will be discussed under Principle 7, delivery of mass-scale, whole-house retrofits will need to fully engage the private-sector supply chain for retrofit services and products. However, providing deep retrofit savings in half or more of the residential building stock is an enormous undertaking that will require a large and capable workforce. Experience and studies point to a significant lack of supply-chain capacity to meet the challenge of deep retrofits at the time-scale required. A successful initiative to promote aggressive levels of whole-house retrofits will need to support the development of a well-trained retrofit service industry.

Attention should also be paid to leveraging interactions between homeowners and vendors who sell other building products and services. Such interactions occur, for example, in the course of replacing windows or heating and cooling systems, while undertaking remodeling projects or repairing/replacing roofs or siding. These are natural "on ramps" to simultaneously sell consumers on efficiency retrofits. Tapping these large efficiency opportunities will require a strategy that creates mutually reinforcing relationships with trade allies.

Principle 4: The Strategy Provides Both Rebates and Attractive Financing

Cost is the single largest barrier to investment in deep retrofits. Financing, particularly through products that have long repayment terms, relatively low interest rates, and other attractive features, can make it possible for many consumers to make substantial efficiency investments. But all available evidence indicates that financing alone will not be enough. Some form of up-front rebates or other cost discounts will also be essential to maximize participation in residential retrofit initiatives.

Experience with a variety of energy efficiency programs suggests that the average public contribution to efficiency investments for homeowners who are not low-income needs to be at least 25% to achieve savings on the order of 20%-35%. The balance would be leveraged from the private sector, either through the homeowner's own financial resources or loans. Some studies indicate that a much higher percentage of subsidy (public capital) to private investment may be required to deliver deep retrofits to existing housing stock, especially when solid-wall insulation is included in the mix. For low income households, it will usually be necessary to pay for all of the up-front investment.

Put simply, a public-private investment partnership, whether formal or informal, will be necessary to fund efforts to achieve aggressive goals in this market.

Principle 5: The Strategy Minimizes Confusion in the Market

For many consumers, the transaction costs of understanding the efficiency potential in their homes and how to address it present serious obstacles, particularly when people are exposed to a barrage of marketing messages throughout their busy day. To be effective, a strategy for encouraging discretionary retrofit efficiency investments must put a premium on simplicity and clarity of message and process.

For this purpose, some jurisdictions have created "one-stop-shopping" to simplify the agreements, language, and processes for consumers and contractors. Where a variety of efficiency service providers are bringing their own messages to the market, a central trusted reference may be needed, to which consumers can turn for information on topics like savings claims for different efficiency measures. Another option is to create social media platforms where consumers can comment on their experience with efficiency service providers. Whatever approaches are taken, a successful strategy will need to minimize confusion in the market.

Principle 6: The Strategy Includes Voluntary Programs *and* Complementary Regulations

Guided by the principles above, a successful residential retrofit strategy for the future will need to offer homeowners a voluntary market development program that is multi-faceted and comprehensive. Drawing on leading international practice and experience to date, *Roadmap for the Future* describes the following key elements of such a program and offers design suggestions for their development:

- ***Technical training and certification of retrofit contractors***
- ***Retrofit advice to consumers***
- ***Marketing to drive both demand and the supply chain***
- ***Rebates and/or other up-front cost discounts***
- ***Innovative financing products***
- ***Quality assurance, possibly including guarantees***
- ***Investment in research and development***
- ***Building-efficiency labeling.***

Experience demonstrates that purely voluntary program offerings will not grow the retrofit market anywhere close to fast enough to comprehensively treat half of all homes in a decade (or even two decades). A successful retrofit strategy for the future will therefore require complementary regulations to move the market. *Roadmap for the Future* discusses why the residential retrofit strategy should include all of the following regulatory components, or at a minimum, introduce them systematically over time:

- **Product efficiency standards and labeling requirements** for lighting, appliances and other electric plug loads, as well as other whole-house measures such as windows, heating equipment and water heating equipment.
- **Building efficiency labeling and disclosure requirements at time of advertisement for sale** that address the building as a whole system, or at a minimum address the highly interconnected efficiency of home heating, cooling and water heating.
- **Minimum building efficiency requirements at time of sale or major renovation** to upgrade existing housing, most likely paced over time (e.g., by focusing on a particular subsection of the housing stock and/or applying requirements initially to only the least-efficient buildings).

Experience has also shown that the collective effectiveness of voluntary programs and regulations can be maximized when they are designed together to be mutually reinforcing. *Roadmap for the Future* explores these interactions with an illustrative example of how the level of financial incentives to homeowners can be effectively synchronized to the pace of increasing regulatory requirements.

Principle 7: The Strategy Delivers Through Performance-Based Obligations

How a strategy is organized to actually deliver results can be as important as the strategy itself. Many jurisdictions have experimented in recent years with various approaches to encourage distribution utilities, competitive retail energy suppliers, quasi-governmental agencies, and other organizations to deliver on efficiency. Experience points to the effectiveness of those particular delivery models that place a performance-based obligation on one or more entities in the market. Building on this experience will be critical for ensuring that the retrofit strategy achieves mass-scale, deep retrofits at the pace required.

A performance-based obligation places accountability for meeting residential retrofit goals on a specific organization, or set of organizations, accompanied by meaningful (positive and/or negative) financial consequences.
While the obligated entities are responsible for results, government and the private sector efficiency supply chain have critical roles to play in this effort, and are tasked with the functions best suited to their strengths. Government establishes the broad policies and priorities for the retrofit strategy, chooses the obligated entity or entities, defines the goals and associated performance indicators, and

establishes funding sources. The private sector is relied upon to finance, sell, and install the efficiency measures necessary to meet the goals, leveraging the efforts of the government and its obligated entities.

Experience over the past decade in North America and Europe provides useful insights for considering the choice of obligated entity or entities, the nature of the obligation, and the funding sources for performance-based delivery. *Roadmap for the Future* explores these insights in some depth. Our observations and conclusions are summarized in Section B.

Principle 8: Government Commitment to the Strategy is Strong and Stable

It will not be possible to grow the market significantly for residential whole-house retrofits unless many existing businesses are prepared to adopt new business models and entrepreneurs are prepared to create and invest in new businesses. Both will require confidence that the overarching policies will remain in effect well into the future. Government commitment to the long-term objectives, voluntary initiatives and regulation, other core elements of the strategy, and the funding necessary to support them must be seen as stable.

Government can signal this commitment through a well-conceived and clearly articulated policy framework that recognizes energy efficiency as a low-cost, zero-carbon heat and power resource that benefits all customers, irrespective of the physical premise where the efficiency measures are installed. As discussed under Principle 4, a stable and sufficient public-private investment partnership will be required for this purpose. Section B summarizes the advantages to raising public capital for efficiency through broad-based system charges, such as distribution tariffs or carbon pricing revenues.

B. Performance-Based Delivery Framework for Mass-Scale Deep Retrofits

Principle 7 highlights the need for a performance-based delivery framework that places accountability for results on one or more market entities, which we refer to as obligated entities. Drawing from international experience, *Roadmap for the Future* explores key issues and considerations for the choice of obligated entities, the nature of the obligation, and the funding sources for performance-based delivery. What follows are summaries of our observations and conclusions.

Choice of Obligated Entity: One Size Does Not Fit All

Over the past couple of decades, different countries, states, provinces, and other types of jurisdictions in both North America and Europe have assigned responsibility for delivering on efficiency goals to a variety of different types of organizations. The most prevalent three have been distribution utilities, competitive retail energy suppliers, and private non-profit or for-profit organizations, usually selected through a competitive bidding process. Each option has advantages and disadvantages, the strength and severity of which can vary depending on local circumstances.

Experience to date and the nature of the challenge ahead suggest that a number of interrelated factors warrant careful consideration when making this choice:

- ***Mission alignment***
- ***Ability to bring a multi-fuel perspective***
- ***Absence of real or perceived conflicts of interest***
- ***Level of trust with consumers and the retrofit services supply chain***
- ***Ability to create partnerships with retrofit businesses, community organizations, and local authorities***
- ***Ability to respond quickly to market feedback and opportunities.***

No single type of organization in the market will be able to address all of these considerations equally well, so there will be important tradeoffs to consider. One of the most important is the issue of whether the obligated entity or entities should be permitted to sell retrofit services, or otherwise own part of the supply chain. *Roadmap for the Future* explores the associated tradeoffs and encourages caution in permitting supply-chain ownership by obligated entities. It also points to potential ways, so far untested, to mitigate this conflict should policymakers determine that permissiveness on this issue is warranted.

Nature of the Obligation: The Devil is in the Details

How the obligation is defined will be critical to the success of the overall effort to achieve deep, massive-scale residential retrofits. Savings goals should ideally be articulated as lifetime savings, rather than, in whole or part, as first-year savings. Short-term performance indicators will need to support, rather than undermine, the long-term goal of achieving a high level of market penetration of comprehensive, deep retrofits. *Roadmap for the Future* suggests alternative ways to define the obligation that are consistent with long-term goals, as well as how to establish rules for "white certificate" valuation and trading (where trading schemes are permitted) that minimize cream-skimming.

Government may also decide to articulate performance goals for the distribution of benefits to particular groups of customers (such as low-income households, seniors) or geographically (e.g., to rural communities). These goals will need to be clearly communicated in the law, regulation, or contract that is used to convey the obligated entities' performance responsibilities.

Finally, a successful performance-based delivery framework requires meaningful consequences for meeting the goals, or failing to do so, and an effective process for independently assessing performance.

Funding the Effort: The Advantage of Broad-Based System Charges

Least-cost strategies to address climate change will require a large commitment of both public and private investment capital in residential building retrofits. Although the source and magnitude of funding has varied, each of the jurisdictions that has assigned responsibility for delivering efficiency to one or more entities in the market has recognized the need to raise public capital as funding for this purpose.

Sources of funding for efficiency have included (1) wires-and-pipes charges (electric and gas distribution utility tariffs), which are paid by all utility ratepayers; (2) carbon allowance auction revenues under cap-and-trade regimes, which are ultimately paid by all power consumers in the region; (3) the balance sheets of competitive retail energy suppliers, whereby the companies front the costs initially, then recover them from their end customers through higher retail energy prices; and (4) revenues obtained from successful competitive bidding in capacity auctions (currently occuring in two U.S. wholesale regional power markets), which are ultimately paid for by all power consumers in the region.

In addition, white certificate trading has been used by some jurisdictions as a source of public funding for efficiency. Like the sources described above, white certificate trading also creates a revenue stream to the actual deliverer/installer of efficiency measures that is paid for by a broader group of consumers. The ultimate payees will vary, depending upon the choice of the obligated entity and to whom that entity can directly or indirectly charge for the cost of purchasing certificates.

Historically, the choice of how to raise public capital has reflected a varying mix of political, institutional, market, and cultural preferences. However, the need for new strategies to deliver savings in buildings at an unprecedented rate and scale suggests several compelling advantages to using broad-based system charge – such as distribution tariffs or carbon pricing revenues – for this purpose.

In particular, when compared with alternatives, system charges can:

- **Provide governments with more flexibility to determine who should be the obligated entities** after considering the advantages and disadvantages of various options.

- **Permit governments and/or regulators to implement a broader range of performance-based business models** for efficiency, including those that create positive revenue streams ("carrots" not just "sticks") for the successful achievement of goals.

- **Place building efficiency improvements on more comparable investment footing** with other infrastructure that delivers energy services to system users, such as grid and pipeline improvements.

For the delivery of mass-scale deep retrofits to be successful – regardless of the choice of obligated entities, the nature of the obligation, or other design elements of the strategy – government will need to bring to the table a sufficient and stable contribution of public capital.

Next Steps

Roadmap for the Future has been shaped by global experience over the past two decades and is intended to provide practical guidance for the development of a residential retrofit strategy capable of meeting the challenge of climate change. The level of residential retrofit efficiency investment required over the next decade to put our economy on the least-cost path is unprecedented, so no one can claim to have a proven, detailed formula that can simply be copied.

Putting the roadmap into practice will require policymakers and efficiency practitioners to consider the most appropriate application of these principles and corresponding design recommendations to local circumstances, learning from past experience, and applying creativity and innovation in their execution.

I. Introduction

Climate science tells us that global greenhouse gas emissions would need to be reduced 80% below 1990 levels by 2050 to keep our planet from warming more than an average of two degrees Centigrade. Many fear that a temperature increase greater than that could lead to disastrous and irreversible changes, such as widespread coral-reef and corresponding fishery die-offs, and/or massive sea-level rises due to the complete melting of the critically important ice sheets in Greenland and elsewhere. As a result, in July 2009 the G8 nations[1] jointly pledged to reduce their GHG emissions by 80% by 2050. All members of the European Union (EU),[2] and a number of other countries have also adopted nearer-term emission reduction targets—for example, 20%-30% reductions by 2020.

Achieving GHG reductions of 80% by 2050 will require a number of changes in the global economy, particularly in the way energy is produced and used. Notably, studies in both North America and Europe point to the transformation required in the power sector. For example, the recent European *Roadmap 2050* study concludes that it will be "virtually impossible to achieve an 80% GHG reduction across the economy without a 95% to 100% decarbonized power sector" (e.g. renewable, nuclear, and/or fossil fuels with carbon capture and storage).[3] Moreover, study simulations suggest that achieving the economy-wide targets is likely to require massive electrification of space heating, water heating, and personal transportation by the 2030s. A study of GHG emission-reduction options for the state of California reached similar conclusions.[4]

The costs will be large, both for expanding electric grids to convert so much fossil fuel use to electricity use and for converting electricity generation to non-carbon energy sources. As explained in the box above, the *Roadmap 2050* study concludes that this cost can be significantly mitigated by substantial investments in energy efficiency.[5] Numerous other studies also highlight the pivotal role that energy efficiency can play in lowering the cost of meeting

Aggressive Efficiency Key to Meeting 2050 Carbon Targets Affordably

A recent report by the European Climate Foundation, *Roadmap 2050*, concludes that it is possible to reduce carbon emissions by 80% by 2050 while decreasing total energy costs compared to a business-as-usual forecast – but only if significant efficiency investments are made. The report analyzes scenarios in which both personal transportation and heating of buildings are electrified while the power system is decarbonized through different combinations of renewable energy, nuclear power, and carbon capture and storage. Although the unit cost of electricity increases 10% to 15% under these scenarios, total energy costs decline by 20% to 30%-- or €350 billion per year (€1500 per household). Improvements in building energy efficiency of up to 2% per year are essential to achieving this result. If only half as much efficiency improvement is achieved and the cost of efficiency is twice as great as forecasted, Europe incurs €300 billion in additional energy costs.

1 The G8 (Group of 8) refers to France, Germany, Italy, Japan, United Kingdom, United States, Canada and Russia.

2 The EU is an economic and political union of 27 member states, located primarily (but not exclusively) in Europe. Members located outside of Europe include Sweden and Finland, among others.

3 European Climate Foundation. *Roadmap 2050*: Practical Guide to a Prosperous, Low-Carbon Europe. 2010, p. 6

4 Energy and Environmental Economics. Meeting California's Long-Term Greenhouse Gas Reduction Goals. 2009.

5 European Climate Foundation. *Roadmap 2050*: Practical Guide to a Prosperous, Low-Carbon Europe. 2010, pp. 10-13.

GHG emission reduction requirements. For example, the California study referenced above states that the combination of energy efficiency improvements and solar photovoltaic (PV) rooftops "are expected to contribute 30 percent of total GHG reductions in 2050" —more than any other strategy other than the combination of electrification (of cars and building heating, among others) and low-carbon generation (43%). An Intergovernmental Panel on Climate Change report found that energy efficiency should be by far the largest source of carbon emission reductions through 2030, and either the largest or second largest source of reductions through the year 2100 (renewables is the largest in some scenarios).[6]

A report by Ecofys-Fraunhofer concludes that Europe can cost-effectively meet its 20% energy savings target by 2020—a key part of its GHG reduction strategy—and reduce annual energy bills by €78 billion in the process.[7] Similarly, a report by McKinsey and Company projects that the U.S. could reduce its greenhouse gas emissions by up to 45% below projected 2030 levels (28% below 2005 levels) by pursuing strategies with a cost of \$50/ton CO_2e or less. Further, the report finds that "almost 40% of the reductions could be achieved at 'negative' marginal costs" (i.e. relative to projected baseline future energy supply costs), and "the cumulative savings created by these negative cost options could substantially offset (on a societal cost basis) the additional spending required for the options with positive marginal costs." Most of the negative cost options are energy efficiency investments, particularly in buildings, equipment, and appliances.[8]

Achieving the level of building energy savings envisioned in these reports will require a truly comprehensive, "all-hands-on-deck" approach. At the highest level, this means significant efforts to achieve deep savings in each of the three major types of markets:

- **New construction—**pushing towards zero net energy impact and/or zero net CO_2 impact from new construction;
- **Equipment purchases—**accelerating the development and purchase of the most advanced new heating, ventilation and air conditioning (HVAC) equipment, along with motors, appliances, lighting, etc.; and
- **Building retrofits—**bringing about significant improvements to the thermal envelope of buildings, as well as selective early retirement of old and inefficient equipment.

Historically, efficiency policies and programs in North America, Europe, and elsewhere have focused most heavily on the first two of these markets, perhaps because they are generally easier to address. With new construction, a builder is already planning to construct a building. With equipment purchases (e.g., when a refrigerator or furnace breaks down and needs to be replaced), a vendor will be making a sale. In both cases, the objective is simply to persuade or require (e.g., through codes or standards) these market actors to build or sell/buy something a little differently. In contrast, most retrofit decisions are discretionary. The fundamental objective and challenge is to *create* a market event.

Further, efficiency improvements represent a small fraction of the total costs of new construction or equipment purchases. For retrofit projects, efficiency improvements may account for most or all of the work, and thus for most or all of the cost. It is also technologically easier and less expensive to do something right the first time (during new construction) than to fix it later (as a retrofit). Treating existing buildings requires detective work. Unlike in new construction, retrofit contractors are typically not familiar with the buildings on which they will work. Nor do retrofit contractors typically start with building plans that they can study. A diverse building stock also requires retrofit contractors to be knowledgeable about a range of construction practices.

Despite the challenges, it is clear that least-cost strategies in the building sector to address climate change will need to include aggressive new efforts to capture savings from retrofit markets. Depending on the region, existing buildings can represent on the order of 40% of total

6 IPCC. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. 2007.

7 Wesselink, et al. Energy Savings 2020: How to Triple the Impact of Energy Saving Policies in Europe. 2010, pp. 5, 14-19.

8 McKinsey. Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost? 2007. A similar McKinsey study was the basis for estimates of efficiency savings potential and cost used in the European *Roadmap 2050* report cited above.

Roughly half of all efficiency and/or carbon emission reduction potential in North American and European buildings is associated with retrofit improvements to existing homes.

energy demand.[9] While aggressive retrofit efforts will be necessary for *all* building types, this paper focuses exclusively on residential buildings, particularly non-low-income single-family homes.[10] This is in part because residential retrofits are complex enough in their own right to warrant a focused investigation, but also because the residential-building sector is increasingly seen as a critical market to address in the context of meeting aggressive GHG emission reduction goals.

Indeed, a variety of studies suggest that 40% to 60% of all efficiency savings and/or carbon emission reduction potential in the buildings sector[11] are associated with retrofit improvements to existing homes. Examples include:

- **U.S.:** Residential buildings account for roughly 60% of all cost-effective energy efficiency potential in 2020 within the buildings sector, with 71% of that potential associated with improving the building shell and heating and cooling equipment, mostly in existing homes.[12]
- **Switzerland:** Approximately 70% of all GHG emission reduction potential from the buildings sector in 2030 is attributed to efficiency improvements in residential buildings. Roughly 90% of that is associated with improving existing building shells (54%) and shifting to wood pellet, solar, or heat-pump heating systems in existing homes (36%).[13]
- **Belgium:** Residential buildings account for roughly 90% of all building efficiency potential in 2030, with 70% associated with improving building shells (51%) and installing more efficient HVAC and water heating systems (20%) in existing homes.[14]
- **Poland:** Approximately 80% of all efficiency potential in 2030 within the buildings sector is estimated to be residential buildings, with nearly 55% of that associated with either improvements to existing building shells (more than 40%) or installing more efficiency HVAC and water heating systems (more than 10%) in existing homes.[15]

In the sections that follow, we identify and explore the challenges and issues associated with tapping the critically important efficiency potential from residential retrofits. Section II discusses the need to treat many more homes than have historically been treated ("going broader") and achieving greater savings per home ("going deeper"). In Section III, we present eight essential principles to guide the development of a strategy for meeting this challenge, based on international experience and leading practices.

The remaining sections of *Roadmap for the Future* explore four key areas of strategy design, based on these principles. Section IV describes in greater detail the design elements for an effective market development program. Section V examines the role and design of complementary government regulations. In Section VI, we present additional recommendations that focus on the challenge of "going deeper" and maximizing savings per home. Section VII describes the pivotal role of a performance-based delivery framework for achieving mass-scale deep retrofits, and explores the key issues to consider in designing one. Finally, Section VIII summarizes "next steps" that must be taken.

9 CEETB. *Regular Inspection and Maintenance of Technical Building Equipment,* pp. 6-10. See also, data presented on energy use in the buildings sector for the U.S. (43%) and U.K. (40%) referenced in Sweatman et al. *Financing Energy Efficiency Building Retrofits.* 2010.

10 Treatment of low-income homes is vitally important for a variety of energy, environmental and social reasons. The unique challenges associated with treating such homes will require consideration of strategy elements that are specific to that market. To limit the focus of this paper, we do not address them in any significant way; however, they clearly deserve considerable exploration. In addition, we recognize there are some advantages to addressing residential buildings and at least some types of commercial buildings through an integrated strategy, which we also have not explored in this paper.

11 For the purpose of this report, the term "buildings sector" refers to residential and commercial buildings – both existing and new buildings projected to be constructed over the next couple of decades. Industrial facilities and their associated savings potential are treated as a separate category.

12 McKinsey. *Unlocking Energy Efficiency in the U.S. Economy.* 2009, pp. 29-30.

13 McKinsey. *Swiss Greenhouse Gas Abatement Cost Curve.* 2009, pp. 17-19.

14 McKinsey. *Pathways to World-Class Energy Efficiency in Belgium.* 2009, pp. 18-20.

15 McKinsey. *Assessment of Greenhouse Gas Emissions Abatement Potential in Poland by 2030.* December 2009, pp. 38-40.

II. The Residential Retrofit Challenge

The scale and scope of the residential retrofit challenge suggested by studies addressing climate change is large and unprecedented. It will require both significantly greater annual retrofit rates than have historically been the case and, at least over time, much deeper levels of efficiency savings from the average home being treated.

The Need to Go Broader

The ability to achieve significant reductions in greenhouse gas emissions – including those on the order of 80% by 2050 – at low cost or with *net reductions* in total energy costs[16] is universally predicated on the assumption that all, or almost all, cost-effective efficiency investments are made over time. For example, all of the scenarios analyzed in the *Roadmap 2050* report referenced in the previous section assume that efficiency measures in the McKinsey 2030 Global GHG Abatement Cost Curve for Europe are "implemented fully and in all sectors." Similarly, McKinsey's estimates that 2030 emissions could be reduced significantly below 2005 levels in the U.S. (up to 28% lower), Switzerland (45% lower), and Poland (31% lower), at either no net cost or very low cost[17], is predicated on the assumption that 90% or more of cost-effective efficiency opportunities are captured.

In the context of the residential retrofit market, putting our economies on the least-cost path to meeting GHG reduction goals will require additional efficiency improvements to the majority of existing homes. This conclusion has already been either indirectly or directly embodied in policy goals established in several jurisdictions. For example, the EU has established a goal of achieving 20% efficiency savings, relative to business-as-usual energy consumption, by 2020.[18] Reaching this goal equates to achieving an average of 40% savings in half of the existing housing stock, if all sectors and all end-uses within each sector were to contribute equally.[19] More specifically, as part of its strategy for meeting its legally binding carbon emission reduction commitment, Great Britain[20] plans to add attic/loft insulation to 10 million homes—roughly half its single family housing stock—by 2015. The government also plans to insulate wall cavities in 7.5 million homes by 2015, and add insulation to 2.3 million homes with solid walls by 2022.[21] Other European countries have also established aggressive goals for residential retrofits. In the U.S., several

16 That is, relative to a "business-as-usual" baseline for meeting projected energy demand, and taking into account the full cost-savings associated with meeting a significant portion of that demand through increased efficiency rather than through the more expensive production and delivery of additional supply-side generation.

17 The US analysis concludes that the cost of abatement options with positive costs up to $50/ton of carbon dioxide equivalent (CO_2e) reduction (the limit analyzed) could be offset by the savings from options, such as efficiency improvements, with negative costs. The Swiss study suggests the cost of options with positive costs up to €100/ton of CO_2e reduction (the limit analyzed) would be more than offset – by €110 million/year – by the measures with negative costs if the real cost of oil was $52/barrel. The net savings would increase to about €850/year with higher fuel prices (i.e. oil prices of $100/barrel with similar increases for other fuels). The Polish study concludes that the cost of options with positive costs up to €80/ton of CO2e reduction would be largely, but not entirely offset by savings from measures with negative costs. The net average cost would be approximately €10/ton of CO_2e reduction.

18 European Parliament. Decision No 406/2009/EC. 2009.

19 We do not expect savings to be achieved in equal proportions from existing and new buildings, let alone from different end uses (e.g. heating vs. appliances) in existing buildings. However, a significant portion of savings will need to come from existing home retrofits (see McKinsey studies referenced in Section I and Wesselink, et al. *Energy Savings 2020: How to Triple the Impact of Energy Saving Policies in Europe.* 2010, pp. 5, 14-19.)

20 Great Britain encompasses England, Scotland and Wales.

21 Committee on Climate Change. *Meeting Carbon Budgets – The Need for a Step Change.* 2009, p. 151.

states, led by the state of Maine's goal of retrofitting 100% of its existing housing stock by 2030,[22] have adopted aggressive goals for market penetration of residential retrofits.

Studies suggest the least cost path to meeting climate goals requires averaging at least 5% annual market penetration of whole-house residential retrofits, yet no jurisdiction is currently reaching even 2% per year.

In short, both the studies of least-cost paths to achieving substantial greenhouse gas emission reductions and the goals of leading jurisdictions suggest that we need to dramatically increase the current rate of home efficiency retrofits. A European construction industry group has suggested retrofit rates need to increase to as much as 4% per year to meet climate goals.[23] Achieving all of the cost-effective savings identified in the studies and policies noted above may require an even higher average annual rate—perhaps 5% or more.

While there are examples of initiatives that have achieved annual market penetrations at that level or higher such as the Hood River, Oregon project of the early 1980s, such examples are of a much smaller scale than an entire state or entire country and involved a level of financial subsidy that is unlikely to be politically feasible at a statewide or national level.[24] No large jurisdiction can claim to have developed and demonstrated an approach to residential retrofits that is capable of averaging a market penetration of 5% per year. Indeed, no country or jurisdiction of any size is currently reaching even 2% of the housing stock annually through whole-house approaches.

Even Great Britain, which appears to have achieved a higher annual market penetration rate in the residential retrofit market than any other country in recent years, has not achieved this mark. The percentage of homes treated with attic insulation there has been impressive: over the two-year period ending in March 2010, energy suppliers facing carbon-emission reduction obligations collectively installed attic insulation in nearly 1.4 million homes, or about 3.5% of all single family homes in the country per year.[25, 26] However, such single measure initiatives are fundamentally different than the whole-house approaches required to ultimately reach truly deep levels of savings in homes (see the "going deeper" discussion below). The number of homes receiving more than one insulation efficiency measure in Great Britain was around one third of the properties treated.[27]

Canada has also achieved among the highest participation rates under its efficiency program, most notably a 3% participation rate in Ontario (its largest province) over the 2009-2010 fiscal year.[28] However, there is evidence to suggest that one-quarter of those homes also received only one measure (e.g., a heating system replacement) and many of the multi-measure participants simply installed efficient new heating and cooling equipment. Fewer than half of participants installed an insulation measure.[29]

Available data also shows that jurisdictions currently

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22 Efficiency Maine Trust. *Triennial Plan of the Efficiency Maine Trust 2011-2013*. 2010, p. 3.

23 Energy Efficiency Action Plan Taskforce of the Construction Sector (E2APT), an informal taskforce of companies, industry groups and NGOs in the construction sector last year called for as much as a tripling of the current 1.2% to 1.4% rate of deep energy renovations of existing buildings (E2APT. *The Fundamental Importance of Buildings in Future EU Energy Savings Policies*. 2010).

24 The Hood River project was a pilot effort designed to test the limits of a residential retrofit program. It offered 100% subsidies for all cost-effective efficiency improvements that could be identified for every electrically-heated home. 85% of eligible homes participated and installed recommended efficiency measures. For more information see: LBNL. *Driving Demand for Home Energy Improvements*. 2010, pp. 87-93.

25 OFGEM. *A Review of the Second Year of the Carbon Emissions Reduction Target*. 2010.

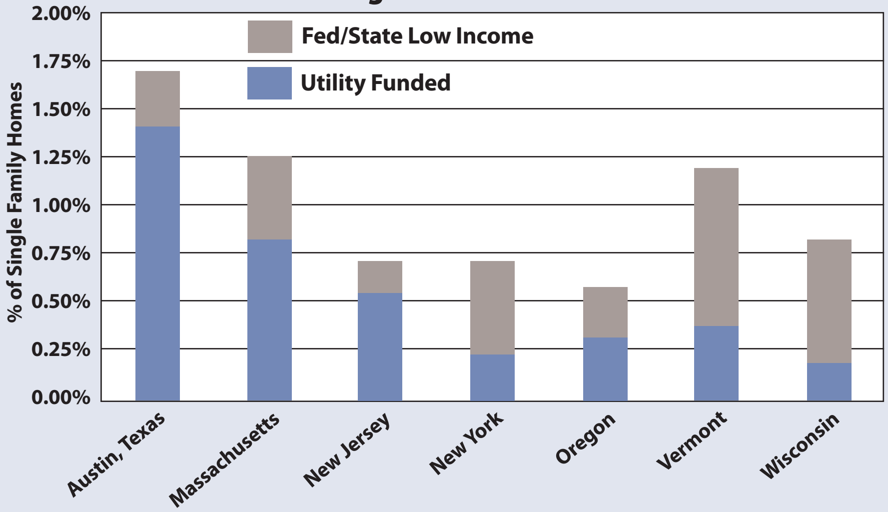
26 Cavity wall insulation was also installed in 1.1 million homes over the same two year period. In addition, subsidized prices on insulation from do-it-yourself stores led to enough sales to benefit over a million homes, though there are questions about the extent to which such sales overlap with the direct installations provided because some of the smaller insulation contractors may have found the subsidized price from retail stores to be cheaper than their normal purchase channel options (OFGEM. *Carbon Emissions Reduction Target Update 08*. 2010.)

27 E. Lees, Eoin Lees Energy (personal communication, October 2010). Lees, E. *Evaluation of the Energy Efficiency Commitment 2005-08*. 2008.

28 Environmental Commissioner of Ontario. Re-Thinking Energy Conservation in Ontario—Results. 2010, pp. 43-45. Canada was also on track to reach approximately 1.7% of its single-family homes nation-wide. However, the Canadian federal government subsequently stopped funding the financial incentives under this program. See: Hamilton, et al. *A Comparison of Energy Efficiency Programmes for Existing Homes in Eleven Countries*. 2010.

29 Environmental Commissioner of Ontario.

Figure 1: **2010 Whole-House Retrofit Participation in Leading U.S. Jurisdictions** [31]



cost of the last increment of efficiency investment is less than the marginal cost of supplying energy. More specifically, efficiency retrofits should be undertaken as long as the cost of doing so is less than the marginal cost of generating the energy and delivering it reliably to consumers, including the incremental cost of investments in transmission and distribution infrastructure.

As discussed above, in the context of the need to achieve 80% reductions in greenhouse gas emissions by 2050, the marginal supply cost may well be the marginal cost of generating and distributing decarbonized electricity to homes heated with heat pumps.

We are unaware of a study that has attempted to quantify the optimal level of efficiency investment and savings in existing homes in this context. Such an analysis would be complex and iterative, factoring in the effects of fuel-switching (e.g., from natural gas or oil heat to electric heat), the marginal cost of electricity production in a decarbonized electric power system (including the substantial marginal costs of the transmission and distribution system improvements needed to support such decarbonization), forecasted reductions in prices for different energy efficiency measures and low-carbon generation techniques, and a variety of other factors. The answer would undoubtedly also vary considerably from one jurisdiction to another due to differences in existing heating fuel mixes, electric generation fuel mixes, building stock, climate, and other factors.

Nevertheless, there is evidence to suggest that the economically optimal level of efficiency is substantially greater than levels currently achieved by leading residential

pursuing whole-house strategies are falling far short of achieving the penetration rates we will need for the future. For example, Germany's existing home retrofit initiative, which is among the most successful whole-house approaches in Europe, is estimated to be treating approximately 0.9% of single family homes per year.[30] As Figure 1 shows, leading jurisdictions in the U.S. have achieved market penetration rates for whole-house retrofits of between roughly 0.75% and 1.75% of single family homes. These rates reflect all efficiency initiatives, including Home Performance with Energy Star programs, other utility (or equivalent) funded programs, and federal and state-funded low-income weatherization programs.

Put simply, the imperative to treat a sufficiently broad range of homes with comprehensive efficiency retrofits will be challenging to meet.

The Need to Go Deeper

The economically optimal level of retrofit efficiency investment in existing homes is the level at which the

30 Hamilton, et al. *A Comparison of Energy Efficiency Programmes for Existing Homes in Eleven Countries.* 2010.

31 Estimates of the number of single-family and duplex homes for each jurisdiction are from the U.S. Census Bureau 2011. Data on federal and state program participation are from U.S. Department of Energy. Weatherization & Intergovernmental Program- About. 2011. Single family participants estimated to be 80% of total participants based on information from B. Adams, U.S. Department of Energy (personal communications, 2011). The 80% figure is a national one, so its use here will likely lead to slight understating of single family participation in more rural states like Vermont and slight overstatement for more urban states like New York. Data on utility-funded programs was provided directly by a number of different program administrators (note that most jurisdictions have two or more relevant utility funded programs). Great effort was made to obtain data only for homes that received at least two major measures. However, precise data in such a form was not available for all utility funded programs in every state. In a couple of cases (e.g. Massachusetts and Oregon), some extrapolation was necessary. However, the potential error associated with such extrapolations is estimated to affect estimates of single-family market penetrations by no more 0.1% or 0.2%.

retrofit efficiency programs. For example, the McKinsey studies of efficiency and/or greenhouse gas emission reduction potential in Switzerland, Belgium, and Poland all conclude that it would be cost-effective to reduce space heating consumption to levels of 30 to 60 kWh/m^2 or lower. This level represents a 50% to 80% reduction relative to the current European average space-heating consumption of approximately 140 kWh/m^2.[32]

By comparison, most current whole-house retrofit programs are averaging 20% to 35% savings in energy used for space heating, space cooling and water heating, the three end uses most appropriately addressed by whole-house retrofits.[33] Combined, these represent ~70% or more of residential site energy use in the U.S. and Europe.[34] For example, the City of Austin's average savings per participant appear to be on the order of 30% of space heating, cooling, and water heating consumption.[35] Programs in New York, New Jersey, Maine, and some other states also appear to average savings of approximately 25% to 35% of heating, cooling, and hot water energy use.[36] Savings from the Canadian national program averaged between 20% and 25% of pre-treatment heating energy use.[37] In Great Britain, for the properties installing more than one insulation measure, the average energy savings was around 28%.[38]

More detailed analysis will be required to determine the level of efficiency investment that is economically optimal in the context of 2050 climate goals, including the likelihood that residential space heating will need to be provided by electricity from a decarbonized power system. Along these lines, the Building Performance Institute Europe recently published a proposed methodology supporting the objective of minimizing costs during a building's lifetime while maximizing environmental benefits for the recast of the European Performance of Buildings Directive.[39] However, all currently available data suggests that we must achieve much deeper levels of savings per home than is typical today and that even over time, meeting that imperative will be challenging. Doing so will likely require greater levels of insulation, super-efficient windows, tighter building envelopes matched with mechanical ventilation, the most efficient heating systems, and other measures whose cost few consumers have been prepared to absorb to date. The challenge will be all the greater given the simultaneous imperative to reach a much broader swath of the market.

32 The International Network for Sustainable Energy. *Sustainable Energy Vision for the EU-27—Phase out of Fossil and Nuclear Energy until 2040.* 2010.

33 Lighting and most other electric "plug loads" are probably most effectively addressed through a combination of equipment efficiency standards and time-of-purchase voluntary efficiency programs.

34 For U.S. data see: EIA. *Share of Energy Used by Appliances and Consumer Electronics Increases in U.S. Homes.* March 28, 2011. The European Environment Agency reports that space heating alone accounts for 67% of household energy use in the EU (see: European Environment Agency. About household consumption.)

35 Average savings of 1890 kWh/home from (Plympton et al. Retrofit Program Delivery Models for Home Performance with ENERGY STAR.) is 16% of the average annual consumption per residential customer of 11,710 (from EIA. *Electric Sales, Revenue, and Average Price 2009.* 2011, Table 6). *The Residential Energy Consumption Survey* data (EIA. 2005 Residential Energy Consumption Survey. 2008) suggest that approximately half of all residential electricity used in Texas is for space heating (~5%), space cooling (~35%), and water heating (~10%). Note that this is not a perfect measure of participant savings because the baseline consumption of participants may differ from the average residential household and the portion of electricity used for space heating, cooling and water heating in Austin participants' homes may be different from the Texas average.

36 M. Dyen, Conservation Services Group (personal communication, September 2010).

37 Id. footnote 30.

38 E. Lees, Eoin Lees Energy (personal communication, October 2010). Lees, E. *Evaluation of the Energy Efficiency Commitment 2005-08.* 2008.

39 See: BPIE. *Cost Optimality.* 2010.

III. Principles for a Successful Whole-House Retrofit Strategy

Overview

The nature of the residential retrofit challenge discussed above demands a new way of thinking about a whole-house retrofit strategy. The vast majority of homes today will still be standing in 2050. However, the occupants of most of those homes are likely to be different. Indeed, many homes will have changed owners numerous times between now and 2050. Thus, while it is essential that an effective strategy to promote efficiency and effectively engage current (and future) homeowners, it must begin to do so in a way that treats the building itself as the long-term client.

As importantly, a successful retrofit strategy for the future needs to view buildings collectively as a critical component of the energy system infrastructure required to decarbonize the economy. To this end, the strategy should be designed to evaluate and pursue such improvements much in the way that other infrastructure (such as highways, gas pipelines, electric grids) upgrade needs are evaluated and pursued – i.e. for the long-term benefit of all users.

However, improving the building infrastructure on a large scale through efficiency improvements requires engaging the interest and "pocket books" of millions of individual building owners and mobilizing them to action. A strategy for achieving the potential of residential retrofits to secure needed economic benefits and carbon reductions must therefore be well-suited to this task.

Experience to date indicates that a successful strategy will need to be:

1. Comprehensive and multi-faceted, addressing the full range of market complexities, including market barriers to efficiency, in an integrated manner.
2. Structured to result in comprehensive treatment – over time – of each home.
3. Supportive of the development of a whole-house retrofit industry and trade allies in the private sector.
4. Capable of providing consumers both financial incentives and access to attractive financing for the portion of efficiency investments they will make themselves, including addressing the unique needs of low income households.
5. Presented as simply and clearly as possible to consumers and other market actors.
6. Designed to include a combination of voluntary market development programs and complementary regulations.
7. Implemented by a delivery framework that includes a performance-based obligation to achieve long-term goals, placed on one or more market entities.
8. Supported by strong government commitment to the overall strategy, including the level of ambition as well as stable (and sufficient) funding.

We present these as high-level principles, recognizing that the specific approaches for putting them into practice will need to be tailored to local market conditions and political realities. Below, we discuss each of them in further detail. The focus of our discussion is on heating, cooling, and water-heating energy, the end uses that are most typically addressed through thermal envelope and HVAC system improvements (including interactions between the two). However, we also touch on interactions between programmatic approaches to addressing those end uses and other "plug loads" (e.g., refrigerators and lighting) in our discussion of the regulatory component for a whole house retrofit strategy.

For the reasons discussed above, we predicate our observations and conclusions on the necessity for future initiatives to be both much broader (treating many more buildings per year) and much deeper (achieving much greater average savings per building).

Principle 1: The Strategy Addresses Market Complexities

The residential retrofit market is complex. There are at least three different layers to this complexity.

The first is technical differences.

Different building types and vintages offer different savings opportunities. For example, homes with hydronic heating systems[40] offer different savings potential than those with forced-air heating systems. Even among homes with forced-air heat, those with ducts in the attic or loft offer different opportunities and challenges than those with ducts inside conditioned space or the basement. Similarly, homes with solid walls offer different challenges than those with wall cavities. There are also innumerable individual quirks and variations in the majority of existing buildings. One-size-fits-all and prescriptive approaches will not capture all the cost-effective opportunities available through comprehensive retrofit. Any initiative must be prepared to technically address all of these differences.

The second layer of complexity relates to market differences. For example, the barriers in treating rental housing are different (and generally more difficult) than those for owner-occupied homes. In addition, some

Table 1: **Market Barriers to Residential Retrofits**

Barrier Type	Barrier Description
Consumers	
Information/ Awareness	• Lack of information on inefficiency of their homes, financial and other impacts of such inefficiency or what can be done about these problems • Difficulty identifying quality contractors (i.e. differentiating between those who are knowledgeable/ skilled and those who are not)
Financial	• Inadequate access to capital for many homeowners • Split incentives for rental property
Risk	• Perceived risk of making major investments in efficiency – don't know that they can trust savings will pay for themselves, don't know if they'll be in home long enough to realize payback, don't think they can sell value of efficiency improvements to home-buyers
Other	• High transaction/hassle costs associated with obtaining information on what work should be done, which contractors are qualified, getting quotes, over-seeing the work, etc. – people are very busy and bombarded with numerous marketing messages already every day • Most efficiency improvements are not "visible" or "sexy" – less "show off" value and more difficult to sell as added value to the home
Contractors	
Information/ Awareness	• Insufficient knowledge/skill for diagnosing and correctly installing holistic home improvements • Quality contractors cannot easily differentiate themselves in the market
Risk	• Requires different business model than just selling heating equipment, windows, or PV systems – risky to pursue
Other	• Weak sales skills make it difficult to sell consumers on major work • Inadequate contractor infrastructure for serving large numbers of customers
Others	
Financial	• Lenders do not value efficiency improvements in underwriting practices • Realtors do not help home-buyers to see added value associated with efficiency

40 Hydronic heating systems use water as the heat medium to distribute heat from a boiler to heat emitters such as radiators.

customers are in the market each year to make a major purchase for their home—whether a new heating system, new windows, new siding or new roof – and others are not. Those in the market for such major investments offer different opportunities for promoting whole house retrofits. Similarly, the very sale of a home offers perhaps the most underutilized, high-potential opportunity to accomplish whole house retrofits. Each of these different market segments and market opportunities must be considered when developing a strategy for promoting massive-scale residential retrofits.

Finally, and perhaps most important, there are many different and important market barriers to achieving massive-scale market penetration of major retrofit investments in homes. The most important of these are summarized in Table 1.

The last two decades are replete with examples of single-tactic approaches that failed to achieve much, particularly in the residential retrofit market. For example, numerous "free audit" programs were launched in the U.S. in the 1980s and 1990s when it was thought that consumers just needed to be educated about their efficiency opportunities. While those programs succeeded in providing audits to large numbers of customers, they had staggeringly low levels of installation of recommended major efficiency measures. Similarly, a variety of loan programs have been offered to consumers over the past several decades, also with almost universally low participation rates. Indeed, one recent study concluded that most of the residential efficiency loan programs in the U.S. reached less than 0.1% of eligible customers in 2007.[41] The barriers to retrofit investments are simply too numerous and complex for any single tactic to move the market. To be successful, any strategy must be multi-pronged and designed to address all key market barriers in an integrated way.[42]

Principle 2: The Strategy Comprehensively Treats Buildings

It has long been suggested that the retrofit of existing homes should ideally be as comprehensive as possible. That is, retrofit programs should be designed to encourage treating as many of each home's cost-effective efficiency opportunities as possible in the initial interaction with a customer and/or to provide mechanisms by which opportunities not addressed during that first initial interaction can be identified and planned for treatment in the future. There are many reasons for this. At the top of the list are technical and related economic considerations.

There are high costs to engaging homeowners and high administrative and transaction costs for providing on-site services. The transaction costs of treating a home—recruiting participants, scheduling visits, travel, performing on-site assessments, and doing any post-installation inspections or quality control reviews—are substantial. If one has to repeat these steps two, three, or four times over many years to reach optimal levels of efficiency, the costs of reaching optimal levels will be significantly increased. Second, multiple visits, even if spread out over a decade, can create significant transaction costs for consumers, making it potentially more difficult to convince them to take the second, third, and fourth step.

More important may be that only partially addressing efficiency opportunities in an initial treatment of a home can make achieving efficiency levels that are optimum for the long run more difficult and expensive, or—worse—*impossible or not cost-effective*. Examples of such lost opportunities include adding insulation without first sealing all significant leaks; installing sub-optimal insulation to solid walls, or replacing windows with sub-optimal ratings; and sealing and insulating ducts in an attic if the ultimate, optimal long-term solution is to move

41 Fuller. *Enabling Investments in Energy Efficiency.* 2008.

42 The Buildings Performance Institute Europe (BPIE) comes to a similar conclusion in its review of 12 case studies covering a range of energy efficiency policy instruments and measures across Europe. The analysis found that a significant proportion of the energy efficiency potential in existing buildings in Europe is not being realized due to a range of barriers, and that the most successful initiatives have involved careful analysis, financial and technical support, and flexibility for adjustments along the way. BPIE. *Financing Energy Efficiency (EE) in Buildings.* 2010.

The Costs of Basing Retrofit Choices on Near-Term Payback

Insulation without air sealing. Adding insulation without first sealing all significant leaks into the attic makes it more difficult and expensive to treat such leaks in the future. Moreover, leaving leaks into an attic untreated could ultimately render the added insulation less effective by allowing moisture to seep into it.

Sub-optimal insulation of solid walls. Solid walls pose major challenges in that they require changes to either exterior sheathing or interior drywall. Either is difficult for home-owners because of the cost of such work (most of which is labor), the disruption in the home during the work, and aesthetic considerations. Therefore, if a decision is made to proceed, it is imperative that as much insulation as can be justified (from a long-term perspective) be installed. Once two inches of foam insulation is added to the exterior of walls and sheathing is reapplied, the cost per unit of savings for adding an additional two or four inches later will be prohibitive.

Sub-optimal window replacements. Installing new Energy Star windows (e.g. with a u-value of ~0.3) today makes it highly likely that the opportunity to upgrade to very high performance windows (e.g. u-values of 0.2 or lower) will be lost for decades. From a long term perspective (e.g., 2050 carbon goals), the incremental cost of choosing higher performance windows today might be justified. However, the full cost of replacing Energy Star windows with high performance windows 10 years from now almost certainly could not.

Sealing and insulating attic ductwork. From a long-term economic perspective, it makes no sense to spend money today sealing and insulating ducts in an attic if the ultimate and optimal solution is to move ducts inside the thermal boundary of the home (or move the thermal boundary of the home to encompass the ducts).

Early retirement of fossil fuel heating equipment. Many efficiency programs today encourage removal of old, inefficient, but still functional gas furnaces or boilers and replacement with new efficient units. While such efforts yield significant near-term savings, they can add to the total long-term cost of reaching optimal levels of efficiency. If replacements take place before thermal loads on the home are reduced to optimal levels, the heating systems will become over-sized once such thermal envelope work has been performed. Over-sizing means paying more because larger systems cost more than smaller systems. Over-sizing can also lead to system inefficiencies due to larger stand-by losses. Perhaps more importantly, if the optimal long-term solution for meeting 2050 climate goals is to convert to smaller space heaters instead of central systems, switch to biomass boilers, or transition to electric heat pumps as suggested by the European *Roadmap 2050* study, then at some point the investment in new gas heating equipment will be counterproductive.

Energy Efficiency First. It is important to maximize cost-effective energy efficiency measures in a property before installing on-site renewables. Otherwise, there is a risk of over-sizing the renewables system and incurring potentially high, unnecessary investment costs.

ducts inside the thermal boundary of the home. Significant and costly lock-in can also occur with early replacements of fossil-fuel heating equipment, (e.g., boilers) when the optimal long-term solution might be to convert to smaller space heaters instead of central systems, switch to biomass boilers, or transition to electric heat pumps. Moreover, moving to renewable household heat generation before reducing heat demand first, through installing energy efficiency measures, is clearly wasteful of capital costs.

Also, to the extent that the most cost-effective measures are implemented in an initial treatment, the remaining, less cost-effective measures will be a much harder "sell" to the consumer. For example, consider that an initial package contains measures averaging $0.02 per kWh of savings, leaving the remaining measures with an average cost of $0.10 per kWh. It will likely be easier to sell a consumer on a blended package at $0.06 per kWh than to come back and try to sell the $0.10 per kWh package. Also, after an initial retrofit job is complete homeowners can be left with the impression that they are "done" —that they have made their homes efficient and do not need to do more. In such cases it can become very difficult to recruit the customer for a second level of investment five years later.

These concerns suggest that it would be ideal for every residential retrofit job to comprehensively address, at one time, all efficiency opportunities that are estimated at the time of the retrofit to be economically optimal in the context of 2050 climate goals. However, the reality is that such treatment will not be possible in most cases. The residential retrofit strategy must therefore be structured to deliver comprehensive retrofits *over time* to the premise, based on a time-scale that works well with the building owner (including consideration of other, non-energy renovations likely to take place). As will be discussed further in Section VII, whether a retrofit efficiency performance obligation is placed on competitive resource suppliers, regulated utilities, organizations hired for this purpose, or anyone else, the nature of the obligation needs to be consistent with this long view, and to drive the obligated entity toward taking it.

Principle 3: The Strategy Expands Private Sector Supply-Chain Capacity

Providing deep retrofit savings in half or more of the residential building stock is an enormous undertaking that will require a large workforce, many of whose members will need to be technically skilled. As will be discussed in Section IV, the current retrofit contractor infrastructure is insufficient to accomplish this goal. It must grow substantially, though the growth will need to be relatively proportional to expected growth in demand. Any initiative to promote aggressive levels of whole-house retrofits must focus some of its efforts on supporting the development of this industry. Fortunately, in at least some countries and states, much good work has already been done to create a good foundation. That foundational work should be leveraged through support for further development of technical standards, training, marketing support, and quality assurance efforts.

While the need to develop the capacity of whole-house efficiency retrofit businesses is widely acknowledged, comparatively little attention has been paid to date to the potential for leveraging another aspect of supply-chain capacity—that of the vendors in potentially allied trades who have numerous interactions with homeowners. In the U.S., for example, we estimate that every year roughly 4% of residential buildings have heating and/or central cooling systems installed or replaced, 3% have windows replaced, 3% have roofs replaced, and 2% have siding replaced.[43] Many others have some form of remodeling done. These are natural "on ramps" to simultaneously sell consumers on efficiency retrofits. However, efficiency programs, at least in North America, have largely ignored these opportunities.

Tapping these opportunities requires new strategies that create mutually reinforcing relationships with trade allies. One approach would be to develop different packages of "premium products" that each vendor can up-sell to their customers. For example, a premium roofing package might include not only a new roof but also attic/loft air sealing and insulation.[44] The strategy could also include recruiting such vendors to sell a broader range of products, and/or providing financial incentives for referrals to other contractors.

In short, residential retrofit strategies need to effectively address the supply-chain side of the market as well as the demand side.

Principle 4: The Strategy Provides Both Rebates and Attractive Financing

The amount of financial capital necessary to achieve deep retrofit savings in half of all single-family homes is very large. For example, if the average cost of even a

[43] Estimates are necessarily approximate. They are based on an average annual "turnover rate" for existing home components. The average assumed life for those components—15 years for central A/C and heat pumps, 18 years for forced-air furnaces; 30 years for boilers, windows and roofs; and 50 years for siding—are based on a life-expectancy analysis conducted for the U.S. National Association of Home Builders (see: NAHB. *Study of Life Expectancy of Home Components*. 2007.) That analysis was based, in turn, on interviews with industry representatives. Note that in some cases—such as for roofs, because the life expectancies of different types of roofs vary considerably—it was necessary to estimate a weighted average based on the authors' best judgment. Assumptions about the saturations of central A/C and different heating systems are based on the 2005 Residential Energy Consumption Survey (see: EIA. *2005 Residential Energy Consumption Survey*. 2008.)

[44] Potentially moving the thermal boundary of the home to the roof itself if there are ducts in the attic, extending eaves so that wall could be built out later, etc..

moderately deep treatment of single family homes (e.g., 50% heating savings) is $20,000, the cost of treating half of the single family homes in the U.S. would be approximately $850 billion. Residential building owners are going to need help in making such investments. Evidence from a variety of efficiency programs suggests that both a reduction in the initial cost (for example, through some form of rebate) and the ability to finance repayment at attractive terms will be necessary to achieve the kind of depth of savings and breadth of participation needed. For low-income households, it may well be necessary to pay for most of the up-front investment, sometimes all of it.

Put simply, a public-private partnership, whether formal or informal, will be necessary to fund efforts to achieve aggressive goals in this market. Experience with a variety of U.S. energy efficiency programs over the past couple of decades suggests that the average public contribution to the funding of efficiency investments for non-low income households needs to be on the order of at least 25% to achieve savings on the order of 20%-35%, with the balance being leveraged from the private sector (either the householder's own financial resources or their lender's source of private capital.)[45] Some types of investments will require more public support, others less. This level of support will be a function of several factors including how quickly the bill savings will pay back the investment, the magnitude of non-energy benefits, the effectiveness of non-financial elements of a program (e.g. marketing, technical support, etc.), and other factors.

Great Britain's experience to date with home retrofits indicates that a much higher percentage of subsidy (public capital) to private investment may be required to deliver deep retrofits to the existing housing stock, especially when solid wall insulation is included in the mix. In a 2010 report, the government reports that under the "CERT" program (Great Britain's program for delivering home energy efficiency measures via an energy supplier obligation), homeowners have typically been willing to invest 30% of standard insulation costs (e.g., loft and cavity wall), and the other 70% was paid for by the obligated energy supplier, ultimately to be passed through to all energy consumers via higher retail energy rates. The report suggests that even with a pay-as-you-save financing scheme in place, an overall public-private split on the order of two-thirds/one-third may be required to achieve broad uptake of more extensive insulation (e.g., solid-wall) in order to meet the government's 2020 savings targets for the sector, especially to reach those unable to qualify for financing.[46]

A subsequent analysis of Great Britain's "Green Deal" proposal to help households and smaller business make energy efficiency investments comes to similar conclusions—that for many investments in comprehensive residential retrofits to break even over 25 years, a substantial injection of subsidy in the form of cash grants, interest rate subsidies, or both will be required.[47]

Principle 5: The Strategy Minimizes Confusion in the Market

Society in developed countries has become increasingly fast-paced. Consumers are exposed to thousands of marketing messages every day: they are also typically extremely busy with a range of work, family, community, and other obligations. As a result, the transaction costs of understanding the efficiency potential in their homes and how to address it are a serious obstacle for many. To be effective, a strategy for encouraging discretionary retrofit efficiency investments must put a premium on simplicity and clarity of message and process.

One option is to employ one-stop shopping to simplify the agreements, language, and processes for consumer and contractor participants.[48] Wisconsin's "Focus on Energy" information portal, with access to services and program offerings, is one example of a consumer-friendly, one-stop shop created for this purpose.[49] If, instead, a variety of efficiency service providers bring their own messages to the market, it will likely be important to create a centralized, trusted reference to which consumers can turn for information on such issues as savings claims for different efficiency measures. It may also be useful to leverage the

[45] For example, Maine's home retrofit program had an average job cost of about $9700, average rebate of about $2600, and average heating savings of about 36%. Efficiency Maine. *2010 Annual Report.* 2011.

[46] HM Government. *Warm Homes, Greener Homes.* 2010. pp. 30-33.

[47] Holmes. *Financing the Green Deal: Carrots, Sticks and the Green Investment Bank.* 2011.

[48] See, for example, Quantum Consulting, Inc.. *National Energy Efficiency Best Practices Study.* 2004.

[49] Wisconsin Focus on Energy. 2011.

growing reliance on social media to enable consumers to get information on retrofit contractors, much like "Trip Advisor" has become an increasingly important consumer reference for the quality and value of different hotels around the world.[50] For example, the website for Efficiency Maine's Home Energy Savings program has a search tool that lists all certified "advisors" within a certain distance of the consumer's location and provides information on the number of retrofit projects they have completed, their customer satisfaction score, which services they sell, and whether they have financing available.[51]

Whichever the approach(es), a successful whole-house retrofit strategy will need to minimize confusion in the market.

Principle 6: The Strategy Includes Voluntary Programs *and* Complementary Regulations

Experience from around the world suggests that it will not be possible to grow the retrofit market anywhere close to fast enough to comprehensively treat half of all homes in a decade (or even two decades) through purely voluntary market development programs.[52] To be sure, there are examples of initiatives such as the Hood River, Oregon project in the 1980s that succeeded in treating efficiency opportunities in as many as 85% of homes, relatively quickly and at least somewhat comprehensively. But the scale of those initiatives was intentionally small and involved offering free installation of efficiency measures to participating customers. We assume it will not be financially or politically possible for governments (i.e. taxpayers) or utilities (i.e. ratepayers) to fully fund widespread comprehensive home retrofits on the scale envisioned in *Roadmap for the Future*. There is certainly no evidence to date to contradict such an assumption.

At the same time, we expect that, in the near term at least, it will not be politically possible to simply mandate that homeowners make deep efficiency retrofits and leave the market to develop the delivery infrastructure to deliver on such mandates. Again, there is no evidence to date of such an approach being considered outside of the worst energy performing homes in private rented building stock.

Thus, some combination of voluntary (for homeowners) and regulatory initiatives will likely be necessary. Perhaps just as important, a strategy that combines voluntary and regulatory approaches (e.g. both building labeling/disclosure requirements and ultimately minimum efficiency standards for existing buildings) is likely to be more effective. This is because regulation, by definition, establishes minimum requirements. Voluntary programs, on the other hand, can be used to explore the frontiers of what might be possible, increase product availability in the marketplace, raise customer awareness, enable contractors to perfect installation techniques, etc.

Ultimately, by testing new approaches and achieving large enough "market shares" to demonstrate that such approaches can be adopted across an entire population, voluntary programs can help to define what the next generation of regulation can require. In the U.S. over the past decade, that has been precisely the experience with the interplay between voluntary efficiency programs and both state and federal building codes and appliance efficiency standards.

Principle 7: The Strategy Delivers through Performance-Based Obligations

Across North America and Europe, a variety of different models for delivery of efficiency initiatives have been tested over the past couple of decades. These include delivery by retail energy suppliers, by distribution utilities, by competitively selected energy efficiency service companies, and by government agencies. While no one model has been clearly demonstrated to be the best or ideal for all circumstances, some important lessons can be drawn from this experience. Most fundamentally, the evidence strongly suggests that assigning full responsibility for meeting goals to one or more market entities (what we call the "obligated entities") and establishing strong financial and/or other

50 Trip Advisor. 2011.

51 Efficiency Maine. *Find A Participating Energy Advisor.* 2011.

52 "Voluntary market development programs," as the term is used in this paper, describes all programs that do not involve regulatory requirements on homeowners—that encourage but do not require homeowners to make efficiency investments. This includes programs run by regulated utilities or other energy suppliers that may themselves be operating under regulatory obligations (e.g. white certificate schemes or Energy Efficiency Portfolio Standards).

incentives for meeting goals (what we call a "performance-based obligation") are both critical to success.

A range of factors should be considered when deciding who should be assigned these obligations. They include mission alignment, the ability to bring a multi-fuel perspective to the work, real or perceived conflicts of interest, the ability to establish and/or maintain consumer trust, the ability to create effective partnerships with the efficiency supply chain and other parties, and the ability to react quickly to market feedback. Each of these will be discussed in detail in Section VII.

The specifics of the nature of the obligation are also critically important. An examination of those that have been most successful in energy-efficiency delivery suggests a number of key success factors. These are discussed more extensively in Section VII, but can be summarized as:

- **Getting goals right.** Goals should focus on ultimate outcomes and be simply stated, quantitative, and measurable. Constructing a set of quantitative performance indicators to measure progress toward and achievement of goals is highly useful for this purpose. It is essential that the goals and associated indicators drive performance toward both short- and long-term objectives for energy savings and carbon reduction.

- **Flexibility in meeting goals within policy parameters.** To be accountable for results in achieving goals, obligated entities need the flexibility to design, implement, and refine strategies and services as best they see fit. If something isn't working, they need to be able to stop doing it: if they see a new, time-sensitive opportunity, they need the freedom to pursue it. It may also be appropriate for government to place some policy-based parameters around that flexibility. For example, for equity or other reasons, government may want to ensure that a minimum portion of the savings is achieved in low-income homes. Similarly, while obligated entities need to have responsibility for all aspects that lead to results—from development of strategies to marketing and promotion, ongoing refinement, day-to-day operations, tracking and reporting—it may also be an appropriate government policy to limit their ability to profit directly from the sale of efficiency services.

- **Accountability and independent assessment of performance.** To achieve results, the structure for assigning responsibilities to obligated entities, whether a contract or other form of appointment, needs to support and reinforce its accountability. Irrespective of which mechanism is chosen, there need to be meaningful consequences, such as compensation hold-backs, penalties, and/or incentives tied to goals. Clarity on how achievement of goals will be measured is required at the outset, and thorough assessments of those achievements must be conducted by agents that are independent of the obligated entities.

Principle 8: Government Commitment to the Strategy is Strong and Stable

It will not be possible to significantly grow the market for residential whole house retrofits unless many existing businesses are prepared to adopt new business models, and entrepreneurs are prepared to create and invest in new businesses. Both will require confidence that the overarching policies will remain in effect well into the future. Government commitment to the long-term objectives, voluntary initiatives and regulation, other core elements of the strategy, and the funding necessary to support them must be seen as stable.

Government can signal this commitment through a well-conceived, clearly articulated policy framework which recognizes that end-use energy efficiency improvements are a low-cost, zero carbon heat and power resource that benefits all customers, regardless of the physical premise where the efficiency measures are installed. In particular, government policies and funding decisions will need to recognize that efficiency improvements in the built environment represent energy system infrastructure that delivers low-cost, low-carbon energy resources to the benefit of the economy as a whole.

As was discussed under Principle 4, a successful whole-house retrofit strategy will require a public-private investment partnership: neither public revenues nor the private resources of individual building owners will be sufficient on their own to realize the full economic potential of energy efficiency. For this partnership to be successful, government will need to bring a sufficient and stable contribution of public capital to the table. As will be discussed further in Section VII, we further believe there are compelling advantages to obtaining funding from broad-based system charges such as distribution tariffs or carbon pricing revenues.

From Principles to Detailed Strategy

It is beyond the scope of *Roadmap for the Future* to present a full, detailed residential retrofit strategy that incorporates all the principles described above. Indeed, we fully recognize that strategy details will need to vary somewhat between jurisdictions based on local market conditions and other considerations. The key is that there should be a well-developed, over-arching strategy that fully encompasses the eight principles outlined above.

In the following sections we provide additional guidance and design recommendations in four key areas. First, we describe what experience to date tells us should be the key elements for a residential retrofit market development program that is massive in ambition and comprehensive in scope. Next, we discuss the regulatory complement to voluntary programs that will be necessary to create sufficient "demand-pull" in the market, and the interplay between these two.

We follow with a closer look at a strategy design for going deeper in retrofit treatment at each premise over time, highlighting the need for a new approach to comprehensiveness in building retrofit. Finally, we discuss the elements of a delivery structure that will be capable of delivering all elements of a successful residential retrofit strategy, making the case for establishing a performance-based obligation for meeting long-term goals on one or more market entities.

IV. Designing a Successful Market Development Program

While a well-conceived policy framework is necessary to address the residential market, it is no guarantee of success. Good policies must be accompanied by a residential retrofit market development program that is massive in its ambition and commitment, comprehensive in scope, and nimble in execution. In this section we outline the key design elements for successful market development, based on experience to date. As will be described in Section V, the market development program should be designed in tandem with mutually reinforcing regulations.

Key Program Design Elements

To be successful, any program design must comprehensively address all major market barriers to adoption of efficiency, as well as take full advantage of market opportunities. As noted above, the barriers to residential retrofit efficiency investments are numerous and complex, as are the efficiency opportunities. Thus, an effective program strategy will also need to be multi-faceted. At a minimum, the following program elements are likely to be essential:

- Technical training and certification of retrofit contractors
- Retrofit advice to consumers
- Marketing to drive both demand and the supply-chain
- Rebates and other cost discounts
- Innovative financing products
- Quality assurance, possibly including guarantees
- Investment in research and development
- Building efficiency labeling

We discuss each of these key elements in greater detail below. In doing so, we recognize that many jurisdictions operate residential retrofit programs in parallel with other efficiency programs targeted to the residential sector. Examples include programs promoting removal of old, inefficient refrigerators or freezers and programs promoting the sale of efficient heating and cooling equipment. In addition, many jurisdictions have stand-alone programs promoting customer-sited renewable energy (e.g., rooftop photovoltaics). Efforts to integrate such programs – particularly their marketing and promotion – with residential retrofit initiatives will be critical to achieving the efficiency and carbon reduction objectives for this sector at least-cost.

Technical Training and Certification for Retrofit Contractors

The need for technical training is driven by several inter-related factors. First, maximizing the efficiency savings realized from a home while ensuring health and safety issues are simultaneously addressed[53] requires sound understanding of a wide range of efficiency measures, building science, and how the house operates as a system. Second, experience in numerous jurisdictions suggests that few private sector contractors currently selling HVAC, insulation, or other efficiency services have sufficient technical training or knowledge to diagnose or treat a full range of residential efficiency opportunities. Indeed, many do not even have sufficient training to ensure that they install their own products properly. For example, numerous studies in the U.S. have demonstrated that most central air conditioners and heat pumps are improperly sized, have inadequate airflow over the coil, and incorrect levels of refrigerant—all of which adversely affect operating efficiency.[54]

Moreover, experience also suggests that most contractors

[53] Examples would include addressing cracked boiler heat exchangers, potential for back-drafting of fossil fuel appliances, mold issues, etc.

[54] Neme, et al. *Energy Savings Potential from Addressing Residential Air Conditioner and Heat Pump Installation Problems.* 1999.

do not take the time to make sure that customers know how to use the installed equipment most effectively to realize the savings. Finally, the existing contractor infrastructure is just a small fraction of the size it would need to be to treat a significant portion of the housing stock over the next decade or two.

In the United States, efficiency programs in most states rely on certifications by the Building Performance Institute (BPI) as the best available indicators that retrofit contractors are sufficiently trained and knowledgeable. BPI offers a number of different certifications, including building analyst, envelope, heating, air conditioning and heat pump and multi-family.[55] The average technician has between two and three certifications, as no one certification would be adequate to comprehensively diagnose and treat all efficiency opportunities.

Table 2 provides estimates of the number of technicians certified as of early 2009 by BPI. Data are provided for the U.S. as a whole, as well as for each of the 10 states with the largest number of certifications per million households. Vermont has the most certified technicians per million households, with a little more than 400. Only one other state, New York, has more than 100. The national average is fewer than 30. We estimate that if a jurisdiction adopted a goal of achieving 25% to 35% energy savings in half of all homes within 10 to 20 years, it would need roughly 500 to 1,000 well-trained technicians for every million households.[56] More would be required if deeper levels of savings were to be achieved.

With one exception, the BPI data indicates that even the leading jurisdictions in the U.S. would need to increase their capacity by at least a factor of four to meet aggressive retrofit goals. Nationally, capacity would need to be increased by a factor of at least 20. Anecdotal evidence suggests the same need to build the industry exists in other countries as well.

***Table 2:* Certified Residential Retrofit Technicians: U.S. Average and Top 10 States**[57]

State	Estimated Individuals with Certifications	Households	Estimated Individuals with Certifications per Million Households
Vermont	103	248,825	415
New York	908	7,114,431	128
New Jersey	310	3,141,956	99
Oregon	120	1,425,340	84
New Hampshire	41	497,054	82
Maine	43	542,158	79
Alaska	14	233,252	60
Indiana	140	2,443,010	57
Connecticut	70	1,323,838	53
Rhode Island	18	406,089	45
U.S. Totals	**2,962**	**111,090,617**	**27**

Needed to Treat 50% of Homes in 10 Years: ~500 to 1000

As discussed above, technical training (though perhaps less comprehensive) and assistance in product development or product "bundling" should also be extended to vendors of HVAC equipment, windows, roofs, siding, and other products whose sale can serve as potential "on ramps" for at least partial retrofits of homes.[58]

For the reasons discussed above, a well-coordinated effort to continually assess and address training needs should be undertaken in designing a residential retrofit

[55] BPI. *Prove Your Worth.* 2011.

[56] If the goal is to treat half of the housing stock over the next decade, that translates to an average of 33,333 homes per year for every million in the jurisdiction. If a weatherization job takes a two-person crew an average of 5 days to achieve 25%-35% average savings, and the average person works about 230 days per year, the average two-person crew can treat 46 homes per year if they did nothing other than efficiency retrofit work. 33,333/46 = ~725 two-person crews needed. We assume here that a two-person crew would need to have one well-trained technician and another less well trained person whose work is overseen by that crew leader. Add to that the number of individuals needed to diagnose and sell the efficiency services, perform quality reviews or inspections, train staff, etc. Achieving deeper levels of savings will also increase the need for well-trained technicians.

[57] Estimates of the number of individuals with at least one BPI certification, calculated as follows: Total certifications (data from BPI) divided by 2.5 (our estimate of the average number of certifications per individual). Note also that BPI certifications are not a perfect proxy for the number of sufficiently trained technicians. While many states rely on BPI, California, Wisconsin and perhaps others have their own systems that are intended to serve similar functions. If their well-trained contractors were counted, one or more of these states would also likely be in the top 10.

[58] Assuming that such partial retrofits can be done in a way that is consistent with achieving deeper savings at a later date. See Section VI.

strategy capable of meeting the climate change challenge. Otherwise, the risk is high that there will be a backlash, as the supply of qualified retrofit contractors fails to keep reasonable pace with increased demand for services as rebates or other cost discounts, financing and regulations roll out under an ambitious retrofit strategy.[59]

Moreover, if a retrofit program is to rely on the private sector to deliver services, it is important to have not only well-trained contractors but also a way for consumers to easily identify them. Quality contractors will also need a way to differentiate themselves in the market. One of the critical lessons from numerous efficiency programs over the years is that success is usually dependent, in large part, on making participation easy for consumers. A corollary to that lesson is that the program needs to keep messages in the market as simple and clear as possible, e.g., "hire contractors on this list." Finally, the creation of a massive residential retrofit market will require numerous existing firms to change their business model and commit themselves to retrofit work as the core of what they do. Before they make such changes, they will need to be convinced that they can make money selling retrofit services, and ideally make more money if they sell quality services that require well-trained staff. Critical to addressing all these needs is certification of technicians and, ultimately, accreditation of businesses that employ certified technicians (and meet other good business practice requirements).

Who Can Be a Retrofit Advisor?

Efficiency program practitioners have debated for years about who should be advising consumers. Some argue that it is critical that advisors not sell retrofit services so that they can be seen as independent and trusted by consumers. Others argue that requiring an independent advisor simply increases transaction costs for consumers and makes it more difficult for contractors to sell their services.

The best approach may be a hybrid – allow contractors to perform assessments but give consumers the option of getting independent help. This may better reflect differing consumer needs and contractor capabilities. However, contractor assessments need to be independently monitored by sampling for quality and accuracy.

Retrofit Advice to Consumers

Retrofit efficiency investments are not an easy sell. Unlike replacement of a water heater or furnace when it fails, most retrofit services are discretionary purchases. Moreover, efficiency investments are usually not as visible as other major home improvements (including solar panels) and therefore provide no "show off" value in the neighborhood or larger community. Most importantly, most consumers have no real understanding of the benefits of efficiency investments, including which measures bring the greatest savings, the potential for mitigating the risk of future fuel price increases, or numerous non-energy benefits such as improved comfort, improved building durability, and health and safety improvements. Knowing where to acquire this understanding and finding the time to do so creates another significant barrier to taking action.

Experience with these and other challenges of selling efficiency retrofits suggests that many consumers could benefit from a retrofit advisor. Moreover, as discussed in this paper, it is important that retrofit efficiency programs achieve as deep savings as possible at each premise, or at least develop a long-term plan for staged retrofit investments to achieve deep savings. Retrofit advisors can play a potentially pivotal role in developing these plans with the consumer.

A number of programs have experimented with different approaches and roles for such advisors. In its original incarnation, for example, the Canadian national program provided financial incentives for the installation of retrofit measures only if the home was independently assessed (including production of an energy rating) both before and after any work was performed. Subsidies were provided for these assessments. However, the assessors were precluded from having anything to do with the retrofit work performed: they could not recommend specific equipment, products or contractors. While this approach had the advantage of providing consumers with independent advice they could trust, it did nothing to reduce the transaction costs that consumers face in identifying and managing retrofit contractors. It actually created extra complexity, by adding additional steps to the process of getting work done.

[59] Goldman, et al. *Energy Efficiency Services Sector: Workforce and Training Needs*. 2010.

As a result, the fraction of initial assessments that turned into completed jobs was lower than hoped. It increased substantially when the program design was changed, and sellers of retrofit services were permitted to conduct the assessments themselves.[60]

Other initiatives in Washington, Wisconsin, New Jersey, and elsewhere have recently experimented with using advisors to sell efficiency retrofits to consumers, arrange for specific contractors to do the work, and even provide or arrange for quality assurance inspections of work performed.[61] In a sense (and to varying degrees), they functioned as both sales people and general contractors for the work performed. While these approaches appear to have had some success at generating consumer investments in retrofits, they have also proved to be fairly expensive.

These and other experiences suggest that further experimenting with the best way to provide the "retrofit advisor" function is needed. It may well be that a combination of approaches will be necessary and that the approaches should evolve over time. For example, while experience in North America suggests that many contractors, including (and sometimes especially) those with good technical credentials, do not have great sales skills, some are quite sophisticated and effective in communicating with consumers about retrofit efficiency investments. Ideally, the number of contractors capable of playing the retrofit advisor role would grow over time. For other consumers, lack of trust in contractors—even if they are good communicators—may make it advantageous to provide independent support.

Regardless of who performs the advisory function, experience and behavioral research emphasize the need for assessors to employ communication and marketing techniques that can motivate home energy action. Assessors will need access to marketing materials and other tools tailored to this purpose, training on how best to use them, and knowledge of the fundamentals of good sales techniques (such as offering consumers the choice of "good," "better," or "best"). To be most effective in achieving its goals, a market development program for residential retrofits should include sales training for assessors that draws on the lessons learned in this field.[62]

Marketing to Drive Demand and the Supply-Chain

A well-conceived, well-funded, long-term marketing campaign will be important to any effort to achieve aggressive goals for a residential retrofit initiative. As noted above, efficiency retrofits are difficult to sell for a variety of reasons. Initially, a marketing campaign will serve two critical and interconnected purposes. First, it must educate and motivate at least a segment of the public. Second, it must drive business to those accredited contractors with quality staff and standards in place.

The marketing strategy will need to be particularly well-considered and managed at the outset of any new retrofit initiative. Experience in New York State showed that many contractors were hesitant to get their workers certified, get their businesses accredited, purchase diagnostic equipment, and develop new marketing materials, etc. until they had some assurance that there were enough consumers for retrofit services to justify changing their business model. This created difficulties at the beginning of the program, with the program needing to drive consumers to businesses that were in short supply because contractors wanted to see demand before they invested in a retrofit business. The program had to be very careful to control the marketing "throttle" so that demand for retrofit services was high relative to the capacity to deliver, but did not significantly outstrip existing contractor delivery capacity.

The marketing strategy should also explore opportunities for leveraging social networks to drive demand. This can include leveraging neighborhood groups, church groups, environmental groups, community leaders, and any other ways in which potential consumers connect with others. By definition, those connections involve a level of trust that sellers of services do not typically have with their consumers. Moreover, community groups are often manifestations of individuals' collective interest in being part of something that advances the common good. Thus, working with or through community groups will make it easier to reach consumers.

There have been a number of successful community-based efficiency initiatives over the past couple of decades,[63] though most have not focused on whole-house retrofits.

[60] Id. footnote 30.

[61] See Ramel & Reisman. *The Community Energy Challenge.* 2010 and Van de Grift & Schauer. *A Hand to Hold.* 2010.

[62] See, for example, Shipworth. *Motivating Home Energy Action.* 2000.

[63] Hewitt, et al. *Recommendations for Community-Based Energy Program Strategies.* 2005.

A number of new community-based programs focused on whole-house retrofits are currently pursuing highly creative social marketing strategies that may provide useful lessons for future efforts. For example, a program in Charlottesville, Virginia, is currently sponsoring a competition between local non-profit organizations, with prizes provided to those that "deliver" the greatest number of program participants.[64] Another interesting idea currently being tested in Portland, Oregon, is the use of schemes to aggregate (through buying clubs or co-ops) retrofit investments.[65]

Rebates or Other Cost Discounts

For the reasons discussed under Principle 4, the availability of rebates or other cost discounts will be key to a successful strategy to deliver mass-scale, whole-house retrofits. In addition to the critical role they play in addressing financial barriers, rebates and other cost discounts serve as an important complement to the marketing strategy, particularly in the initial launch of a retrofit program. Their availability provides retrofit contractors with a compelling "hook" for discussing efficiency investments with consumers. In addition, the fact that the rebate is being offered by an organization that consumers trust—whether a utility, government agency, or whatever other program sponsor is leading the initiative—lends credibility to the notion that there is value in pursuing retrofit work ("if it wasn't worth considering, why would such an organization offer a rebate for the work?"). This is particularly true if the rebate is linked to a government tax rebate as in France, where the tax breaks available for gas boiler replacements have led to that measure dominating the energy savings in the first phase of their certificates.[66]

The design details of these financial incentives will also be very important. Among the issues to consider are:

- **What is rebated?** Some programs in the past provided substantial (in some cases, 100%) subsidies for audits. When these were not tied to completion of retrofit work, the result was often very large numbers of audits whose recommendations were not heeded. Many programs now subsidize audits, but only if retrofit work actually follows. Given both the potential value in developing long-term retrofit strategies for homes discussed above and the typical practice today of not developing such plans, similar incentives for the development of long-term plans may also be appropriate. Rebates should also be directed at the actual installation of efficiency measures.

- **Structure of efficiency measure rebates.** A variety of programs have experimented with different incentive structures, including "a la carte" incentives for individual retrofit measures; paying per point of improvement on an energy rating scale; offering rebates only for those jobs that meet certain "comprehensiveness thresholds"; and tiered structures that offer small incentives for modest investments and much higher incentives or bonuses for more comprehensive jobs involving multiple measures. There is evidence that pure "a la carte" incentive structures can lead to less comprehensive jobs.[67] There is also evidence that structures that provide larger incentives for going deeper tend to be effective in driving program participants in that direction.

- **Size of rebates.** The rebate for retrofits needs to be large enough to be seen as significant – probably at least on the order of 25% of the cost of the efficiency retrofits, and higher for more comprehensive or deeper retrofits. On the other hand one must be careful, as with a marketing campaign, not to make rebates so rich as to create too much demand for the size of the accredited contractor delivery infrastructure, otherwise the program can have the unintended consequence of driving up prices for retrofit services. It is also important to recognize that selection of program rebate levels should depend in part on any related government tax incentives and the attractiveness of financing. Rebates can be lower where such complementary features are also in effect.

[64] The idea is that the "winning" non-profit will receive a free energy efficiency assessment and then follow up retrofit investments for its own buildings.

[65] Thus far, the aggregation has focused exclusively on solar PV installations. However, the city plans to explore this year how to adapt that model to efficiency. M. Johnson, Energy Trust of Oregon (personal communication, April 2011).

[66] Indeed the French energy suppliers have not directly subsidised gas boilers, relying on marketing the tax break at a time of boiler replacement. See Lees. *European and South American Experience of White Certificates.* 2010.

[67] See Canadian chapter of Hamilton, *Id.* footnote 30.

- **Changes over time.** It may be possible to reduce financial incentives after an initial program launch has succeeded in getting the market going. Any such changes will need to be part of a program evolution that looks at the mix of strategies in an integrated way and is based, to the degree possible, on feedback from the market.

Innovative Financing

As discussed above, the costs associated with deep efficiency retrofits are substantial. As a point of reference, the majority of deeper, comprehensive retrofits will likely cost on the order of $10,000 to $20,000 (or more) in the U.S. Many homeowners will need financing to undertake these projects. Moreover, while financial incentives can and should be used to reduce the first-cost barrier to homeowners, significant increases in both the number and depth of retrofits will require innovative financing instruments to bring more private capital to the table.[68]

The success of standard financing products in supporting residential retrofit programs has been very limited. One reason stems from the fact that those most in need of financing are generally ineligible due to lack of adequate credit. Another is the short financing term relative to typical payback periods required to provide positive cash flow to consumers and lenders from retrofit investments (on the order of 20 years). In addition, there may be considerable risk that the homeowner will not own the home long enough to recoup the benefits of the investment. This risk arises from a combination of factors, including uncertainty over the value of the efficiency investments (on the part of both buyers and lenders) and the inability to transfer the repayment obligation to new owners under most financing products.

In recent years there has been a flurry of interest in innovative financing products that address many of these issues. Mortgage products (i.e., refinancing to finance retrofits, and time-of-sale Energy Improvement Mortgages) and home equity loans have an unrealized potential to help in certain portions of the market, particularly if these products are developed and aggressively marketed. Of particular note has been widespread interest in the U.S. in property-assessed clean energy (PACE) financing. Under this mechanism, municipalities provide funds for energy retrofits with repayment obligations over long terms (e.g., 20 years) through an assessed fee that is tied to the property, rather than the property owner; if the owner moves, the new homeowner assumes the repayment obligation. However, a recent decision by the Federal Housing Finance Agency said that any such programs that treat energy retrofit loans as first liens do not meet the financial requirements of federal mortgage banks Fanny Mae and Freddie Mac, which has effectively stopped development of this mechanism in many U.S. communities.[69]

Electric and/or gas utility on-bill financing has drawn interest for similar reasons, as have the type of purchased-power agreements that have been pioneered with renewable energy systems. The city of Portland, Oregon, has just completed a pilot program (and is now launching a full-scale program) in which it arranged for retrofits to be financed for up to 20 years on the customer's utility bill.[70] The U.K. is also currently exploring the potential for "green deal loans" whose repayment obligation would be attached to the property meter rather than individual homeowners.[71] Germany has one of the longest standing loan programs for residential retrofits. It is run and effectively promoted by the Kreditanstalt für Wiederaufbau (KfW) Förderbank, which is owned by the German government and its states, but all lending is done through a large number of local lending institutions. The KfW loan program has a variety of attractive features, including low and fixed rates, a 10-year term, the ability to finance 100% of the investment, the ability to combine the loan with other public funds, the possibility of repayment at any time with no extra charge, and waiving of up 15% of the principal if the estimated retrofit savings are sufficiently deep and certified by an authorized energy consultant.[72]

Further development and deployment of such financing

68 The challenge of attracting private investment capital and developing appropriate financing models for this sector is explored in *Financing Energy Efficiency Building Retrofits: International Policy and Business Model Review and Regulatory Alternatives for Spain.* 2010.

69 Some communities are treating PACE loans as second liens, but many communities are not willing to take the risk that property taxes would not be paid if the home-owner defaulted on the home mortgage. For a summary of the Fanny Mae and Freddie Mac actions and developments around PACE, see Zimring, et al. *Clean Energy Policy Brief: Pace Status Update.* 2010.

70 M. Johnson, Energy Trust of Oregon (personal communication, April 2011).

71 Department of Energy & Climate Change. *The Green Deal.* 2010.

72 Green Max Capitol Advisors. *Lessons Learned from Energy Efficiency Finance Programs in the Building Sector.* 2009. pp. 15-16 and 27-32.

strategies is not only useful, but likely to be essential to both massively ramp-up the number of retrofits and achieve deep savings.

Quality Assurance

Among the key market barriers to investment in home efficiency retrofit work is that consumers do not know which retrofit contractors to hire and do not understand or trust claims about the benefits of efficiency. Promoting both certified technicians and accredited contractors is important to reducing consumer transaction or hassle costs and addressing consumer uncertainty. However, it is not enough. Every residential retrofit program in North America that has checked on the quality of work being performed has found some substandard work and identified at least a few retrofit contractors who routinely fail to follow industry best practices. This occurs even under programs that promote only accredited contractors who employ certified technicians. It is also worth noting that all such programs have been on a much smaller scale and with much slower ramp-ups than is contemplated in *Roadmap for the Future*. A much larger program is likely to require much more quality assurance.

In some cases, substandard work is unintentional; the contractor will simply have missed something or misdiagnosed something. In other cases, work will be substandard because the contractor intentionally cut corners or worse. Either way, the result is likely to be lower levels of energy savings. Just as important is the damage that a reputation for poor quality can have on the prospects for achieving aggressive, long-term participation and savings.

The only way to head off such potential problems is to put in place a rigorous set of processes for ensuring that work being performed under the auspices of the program is of good quality. The leading practices include spot-checking of completed installations, with more intense scrutiny of the work being performed by contractors that are new to the program or those with a history of failing inspections. Contractors who routinely perform substandard work should ultimately lose program accreditation and be removed from the customer referral list. For political reasons, this has not always proven to be an easy thing to do. However, program experience in the U.S. and Europe suggests it is absolutely vital.

Research and Development

Much has been learned in recent years about both the technical opportunities for improving home energy efficiency through retrofits and the programmatic features that are important to growing the market for such investments. However, there is still a lot more to learn, particularly as we strive to obtain increasingly deeper levels of savings per home and treating an order of magnitude more homes. Therefore, investing in research and development should be an integral component of the residential retrofit strategy. Initial, short-term topics for research and development, covering both technical and market process issues, may include:

- **Air sealing opportunities.** Blower door testing to identify these opportunities is ubiquitous in North American retrofit programs, accounting for the largest portion of savings in many homes. However, there are questions about its applicability for retrofits in some European countries. For example, technical and regulatory concerns about the impacts of air sealing have been raised in the U.K. and as a result, testing for air sealing opportunities is not pursued to any significant degree.[73] Given the large potential savings associated with air sealing measures, it is important to fully assess and address these concerns.

- **Heat pump installations.** If space heating may ultimately need to be electrified (with electricity coming from a decarbonized power system), it will be increasingly important to pursue the most appropriate heat pump technologies and address associated installation issues. Research topics could include comparisons of the performance of ductless versus ducted systems and ways to minimize heat pump installation problems that can significantly affect operating efficiency.

[73] In the U.S., blower-doors are used to pressurize or depressurize a house in order to measure leakage rates and identify the most important opportunities for sealing leaks, such as plumbing or electric penetrations into attics. Current U.K. regulations provide barriers to air sealing due to prevailing concerns about humidity and air quality being compromised by the building envelope becoming "too tight." In addition, addressing these concerns via mechanical ventilation retrofits does not generally seem to be considered a practical option.

- **Deep savings measure packages.** Retrofit programs in North America commonly target and achieve average savings on the order of 20%-35%. There has been some testing in Europe and North America of much more aggressive "Passivhaus" retrofits. However, much more needs to be done to get to the point where measure packages capable of achieving 50% or more savings per home can be effectively mass-marketed. Similarly, to simplify both the home efficiency assessment process and the sale of efficiency measures following such an assessment, there may be value in developing "pattern books" or semi-standardized efficiency packages that would be routinely sold to homes with common attributes.

- **Streamlined audits and/or performance testing.** Thorough assessment of efficiency opportunities in homes is critical to maximizing savings. On the other hand, mass marketing of retrofit services demands that fixed costs, such as the cost of conducting energy assessments/audits, be minimized. There is some research currently underway in the U.S. into how to streamline audits and related performance testing without sacrificing (perhaps even improving) the quality of the information received.[74] However, more could be done in this area.

- **Improved marketing.** There are undoubtedly ways to more effectively market retrofit services that could be explored through research and pilot testing of new ideas. Social marketing approaches may warrant special attention.

- **Sales tools.** Once marketing has persuaded a consumer to seek advice about making a retrofit investment, the challenge will be to persuade them to choose as comprehensive a package of efficiency measures as possible. Research and pilot testing of different kinds of sales tools (e.g., different ways to present information to consumers) could be invaluable in meeting that challenge.

- **Relationship between efficiency and loan risks.** Research in several American cities has recently demonstrated that transportation efficiency—the amount of money consumers need to invest in transportation due to where they live (related to such factors as distance from work, accessibility of mass transit, etc.) —had a significant impact on foreclosure rates.[75] This work could to be extended to assess the impacts of building efficiency on loan risks, so that lenders can be educated and begin to more effectively factor building efficiency into lending practices.

Building Labeling

As discussed in more detail in the next section, building efficiency ratings and labels are essential components of any time-of-sale efficiency disclosure regulations. However, even in the context of a purely voluntary program they offer value to homeowners by giving them a credential they can market at the time of sale.

Mapping Strategies to Key Barriers

Principle 1 highlights the need to address all key market barriers in designing a residential retrofit strategy. Table 3 shows how the program elements described above will collectively address them.

[74] Earth Advantage Institute. *Energy Performance Score 2008 Pilot: Findings and Recommendations Report.* 2009.

[75] Henry. *Reducing Foreclosures and Environmental Impacts through Location-Efficient Neighborhood Design.* 2010.

Table 3: **Mapping Strategies to Barriers**

(Most important strategies in red)

	Tech. Training	Certification	Retrofit Advisors	Sales Training	Marketing	Cash Discount	Financing	Building Labels	Quality Control	RD&D
Consumers										
• Lack info on benefits of efficiency			■	■	■					□
• Difficult to differentiate good contractors from bad		■			□				□	
• Access to capital						■	■			
• Split incentives (renters)						■	■	□		
• Risk – Are savings real? Is cost recoverable at sale?			□	□	□	■		■	□	
• Transaction/Hassle costs		■	■	□	□	■				
• Efficiency not visible or “sexy”				□	□	■		■		
Contractors										
• Lack technical tools/skills	■									□
• Difficult to differentiate good contractors from bad		■			□				□	
• Weak sales skills			■	■						□
• Inadequate numbers, infrastructure	■	■			□	□	□	□		
Others										
• Lenders don’t value efficiency in appraisals								■		■

V. Regulations to Promote Whole-House Retrofits

Voluntary programs will not be able, by themselves, to drive enough homeowners to comprehensive retrofit investments in time to meet GHG emission reduction goals at least cost to society. Indeed, even community-based programs that offered retrofit services free of charge, as in the Hood River, Oregon program—something that no one is contemplating given the massive scale of retrofits required in the coming decades—left 15% of eligible customers untreated. Principle 6 recognizes that meeting GHG reduction goals at least cost will require regulations to complement aggressive, voluntary programs. The regulatory complement should ideally include all the following key components; or at a minimum, these should be introduced systematically over time.

1. **Product efficiency standards and labeling.** Regulations in this area should address lighting, appliances and other electric plug loads as well as key whole-house measures such as windows, heating equipment, and water heating equipment. This will ensure that a "floor" of efficiency is established over time for all major building components that are naturally replaced with some frequency. Standards should be made stricter over time. They should also address operating efficiencies under typical field conditions, which are often not well-addressed by current equipment efficiency ratings or standards. Many countries and regions have adopted product efficiency standards and labeling, and regulators and government can and should draw from leading practices around the world.[76]

2. **Building efficiency labeling and disclosure requirements at time of advertisement for sale.** Equipment efficiency standards address only some efficiency elements of a home. They need to be complemented by approaches that address home efficiency on a system basis, or at a minimum address the highly interrelated efficiency of home heating, cooling, and water heating. Requiring an assessment of the efficiency of a home and disclosure of the results to prospective buyers can send persuasive signals to the home market regarding the potential for and value of efficiency upgrades.[77] It is worth noting that European countries, Australia and some other jurisdictions now have several years of experience with efficiency labeling and disclosure requirements.[78] That experience highlights how labeling and disclosure requirements can move the market to value efficiency investments,[79]

[76] In particular, the Collaborative Labeling and Appliance Standards Program (CLASP) is a resource for international best practices on these issues. See http://www.clasponline.org.

[77] It may also be worth exploring other regulatory options, such as encouraging or obligating lenders to value efficiency when making loans for the purchase of homes.

[78] See http://www.buildingrating.org/ammap for information on efficiency labeling and disclosure policies around the world. The 2009 revised EU Directive on Energy Performance in Buildings will require an Efficiency Performance Certificate to be in place before advertising the property for sale or rent among all 27 member states.

[79] For example, in Australia, an improvement of one "star" (on a scale of 0 to 6 stars) in the rated efficiency of a home was found to increase the value of the home by approximately 3%, or about $9000. See *Australian Department of the Environment, Water, Heritage and the Arts. Energy Efficiency Rating and House Price in the ACT.* 2008. A study of the use of Energy Performance Certificates in the Netherlands concludes that efficiency labeling aided the marketing and selling of a property—particularly in areas of weak market demand—and that properties with an A, B or C certificate (i.e. more efficient homes) had a 2.8% higher sales price. See Brounan & Kirk. *On the Economics of EU Energy Labels in the Housing Market.* 2010.

as well as how implementation barriers can inhibit their effectiveness.[80] Several jurisdictions in the U.S. have also recently launched labeling and disclosure requirements, although most are focusing initially on commercial buildings. However, the city of Austin, Texas has been implementing a residential efficiency assessment and disclosure requirement since June 2010.

3. **Minimum building efficiency requirements at time of sale.**[81] Effective efficiency labeling and disclosure requirements should provide enough of an incentive for some home sellers and/or home buyers to make significant retrofit efficiency investments. However, experience to date suggests that only a modest portion of the market opportunity is likely to be addressed when follow-up on such efficiency assessments is purely voluntary.[82] Achieving widespread market penetration of substantial residential retrofits is likely to require that all homes put up for sale meet a minimum efficiency standard, focused particularly on the thermal envelope and HVAC systems of the building. Such requirements have been implemented on a limited scale in several U.S. cities.[83] For both practical and political reasons, time-of-sale or similar mandatory requirements to upgrade existing housing will probably need to be paced over time. Pacing could take the form of focusing on a particular subsection of the housing stock, and/or applying requirements initially to only the least efficient buildings. As the market becomes conditioned to such requirements and the infrastructure for performing the retrofit work becomes more sophisticated, the standards can be made gradually more stringent and broad-based. The point is that a successful retrofit strategy will recognize the pivotal role of mandatory standards for upgrading the existing housing stock, and develop an appropriate implementation timeline given the circumstances.

The interplay between the voluntary market development program discussed in Section IV and the regulatory requirements discussed above can be particularly important, not least because linkages between the two will clearly signal to market actors that regulatory action will be ratcheted up over time. Experience has also shown that the effectiveness of both can be maximized when designed together to be mutually reinforcing, in particular by synchronizing the rebates and other cost discounts offered under the voluntary program with the pacing of regulatory requirements.

In very general terms, the interplay occurs in this sequence: 1) minimum requirements are announced to come into effect in future year X, 2) rebates/cost discounts under the voluntary program are offered to assist homeowners in meeting the minimum requirements, along with higher incentives to induce them to go well beyond the minimum, 3) the offering of rebates/cost discounts for work to meet the minimum requirements are phased out by Year X, and 4) the experience with deeper savings from the voluntary program now supports future tightening of the minimum requirements in year Y: and this interplay between staged regulation and financial incentives continues.

80 The Buildings Performance Institute Europe (BPIE) recently reviewed the implementation of labeling requirements in 12 EU countries, and evaluated both successes and barriers to implementation. See Buildings Performance Institute Europe. Energy Performance Certificates Across Europe: From Design to Implementation. 2010. A specific example of implementation barriers is highlighted in a recent evaluation of Denmark's time-of-sale labeling and disclosure requirement, which documented that the requirements were not well enforced. Only half of home buyers actually received the disclosures. Kjaerbye. Does Energy Labeling on Residential Housing Cause Energy Savings? 2009. pp. 527-537.

81 Time of sale is not the only "trigger" to consider for requiring minimum efficiency improvements to existing buildings—but it is the one discussed most widely. Major renovations could trigger the requirements (and do in some US jurisdictions). In some cases, it may be appropriate to require efficiency upgrades to a minimum standard without any sale or renovation contemplated, especially for the least efficient buildings.

82 It is difficult to draw definitive conclusions on this point because, as the BPIE study referenced above demonstrates, lessons learned from the earliest efficiency labeling and disclosure requirements are only now beginning to be used to modify such policies so they can be more effective. However, decades of experience with efficiency programs suggest that efficiency information alone is not likely to be sufficient to produce both the breadth and depth of investment in home retrofits that is cost-effective. Also, preliminary data from the Austin, Texas disclosure requirement suggests that about 10% of the homes affected by the disclosure requirement have elected to make retrofit investments through the city's Home Performance with Energy Star program. T. Kisner, Austin Energy (personal communication, December 2010).

83 The cities of Berkeley, San Francisco, Burlington (Vermont), Memphis, and several other communities in the U.S. currently have such minimum efficiency standards for residential properties (in some cases, only rental properties). However, such standards are typically currently used to eliminate the worst inefficiencies rather than generate deep savings.

Figure 2 presents a conceptual depiction of the market penetration of whole-house retrofits under this type of integrated voluntary/mandatory strategy. The market penetration assumes that the voluntary market development program is launched in 2012, and mandatory efficiency labeling and disclosure requirements begin two years later (2014). An initial tier of minimum efficiency requirements at time of sale (level X) goes into effect in 2019, with a second, more stringent tier (level Y) becoming effective five years later in 2024. The "standard" financial incentives offered under the voluntary program are eliminated in 2019, when the initial level X requirements take effect and the "aggressive" incentives are eliminated when the more stringent level Y requirements take effect in 2024.

Figure 2 illustrates a cumulative market penetration of roughly 50% over 15 years. Slightly less than half of the retrofits are driven by time-of-sale minimum efficiency requirements, and slightly more than half are driven by the voluntary program (including a significant assist from time-of-sale labeling and disclosure requirements). Figure 3 provides a conceptual depiction of how average savings per retrofit would gradually increase over time under this scenario.

Figure 2: **Conceptual Forecast of Cumulative % of Homes w/Retrofits**

(With staged regulations and evolving financial incentives)

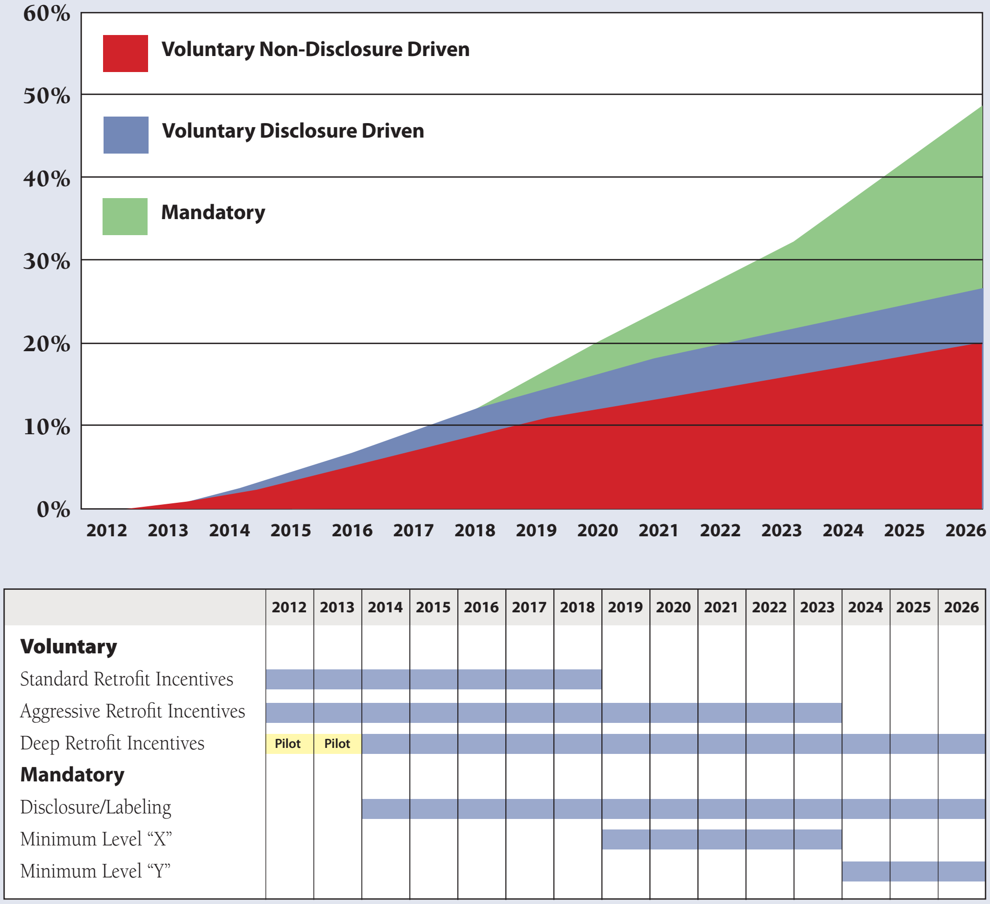
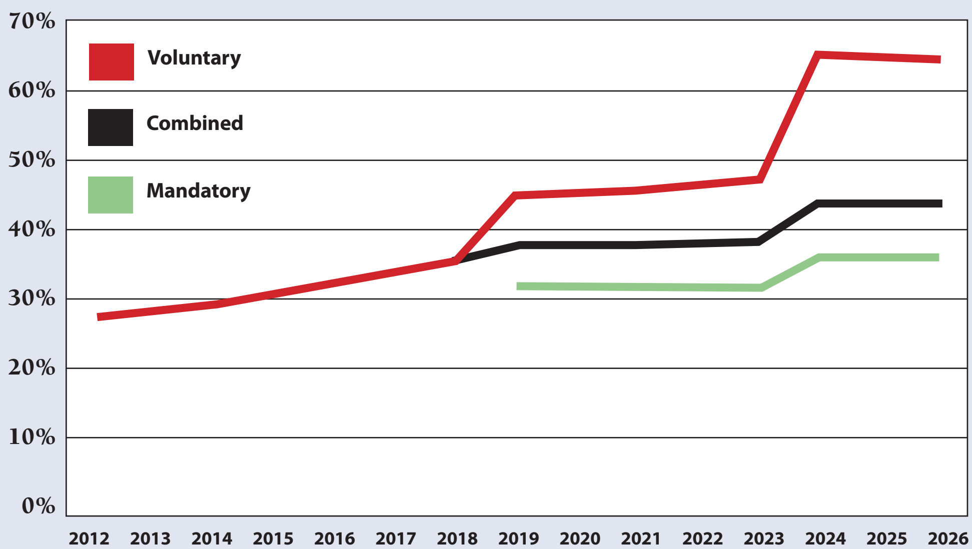


Figure 3: **Conceptual Forecast of Average Savings Per Retrofit**



We emphasize that Figures 2 and 3 rely on a simplistic scenario analysis developed principally for illustrative purposes, and necessarily based on a number of assumptions.[84] The details of the voluntary program design, the structure of the mandatory requirements, and the market's likely reaction to both will be more complex than depicted. For example, in the U.S. it may be important to separately forecast federally funded low-income retrofits rather than leave them bundled with other voluntary program retrofits. Similarly, the analysis of the impacts of a mandatory minimum efficiency standard at time of sale would need to be refined to capture the effects of a "cap" on the level of efficiency investment required of the home-seller that might be put in place to address unique difficulties associated with upgrading the efficiency of some homes. The analysis would also need to be more sophisticated in forecasting home turn-over rates – e.g. to reflect the fact that some homes will turn-over multiple times during the forecast period. Numerous other modifications to assumptions would also undoubtedly be warranted given local conditions.

Nonetheless, the scenario presented above has value in highlighting a couple of key points. First, it illustrates that *both* a well-funded, voluntary, market development program *and* regulations regarding the efficiency of existing homes will likely be necessary to retrofit half of all homes over the next decade or two – the time horizon many jurisdictions are currently considering. Second, it points to the importance of conducting an integrated forecast of this type to assess the likelihood that strategies put in place will achieve ultimate policy objectives. In particular, strategic planning – including decisions on the types of efficiency investments promoted and the nature of minimum efficiency requirements at the time-of-sale of a home – should be conducted with long-term cumulative savings objectives in mind, potentially well beyond a 10-year planning horizon.

84 For example, the analysis assumes that market penetration through the voluntary program will start at 0.25% in the first year, increase to 1.7% when the time-of-advertisement for sale disclosure requirements go into effect, and peak several years later at 2.7% (higher than any voluntary whole house program has achieved to date). It also assumes that 7% of the single family housing stock is sold each year (roughly the percentage in the U.S.), that the labeling and disclosure program will lead to 10% of home sellers or buyers not otherwise mandated to improve efficiency to invest in retrofits (consistent with preliminary data from the city of Austin, Texas). In addition, it assumes that the Tier 1 minimum efficiency requirements will cause roughly one-third of all homes being sold to make retrofit investments and that the Tier 2 minimum efficiency requirements will cause a little more than half of all homes being sold to make retrofit investments.

VI. Going Deeper: Tapping the Optimal Savings Potential of Each Home

In Section II, we described the need for a retrofit strategy to be both broader and deeper than ever before, in order to meet the level of ambition set out by many states and countries and, perhaps more importantly, to achieve the levels of GHG emission reductions necessary to stabilize the global climate at the lowest possible cost. The challenge of going deeper raises several cross-cutting issues that warrant further consideration. Chief among these are how to determine the "optimal" level of savings per home and also address the reality that few homeowners will be prepared to make a single investment of the magnitude necessary to achieve that level.

How Deep? Defining Society's Economically Optimal Level of Efficiency

The imperative of achieving 80% reductions in GHG emissions by 2050 puts a premium on making decisions about the efficiency measures to promote from a longer-term, societal perspective. This includes recognizing and minimizing lost opportunities —that is, minimizing the extent to which installing measures today renders achieving additional efficiency and associated carbon abatement impossible or less cost-effective, perhaps even *non* cost-effective, in the future (see Section III).

For example, the *Roadmap 2050* study projects that meeting 2050 GHG emission reduction goals will require switching the fuel used for home heating from natural gas to electricity supplied from a decarbonized power system. In this case, the determination of which measures are cost-effective should not be based on current natural gas prices or forecasts of gas prices in a world without GHG emission constraints. Rather, society's economically optimal level of efficiency should be assessed using forecasts of the marginal cost of electricity from a decarbonized power system (including the marginal cost of adding transmission and distribution system capacity) as the basis for comparison.[85]

As noted in Section II, we are unaware of an analysis that has forecast such marginal costs (or avoided costs as they are often termed in North American utility regulation) for a decarbonized electric power system to which building heating and personal transportation loads have been added. Such an analysis would be invaluable for efficiency program planners. However, as also discussed in Section II, there is reason to believe that the depth of retrofit savings that is cost-effective would be much greater than is typically promoted or achieved in programs today.

At a minimum, if the building owner is considering installing rooftop photovoltaic (PV), or other forms of clean, customer-sited generation, then the assessment of how deep to go with efficiency improvements from society's perspective should be based on a comparison of the cost per ton of GHG emissions abatement between the two. In other words, the economically optimal decision would be to continue to invest in retrofit efficiency improvements until the cost per ton of abatement for the next increment of savings just equals the cost per ton associated with the investment in rooftop PV.

Consumers' Inability to Make Deep Retrofit Investments All at Once

Even with attractive rebates and financing, many building owners will simply not be prepared to spend, at one time, what it would take to achieve the savings level

[85] Note that the *Roadmap 2050* study suggests that efficiency investments could significantly lower the total costs of achieving a decarbonized power sector for Europe by significantly lowering the level of investment that would otherwise be needed to expand the transmission and distribution systems under "business-as-usual" scenarios.

that is economically optimal in the context of 2050 GHG reduction goals. Therefore, while a home retrofit strategy must be designed to offer comprehensive treatments with the objective of achieving savings that are as deep as possible, it also needs to consider many consumers' inability to make the improvements all at once.

This requires a strategy that views the building owner as well as the building itself as an ongoing client, with the goal of achieving a comprehensive retrofit over time consistent with longer-term goals. The following principles provide guidance for development of this strategy:

- **Treat the house as an integrated system.** A systems approach to retrofits recognizes the significant interactive effects among various end-uses and efficiency measures that affect overall savings and carbon reductions. Decisions on energy systems can also have significant implications for other issues of concern to homeowners such as aesthetics, moisture problems, indoor air quality, and comfort. Programs that promote a systems approach to retrofitting homes are much more likely to both identify the ideal path for improving efficiency and address consumer interests and concerns.

- **Develop long-term energy retrofit plans for homes.** A long-term retrofit plan provides a blueprint for the staging of measures from an optimal efficiency investment perspective, while helping homeowners plan and pace their financial commitment as needed. The plan can also help to clarify to homeowners what an appropriate end point might be, factoring in not only energy efficiency benefits, but non-energy benefits such as improved comfort, building durability, sound-proofing, and indoor air quality as well. The plan could also benefit retrofit contractors by allowing them to develop an ongoing relationship with customers rather than treating retrofit jobs as one-time interactions. It could include both efficiency and renewable energy measures. Such plans could even be seen as individual, building-specific roadmaps to 2050 goals, such as near-zero carbon emissions.

- **Encourage the proper sequencing of efficiency measure installations.** Proper sequencing ensures that initial investments in efficiency put the home on a path toward achieving deeper savings in the future, rather than making it more difficult in the future (consistent with plans discussed in the point above). One example of an approach to encourage proper sequencing is reflected in the Prescriptive Whole House Retrofit Program proposed by the California utilities, which specifies the following retrofit measure loading order: (1) air sealing, (2) insulation, (3) HVAC system upgrades, (4) hot water system upgrades, and (5) renewables.[86] In the context of meeting aggressive GHG reduction targets, the sequencing of upgrades (hence, the loading order) may also need to take into account potential fuel-switching requirements for home space and water heating, as discussed above.

- **Encouraging as deep a treatment as possible for each measure pursued.** As described under Principle 2, decisions over the type of window to install, the amount of insulation to apply, and similar decisions for other measures being installed in a retrofit treatment can have major implications for the overall level of savings, and associated costs, for the building over time. In the context of achieving 2050 GHG reduction goals, the 2050 end point could guide such decisions. For any measure or building component that will last until 2050, the level of efficiency should be consistent with the levels of efficiency necessary to meet GHG reduction goals at least cost.

- **Encouraging bundling treatment of some efficiency measures.** Some efficiency measures are most effectively bundled together, rather than installed or evaluated for cost-effectiveness separately. For example, air sealing and insulation are ideally pursued together, as we discuss in Section III. Similarly, as thermal loads on a home are reduced, one should consider the potential efficiency (and possibly cost) advantages of simultaneously replacing individual heating and water heating equipment with right-sized, integrated systems. Therefore, the retrofit

[86] California Public Utility Commission. *California Investor Owned Utilities, 2010-2012 Energy Efficiency Portfolio Program Implementation Plan.* 2010. Base load reduction measures such as efficient lighting and appliances can be installed at any time.

strategy needs to encourage homeowners to invest in bundled measures where advantageous, and to reflect that bundling in the long-term retrofit plan. This also argues for moving regulatory cost-effectiveness requirements away from a measure-specific focus.[87]

- **Encourage moving as far into the retrofit measure loading order as possible during each treatment of the home.** Once it has been determined which measures are cost-effective in the context of 2050 GHG reduction goals, the strategy should encourage consumers to pursue as many of them as possible during each home retrofit project.

Focusing on longer-term objectives linked to GHG reduction targets represents a significant departure from—and likely conflicts with—many current strategies that are structured, intentionally or not, to maximize the amount of savings realized per home per dollar or euro spent today. To strike a better balance between short- and long-term objectives, policy-makers may need to revise or refine the policy frameworks underlying current strategies (e.g., utility GHG reduction obligations with or without tradeable white certificate schemes, energy efficiency performance standards, or reward systems). Indeed, many well-intentioned policies and strategies to achieve relatively short-term (annual or even 5 or 10-year) reduction targets are likely to lead to more "skimming," and more unnecessary raising of total long-term costs than appears to be expected or understood.

We discuss further the importance of "getting the goals right" in the following section.

[87] Wigington. *Staged Approaches for Deep Energy Reductions in Existing Homes.* 2010.

VII. Performance-Based Delivery for Mass-Scale Deep Retrofits

Achieving mass-scale implementation of deep residential efficiency retrofits will require a multi-pronged strategy that is focused on both driving demand and ensuring adequate technical and market capacity to deliver quality work. The delivery strategy will need to be responsive to market feedback, effectively communicated to consumers and other key market actors, and made as simple to participate in as possible. A successful strategy requires active engagement by a wide variety of market actors, including private-sector product and service providers, financing institutions, government authorities, community organizations and a host of market innovators that bring new ways of developing products, services, and messaging to the public.

Experience to date suggests that ***the most successful delivery strategies include a performance-based obligation on one or more entities in the market.*** Put another way, success can be clearly tied to both assigning responsibility for meeting energy savings goals and ensuring that there are consequences – financial and possibly others – for meeting or failing to meet those goals. It is notable that in the American Council for an Energy Efficiency Economy's (ACEEE's) "2010 State Energy Efficiency Scorecard," each of the five states that scored the highest in the effectiveness of their electric and gas utility efficiency initiatives have both energy efficiency savings targets (or comparable policies)[88] and performance-based contracts or regulations that provide financial incentives and/or penalties for meeting those targets.[89] Recent research on efficiency delivery structures in the U.S. finds that many jurisdictions experience immediate and substantial increases in efficiency investment following adoption of performance-based incentives tied to savings accomplishments.[90]

Similarly, a comparative analysis of two adjacent Canadian gas utilities, one which became eligible to earn shareholder incentives for success in promoting efficiency investments to its customers and one without such incentives, found that the energy savings generated by the utility eligible to earn shareholder incentives increased twice as fast as its neighbor.[91]

The combination of an obligation on responsible market actors with financial accountability for energy efficiency delivery appears to be a consistent, powerful driver for success in Europe as well. All major European obligations currently carry penalties for failing to meet targets.[92] To date, with the exception of one small electricity distributor in Flanders, all targets established for all obligated entities have been met.[93]

In short, all available evidence suggests that the approach of using a performance-based obligation is highly

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88 For example, a loading order policy that requires all cost-effective end-use energy efficiency to be added to the resource mix first, before undertaking investments in more costly supply-side alternatives.

89 See ACEEE. Energy Efficiency Resource Standards (EERS) Summary. December 2010. and ACEEE. 2010 State Energy Efficiency Scorecard. (Report E107). October 2010. Each of the 10 highest-ranking states listed in the 2010 Scorecard has adopted an energy efficiency resource standard or comparable policy, as described in these documents. Nine of the ten top-performing states have also put in place some form of positive financial incentive to reward performance, in addition to removing key financial disincentives to efficiency (e.g., through "decoupling").

90 ACEEE. *Carrots for Utilities: Providing Financial Returns for Utility Investments in Efficiency.* January 2011.

91 Neme, C. & Millyard, K. *Shareholder Incentives for Gas DSM: Experience with One Canadian Utility.* Proceedings of ACEEE 2004 Summer Study Conference on Energy Efficiency in Buildings.Volume 5.The paper presents several reasons why the impact of the shareholder incentive was likely even greater than the magnitude of the differences in observed savings would suggest.

92 See World Energy Council. *Case Study on Energy Efficiency Measures and Policies.* March 2010. Tables 1 and 2.

93 E.Lees. (personal communication, October 2010). Even in the Flanders case, the overall savings target was met; it was just the residential allocation that was not met.

effective.[94]

In the remainder of this section, we explore the core components of a performance-based delivery framework and the decisions that need to be made in designing them, including:

- What roles and responsibilities different parties will be expected to play
- Who will be held accountable for ensuring goals are met
- How the goals and accompanying performance-based obligation are structured to achieve deep, massive residential retrofits
- How to fund the performance-based delivery of efficiency savings.

A study of two adjacent Canadian gas utilities – one with a shareholder incentive for success in promoting efficiency investments to its customers and the other without – found that the utility with incentives increased savings twice as quickly.

Our objective in doing so is to provide policymakers and interested stakeholders with insights into the critical issues that should be considered. There does not appear to be a single approach that will work best all the time, in every jurisdiction. Moreover, what will be politically or otherwise possible to do will vary from one jurisdiction to another. However, it is important that judgments about which paths to take be informed by an understanding of what experience suggests would be the potential advantages and disadvantages of the different choices available.

Roles and Responsibilities of Different Parties

A performance-based delivery framework places accountability for meeting residential retrofit goals on a specific organization or set of organizations, what we call the "obligated entities" for the balance of *Roadmap for the Future*. As we use the term, *accountability* refers both to responsibility for successful achievement of the goals and to reasonable flexibility in determining how best to achieve them. While accountability is always important, the scope of the residential retrofit challenge discussed in this publication makes it even more imperative to require accountability in the delivery of energy efficiency services to this sector.

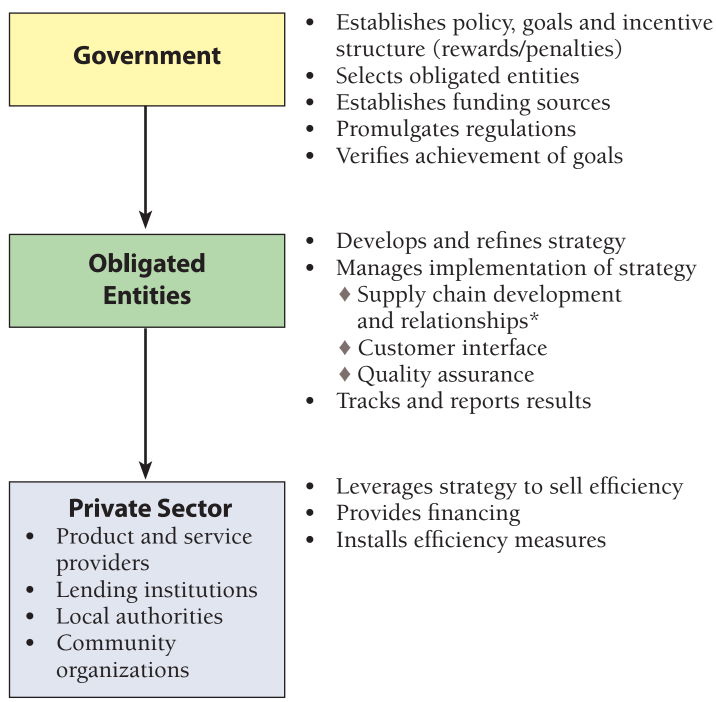
[94] To be sure, there has been some consternation about how some of the targets were met—particularly concern about heavy reliance on compact fluorescent lamps. However, that suggests problems with the initial design of goals given to the obligated entities rather than to any inherent problems with mechanism of a performance-based obligation.

While the obligated entities should be made directly accountable for results and face meaningful performance-based consequences, government also has a key role to play. In addition to establishing the policy framework for the retrofit initiative, government will need to define the performance parameters of the obligation and consequences for achieving or failing to achieve the goals. It will also need to establish funding sources, oversee and verify the work of the obligated entities, promulgate complementary regulations, and reinforce the objectives of the initiative through its communications with the public.

The development of a robust, competitive private sector infrastructure for the delivery of efficiency services is also critically important. Specifically, the private sector should be relied upon to leverage the efforts of the government and its obligated entities to finance, sell, and install the efficiency measures necessary to meet goals.

These roles are summarized in Figure 4 and discussed further below.

Figure 4: **Performance-Based Delivery: Overview of Roles and Responsibilities**



**Note: If obligated entities are also selling their own retrofit services, government may need to assign this role differently.*

Government

Government[95] has a number of critical roles to play. First and foremost, it will need to establish a policy framework that sets objectives and guides the activities and strategies of the obligated entities. This includes setting high-level energy savings or carbon reduction goals. As discussed in more detail below, this policy framework also needs to address any non-energy objectives, such as targeting certain parts of the market (e.g., low income customers) or equitably treating different groups of consumers. It also includes establishing the high-level conceptual approach to achieving goals, such as having both a voluntary market development program and complementary regulations, encouraging comprehensiveness, and promoting the development of the private sector delivery infrastructure. Needless to say, government must also be the entity responsible for promulgating any regulatory elements of a high-level strategy, such as minimum product efficiency standards, building labeling and disclosure requirements, or minimum building efficiency requirements.

Second, government must make decisions about who will serve as the obligated entities. A range of options are discussed in some detail below, along with issues to consider in deciding which approach to take. Third, government will need to establish the structural arrangement through which the obligated entities will be held accountable. This includes articulation of specific performance goals, such as the crafting and weighting of performance indicators, consequences for achieving or failing to achieve the performance goals,[96] the mechanisms by which achievement of the goals will be verified,[97] and the nature of any constraints regarding how the obligated entities can meet goals. These features of the obligations will need to be communicated through a contract for services, regulation, and/or public law.

In addition, government is responsible for identifying the sources, mechanisms and – directly or indirectly – the level of public financial support for the work carried out by the obligated entities. A wide range of mechanisms have been used for this purpose, from volumetric levies on energy bills to general taxes, energy-supplier gross-receipts taxes, indirect funding through obligations established for energy suppliers, carbon taxes, emission compliance revenues, cap-and-trade market revenues, or variants and combinations of these sources. Below, we present a number of key observations in considering these options.

Finally, government must also ensure that there are independent, periodic assessments of the performance of the obligated entities, including both savings results and other elements of management performance. Government must then ensure that the promised consequences for either meeting or failing to meet performance obligations are implemented.

Obligated Entities

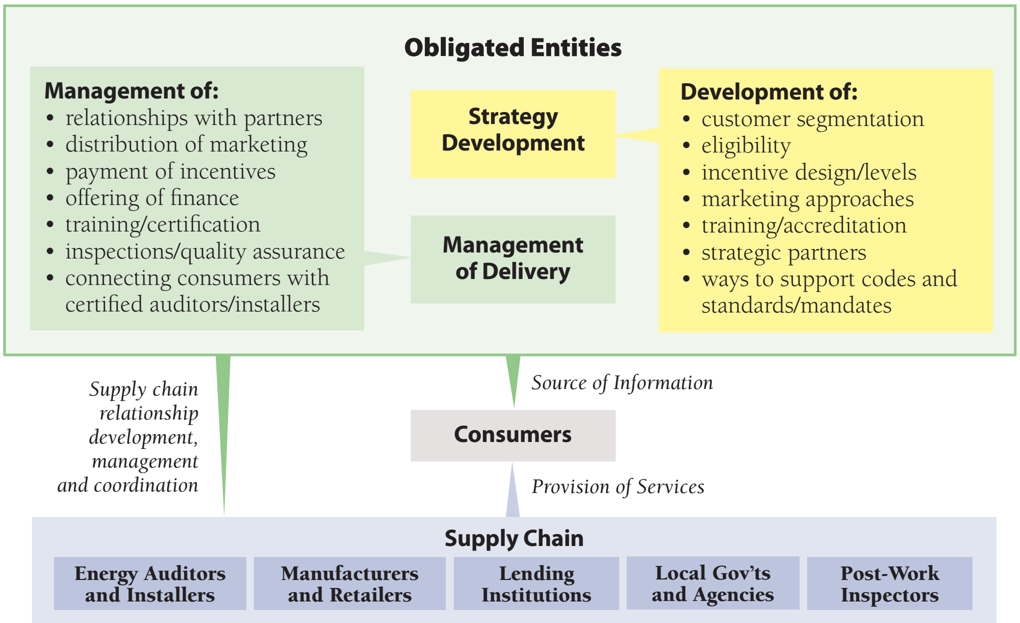
As illustrated in Figure 5, within the confines of high-level policy guidance and funding sources established by government, each obligated entity should be charged with developing, implementing, and continually refining the strategy needed to meet the goals set by government. Obligated entities must also manage and coordinate the implementation of each component of the strategy (e.g. all of the elements discussed in Section IV above). This includes developing and managing relationships with the manufacturers, retailers, private lenders, contractors, auditors, and other elements of the supply chain for delivering efficient products and services to homes. To successfully meet the performance objectives (goals), effective partnerships with local authorities and community organizations will also need to be forged. The obligated entities will also be responsible for providing efficiency information to consumers, including the provision of referrals to qualified retrofit professionals.

95 The term “government” here applies to government at whatever level may be relevant to individual circumstances, including municipal or town government, state or provincial government, and/or national government. Depending on the context, utility or environmental regulators may also assume many or even most of the government functions described in this section.

96 Options can include financial rewards and/or penalties tied to performance (including contract payment hold-backs) and/or the extension, termination or reassignment of their responsibilities and obligations.

97 Including which performance parameters will be measured using pre-installation (*ex ante*) estimates and which using post-installation (*ex post)* measurement.

Figure 5: **Responsibilities of Obligated Entities**



Of course, with responsibility goes accountability. Thus, the obligated entity is accountable for meeting initiative goals. As such, it must also track and regularly report on its progress in the market.

Private Sector

As reflected in Figures 4 and 5, achieving widespread market penetration of residential efficiency retrofits will require the development of a robust, competitive private sector infrastructure for the delivery of such services.

Perhaps most importantly, part of the work of selling and all of the work of actually installing efficiency measures should be performed by a network of qualified private sector businesses. As discussed in Section IV, efforts by the obligated entities to drive demand for residential retrofits will create an impetus for this network to grow. At the same time, assuring quality and consumer protection in a large-scale program makes it imperative that contractors be trained and certified to conduct this work. The obligated entities should have an interest in there being an adequate base of quality contractors, and play a key role in assuring that only certified contractors are used. Inspections and consumer feedback to the obligated entities would serve as an ongoing mechanism to assess contractor performance. The obligated entities could support those contractors who meet program standards by establishing mechanisms through which they are referred to consumers. It would also be expected that the obligated entities would rely heavily on contractor reporting regarding analysis, measures, costs, etc.

Other parts of the private sector also have potentially important roles to play. Lending institutions can be critically important sources of financing. Community organizations can support initiatives, particularly by helping the obligated entities identify and reach out to potentially interested customers through affinity marketing,[98] community-based marketing, and other means. Local authorities can be important delivery partners, whether through locally supported financing, support for community-based marketing, or other means.[99]

98 We refer here to the marketing of efficiency services through organizations with which consumers already have relationships. Examples can range from HVAC contractors with whom consumers have annual service contracts (e.g. to service their boilers) to more community-based organizations such as environmental groups or churches.

99 Local authorities would be considered part of "government" when they are the principal initiators of policy to drive retrofits. This is the case in several communities in North America and Europe. However, in cases in which higher levels of government are developing policy goals and establishing obligations, local authorities can also play important support roles, particularly if they are engaged effectively by the obligated entities. It is in that sense that we also identify them as potentially important elements of the "private sector" and "supply-chain" in Figures 4 and 5, although they can clearly have a cross-cutting role to play in the delivery of efficiency.

Choice of the "Obligated Entity"

A Range of Options

Over the past couple of decades, different countries, states, provinces, and other types of jurisdictions in both North America and Europe have assigned responsibility for delivering on efficiency goals to a variety of different types of organizations. Examples include:

- **The government itself** (e.g., New York, Canada,[100] and many local authorities);
- **Quasi-governmental "crown corporations"** (Hydro Quebec and others in Canada);
- **Monopoly distribution utilities** (California, Illinois, Massachusetts, and many other states in the U.S.; Brazil; Denmark; Italy; and gas utilities in most of Canada);
- **Sole-purpose public corporations** (the Oregon Energy Trust);
- **Contracted private organizations** (Vermont, Wisconsin, New Jersey, New Orleans in the U.S.; England [for the Warm Front program]);[101]
- **Competitive retail energy suppliers** (U.K.,France);
- **Combinations of two or more of the above** (New York).

Different approaches have been taken in different jurisdictions for a varying mix of political, institutional, cultural, market, and/or other reasons. The two leading options in North America have continued to be distribution utilities and private, non-utility organizations. Placing the performance obligation on distribution utilities is the most prevalent model. At a statewide or provincial level, nine states or provinces have chosen non-utility models: Oregon, Wisconsin, Vermont, Maine, Delaware, New Jersey, the District of Columbia, New Brunswick, and Nova Scotia.[102] Currently in Europe, the two prevailing approaches are to assign energy savings and/or emission reduction obligations to the distribution utilities or the retail energy suppliers.

Key Factors to Consider

A number of proceedings and papers have explored the question of what type of organization is most effective as the obligated entity.[103] They largely conclude that there is no one best choice: each model has both advantages and disadvantages, the strength and severity of which can vary depending on local circumstances. However, both experience to date and the nature of the challenge ahead suggest that a number of factors warrant careful consideration when determining who should be the obligated entities. These include:

- **Mission Alignment.** Ideally, the fundamental mission and purpose of the obligated entity should be closely aligned, from the outset, with the goals of the efficiency initiative that they are charged with delivering. If it is not, then financial incentives for good performance and/or consequences for sub-par performance need to be adequate to effectively realign it. For example, as discussed above, the jurisdictions that have most successfully used distribution utilities as the obligated entities have typically created strong shareholder incentive and/or penalty mechanisms to

[100] As was discussed in Section II, for more than a decade the government of Canada directly ran a national program to promote investments in whole house efficiency retrofits (originally called "EnerGuide for Houses," then more recently called "ecoENERGY"). However, the program was recently terminated. The government's stated reason for terming the program was budgetary pressures, brought on in part by the program's success in increasing participation in recent years.

[101] These include a mix of for profit (e.g., New Jersey, New Orleans) and non-profit (Vermont and Wisconsin) organizations. However, in most cases there has been no stated preference, with for-profits and non-profits simply competing against each other in bidding processes.

[102] Three of these jurisdictions recently completed processes to determine the performance-based delivery framework for energy efficiency. (1) In Nova Scotia, an investigation of alternatives resulted in the establishment of Efficiency Nova Scotia Corporation, an independent, sole-purpose non-profit entity that will deliver all energy efficiency efforts in the province. A system charge levied on all electricity ratepayers currently funds this effort, with anticipated additional taxpayer funding and associated responsibilities for non-electric efficiency. (2) For Delaware, the state government has established a "Sustainable Energy Utility," with the primary funding coming from regional carbon market revenues. A private contractor was awarded a performance-based contract to act as the obligated entity after a competitive solicitation (http://www.energizedelaware.org/). (3) In Washington, D.C., the district government has contracted for the operation of a Sustainable Energy Utility funded by distribution system charges, paid by both gas and electric consumers, using a six-year performance based contract. (http://green.dc.gov/green/cwp/view,A,1224,Q,463662.asp/).

[103] See, for example, ACEEE- Brown, M. *Policy Models for Administering Ratepayer Funded Energy Efficiency.* 2009. and Harrington, C. & Murray, C. *Who Should Deliver Ratepayer Funded Energy Efficiency? A Survey and Discussion Paper.* 2003.

reward good performance and counter-balance those financial incentives the utilities have had to increase energy sales. Presumably, in jurisdictions where there has been effective "decoupling" of utility sales from profits,[104] distribution utility administration would be more likely to be successful than in situations where this has not occurred.

- **Multi-Fuel Perspective.** In virtually every jurisdiction, a mix of fuels is used to heat, cool and provide other services in homes. In addition, some efficiency measures are cost-effective only when all fuel savings are considered (particularly in homes with, for example, natural gas heating and electric central air conditioning). Also, retrofit contractors and many other market actors do not generally orient their businesses around one fuel. Thus, to have any chance of achieving aggressive goals, the obligated entity must be well-positioned to promote savings from all fuels. It will be important that the obligated entity does not have any inherent business biases in favor of, or limitations in addressing, one fuel or another.[105]

- **Conflicts of Interest.** The obligated entity's role will be harder to fulfill if it has, or even has the appearance of having, conflicts in performing its role. For example, obligated entities can be seen as biased in recommendations to consumers if they or their affiliates directly sell efficiency products or services. This is discussed further below.

- **Consumer Trust.**The obligated entity's role will be easier to fulfill if it has the trust of both consumers and the retrofit-services supply chain with which it needs to work. Trust is obviously enhanced by an absence of conflicts of interest. However, other things can also matter, such as confidence in a familiar and trusted brand. It is worth carefully considering the current level of trust consumers have with organizations that might be considered for the role.

- **Ability to Create Partnerships.** Success in the residential market will ultimately require effective partnership with a wide range of players in the supply chain. Relevant players include not only manufacturers, distributors, retailers, and contractors who sell and install efficiency measures, but also lending institutions, local authorities, community organizations, and others. These organizations are already talking to, working with, and often selling consumers on a range of investments in their home. In many cases, they are the primary influencers of customer decision-making. Existing interactions, transactions, and trust will need to be leveraged as much as possible if aggressive goals are to be achieved. The ability to develop such partnerships should be an important criterion in the selection of obligated entities.

- **Nimbleness.** The obligated entities will be most effective if they are capable of quickly modifying their strategies for meeting goals in response to market feedback and new opportunities.

In any given jurisdiction, no organization may have the perfect combination of these attributes. Thus it may be necessary to make compromises in some areas in favor of others. However, it will be important that any such

[104] "Decoupling" refers to a regulatory tool designed to separate a utility's revenue from changes in energy sales, which can be implemented for the regulated monopolies in the natural gas or electricity industry (e.g., distribution utilities). For an explanation of decoupling design options and implementation considerations, see: "Revenue Decoupling: Standards and Criteria" at www.raponline.org.

[105] Being involved in the provision of electricity or competing fuels could potentially be seen as such a bias if fuel switching or supplier switching are options available to consumers. In particular, it may be necessary in the long term to fuel-switch from gas heat to biomass heating systems or renewable-energy-powered electric heat to meet carbon reduction goals. This raises concerns about conflicts if gas utilities or oil suppliers (who may be perceived as having an incentive to discourage switching away from their fuel) are acting as obligated entities to coordinate deep residential retrofits. For the opposite reason (i.e. because they may promote fuel-switching to electricity even if it is not the best option), it may also be problematic if electric utilities are obligated entities. Some jurisdictions (e.g., California) have adopted fuel-switching rules and require coordinated program delivery among single-fuel utilities in order to address these potential conflicts. However, it may be increasingly difficult to effectively mitigate them in the context of a residential retrofit initiative charged with obtaining deep carbon reductions and beginning to plan now for such deep reductions for each home.

tradeoffs are recognized and carefully considered. It may also be important to leave open the possibility that the selection of obligated entities could change over time if results in early years suggest that some advantages of the initially chosen model were overestimated, and/or some disadvantages were underestimated.

Geographic Focus or Market Focus

One additional issue to consider is whether or not obligated entities will be given sole responsibility for meeting efficiency goals within a specific geographic region. A geographic "franchise" model has generally been adopted in North America, where distribution utilities are assigned responsibility for efficiency initiatives in their distribution territory or where independent parties have been assigned such responsibilities for entire states or provinces. In contrast, where competitive retail energy suppliers are assigned energy savings and/or emission reduction obligations (as in the case in some EU member states), those companies have been given the flexibility to achieve those goals through installations in any customers' homes, whether homes to which the supplier sells fuel or homes to which the supplier's competitor sells fuel. For example, in the U.K., retail energy suppliers compete for retrofit efficiency participants. Put another way, every homeowner has the choice of different (though at times similar) retrofit efficiency offerings.

These two contrasting approaches have different advantages and disadvantages. The principal advantage of the North American, geography-based efficiency obligations is that there is less confusion in the market. Consumers hear one message from the obligated entity responsible for achieving savings in their region. Anecdotal evidence communicated to the authors from a couple of jurisdictions where there were overlapping responsibilities (and funding sources/programs) suggests that the competition between obligated entities for efficiency program participants created greater transaction costs, confusion, and frustration for consumers. Anecdotal evidence from another jurisdiction with competing programs also suggests that there is a potential for the program costs of acquiring efficiency to increase as competing obligated entities attempt to outbid each other for participants. This is advantageous to program participants, but it disadvantages all others who pay for efficiency programs through their energy bills.

On the other hand, imposing the obligation on competing energy suppliers has at least the theoretical potential to drive down the costs of meeting goals. Energy suppliers that are less efficient at attracting participants will need to spread those higher efficiency-obligation costs across the units of energy they sell, in the process potentially losing customers to less expensive competitors. In addition, as discussed further below, there may be long-term advantages in having competing energy suppliers increasingly seeing themselves as competing energy service providers, bundling fuel supply and efficiency investments in the most appropriate mix for each customer.

We are unaware of any empirical studies of these advantages and disadvantages. They clearly warrant careful consideration and further analysis.

Obligated Entities as Sellers of Retrofit Services

In order to be most effective in influencing customer decisions – from whether to participate in a program to the level of investment in efficiency to make – it is important for the obligated entities to be perceived by consumers as:

- A trusted advisor
- An objective source of unbiased information
- A technical expert
- An ally of the consumer, looking out for their interests.

Obligated entities can only be seen as unbiased in recommendations to consumers if neither they nor their affiliates directly sell efficiency products or services. Customer trust can be adversely affected if they are permitted to sell efficiency products or services, which can reduce the number of customers who are willing to rely on their advice. This can also adversely affect relationships with manufacturers, contractors, and others that are part of the supply chain.

This is something that some U.S. utilities experienced beginning in the late 1990s, when they created affiliated organizations to sell, install, and service residential air conditioners. HVAC contractors in such jurisdictions refused to believe that the utility was not using its role as an obligated entity in an unbiased fashion. At least some stopped participating in the utilities' HVAC efficiency programs because they did not want to provide any of their companies' business or customer information to the utility for fear it would eventually be used to take business away from them.[106] There is also potential for obligated entities that sell efficiency products and services to use their positions in managing funding for efficiency initiatives to squeeze out competitors. This could have important adverse, long-term consequences for the development of a broad-based retrofit services market.

In addition, if obligated entities sell retrofit products and services, there may also need to be limitations on the range of responsibilities they can assume. This, in turn, would complicate the management structure of the initiative. For example, it would not be appropriate to have the obligated entities set standards for efficiency retrofits, certify retrofit contractors, or conduct inspections of the quality of completed retrofit jobs if they are themselves providing some of these retrofit services. Government would either need to assume these roles itself or, more likely, identify a different, independent party to perform them on its behalf.

To address consumer concerns about the objectivity of advice received from the obligated entities that also sell retrofit products or services, it may also be advisable to put in place independent information systems through which consumers could obtain objective information about, for example, the quality of work done by different retrofit contractors. The state of Maine currently has on its website an electronic tool that allows interested consumers to identify all certified and insured retrofit contractors within a certain distance from the location of their home. Each listing includes such information as the types of services offered, the number of projects completed through the state's program, and a customer-satisfaction rating on a scale of 0 to 5.[107]

If government decides to make either distribution utilities or retail energy suppliers the obligated entities (see discussion below), the inability to sell efficiency products or services can create long-term dilemmas for such organizations. In the context of a mandate to reduce GHG emissions by 80% by 2050, energy suppliers (particularly those selling natural gas, fuel oil, or other fossil fuels) may increasingly see their long-term business prospects as less than rosy. Selling efficiency services – a market that, in contrast to sales of gas or other fossil fuels, should be growing in the future – could be seen as an attractive addition to their business portfolios. Indeed, that is the case in the U.K., where British Gas and E.On, two of the six major energy suppliers, have embraced selling efficiency services as a core part of their business models. In some respects this is a change that efficiency advocates have seen as desirable because it represents a step towards treating efficiency on an equal basis with supply options as a resource to meet consumers' needs.

Thus, government is faced with some difficult choices. By precluding the obligated entities from selling retrofit products or services, it can maximize consumer trust in the obligated entities, maximize the private-sector retrofit-services supply-chain support of the obligated entities, and streamline the management structure of the initiative. However, in doing so it may implicitly limit its range of options for who can serve as an obligated entity.

It may be possible to reduce the adverse impacts of allowing obliged entities to sell retrofit products or services. This could be accomplished through limits on how much retrofit work could be performed by the obligated entity (or its affiliates), establishment of independent certification of retrofit service providers, independent sources of information on the quality of work performed by retrofit service providers, and/or by other means. However, the extent to which these approaches can effectively mitigate adverse effects on the market is untested. For this reason, we recommend caution in permitting supply-chain ownership by obligated entities.

Nature of the Obligation

In addition to designating who should become an obligated entity, government will need to specify the nature of that obligation, including the details on how performance will be evaluated. Experience tells us that how the obligation is defined will be critical to the success of the overall delivery framework in achieving deep, massive-scale residential retrofits. In particular, if it is defined to give equal weight to every unit of savings ("nega-watt" hours) achieved through efficiency, then – as we have seen

[106] C. Neme, personal communications with HVAC contractors in New Jersey when Public Service Electric and Gas, the state's largest utility, which was also charged with delivering ratepayer-funded efficiency programs, created an affiliated HVAC business. Though the utility repeatedly stated that efficiency program information was not shared with its affiliate, some HVAC contractors did not trust such claims.

[107] This may be a valuable consumer tool even in cases in which the obligated entity is not selling its own efficiency services (as in Maine). See: http://www.efficiencymaine.com/at-home/hesp_program/find_an_energy_advisor

in the past – delivery will focus on short-term "cream-skimming" efforts that, at least in some cases, could make achieving deep savings at each premise more costly or even impossible to achieve in the future.

For example, a recent case study commissioned by World Energy Council and Agence de l'Environnement et de la Matrise de L'Energie raises concerns over the short-term focus of U.K.'s current supplier obligation, particularly in view of the government's targets to lower carbon emissions from individual residential properties by 40% or more. Consequently, the U.K. Government is undertaking a major review of how the energy efficiency obligations from January 2013 onward might better address these concerns.[108]

Four aspects of defining the obligation warrant particular attention:

- Goals, both short-term and long-term
- Any constraints on what can be done to meet goals
- Mechanisms by which accountability is enforced
- Independent assessment of achievements.

Each of these is explored in some detail below.

Getting Goals Right

The foundation of any performance-based delivery structure is a set of carefully considered, clearly defined, short- and long-term goals. Goals should focus on ultimate outcomes, be simply stated, and be measurable. It is highly useful to measure progress toward and achievement of goals by constructing a set of quantitative performance indicators. The relative importance of different goals and performance indicators should be explicit, preferably through quantitative weighting.

It is also critically important that government establish short-term performance measures that are consistent with long-term goals, in order to encourage (rather than discourage) the strategy described in Section VI for tapping the optimal savings potential of each home over time. This strategy includes the sequencing of efficiency measure installations to minimize cream-skimming and the lost opportunities that cream-skimming can create. Cream-skimming results in the pursuit of only the lowest cost efficiency measures, often those measures that are relatively short-lived. This tends to leave behind other cost-effective opportunities that can be lost irretrievably, or rendered much more costly to achieve in the future.

In fact, a number of jurisdictions in North America have seen obligated entities place too much emphasis on short-lived measures and short-term cost-effectiveness metrics, at least in part because their savings goals were expressed as first-year savings rather than lifetime savings. For example, in its most recent three-year plan, Commonwealth Edison in Illinois proposed that more than a quarter of its residential electric savings come from a program whose savings are projected to last only one year. Its reasoning was that, even though the program was more expensive per unit of *lifetime* savings than many others, it cost less than all others per unit of *first-year* savings.[109]

Some countries in Europe have also encountered the downsides of expressing savings goals in terms of first-year savings. The Danish Energy Agency recently proposed changes to address this concern by giving only half credit to measures whose savings lasted less than four years and full credit to all others.[110] However, this approach will still not provide adequate incentive to value longer-lived measures: for example, a measure with a 15-year life is counted the same as one with a five-year life.

Put simply, savings goals should be articulated as either lifetime savings or first-year savings with a required minimum average-measure life (15 years, or some other appropriately long period).[111] In the latter case, the first-year savings target might get ratcheted up if the average-measure life is lower than the stipulated minimum. This would have the same effect as a lifetime savings target, but would maintain the potentially useful optics of presenting goals as a fraction of annual sales.

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108 World Energy Council. *Case Study on Energy Efficiency Measures and Policies.* March 2010. p. 52.

109 Illinois Commerce Commission. Direct Testimony of Chris Neme (Docket No. 10-0570). November 3, 2010. (http://www.icc.illinois.gov/docket/files.aspx?no=10-0570&docId=157616)

110 Bach, P. Danish *Scheme for Energy Saving Obligations for Energy Utilities.* Presentation at the European workshop on experiences and policies on energy savings obligations and white certificates. January 27-28, 2011.

111 Another option is to express goals as a function of the net present value of the lifetime costs and savings. Such metrics are used in a number of North American jurisdictions, including Vermont and Ontario.

In addition, if the long-term goal is to achieve a very high level of market penetration with comprehensive, deep retrofits, then it is important that short-term performance metrics not undermine this goal by placing a high weight on indicators such as maximizing the number of participants, or maximizing savings – even lifetime energy or cost savings – from just one or two years of program implementation. Instead, short-term performance indicators might focus, at least to some degree, on the number of homes for which retrofit measures were installed in the ideal loading order,[112] the number of homes for which individual retrofit elements were consistent with long-term plans for the home,[113] and/or the number of deep retrofits completed. Alternatively, policy-makers could require that a minimum portion of annual or lifetime savings targets be met by savings from deep retrofits – perhaps defined as something like homes achieving at least 50% heating, cooling, and water heating savings – with the minimum requirement growing over time (e.g., starting at 5% in the first year and growing at five percentage points per year thereafter).

Where obligated entities are permitted to purchase white certificates from others to demonstrate fulfillment of their performance obligation, it may be particularly challenging to ensure that the savings "currency" traded is reflective of longer-term objectives, including the achievement of deep retrofits on each premise. Keys to success will be careful consideration of how the performance obligation is defined, and ensuring that the corresponding rules for white certificate valuation and trading are structured to minimize cream-skimming. For example, a differentiated white certificate scheme might be considered that assigns long-lived measures more tradable certificates than short-lived measures.[114] Alternatively (or in addition), limits could be placed on the percentage of white certificates that the obligated entity could hold from certain categories of installed measures or end-uses, such as lighting. Minimum requirements could also be established for the number of white certificates originating from more comprehensive, long-lived treatments (such as those that include solid wall insulation).[115]

Finally, it also behooves government to inform the obligated entities of their cumulative energy or carbon savings obligation over the longer-term, for example to announce the savings levels they will be expected to achieve in 10+ years. Doing so underscores the importance of developing an implementation strategy that is consistent with longer-term goals, while also reinforcing those performance indicators that are designed to encourage comprehensive retrofit treatments.

Flexibility in Meeting Goals Within Policy Parameters

As noted above, it is generally desirable to provide obligated entities as much leeway as possible in determining how to meet goals, particularly when the goals will be quite aggressive. Those responsible for results need to have corresponding flexibility to design, implement and refine strategies and services as best they see fit. If something isn't working, they need to be able to stop doing it. If they see a new, time-sensitive opportunity, they need the freedom to pursue it. Because markets can change quickly and market feedback can sometimes be surprising, it is important that the obligated entities be able to respond quickly without having to go through cumbersome, resource-intensive, and/or time-consuming external approval processes.

That said, it may also be appropriate for government to impose some high-level constraints on obligated entities as long as those constraints are associated with particular policy objectives. One possible example would be to prohibit the obligated entity from selling retrofit products or services discussed above, in order to establish

[112] See Section VI for one example of a loading order that encourages the proper sequencing of efficiency measure installations.

[113] For example, attic/loft insulation added to 50 centimeters, if that level is demonstrated to be cost-effective under long-term, 2050 GHG emission reduction requirements, rather than to the 25 centimeters that may be economically optimal today without such longer term considerations. Another example might be the fraction of window replacements made with super-efficient windows.

[114] This approach is similar to how renewable technologies receive a differentiated number of renewable energy credits under certain renewable obligation trading schemes (e.g., in Great Britain).

[115] Akin to the way some U.S. jurisdictions have both a renewable energy portfolio standard that specifies the amount of renewable energy credits that must be acquired from a combination of renewable energy resources, as well as smaller minimum requirements for credits that must be acquired from specific types of renewables (e.g., New Jersey's solar set-aside requirements).

a level playing field among vendors and service providers. Another might be establishing a communications "brand" that obligated entities are required to use in promoting efficiency to ensure consistency in messaging to consumers, as well as ensure that the initiative is not just about improving the brand identity of the obligated entity.[116] Still others may relate to policy decisions to target or achieve equity in the distribution of benefits among different groups or areas.[117] For example:

- **Equity among different groups of consumers.** While there are common benefits shared by all consumers from most energy efficiency activities, participating consumers benefit more than non-participants. As a matter of policy, it is often an objective that every customer be afforded the *opportunity* to directly participate in energy-saving initiatives and services. Therefore, it may also be desirable to set an objective for equity in the distribution of benefits across rate classes or consumer segments (e.g., residential, commercial, or industrial).[118]

- **Serving consumers with high barriers to participation.** There are certain consumers who may have both a higher individual need for efficiency and a lower ability to participate. Most notable among these are low-income customers.[119] Other groups where equity may be a concern include seniors, renters, and small businesses. Services and initiatives that are designed for the *majority* of customers in various markets may not succeed in attracting participation from these particular types of customers. Making their participation an objective may be desirable, either as part of assuring that all customers have the opportunity to participate, or because of the other social or economic benefits of their participation. An objective could be stated either in terms of equitable distribution of benefits or (for simplicity) of spending to these target populations.[120]

- **Geographic distribution of benefits.** This also speaks to assuring that all consumers have the opportunity to participate (including those living in rural areas) and could help to ensure that a provider of efficiency services seeks to build a territory-wide infrastructure for delivery of services. In Vermont, for example, this objective has been reflected in the establishment of a contractual performance indicator that establishes a minimum level of total resource benefits to be achieved for each of the 14 counties in the state, proportional to their respective share of funds supporting energy-efficiency efforts.

Any such constraints must be established as part of the law, regulation, contract, or whatever other mechanism is used to convey the performance objectives. They can either be requirements, or additional performance goals for which rewards or penalties for achievement or lack thereof would apply.

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[116] Jurisdiction-wide communication branding for efficiency initiatives is a familiar practice in California ("Flex-Your-Power"), Vermont ("Efficiency Vermont") and other U.S. states irrespective of what organizations are selected to fulfill the obligated entity role, or accredited under the initiative to provide home assessments and install measures.

[117] Placing these types of distributional requirements on the obligated entities will also restrict their ability to maximize overall portfolio economic benefits (including carbon reductions), particularly the more focused and tighter the restrictions. If there are compelling policy (or political) reasons for doing so, then these tradeoffs should be carefully considered in designing the distributional requirements.

[118] For example, it might be an objective of the portfolio that the net present value (NPV) of lifetime total resource benefits for each group be within 15% (or some other number) of their contribution to the public support for efficiency investments through rates, levies or taxes (for example 35% residential, 35% commercial and 30% industrial).

[119] Such requirements for treating low income customers are common (in varying forms) in both the U.S. and the U.K.

[120] A target could be set that is equal to (or even higher than) their representation in the overall customer population. For example, if low-income customers represent 15% of all customers, it could be an objective that they receive 15% (or more) of all spending (or all benefits).

Accountability for Meeting Performance Goals

The structure by which obligated entities are assigned their responsibility, whether a contract or other form of appointment, needs to support and reinforce the accountability of the obligated entities to achieve results. At the same time, accountability for meeting performance goals needs to balance factors that the obligated entities can control and influence in coordinating the delivery of retrofit services, versus those that it cannot.[121]

While there are a number of mechanisms to do this, there need to be meaningful consequences, such as compensation hold-backs, penalties, and/or positive financial incentives tied to goals. These consequences should be of an adequate magnitude to make it extremely important to the obligated entities that the goals be achieved. While there has been heated debate in numerous jurisdictions about how much of an incentive (or penalty) is enough to motivate excellence and goal achievement, it is worth noting that the average financial incentives earned by U.S. distribution utilities operating in states with incentives for effective efficiency programs is 10%-11% of efficiency program spending.[122]

Further, while having the obligated entities take a long-term view requires a certain level of assurance that they will remain in this role, this needs to be carefully balanced with an understanding that ongoing poor performance relative to goals can result in their removal.[123]

Independent Assessment of Performance

If, as suggested above, the obligated entities are to be held accountable for performance relative to goals – perhaps with penalties and rewards and the ability to continue being the obligated entities at stake – then there must be a reasonably thorough assessment of whether goals were met. The budget necessary for such an assessment must be planned from the start. Also, it is critically important that the assessment be both commissioned and conducted by agents that are independent of the obligated entities.

For example, in Vermont, the responsibility for evaluating the effectiveness of Efficiency Vermont's performance is vested with the state's Department of Public Service. That agency then contracts with evaluation professionals to conduct both various market evaluation studies and extensive verification of Efficiency Vermont's annual savings claims. In California, the regulatory commission staff oversees independent contractors in evaluating program performance in a similar manner. Similarly, in the U.K. and Italy, the energy regulator is responsible for verifying that the obligated entities have met their targets. In some other jurisdictions, the obligated entities are required to contract for third-party evaluations and report results to regulators or government, at which time the results are subject to review and potential challenge by interested stakeholders or agency staff.

In any event, careful consideration must be given to the evaluation protocols adopted for the purpose of assessing obligated entities' performance, as well as the dispute resolution process by which evaluation results may be challenged and resolved.[124]

[121] Achieving this balance is not without difficulty, as evidenced by the recent controversy in California over the assessment of utility performance for the 2008-2010 funding period. See California Public Utility Commission. *Decision Regarding the Risk/Reward Incentive Mechanism Earnings True-up for 2006-2008* (D.10-12-049). January 29, 2009 and more generally, see: Vine, E. et al. *Emerging Issues in the Evaluation of Energy Efficiency Programs: The U.S. Experience.* November, 2010.

[122] ACEEE-Hayes, S., Nadel, S., Kushler, M. & York, D. *Carrots for Utilities: Providing Financial Returns for Utility Investments in Efficiency* (Report Number U111) January, 2011.

[123] While the potential for losing the franchise as obligated entity can serve as a powerful motivator for achieving performance indicators, there is a downside here. To accomplish both deep and wide residential retrofits over time, the obligated entities require adequate motivation to engage in long-term strategies that may ultimately be more effective and less costly than short-term options, as well as to enter into long-term agreements, commitments, and partnerships. This requires carefully balancing security and risk. For example, bidding efficiency resources into the regional electric-capacity market in New England requires a commitment to deliver a specified MW savings three to eight years in the future, and a number of policy and behavioral strategies may take many years of effort before results may be realized. The structure that may best promote an appropriate balance is one where the default is continued assignment of the role to the obligated entities as long as they continue to provide consistent high performance, including, but not limited to, attainment of performance goals.

[124] See: Vine, E. et al., *Evaluation and Performance Incentives: Seeking Paths to (Relatively) Peaceful Coexistence.* November, 2010, and Rufo, M.W. *International Energy Program Evaluation Conference Proceedings.* 2009. pp.1030-1041.

Funding Performance-Based Delivery of Efficiency

As discussed in sections II and III, least-cost strategies to address climate change will require a large commitment of investment capital in residential building retrofits, particularly on the time scale required to meet aggressive 2050 carbon reduction targets. Evidence from a variety of efficiency programs and delivery strategies to date suggests that both a reduction in the initial costs (e.g., some form of rebate or other cost discount) and the ability to finance repayment at attractive terms will be necessary to achieve the kind of depth of savings and breadth of participation needed. For low-income households, it will almost certainly be necessary to pay for most of, if not all, the entire up-front investment. Accordingly, Principle 4 in Section III highlights the need for a public-private investment partnership to achieve aggressive goals in this market.

All of the jurisdictions that have assigned responsibility for delivering on efficiency goals to one or more entities in the market have recognized the need to raise public capital for this purpose. In various ways, they have established a public-private investment partnership whereby some portion of the cost to deliver energy efficiency is borne by a greater group of consumers than those individual households or businesses installing the efficiency measures on their premises in any given year.

Approaches

Over the years, various approaches toward raising the public capital required to leverage private investment in efficiency have been undertaken. For example, where governments have placed the obligation on competitive retail energy suppliers (e.g., U.K., France), the costs of marketing, cost discounts, and administrative expenses associated with delivering efficiency measures to participating customers are passed on to all of their end-customers via market energy prices. The cost of meeting the performance obligation is thus treated as a cost of business, similar to other environmental requirements. Put another way, the funding required to cover the socialized costs of delivering efficiency under this model is raised "on the balance sheets" of the retail energy suppliers, then ultimately repaid through market revenues that flow back to them.

When the obligation is on a distribution utility (as in California, Illinois, Massachusetts, and many other states in the U.S.; also Brazil, Denmark, Italy, and gas utilities in most of Canada), these socialized costs are reflected in "wires and pipes" charges (e.g., distribution tariffs) paid by all system users. That is, they are reflected in the infrastructure costs of the gas and electricity system, no matter where individual customers may elect to purchase their retail electricity or natural gas. If the obligated entity is a sole-purpose public corporation, contracted private organization, or quasi-governmental agency (as in several U.S. states and jurisdictions in Canada, as well as the Warm Front program in England) the socialized costs of delivering efficiency are also typically passed on to customers, through distribution tariffs and/or other levies/taxes. Even where performance obligations are accompanied by tradeable white certificate schemes (e.g., Italy and France), some portion of the cost of delivering efficiency is ultimately socialized across a broader set of consumers, ratepayers, or taxpayers than those individual households or businesses where the measures are physically installed.[125]

Moreover, in some jurisdictions in the U.S., obligated entities can also socialize a portion of their efficiency investments by successfully bidding efficiency into capacity markets, receiving a revenue stream for the reliability value of the installed measures from the wholesale power market system operator.[126] Market revenues from cap-and-trade regimes have also been utilized as a source of public investment in efficiency, most notably among the 10 U.S. states participating in the Regional Greenhouse

[125] In simple terms, a white certificate is a piece of paper stating that the seller has reduced energy consumption by a "unit" of savings. The purchaser can hand the paper to regulators to demonstrate compliance with its obligation (or resell it to the ultimate entity that has the obligation). But who ultimately pays the revenue stream to the certificate seller depends upon whomever the obligated entity can ultimately charge when it buys the certificate: taxpayers (if the obligation is on public authorities), end consumers of energy through energy prices (if the market is liberalized and the obligation is on private suppliers or generators), tariffed ratepayers (if the obligation is on distribution utilities), or all consumers of end products from the energy-intensive industry, if that's where the obligation rests.

[126] See: Regulatory Assistance Project- Gottstein, M. & Schwartz, L. *The Role of Forward Capacity Markets in Increasing Demand-Side and Other Low-Carbon Resources.* May, 2010.

Gas Initiative.[127] Under either of these approaches, the public capital for efficiency is raised on a system-wide basis (from all system users), by creating market revenues that reflect the value of carbon reductions (in the case of auction revenues) or reliability improvements (in the case of capacity payments) in the power sector.

Some Considerations

Historically, the choice of approach for raising public capital has reflected a varying mix of political, institutional, market, and cultural preferences. A detailed exploration of the advantages or disadvantages of these approaches is beyond the scope of *Roadmap for the Future*. However, we highlight below some key advantages of using broad-based system charges to fund efficiency in the context of achieving mass-scale deep residential retrofits.

A major theme of *Roadmap for the Future* is that achieving the efficiency potential from residential retrofits requires a new strategy to treat buildings collectively as a critical component of the energy system infrastructure required to decarbonize the economy. Relying predominantly (or exclusively) on the constrained balance sheets of competitive retail suppliers for public funding of efficiency – as is the case in some European countries – does not appear to comport with this vision. Instead, it places infrastructure investments to deliver clean "negawatts," "nega-therms," and "negawatt-hours" on very unequal footing relative to investments in electricity and natural gas infrastructure (e.g., transmission, distribution facilities) that deliver kilowatts, kilo-watt hours and therms to system users. The latter investments are traditionally paid for through the collective balance sheet of the entire heat and power system, including the regulated electric and gas distribution utilities. This suggests that the public capital required for mass-scale efficiency improvements to the built environment should similarly be raised through broad-based system charges, such as distribution utility tariffs or carbon pricing revenues, rather than through mechanisms that rely on a relatively small number of private market actors (e.g., competitive retail energy suppliers) to carry these costs on their company balance sheets.

There are several compelling reasons for doing so. As described above, determining who should be the obligated entities—as well as how their accountability for results should be structured—requires a careful assessment of advantages and disadvantages that may be specific to local circumstances. Broad-based system charges have the advantage of providing governments with flexibility in making these choices. In particular, since the source of revenue is not tied to the balance sheets of competitive retail supply companies, this approach more readily permits governments to select other entities to be accountable for delivering deep retrofit savings, should it determine that there are advantages in doing so.

The use of broad-based system charges also permits governments and/or regulators to implement a broader range of performance-based business models for efficiency than is possible under a supplier obligation model – even when retail energy companies serve as the obligated entities. As discussed above, a number of jurisdictions have successfully created viable business models through performance contracting and other approaches that provide a positive revenue stream to successful deliverers of efficiency savings. These approaches require a source of revenues that captures the long-term value of efficiency to the system (including avoided transmission, distribution, capacity, energy, and environmental costs), which then can be equitably shared for a "win-win" outcome among system users, the obligated entities, and private sector efficiency supply-chain.[128] Various approaches for doing so have been implemented over the past two decades in North America in varying degrees of comprehensiveness. Notably, all have been funded in large part through broad-based system user

[127] Collectively, RGGI states invest over half of their carbon allowance auction revenues in energy efficiency. (http://www.rggi.org/rggi_benefits/why_efficiency). For a discussion of the benefits of using carbon allowance auction revenues under cap-and-trade regimes or carbon tax revenues to fund end-use energy efficiency, see Cowart, R. *Price Alone is Not Enough: Why Energy Efficiency Policies Are Needed to Lower Costs and Strengthen the European Carbon Trading System* (Summer Study Paper 2-432). European Council for an Energy Efficient Economy. Forthcoming June 2011.

[128] One example of how system charges can create a viable business model for efficiency under a performance-based obligation is described in Satchwell, A., Cappers, P., & Goldman, C. *Carrots and Sticks: A Comprehensive Business Model for the Successful Achievement of Energy Efficiency Resource Standards.* Lawrence Berkley National Lab. March, 2011.

charges (e.g., distribution utility tariffs).[129]

A related – and perhaps the most important – advantage of using broad system charges as the vehicle for raising public capital for efficiency is the time horizon of the decision-making. Investments in poles and wires are made with an eye to what is needed for the next several decades. The substantial carbon reduction requirements for the heat and power sectors require a stream of public capital investment over a commensurate time horizon. Public investments that rely on government budget appropriations, investment decisions by retail energy suppliers or other approaches that take a shorter-term view are unlikely to be adequate or stable enough to meet the challenge of climate change.

[129] For further discussion of these issues and associated business models, see the following presentation by Neme, C. & Peterson, P. Unlocking the Value. Electricity Market Reform workshop on Demand-Side. London. March 3, 2011. See also ACEEE-Hayes, S., Nadel, S., Kushler, M. & York, D. *Carrots for Utilities: Providing Financial Returns for Utility Investments in Efficiency.* January 2011 for a description of the various U.S. approaches to provide financial rewards for performance-based delivery of efficiency that are typically funded by all system users through electricity and natural gas distribution charges.

VIII. Next Steps

As described in the preceding sections, the *Roadmap for the Future* for achieving mass-scale deep residential retrofits is premised on a paradigm shift in the way efficiency improvements to buildings are evaluated, pursued, and funded. Policymakers, efficiency practitioners, the media, and the general public all have important roles to play in changing the narrative around efficiency so that residential building retrofits become more universally recognized as a least-cost strategy for reducing GHG emissions that produces economic benefits to all system users.

In addition, many countries, states and provinces are in the process of developing and implementing efficiency action plans and other policies to deliver more aggressive levels of efficiency – or they may be in the future. The eight key principles presented in *Roadmap for the Future* offer practical guidance for those efforts as well as a useful check-list for residential retrofit initiatives under consideration.

In particular, *Principle #1* highlights the need for a residential retrofit strategy that is multi-faceted – addressing all key market barriers and opportunities – and as easy as possible for consumers to understand and participate. *Principle #2* emphasizes the need to focus efforts on comprehensive treatment *over time* of all cost-effective efficiency opportunities in each home. Approaches for ensuring this result include: (1) promoting the development of long-term efficiency investment plans for each home, (2) developing financial incentives and marketing messages that encourage the proper sequencing of measure installations, (3) bundling measures that should ideally be treated together, and (4) going as deep on each efficiency measure installed as can be justified in the context of 2050 GHG reduction goals.

A strategy consistent with *Principle #3* will catalyze and support the development of the supply chain for retrofit products and services. *Principle #4* recognizes that the voluntary program will need to offer consumers rebates (or other cost discounts) as well as attractive financing, while addressing the unique needs of low-income households. This, in turn, will require a stable and sufficient public-private investment partnership for funding efforts to achieve aggressive goals in this market.

A successful strategy will also place a premium on minimizing confusion in the market, consistent with *Principle #5*. And a strategy that reflects *Principle #6* will include both voluntary programs as well as complementary regulations – e.g. minimum product efficiency standards, building efficiency labeling and disclosure requirements, and eventually minimum building efficiency requirements at time of sale.

Principle #7 defines a successful delivery framework for mass-scale deep retrofits as one that places a performance-based obligation on one or more market entities, accompanied by meaningful (positive and/or negative) financial consequences. Finally, *Principle #8* recognizes that success requires a long-term government commitment to the strategy, including a commitment to raising public capital for efficiency – preferably through broad-based system charges.

Experience suggests that the way these guiding principles are applied will be very important. *Roadmap for the Future* offers a number of more specific and detailed design recommendations that merit serious consideration, drawing on lessons learned from past experience. However, the level of residential retrofit efficiency investment required to meet the climate change challenge is unprecedented and therefore, no one can claim to have a proven, detailed formula that can simply be copied. While learning from the past is essential, creativity and innovation must also be part of the effort to develop local approaches to the principles and design elements presented in this paper. Making a commitment to that effort is the next step for putting the *Roadmap for the Future* into practice.

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Efficiency Maine
Home Energy Savings Program
Final Report

December 2012

Efficiency Maine Home Energy Savings Program: Final Report

I. EXECUTIVE SUMMARY

In 2010 and 2011, Efficiency Maine invested $11 million to deliver a market-based, residential energy efficiency program. This program targeting existing homes in Maine stimulated $26 million of homeowner investments. The Program offered rebates to homeowners to make energy upgrades. As a result of the Program, the efficiency of 3,212 homes was improved by an average of 40%. This represents a more than 100-fold increase in the number of reported whole-house upgrades when compared to the Program's predecessor, Efficiency Maine's Home Performance with ENERGY STAR® Program. The Home Performance Program did not offer rebates.

Homeowners directly hired independent Participating Energy Advisors with Building Performance Institute (BPI) certifications to conduct 5,140 energy audits, and earned rebates only once qualifying upgrades had been completed. These assessments were conducted at market prices and using BPI standards. Only audits that resulted in energy upgrades qualified for rebates. More than 100 Advisors signed up to participate in the Program.

The average upgrade, including the energy audit, cost $8,347 and qualified for an average rebate of $2,611. In total—in the midst of a recession—Maine homeowners invested $26.8 million to improve the efficiency of their homes. Assuming a 20-year measure life, and considering homeowner, rebate and program delivery and marketing costs, the cost of heating oil saved was $1.16/gallon, at a time when heating oil cost between $2.66 and $3.66/gallon (source: Maine Governor's Energy Office, Current Heating Fuel Prices). The Program's net TRC Test benefit/cost ratio was 2.56. In other words, for every dollar invested by Efficiency Maine and homeowners, a $2.56 benefit was recognized over the life of the upgrade.

The success of the Efficiency Maine Program can be attributed to many factors, the most significant of which were as follows:

1. A focus on leveraging market forces.
2. An emphasis on demand creation (all-out marketing and bonus rebates tied to deadlines).
3. A continuous cycle of measuring results, evaluating, planning and implementing changes.
4. An emphasis on paying *only* for desired results (rebates for completed upgrades, not audits).

By successfully delivering the Program, Efficiency Maine demonstrated that the rate with which large-scale deep energy upgrades are conducted can be dramatically increased by focusing on demand creation in a market-based program.

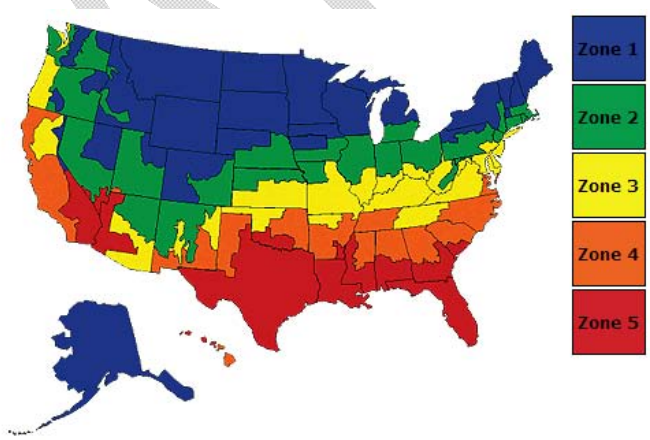
This report covers the methods employed by the Efficiency Maine Program to dramatically increase the rate of completed upgrades and improved energy efficiency in thousands of Maine homes.

II. BACKGROUND

A. *Maine*

Maine has a challenging energy profile due to the following:

1. Old housing stock. Maine has the 5th oldest housing stock in the nation. (source: Maine State Housing Authority, Maine Department of Economic and Community Development, Maine Consolidated Plan, Five Year Plan: 2010-2014, 2010 Action Plan)
2. Cold climate (see Figure 1).
3. Below average income level. In 2009, the mean household income in Maine was 16% lower than the national average (source: U.S. Census Bureau, American Community Survey Brief, Household Income for States: 2008 and 2009 ACSBR/09-2)
4. Heavy reliance on heating oil. Maine is the most heating-oil-dependent state in the country.[1] Heating oil is used as the primary fuel in 80% of Maine households (source: U.S. Census Bureau, Census of Housing, Historical Census of Housing Tables). (Also see Figure 2.)



Climate Zones

Climate Zone	Cooling Degree Days	Heating Degree Days
1	Fewer than 2,000	More than 7,000
2	Fewer than 2,000	5,500 to 7,000
3	Fewer than 2,000	4,000 to 5,499
4	Fewer than 2,000	Fewer than 4,000
5	2,000 or More	Fewer than 4,000

[1] For more information about high heating oil costs, see "High Heating Oil Costs Hurt More in Northeast," by Cardwell D. and C. Krauss, *The New York Times*, January 21, 2012.

Figure 1. U.S. Climate Zones (source: [The American Society for Healthcare Engineering of the American Hospital Association, Map of Climate Zones]())

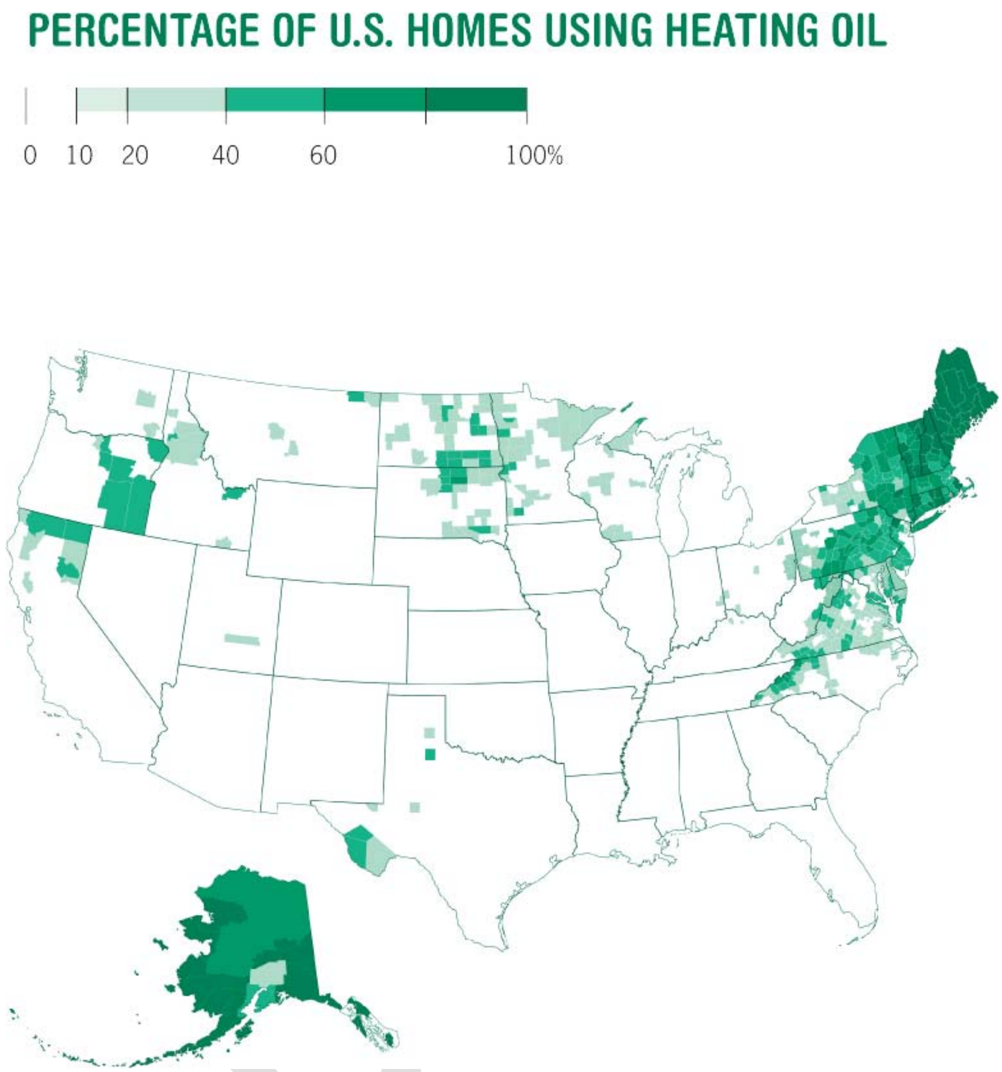


Figure 2. Percentage of U.S. Homes Using Heating Oil (representation of a graphic presented in *The New York Times*, January 21, 2012)

B. *2008 Heating Oil Price Crisis*

When heating oil prices spiked during the 2007–2008 heating season (see Figure 3), with prices approaching $4/gallon for the first time, Maine families were hit hard. With the average home consuming more than 1,000 gallons of heating oil/year, there was deep and widespread concern that many families would not be able to afford to heat their homes, and would be forced to leave the state. It was in this climate that a new emphasis on home weatherization was born.

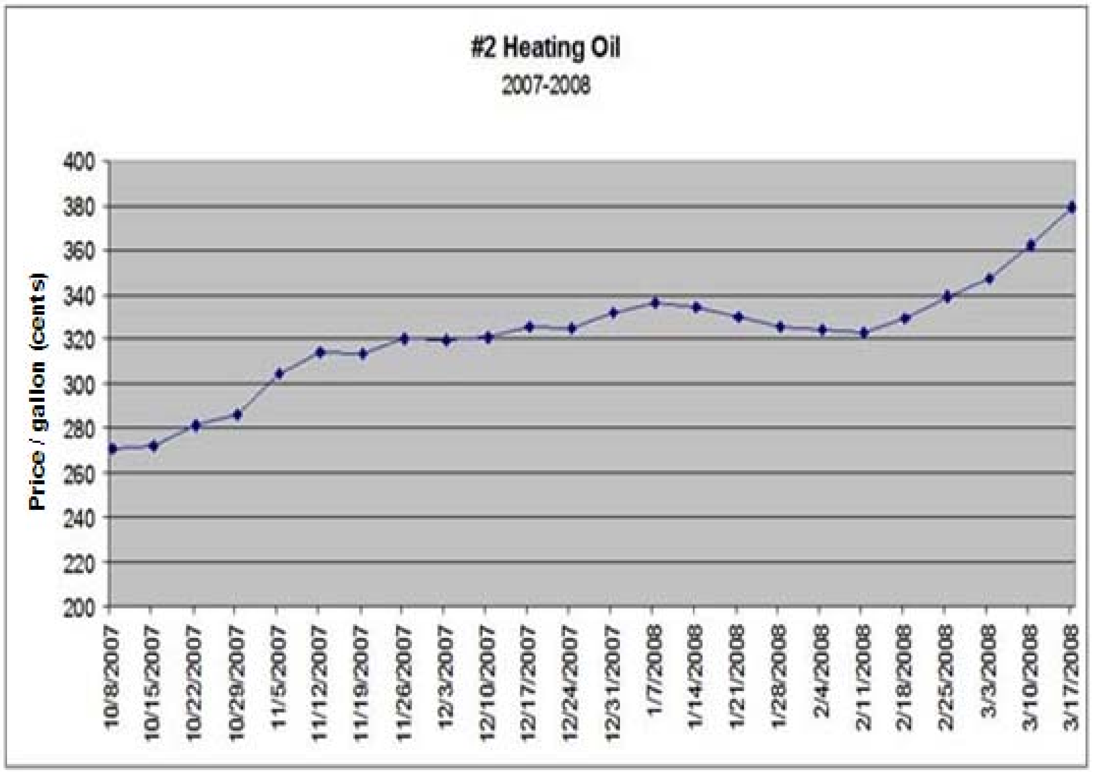


Figure 3. Maine Heating Oil Prices, 2007–2008 (source: Maine Governor's Energy Office)

C. *Home Performance with ENERGY STAR®*

One of the first manifestations of this focus was the Home Performance with ENERGY STAR Program, which was operated by Efficiency Maine in 2008 and 2009. The primary focus of the program was contractor training. It was during this time that many of the Participating Energy Advisors who supported the Efficiency Maine Program received their BPI certifications. Trained contractors appeared on a list on the Efficiency Maine website. Contractors were also taught how to generate energy models of homes, and were encouraged to model and report the homes they were working on to Efficiency Maine. The success of the program, however, was limited due to funding constraints. Only 40 upgrades were reported during this two-year span.

D. *An Act Regarding Maine's Energy Future*

A more significant development that occurred in the wake of the 2008 heating oil price spike was the enactment of Legislative Document (LD) 1485, *An Act Regarding Maine's Energy Future* on June 12, 2009. It established the quasi-governmental Efficiency Maine Trust to operate an integrated suite of energy efficiency and renewable energy programs, and targets for energy conservation, including "weatherizing 100% of residences and 50% of businesses by 2030."

E. *American Recovery and Reinvestment Act*

While Maine was taking steps to address its energy future, so was the federal government. On February 17, 2009, a $787 billion economic stimulus package, the American Recovery and Reinvestment Act (ARRA), was signed into law. Among its many provisions was an allocation of $27.2 billion for energy efficiency and renewable energy research and investment. The magnitude of this investment was unprecedented. Efficiency Maine was awarded $27 million, and initially applied $10 million to the Program. (Another $2 million was devoted to the program in 2011.)

F. *Program Delivery Team*

As a result of two competitive bid processes, Efficiency Maine awarded a Program management contract to Conservation Services Group, and a Program marketing contract to Vreeland Marketing. Efficiency Maine officially launched the Program on January 6, 2010.

G. *Objectives*

The initial goal for the Efficiency Maine Program was to upgrade the energy efficiency of 4,000 Maine homes by at least 25% in two years, which would be the equivalent of saving one million gallons of heating oil/year. Efficiency Maine also set out to promote market transformation by significantly modifying homeowner expectations of their homes, and developing contractor capabilities, resulting in long-term change in the industry.

III. PROGRAM DESIGN

A. *Mission*

The political and economic climate, both in Maine and across the country, had a significant influence on the multi-faceted mission that served as the foundation for the Efficiency Maine Program's design. This mission also established the context for all program-related activities, and was as follows:

1. Start Maine down a path that would lead to meeting the requirements of LD 1485—weatherizing 100% of the homes in the state by 2030.
2. Stimulate the energy efficiency industry to increase skills and capacity.
3. Encourage high homeowner expectations of their homes.
4. Demonstrate that large-scale weatherization can be delivered cost effectively using public funds.

The Program presented Efficiency Maine with the opportunity to make significant progress in moving this mission forward. In the absence of well-funded programmatic support for residential weatherization, few homes had been upgraded in the years leading up to the Efficiency Maine Program, and despite progress that had been made with the Home

Performance with ENERGY STAR Program, the number of certified, insured and experienced contractors available to homeowners was small.

B. *Guiding Design Principles*

The most fundamental guiding design principles for the Efficiency Maine Program related to leveraging market forces. The Program was specifically designed to transform homeowner expectations of their homes, and develop contractor capabilities. The Program was also developed to leverage other funding sources.

1. *Transforming Homeowner Expectations*

Shortly after the Efficiency Maine Program was launched, two focus groups were used to learn about homeowner perceptions of various aspects of the Program, including weatherization, contractors and rebates. One of the most striking observations from these focus groups was that most homeowners thought their own homes were more efficient than average. This became known as the "Lake Wobegon" effect.

Contrary to this belief, "efficient" is not an accurate assessment of the average Maine home. The average home has not been weatherized, and is about as efficient now as it was when it was built. As was noted previously, most homes in Maine are old, and in the absence of statewide building codes were built using sub-standard practices. Many homes are not insulated, and most are quite drafty. These homes suffer from ice dams, frozen pipes and cold, drafty rooms in the winter, and stiflingly hot rooms in the summer. Maine homeowners have long accepted these circumstances. Efficiency Maine set out to transform their expectations, and took many steps to show homeowners opportunities for improving their homes.

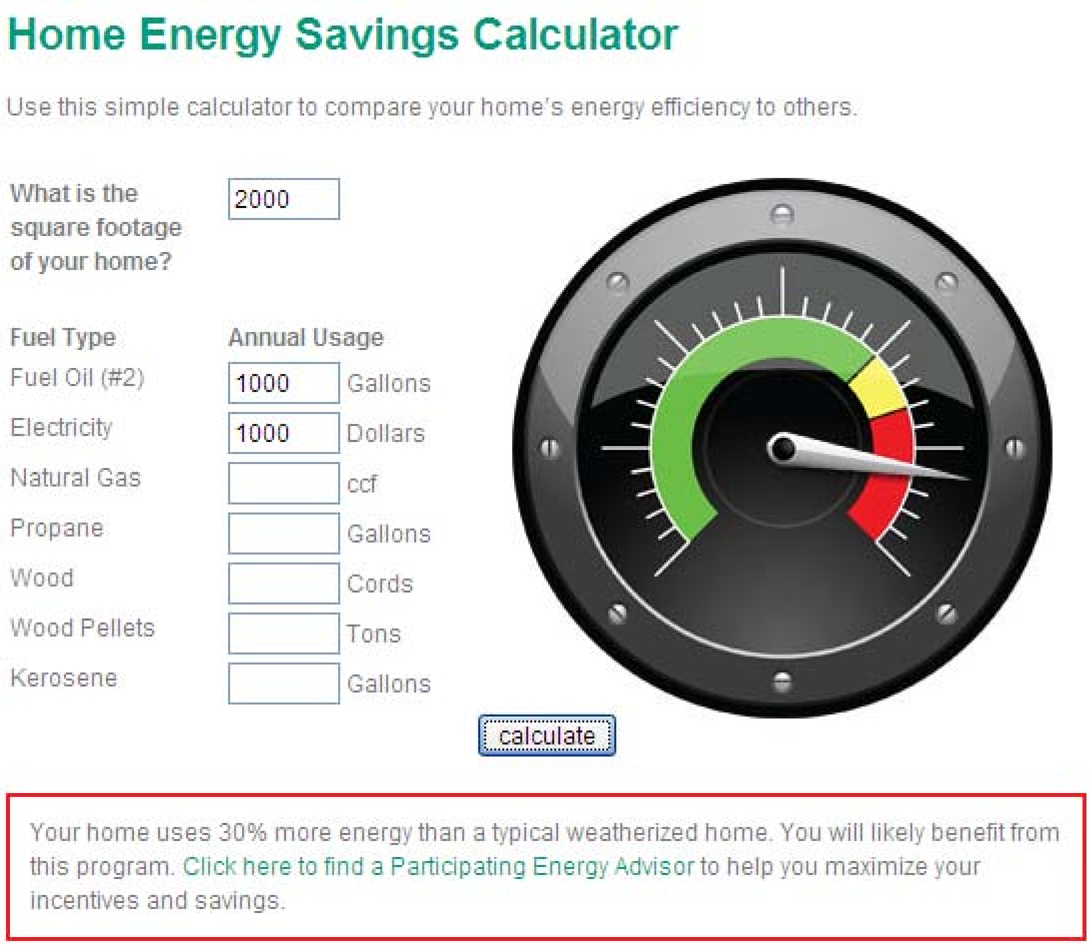


Figure 4. Efficiency Maine Home Energy Savings Calculator

The Program's first step for homeowners was to have an audit, which typically cost $500. The second step was to get an upgrade if the cost was justified. This resulted in having to convince homeowners to make an initial investment of $500 on an audit without knowing if cost-effective upgrade opportunities could be identified.

To alleviate homeowner concerns the Home Energy Savings Calculator (see Figure 4) was added to the Efficiency Maine website. The Calculator gave homeowners a better sense of the value of an audit, and the likely cost-effectiveness and rebate-eligibility of an upgrade.

With a few simple entries about the size and energy use of their homes, homeowners were quickly able to determine how the energy use of their own home compared to a baseline. The design of this Calculator evolved as the program matured. The Calculator was initially modeled after the ENERGY STAR Home Energy Yardstick. Electrical usage was shown in kilowatt hours, but was changed to dollars because it was discovered that more people knew their electrical usage in dollars than kilowatt hours.

The Calculator was also initially configured to show energy use compared to an *average* home. This was deemed to be conservative and left homeowners with average homes thinking their energy usage was acceptable, when in fact it wasn't. The baseline was then changed to a "typical weatherized home," giving homeowners a better sense of whether or not they could benefit from the Program. This change also encouraged more homeowners to participate by leveraging the power of peer pressure.[2] Studies have indicated that peer pressure is an effective way to motivate "green" behavior; homeowners are more likely to limit energy use when they've been informed their neighbors are doing it or it's good for their community. When homeowners implicitly compared their energy usage to that of others in Maine, they were influenced by peer pressure to participate in the Program.

In order to ensure that homeowners took the immediate next step in the process, a hyperlink guiding them to the Participating Energy Advisor Locator was added to the results generated by the Calculator. This is but one example of many modifications that were made to minimize the number of prospective participants who got lost in the shuffle of the many steps in the Program's long process.

Case studies (see Appendix A) and savings examples were also added to the website to highlight the benefits of participation, and the extent to which homes could be improved. The savings examples were initially based on the payback period, but some customers interpreted that as the number of years they would be worse off financially. To overcome this barrier, Efficiency Maine switched the bottom line of the examples from payback period to immediate savings (see Figure 5).

IMMEDIATE SAVINGS MODEL (preferred) VS. **PAYBACK MODEL**

IMMEDIATE SAVINGS MODEL (preferred)	
Annual heating oil costs	$3,230
Projected energy savings	25%
Dollars saved annually	$ 808
Total project cost (including audit) to finance	$5,500
Amount to finance	$5,500
Annual loan payment (15 year, 4.99% APR)	$522
IMMEDIATE ANNUAL SAVINGS STARTING YEAR ONE	$286

PAYBACK MODEL	
Annual heating oil costs	$3,230
Projected energy savings	25%
Dollars saved annually	$ 808
Total project cost	$5,500
PROJECTED PAYBACK	6.8 years

Figure 5. Efficiency Maine Program Savings Models

Based on recommendations from the U.S. Department of Energy's report "Driving Demand for Home Energy Improvements,"[3] which served as an important resource for the Program, the case

[2] For more information about the power of peer pressure, see "The Secret to Turning Consumers Green," by Simon, S., *The Wall Street Journal*, October 18, 2010.

[3] For more information about motivating homeowners to invest in energy upgrades, see *Driving Demand for Home Energy Improvements* (LBNL-3960E), by Fuller, M., C. Kunkel, M. Zimring, I. Hoffman, K.L. Soroye, and C. Goldman, September 2010.

studies included vivid personalized examples. Real people, real names and real towns were used in order to strengthen homeowners' connection to the Program, and leverage peer pressure. In fact, Efficiency Maine's case studies featured actual Program participants, and were designed to appeal to a wide range of motivations:

1. Anne M. made her house warm and comfortable for years to come. This case study was intended to appeal to the generation of homeowners making investments to prepare their homes for retirement. Anecdotally, Participating Energy Advisors reported that over 50% of their customers fell into this category.
2. Marieta A. put an end to ice dams on her two-year-old home in Gorham, Maine. During the winter, many Maine homes are subject to ice damming that often leads to costly roof leaks. Despite the fact that the majority of ice dams are caused by air leakage and inadequate attic insulation, most homeowners call roofers when they occur. The purpose of this case study was to establish a better link between weatherization and ice dam prevention.
3. Al H.'s deep energy upgrade delivered whole house comfort and savings. This case study was used to show the depth of savings that could be achieved as a result of a higher level of investment in efficiency. Al experienced a reduction in overall energy use in excess of 75%.
4. Stuart and Jane's energy upgrade made cold, drafty rooms a thing of the past. Many homes in Maine have cold, drafty rooms, and most homeowners accept this as par for the course. This case study was used to change that notion by squarely focusing attention on the potential for improved comfort. In addition, by featuring their 19th century home, this case study also helped dispel a common myth that older homes cannot be upgraded.
5. The increase in comfort and savings at Toby W.'s rental property gave tenants more reasons to stay. The Program was designed so that owners of small, multifamily buildings could qualify for the highest rebates. This case study was designed to draw multifamily building owners to the Program.

Efficiency Maine was initially reluctant to cite the average cost of energy audits ($500) and upgrades (>$8,000) due to the fear that this information would drive potential customers away from the Program. In addition, there was hesitation about highlighting projects that did not show an immediate, positive cash flow. However, positioning weatherization as a way to save a lot of money was ineffective, because most investments in weatherization only result in a marginally favorable cash flow, and many only break even.

Fortunately, non-financial benefits were found to be effective drivers for participation[4]. Efficiency Maine took advantage of every opportunity to highlight the non-financial benefits

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[4] These findings support the research *Beyond the Foundation: Using consumer insights to build the energy efficiency market* that The Shelton Group performed for Efficiency Vermont in 2010.

associated with investing in efficiency, particularly comfort. This became a common theme, not only throughout the case studies, but in the Program in general. After several months of operation, the tagline "Home Comfort Paid for by Energy Savings" was added to the Program name. The tagline was often accompanied by an image of family members walking in bare feet across wood floors, an experience that few people in Maine can enjoy in the winter as a result of the uncomfortably cold temperatures inside their homes.

With regard to communicating about the cost for audits and upgrades, Efficiency Maine found value in openly sharing the information that the average cost of energy audits was $500 and upgrades was more than $8,000. Transparency attracted the right prospective participants to the Program.

Efforts to convey these messages were not limited to the Efficiency Maine website. Many of the case studies, for example, were highlighted in TV advertisements, which could also be viewed online. Print materials were produced for use at home shows and other public events. Two one-page brochures—Myths and Facts (Appendix B) and a Homeowner Checklist (Appendix C)–– were extensively distributed.

The Myths and Facts brochure addressed common misconceptions related to weatherization, such as the cause of ice dams and the risks vs. benefits of an airtight home. The brochure was customized to account for the Maine climate and the unique attributes of Maine homes. For example, the water in many Maine homes is heated by tankless coils integrated with oil boilers. This is one of the most inefficient ways to produce hot water, because the boiler must maintain hot water over the course of the entire year (as opposed to just the heating season). However, many homeowners incorrectly believe that this is an efficient way to produce hot water because there is no need to store a large volume of hot water in a tank. Accordingly, the inefficiency of tankless coils was addressed in the brochure:

- **Myth:** A boiler without a storage tank is efficient because you're not storing hot water.
- **Fact:** With the exception of modern, on-demand water heaters, tankless water heating systems are the least efficient.

There are also a number of historic homes in Maine. To address concerns about the potential for compromising the historic quality of homes, the qualifications of Participating Energy Advisors were promoted:

- **Myth:** Historic homes can't be weatherized.
- **Fact:** The important thing to remember is that a trusted professional makes all the difference. Efficiency Maine Participating Energy Advisors are certified by the Building Performance Institute (BPI) to identify energy-saving opportunities, while still preserving the integrity and character-defining features of older homes.

These are just two of the 10 myths that Efficiency Maine attempted to dispel. For more examples, please see the Myths and Facts brochure, Appendix B.

To help homeowners determine if their home was a good candidate for weatherization, Efficiency Maine developed a simple Homeowner Checklist. Grassroots advocacy groups included the Homeowner Checklist with other informational materials that they distributed to Maine homeowners when performing simple walk-through energy audits. With an eye towards collaboration rather than competition, Efficiency Maine encouraged these groups to attach their own business cards to the Homeowner Checklist, and included a placeholder for this purpose. To view the Homeowner Checklist, please see Appendix C.

During a later phase in the program, Efficiency Maine considered the concept of using reference selling to change homeowner expectations of their homes. Efficiency Maine designed a coupon that could be distributed to rebate recipients. The total value of the coupon was $200–$100 for the referrer (the coupon recipient), and $100 for the new participant. It was only redeemable upon completion of an upgrade by the new participant. The intention was to use this approach to spread the word about the benefits of participation. Multiple coupons could be issued to every one of the growing number of rebate recipients, resulting in the creation of highly credible "sales force" that would have direct access to many of the most highly qualified prospects. This concept was appealing, because the cost was low and the potential to drive demand was high. It was also considered to be highly sustainable, because it was a method that could be easily adopted by Participating Energy Advisors and other organizations. The reference coupon was never used because other attempts to increase demand were so successful that active marketing was suspended for the last several months of the Program.

In Maine, many homeowners subscribe to the "if it ain't broke, don't fix it" philosophy. The numerous steps taken to address homeowner expectations of their homes were intended to shift this mindset.

2. *Encouraging Development of Participating Energy Advisor Capabilities*

To achieve the Program's goal of helping Participating Energy Advisors develop their capabilities, two approaches were used. One was the development of Program requirements needed to participate in the program. The second approach was to make optional capabilities apparent to the market and let customers select Energy Advisors based on what was important to them.

The Program requirements were primarily based on third-party certifications:

1. Building Analyst (issued by the Building Performance Institute)
2. Maine Limited Energy Auditor Technician (LEAT) License (issued by Maine State Office of Professional and Occupational Regulation)

General commercial or professional liability insurance (minimum coverage: $500,000) and Workers compensation insurance (minimum coverage: $500,000, with exceptions for sole proprietors or LLC corporations without employees) were also required.

By requiring certification, the Program motivated many contractors to get formal training. Some insulation installers attended BPI training simply to get listed on the Program's Locator. Some shared that learning building science for the first time helped them better understand how to do their jobs and how to articulate the value of their work with homeowners.

Optional capabilities or services highlighted for homeowners, included:

1. **Financing**. Program staff worked with the Electric and Gas Industries Association (EGIA) and AFC First to offer training on available financing offerings. If Advisors chose to offer financing to homeowners, it was noted on the Advisor Locator.
2. **Solar.** If Advisors had NABCEP certification, they were listed on the Advisor Locator as offering "Solar" services
3. **Code of Conduct**. Efficiency Maine developed an optional Code of Conduct based on customer feedback. If Advisors committed to following this code, it was noted on the Advisor Locator.

Sharing the results of Quality Assurance inspections also helped to develop capabilities. Having a free, highly experienced mentor on-site was a resource that installers had rarely had access to. Technical Field Representatives also provided free training on its energy modeling application, RealHomeAnalyzer. Advisors were taught how to use the application and how to handle different energy situations from a building science point of view.

In an effort to cultivate "cross-silo" collaboration, Efficiency Maine also co-sponsored a "mixer" with HVAC professionals and energy efficiency professionals to help the two groups learn how to spot opportunities for one another and to build a network of relationships. HVAC professionals were shown how to identify weatherization opportunities they were likely to see (e.g. photos of unsealed chimney chases, uninsulated bulkhead doors, etc) and taught how to sell the opportunities to homeowners (by providing rules of thumb for cost savings). Likewise, energy advisors who often had little HVAC experience were shown what low hanging fruit looks like on the HVAC side (tankless coils, leaky ducts, etc) and given some savings estimate to share with homeowners when referring HVAC professionals.

Efficiency Maine sought to leverage market forces by making the availability of the optional services or commitments visible on the Advisor Locator. Advisors were not forced to commit to or provide the optional services, but their capability or lack of capability was clear on the web-based Locator. When Advisors saw their more qualified competitors climbing to the top of the active list, they were motivated to pursue training. Leveraging this market-based pressure using the web-based Advisor Locator was very effective.

The earliest version of the Advisor Locator was crude. It was a spreadsheet containing basic information about the Advisors, condensed into a two-page PDF that was difficult to read. More important, it lacked information that would enable potential customers to effectively compare one Advisor to another. Homeowners, for example, could not differentiate between "hobbyists" and the Advisors who had demonstrated the most success in moving projects through to completion. Similarly, they could not determine who was likely to turn their audit into an upgrade, nor could they determine anything about the level of customer satisfaction associated with any of the Advisors.

Efficiency Maine developed a user-friendly, online tool with enhanced features. With the new iteration of the Advisor Locator, homeowners could identify local Advisors by simply entering their zip code and search radius. To facilitate comparison shopping, the resultant list of Advisors could be sorted by clicking on any of the following column headers:

1. **Projects completed.** The quantity of completed Program projects was used as the default for sorting the list. The most active Advisors (those with demonstrated success in moving the most projects through to completion) always appeared at the top of the list.
2. **Customer satisfaction.** All rebate recipients were asked to participate in a short survey that was used to gauge their level of satisfaction. Respondents assigned a numerical value to their satisfaction level, and the average of these values for a given Advisor was presented on the Locator. Participants of focus groups arranged by Efficiency Maine expressed a high level of distrust of contractors as the primary barrier to having their homes upgraded. Posting each contractor's customer satisfaction score helped to address this significant objection. (Also see *Compliance with Code of Conduct*, #6, below.)
3. **Distance.** Only Advisors based within the homeowner-specified radius would appear on the Locator. Initially, the default radius was set to 25 miles, but this ended up sending so many prospects to the same most active Advisors that they were swamped and unable to respond to calls. This frustrated prospective Program participants, and led to a loss of qualified leads. It was addressed by changing the default radius to 10 miles.
4. **Service offerings.** Audits, weatherization, heating systems, windows, and solar and general contracting were all services offered by contractors who participated in the Program. The cost-effectiveness of installing new windows, new doors and solar energy systems is generally low when compared to weatherization, which was a requirement for participation, but more customers tend to be drawn to these measures, so they were included. The idea was that these service offerings would attract more "window shoppers," who would then be given custom data on their homes highlighting a range of measures including their original wish. Equipped with this information, the homeowners would be better able to make informed decisions.
5. **Availability of financing**. Given the economic climate at the time and the fact that most people in Maine had incomes below the national average, the availability of financing was seen as essential to success. At the outset, most Advisors had only had technical (building science) training, and little experience with other aspects of business operations, including financing. Efficiency Maine worked with the Electric & Gas Industries Association (EGIA) and AFC First to create opportunities for training. Multiple webinars were offered, and Advisors that made financing available to their customers were highlighted on the Locator.

6. **Compliance with Code of Conduct**. Efficiency Maine's Code of Conduct (see Appendix D) was developed to address homeowner concerns related to contractor conduct. (Also see *Customer satisfaction*, #2, above). The Code of Conduct was voluntary, based on feedback from homeowners and included a list of 14 items that were intended to improve Advisor-customer relations. Advisors who signed the Code agreed to, among other things, the following:
    - Calling the homeowner if they expected to arrive more than 15 minutes late.
    - Placing equipment on drop cloths, and removing shoes or using protective foot coverings when working inside the home.

    These Advisors earned a checkmark in the Code of Conduct column on the Locator. More than half of the Advisors made this commitment within two weeks of the introduction of the Code.
7. **Advisor's comment field**. A 160-character Advisor's comment field was also added to make it easier for Advisors to share information with their potential customers, and allow homeowners to identify Advisors who best fit their preferences. The content of the comments was restricted; all comments had to relate to one or more of the following:
    - Differentiating, relevant and verifiable claims, such as other certifications or recognition.
    - Pricing, including special offers.
    - Geography covered.
    - Other services not on the Locator, such as multifamily or mold mitigation.
    - Availability, such as "Now booking audits in February."

    In order to distinguish them from information presented by Efficiency Maine, Advisor's comments appeared in red text, just beneath their contact information, in the following format: Advisor comment: "[comment]", as of day/month/year.

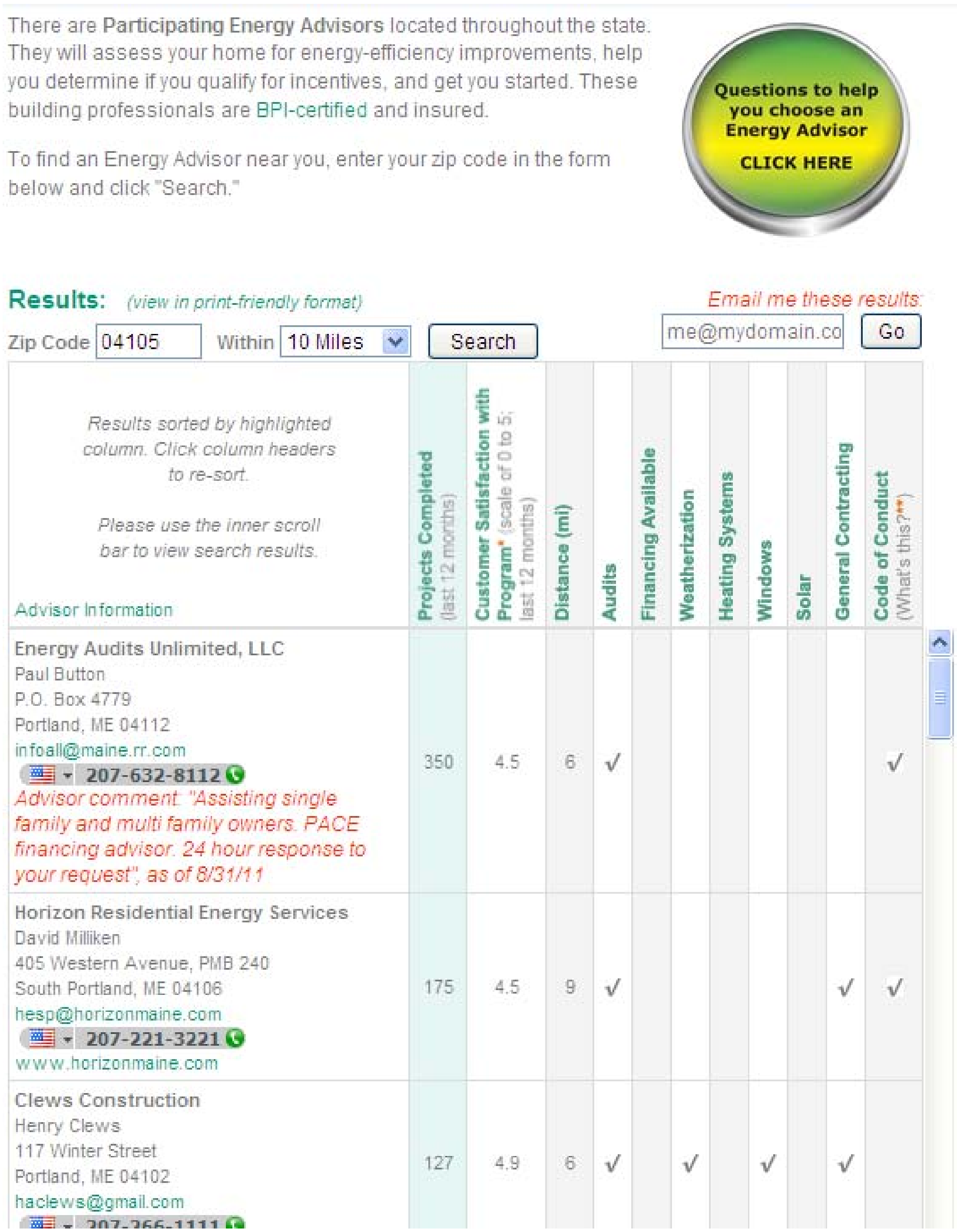
8. **Questions to help choose an Advisor.** A list of questions homeowners could use to help them choose an Advisor (see Appendix E) also included information that would help guide the homeowner's decision-making and expectations, for example:
- **Question**: Do you offer all the energy-efficiency services I may need following my audit? If not, do you have professionals you can recommend?
- **Guidance**: Some homeowners are happy to manage subcontractors and prefer an independent advisor who has no financial interest in the work. Other homeowners prefer to have their Advisor do the general contracting for them.

    This list was expanded and refined as more communication gaps between Advisors and homeowners were identified, and the link to this list was emphasized by presenting it as a large, colorful button (see Figure 6).

The Efficiency Maine Program was structured so that homeowners were initially funneled to the Advisor Locator. For many, it was the first point of contact with the Program.

1. Homeowners who contacted Efficiency Maine in search of an Advisor were directed to the Locator, and encouraged to choose an Advisor based on their own personal preferences.
2. "Hire a Participating Energy Advisor (hyperlinked to Locator) to perform a home energy audit" was the first step listed on the "How It Works" section on the website and in print materials.
3. The results generated by the Savings Calculator included a hyperlink to the Locator as well.

Find a Participating Energy Advisor


There are **Participating Energy Advisors** located throughout the state. They will assess your home for energy-efficiency improvements, help you determine if you qualify for incentives, and get you started. These building professionals are BPI-certified and insured.

To find an Energy Advisor near you, enter your zip code in the form below and click "Search."

Results: *(view in print-friendly format)* *Email me these results:*

Zip Code 04105 Within 10 Miles Search me@mydomain.co Go

Results sorted by highlighted column. Click column headers to re-sort.

Please use the inner scroll bar to view search results.

Advisor Information	Projects Completed (last 12 months)	Customer Satisfaction with Program* (scale of 0 to 5; last 12 months)	Distance (mi)	Audits	Financing Available	Weatherization	Heating Systems	Windows	Solar	General Contracting	Code of Conduct (What's this?**)
Energy Audits Unlimited, LLC Paul Button P.O. Box 4779 Portland, ME 04112 infoall@maine.rr.com 207-632-8112 *Advisor comment: "Assisting single family and multi family owners. PACE financing advisor. 24 hour response to your request", as of 8/31/11*	350	4.5	6	√							√
Horizon Residential Energy Services David Milliken 405 Western Avenue, PMB 240 South Portland, ME 04106 hesp@horizonmaine.com 207-221-3221 www.horizonmaine.com	175	4.5	9	√						√	√
Clews Construction Henry Clews 117 Winter Street Portland, ME 04102 haclews@gmail.com 207-266-1111	127	4.9	6	√		√		√		√	

Figure 6. Participating Energy Advisor Locator

The Program established the minimum criteria for qualification as a Participating Energy Advisor. Rather than develop its own standards, Efficiency Maine used standards that were established by independent organizations, and already recognized across the state, and in some cases, the country, namely:

1. **Building Performance Institute (BPI) certification.** BPI is a "national standards development and credentialing organization for residential energy efficiency retrofit work." BPI standards are used as a baseline for contractor qualification in many programs across the country. BPI certification was required.
2. **Maine Limited Energy Auditor Technician licensure.** The State of Maine requires auditors who perform BPI safety tests to obtain Limited Energy Auditor Technician licenses; these oil and/or propane licenses were required.
3. **Liability and Workers Compensation insurance.** A minimum of $500,000 in coverage was required for both insurance policies.

The description of the qualification process, and a Participating Energy Advisor Agreement Form were posted on the website.

3. *Leveraging Other Funding Sources*

To help encourage deep energy upgrades, Efficiency Maine designed the Program to leverage other funding sources. This was achieved by the following strategies:

1. **Paying rebates for only a percentage of the total upgrade cost, and only up to a maximum.** On average, rebates covered only about one third of the total cost of upgrades. Homeowners were responsible for the remainder of the cost. Many of them contributed thousands of dollars to the cost of their upgrades, and sought to take advantage of other potential funding sources. $8.4 million in rebates helped to offset private investments totaling nearly $27 million.
2. **Allowing customers to qualify for other incentives.** Efficiency Maine concurrently ran several other residential energy efficiency and renewable energy programs, including a Replacement Heating Equipment Program and Renewable Energy Programs. Efficiency Maine customers were encouraged to earn as many rebates as possible. This was referred to as double- and triple-dipping. For example, some participant's upgrades included a heating system replacement and a renewable energy system installation, earning three rebates that amounted to over $5,000 in some cases.

   The Program also actively sought information about other efficiency-related incentives, such as federal tax incentives, trade association and utility rebates and bank loans, and encouraged homeowners to take advantage of these as well. In so doing, Efficiency Maine served as a clearinghouse or one-stop shop for efficiency-related incentives, and included information about them in print materials and on the website, with the maximum benefit resulting from participating in all programs often cited.

By leveraging other funding sources, Efficiency Maine made it easier for homeowners to participate in the Program, and make larger investments in the efficiency of their homes. This contributed to a higher-than-anticipated depth of energy savings. On average, participants invested more than $8,000 in their homes, resulting in a 40% reduction in projected energy use.

4. *Focusing on Results*

Nearly every aspect of the Program's design was conceived with the goal of saving one million gallons of heating oil/year in mind. This resulted in a performance-based focus—because audits alone do not save energy—examples of which include the following:

1. **Paying only for upgrades, not audits.** For Advisors who had difficulty convincing homeowners to upgrade, not paying for audits was a contentious topic. But by *not* paying for audits, the Advisors who actually completed upgrades were rewarded. For example, several Advisors offered low- and no-cost audits to their customers, and made their profits on the upgrades that ultimately saved money for homeowners. Paying for audits undoubtedly would have resulted in more audits, but fewer upgrades.
2. **Offering cooperative marketing dollars only to the most active Advisors.** A $500 cooperative marketing bonus was offered to the first 10 Advisors who upgraded 10 homes each. The bonus was only moderately motivating, but it concentrated the funds on the Advisors who established a track record of turning audits into upgrades.
3. **Using quantity of completed upgrades for Advisor order on the Locator.** The quantity of completed upgrades was used as the default for sorting the order in which Advisors initially appeared on the Locator. This default helped to show homeowners which Advisors were the most likely to help them achieve a completed upgrade and qualify for a rebate. Advisors reported that when they managed to earn the top spot on the Locator, they benefited significantly in getting qualified leads. By contrast, the "hobbyists," who did not facilitate upgrades, ended up with far fewer leads.

5. *Avoiding Picking Winners*

While designing the Program, Efficiency Maine worked hard to avoid "picking winners," and maintained an impartial stance. One Advisor was never promoted over any of the others, and Efficiency Maine's communications were distinguished from those of the Advisors. For example, Advisor comments were clearly identified as such on the Locator.

In addition, one business model was never favored over another. Regardless of their business model, all contractors who were able to satisfy the Participating Energy Advisor qualification criteria were allowed to participate in the Program. Some of the Advisors only offered energy audits; others were also able to provide installation services. The results showed that both business models worked well.

The eligible measures list was not prescribed; any measure that resulted in energy savings was an eligible measure. This gave Advisors the flexibility to address the wide range of conditions that exist in Maine homes, and contributed to the comprehensive nature of many of the upgrades.

Advisors were given access to RealHomeAnalyzer, an online energy modeling tool offered by Conservation Services Group at no charge, but Advisors who preferred to use other modeling tools, such as REM/Rate and TREAT, were allowed to do so. This resulted in increased Advisor participation and satisfaction.

C. *Incentives*

Program participants were offered two tiers of rebates (see Figure 7). Tier One was for upgrades that were projected to save at least 25% of the energy used for heat and hot water in their home. Tier Two was for more comprehensive upgrades that were projected to result in an annual heat and hot water energy consumption reduction of 50% or more.

TIER	SAVINGS	REBATE	MAXIMUM
One	25 - 49%	30% of Project Cost	$1,500 per residential unit
Two	≥50%	50% of Project Cost	$3,000 per residential unit

Figure 7. Efficiency Maine Program Incentive Structure

Multifamily building owners could qualify for multiple incentives (one per dwelling unit). The maximum incentive amount for a single owner of multiple dwelling units was $48,000.

In response to a higher-than-expected level of participation in combination with limited funding, Tier 2 was eliminated during the second year of the Program. This allowed for a prolonged period of operation, and more rebates issued to more homeowners.

D. *Eligibility*

All Maine homeowners and multifamily building owners of all income levels were eligible to participate. (Given a history of programs that were only available to low-income Maine residents, the eligibility of Maine homeowners, *regardless of income*, was emphasized in Program marketing.) Rebates were issued to owners of one- to four-dwelling-unit structures, up to four stories. To qualify for a rebate, homeowners were required to do the following:

1. Hire a Participating Energy Advisor to perform an audit and final inspection.
2. Include weatherization measures (air sealing and/or insulation) in the work scope, if recommended by the Advisor.
3. Invest in efficiency improvements that were projected to save at least 25% of the energy used for heat and hot water in their home.

All rebate requests were subject to pre-approval and the issuance of rebate reservation letters, which were issued on a first-come, first-served basis and valid for 90 days.

E. *Eligible Measures and Installation Requirements*

Any measure that resulted in energy savings was an eligible measure. Efficiency measures against which rebates were applied included, but were not necessarily limited to, the following:

1. Air sealing
2. Insulation
3. Low-flow showerheads and aerators
4. Compact fluorescent light bulbs
5. Pipe and/or duct insulation
6. Programmable thermostats and other controls
7. High efficiency heating equipment
8. High efficiency water heating equipment
9. Solar water heating equipment
10. High efficiency replacement windows

Other measures that may not have directly resulted in energy savings, but were required to ensure occupant health and safety, were also eligible. These measures included, but were not necessarily limited to, the following:

1. Installation of mechanical ventilation equipment, such as exhaust fans or heat exchangers
2. Remediation of asbestos and/or lead paint
3. Repairs to prevent leaks
4. Remediation of mold and mildew
5. Replacement of rotted or damaged structural components
6. Repairs to chimneys and/or venting repairs to combustion equipment
7. Installation of gas line (from meter to heating and/or water heating system only)

The cost of the audit could also be applied against a rebate; however, a rebate was *not* available for audits that did not result in an upgrade.

The original design of the Program included a provision that required all homeowners to use Participating Energy Advisors for all phases of the work. With thousands of projects to complete and only a limited number of Advisors who offered installation-related services, this requirement was quickly revisited and modified to allow any professional to perform installation -related services, as long as a Participating Energy Advisor inspected the work and found that it included all measures associated with the original work scope, and met all applicable BPI standards for occupant health and safety. This Program modification also added an extra level of comfort for homeowners who wanted to use a contractor of their own choosing. As noted previously, homeowner distrust of contractors, as observed during focus groups, was seen as a potential barrier to the success of the Program.

F. *Process*

The Program was designed to have a simple process to make it as easy as possible for homeowners to qualify for a rebate. In print materials and on the website, the process was often described as being as easy as A, B, C:

A. **Audit.** Hire a Participating Energy Advisor to perform a home energy audit, and identify potential energy saving improvements.
B. **Button Up.** Hire a professional to make your pre-approved energy savings improvements.
C. **Check.** Get up to $1,500 back from Efficiency Maine. Additional incentives may apply.

The following is a more detailed description of the process:

1. **Conduct energy audit.** Homeowners hired Advisors to conduct energy audits. The cost of the audit was the homeowner's responsibility. Prices varied. Receiving an audit did not guarantee rebate eligibility. In order to qualify for a rebate, the Advisor had to demonstrate the potential for at least 25% energy savings.
2. **Finalize work scope.** Working collaboratively with the Advisor, the homeowner decided which measures to include in the work scope. Air sealing and insulation, if recommended by the Advisor, were required.
3. **Reserve rebate.** After the audit, a rebate reservation form, audit report and energy model were submitted to the Program for review and pre-approval. When projects were approved, a rebate reservation letter that specified how much funding was being reserved (the rebate maximum) and for how long (90 days) was sent to the homeowner.
4. **Perform upgrade.** Identified, pre-approved efficiency improvements were completed and/or overseen by Advisors.
5. **Inspect work.** All completed projects were inspected by Advisors, who confirmed completion of the work, and payment of all contractors. A BPI health and safety compliance evaluation and final blower door test were also performed at this time.
6. **Submit completion paperwork.** Upon completion of the work, the homeowner, or more commonly, the Advisor acting on behalf of the homeowner, submitted the following items to the Program:
    a. A completed and signed rebate claim form.
    b. A description of work scope changes that may have impacted cost or energy savings.
    c. Post-upgrade blower door test-out results.
    d. Copies of detailed invoices documenting work completed on the house and itemizing labor and material costs.

7. **Process and pay rebate.** Rebate claim forms and supporting documentation were reviewed, and eligibility requirements confirmed. The rebate was then issued and paid to the homeowner.
8. **Conduct Quality Assurance inspections.** 15% of projects were randomly selected for Quality Assurance inspections that were performed either before or after the upgrade. The data collected was used to coach Advisors, and make general improvements.

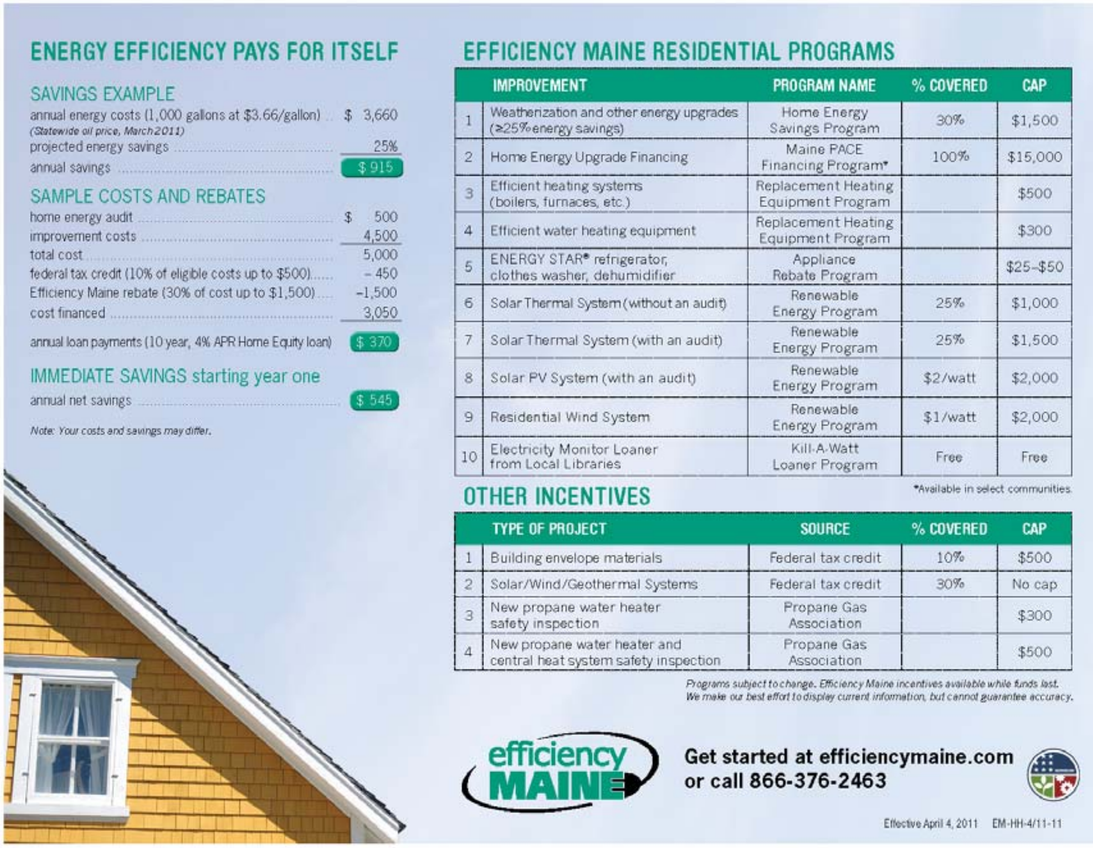
G. *Naming the Program*

Efficiency Maine ran a training-focused weatherization program from 2008 to 2009 that was referred to as the Home Performance with ENERGY STAR Program. This was originally adopted as the name for what would become the Efficiency Maine Program, but the name was changed to the Efficiency Maine Weatherization Program amid concerns that “Home Performance” would not resonate well with homeowners, and “ENERGY STAR” would create brand confusion. In fact, homeowner focus groups rated “Home Performance with ENERGY STAR” as one of the worst possible program names, and it was noted that “home performance” seemed more like something associated with entertainment centers than with energy efficiency. “ENERGY STAR” was closely affiliated with appliances, and therefore confusing and misleading.

The name Efficiency Maine Weatherization Program was also subject to criticism, largely as a result of the term “weatherization,” which is often associated with low-income programs. Several new names, including the names of similar programs across the region, were subsequently considered. Ultimately, the Efficiency Maine Home Energy Savings Program was selected as the full name.

IV. Additional Incentives

The Program rebate was just one of many incentives available to homeowners in 2010 and 2011. Efficiency Maine and other organizations also offered several other incentives at this time. The Program encouraged Advisors and homeowners to use all available incentives. A summary of programs was included in the Program brochure (see Figure 8) and on the Program website. double-dipping on incentives, and trained Advisors to be aware of these opportunities.



ENERGY EFFICIENCY PAYS FOR ITSELF

SAVINGS EXAMPLE

annual energy costs (1,000 gallons at $3.66/gallon) (Statewide oil price, March 2011)	$ 3,660
projected energy savings	25%
annual savings	$ 915

SAMPLE COSTS AND REBATES

home energy audit	$ 500
improvement costs	4,500
total cost	5,000
federal tax credit (10% of eligible costs up to $500)	– 450
Efficiency Maine rebate (30% of cost up to $1,500)	–1,500
cost financed	3,050
annual loan payments (10 year, 4% APR Home Equity loan)	$ 370

IMMEDIATE SAVINGS starting year one

annual net savings	$ 545

Note: Your costs and savings may differ.

EFFICIENCY MAINE RESIDENTIAL PROGRAMS

	IMPROVEMENT	PROGRAM NAME	% COVERED	CAP
1	Weatherization and other energy upgrades (≥25% energy savings)	Home Energy Savings Program	30%	$1,500
2	Home Energy Upgrade Financing	Maine PACE Financing Program*	100%	$15,000
3	Efficient heating systems (boilers, furnaces, etc.)	Replacement Heating Equipment Program		$500
4	Efficient water heating equipment	Replacement Heating Equipment Program		$300
5	ENERGY STAR® refrigerator, clothes washer, dehumidifier	Appliance Rebate Program		$25–$50
6	Solar Thermal System (without an audit)	Renewable Energy Program	25%	$1,000
7	Solar Thermal System (with an audit)	Renewable Energy Program	25%	$1,500
8	Solar PV System (with an audit)	Renewable Energy Program	$2/watt	$2,000
9	Residential Wind System	Renewable Energy Program	$1/watt	$2,000
10	Electricity Monitor Loaner from Local Libraries	Kill-A-Watt Loaner Program	Free	Free

*Available in select communities.

OTHER INCENTIVES

	TYPE OF PROJECT	SOURCE	% COVERED	CAP
1	Building envelope materials	Federal tax credit	10%	$500
2	Solar/Wind/Geothermal Systems	Federal tax credit	30%	No cap
3	New propane water heater safety inspection	Propane Gas Association		$300
4	New propane water heater and central heat system safety inspection	Propane Gas Association		$500

Programs subject to change. Efficiency Maine incentives available while funds last. We make our best effort to display current information, but cannot guarantee accuracy.

efficiency MAINE

Get started at efficiencymaine.com or call 866-376-2463

Effective April 4, 2011 EM-HH-4/11-11

Figure 8. Summary of Programs on Efficiency Maine Program Brochure

A. *Efficiency Maine Incentives*

Efficiency Maine runs several programs "to help businesses and residents all over Maine use energy resources more efficiently, reduce energy costs, and lighten the impact on Maine's environment from the burning of fossil fuels." The following ran concurrently with the Efficiency Maine Program:

1. Replacement Heating Equipment Program. Rebates amounting to as much as $500 were available to customers who installed high efficiency heat and/or hot water systems. Higher rebates were available to homeowners who installed more than one high efficiency appliance.
2. Solar Thermal Program. Homeowners who installed solar thermal systems were eligible to receive a rebate amounting to 25% of the project cost, up to a maximum of $1,000. A $500 bonus was available to homeowners who made other efficiency-related investments.
3. Solar Electric Program. Homeowners who installed solar electric systems were eligible to receive a rebate amounting to $2/watt, up to a maximum of $2,000.

4. Wind Energy Program. Homeowners who installed wind energy systems were eligible to receive a rebate amounting to $2/watt, up to a maximum of $2,000.

In addition to the incentives listed above, the Efficiency Maine Program also included incentives that went well beyond the basic rebate structure:

1. **$1,000 summer bonus.** This incentive was wildly successful, and had a profound effect on the Program. Its purpose was to stimulate program activity, and generate more upgrades during the summer, a typically slow period for the industry. A $1,000 summer bonus was offered to customers who signed up before August 31, 2010, and completed their upgrade before December 31, 2010 (see Figure 9). A bonus was applied to every dwelling unit (for example, a duplex owner would receive an extra $2,000), and the amount was *not* adjusted if the project cost was low.

Figure 9. Efficiency Maine Program Sign-up Deadline Announcement

The $1,000 summer bonus was announced in early June, and initially was only available to participants who completed their upgrades before August 31, 2010. It was so popular that virtually every Advisor in the state acquired a full schedule. One complained he was getting so many leads (15/day) he couldn't afford the time to call homeowners back and decline. As the summer progressed and the window of opportunity to take advantage of the promotion became increasingly narrow, more and more potential customers expressed frustration over the fact that they wanted to take advantage of the offer, but simply couldn't find an available Advisor. To accommodate these homeowners, Efficiency Maine changed the terms of the offer, allowing anyone who simply reserved a rebate by August 31 to qualify. This, however, still didn't allow some homeowners enough time to get an audit, so the offer was changed again to allow anyone who signed up for the promotion by August 31 to qualify. This change finally accommodated homeowner demand.

This incentive also demonstrated the value of deadlines. By the last week of August, hundreds of customers had signed up. Hundreds more signed up over the course of the final days and hours, and by the deadline, more than 2,000 people had signed up to participate.

2. **$5,000 increase in rebate maximum for natural gas.** Due to challenges with promoting the program, raising the incentive exclusively was considered. For a limited period of time (a three-month pilot based on finite funding), a $5,000 increase in the rebate maximum was offered to natural gas customers. This incentive brought the potential rebate total for natural gas customers to $8,000, plus the $1,000 summer bonus listed above. In spite of the rich rebate, this incentive was not terribly conclusive and did not prompt the expected response. Offering less money with a deadline (the $1,000 summer bonus) resulted in a greater response.

When compared with higher incentives, deadlines were found to be more successful and more cost-effective. However, neither deadlines nor higher incentives were effective without sufficient marketing.

B. *Other Local Programs*

Several other local efficiency-related programs ran concurrently with the Efficiency Maine Program:

1. The Propane Gas Association of New England offered customers $300 rebates for water heaters, and $500 rebates for combined heat and hot water systems through June 2011.
2. Maine's largest car dealership offered employees a payroll deduction program to use for audits and upgrades.
3. A statewide environmental advocacy organization partnered with Advisors to offer discounts on audits to its members.
4. Select towns gave free audits as municipal incentives.

C. *Federal Tax Credits*

Federal tax credits available during the Program included the following:

1. In 2010, weatherization and heating system tax credits of up to $1,500 (30% of project cost).
2. In 2011, the weatherization and heating system tax credits were reduced to $500.
3. Renewable energy system tax credits equal to 30% of project cost with no maximum.

Homeowners who qualified for the Program almost always also qualified for a federal tax credit. When promoting the Program, the tax credit amount was routinely added to the rebate amount to show homeowners the maximum incentive.

As noted previously, participants were encouraged to take advantage of as many credits and incentives as possible. (See Figure 10.)

ENERGY UPGRADE SAVINGS EXAMPLE

Typical Single Family Home	
Annual Heating Oil Costs	$3,000
Projected Energy Savings	25%
Dollars Saved Annually	$750
Audit Cost	$500
Upgrade Cost	$7,500
Total Cost	$8,000
Federal Tax Credit	($1,500)
Efficiency Maine Rebate	($1,500)
Propane Gas Association Rebate	($500)
Natural Resources Council Member Discount	($100)
Amount to Finance	$4,400
Annual Loan Payment (15 year, 4.99% APR)	$417
Immediate Annual Savings Starting Year One	$333

Figure 10. Efficiency Maine Program Upgrade Savings Example

V. DRIVING DEMAND

Six months into the Program, only 50 upgrades had been completed. Given the Program goal of 4,000 total upgrades during a two-year period, the Program was not on track and something had to be done.

As has been previously stated, the Program evolved from the Home Performance with ENERGY STAR Program that Efficiency Maine operated in 2008 and 2009. The primary focus of the Home Performance with ENERGY STAR Program was contractor training, and many of the Participating Energy Advisors who supported the Program received their BPI certifications during this time.

Initially it was necessary for the Program to concentrate on finding and recruiting Advisors, because the number of certified, insured and experienced contractors identified by the Program and available to homeowners was still small. But at six months, the Program had 100 auditors. On average, an auditor can complete two audits/week, or 100 audits/year. Therefore, 40 auditors could have reached the goal in a single year. While necessary, recruiting additional advisors was not sufficient to ensure Program success.

In fact, it quickly became evident that lack of homeowner interest was the chief barrier to success. Driving homeowner demand soon became the center of the Program's attention.

A. *Messaging Strategy*

The use of one year-round core message, coupled with seasonal hooks, worked best for the Program. This messaging strategy was used across all delivery channels. For example, in January the message was "Home Comfort Paid for by Energy Savings" with the seasonal hook "Preventing Ice Dams." In March the message was "Home Comfort Paid for by Energy Savings" with the seasonal hook "Preventing Wet Basements." While the mix of delivery channels varied by the need to drive demand, the use of the core message coupled with a seasonal hook was consistent. (See Figure 11.)

Core Message	Season	Seasonal Hook	Delivery Channels
Home Comfort Paid for By Energy Savings	Winter	Preventing Ice Dams	1. Efficiency Maine website 2. Public relations 3. Email outreach 4. Telephone outreach 5. Community cable presence 6. Utility bill stuffers 7. Utility websites 8. Targeted direct mail 9. Partner organization outreach 10. Statewide speaking engagements, such as building trade associations, homeowner events and town energy committees 11. Participating Energy Advisor events 12. Tradeshows and fairs/Home shows and fairs 13. Web advertising 14. Print advertising 15. Radio advertising 16. TV advertising
	Spring	Preventing Wet Basements	
	Summer	Summer Promotions	
	Fall	Heating System Replacements	

Figure 11. Efficiency Maine Program Messaging Strategy

B. *Message Development*

After much research and testing, "Home Comfort Paid for by Energy Savings" was ultimately selected as the year-round core message because it motivated homeowners to take action. Houses in Maine were cold and drafty, and homeowners assumed either there was nothing that could be done about it or the upgrades necessary to make a house warm were prohibitively expensive. "Home Comfort Paid for by Energy Savings" helped homeowners to take action, because it addressed their concerns and misconceptions. For example, many Program materials featured images of a family in bare feet on a wood floor to visually support the core message of home comfort (see Figure 12).

Prior to selecting "Home Comfort Paid for by Energy Savings," Efficiency Maine had conversations with hundreds of homeowners. As part of those conversations, the following messages were explored and ultimately discarded:

DISCARDED MESSAGES

1. **Building science.** Homeowners were no more interested in building science than car buyers would be interested in a lecture on internal combustion engines.
2. **Upgrades improve home value**. No evidence was found to support the concept that upgrades improve home value.
3. **Environmental benefits.** The concept of environmental benefits, such as reducing the homeowner's carbon footprint, only appealed to a small segment, and backfired with most others.
4. **Saving money.** The message "You'll save lots of money" did not resonate with homeowners, because the payback period was five to 10 years, and homeowners typically change houses every seven years. In addition, weatherization was seen as a break-even investment.

5. **Getting cash back.** Early on, the concept of "getting cash back" was used, but because of the financial arguments given in #4 above, its use was discontinued.
6. **Energy independence.** The Program took place during the war in Iraq, so the concept of energy independence was explored. This concept only appealed to a small segment.
7. **Patriotism.** Same as #6 above.

These messages were discarded because they did not work for the Maine market. "Home Comfort Paid for by Energy Savings" proved to be the most motivating message for Maine.

Figure 12. Efficiency Maine Program Handout

C. *Seasonal Hooks*

As has been already stated, seasonal hooks were developed for rotational use, coupled with the year-round core message. The use of the hooks was based on pain points and points of action for homeowners:

1. **Winter: Preventing ice dams.** Homeowners in Maine struggle with ice dams that can lead to costly roof leaks (a pain point). But they didn't connect ice dams with the need

for weatherization. The Program strived to make the connection for them. (Anecdotally, ice dams were a key driver for weatherization.)

2. **Spring: Preventing wet basements.** Many homeowners in Maine are challenged by wet basements that can lead to health issues and property damage (a pain point). But they didn't connect wet basements with the measures covered by the Program. The Program strived to make the connection for them.
3. **Summer: Promotions.** Promotions, such as the $1,000 summer bonus, were used to stimulate activity during a typically slow period for the industry.
4. **Fall: Heating system replacements.** Fall is when most heating systems are replaced. Some replacements are planned, others are emergencies. The Program concentrated on homeowners planning to replace their heating systems. (Emergency heating system failures in winter were not good Program candidates.) In anticipation of the onset of the heating season, homeowners were reminded that if they were already planning to replace their heating system (a point of action), it was a good time to weatherize, too. Using heating system upgrades was particularly attractive due to the sheer volume of demand. An estimated 20,000 replacements occur annually, which is ten times greater than the Program goal of 2,000 upgrades annually. (This estimate was based on the number of homes in Maine [roughly 500,000] and the approximately 25-year life of a heating system.)

The Program used pain points, such as ice dams and wet basements, and points of action, such as heating system replacements, to drive demand.

D. *Language Matters*

Word choice made a big difference in driving demand, because some words proved to be motivating, while others were inhibiting. Through a combination of activities, including conducting focus groups, having conversations with homeowners, talking with Advisors and reviewing the latest research on ways to motivate "green" behavior, Efficiency Maine reached the following conclusions about the use of language in the Program:

1. **"Participating Energy Advisors."** Efficiency Maine wanted to find a term that would most accurately describe the role auditors would play in the Program, and connote benefits to homeowners. In addition, the Program didn't want to imply endorsement, or make unsupported claims about auditors' qualifications. Therefore, a number of words in different combinations were considered (see Figure 13).

MODIFIER	THOUGHTS/CONCERNS	NOUN	THOUGHTS/CONCERNS
Qualified	Implies claim of competency by Efficiency Maine	Energy Auditor	Negative connotation with tax auditor
Certified	Implies claim of competency by Efficiency Maine	**Energy Advisor**	Positive partner with ability to be part of the whole process
Registered	True, but weak	Contractor	Negative connotation for homeowners
Participating	Indicates they are capable of getting rebates for the homeowner and comply with all program requirements	Vendor	Negative connotation for homeowners

Figure 13. Participating Energy Advisor Descriptor Selection Process

In addition, the Program wanted to steer away from "auditor," with its potentially negative associations with a tax audit, and make the distinction between auditors who would *only* audit a house, and those who would work with homeowners through the entire process. Ultimately, auditors affiliated with the Program were referred to as "Participating Energy Advisors" to emphasize their expertise, and reinforce their role as professionals offering more than just an audit, and advising homeowners on how to maximize their investment.

2. **Energy upgrade.** The term "energy upgrade" was used instead of "retrofit," because homeowners had negative associations with "retrofit," and positive associations with "upgrade." In addition, "energy upgrade" emphasized what homeowners would gain.
3. **Focus on benefits.** Words that expressed what people want to buy, such as comfort and warmth, were used instead of words that describe what contractors sell, such as air sealing, HVAC and insulation.

The U.S. Department of Energy's report "Driving Demand for Home Energy Improvements" supplied invaluable guidance and information to Efficiency Maine. In particular, the report served as a vital resource regarding the use of language in the Program.

E. *Delivery Channels*

The Program used as many delivery channels as possible to convey the year-round core message and seasonal hooks. These channels were prioritized based on cost-effectiveness and used as funding permitted and goals required. These channels (listed in order of priority) included the following:

1. Efficiency Maine website
2. Public relations
3. Email outreach
4. Telephone outreach
5. Community cable presence
6. Utility bill stuffers (See Figure 14.)
7. Utility websites
8. Targeted direct mail
9. Partner organization outreach
10. Statewide speaking engagements, such as building trade associations, homeowner events and town energy committees
11. Participating Energy Advisor events
12. Tradeshows and fairs/Home shows and fairs
13. Web advertising
14. Print advertising
15. Radio advertising
16. TV advertising

Figure 14. Efficiency Maine Program Utility Bill Stuffer

The delivery channels were employed in response to the need to drive demand. Those at the top of the list were used first; those at the bottom, such as TV advertising, were reserved as the last resort for demand creation.

The next delivery channel to be tested by the Program would have been referrals from "graduates" (homeowners who had completed upgrades through the Program). The Program had high expectations that referrals would have been very successful, but rebate funding was exhausted before more demand was needed.

F. *When to Market*

There are two schools of thought regarding when to market the Efficiency Maine Program:

1. Level the year-round demand by investing in the traditionally slow summer season, when homeowners are least likely to act.
2. Maximize the return on marketing dollars by investing during the fall and early winter peak demand season, when homeowners are most likely to weatherize anyway.

The Program was marketed so successfully in anticipation of the slow summer season that demand was driven right through the peak season. The question of when was the best time to market the Program was never really resolved.

VI. MANAGING THE PROGRAM

Efficiency Maine was dedicated to a continuous cycle of measuring results, evaluating, planning and implementing changes. Program feedback was aggressively sought and acted on. The Program strove to collect as many viewpoints as possible, and would not have been nearly as successful without the contributions of numerous individuals and organizations.

A. *Homeowner Input*

There were a number of means employed for gathering homeowner input on various aspects of the Program. Homeowner opinions were sought to initially develop the Program, and homeowner feedback was gathered as part of the Program's commitment to ongoing review.

1. **Focus groups.** Focus groups were conducted early on to gather input from Maine homeowners regarding perceptions about weatherization and energy efficiency programs. A third party was hired to facilitate two focus groups. The focus group participants were selected based on agreed upon parameters, such as age, household income, and the number of years the homeowners had lived in their homes. The focus groups were observed live, i.e., the Program management team was able to listen and

watch the participants, but the participants were not able to see the Program managers. There was a break toward the end of the focus group sessions to allow the Program the opportunity to develop any other questions to be answered by the focus groups. The participants did not know Efficiency Maine was the sponsor until the focus group sessions were almost over. In addition to the qualitative data gathered on the name of the Program, the participants also offered input on their perceptions of contractors and their understanding and perceived value of home energy audits. Unexpected key takeaways from the focus groups were the following:

a. Most homeowners thought their own homes were more efficient than average. This became known as the “Lake Wobegon” effect.
b. A significant number of homeowners indicated a distrust of contractors as the primary barrier to having their homes upgraded.
c. Homeowners believed they could do weatherization improvements themselves.
d. Homeowners felt confident in their knowledge of their homes and did not think they needed energy audits.

2. **Homeowner events**. The Program had a presence at events geared to homeowners, such as home shows throughout the state and environmental fairs run by employers and local communities.

3. **Customer satisfaction surveys.** To collect data on the overall experience of the Program, customer satisfaction surveys were used. The Program conducted phone surveys, and print surveys were mailed to those unavailable by phone. Using *The Ultimate Question: Driving Good Profits and True Growth* by Fred Reichheld as a guide, homeowners were asked “On a scale of 0-5 (with 5 being the best), how likely would you be to recommend the Efficiency Maine Program to a friend or neighbor?” After reviews on at least five homes per Advisor had been received, a satisfaction rating (based on an average) was posted on the Efficiency Maine website. There was a 39% response rate from homeowners, with an overall average score of 4.67. There were many positive comments, such as “The best part is that the house is warmer in the winter!” and “The results were very satisfying . . . saving energy and money. Please keep this program going!”

4. **Call center monitoring.** Program staff monitored calls received by customer service representatives for one hour each week to determine if training was needed to improve interactions with homeowners, and identify other opportunities for Program improvements. Approximately 100 improvements were identified, and made over the course of the Program.

B. *Advisor Feedback*

Feedback from Advisors—especially the most active ones—was a crucial source of Program improvements and insights. In addition, feedback gathered from observing Advisors *interacting* *with homeowners* proved to be invaluable. The importance of energy efficiency program managers getting out from behind their desks and into the field cannot be underestimated.

1. **Program Manager field observations.** Time spent in the field with the most active Advisors yielded some of the most valuable ideas for Program improvements. For example, the need for sales training and a Code of Conduct were identified during field visits.

2. **Technical Field Representative interactions.** Three Technical Field Representatives were assigned to provide technical, programmatic and energy modeling support to the Advisors. The Technical Field Representatives were highly qualified, had diverse backgrounds and were well-respected. They served as a significant conduit for information. Their daily interactions with the Advisors led to a number of Program insights. The Advisors gave positive feedback about their experiences with the Technical Field Representatives.

The most active Advisors were considered the key to vital feedback. It was more worthwhile to understand their feedback than that of less active Advisors. The feedback of “hobbyists” (those with few or no project completions) was not considered to be as valuable, because some of them shared views without necessarily having a high level of activity or experience to support them. This was referred to internally as listening to the “eagles” (most active Advisors), and not the “ducks” (less active Advisors).

C. *Third Party Review*

The Program also sought feedback from third parties about specific best practices related to the following:

1. Sales training
2. Marketing
3. Rebates
4. Quality Assurance (QA) processes

Early on, Unitil, a local electric and natural gas utility, informally reviewed the Program. One key recommendation was the use of the ENERGY STAR Home Energy Yardstick, a web-based tool for comparing a home's energy use to similar homes in the same area. The Program’s Savings Calculator was initially modeled after the ENERGY STAR Home Energy Yardstick, and served as an essential tool for assuaging homeowner concerns about investing in an audit without some indication that they were likely to qualify for a rebate.

Energy Futures Group, part of the U.S. Department of Energy’s Technical Assistance team, provided a mid-program review, and shared best practices from other programs. Most of the best practices had already been adopted by the Program prior to the Department of Energy’s review.

The Cadmus Group was hired to conduct a third-party evaluation after the conclusion of the Program. Among the findings in the Cadmus evaluation was a cost-effectiveness analysis, based on the Total Resource Cost (TRC) Test. The Program's net TRC Test benefit/cost ratio was 2.56. In other words, for every dollar invested by Efficiency Maine and homeowners, a $2.56 benefit was recognized over the life of the upgrade.

D. Feedback from Program Delivery Team

Given the Program's dedication to a continuous cycle of measuring results, evaluating, planning and implementing changes, the frequency of tracking was very important. Aspects of the Program were tracked every seven days, with an eye toward identifying bottlenecks and alleviating them. (See Figure 15.) The following aspects were tracked, because they were actionable indicators to determine needed next steps, such as increased demand creation or Advisor support.

1. Marketing efforts
2. Call center activity
3. Web activity
4. Number of completed audits
5. Number of rebate reservations
6. Number of completed upgrades
7. Customer satisfaction
8. Number of active Advisors
9. QA Inspections. (Technical Field Representatives conducted QA inspections on 15% of pre- or post-upgrade homes.)

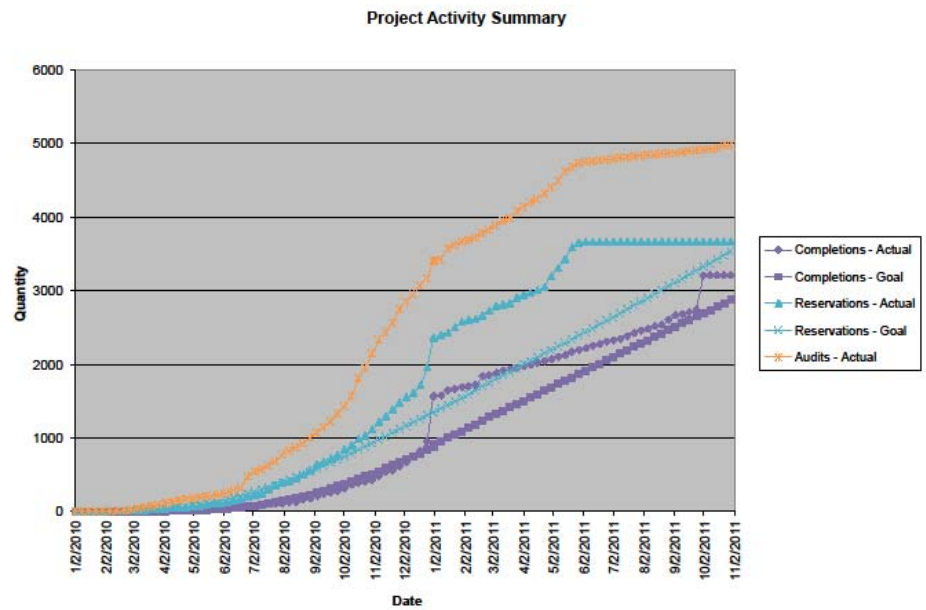


Figure 15. Efficiency Maine Program Reporting Summary

Making decisions based on the data worked better than relying on anecdotal information. Anecdotes were often grossly wrong. For example, one Advisor thought he was closing 90% of his leads when in fact he was closing only 10%.

E. Internal Quarterly Reviews

The extended Program Team met on a quarterly basis to review the Program, discussing accomplishments, issues of concern and future strategies. Representatives from the marketing vendor Vreeland Marketing and the Program management vendor Conservation Services Group would present results and proposed activities to Efficiency Maine management. The extended Program Team included Conservation Services Group executives, who work with similar programs throughout the country, and Vreeland Marketing executives, who work in multiple fields. The extended Program Team participated in the reviews in order to assist with benchmarking and share best practices.

F. Monthly Advisory Board Meetings

The Program Advisory Board was comprised of members who had diverse interests in the Program, and offered a broad range of perspectives. The Advisory Board members included the most active Advisors, as well as advocates, homeowners, heating oil dealers, peer utility representatives, trade association representatives and trade school representatives.

Monthly Advisory Board meetings were held to gather feedback, and find ways to improve the Program. The meetings also served as a forum for professionals to learn from one another. Though it was not a decision-making body, the Program Advisory Board's recommendations were taken very seriously. Their recommendations were prioritized, then implemented or dismissed. The status of the recommendations was reported at the following month's meeting. While very few promises were made up front, many of the recommendations were implemented. Attendance at the meetings was high because the Advisory Board members saw that their input was valued and acted upon.

VII. Support for Participating Energy Advisors

Vital to the Efficiency Maine Program's success were the Participating Energy Advisors who could evaluate home energy efficiency and perform high-quality building improvements using the latest building science technology. These Advisors were supported in a number of ways that are ranked as follows:

A. High Impact Support Methods (would definitely be used again)

1. **Weatherization sales training.** Efficiency Maine collaborated with Dale Carnegie of Maine to provide weatherization sales training, along with upgrade proposal tools. The tools included an audit checklist template that integrated building science with the art of selling and an audit report template (see Appendices F-G). The training developed by Efficiency Maine became a model for weatherization sales training nationally.[5] Weatherization sales training for Advisors, along with several other initiatives, proved to be a key means of converting more audits into upgrades, and helped drive close rates from 10% to more than 60%.

2. **Advisor Locator.** Participating Energy Advisor listings on the Advisor Locator (on the website) proved to be a vital and robust marketing tool.

3. **Online energy modeling tool.** Advisors were given free use of an online energy modeling tool (RealHomeAnalyzer, a Conservation Services Group product), as well as technical support. The online tool made it possible to get live updates at any time. Technical Field Representatives could access the data on the web, and offer energy modeling assistance from their offices. In addition, web-based modeling meant that Advisors didn't have to submit any data, Efficiency Maine had access to data (such as the number of audits) in real time and data was immediately available for Program

[5] A policy brief was written about the Efficiency Maine Program weatherization sales training. See *Contractor Sales Training: Providing the Skills Necessary to Sell Comprehensive Home Energy Upgrades*, August 17, 2011, part of the Lawrence Berkeley National Laboratory Clean Energy Program Policy Brief series.

reporting and analysis. The tool was well received by most of the Advisors, who continued to use it even after the program ended.

4. **Single point of contact for technical support.** The Program made available three Technical Field Representatives to provide free building science technical support to approximately 100 Advisors statewide. Each Advisor was assigned to one Technical Field Representative, and therefore had a single point of contact, on the phone and in the field, for auditing, modeling and upgrade advice. The Technical Field Representatives were highly trained, and had broad industry experience, having conducted thousands of audits in multiple programs nationwide. The Advisors benefitted from the Technical Field Representatives' diverse backgrounds, which included auditing, building, inspecting, training and weatherization sales.

   The availability of the Technical Field Representatives created an unprecedented opportunity for collaboration and information exchange. The Advisors had never had access to these kinds of trusted, independent resources before the Efficiency Maine Program. Previously, they were often forced to figure out things on their own, or seek assistance from their competitors, their suppliers or the web. Furthermore, the Technical Field Representatives encouraged collaboration and facilitated the exchange of information (such as best practices), because they were allies, not competitors. The Program received consistently positive feedback regarding the Technical Field Representatives.

B. Medium Impact Support Methods (would likely be used again)

1. **Sales tools.** Free electronic and print marketing materials were made available to Advisors. Many of the pieces included a blank area where Advisors could add their business card to customize the piece. (See Figure 16 for layout example.) Primary sales tools included the following:

   a. The Program brochure provided an overview of the Program, including contact and incentive information.
   b. The Myths and Facts brochure addressed 10 common misconceptions related to weatherization. It dispelled myths, such as historic homes can't be weatherized (see Appendix B).
   c. The case studies featured actual Program participants, using real names of people and places. The case studies were designed to appeal to a wide range of motivations for Program participation, such as making long-term investments, preventing ice dams and improving comfort.
   d. The Homeowner Checklist listed questions designed to help homeowners determine if their home was a good candidate for weatherization.

   Making the sales tools (see Appendices A-C) available on the website to download and print provided the Advisors with convenient unlimited access.

2. **List of BPI training providers.** BPI certification was required for the Program. Having the list of BPI training providers on the website made it easy for prospective Advisors to get

training quickly. The Program did not give BPI training directly; it served as a "matchmaker" between Advisors and trainers.

3. **Program manual.** The 16-page manual described all of the processes and rules of the Program. Although it was rarely read, it was kept public (posted on the website) in the interest of transparency.
4. **Frequent communication**. Periodic program updates (such as changes, results and updates) were distributed to Advisors via email blasts. This kept them very informed which helped to make them strong ambassadors of the Program.
5. **Recorded webinars.** The Program tried many different methods of support for the Advisors. Recorded webinars (posted on the web with notification via email) were not tried, but would be if the opportunity arose. Training was conducted via conference call, so that Advisors would not have to travel, but they often asked for recordings. Finding a time for training that worked for everyone was difficult.

Weatherization Myths and Facts

Myth #1 The solution for ice dams is to call a roofer.
Fact. Ice dams aren't a roofing problem. Ice dams form when attics are unintentionally heated by air leaks and/or insufficient insulation. This causes snow on the roof to melt, and freeze on the eaves, creating ice dams. You can reduce the risk of ice dams by sealing attic air leaks and adding insulation.

Myth #2 The solution for frozen pipes is to call a plumber.
Fact. Though a plumber can repair frozen pipes, weatherizing is the best way to avoid having them freeze in the first place.

Myth #3 It's easy to tell where my home is losing energy.
Fact. Many homeowners think the biggest air leaks are around windows and doors. While these leaks can be significant, most air leaks are hidden from view, passing through floors and ceilings, around chimneys, pipes, ductwork, etc. A Participating Energy Advisor, using specialized equipment and a computer model, can identify and quantify the extent of your energy loss.

Myth #4 A boiler without a storage tank is efficient because you're not storing hot water.
Fact. With the exception of modern, on-demand water heaters, tankless water heating systems are the least efficient.

Myth #5 The best way to deal with uncomfortably hot rooms is with an air conditioner.
Fact. With professional weatherization you can often address the source of the discomfort without using energy-draining air conditioners. Professional weatherization cannot only keep rooms warmer in the winter, but also keep them cooler in the summer.

Myth #6 Newer homes don't need weatherization.
Fact. Houses built before June 2010 were not subject to any state energy efficiency building codes. Therefore, the age of a home is not necessarily a good indicator of energy efficiency.

Myth #7 A dehumidifier is the best solution for everything from damp basements to mustiness.
Fact. A Participating Energy Advisor can identify moisture sources and recommend ways to reduce moisture in your home without using energy-draining dehumidifiers.

Myth #8 Making your house too airtight is dangerous. Houses have to breathe.
Fact. While houses do need fresh air, most homes have more air leaks than necessary. Even worse, incoming air usually enters homes through basements, garages and crawl spaces, which can compromise air quality. Controlling the flow of air in your home can save energy and improve air quality, too.

Myth #9 A humidifier is the best way to keep your home comfortable during a dry Maine winter.
Fact. Air leakage is the most common cause of excessive dryness. When cold air enters the house and is heated, the relative humidity is significantly reduced. Air sealing can help keep your home at a comfortable humidity level, without the need for a humidifier.

Myth #10 Historic homes can't be weatherized.
Fact. The important thing to remember is that a trusted professional makes all the difference. Efficiency Maine Participating Energy Advisors are certified by the Building Performance Institute (BPI) to identify energy-saving opportunities while still preserving the integrity and character-defining features of older homes.

ACME
WEATHERIZATION
Augusta, Maine
800-222-2222

EM-MB-03/11-02

efficiency MAINE efficiencymaine.com • 866-376-2463

Figure 16. Efficiency Maine Program Customizable Myths and Facts Brochure

C. Low Impact Support Methods (would not be used again)

1. **Co-op marketing dollars.** Advisors were offered $500 for every five completed upgrades to be used for co-op marketing. Even though Efficiency Maine matched Advisor marketing investments, this may not have had the desired effect on driving incremental marketing efforts, and may have been more of a windfall for the Advisors who would have invested in marketing anyway.

2. **Advisor website.** A password-protected website was set up for Advisors, and included the following materials and tools:
    a. Lawn sign artwork
    b. Door hanger artwork
    c. Logos for ads
    d. Participating Energy Advisor logos
    e. Print ad template
    f. Revisable PowerPoint for use with homeowners
    g. Program updates
    h. Technical standards/articles from BPI, EPA, ASHRAE and other sources

    Google analytics showed that the Advisors rarely used the password-protected website. Password protection was a mistake, because it discouraged the Advisors from using the website.

VIII. TIMELINE/RESULTS

October 2009:	Issued Program management and Program marketing RFPs.
November 2009:	Awarded Program management contract to Conservation Services Group.
December 1, 2009:	Announced Program to Advisors at weatherization trade association meeting.
January 2010:	Awarded Program marketing contract to Vreeland Marketing.
January 6, 2010:	Launched Program with kickoff event, featuring Governor of Maine, at Governor's office at State House.
June 1, 2010:	Reached milestone of 50 market-based, whole house energy upgrades. At this time, cost of heating oil was low ($2.50/gallon), and slow summer season had begun. Had challenges with getting participants, so

	introduced $1,000 summer bonus promotion for upgrades completed by August 31, 2010.
August 2010:	Demand was so high that virtually all Advisors were booked. Homeowners were unable to take advantage of promotion. Deadline for completed upgrades was extended to December 31, 2010, as long as project was registered by August 31.
October 1, 2010:	Reached milestone of 300 energy upgrades. For first time, Program hit goal of 36 completions/week.
December 18, 2010:	Reached milestone of 792 energy upgrades, with 60+completions/week. By this point, more than 2,600 energy audits had been conducted, and homeowners (or their contractors) had submitted nearly 1,600 rebate reservations. In six months since introduction of $1,000 summer bonus promotion, Program had been turned around, and rate of energy upgrades was equal to more than 3,000 completions/year. Approximately 200 additional completions were projected for final two weeks of year, bringing total to nearly 1,000 for first year of Program. *Then something unexpected happened*. In final two weeks of year, more completion forms were submitted than in entire previous 50 weeks combined. Final tally for first year was 2,900 audits completed with 1,668 homes upgraded.
January 2011:	Demand had been so high that marketing efforts were significantly reduced, and Tier Two incentive (for more comprehensive upgrades) was eliminated.
May 23, 2011:	Last rebate reservation was accepted; all funding was committed.
September 30, 2011:	Final upgrade completed three months ahead of schedule.

Final Program results were as follows:

- 5,140 BPI audits
- 3,667 rebate reservations
- 3,212 upgrade completions
- 65% close rate
- 40% total average efficiency improvement
- $11.3 million spent on Program delivery, marketing and rebates (70% on rebates)
- Average rebate: $2,611
- Average total job cost: $8,347
- Total construction investment, including homeowner contribution: $26.8 million during one of slowest construction periods in history.
- $1.16/gallon of heating oil saved (total program cost of homeowner + rebate + Program delivery + marketing was $1.16 for every projected gallon of heating oil saved)
- Net Total Resource Cost Test benefit/cost ratio was 2.56
- Average upgrade saved 40% on heating costs. Given that average home uses about 1,000 gallons/year of heating oil, this means savings of 400 gallons/year or 8,000 gallons over 20-year life of upgrade.
- Participating homeowners were saving about $1,000/year/home or $1.63 million/year across whole program for life of measures.
- More than 90 small businesses grew to service this market, adding significant numbers of jobs to payrolls.

IX. LESSONS LEARNED

When the Efficiency Maine Program launched in January 2010, unemployment was high (8.5%) and heating oil prices were relatively low ($2.74/gallon), giving homeowners less financial motivation to invest their money in energy efficiency. Focus groups revealed homeowner distrust of contractors, and an unfounded confidence in the efficiency of their homes, which were challenges for the Program. Focus groups also showed homeowners often felt they could do the work themselves, instead of paying a professional as was required by the Program. For these reasons, as well as the fact that energy upgrades required a substantial investment in order to qualify for Program rebates, many homeowners were not inclined to act.

In spite of this environment, Efficiency Maine showed that with $11 million of funding more than 3,000 homes can be significantly upgraded each year. Furthermore, Efficiency Maine also helped transform the market by modifying homeowner expectations of their homes, and developing contractor capabilities, resulting in long-term change in the industry.

These achievements were the result of leveraging market forces, focusing on demand creation, carefully designed incentives and continuously re-assessing the Program. They also would not have been possible without the following:

1. **Savings Calculator**. The implementation of the Savings Calculator (initially modeled after the ENERGY STAR Home Energy Yardstick) helped transform homeowner expectations. The addition of the Calculator to the Efficiency Maine website addressed the homeowner concerns: "Why should I pay for an audit if I don't know if I'll save energy?" and "Why should I invest in an upgrade without knowing if it will be cost-effective?" The Calculator gave homeowners a sense of the how likely they were to benefit from investing in their home. It compared the homeowner's energy usage to a "typical weatherized home," showing homeowners whether or not they could benefit from the Program. By comparing their energy usage to that of others in Maine, the Calculator also used peer pressure to encourage participation in the Program. Additionally, in order to ensure that homeowners took the immediate next step in the process, the Calculator linked them directly to the Participating Energy Advisor Locator.

2. **Participating Energy Advisor Locator.** The Program was designed to leverage market forces to encourage Participating Energy Advisors to develop their capabilities, and the Participating Energy Advisor Locator was the centerpiece of this effort. While it began as a crude tool (a PDF), it was made more sophisticated over time. With the development of the Advisor Locator into a user-friendly, online tool with enhanced features, homeowners could identify local Advisors by simply entering their zip code and search radius, and then shopping for an Advisor by comparing the quantity of completed upgrades, the availability of financing, customer satisfaction, compliance with the Code of Conduct and other criteria. The quantity of completed upgrades was the default sort order, which helped to show homeowners which Advisors were the most likely to help them complete an upgrade and qualify for a rebate. This also helped to drive performance, because Advisors who earned the top spot on the Locator benefited significantly in getting qualified leads.

3. **Participating Energy Advisor selection guidance.** A list of questions was posted on the website (see Appendix E) to help homeowners choose an Advisor. The list included questions such as whether or not the Advisor would conduct the audit only, or provide a full range of services. The list also included information that would guide decision-making and expectations, such as "Some homeowners are happy to manage

subcontractors and prefer an independent advisor who has no financial interest in the work. Other homeowners prefer to have their Advisor do the general contracting for them." As part of the continuous cycle of evaluating and implementing changes, the list was expanded and refined as additional communication gaps between Advisors and homeowners were identified.

4. **Code of Conduct**. Focus groups uncovered the fact that the primary reason homeowners are reluctant to upgrade their homes was a distrust/dislike of contractors. A Code of Conduct (see Appendix D) was developed to address homeowner concerns related to contractor conduct. The Code of Conduct was based on feedback from homeowners and included a list of 14 items that were intended to improve Advisor-customer relations. Advisors who committed to follow the Code agreed to cleanliness, timeliness and refraining from the use of profanity, among other things. This voluntary commitment was reflected on the Locator. More than half of the Advisors made this commitment within two weeks of the introduction of the Code.

5. **Weatherization sales training.** Sales training (along with presentation tools) was developed by Efficiency Maine in collaboration with Dale Carnegie, and became a model for weatherization sales training nationally. Providing weatherization sales training to Advisors was an essential means of teaching them how to better communicate with homeowners, and converting more audits into upgrades. Weatherization sales training, along with other initiatives, increased close rates from 10% to 60%.

6. **Weekly tracking.** To actively manage demand creation activities, many aspects of the Program were tracked on a weekly basis, including call center and website activity, customer satisfaction and numbers of completed audits, rebate reservations and completed upgrades. These were actionable indicators used to determine needed next steps, such as Advisor recruiting, and assess the cause and effect of marketing efforts.

7. **Program staff field observations.** Information gleaned from Program staff field visits—especially while observing Advisors interacting with homeowners—was a crucial source of Program improvement ideas. Some of the most effective ideas, such as the aforementioned Code of Conduct and weatherization sales training, came from field observations. This type of beneficial feedback cannot be gathered unless energy efficiency program staff get out into the field

8. **Monthly Advisory Board meetings.** Monthly meetings with Advisory Board members (Advisors and industry representatives with diverse interests in the Program) were held to gather program feedback. Key Advisory Board recommendations were implemented

quickly. Monthly meeting attendance was high, because Advisory Board members saw that their input was acted upon.

9. **Avoiding picking winners.** Although frequently tempted, the Program staff worked very hard to avoid "picking winners," and let the market make choices instead. For example, rather than requiring Advisors to be independent of installation companies as some advocated, the Program allowed both audit-only and full service companies to participate. The Advisor Locator clearly showed the services of all contractors, which helped homeowners make their own decisions. Roughly half of homeowners chose independent Advisors and the rest chose Advisors that acted as a one- stop-shop. This philosophy was applied to many other aspects of the program and, in all cases, market forces determined the winners.

10. **Listening to "eagles" not "ducks".** Frequently and proactively seeking feedback was one of the keys to the Program's success, but there was an important subtlety – knowing who to ask. Often the people most willing to spend time sharing their opinions were those least qualified to give helpful advice. The Program intentionally sought out the top performers ("eagles") for feedback.

11. **Marketing.** Driving demand was a vital aspect of the Program because the lack of homeowner interest was found to be the chief barrier to success. "Home Comfort Paid for by Energy Savings" was selected as the year-round core message because it motivated homeowners to take action. Prior to selecting "Home Comfort Paid for by Energy Savings," Efficiency Maine had conversations with hundreds of homeowners and Program participants, and explored many concepts and phrases. The Program found that the core message, coupled with seasonal hooks, worked best. While multiple delivery channels were employed, the use of the core message, coupled with a seasonal hook, was consistent.

12. **Attention to word choice.** Words that expressed homeowner benefits, such as comfort and warmth, were used instead of words that describe what contractors sell, like air sealing and insulation. In addition, real people, real names and real towns were used in order to strengthen homeowners' connection to the Program. The DOE Lawrence Berkeley National Laboratories report "Driving Demand for Home Energy Improvements" served as an indispensable resource for the Program's process for determining the most effective language.

13. **Incentives and deadlines that drive demand.** The limited-time summer bonus was highly successful, and had a profound effect on the Program. Though it was only $1,000 compared to the ongoing $3,000 program rebate and $1,500 federal tax credit, the fact

that it expired at the end of August drove a disproportionate surge in demand. The incentive stimulated so much Program activity (during the otherwise slow summer season) that Advisors' schedules were essentially booked across the state for months. By the initial deadline, hundreds of customers had signed up. Homeowner demand continued to grow, and by the final deadline, more than 2,000 people had signed up to participate.

IX. CONCLUSION

Thanks to an $11M ARRA grant in 2010, Efficiency Maine was able to demonstrate that an energy efficiency program can drive high volumes of relatively deep energy upgrades in a highly cost-effective way. In the midst of a deep recession when homeowners were financially strapped and energy was temporarily cheap, over 3,000 homeowners were motivated to invest nearly $6,000 of their own money to upgrade their homes in one year. This represented a 150-fold increase over the previous years that had no rebates and significantly less marketing funding. The average upgrade cost $8,347 and increased whole house energy efficiency by 40%. Third party evaluation showed that each dollar spent on the program (program delivery, rebates and homeowner contribution) produced a $2.56 direct benefit.

There were four critical success factors of the Program: 1) leveraging market forces to accelerate results 2) focusing on driving demand more than workforce development 3) carefully designing incentives to reward results rather than activity (upgrades, not audits) and 4) continuously monitoring results and re-assessing the Program to incorporate lessons learned.

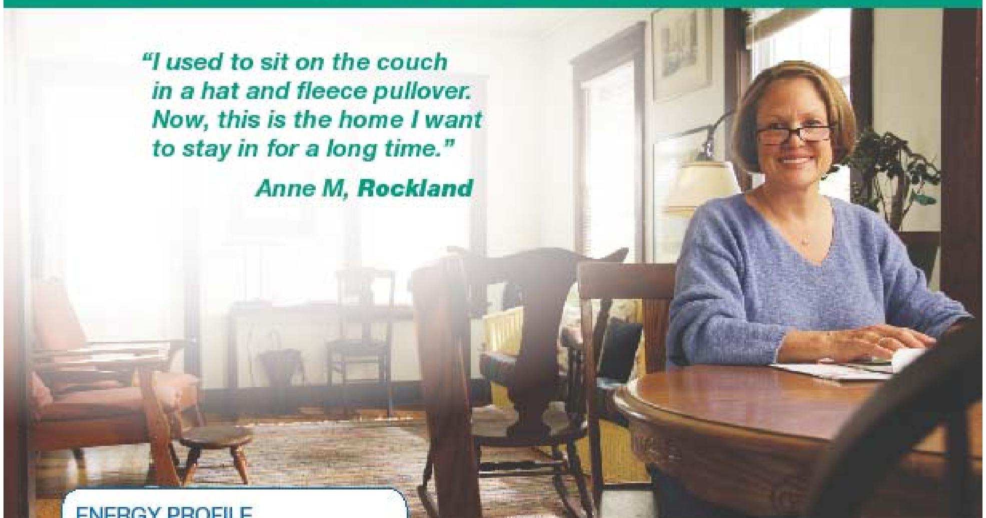
Residential energy upgrades have the immediate impact of creating jobs and several long-term impacts including: economic stimulus from energy savings, increased home comfort, and reduced environmental impact. Efficiency Maine's program proves that funding residential energy efficiency programs can produce significant results.

XI. APPENDIX

A. Case Studies
B. Myths and Facts brochure
C. Homeowner checklist
D. Code of Conduct
E. How to Select a Participating Energy Advisor (Registered Vendor)
F. Audit Checklist Template (featuring building science integrated with sales)
G. Audit Report Template

Appendix A. Case Studies

Making a home warm and livable for years to come



ENERGY PROFILE

Initial energy costs	$1,850/yr
Projected energy savings	35%/yr
Annual savings	$ 648

Costs and Rebates

Improvement costs	$ 11,600
Efficiency Maine rebate (30% of cost up to $1,500)	$ –1,500
Efficiency Maine Summer Special rebate '10	$ –1,000
Federal tax credit (2010)	$ –900
Out of pocket	$ 8,200
Annual loan payments (10 year, 4.875% APR loan)	$ 1,038/yr
Cost for comfort per year until loan is paid off	$ 390

These numbers reflect actual expenses and incentives available at the time. Check efficiencymaine.com for current incentives.

Anne's home in Rockland was relatively new, but very cold. As a first-time homeowner, she wanted to make improvements that would make her home comfortable and livable well into the future. Motivated by the Home Energy Savings Program, Anne invested in energy efficiency. With financing, her newfound comfort is costing her less than $35 a month.

Challenges
- Uncomfortably cold living spaces
- High heating and electric bills
- Damp, musty basement

Improvements
- Insulation in attic and walls
- Insulation and moisture barrier in basement
- Air leaks sealed
- Heating system ducts and hot water pipes sealed and insulated

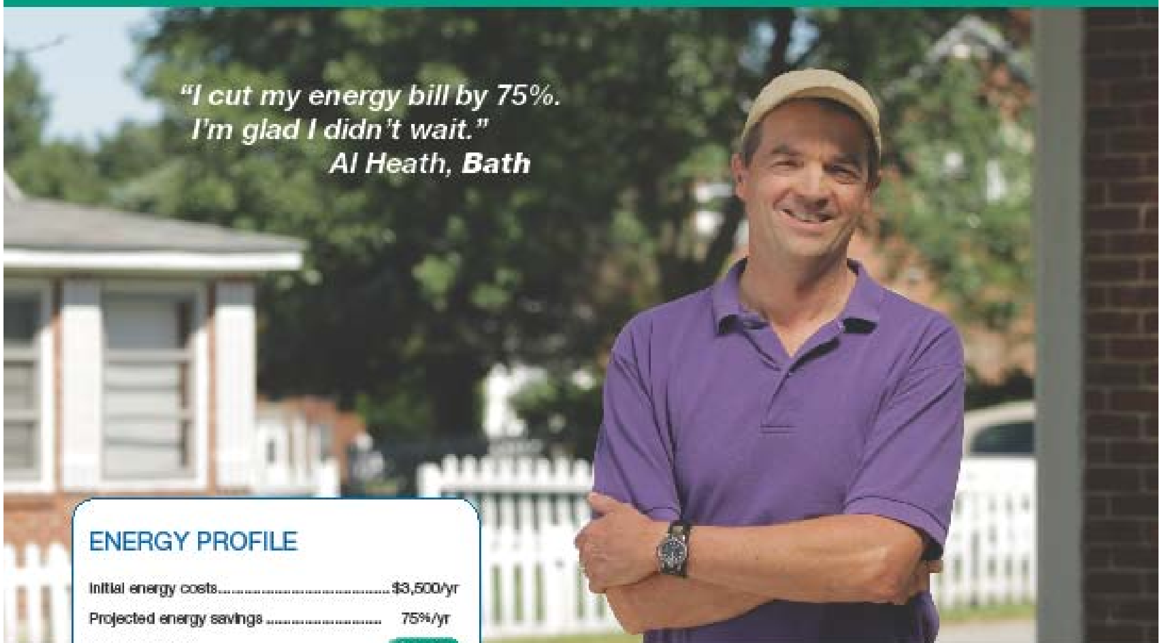
Benefits
- Home is warm, comfortable – and relaxing
- Dry basement offers added space for storage
- Dramatically lower heating costs

Get started at **efficiencymaine.com** or call **866-376-2463**.
Program subject to change. Incentives available while supplies last.

efficiency MAINE

EM-CS1-0111-01

Deep energy upgrade delivers whole-house comfort & savings



ENERGY PROFILE

Initial energy costs	$3,500/yr
Projected energy savings	75%/yr
Annual savings	$ 2,625

Costs and Rebates

Improvement costs	$ 18,000
Efficiency Maine rebate (50% of cost up to $3,000)	–3,000
Efficiency Maine Summer Special rebate '10	–1,000
Efficiency Maine freezer rebate	-75
Efficiency Maine water heater rebate	-150
Federal tax credit (2010) (30% of cost up to $1,500)	–1,500
Out of pocket	$ 12,275
If financed, annual loan payments (10 year, 6% APR loan)	$ 1,635
IMMEDIATE SAVINGS starting year one (if financed) annual net savings	$ 990

These numbers reflect actual expenses and incentives available at the time. Check efficiencymaine.com for current incentives.

efficiency MAINE

Al purchased a 1940s home in Bath, Maine. He undertook a deep energy upgrade with the goal of reducing his overall energy consumption by at least 75%. The upgrades are expected to save thousands of dollars a year. They also deliver a whole new level of comfort.

Challenges

- Poor insulation
- Wet, "nasty" basement
- Drafty rooms

Improvements

- Insulation in attic and walls
- Moisture barrier and insulation in basement
- Sealing of air leaks
- ENERGY STAR® lighting and appliances

Benefits

- Even heat and comfort throughout the house
- Basement can now be used for storage and extra living space
- Home stays warmer in winter and cooler in summer

Now is the time to invest in energy-efficiency upgrades for your home. Get started at **efficiencymaine.com** or call **866-376-2463**.

Program subject to change. Incentives available while funds last.

EM-CS1-111-02

Appendix B. Myths and Facts brochure

Weatherization Myths and Facts

Myth #1 The solution for ice dams is to call a roofer.
Fact. Ice dams aren't a roofing problem. Ice dams form when attics are unintentionally heated by air leaks and/or insufficient insulation. This causes snow on the roof to melt, and freeze on the eaves, creating ice dams. You can reduce the risk of ice dams by sealing attic air leaks and adding insulation.

Myth #2 The solution for frozen pipes is to call a plumber.
Fact. Though a plumber can repair frozen pipes, weatherizing is the best way to avoid having them freeze in the first place.

Myth #3 It's easy to tell where my home is losing energy.
Fact. Many homeowners think the biggest air leaks are around windows and doors. While these leaks can be significant, most air leaks are hidden from view, passing through floors and ceilings, around chimneys, pipes, ductwork, etc. A Participating Energy Advisor, using specialized equipment and a computer model, can identify and quantify the extent of your energy loss.

Myth #4 A boiler without a storage tank is efficient because you're not storing hot water.
Fact. With the exception of modern, on-demand water heaters, tankless water heating systems are the least efficient.

Myth #5 The best way to deal with uncomfortably hot rooms is with an air conditioner.
Fact. With professional weatherization you can often address the source of the discomfort without using energy-draining air conditioners. Professional weatherization cannot only keep rooms warmer in the winter, but also keep them cooler in the summer.

Myth #6 Newer homes don't need weatherization.
Fact. Houses built before June 2010 were not subject to any state energy efficiency building codes. Therefore, the age of a home is not necessarily a good indicator of energy efficiency.

Myth #7 A dehumidifier is the best solution for everything from damp basements to mustiness.
Fact. A Participating Energy Advisor can identify moisture sources and recommend ways to reduce moisture in your home without using energy-draining dehumidifiers.

Myth #8 Making your house too airtight is dangerous. Houses have to breathe.
Fact. While houses do need fresh air, most homes have more air leaks than necessary. Even worse, incoming air usually enters homes through basements, garages and crawl spaces, which can compromise air quality. Controlling the flow of air in your home can save energy and improve air quality, too.

Myth #9 A humidifier is the best way to keep your home comfortable during a dry Maine winter.
Fact. Air leakage is the most common cause of excessive dryness. When cold air enters the house and is heated, the relative humidity is significantly reduced. Air sealing can help keep your home at a comfortable humidity level, without the need for a humidifier.

Myth #10 Historic homes can't be weatherized.
Fact. The important thing to remember is that a trusted professional makes all the difference. Efficiency Maine Participating Energy Advisors are certified by the Building Performance Institute (BPI) to identify energy-saving opportunities while still preserving the integrity and character-defining features of older homes.

efficiencymaine.com
866-376-2463

EM-MB-03/11-02

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Appendix C. Homeowner checklist

Does Your Home Need an Energy Upgrade?

If you answer "yes" to any of the questions below, your home could be a good candidate for the ***Home Energy Savings Program***. The best way to be certain is to hire a Participating Energy Advisor to perform a professional home energy audit.

1. Does your home experience any of the following?
   - Ice dams .... Yes ____ No ____
   - Frozen pipes .... Yes ____ No ____
   - Hot/cold rooms .... Yes ____ No ____
   - Drafts .... Yes ____ No ____
   - Damp basement .... Yes ____ No ____
   - Mustiness .... Yes ____ No ____
2. Do you use a:
   - Dehumidifier .... Yes ____ No ____
   - Humidifier .... Yes ____ No ____
   - Air Conditioner .... Yes ____ No ____
3. Are you considering replacing your heating system?
   .... Yes ____ No ____
4. Is your hot water produced directly by your boiler, without a storage tank?
   .... Yes ____ No ____
5. Are you considering replacing your windows?
   .... Yes ____ No ____
6. Is your home poorly insulated?
   .... Yes ____ No ____
7. An average 2,000 square foot home costs about $2,000 per year to heat. Are you paying more than $1 per square foot per year for heat? .... Yes ____ No ____
8. Are you willing to invest or finance the $5,000 - $10,000 needed for an energy upgrade?
   .... Yes ____ No ____

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EM-CL-10/11-04

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Appendix D. Code of Conduct

CONTRACTOR CODE OF CONDUCT

I recognize that working in homes can be disruptive. I am committed to respecting the homeowner's property, minimizing disruption, and leaving the condition of the home as I found it or better.

All employees working for ______________________________ (company name) will:

1. Provide identification that includes their relationship to this company at the request of the homeowner.
2. Call the homeowner if they expect to arrive more than 15 minutes late.
3. Respond to customer calls and emails in a timely manner (within minutes or hours, but never more than a day).
4. Not arrive at any customer's home unexpectedly.
5. Work at reasonable times; they will not arrive before 8AM or stay after 5PM without the homeowner's permission.
6. Not use inappropriate language at the worksite.
7. Not use the bathroom, kitchen, electronics or telephone without permission.
8. Not use tobacco products, alcohol or drugs while at the worksite.
9. Not borrow anything from the homeowner without asking.
10. Ensure that the homeowner's pets stay inside (or outside) the home per direction of the customer.
11. Notify the homeowner immediately if any damage to property occurs when they are working.
12. Place equipment on drop cloths, and remove their shoes or use protective foot covering when working inside the home.
13. Make the work area safe and clean by sweeping or vacuuming at the end of each workday.
14. Not leave behind trash, surplus materials or tools unless they have specific permission from the homeowner.
15. Set thermostats and heating systems back to original levels at the end of each workday.

Company President and/or Owner	
Signature	
Date	

efficiencymaine.com 866-376-2463 REV 10/26/12

Appendix E. How to Select a Participating Energy Advisor

How to Select a Registered Vendor

Questions to Ask All Contractors:

1. Do you have references I can contact?
2. How soon can you begin? And how quickly will my work be completed?
3. Do you provide a standard contract? (Find a sample contract from the Maine Attorney General's Office here.)
4. What are your payment terms and conditions? (For example, do you require a deposit and when is final payment due?)
5. Do you require your employees to sign a Contractor Code of Conduct committing to professional conduct at the worksite? See Efficiency Maine's Code of Conduct here.

Questions to Ask References:

1. What work did this company do for you? (Ideally it's relevant to what you are considering.)
2. When? (Hopefully it's recent enough to reflect on the vendor's current capabilities, but long enough ago so that they've had a chance to experience the results.)
3. How would you rate your satisfaction with the work (0-10)?
4. How would you rate your satisfaction with the company (0-10)?
5. Why did you choose this company? (e.g. Is there any special relationship between the reference and the company?)
6. Is there anything else I should ask? (This question can uncover some interesting points.)

Additional Questions to Ask Energy Advisors:

1. Does your company participate in Efficiency Maine's Air Sealing Incentive Program?
2. What kind of information will I receive from you following my home energy audit? (Expect a list of recommended energy efficiency improvements, along with the cost and the projected energy savings of each measure.)
3. What percentage of your audits includes recommendations for heating system replacement or controls? (Best practice is close to 100%)
4. Do you offer all the energy-efficiency services I may need following my audit? If not, do you have professionals you can recommend? (Some homeowners are happy to manage subcontractors and prefer an independent advisor who has no financial interest in the work. Other homeowners prefer to have their advisor do the general contracting for them.)
5. What do you charge for an audit?
6. Do you help homeowners apply for Maine PACE and PowerSaver Loans? What do you charge for that service?
7. What do you charge for a final inspection/test-out at the completion of the job?
8. If I hire you to do the audit, and someone else to do the install, will you still perform a final inspection?
9. Do your workers seal sources of air leakage with a blower door in operation to ensure that sealing has occurred where it is needed?

12/10/2012

Appendix F. Audit Checklist Template (building science integrated with sales) page 1 of 6

The Home Energy Savings Program Audit Checklist

RAPPORT		Name	
		Address	
		Town	
		Phone Number (Home)	
		Phone Number (Work)	
		Phone Number (Cell)	
		email	
		What prompted your call today?	
INTERESTS	Situation		
		Ice Dams?	
		Frozen pipes?	
		Hot/cold rooms?	
		Drafts?	
		Damp basement?	
		Mustiness?	
		Humidifier used?	
		Dehumidifier used?	
		Air Conditioner used?	
		Heating system replacement needed or desired?	
		Window replacement needed or desired?	
		Solar and/or renewable energy system needed or desired?	
		Poor insulation?	
		Paying more than $1 per square foot a year for heat?	
		How long do you intend to live in your current house?	
	Motivation? Rate 0-10		
		0-10 for being green	
		0-10 for saving energy	
		0-10 for renewable energy	
		0-10 for increasing comfort	
		0-10 for saving money	
		0-10 for increasing safety	
		0-10 for increasing interior air quality	
		Is there anything else?	

F. Appendix Audit Checklist Template (building science integrated with sales) page 2 of 6

INTERESTS

Timeline

	Timeframe for making the decision?	
	Timeframe for completing the work?	

Financial

	A maximum incentive requires spending at least $6,000. Are you prepared to invest at least this amount?	
	Planning to use, or interested in, financin g?	

Confirmation

	Will another person be involved in the decision making process? If so who is it?	
	Other decision-maker's needs?	
	If I could come up with a proposal that would address these needs are you prepared to move ahead with the project?	

Capability

	Based on what you told me, I <<do/do not>> think it makes sense to move forward.	

SOLUTION

Audit Planning

	In our audits, we use a blower door, infrared camera and combustion safety testing equipment to gather data for our energy modeling software. The audit costs <<$XXX>> and is payable at the time of the audit. It takes <<X>> hours and it is best if you are present. If you heat with wood, please make sure there is no fire for the preceding 24 hours.	
	Audit Date	
	Time	
	Will other decision-makers be present?	
	Re-confirmed 1 day in advance?	

Appendix F. Audit Checklist Template (building science integrated with sales) page 3 of 6

RAPPORT

Home Visit

	Smile	
	Conform convenient time for audit?	
	Compliment home	
	Offer to remove shoes	
	Ask customer to sit at kitchen table for brief interview	

Kitchen Table Interview

	Provide agenda for audit	*Credentials*
		Brief Interview
		Exterior Inspection
		Interior Inspection
		Blower Door Test
		Combustion Safety Testing
		Debrief
	Is it OK to proceed?	
	Credentials: (EM PEA, BPI, LEAT, MABEP, Lead Safe, Sales Training (e.g. Dale Carnegie), etc.)	
	Review general home issues (above)	
	Review customer's interests (above)	
	Confirm decision-makers (above)	
	Confirm timeframe for making the decision (above)	
	Confirm timeframe for completing the work (above)	
	Collect audit payment	

Demographics/Building Model — NOTE: Red text is used to highlight required RHA input s

	Number of occupants?	
	Year built?	
	Is it an apartment building? If so, how many units?	
	How long do you plan to live in this house?	

EXTERIOR INSPECTION

Exterior Inspection

	Direction house faces	
	Adjoining dwelling(s)	
	Adjoining buffered space(s)	
	Exterior wall type	
	Number of floors	
	Measure footprint	
	Look for potential discontinuities in thermal/air barriers (porch roofs, additions, etc.)	
	Attached garage	
	Roof venting scheme	
	Siding type	
	Insulation under siding	
	Foundation insulation	
	Window type	
	Look for exhaust appliance termination – bath, kitchen, etc.	
	Find stack pipes	
	Find chimneys	
	Observe grade around house	
	Gutters and downspouts	
	Check for bulk moisture issues	
	Check for obvious structural issues	
	Test gas tanks and pipes for leaks	

Page 3 of 6 Audit Checklist_v 1.1, 01-06-11

Appendix F. Audit Checklist Template** (building science integrated with sales) **page 4 of 6

INTERIOR INSPECTION

Basement

	Basement types – crawlspace, slab, full, et c	
	Wall and Rim Joist R-value	
	Obvious infiltration sites	
	Mold	
	Excessive moisture – cause?	
	Asbestos insulation	
	Open chases	

Heating System

	Heat system location	
	Heat system type	
	Fuel	
	Burner details	
	Venting type	
	Approximate manufactured date	
	Output capacity	
	Distribution type	
	Outdoor temperature reset installed?	
	Intellicon installed?	
	Always hot or cold start?	
	Turn off boiler. Leave car ke y near switch	

Domestic Hot Water System

	Domestic hot water system location	
	DHW type	
	Fuel	
	Venting	
	Energy factor	
	Tank gallon capacity – tankless coil or on demand = 10 gallons	
	Approximate manufactured date	

Living Space

	Wall R-Values	
	Average ceiling height	
	Close and lock all windows	
	Open all closet and interior doors	
	Look for potential discontinuities in thermal/air barriers	
	Look for infiltration sites	
	Find all vent fans	
	Find washer and dryer	
	Find attic access	

Electrical

	Lighting upgrade potential?	
	Refrigerator remove/replace	
	Freezer remove/replace	
	Clotheswasher	
	Dishwasher	

Attic

	Attic insulation nominal R-Value	
	Attic insulation condition/ gaps	
	Observe any openings into living space	
	Look for mold	
	Look for water entry issues	
	Look for vermiculite	
	Note exhaust fan duct runs and terminations	

Page 4 of 6 Audit Checklist_v 1.1, 01-06-11

Appendix F. Audit Checklist Template (building science integrated with sales) page 5 of 6

PERFORMANCE TESTING

Blower Door Test

	Estimate results if vermiculite and/or asbestos is present	
	Place house in testing condition	
	Record CFM @ -50 Pa	
	Observe infiltration effects with IR camera	

Worst Case CAZ Depressurization

	Record baseline pressure in CAZ with respect to outside	
	Turn on all exhaust appliances	
	Turn on air handler if present. Leave on if it increase depressurization, turn off if it decreases depressurization.	
	Open/Close doors to get maximum depressurization	
	Subtract baseline from worse depressurization	

All Heat and Hot Water Appliances

	Test gas pipes and connections for leaks	
	Observe venting pipe runs	
	Insulated ducts/pipes	

Spillage

	Maintain worst case CAZ depressurization	
	Turn on combustion appliance	
	Check spillage for one minute	
	Repeat for other heat and hot water appliance s	

Steady State Draft Test

	Run appliance for 10 minutes	
	Measure draft in vent pipe	

CO at Steady State

	Record CO with probe in ven t	
	Test efficiency if desired	
	Repeat for other heat and hot water appliance s	

Retest Draft and Spillage (if failed above)

	Discontinue worse case depressurization and test draft and spillage	
	Repeat for other heat and hot water appliance s	

Retest DHW Heater if Flues are shared or DHW flue enters chimney below heater connection

	Test Draft and Spilla ge	

Other Combustion Appliances

	Test for gas leaks	
	Test CO at steady state	

Appendix F. Audit Checklist Template (building science integrated with sales) page 6 of 6

MISCELLANEOUS	**If Upgrades to these areas are anticipated**		
		Measure attic area to be upgraded	
		Note attic access opportunity	
		Foundation/Floor existing R-Value and areas	
		Exterior wall R-Value and areas	
		Window sizes, types, directions	
		Door types, sizes	
		Faucet aerator	
		Showerhead	
	Non-energy remediation opportunities		
		Vermiculite	
		Other potential sources of asbestos	
		Knob and tube wiring	
		Mold	
		Water entry	
SOLUTION	Summary with Homeowner		
		Avoid criticism	
		Review positive features of the home	
		Review decision-maker interests	
		Describe likely recommendations and benefits directly related to the customer's interests	
		Walk around inside and outside as needed to describe upgrades	
		Give rough estimates of costs for the measures and the resulting incentives	
		Offer to help with financing	
		Would they like to proceed?	
		If no, why not?	
		Determine next step(s) – get firm quotes, schedule final proposal review with ALL decision-makers	

Page 6 of 6 Audit Checklist_v 1.1, 01-06-11

Appendix G. Audit Report Template (page 1 of 19)

<< Insert Picture of Customer Home>>	<<Contractor Logo>>

<<Contractor Name>>
<<Contractor Contact Name>>
<<Contractor address>>
<<Contractor Town/City, State, Zip>>
<<Contractor Telephone #>>
<<Contractor Fax #>>
<<Contractor email address>>

CREDENTIALS

** Efficiency Maine Participating Energy Advisor * Building Performance Institute Building Analyst * State of Maine Limited Energy Auditor Technician * Lead Safe Certified * Member: Maine Association of Building Energy Professionals*

Recommendations and Project Proposal for **<<Homeowner Name>>**	
Prepared By:	
Date:	
Site Address:	
Decision-Maker Name(s):	

Introduction:

Good news - this report includes recommendations that address:

Homeowner Interests:
1.
2.
3.
4.
5.

- 1 - Version 1.1, 01-06-11

Appendix G. Audit Report Template (page 2 of 19 remainder not shown)

RECOMMENDATIONS SUMMARY

#	Recommendation	Gross Cost	Rebate	Net Cost $	Net Cost $/Month (if financed)	Estimated Monthly Savings	Estimated NET Monthly Savings (Cost)	Homeowner Interests Addressed:
1	Insulation	$ -						
2	Air Sealing	$ -						
3	Moisture	$ -						
4	Other	$ -						
5	Other	$ -						
Subtotal		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	
6	HVAC	$ -						
7	Solar	$ -						
8	Other	$ -						
9	Other	$ -						
10	Other	$ -						
TOTALS		**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**This proposal is good for 90 days.**

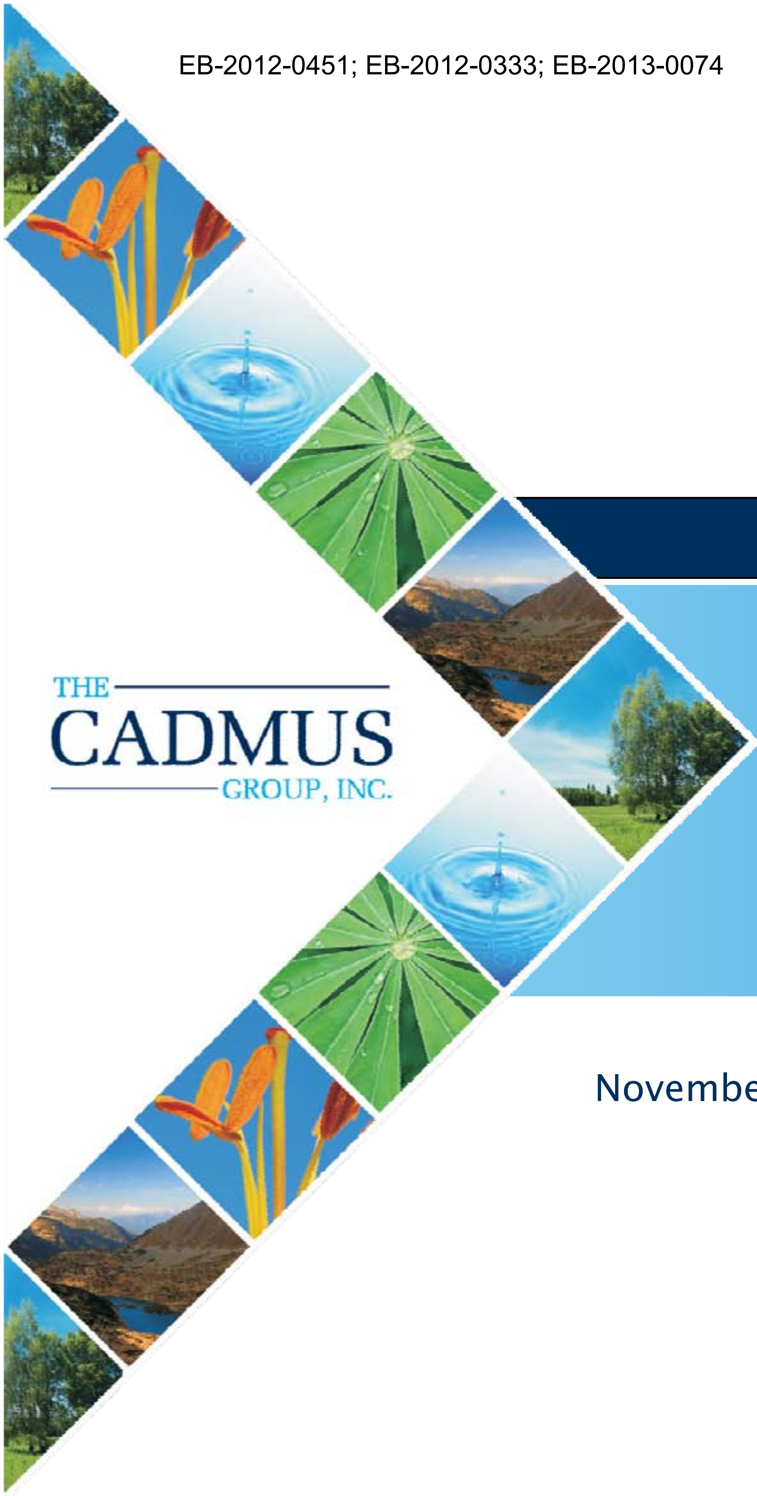
<<NOTE: Costs are estimated and subject to change as subcontractors are selected.>>

Rebates Included Above

$ -	Efficiency Maine Home Energy Savings Program - Standard Offer (30% of project cost up to $1,500)
$ -	Federal Tax Credit for Weatherization (10% of project cost up to $500)
$ -	Efficiency Maine Replacement Heating Equipment Program ($300 - $500)
$ -	Federal Solar/Wind/Geothermal (30% of Project Cost - no maximum)
$ -	Efficiency Maine Solar Thermal (25%, $1,500 maximum)
$ -	Efficiency Maine Solar PV ($2/watt, $2,000 maximum)
$ -	Efficiency Maine Wind ($1/watt, $2,000 maximum)

CUSTOMER ACCEPTANCE:

Name Signature Date



Efficiency Maine Trust
Home Energy Savings Program
Final Evaluation Report

November 30, 2011

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Contents

Figures

Tables

Executive Summary

This report presents the results of an impact evaluation of the Efficiency Maine Trust (Efficiency Maine or Trust) Home Energy Savings Program (HESP or Program), conducted by The Cadmus Group, Inc. (Cadmus). The HESP is a residential, whole-house, energy-efficiency program that targets existing homes in Maine, and is available to any residence in Maine that is heated during the winter (regardless of occupants' income levels).

The evaluation addressed the following research objectives:

- Determine energy savings;
- Evaluate the cost-effectiveness and job creation potential (due to funding from the American Recovery and Reinvestment Act (ARRA));
- Compute carbon emissions reductions and environmental impacts; and
- Assess customer satisfaction.

Cadmus understands Efficiency Maine could offer a rebate to Maine residents for whole-home retrofits because of the availability of ARRA funds. The funds have since been exhausted. The HESP program structure remains to help residents initiate and complete whole home retrofits and participants can borrow through the Maine PACE program to help finance the upgrades, but the monetary rebate/partial reimbursement is no longer offered. However, some of the recommendations in this report are contingent on the availability of future funding.

Energy Savings

Cadmus visited 41 HESP project sites and, using engineering review and simulation modeling, estimated gross program savings (verified savings) and realization rates. Cadmus compared verified savings with the limited number of utility bills available. Given the number of bills and variability of fuel deliveries, this was a qualitative assessment, rather than a formal billing analysis. Cadmus determined net savings via a customer survey.

As a result of the analysis, Cadmus determined the following:

- **The average gross realization rate for the verified measures was 90%.** Realization rates varied among the installed measures and can be found in Table E-1.

Table E-1. Realization Rate by Measure Type

Measure Type	Reported Savings	Verified Savings	Realization Rate
Air Sealing	566	585	103%
Attic Hatch	29	18	62%
Basement Insulation	381	305	80%
Ceiling Insulation	568	328	58%
Wall Insulation	462	584	127%
Furnace/Boiler	82	51	62%
Total (41 Sites)	2,087	1,871	90%

- **Cadmus found that program documented and claimed (reported) HESP measure installations matched field observations, except at a few sites.**
  - Cadmus staff conducted blower door testing at 31 of the 41 sites. At these sites, air sealing results were nearly identical (99%) of values reported by Efficiency Maine.
  - The verified area in square feet of insulation was 98% of the reported area.
- **The Efficiency Maine HESP had a gross program realization rate of 88% and a net program realization rate of 76%.**
  - Table E-2 and E-3 compare annual reported energy savings by fuel type with annual verified gross energy savings by measure type, and by fuel type, respectively. These data were expressed in MMBTUs, where all fuel types, including electricity, were converted to MMBTUs.

Table E-2. Annual Energy Savings by Fuel Type

Annual Energy Savings by Fuel Type (MMBTUs)	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	Net-to-Gross (NTG)	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n)
Fuel Oil	132,063	110,638	84%	0.86	95,148	72%	8,373
Natural Gas	1,244	4,965	399%	0.86	4,270	343%	2,070
Propane	763	2,052	269%	0.86	1,765	231%	1,376
Wood	3,635	3,315	91%	0.86	2,851	78%	374
Kerosene	732	615	84%	0.86	529	72%	102
Electric	3,024	2,908	96%	0.86	2,501	83%	749
Corn Pellet	22	17	76%	0.86	15	65%	17
Total (1780 Sites)	141,485	124,509	88%	0.86	107,077	76%	13,061

Table E-3 shows *lifetime* net energy savings attributable to the HESP.

Table E-3. Lifetime Energy Savings by Fuel Type

Lifetime Energy Savings by Fuel Type (MMBTUs)	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	Net-to-Gross (NTG)	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n)
Fuel Oil	3,044,152	2,569,517	84%	0.86	2,209,785	73%	8,373
Natural Gas	87,296	156,880	180%	0.86	134,917	155%	2,070
Propane	55,068	76,932	140%	0.86	66,162	120%	1,376
Wood	91,216	83,203	91%	0.86	71,555	78%	374
Kerosene	17,617	14,786	84%	0.86	12,716	72%	102
Electric	40,278	37,597	93%	0.86	32,333	80%	749
Corn Pellet	563	426	76%	0.86	367	65%	17
Total (1780 Sites)	3,336,191	2,939,342	88%	0.86	2,527,834	76%	13,061

Carbon Emissions Reductions and Environmental Impacts

Cadmus calculated displaced greenhouse gas emissions, associated with Efficiency Maine's HESP. To conduct this analysis, Cadmus used verified net energy impacts, in terms of net tons of carbon emissions, avoided over the effective useful life of the projects.

Table E-4. Annual and Lifetime Carbon Emissions Displaced from HESP

Fuel Type	Total GHG Emissions Displaced Tons CO2e	
	Annual	Lifetime
All Fuels (without Biomass)	8,443	196,735
Biomass	347	8,707

Cost-Effectiveness of ARRA-Funded Programs

Table E-5 presents results of cost-effectiveness analysis, based on the Total Resource Cost (TRC) Test, calculated using gross reported savings, adjusted realized savings, and adjusted net savings. The HESP is comfortably cost-effective in all three scenarios.

Table E-5. Program TRC

Value	Reported Gross Savings Scenario	Verified Gross Savings Scenario	Verified Net Savings Scenario
MMBTU Savings	141,485	124,509	107,077
Avoided Energy Benefits	$70,097,059	$59,597,884	$51,254,180
Added Energy Costs	$6,879,199	$4,710,016	$4,050,614
Participant Incremental Costs	$16,387,212	$16,387,212	$14,093,002
Program Delivery	$1,078,868	$1,078,868	$1,078,868
Marketing	$642,111	$642,111	$642,111
Administration	$187,155	$187,155	$187,155
TRC Benefits	$70,097,059	$59,597,884	$51,254,180
TRC Costs	$25,174,546	$23,005,363	$20,051,751
TRC Ratio	2.78	2.59	2.56

The DOE SEP-RAC test is an alternate, cost-effectiveness metric, evaluating whether projects save at least 10 million source BTUs (10 MMBTUs) annually, the threshold for ARRA-funded programs. The HESP saves 13.41 net adjusted MMBTU per $1,000 in ARRA expenditures, passing the SEP-RAC test. Table E-6 provides details of the SEP-RAC test analysis.

Table E-6. Components and Results of the SEP-RAC Test

Category	Value
RHA MMBTU Savings – Adjusted Gross	124,509
TR MMBTU Savings – Gross	8,762
Total Gross MMBTU Savings	133,271
Net-to-Gross Ratio	86%
Total Net MMBTU Savings	114,613
HESP Incentives (Including Bonus Payments)	$6,641,237
Program Delivery	$1,078,868
Marketing	$642,111
Administration	$187,155
Total ARRA Expenditures	$8,549,371
MMBTU/$1000	13.41

Customer Satisfaction

This evaluation included talking with HESP participants about their program experiences. Cadmus conducted surveys, overseeing implementation of 100 participant surveys by a subcontractor, the Gilmore Group; this included full participants—defined as those completing home energy upgrades and receiving an HESP rebate—and partial participants, defined as those with an energy audit but not following through to completion. Cadmus also talked with participants during site visits. At the highest level, survey results indicate the following:

- **Program participants were very satisfied.** Field staff described participants as very satisfied with services and incentives they received. Participants reported being more comfortable in their homes, and seeing a noticeable decreases in their fuel bills.
    - Most full survey participants (87%) reported being "very satisfied" with program participation.

- The HESP rebate motivated participants to initiate the audit and invest in improvements, as did the possibility of saving money on their energy bills.
- The rebate provided a more effective incentive to complete energy upgrades, compared to tax credits.
- Upfront costs presented the most significant participation barrier to making recommended energy upgrades.

Key Recommendations

Cadmus recommends that Efficiency Maine:

1. Continue to emphasize the importance of thorough air sealing practices.
2. Work with its energy advisors to:
    a. Ensure they target areas within the home that will lead to the greatest energy savings achievements (e.g., empty wall cavities).
    b. Emphasize the importance of installation quality.
    c. Continue building partnerships and supplying contractors with information that can be used to help promote program offerings.
3. Consider expanding its current marketing techniques by:
    a. Using “homeowner stories” in program promotional channels beyond the Website.
    b. Developing marketing messages that inspire residents’ trust, and highlight participants’ very positive experiences with program paperwork.
    c. Enhancing the “return on investment” (ROI) appeal for low-cost measures to increase uptake on these recommended improvements.

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1. Introduction

1.1 Evaluation Objectives

The Efficiency Maine Trust (Efficiency Maine or Trust) hired The Cadmus Group, Inc (Cadmus) to verify energy savings and program effects of the Home Energy Savings Program (HESP). The HESP was funded by the State Energy Program (SEP) American Recovery and Reinvestment Act (ARRA) funds. Cadmus' evaluation estimated the:

- Gross and net energy savings impacts over the effective useful life (EUL) of the program's actions;
- The net tons of carbon not released into the atmosphere over the EUL of projects implemented;
- The number of short-term and long-term, and full-time and part-time jobs generated due to the program; and
- Results of the SEP Recovery Act cost-effectiveness test, applied to the energy impacts achieved.

1.2 Program Description

From December 2009 through 2011, Efficiency Maine delivered a residential whole-house efficiency program, targeted toward existing homes in Maine. Any Maine home heated during the winter was eligible to apply for and receive a program rebate, regardless of income level of the owner or occupant.

Predominantly a weatherization program, HESP focused on air sealing and on wall, attic and ceiling insulation measures. Other eligible measures included heating system replacement, domestic hot water (DHW) system replacement, controls, windows, doors, and renewable energy systems, such as wind or solar.

The program sought to weatherize and improve the overall energy efficiency of residences throughout Maine and to, on average, achieve 25% total annual energy savings per residence. The program addressed all fuels (heating oil, kerosene, natural gas, propane, wood, and electricity), primarily focusing on fuels used for space heating and hot water.

The program offered financial incentives (rebates) to homeowners for the installation of eligible efficiency measures. The program offered two incentive levels:

- Tier 1 (a maximum of $1,500 per home) for projects projected to save at least 25% of the annual thermal (heating and hot water) energy used in the home; and
- Tier 2 (a maximum of $3,000 per home) for more comprehensive projects, such as multi-measure installations projected to result in energy reductions of 50% or more.

1.3 Evaluation Design

The evaluation sample frame was designed to use as much program data as possible, while still ensuring evaluation participants would have had a chance to observe changes within their home post-measure installation, and decreasing the risk that Cadmus technicians would inspect sites where the installation was incomplete. Considering these factors, the sample frame was defined as HESP participants who received an energy audit between December 1, 2009, and December 31, 2010. This resulted in a total of 1,780 sites as a part of the evaluation population.

Table 1 shows how the evaluation period compares to the total program period.

Table 1. Program and Evaluation Period Metrics

Metric	HESP Program	Evaluation Period
Audits Completed	5,026	1,780
Rebate Reservations (Actual)	3,667	1,780
Completed Upgrades (Actual)	3,211	1,540
Average Upgrade Cost	$8,349	$12,286
Total Cost, All Upgrades	$26,810,236	$19,019,182
Average HESP Incentive Paid	$2,610	$2,585
Total HESP Incentives Paid	$8,380,265	$4,559,951

Cadmus used a variety of techniques to evaluate impacts of the HESP, as shown in Table 2.

Table 2. Summary of Evaluation Tasks

Action	Impact	Process	Details
Verify Measure Installation	✓		Conducted 41 site visits (includes on-site, detailed customer interviews) and measurement and verification.
Engineering and Simulation (Modeling) Analysis	✓		Developed revised deemed unit savings estimates for installed measures and conducted an engineering analysis (including engineering review and simulation modeling) to estimate program savings and gross realization rates.
Analyze Energy Bills (limited)	✓		Examined gas, electric, oil, and propane bills as a point of comparison to modeling. After extensive efforts Cadmus obtained 5 gas bills, 15 fuel oil bills, and 2 propane bills. Cadmus was able to report findings for a total of 19 bills (15 fuel oil bills and 4 gas bills).
Survey Participants		✓	Conducted telephone survey to measure customer satisfaction and areas for improvements and attribution. (n=70)
Survey Partial-Participants		✓	Conducted telephone survey to measure program awareness and reasons for not participating. (n=30)

The impact analysis compared program savings estimated from Cadmus' engineering and simulation modeling (verified savings) to the program's reported savings. The verified energy savings were based on data Cadmus collected from the 41 site visits.

Responses from the full and partial participant survey were used to calculate net-to-gross (NTG) and obtain a qualitative understanding of program spillover.

Verified energy savings were qualitatively compared with energy consumption observed through the billing data, which was collected separately from Maine fuel providers.

Cadmus estimated additional HESP impacts including the number of jobs created, the program's Total Resource Cost (TRC) and MMBTUs saved per $1,000 spent, and the displaced greenhouse gas emissions in terms of net tons of carbon emissions avoided over the EUL of the measures.

2. Methodology

2.1 Impact Evaluation Methodology

Sampling

Cadmus designed a site visit sample to reach the goal, stated in the proposal, of a one-tailed 90% confidence and ±10% precision (90/10) across the HESP's participants. In designing the sample, Cadmus estimated 41 site visits would be required to reach 90/10.

Site Visits

Cadmus visited 41 HESP sites during the first two weeks in August 2011. During these site visits, Cadmus technicians:

- Offered $25 gift cards as an incentive to participants who agreed to partake in a site visit.
- Verified the installation of claimed measures:
  - Type of measure;
  - Application area of the measure;
  - Thickness (where applicable) of the installation; and
  - R-Value (where applicable) of the installation.
- Documented the quality of the installation and operation.
- Gathered efficiency measure characteristics (e.g., furnace model and efficiency setting).
- Used infrared cameras or thermal scans (where possible) to check for proper installation of wall insulation.
- Completed blower door tests (where possible) to determine air exchanges per minute to assess the success of building weatherization. Figure 1 illustrates an installed blower door during a site visit.

Figure 1. Illustration of Blower Door Testing

- Recorded temperature and schedule settings of programmable thermostats.

- Checked aerator and showerhead flow rates through flow bags.
- Interviewed participants to better understand their use of their home's heating system(s).
- Gathered the necessary home characteristics (e.g., square footage of home, number of windows).

Engineering and Simulation Analysis

Cadmus examined HESP program databases, visited 41 sites, and gathered detailed information about each site, as described in the previous section. Using collected house and user behavior data, Cadmus used REM/Rate[1] software to create a model that simulated the energy performance of each house and estimated its energy consumption during (1) pre-installation conditions and (2) post-installation conditions.

To establish the home's state prior to the weatherization, Cadmus staff interviewed the homeowner and inspected the structure to determine baseline insulation levels, and assess the operational mechanical equipment installed. Each home was then modeled based on the level of energy efficiency observed during the site visit (post-installation conditions: installed measure and home characteristics) and the level of energy efficiency before participation in the HESP program as indicated by the homeowner and, where possible, verified by Cadmus (pre-installation conditions).

Cadmus used REM/Rate to evaluate weather-dependent measures[2]. Weather-dependent measures include air sealing, insulation (wall, ceiling, and basement or crawlspace), attic hatch, and heating equipment. Two REM/Rate models were run for each house, taking into account heating system type, and observed wall, ceiling, and basement dimensions, and insulation values.

The resulting total home energy savings from the models divided into per-measure energy savings values. The difference in the pre- and post-consumption was used to estimate energy savings at the measure level. Cadmus compared the verified savings for each house and measure to reported values, producing realization rates at the measure level.

Utility Billing Analysis

At the start of the evaluation, Cadmus planned to collect billing data from the 41 site visit participants to assess their fuel consumption during the 12-month period prior to the installation of HESP measures, and compare this with their consumption during the 12-month period after the installation. The intent was to give Cadmus a qualitative view of consumption to compare with results of the modeling efforts.

[1] REM/Rate software produces a home energy rating report based on the RESNET (Residential Energy Services Network) National HERS Technical Standards. It is endorsed by RESNET and is HERS BESTEST certified. REM/Rate is designed in accordance with the Mortgage Industry National Home Energy Rating Systems Standard, a widely accepted standard to gauge home energy performance and apply a HERS rating. Our experience with REM/Rate has shown it to accurately model insulation and predict energy usage, and provide accurate and cost-effective energy savings results for typical residential homes.

[2] Cadmus verified the installation of hot water, lighting, and appliance measures during site visits.

Cadmus believed this comparison would be a valuable addition to the evaluation, but anticipated that the billing analysis could be constrained by the small sample, or difficulty when interpreting fuel deliveries. Unfortunately, it was more challenging to obtain and interpret fuel data than expected so the analysis was limited to simple comparison of the billing data with our engineering analysis of savings for a subsample of sites.

Verified Savings and Realization Rate

Cadmus used data collected from the site visits to complete the engineering and simulation analysis. This analysis estimated verified energy savings attributable to the HESP. These verified gross energy savings were then compared with reported gross energy savings to determine realization rates. For this report, gross realization rate has been defined as follows:

[Verified Gross Energy Savings / Reported Gross Energy Savings = Gross Realization Rate]

Cadmus determined gross realization rates for the following specific measure types:

- Air sealing
- Attic hatch
- Basement insulation
- Ceiling insulation
- Wall insulation
- Furnace/Boiler

The realization rate for furnace or boiler replacement measures resulted from Cadmus' modification of assumed efficiency levels. Out of the 41 sites sampled, four sites completed furnace or boiler replacements. The sample of four sites was too small to predict a realization rate, so Cadmus completed a file review of 247 of the 480 heating system replacements. The measure's baseline efficiency was fixed at 80% based on Cadmus' experience that all but the oldest units have moderate efficiencies. The nominal furnace efficiency was retained (e.g. 93%), however the upper level of the replacement boiler efficiency was set to 90% based on our concern that return water temperatures limit upper level efficiencies in practice. (See Appendix C for a detailed discussion of condensing efficiencies.) Savings were calculated from these adjusted efficiency levels and consumption predicted by the implementation contractor. Savings were further adjusted by a ratio of Cadmus' modeled consumption and the predicted consumption which decreased the savings by about 5%.

Cadmus applied measure-level savings estimates to all relevant measures in the population. This led to verified annual energy savings for the program (in MMBTUs). This was then broken out by fuel type to obtain annual energy savings (in fuel-specific units).

Then, Cadmus estimated the lifetime verified energy savings by fuel type by applying the EUL values of the specific measures (as provided in the HESP database) to all measures installed as a part of the projects within the sample frame.

Subsequent analysis led to an overall program gross realization rate, which was the ratio of the total verified gross energy savings to the total reported gross energy savings for the specific measures.

Net Savings and Attribution Analysis

In the participant survey, Cadmus asked targeted questions to pinpoint attribution of impacts to SEP ARRA funding. The questions had varied approaches to ensure effects attributable to the SEP ARRA funds would be differentiated from effects attributable to other funding sources included in the program (e.g., federal tax credits), and from effects of other events and sources not related to SEP ARRA funds.

The results of these questions were tabulated and analyzed using methods similar to those of the overall participant and partial participant surveys.

Cadmus used the survey results to develop estimates of freeridership. These estimates were then used to compute an NTG ratio. The NTG ratio was applied to the verified gross savings to determine verified net savings. For this report, net realization rate has been defined as follows:

[Verified Net Energy Savings / Reported Gross Energy Savings = Net Realization Rate]

Additionally, the estimated net savings served as the inputs for the TRC and SEP Recovery Act Cost (SEP-RAC) tests.

Greenhouse gas emissions reduction equivalents associated with verified energy impacts, in terms of net tons of carbon emissions avoided over the effective useful life of the projects, were also calculated using the net verified savings.

Cost-Effectiveness Analysis

Cadmus calculated HESP cost-effectiveness using the SEP-RAC test and the TRC test. The SEP-RAC test, developed by the Department of Energy (DOE), specifies that, on average, each state's portfolio of programs' energy impacts should be no less than 10 million source BTUs per year, per $1,000 of SEP ARRA funds spent. The TRC test is an industry-standard metric for evaluating program cost-effectiveness outlined in the California Standard Practice Manual,[3] which compares energy savings benefits (avoided costs) to program administrator and customer costs.

For the cost-effectiveness tests, Cadmus used net savings determined by verified gross energy savings and the NTG ratio. This approach will aid the Trust in successfully determining the program's cost-effectiveness, with respect to achieving its declared energy-efficiency goals.

[3] California Public Utilities Commission (CPUC). 2001. *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects*. Sacramento, CA: Governor's Office of Planning and Research, State of California.

2.2 Survey Research Methodology

Survey Sampling

Efficiency Maine provided Cadmus with a participant list for all participants in the sample frame, which included contact information and identified program steps participants completed. Cadmus conducted a survey using a random sample of full and partial participants, completing: 70 interviews with full participants; and 30 interviews with HESP partial participants.

Table 3. Participant Sampling

Measure	Total Participants	Completed Surveys
Full Participants	1,548	70
Partial Participants	216	30

This evaluation defines a full participant as someone who received an HESP rebate from Efficiency Maine for installing energy improvements in their home, and a partial participant as someone who completed the energy audit portion of HESP, but had not completed improvements and received a rebate at the time of the survey.

The survey instrument had items in common and unique to each participant type. Through the telephone survey, Cadmus sought to explore participants' experiences with the HESP.

Survey Analysis

Cadmus used the survey results to examine topics within the objectives outlined below as well as to provide inputs for an NTG calculation, including freeridership and spillover issues. This report's Impact Analysis Findings section presents details on the NTG analysis, including the relevant survey findings.

Surveys sought to collect participant responses regarding the following topics:

- Sources of program awareness, energy advisor selection, and qualification elements.
- Participant motivations (reasons for completing an audit and for completing installation of efficient measures).
- Participant barriers (reasons for not participating or not completing installation of efficient measures).
- Participant experience and satisfaction with:
    - Program administration;
    - Incentives and program requirements; and
    - Post-installation results.
- Perceptions of program benefits.
- Household and participant characteristics (demographics).

There were instances where Cadmus received non-responses and "don't know" responses. As a result, the base size (n=number of responses) for responses to certain questions fell below 70 for full participants, 30 for partial participants, or 100 for all participants.

3. Participant Profile and Characteristics

3.1 Demographics

Table 4 shows household and individual characteristics for full and partial HESP participants, based on the survey data. On average, 2.6 persons were living in HESP participant households. Full participants tended to have smaller households than partial participants. Specifically, 63% of full participant households included one or two people living in the home full-time, while 61% of partial participant households included three or more people living in the home full-time. All full and partial survey respondents owned their homes.

Full participants were, on average, older than partial participants, with 53% of full participants ages 55 or older, compared to 27% of partial participants.

The most common income bracket for both full and partial participants was $50,000 to $100,000, with 54% of participants reporting that level. A total of 35% of partial participants reported annual household incomes of $100,000 or higher, compared to 16% of full participants. More full participants (30%) lived in households making $50,000 or less annually than did partial participants (12%).

Table 4. Demographic Information

Number of people living in home on a full-time basis	Full (n=69)		Partial (n=28)		Total (n=97)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
1	12	17%	3	11%	15	15%
2	32	46%	8	29%	40	41%
3	10	14%	6	21%	16	16%
4	12	17%	7	25%	19	20%
5	1	1%	3	11%	4	4%
6	2	3%	1	4%	3	3%
Homeownership status	Full (n=70)		Partial (n=30)		Total (n=100)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Own	70	100%	30	100%	100	100%
Rent	0	0%	0	0%	0	0%
Age category of survey respondent	Full (n=69)		Partial (n=30)		Total (n=99)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
18 to 24	0	0%	0	0%	0	0%
25 to 34	4	6%	3	10%	7	7%
35 to 44	10	14%	5	17%	15	15%
45 to 54	18	26%	14	47%	32	32%
55 to 64	23	33%	2	7%	25	25%
65 to 74	11	16%	5	17%	16	16%
75 or more	3	4%	1	3%	4	4%
Annual household income	Full (n=61)		Partial (n=26)		Total (n=87)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Less than $25,000	1	2%	1	4%	2	2%
$25,000 up to $50,000	17	28%	2	8%	19	22%
More than $50,000 up to $100,000	33	54%	14	54%	47	54%
More than $100,000 up to $200,000	8	13%	8	31%	16	18%
More than $200,000	2	3%	1	4%	3	3%

Highest educational attainment	Full (n=68)		Partial (n=30)		Total (n=98)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Less than a high school diploma	1	1%	2	7%	3	3%
Completed high school diploma or equivalent (GED)	4	6%	0	0%	4	4%
Some college	1	1%	2	7%	3	3%
Completed a 2 year or technical degree/certification	5	7%	3	10%	8	8%
Completed a four year degree	25	37%	7	23%	32	33%
Graduate or professional degree-MA, MSc, PhD, LLB	32	47%	16	53%	48	49%
Gender of survey-taker	**Full (n=70)**		**Partial (n=30)**		**Total (n=100)**	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	42	60%	18	60%	60	60%
Female	28	40%	12	40%	40	40%

3.2 Descriptive Statistics

As a part of this evaluation, Cadmus completed basic data analysis to compile descriptive statistics regarding the homes participating in the HESP. The tables below show reported data as well as the data collected by Cadmus during the site visits.

Table 5. HESP Participant Home Descriptive Statistics

Statistic	Program Reported Averages (1780 Sites)	Program Reported Averages (41 Sites)	Verified Averages (41 Sites)
Occupants	3.09	2.51	Not collected
Living Space Square Footage	2,296	1,948	2,314

Fuel and Distribution Type

The subsequent charts and tables show the reported and verified primary heating system and fuel types for all of the sites within the evaluation period. This analysis was performed for the four different participant subsets:

1. The data from all projects within the evaluation period as reported in the HESP database. The population size is 1,780, unless otherwise specified.
2. The data from the projects within the evaluation period that were a part of Cadmus' site visit sample as reported in the HESP database. The sample size is 41, unless otherwise specified.
3. The observed (verified) data from the Cadmus site visits. The sample size is 41, unless otherwise specified.
4. The responses received from the full and partial participant survey. The sample size is 30, 70, or 100, or specified otherwise.

Primary Fuel Type

This section outlines primary fuel types used by the HESP participants, based on program data and Cadmus site inspections. The majority of residents in Maine heat their homes with oil. This was also the case with HESP participants as the primary fuel source for three-quarters of all participants was oil. Nine percent heated their home primarily with natural gas, and 6% primarily heated with propane.

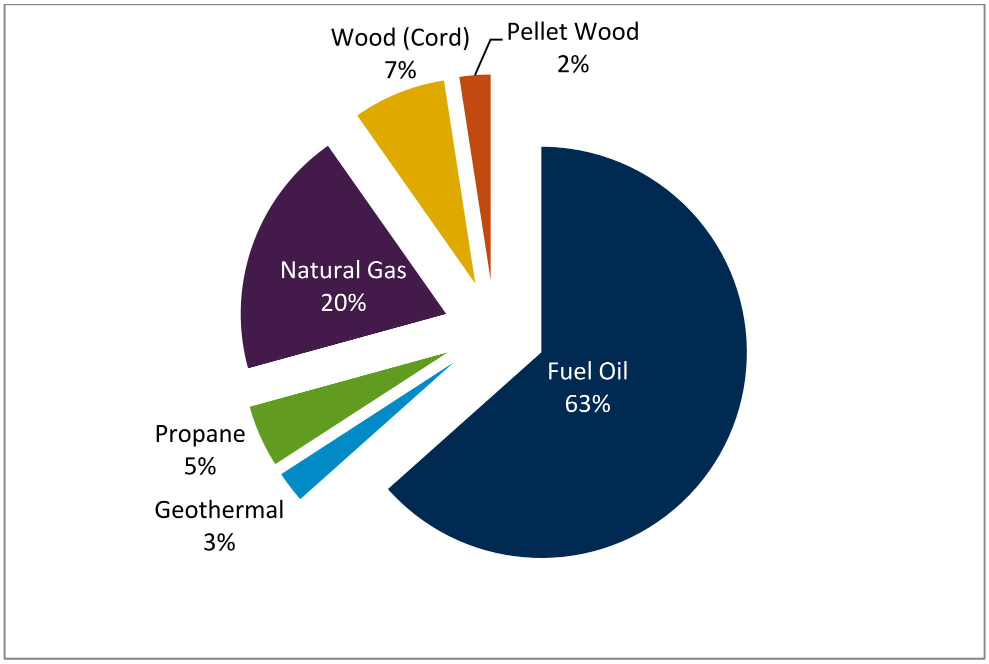
The distribution of reported primary fuel type of sampled sites was similar to that for the entire sample frame, showing the random sample generally represented the larger population.

Table 6. Primary Fuel Type

Primary Fuel Type	Reported Primary Fuel Type (Total Sites)	Reported Primary Fuel Type (Sampled Sites)	Verified Primary Fuel Type (Sampled Sites)
Fuel Oil	74.94%	68.29%	63.41%
Natural Gas	8.71%	9.76%	19.51%
Propane	6.12%	4.88%	4.88%
Wood	1.97%	2.44%	7.32%
Electric	1.07%	0%	0%
Kerosene	0.96%	0%	0%
Geothermal	0%	0%	2.44%
Pellet Wood	0%	0%	2.44%
Not Listed	6.24%	14.63%	0%
Total (Sites)	1,780	41	41

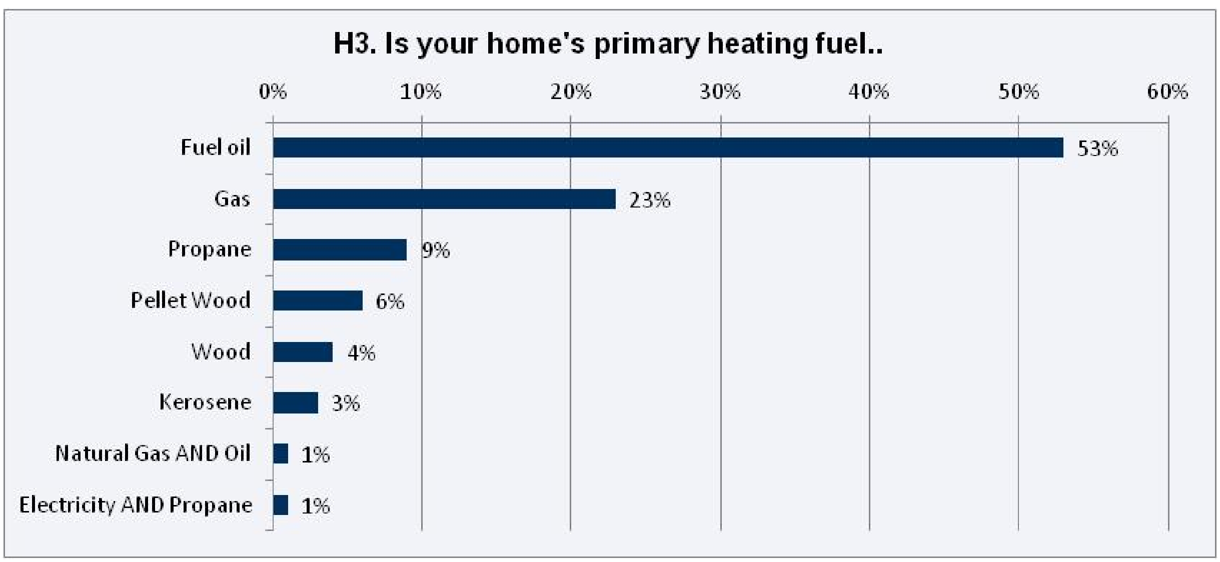
The fuel types observed during Cadmus' site visits generally matched that reported in program data. Oil and natural gas were the two most dominant fuel types. However, Cadmus technicians documented geothermal and pellet wood as a primary source of fuel for 5% of participants. There was a higher usage of natural gas and wood observed by Cadmus.

Figure 2. Primary Fuel Type (41 Sites: Cadmus Observations)



According to the participant surveys, fuel oil was the most common primary heating source fuel, matching the population at the site visit sample. Gas and propane did not match as closely, however, participants may not fully understand their fuel use.

Figure 3. Home's Primary Heating System Fuel Type



Secondary Fuel Type

The HESP program database and Cadmus site visits also captured secondary fuel types. Only a small portion of the participants (n=175) in the evaluation period reported any secondary fuel source in program data. Of those 175, 31% used oil as their secondary source and 21% used wood. Thirteen percent used natural gas and 12% used propane.

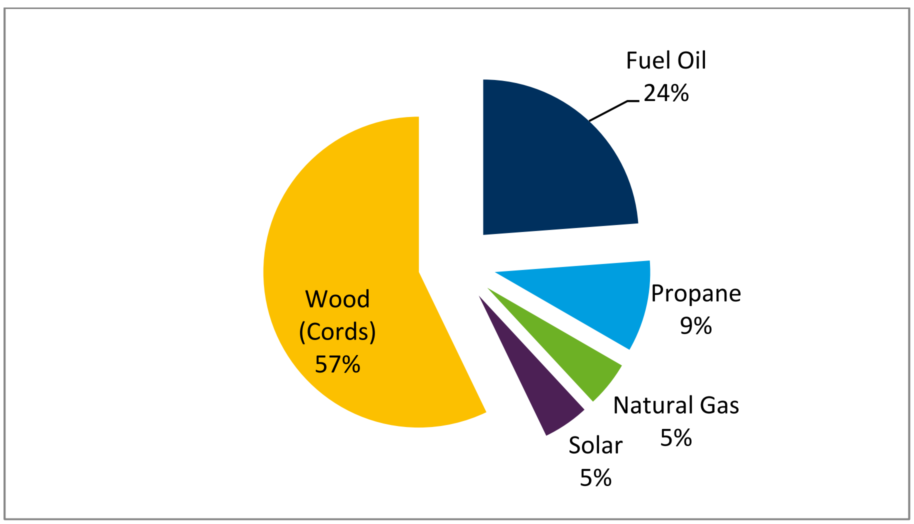
Table 7. Secondary Fuel Type

Secondary Fuel Type	Reported Secondary Fuel Type (Total Sites)	Reported Secondary Fuel Type (Sampled Sites)	Verified Secondary Fuel Type (Sampled Sites)
Corn Pellet	1.14%	0%	0%
Electric	12.00%	0%	0%
Natural Gas	13.14%	20%	4.76%
Kerosene	6.86%	0%	0%
Oil	30.86%	20%	23.81%
Pellet Wood	2.86%	0%	0%
Propane	12.57%	40%	9.52%
Wood	20.57%	20%	57.14%
Solar	0%	0%	4.76%
Total (Sites)	175	5	21

Secondary fuel type was only reported in the HESP database at five of the 41 sampled sites (12%). During the site visits, Cadmus identified a total of 21sites (16 additional sites) that used a secondary heating source, with 57% using wood, 24% using oil, 9% propane, 5% natural gas, and 5% solar.

Program implementation staff has reported energy auditors likely did not record this information when submitting to Efficiency Maine, which would explain why Cadmus observed additional secondary heating systems beyond those reported in the database.

Figure 4. Secondary Fuel Type (21 Sites: Cadmus Observations)



HVAC Distribution System

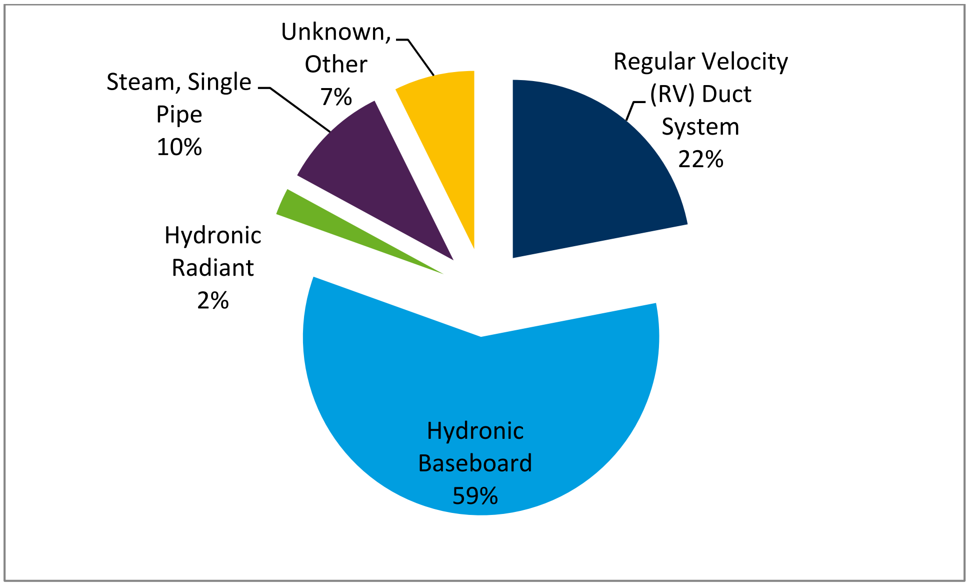
Primary HVAC Distribution System

The majority of the participating sites in the HESP used hydronic baseboards (hot water baseboard) to distribute heat. The second largest portion used a regular velocity duct system (Table 8). The reported primary heating distribution systems for the sites Cadmus sampled were similar to overall participant population. Cadmus technicians found similar results on-site.

Table 8. Primary HVAC Distribution System

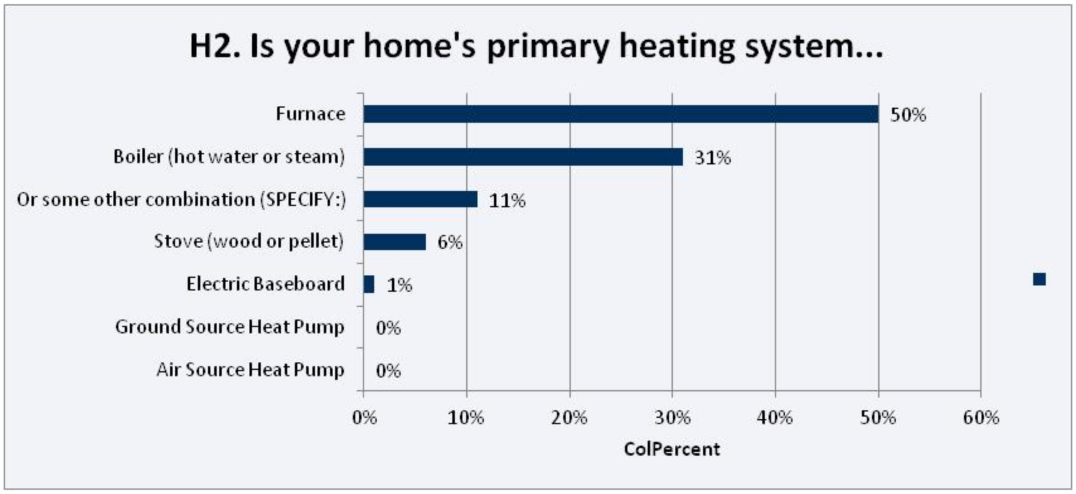
Primary Distribution System	Reported Primary Distribution System (Total Sites)	Reported Primary Distribution System (Sampled Sites)	Verified Primary Distribution System (Sampled Sites)
High Velocity (HV) Duct System	0.11%	0%	0%
HV Duct System with Electronically Commutated Magnet (ECM) Motor	0.11%	0%	0%
Regular Velocity (RV) Duct System	18.20%	19.51%	21.95%
RV Duct System with ECM	0.28%	0%	0%
Electronic Baseboard	0.84%	0%	0%
Electronic Radiant	1.01%	0%	0%
Gravity (75 and 91)	0.28%	0%	0%
Hydronic Baseboard	59.61%	56.10%	58.54%
Hydronic Radiant	2.58%	2.44%	2.44%
Space Heater	4.94%	2.44%	0.00%
Steam, Single Pipe	5.11%	4.88%	9.76%
Steam, Two Pipe	0.67%	0%	0%
Unknown, Other	6.24%	14.63%	7.32%
Total (Sites)	1,780	41	41

Figure 5. Primary HVAC Distribution System (41 Sites: Cadmus Observations)



HVAC distribution systems were also captured during the participant survey, but with different results. According to participants in the survey sample, furnaces were the most common type of primary home heating (50%), with boilers accounting for about one-third (31%), while the program database and on-site observations showed almost 79% used a boiler, and less than 20% used a furnace (ducts). Responses to this question could be to the result of customer confusion about heating systems.

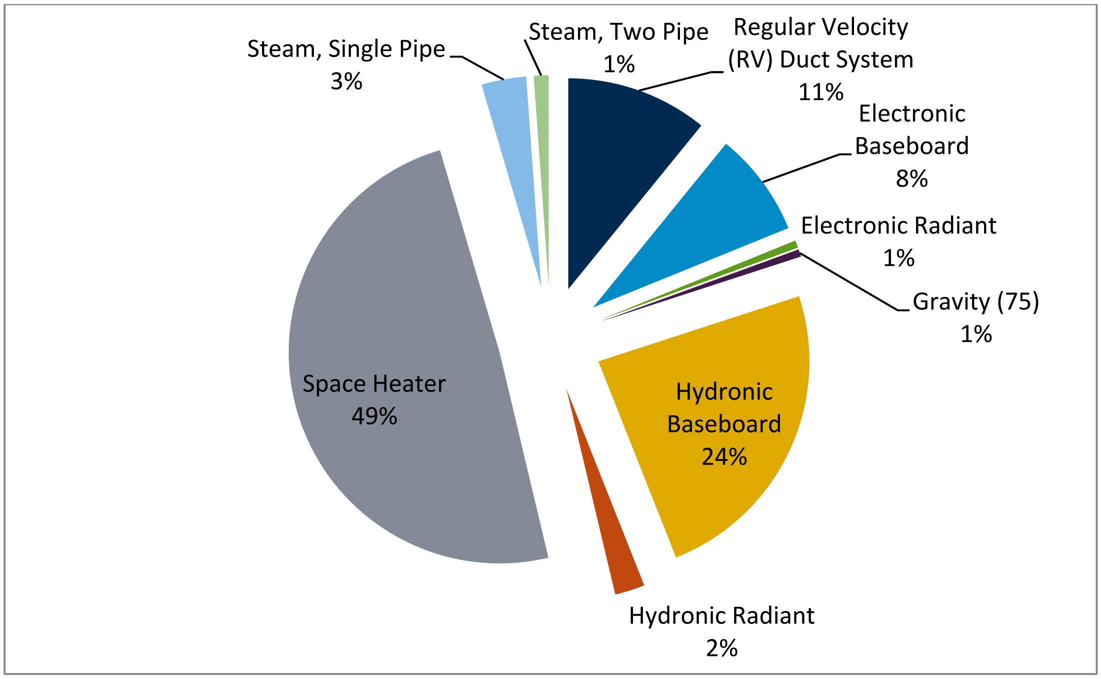
Figure 6. Home's Primary Heating System



Secondary HVAC Distribution System

Figure 7 displays reported secondary heating system types and fuels for all of the sites where a secondary fuel source was reported (n=175). Heating with a space heater was the most frequently observed secondary heating distribution system type at 49%, followed by hydronic baseboard at 24%.

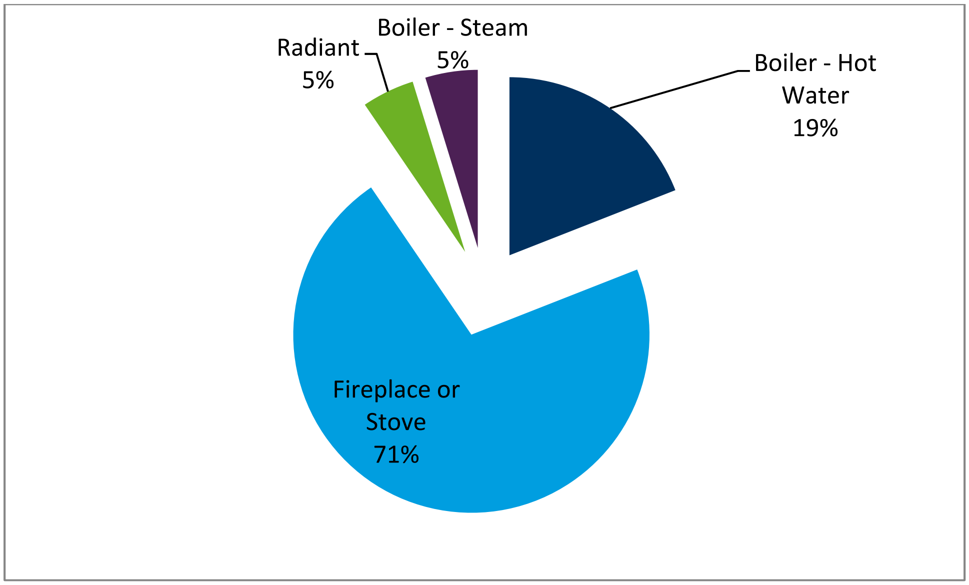
Figure 7. Secondary HVAC Distribution System (175 Sites: Reported Data)



Space heaters were the dominant reported secondary heating system type at the five sampled sites where a secondary fuel source was reported. Hydronic baseboard and electric radiant was seen as a secondary source by 20%.

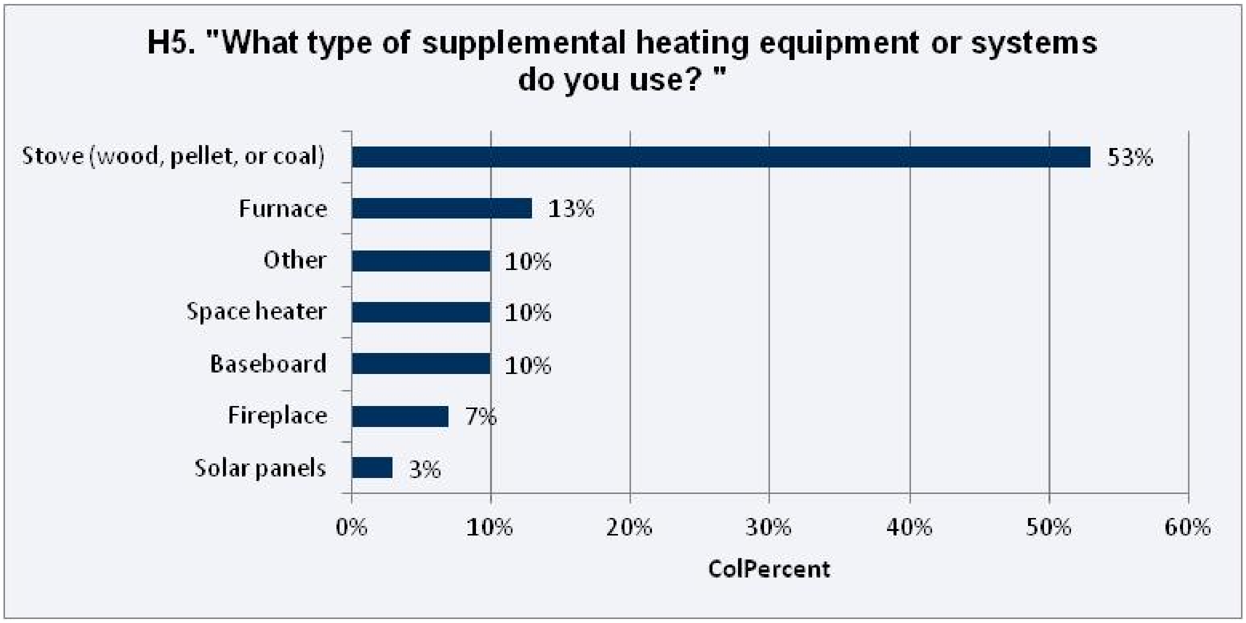
Cadmus observed additional secondary heating systems beyond those reported in the database. Figure 8 summarizes the secondary heating systems found during the site visits: 71% of inspected sites with a secondary distribution system used wood (fireplace or stove) as a secondary heating distribution type. It has been reported that contractors likely did not record this information when submitting to Efficiency Maine.

Figure 8. Secondary HVAC Distribution System (21 Sites: Cadmus Observations)



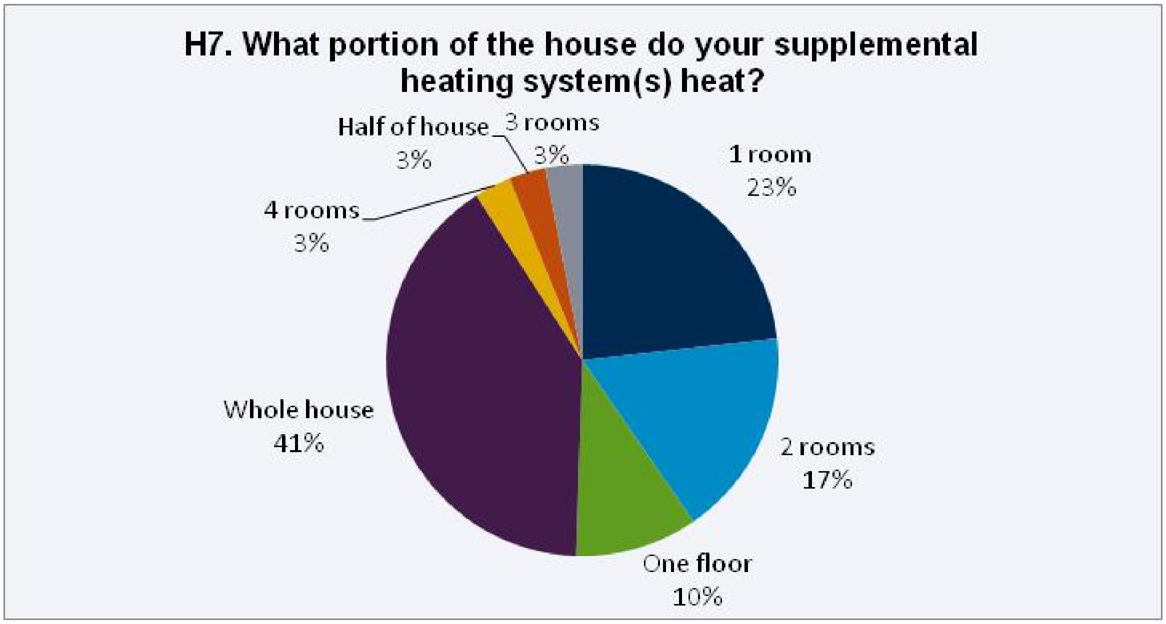
A majority of the survey participants (53%) with secondary heating systems indicated they used a stove for secondary heating.

Figure 9. Type of Supplemental Heating System (n=30)



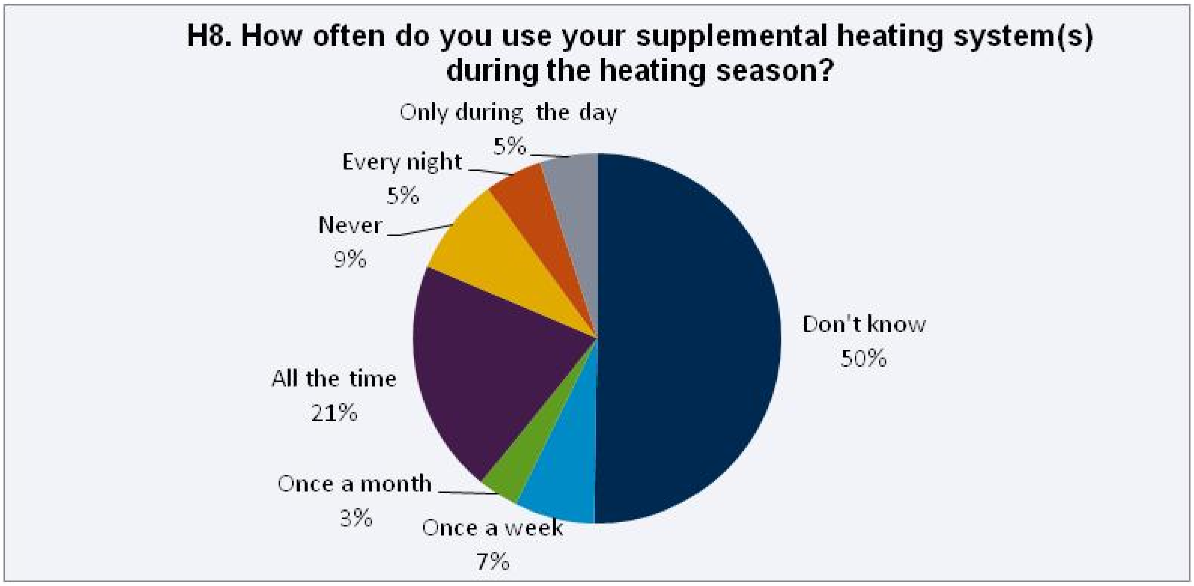
In addition to observing types of equipment and fuel sources in place within the homes of HESP participants, Cadmus also documented certain behaviors affecting the operating energy efficiency of the homes. Survey respondents with supplemental heating systems tended to use it to heat the whole house (41%). About one-quarter (23%) used it to heat a single room.

Figure 10. Portion of House Heated by Supplemental System (n=30)



The survey also addressed the frequency with which supplemental heating is used. Half of survey respondents (50%) did not know how frequently they used the supplemental heating system. One in five (21%) said they used it all the time.

Figure 11. Frequency of Supplemental Heating Use (n=29)



Water Heating Type and Fuel

Water Heating Fuel

The program database and Cadmus site visit data also documented the water heating fuel used by HESP participants. For the sample frame, program data show the majority of customers used oil, with the second most common fuel electricity; 9% and 8% used natural gas and propane, respectively.

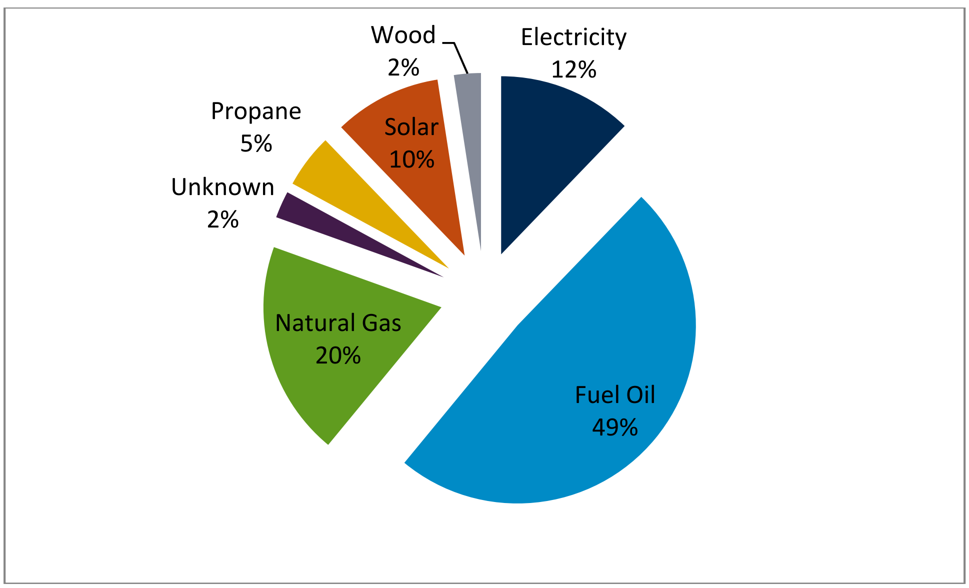
Table 9. Water Heating Fuel Type

Water Heating Fuel Type	Reported Water Heating Fuel Type (Total Sites)	Reported Water Heating Fuel Type (Sampled Sites)	Verified Water Heating Fuel Type (Sampled Sites)
Electric	23.43%	8.57%	12.20%
Natural Gas	9.44%	11.43%	19.51%
Kerosene	0.22%	0%	0%
Oil	52.08%	68.57%	48.78%
Other	0.67%	0%	0%
Propane	7.58%	8.57%	4.88%
Wood	0.11%	0%	2.44%
Solar	0%	0%	9.76%
Unknown, Other	6.46%	2.86%	2.44%
Total (Sites)	1,780	35	41

Some similarities were seen within the sample frame from the HESP database. The majority of customers used oil (69%). However, the second largest group used natural gas (11%), closely followed by propane and electricity (both with 9% of customers using this fuel type).

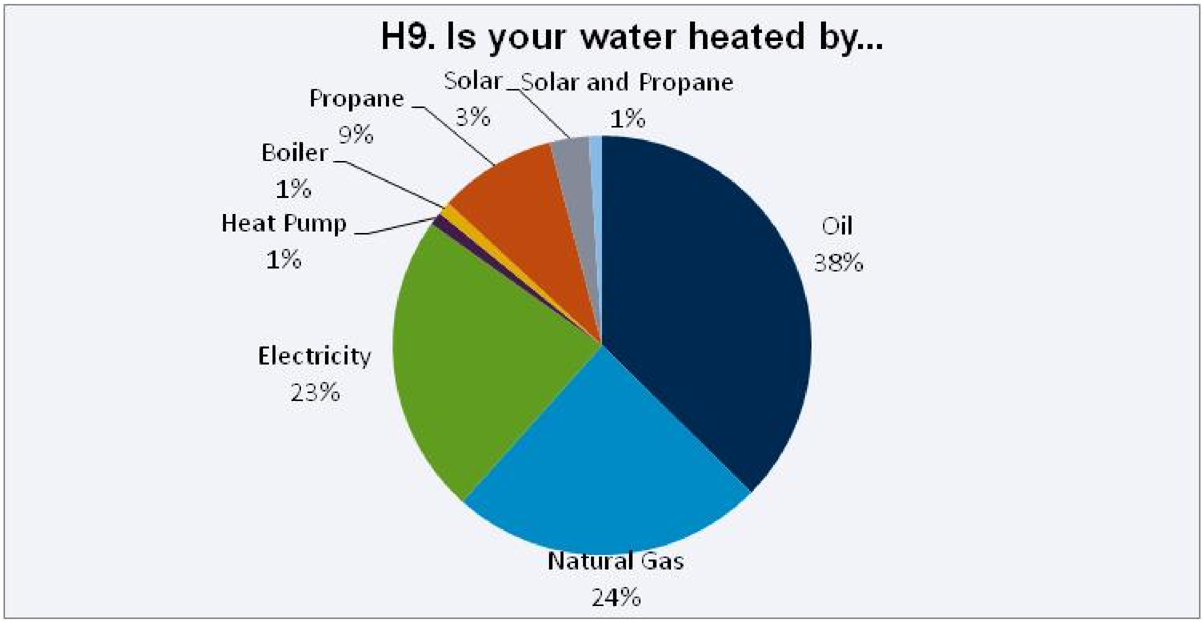
While the percentages were similar, a few additional fuel types were documented by Cadmus. Forty-nine percent of the sites sampled used oil to heat their water, 20% used natural gas, and 12% used electricity. However, solar was also a source of heat, with 10% using solar. There is a higher use of electricity reported in the HESP database.

Figure 12. Water Heating Fuel Type (41 Sites: Cadmus Observations)



This information was also captured during the survey, and some similarities were seen. Fuel oil was also the most common (yet, at a lower observance rate of 38% compared with the other three data sets) fuel type used for water heaters. There is higher electricity usage; similar to the HESP database, but different from the verified site data. Figure 13 shows the proportion of different water heating fuel types.

Figure 13. Water Heating Fuel Type (n=70)



Water Heating System

The charts that follow show the water heating system type documented for all sites in the HESP database, within the evaluation period and within the sample frame. The third chart shows data obtained during Cadmus' site visits. Table 10 shows that 37% of the participants used a storage tank, 28% had a tankless water heater, and 19% used an indirect water heater.

Table 10. Water Heating Type

Water Heating System Type	Reported Water Heating System Type (Total Sites)	Reported Water Heating System Type (Sampled Sites)	Verified Water Heating System Type (Sampled Sites)
Heat Pump	0.06%	0%	0%
Indirect	19.21%	19.51%	51.22%
On Demand	4.21%	4.88%	0%
Tank	36.52%	24.39%	41.46%
Tank High	4.89%	4.88%	0%
Tankless	28.37%	31.71%	7.32%
Tankless Backup	0.11%	0%	0%
Unknown, Other	6.63%	14.63%	0%
Total	1,780	41	41

Of sampled sites, the predominant water heating system was tankless water heaters, with 32% of the 41 participants using this system. Twenty-four percent used a storage tank, and 19% used an indirect water heater.

Cadmus' review of the hot water system type produces results different from those in the HESP database. Forty-six percent of participants used an indirect water heater, 39% used a storage tank, and only 7% had a tankless water heating system installed, as shown in Figure 14.

Figure 14. Water Heating System Type (41 Sites: Cadmus Observations)

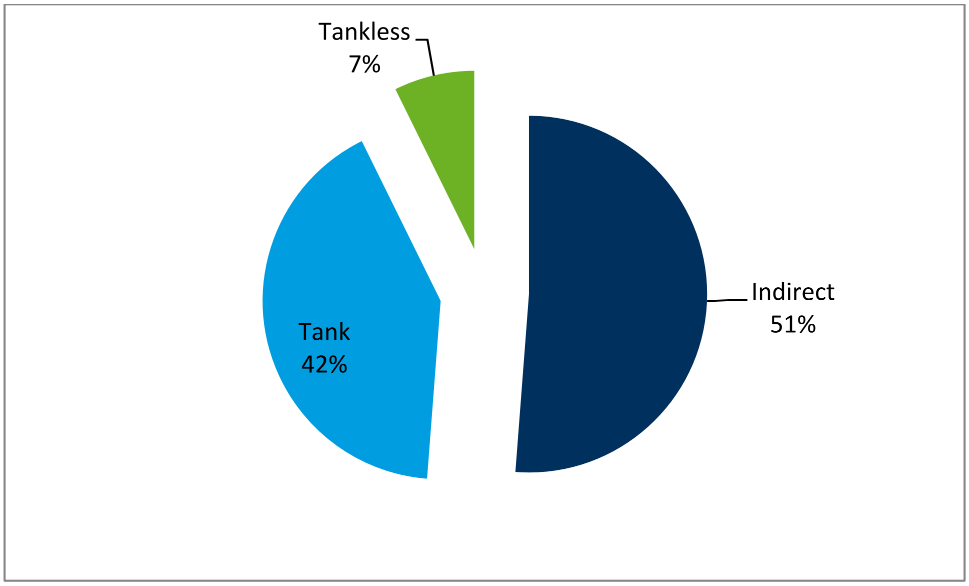


Table 11 shows average water temperature and thermostat settings. The average water temperature of sites visited was 124 °F. This is an efficient setting and typical of what Cadmus sees in other locations. We do not recommend lower settings because of concerns over bacterial growth. The average thermostat setpoint on a weekday, when the participant was home, was just below 67 °F. This is lower by several degrees than we see in other locations. The average setpoint during the week, when the participant was sleeping, was just above 63 °F.

Table 11. Behavioral Statistics

Statistic	Verified Average (41 Sites)
Water Temperature (°F)	123.9
Thermostat Setpoint Weekday (at home)	66.6
Thermostat Setpoint Weekday (at home while sleeping)	63.4

3.3 Site Visit Observations

In this section, Cadmus presents selected observations made during the 41 sites visits.

Cadmus field staff received positive feedback from many program participants, and noted the following:

- Overall, participants reported high satisfaction with the program, and were very happy about services and incentives they received.
- Participants displayed a high interest level in home performance during site visits.
- Participants were familiar with energy efficiency, and with steps that could be taken to improve the efficiency of their homes.
- Many participants reported being more comfortable in their homes after participation. Some heating oil users reported a noticeable decrease in fuel use since project implementation.

Overall, contractor performance was successful and effective. In general, Cadmus found that the measures reported in the program database were installed. Specific findings include:

- Air sealing appears to have been completed excellently, and the quality of contractor air sealing work was high.
  - Results of our blower door tests appear to indicate homes have been tightly sealed, in some instances exceeding IECC 2009 Code.
  - Cadmus completed 31 blower door tests (BD) during the 41 site visits for the HESP evaluation. Table 12 details the number of sites (n=10) where a BD test was not performed, and the reasons why Cadmus could not complete them.

Table 12. Reasons for Blower Door Test Incompletes

Reason for Not Completing BD	Quantity
Participant Declined Test	4
Site Required Two or more BD Kits	3
No Insulation Installed	1
Could Not Pressurize Home	1
Tenant Not Home to Permit Access to Seal Unit	1
Total	10

- Bulkhead doors were insulated and sealed with weather-stripping and were generally very well built (illustrating contractors’ high-quality work). Bulkhead doors were, in many cases, custom-built doors in the foundation wall, made of plywood and rigid foam that were weather-stripped.

- Figure 15 shows insulated and sealed bulkhead doors, which were generally constructed with 2 inches of rigid foam and plywood. Weather stripping was applied to seal air leakage.

Figure 15. Basement Bulkhead Doors

- Attic hatches and pull-down stairs were similarly weather-stripped and insulated well. They were pulled tight with clasps, and fit frames well.
  - Figure 16 shows a new attic access built by a contractor to replace an existing attic access. The door was solidly built, and insulated with several sheets of 2 inches of rigid foam. The door's perimeter was sealed with rubber weather stripping and secured with clasps. This is a good example of particularly effective work completed by the HESP contractor.

Figure 16. Attic Hatch

- Rim joist insulation was also completed well. Figure 17 shows 2 inches of rigid spray foam applied to rim joists. This type of insulation doubles as an air barrier sealing up the home.

Figure 17. Rim and Band Joist Insulation

- According to Cadmus' observations, accurate insulation square footage measurements were made. When verifying the installed square footage of the insulation measures, the verified and observed values were within 97%[4] of the values reported in the HESP database. As can be expected in any large-scale program, there were some minor discrepancies noted:
  - In a few cases, contractors documented the total area of insulation, rather than simply documenting what was added. Documenting additional insulation was the appropriate method of data entry.
  - At one site, the program data reported 600 square feet of spray insulation installed in the basement walls. Cadmus measured only 483 square feet of insulation. Cadmus explains the estimation difference below:
    - The wall heights of this basement were between 2 and 6 feet (the result of completing multiple additions to the home). The original estimate appeared to have been based on 4 feet of insulation around the entire perimeter (not excluding areas with shorter foundation walls). Figure 18 and Figure 19 show the layout of this particular basement.

[4] When Cadmus excludes the measures that were not verified as installed, the verified square footages are within 99% of the HESP database reported square footages.

Figure 18. Six-Foot Wall

Figure 19. Two-Foot Wall

- Infrequently, insulation was installed in areas where it would be marginally effective (i.e., areas where no, or minimal energy savings would result: adiabatic walls, floor of a partially conditioned basement, etc…).

- Additionally, contractors were diligent when sealing and insulating hard-to-reach areas and building additions.
  - Many participating homes were over 100 years old with many remodels and additions. Contractors were meticulous, and made great efforts to insulate and seal areas generally difficult to address.
  - Cadmus used infrared cameras (thermal scans) to check for proper installation of wall insulation[5]. Figure 20 shows what was seen from infrared inspections performed in

[5] These devices work best when the outdoor temperature is 20 degrees less than the indoor temperature. Daytime temperatures during the site visits in August were in the high 60s to low 70s, but were not overly different from ambient indoor temperatures. On sunny days, attics with no or limited access could be viable for analysis because the sun could heat the roof to high-enough temperatures. Ideal conditions for infrared inspection would require temperatures below 50 degrees Fahrenheit (F) or above 90 degrees F. Consequently, infrared camera images and results were inconclusive.

Maine due to a low temperature difference. Framing is barely visible, and possible insulation voids are not visible at all. This photo illustrates infrared inspection is not effective during times of low temperature difference between the conditioned space and the outdoors. Cadmus could achieve useful thermal images at only two of the 41 homes.

Figure 20. Sloped Ceiling of a One-and-a-Half Story Maine Cape-Style Home

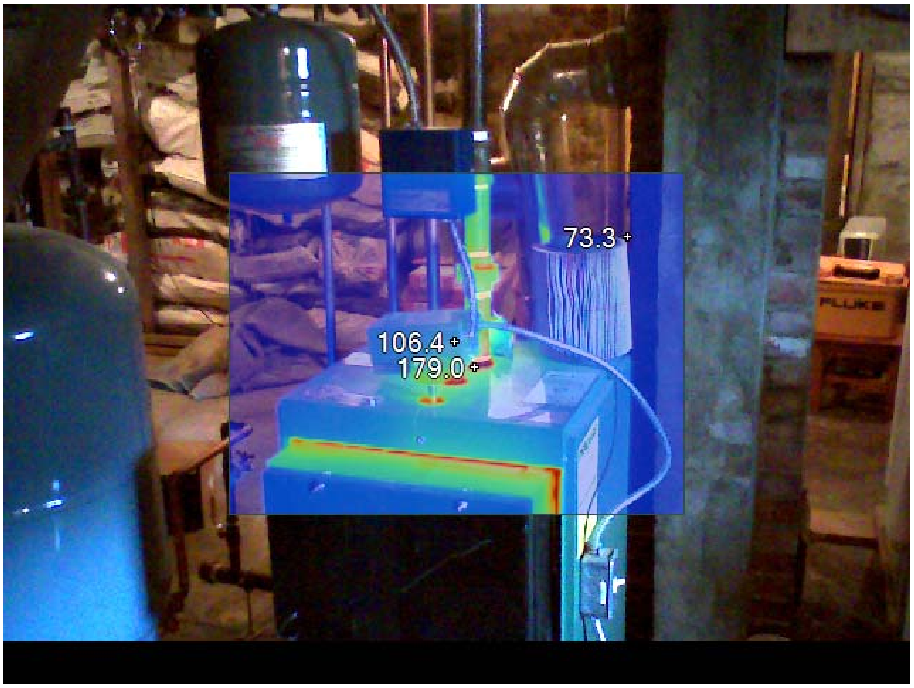
- We observed that contractors did an excellent job of dealing with closed constructions (e.g., walls, ceilings). However, based on our experience observing home construction, there are house elements that are a challenge to insulate.
  - The common home type observed in Maine was a cape-style home, with an upper floor built into the roofline. This type of construction contains cavities that are "closed-off," but must be individually insulated. This means the wall and ceiling interiors are only accessible if holes are drilled, or if framing is modified. Also, when insulating closed constructions, conditions are not optimal due to plumbing, wiring, and other obstructions in the cavity. Due to this complexity, contractors and residents sometimes also deem it cost-prohibitive to pursue complete insulation.
  - While infrared inspection of sloped ceilings and walls was inconclusive, site visit evidence sometimes suggested installed insulation did not always fill the entire cavity, and the necessary insulation density was not achieved. At one HESP site (shown in Figure 21 and Figure 22), where IR inspection of the attic was possible, the ceiling showed insulation voids in hard-to-reach areas: where the roofline changed and at transitions between sloped and flat ceilings.

Figure 21. Temperature Differential in a Closed Structure (A)

Figure 22. Temperature Differential in a Closed Structure (B)

- Cadmus also identified several situations where the insulation installed around piping was less than adequate.
    - Figure 23 shows a boiler system with an indirect water heater. A boiler generally must run all year as it provides domestic hot water to the home. These large, cast iron boilers and their plumbing produce substantial heat, dissipated to basements. During non-heating months, this heat is generally wasted in the basement. This particular home had, as part of the HESP program, insulated the ceiling of the basement. This insulation made the basement uncomfortably warm in the summer and, according to the homeowner, quite warm all winter. While some heat in the basement is necessary to provide freeze protection for plumbing, insulating the direct hot water loop would be useful to prevent wasted heat.

Figure 23. Indirect Water Heater



Overall, Cadmus found a low incidence of installation issues at the sites visited. Based on observations during site inspections, contractors were thorough and performed high-quality work. This is especially impressive, considering the age of some homes and complexity of some of the insulation and air sealing projects. While most homes that had installed wall insulation as part of their HESP participation could not be verified for proper density with thermal inspection, the otherwise high-quality work supported the impression that a thorough job was likely done.

4. Impact Analysis Findings

4.1 Gross Savings

Using Rem/RATE, Cadmus created a model that simulated how energy is used and wasted in a sampled home in Maine. The models' inputs included all data collected by Cadmus during site visits.

The model enabled Cadmus to create energy savings figures for each home and for measures installed within each home. Cadmus computed measure-level savings for air sealing, attic hatch, basement insulation, ceiling insulation, wall insulation, and furnace or boiler. The realization rate of each of these measures is present below in Table 13.

Table 13. HESP Realization Rate: Measure-Level

Measure Type	Reported Savings	Verified Gross Savings	Realization Rate
Air Sealing	565	585	103%
Attic Hatch	29	18	62%
Basement Insulation	381	305	80%
Ceiling Insulation	568	328	58%
Wall Insulation	462	584	127%
Furnace/Boiler	82	51	62%[6]
Total (41 Sites)	2,087	1,871	90%

These measure-level verified gross savings were compared with the HESP database reported savings to obtain gross realization rates. The resulting realization rates ranged from 58% to 127%. Relative to savings reported in the program database, the Cadmus savings estimates, based on site visit data and REM/Rate modeling, were higher for wall insulation and air sealing, but lower for attic hatch, basement and ceiling insulation, and furnace and boiler installations.

The three measures with the lowest realization rates were the ceiling insulation, furnace or boiler replacement, and attic hatch measures. Ceiling insulation installation, when measured in the field and modeled using REM/Rate, saved participants 58% of the energy, compared to the program-reported figures.

The 62% realization rate for furnace or boiler replacement measures resulted from Cadmus' modification of assumed efficiency levels, as described in the Methods section.

While modeled attic hatch savings were lower than those reported for attic hatch upgrades, Cadmus engineers believe that this is an important upgrade and that, in some cases, savings might be higher due to leaky, or poorly insulated existing hatches.

Air sealing showed savings at a level that is 103% of the reported values. Cadmus also compared reported savings from air sealing with values calculated by Cadmus for the 41 sites in

[6] Realization rate is based on file review of furnace or boiler replacement measures.

the evaluation sample. This method involved computing the average CFM 50[7] reduction for the 30 sites that received a blower door test and had pre-existing measurements.[8]

Cadmus found the average CFM 50 reduction for sites tested was 1,396, whereas the CFM 50 reduction from the 30 sites in the HESP database was 1,416. The reported data (n=1,391) had an overall average CFM 50 reduction of 1,662. This data is shown in Table 14.

Table 14 also shows the reported CFM 50 values for sampled sites and for the entire database. A minimal difference occurred between the reported (inspected) data and the data Cadmus collected during the site inspections.

Table 14. Comparison between Reported Database and Verified Infiltration Values

	Sample Size (n)	Pre-Sealing CFM 50 (Reported)	Post-Sealing CFM 50	CFM 50 Reduction	Percent Infiltration Reduction	Ratio
Proposed (HESP Database)	2,103	4,658	2,916	1,742	37.4%	95%
Measured (HESP Database)	1,391	4,487	2,837	1,662	36.8%	
Sampled (HESP Database)	30	3,698	2,399	1,416	35.1%	99%
Sampled (Cadmus)	30	3,698	2,343	1,396	36.7%	

"Proposed (HESP Database)" compares the measured, pre-installation infiltration rate with the proposed (energy advisors' best guesses) post-installation infiltration rate reported in the database. "Measured (HESP Database)" compares the measured, pre-installation infiltration rate with the data documented by the energy advisor after completing a post-installation inspection (CFM 50 value after efficiency measures were installed and the project was completed). Finally, Cadmus computed the CFM 50 reductions as reported for the sample frame (n=30) and as measured and verified by Cadmus during the site visits.

The average percent infiltration reduction for the evaluated sample (36.7%) was essentially the same as the average measured percent reduction (35.1%) reported in the database for these sites. It is likely that the lower CFM 50 reduction of 1,396 (when compared with the reduction measured in the population 1,662) can be explained by the smaller sample size rather than an evidence of lower savings.

4.2 Net-To-Gross Analysis

Cadmus implemented an NTG methodology to examine the energy savings attributable to the program and not to other factors. Freeridership and spillover are the two components that comprise NTG. Freeriders reduce savings attributable to an energy-efficiency program because they are participants who would have purchased a measure without a program's influence. Spillover—the amount of additional savings obtained by participants investing in additional energy-efficient measures or activities due to their program participation, but not incented by the program—increases savings attributable to the program.

[7] CFM 50 is the air leakage measured with a blower door in cubic feet per minute (CFM) with a house pressurized to 50 Pascals.

[8] One site within the HESP database did not have a pre-existing CFM value; so a comparison could not be completed.

Freeridership Analysis

The freeridership estimation[9] determined freeridership using patterns of responses to a series of five simple questions. The questions, which allowed "yes," "no," or "don't know" responses, dealt with whether participants would have installed the same equipment in the program's absence, at the same time, at the same amount, and at the same efficiency. Response patterns to these questions were assigned freerider scores, and confidence and precision estimates were calculated on score distributions.

A detailed explanation of Cadmus' freeridership methodology is included in Appendix A. The appendix explains the survey design, and describes Cadmus' freeridership methodology. It also provides:

- Full-text versions of the NTG survey questions administered to participants;
- The freeridership scoring matrix, showing all possible combinations of responses to the freeridership survey questions; and
- The scores Cadmus assigned each combination.

After conducting participant surveys, which contained the relevant questions, Cadmus converted resulting responses into a freeridership score for each participant, using an Excel-based matrix. Each participant's freerider score was derived by translating responses into a matrix value, and then using a rules-based calculation to obtain the final score[10]. Table 15 shows results of freeridership calculations for HESP measures. Overall, the program had an average freeridership of 14% across all 70 respondents.

Table 15. HESP Freeridership Results

Program	N	FR
HESP	70	14%*

* ± 4.5% Absolute Precision

Thirty-nine percent (27 out of the 70) answered they would not have installed the measure within one year, in absence of the HESP. These respondents were scored as 0% freeriders because they were not seriously considering installing the measure within one year.

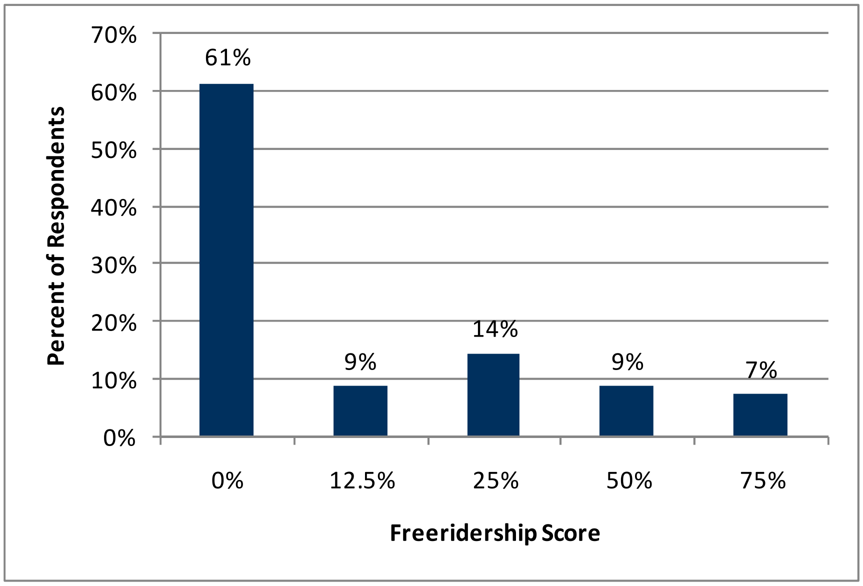
Figure 24 shows a distribution of respondents by the freeridership score assigned to each. Approximately 61% of survey respondents were scored as non-freeriders (0%), while 23% of respondents are exhibiting low levels of freeridership (12.5% and 25%). Nine percent of

[9] This approach is described in the freeridership methodology section in Appendix A. This specific approach was based on a previously developed approach by the Senior Vice President of the Cadmus Group, M. Sami Khawaja, Ph.D. It is cited in the National Action Plan for Energy Efficiency (NAPEE) Handbook on DSM Evaluation (2007, page 5-1), which can be found here: http://www.epa.gov/cleanenergy/documents/suca/evaluation_guide.pdf.

[10] Appendix A presents all combinations of responses received for HESP, and the scores assigned to each combination. Participant responses tended to group around a subset of common patterns. Freeridership scores were calculated for each measure category, based on the distribution of scores within the matrix.

respondents are showing a moderate level of freeridership (50%), while 27% of respondents were scored at a higher level of freeridership (75%). The analysis indicated none of the respondents were true (100%) freeriders.

Figure 24. Overall Distribution of HESP Freeridership Scores



Spillover Analysis

Participant spillover measures additional energy savings obtained by program participants who invest in additional energy-efficient measures or activities due to their program participation, but who are not incented by a program. A "spillover response" survey indicates the participant reported purchasing or installing other energy-efficiency improvements following their participation in HESP.

Spillover responses are considered attributed to the program if the respondent answers participation in HESP was very influential in deciding to make other energy-efficient improvements or purchases outside the program. As part of this evaluation, participant spillover savings were not quantified because participants did not provide many responses that could indicate spillover. Spillover actions mentioned by full participant respondents highly influenced by the HESP program are listed in Table 16.

Table 16. Qualitative Spillover Responses Attributable to Program

Spillover Response
We did an efficient air cooling system and refrigerator, washer, and dryer
Sealed the basement
Insulation garage door
Weatherizing
Upgraded to more modern air conditioning to save on electricity
Inexpensive minor things like sealing gaps
There's a place from the garage to the attic that is not accessible, and so we poked a whole in the wall, added more insulation
We had the entire house rewired, and put in 30 more outlets so we can plug in energy efficient appliances, and put fans to distribute the air more properly, they are all energy star, the roof, is a metal reflective roof
We figured out that when we don't need hot water we shut off our furnace during the summer, we save oil, because we have a hot water reserve tank
Washer and dryer
Mini split system
Put in all new windows and thermal window

Additionally, six full-participant respondents reported that, after participating in the program, they purchased CFLs not marked down, discounted, or eligible for a coupon. These respondents said their participation in HESP was very influential in their decision to purchase additional CFLs outside the program.

NTG

Table 17 shows NTG calculation results for HESP measures. Because spillover was not quantified, the net to gross value only takes into account the freeridership rate. Overall, the program had an average NTG of 86%, across all 70 respondents. The calculation used for the final NTG estimate for the HESP was: [1 – Freeridership % = NTG].

Table 17. HESP NTG Results

Program	N	FR	NTG
HESP	70	14%	86%

4.3 Program-Level Savings

Cadmus used the calculated measure realization rates to determine annual verified gross savings estimates for the HESP. The evaluation sample (n=41) did not include certain measures, and, in those instances, Cadmus used a realization rate of 1. To compute annual verified net energy savings, Cadmus applied the NTG ratio to verified gross savings.

Table 18 lists the program-level savings by verified measure type.

Table 18. Annual Energy Savings by Measure Type in MMBTUs

Measure Type	Reported Gross MMBTU Savings	Verified Gross MMBTU Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)	Verified Net Savings	Measures (n)
Air Sealing	42,993	44,467	103%	0.86	38,242	89%	1,846
Attic Access: Existing (Hatch)	2,107	1,310	62%	0.86	1,127	53%	1,248
HVAC: System (Furnace/Boiler)	14,649	9,139	62%	0.86	7,859	54%	730
Insulation: Attic	30,732	17,756	58%	0.86	15,270	50%	2,849
Insulation: Basement/Floors	20,353	16,309	80%	0.86	14,026	69%	2,656
Insulation: Walls	18,394	23,271	127%	0.86	20,013	109%	967
Remaining Measures	12,257	12,257	100%	0.86	10,540	86%	2,765
Total[11] (1780 Sites)	141,485	124,509	88%	0.86	107,077	76%	13,061

Savings were broken out by fuel type. Annual Energy Savings by fuel type (in MMBTUs) can be seen in Table 19.

Table 19. Annual Energy Savings in MMBTUs

Annual Energy Savings by Fuel Type (MMBTUs)	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n)
Fuel Oil	132,063	110,638	84%	0.86	95,148	72%	8,373
Natural Gas	1,244	4,965	399%	0.86	4,270	343%	2,070
Propane	763	2,052	269%	0.86	1,765	231%	1,376
Wood	3,635	3,315	91%	0.86	2,851	78%	374
Kerosene	732	615	84%	0.86	529	72%	102
Electric	3,024	2,908	96%	0.86	2,501	83%	749
Corn Pellet	22	17	76%	0.86	15	65%	17
Total (1780 Sites)	141,485	124,509	88%	0.86	107,077	76%	13,061

[11] Includes all measures installed within evaluation period.

Cadmus converted the savings figures into fuel consumption units, as shown in Table 20.

Table 20. Annual Energy Savings by Fuel Type (in Consumption Units)

Annual Energy Savings by Fuel Type	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n=13,061)
Fuel Oil (gallons)	953,526	798,827	84%	0.86	686,991	72%	8,373
Natural Gas (therms)	12,440	49,646	399%	0.86	42,696	343%	2,070
Propane (gallons)	8,342	22,423	269%	0.86	19,284	231%	1,376
Wood (cord= 24 MMBTU)	151	138	91%	0.86	119	78%	374
Kerosene (gallons)	5,424	4,558	84%	0.86	3,920	72%	102
Electric (kwh)	886,127	852,013	96%	0.86	732,731	83%	749
Corn Pellet (7400 BTU/lb)	3,030	2,289	76%	0.86	1,969	65%	17

For this report, Cadmus calculated lifetime verified gross and net energy savings generated by the HESP. Cadmus used the reported EUL of the measure included in the program data to calculate lifetime verified net energy savings. These data (in MMBTUs) are shown in Table 21.

Table 21. Lifetime Energy Savings in MMBTUs

Lifetime Energy Savings by Fuel Type (MMBTUs)	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n)
Fuel Oil	3,044,152	2,569,517	84%	0.86	2,209,785	73%	8,373
Natural Gas	87,296	156,880	180%	0.86	134,917	155%	2,070
Propane	55,068	76,932	140%	0.86	66,162	120%	1,376
Wood	91,216	83,203	91%	0.86	71,555	78%	374
Kerosene	17,617	14,786	84%	0.86	12,716	72%	102
Electric	40,278	37,597	93%	0.86	32,333	80%	749
Corn Pellet	563	426	76%	0.86	367	65%	17
Total (1780 Sites)	3,336,191	2,939,342	88%	0.86	2,527,834	76%	13,061

Cadmus also converted lifetime savings figures into fuel consumption units. The results of this are shown in Table 22.

Table 22. Lifetime Energy Saving by Fuel Type

Lifetime Energy Savings by Fuel Type	Reported Gross Savings	Verified Gross Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross * NTG)	Net Realization Rate	Measures (n=13,061)
Fuel Oil (gallons)	21,979,438	18,552,471	84%	0.86	15,955,125	73%	8,373
Natural Gas (therms)	872,964	1,568,801	180%	0.86	1,349,169	155%	2,070
Propane (gallons)	601,841	840,789	140%	0.86	723,079	120%	1,376
Wood (cord= 24 MMBTU)	3,801	3,467	91%	0.86	2,981	78%	374
Kerosene (gallons)	130,496	109,524	84%	0.86	94,190	72%	102
Electric (kwh)	11,801,276	11,015,827	93%	0.86	9,473,611	80%	749
Corn Pellet (7400 BTU/lb)	76,108	57,596	76%	0.86	49,533	65%	17

The verified annual net energy savings of the HESP are 107,077 MMBTUs. The verified net lifetime energy savings of the HESP are 2,527,834 MMBTUs. These two calculations yield a gross realization rate of 88%. The final, net realization rate of the Efficiency Maine HESP is 76%.

The Program reported reducing residents' energy consumption by 40%, on average. Cadmus observations verify that the Program saved customers 31% in energy savings, on average

4.4 Utility Bill Review

As part of this evaluation, Cadmus attempted to obtain direct fuel usage data from billing or delivery information for selected sites to augment the engineering analysis. The difficulty of obtaining billing data for the sample sites became apparent as the evaluation progressed.[12] It was challenging to collect viable liquid fuel usage data for Maine residents due to the following:

- Unlike other areas of the country, where residents are served primarily by one utility company, Maine has many different fuel suppliers from which to choose.
    - To obtain the fuel oil and propane delivery information, Cadmus had to contact a large number of individual fuel companies (n=28) directly.
- Individuals often chose to use multiple suppliers during the course of a heating season.
- Individuals used multiple fuel types.
- Utility companies were non-responsive to Cadmus' requests.

[12] In total, Cadmus spent nearly half as much time attempting to collect bills as its staff spent in the field at the 41 houses, yet, satisfactory bills for less than half of the houses were obtained. The process Cadmus used to attempt to obtain fuel usage information is explained in Appendix D.

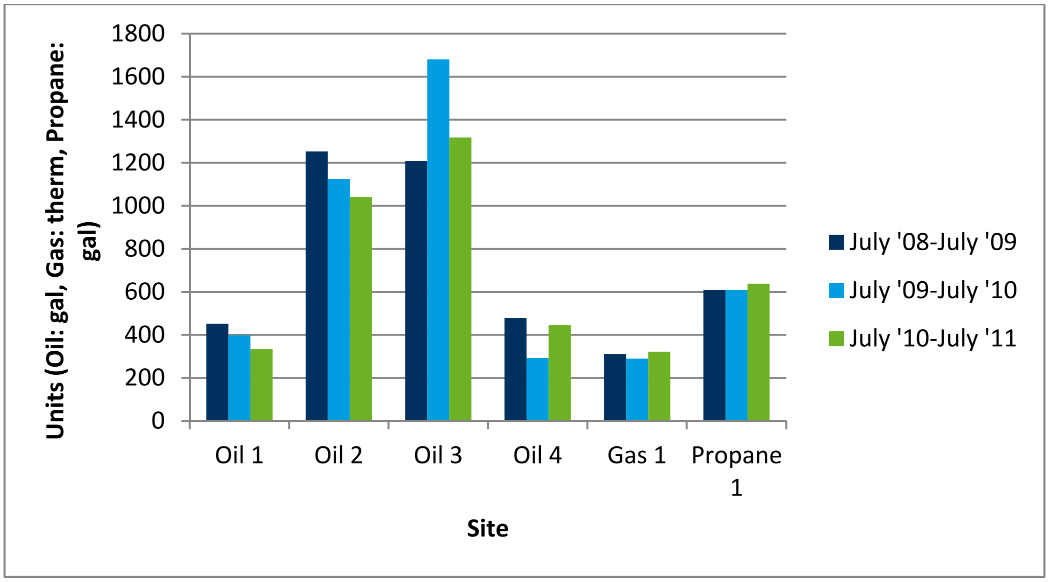
- To obtain Unitil gas billing data, Cadmus had to contact participants directly to receive their billing data (per the request and recommendation of Unitil). Many customers were not willing to provide the data, or, simply, did not provide the data.
- As billing data is proprietary, residents were asked to sign an authorization form to allow Cadmus to receive their information. If customers were not willing to complete the form (n=9), Cadmus could not receive the information from the fuel provider.

Ultimately, Cadmus could obtain usable fuel usage information from only 19 of the 41 sampled participants. Unfortunately, subsequent to that, many bills received also were difficult to interpret in the billing analysis due to the following:

- Oil was delivered inconsistently. Customers often did not receive "fill-ups," meaning their oil tank was not empty when they ordered additional fuel, making it difficult to track consumption consistently.
- Residents received deliveries infrequently. As a result, assumptions were made to determine when fuel was consumed and how frequently.
- More than half of the sites used supplemental fuel. The most significant supplemental heat source was wood, used by 57% (12 residents) of sampled residents with supplemental fuel. In the survey, a large portion of sites with supplemental fuel used it continuously or often, and 60% heated 3 rooms or more with that heat.
    - Seven percent of participants used wood and 2% of participants used pellet wood as the primary fuel source for their home.

Cadmus collected 9 sets of bills for 2008-2009, 19 for 2009-2010, and 22 for 2010-2011 (though these bill sets are subject to missing deliveries). Of these sets, only 5 sets of oil bills and one set of gas bills included all three heating seasons, which is shown in Figure 25.

Figure 25. Fuel Deliveries as Indicated by Bills



Given that inventory carry over can significantly impact annual bills, there is no reliable way to calculate changes in pre- and post-program consumption. The absolute magnitude of the oil bill yearly deliveries has variability between 2.8 and 6.5 to 1, and many yearly usage amounts are far lower than expected.

Cadmus determined that the data obtained would not support the statistical billing analysis proposed as a part of the evaluation.

The fuel savings observed in the limited billing data Cadmus was able to obtain fell below what was modeled and expected. This likely could be attributed to the following:

- The widespread use of supplemental heat. There is clear evidence from field observations, file records, and surveys that many customers have wood as a secondary heat source and use it often. The homeowner for Oil 1 indicated that wood is the primary heat source. Oil 2 uses wood for cold days to supplement oil heat. Oil 3 heats only with oil. No notes regarding supplemental heat use for Oil 4 and Gas 1 were recorded, but their use is consistent with use patterns of residents with a substantial use of supplemental fuel. Propane 1 had converted from kerosene, and it is not known whether any residual use of kerosene remains.

- Missing deliveries, due to price-shopping suppliers and differing delivery dates, especially relating to summer usage, make it difficult to interpret data as does fuel storage potential. For example, one homeowner with a small house had 600 gallons of storage capability and held a large inventory of fuel oil.

4.5 Job Impacts

Cadmus estimated the number and type of short-term and long-term jobs generated due to the HESP. As agreed upon with the Trust, Cadmus took a simple approach to this analysis, using the U.S. DOE's analytical protocol, which assumes one job-year is created for every $92,000 in program spending.

Efficiency Maine's total ARRA expenditures were calculated at $8,549,371. Per the DOE analysis, the HESP program should have created approximately 93 job-years through its implementation.

4.6 Cost-Effectiveness

Total Resource Cost Test

Assessment of cost-effectiveness for the HESP began with a valuation of each energy efficiency measure's net "total resource" benefits, as measured by electric avoided costs and the measure's total incremental installed costs. The program was deemed cost-effective if its net "total resource" benefits were positive, as calculated:

$$\frac{\textit{Total Resource Benefits}}{\textit{Total Resource Costs}} \geq 1$$

where,

$$\textit{Total Resource Benefits} = \text{NPV}\left(\sum_{\text{year}=1}^{\text{measurelife}}\left(\sum_{i}^{i=8760}(\text{impact}_i \times \text{avoidedcost}_i)\right)\right)$$

and,

$$\begin{aligned} &\textit{Total Resource Cost} \\ &= \Bigg(\text{NPV (Incremental Measure Costs + Utility Costs)} \\ &+ \left(\sum_{\text{year}=1}^{\text{measurelife}}\left(\sum_{i}^{i=8760}(\text{increasedfuelusage}_i \times \text{marginalfuelcost}_i)\right)\right)\Bigg) \end{aligned}$$

The Trust provided cost and savings information as well as the inputs shown in Table 23. Cadmus calculated TRC results for each HESP project in the evaluation period that had been modeled with RHA[13] in the program database. Measure-level TRC results for RHA homes could not be calculated as costs were only available and provided at the project level.[14]

Realization rates calculated by Cadmus were applied to savings values provided by Efficiency Maine.

Table 23. TRC Inputs and Assumptions

Category	Value
Discount Rate	4.51%
Line Loss	6.50%
2010 Avoided Costs by Fuel	
Electric Energy, Winter Off Peak ($/kWh)	$0.06
Electric Energy, Winter On Peak ($/kWh)	$0.07
Electric Energy, Summer Off Peak ($/kWh)	$0.05
Electric Energy, Summer On Peak ($/kWh)	$0.07
Electric Demand, Winter ($/KW)	$0.00
Electric Demand, Summer ($/KW)	$67.15
Transmission and Distribution ($/KW)	$80.00
Natural Gas Heating ($/MMBTU)	$9.58
Natural Gas Water Heat ($/MMBTU)	$12.32
Kerosene ($/MMBTU)	$15.49
Oil ($/MMBTU)	$15.95
Propane ($/MMBTU)	$24.52
Wood ($/MMBTU)	$10.12
Corn Pellet ($/MMBTU)	$10.12

[13] TRC results could not be calculated for projects where savings were reported using TREAT or REM/Rate. Measure-level information was not provided for these projects.

[14] It would have introduced error into the calculations to attempt to allocate the project level costs to measure level costs.

Table 24 shows annual MMBTU savings, avoided fuel costs, and increased fuel costs for each fuel type for the HESP. Reported savings reflected total savings associated with projects, adjusted for any increased fuel consumption as a result of fuel switching. Lighting savings reflected baseline changes due to Energy Independence and Security Act (EISA) legislation.

Table 24. Annual Savings, Avoided Fuel Costs, and Added Fuel Costs, by Fuel Type

Fuel Type	MMBTU Savings	Avoided Fuel Costs	Added Fuel Costs
Electric	2,908	$1,571,123	$157,571
Natural Gas	4,965	$2,500,148	$1,425,241
Propane	2,052	$4,825,491	$2,939,778
Oil	110,638	$49,874,294	$187,398
Kerosene	615	$283,394	$0
Wood	3,315	$540,640	$28
Corn Pellet	17	$2,794	$0
Total Adjusted Gross Values	124,509	$59,597,884	$4,710,016
Total Net Values	107,077	$51,254,180	$4,050,614

Incremental participant measure costs were based on reported project costs and standard industry baseline cost sources the Database of Energy Efficient Resources (DEER) and ENERGY STAR. Costs were adjusted to reflect federal tax credits, consistent with the California Standard Practices Manual.

A TRC analysis was conducted on three savings scenarios. The first scenarios calculated cost-effectiveness using gross reported savings. The second adjusted these gross savings values using the realization rates described above. The third scenario adjusted both savings and project costs using a NTG ratio of 86%. In all three scenarios, the HESP passed the TRC test comfortably. Table 25 presents the results of the TRC analysis.

Table 25. TRC Results for the HESP

Value	Reported Gross Savings Scenario	Verified Gross Savings Scenario	Verified Net Savings Scenario
MMBTU Savings	141,485	124,509	107,077
Avoided Energy Benefits	$70,097,059	$59,597,884	$51,254,180
Added Energy Costs[15]	$6,879,199	$4,710,016	$4,050,614
Participant Incremental Costs	$16,387,212	$16,387,212	$14,093,002
Program Delivery	$1,078,868	$1,078,868	$1,078,868
Marketing	$642,111	$642,111	$642,111
Administration	$187,155	$187,155	$187,155
TRC Benefits	$70,097,059	$59,597,884	$51,254,180
TRC Costs	$25,174,546	$23,005,363	$20,051,751
TRC Ratio	2.78	2.59	2.56

[15] The California Standard Practice Manual, the industry standard for cost-effectiveness evaluation, notes any added fuel costs resulting from DSM programs should be considered as components of TRC Costs, rather than as reductions to TRC Benefits. Here, "added energy costs" refers to these increased fuel costs from fuel-switching programs. For fuel-switching measures (like replacing a propane furnace with a higher-efficiency natural gas furnace), there is a reduction in supply costs for one fuel, and an increase for another fuel. The overall effect should be a decrease in fuel costs. Added fuel costs and avoided fuel costs are separated out so that the avoided costs can be factored into TRC Benefits, and the added costs can be factored into TRC Costs.

SEP-RAC Test

The U.S. DOE SEP-RAC test compares net MMBTU savings per $1,000 of ARRA expenditures (costs).

Costs used in the SEP-RAC test were the sum of all the Trust's expenditures, related to the HESP, through the end of the evaluation period. This included measure incentives (excluding any partner rebates paid by Unitil), program delivery expenditures, marketing costs, and administrative costs. MMBTU savings were provided for each home.

Similar to the TRC test process, measure-level savings information was provided for homes with savings evaluated using the RHA method. The realization rates established through engineering analysis were applied to RHA homes.[16] MMBTU savings for both RHA and TREAT or REM/Rate homes were adjusted using a NTG ratio of 86% (as noted previously).

The DOE SEP-RAC test is an alternate cost-effectiveness metric, evaluating whether projects save at least 10 million source BTUs (10 MMBTUs) annually, the threshold for ARRA-funded programs.

The Trust's Program saved 13.41 net MMBTU per $1,000 in ARRA expenditures, passing the SEP-RAC test. Table 26 provides details of SEP-RAC test analysis.

Table 26. Components and Results of the SEP-RAC Test

Category	Value
RHA MMBTU Savings – Adjusted Gross	124,509
TR MMBTU Savings – Gross	8,762
Total Gross MMBTU Savings	133,271
NTG Ratio	86%
Total Net MMBTU Savings	114,613
HESP Incentives (Including Bonus Payments)	$6,641,237
Program Delivery	$1,078,868
Marketing	$642,111
Administration	$187,155
Total ARRA Expenditures	$8,549,371
MMBtu/$1000	13.41

4.7 Carbon Emission Displacement

Cadmus calculated displaced greenhouse gas emissions associated with Efficiency Maine's HESP. To conduct this analysis, Cadmus used the verified net energy impacts, in terms of net tons of carbon emissions avoided over the EUL of the projects. Cadmus used the following tools

[16] As savings for TREAT and REM/Rate homes could not be separated by end use or measure type, these savings were not adjusted.

in this analysis: the World Resource Institute's GHG Protocol;[17] and the Maine Department of Environmental Protection (DEP) Greenhouse Gas Worksheet (Worksheet).[18]

Data used to calculate the displaced greenhouse gas emissions over the EUL, as well as annually, can be seen in Table 19 (*Annual Energy Savings in MMBTUs*) and Table 21 (*Lifetime Energy Savings in MMBTUs*). Cadmus did not factor in emissions from corn pellets in this analysis as the amount claimed was insignificant when compared with other fuels.

Cadmus referenced Maine's DEP requirements for emission factor selection. According to the DEP, "Greenhouse gas inventories are still evolving and the Department will accept any emission factor with proper documentation."[19] The three primary sources of emissions factor information indicated by DEP were:

- The World Resource Institute (WRI)/World Business Council for Sustainable Development;
- The U.S. Environmental Protection Agency, AP-42; and
- DOE, Energy Information Administration.[3]

The DEP Worksheet uses emissions factors from the Intergovernmental Panel on Climate Change (IPCC) National Greenhouse Gas Inventory Program.[20] Cadmus utilized this Worksheet to calculate displaced annual and lifetime greenhouse gas emissions for the HESP. When possible, emissions factors from the Worksheet were used; however, if a fuel type was not included in the Worksheet, Cadmus obtained emissions factors from two other primary sources: the GHG Protocol Initiative;[21] and DOE, Energy Information Administration.[22]

Using the fuel type, the amount of fuel, and the emissions factor, Cadmus calculated carbon dioxide (CO2) emissions, methane (CH4) emissions, and nitrous oxide (N2O) emissions, displaced in tons per year. Using the global warming potentials from the 2007 IPCC Fourth Assessment Report, Cadmus converted the annual and lifetime greenhouse gas emissions displaced into net tons of CO2 equivalent.

The WRI requires reporting CO2e emissions from biomass separately from GHG emissions from fossil fuels because biomass emissions are considered accounted for by land-use analysis.[23] Therefore, values of total GHG emissions from fossil fuels have been reported separately from the total CO2e emissions from biomass in this analysis. Table 27 shows the results.

[17] http://www.ghgprotocol.org/calculation-tools/all-tools
[18] http://maine.gov/dep/air/emissions/ghg-tools.htm
[19] http://maine.gov/dep/air/emissions/ghg-rptng.htm
[20] http://www.ipcc-nggip.iges.or.jp/public/gl/invs6.htm (as of 2 July 2003), http://maine.gov/dep/air/emissions/ghg-tools.htm
[21] http://www.ghgprotocol.org/templates/GHG5/layout.asp?type=p&MenuId=OTAx
[22] http://www.eia.gov/pub/oiaf/1605/cdrom/pdf/e-supdoc.pdf
[23] http://www.ghgprotocol.org/calculation-tools/faq

Table 27. Annual and Lifetime Carbon Emissions Displaced from HESP

Fuel Type	Total GHG Emissions Displaced Tons CO2e	
	Annual	Lifetime
All Fuels (without Biomass)	8,443	196,735
Biomass	347	8,707

In completing these calculations, Cadmus relied on several assumptions.

The amount of carbon displaced was an estimation, based on best practice tools available. As referenced above, per Maine's DEP requirements for emission factor selection, Maine does not have one singular methodology for calculating displaced carbon emissions at this time. If another tool was used, calculations could come out slightly differently.

In calculating carbon emissions displaced over the effective useful life of each measure type, Cadmus applied currently available emissions factors to these savings, by measure and fuel type, over the effective useful life of the measure.

In the future, depending on legislation and the progression of study in this area, emissions factors will likely be updated. Thus, the level of rigor for this study is not sufficient to monetize these carbon data.

5. Survey Analysis Findings

Through the participant and partial participant surveys, Cadmus found the following:

Program Awareness: Efficiency Maine's print and media marketing materials reached Maine residents, and drove program participation. Contractors provided another effective channel to inform residents about the program and to encourage their continued participation after residents began to understand benefits gained through implementation of energy-saving improvements.

Program Information Sources: All participant classes used the Efficiency Maine Website as their primary source for identifying an energy advisor to conduct the home energy assessment or audit. To select energy advisors, full participants also used contractors they already knew, while partial participants relied on word-of-mouth and referrals from Efficiency Maine.

Participant Profile: When compared to full participants, partial participants tended to be younger and have larger households. Household and respondent characteristics identified through these surveys may prove useful for messaging and segmentation efforts.

5.1 Motivations and Decisions

The HESP rebate and the potential to save money on energy bills motivated residents to begin participating in the program by having an energy audit. Among those who completed energy upgrades (full participants), respondents indicated the rebate provided a greater incentive than the federal tax credit. The two incentives' combined effects may have motivated, at most, an additional 31% to make improvements.

Participants (full and partial) reported that energy advisors most commonly recommended all types of insulation and air sealing. These measures were also the ones most commonly installed, as recorded in the program database.[24] Very few survey respondents installed low-cost measures, such as CFLs and low-flow showerheads, as part of their HESP project. This survey finding is consistent with data regarding installed measures in the program database.

Initial Program Participation

To better understand outreach channels proving most influential with participants, Cadmus asked about participants' initial contacts with the program. HESP participants (both full and partial combined) most commonly (36%) cited print advertising and media as their first source of information about HESP. Print advertising included brochures, newspaper ads, and direct mailings; and media sources included radio and TV spots. After print advertising and media, full participants most frequently (29%) first learned about the program through a contractor, while partial participants most often (24%) learned about the program through word-of-mouth/recommendations from others.

Figure 26 depicts multiple sources first informing full and partial participants about the program.

[24] The program database extract, provided by Efficiency Maine for the evaluation, was used to generate the survey sample.

Figure 26. Initial Program Exposure, All Participants (n=88, Multiple Responses Allowed)

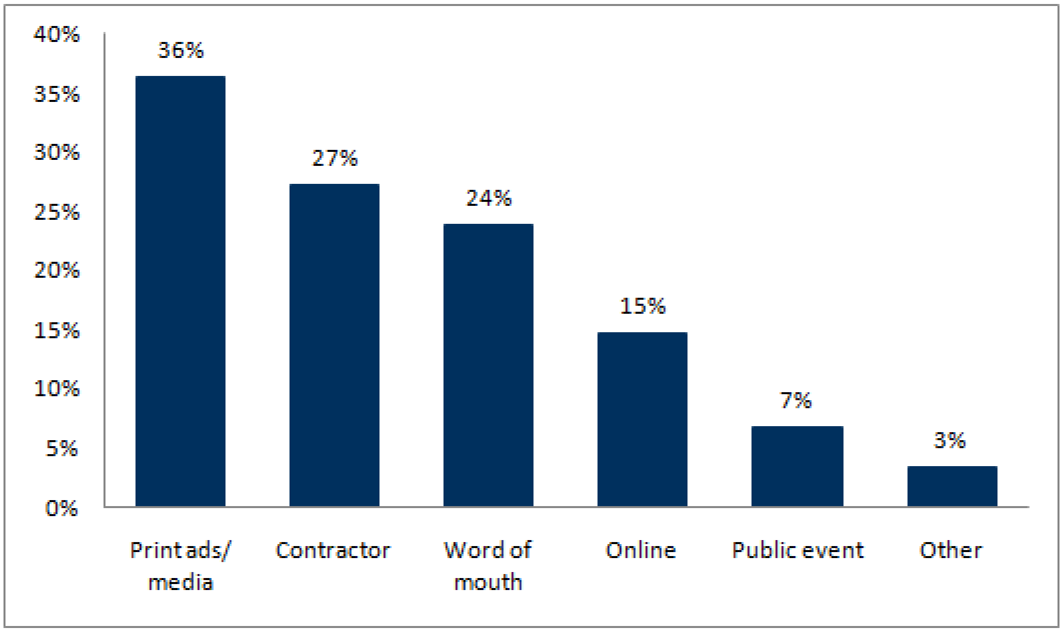
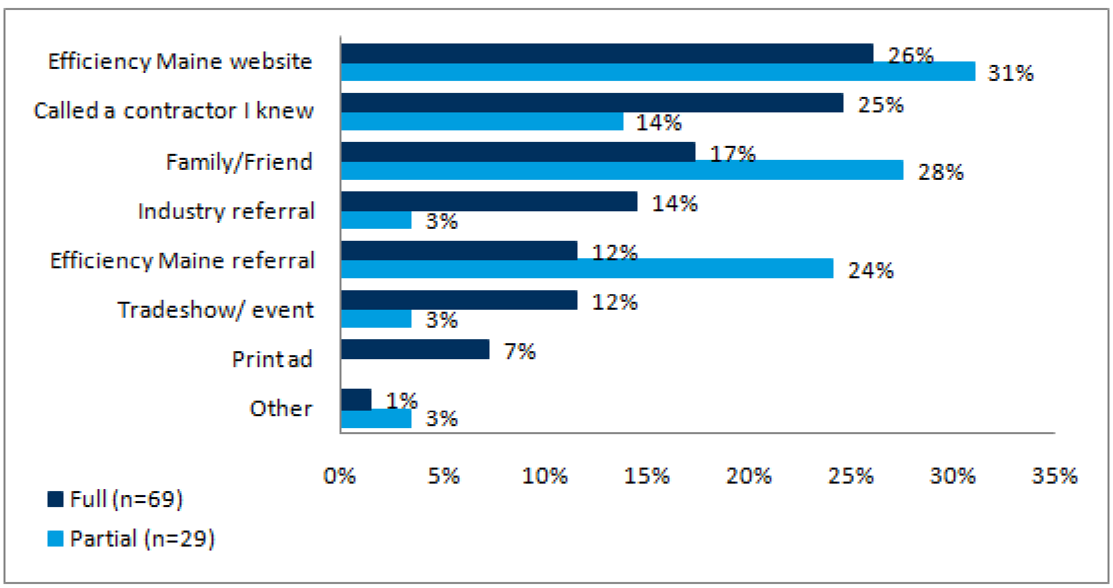


Figure 27 illustrates reported sources participants utilized to find energy advisors to conduct home energy audits. Both full (26%) and partial (31%) participants most frequently relied on Efficiency Maine's Website to find energy advisors. Full participants (25%) also commonly called contractors they already knew, while partial participants also relied on family and friends (28%) and referrals from Efficiency Maine (24%).

Figure 27. Energy Advisor Selection Sources (Multiple Responses Allowed)

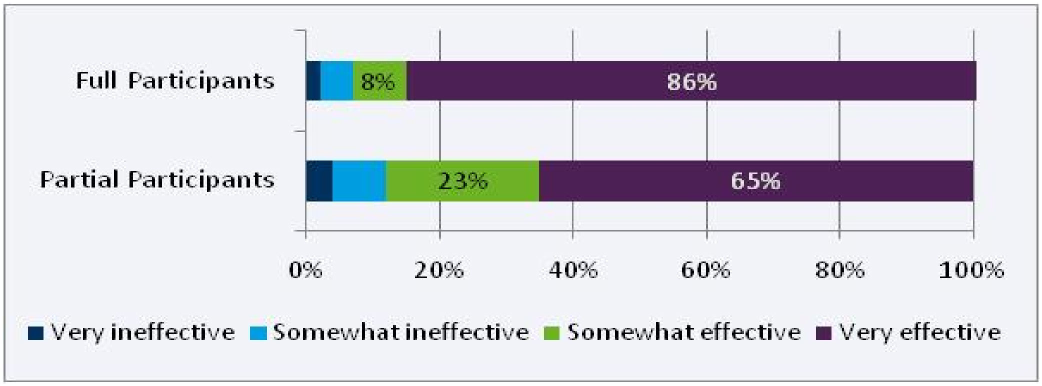


Once participants selected an energy advisor, the advisor conducted an energy audit to assess efficiency measures and improvements to decrease energy use in their homes.

Both full (94%) and partial (88%) participants found audit reports somewhat to very effective. More full participants than partial participants found them very effective. Qualitative responses indicated they found the reports clear and detailed. Participants liked being presented with options for improvements and their associated savings estimates. A typical positive comment was: "*I was amazed at what energy was saved by doing such little things.*"

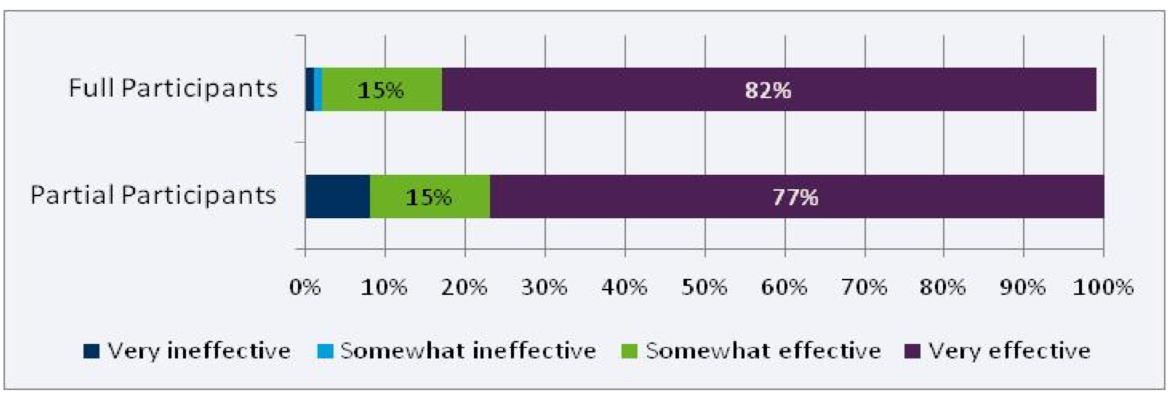
Conversely, some participants had negative comments, including that they waited "a long time" to receive the audit report, or, in a couple of cases, never received it. Figure 28 shows respondents' ratings for the audit report's effectiveness.

Figure 28. Effectiveness of Audit Report



Full (97%) and partial (92%) participants also attributed similar effectiveness levels to the energy advisor. Several respondents indicated the advisor "explained things thoroughly" and "identified improvements that I wasn't aware of." Figure 29 shows respondents' ratings for the energy advisor's effectiveness.

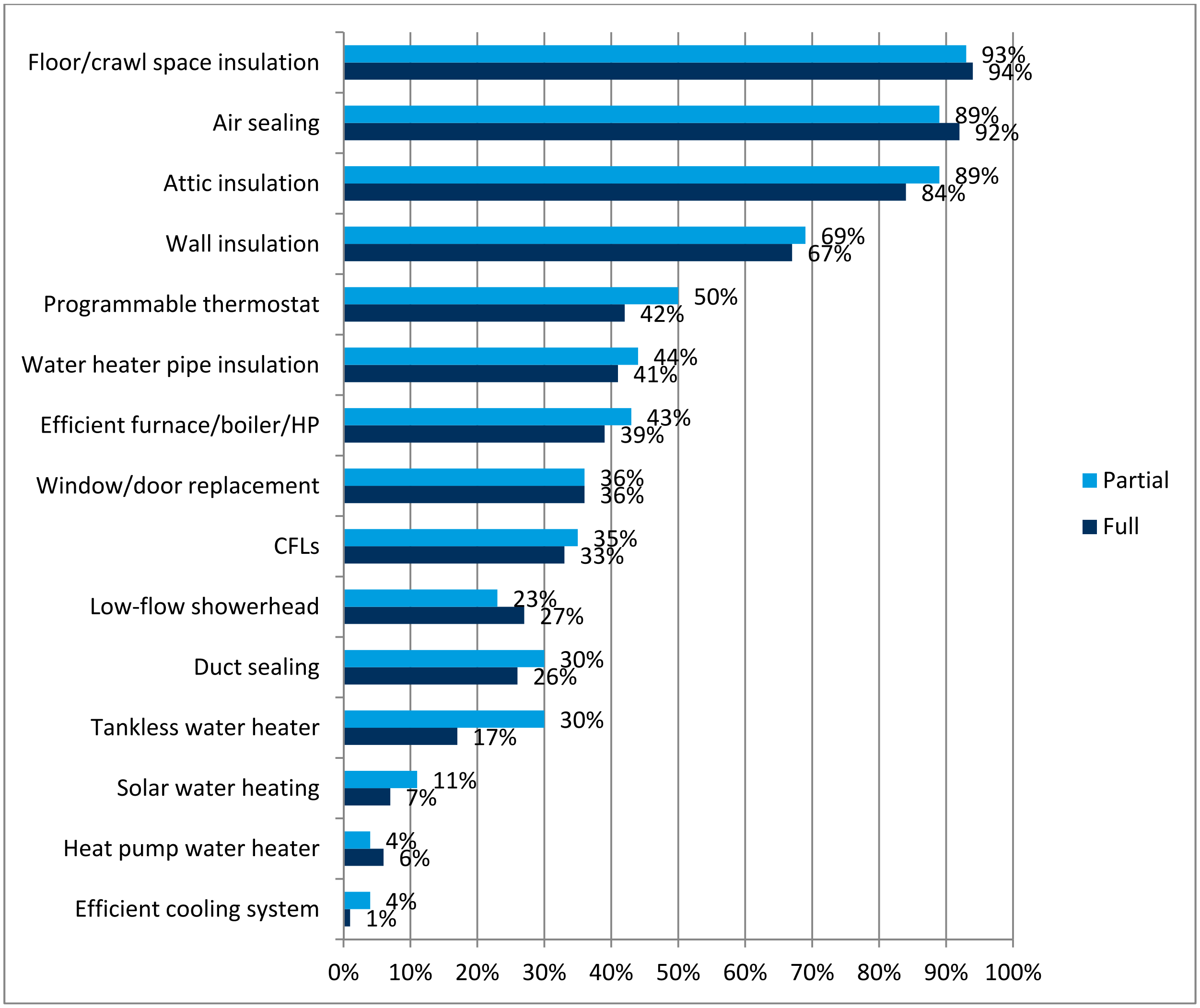
Figure 29. Effectiveness of Energy Advisor



Audits led to recommendations for energy-efficiency improvements to each home. Improvements recommended through the energy audit process were consistent between full and partial participants, with floor and crawl space insulation (93%–94%) and air sealing (89%–92%) most commonly recommended measures. Lower-cost measures, such as CFLs and low-flow showerheads, were recommended for one-quarter (23%–27%) to one-third of (33%–35%) participants.

When partial participants were asked if any of the recommended improvements had been completed in their homes, two-thirds (67%) said “yes” (33% said “no”). Of the 20 partial participants that had completed some improvements, attic insulation (65%) was the most common measure, followed by air sealing (50%) and floor/crawlspace insulation (45%). Only one participant reported purchasing a CFL, and none reported installing low-flow showerheads or aerators.

Figure 30. Recommended Improvements

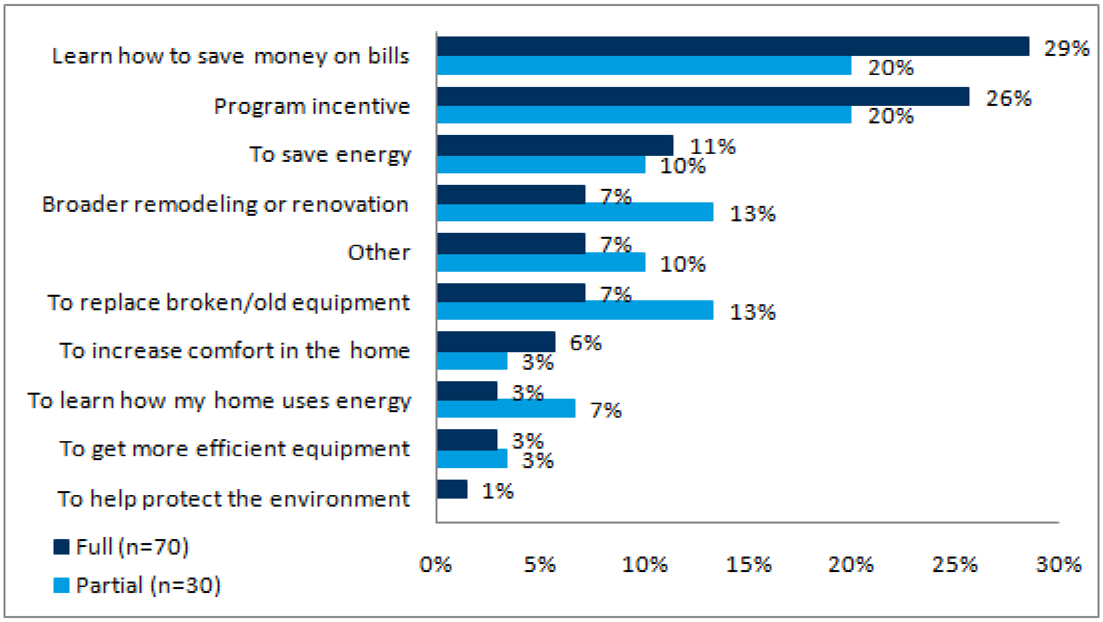


Participation Motivations

To assess program motivations, Cadmus asked survey questions designed to help Efficiency Maine better understand elements influencing residents to participate in the program.

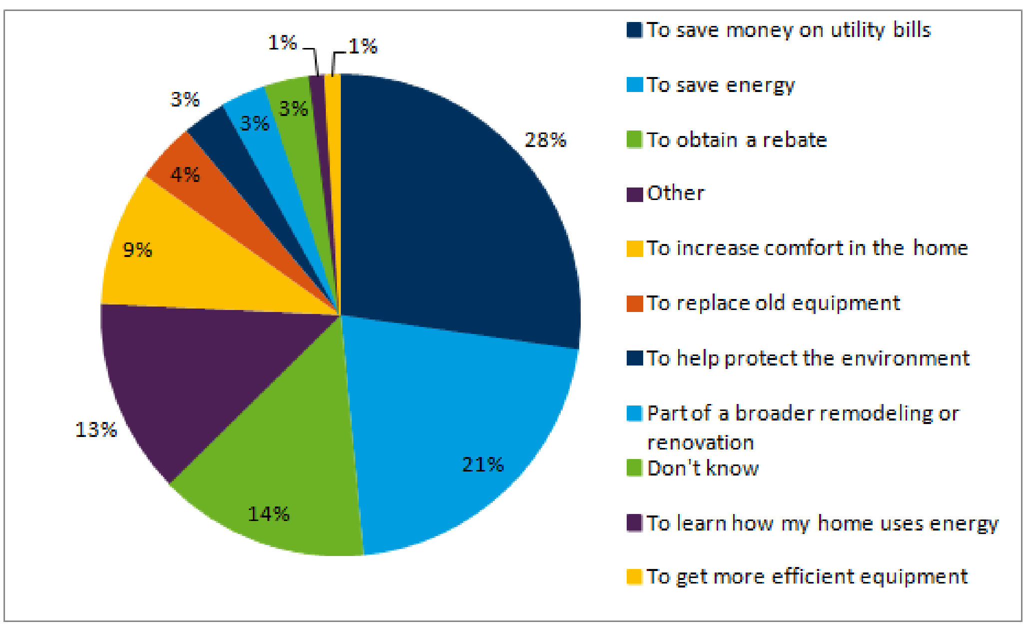
Figure 31 illustrates reported reasons why full and partial participants chose to receive energy audits. Desire to identify ways to save money on utility bills (26% of full and partial participants) and receipt of the program’s rebate (24% of full and partial participants) provided the two most common motivating factors leading participants to complete a home energy audit.

Figure 31. Home Energy Audit Motivations



When asked to identify the most important reason in deciding to complete energy-efficiency improvements to their homes after receiving audits, full participants most often cited saving money on utility bills (28%) or saving energy (21%). Full participants also referenced the HESP rebate and increasing their homes' comfort as motivations.

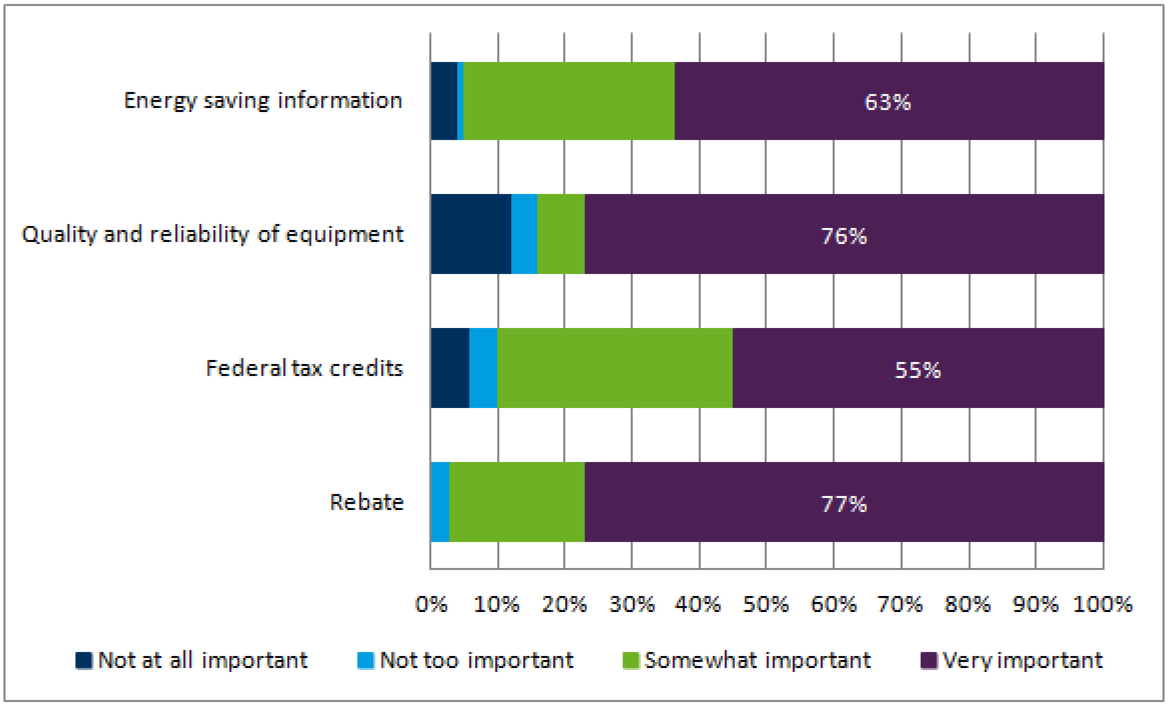
Figure 32. Energy Improvement Installation Motivations



Participation Decision Factors

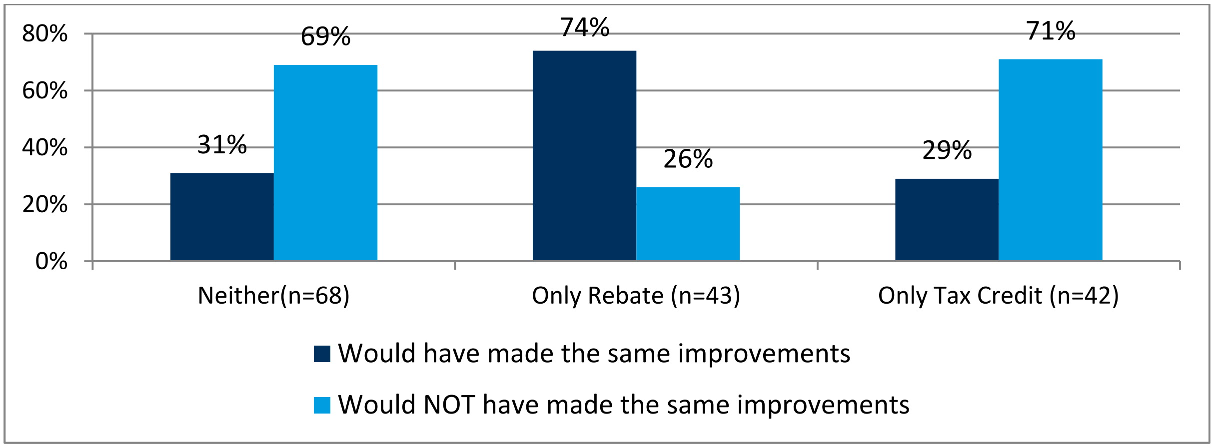
As federal tax credits were available for home energy improvements during the same period, surveys asked full participants about the importance of these incentives as well as program rebates. Figure 33 shows how full participants rated the importance of federal tax credits and HESP rebates to participants' decisions to invest in energy-saving improvements. More than three-quarters (77%) of full participants saw the HESP rebate as a very important factor in their decision to invest in energy improvements, and more than half (55%) saw the federal tax credit as a very important factor. Energy saving information, and quality and reliability of equipment were noted to be more important than the federal tax rebate.

Figure 33. Influences on the Decision to Invest in Energy Improvements



Surveys asked participants about the interactive influence of tax credits and the HESP rebate by having them estimate whether they would have completed the home-energy improvements, had either or both of these two incentives not been available to them. Figure 34 shows the relative influence of the tax credit and the HESP rebate, as reported by full participants' decisions to make improvements.

Figure 34. Interactive Influence of Federal Tax Credit and Rebate



Without either the rebate or the tax credit, more than two-thirds of participants (69%) would likely not have made the same improvements. Without the rebate, less than one-third (29%) would have made the improvements, had only tax credits been available. Without the tax credit, the rebate sufficiently incented about three-quarters of participants (74%) to make improvements.

5.2 Barriers

The upfront costs of making energy improvements presented the primary reason partial participants did not follow through with making improvements at this time. Some partial participants indicated they made improvements, and had submitted a rebate claim form, or were waiting on contractors' availability to complete the work.

Although participation barriers can be best understood from a nonparticipant perspective, surveying nonparticipants fell beyond the evaluation's scope. To examine barriers to participation, the survey included a question asking participants to determine whether they had concerns about participating before pursuing the energy assessment. The survey also included questions to identify when and why partial participants discontinued their participation.

In terms of general concerns before having the energy assessment, relatively few full (26%) or partial (24%) participants reported concerns about participating in the program. Most concerns cited were financial. Among full participants who reported concerns, one-third (33%) cited the high upfront costs associated with the program, and another third (33%) expressed concerns that the rebate amount would be too low, and/or they might not ultimately qualify for and receive the rebate. Others (22%) expressed concerns that the program application and participation process would "be a hassle" and take too long or too much effort.

Table 28. Full Participant Concerns, Prior to Participation (n=18)

Response	Full (n=18)	
	Frequency	Percent
Upfront costs (audit and improvements)	6	33
Incentive/ rebate would be too low	6	33
Process would take too long	4	22
Trusting contractor to do the paperwork	1	6
Finding a contractor that met program qualifications	1	6

Among partial participants who reported concerns, just under half (45%) expressed concerns about upfront costs. Partial participants cited the timing of the installation as another barrier: either they actually proceeded and made efficiency improvements, and had a rebate claim in progress; or they were waiting for their contractors to have the time to perform the installations; or they had not yet had time to pursue completing the improvements. Table 29 presents partial participant responses.

Table 29. Participation Barriers (Multiple Responses Allowed)

Response	Partial (n=30)	
	Frequency	Percent
Installation was too expensive/don't have the money	14	45
I made the improvements—rebate application in progress	5	15
Construction delay/contractor's schedule	2	6
Waiting to do insulation—on cool day/when we can replace siding	2	6
Planning to make the improvements/haven't had time yet	2	6
Don't have audit report yet	1	3
Did not know how to proceed (i.e., don't know what the next steps are)	1	3
No improvements were recommended	1	3
Other	3	10

5.3 Satisfaction

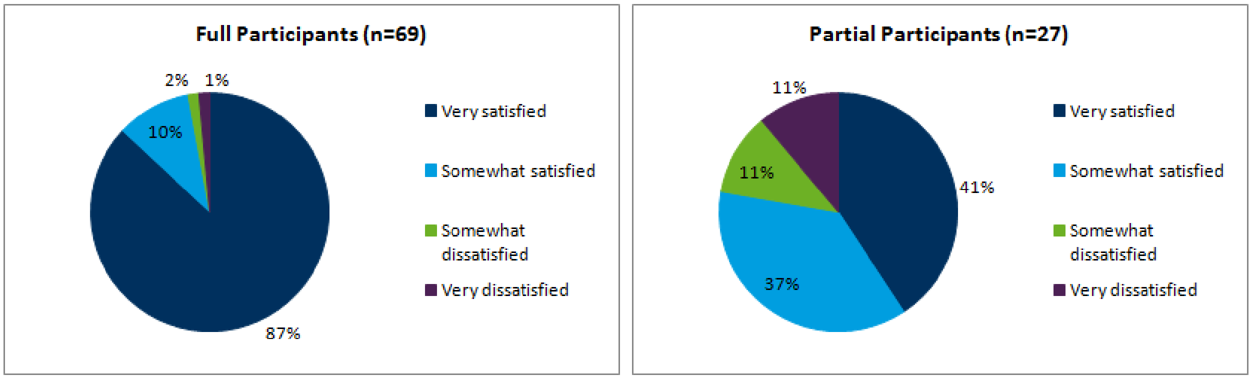
A significantly greater number of full participants (87%) expressed high satisfaction with the program than partial participants (41%). Nearly all (92%) participants said they would recommend the program to a friend.

Nearly all full participants (91%) said their homes became more comfortable following improvements (i.e., most noticed more consistent temperatures throughout their homes, and found they needed to run their heating systems less frequently). Most (82%) said the program met their expectations.

This section and a few of the appendices present topics covered by the survey, and the major survey results and conclusions.

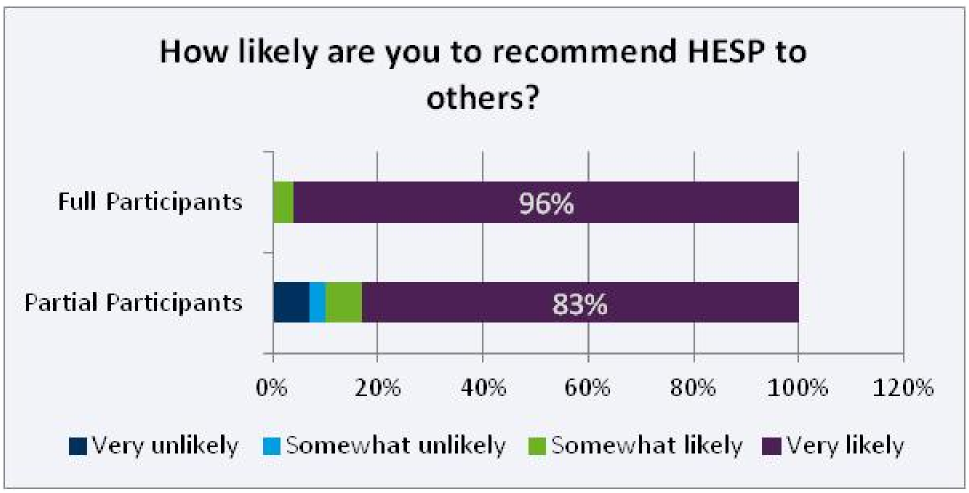
Participants expressed strong satisfaction levels with their overall program experience. Most full participants (87%) reported being "very satisfied" with their program experience overall. Although less than one-half (41%) of partial participants were "very satisfied," over three-quarters (78%) reported some satisfaction level with the program. Figure 35 depicts differences at full and partial participant satisfaction levels.

Figure 35. Overall Program Satisfaction



High satisfaction levels also emerged when participants were asked whether they would recommend the program to others. Almost all full participants (96%) and most partial participants (83%) would be "very likely" to recommend the program to someone else.

Figure 36. Likeliness to Recommend



The survey also explored reasons behind dissatisfaction with the program. As shown in Figure 35, partial participants reported higher dissatisfaction levels than full participants, with 22% of partial participants dissatisfied with their program experiences. Reasons partial participants cited for dissatisfaction included:

- *"I think it's too complicated, too much paperwork, and the incentives are not enough."*
- *"They set a bad tone to start by not letting me know how to prepare for the audit."*
- *"[There were] problems with the contractors, scheduling, and materials."*

Dissatisfaction reasons helped inform program recommendations, discussed at greater length in this report's Conclusions and Recommendations section.

Satisfaction with Program Administration

To further investigate participant satisfaction, the survey asked about participants' experiences regarding administrative aspects of the program. Questions addressed topics such as: lengths of time between application submissions and payment receipts (rebate turnaround times), application processes, contractor performance, and paperwork.

Full participants expressed strong satisfaction with contractors and their work: 84% reported being "very satisfied" with the level of customer service and professionalism provided by contractors. As shown in Table 30, 79% of full participants reported being "very satisfied" with the quality of work performed by their contractors to make the energy-saving improvements to their home.

Table 30. Contractor Work Performance

Response	Full (n=68)	
	Frequency	Percent
Very satisfied	54	79
Somewhat satisfied	10	15
Somewhat dissatisfied	4	6
Very dissatisfied	0	0

Once participants completed installation of the efficient measures, they were required to submit a rebate claim form to Efficiency Maine before they could receive the rebate payments. Reported rebate turnaround times varied from one week to four months. More than three-quarters (76%) of full participants found HESP paperwork "very easy" to complete. As shown in Table 31, most full participants (43%) waited three to four weeks from the time they submitted their rebate claims form to receipt of a rebate, and 87% received their rebate within eight weeks.

Table 31. Rebate Turnaround Times

Response	Full (n=61)	
	Frequency	Percent
1 to 2 weeks	8	13
3 to 4 weeks	26	43
5 to 8 weeks	19	31
More than 8 weeks	8	13

As shown in Table 32, 83% of full participants were "very satisfied" with the time required to receive rebate payments from Efficiency Maine.

Table 32. Satisfaction with Rebate Turnaround Times

Response	Full (n=69)	
	Frequency	Percent
Very satisfied	57	83
Somewhat satisfied	5	7
Somewhat dissatisfied	0	0
Very dissatisfied	7	10

Analysis indicated no correlation between the amount of time required to receive the rebate and the satisfaction level, as half of respondents in the "more than eight weeks" category reported being "very satisfied," and the other half reported dissatisfaction.

Almost all (99%) full participants reported satisfaction with the rebate payment amount.

Satisfaction with Program Results

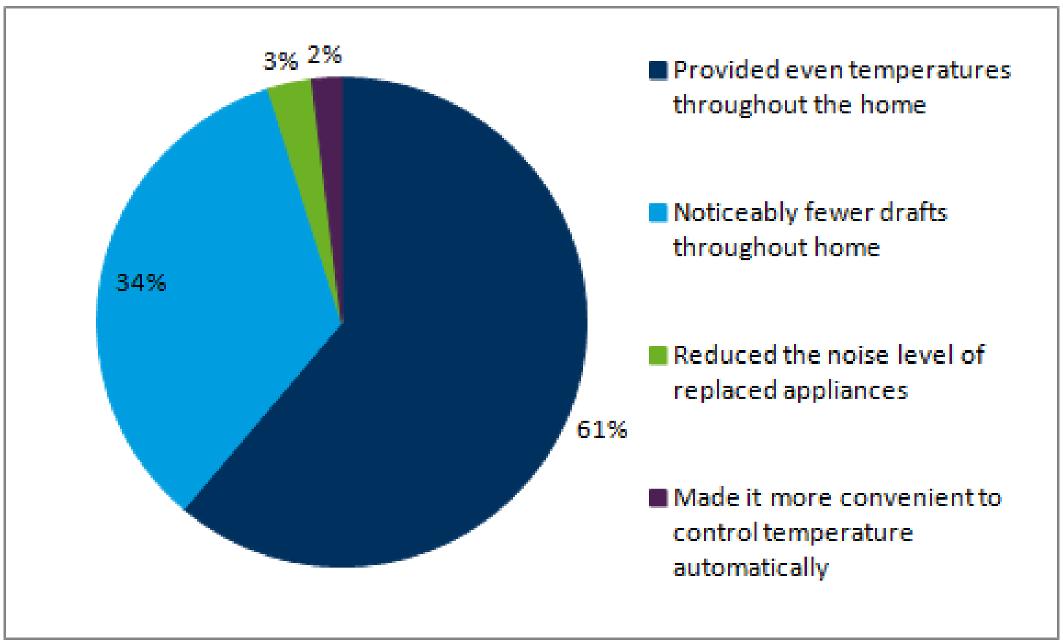
As shown in Table 33, 91% of full participants reported their homes were more comfortable after energy-savings improvements, and none reported them as less comfortable.

Table 33. Home Comfort Level Changes

Response	Full (n=70)	
	Frequency	Percent
More comfortable	64	91
Less comfortable	0	0
About the same	2	3
Don't know/Not enough time to notice a difference	4	6

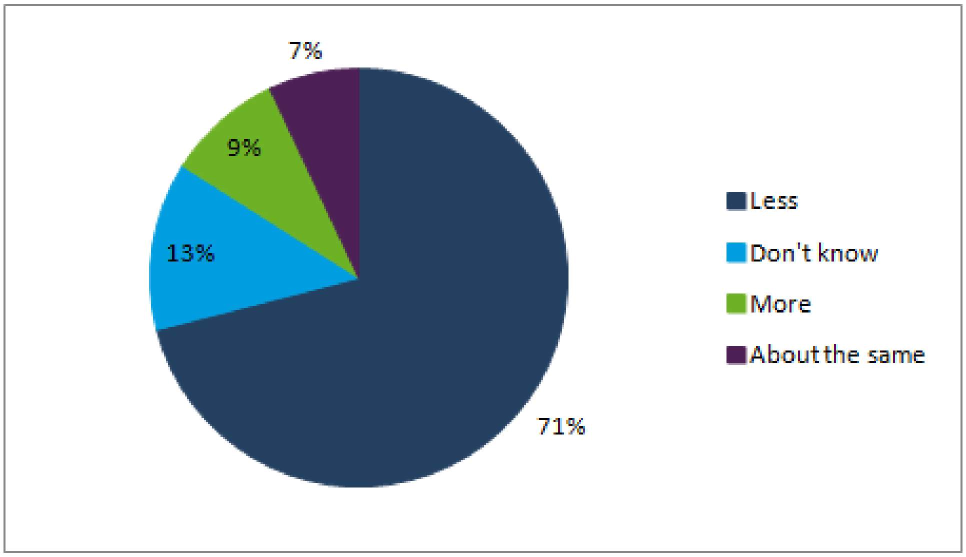
Figure 37 lists ways participants found their homes more comfortable after completing the improvements. Most cited consistent temperatures and fewer drafts throughout homes (61% and 34%, respectively).

Figure 37. Post-Program Home Comfort Level Improvements (Multiple Responses Allowed)



Further, most participants (71%) reported they ran their heating systems less frequently after energy-saving improvements to their homes (as shown in Figure 38).

Figure 38. Post-Program Heating System Usage



In addition, nearly two-thirds (64%) of participants reported their energy bills decreasing after making energy improvements. Three percent reported their energy bills increased, and 11% said they stayed the same (as shown in Table 34).

Table 34. Post-Program Energy Bill Changes

Response	Full (n=70)	
	Frequency	Percent
Bills have gone down	45	64
Bills have gone up	2	3
About the same	8	11
Haven't noticed	9	13
Don't know	6	9

As shown in Table 35, most participants (82%) said their energy bills changed as expected through participating in the program.

Table 35. Post-Program Energy Bill Expectations

Response	Full (n=45)	
	Frequency	Percent
Expectations met	37	82
No	2	4
Don't know	6	13

Nearly all (91%) participants cited increased comfort in their homes as the primary benefit to the program, followed by a decreased need to run heating systems, and lower bills.

6. Recommendations and Conclusions

6.1 Energy-Efficiency Recommendations

The Efficiency Maine HESP reported savings and program verified savings for the 41 houses examined were similar, resulting in a realization rate of 90%. Table 36 and Figure 39 and Figure 40 show energy savings results for the 41 evaluated sites.

Table 36. Final Gross Realization Rate and Savings—By Measure

Measure Type	Reported Savings	Verified Savings	Realization Rate
Air Sealing	566	585	103%
Attic Hatch	29	18	62%
Basement Insulation	381	305	80%
Ceiling Insulation	568	328	58%
Wall Insulation	462	584	127%
Furnace/Boiler	82	51	62%
Total (41 Sites)	2,087	1,871	90%

Figure 39. 41 Site Total Energy Savings: HESP Database

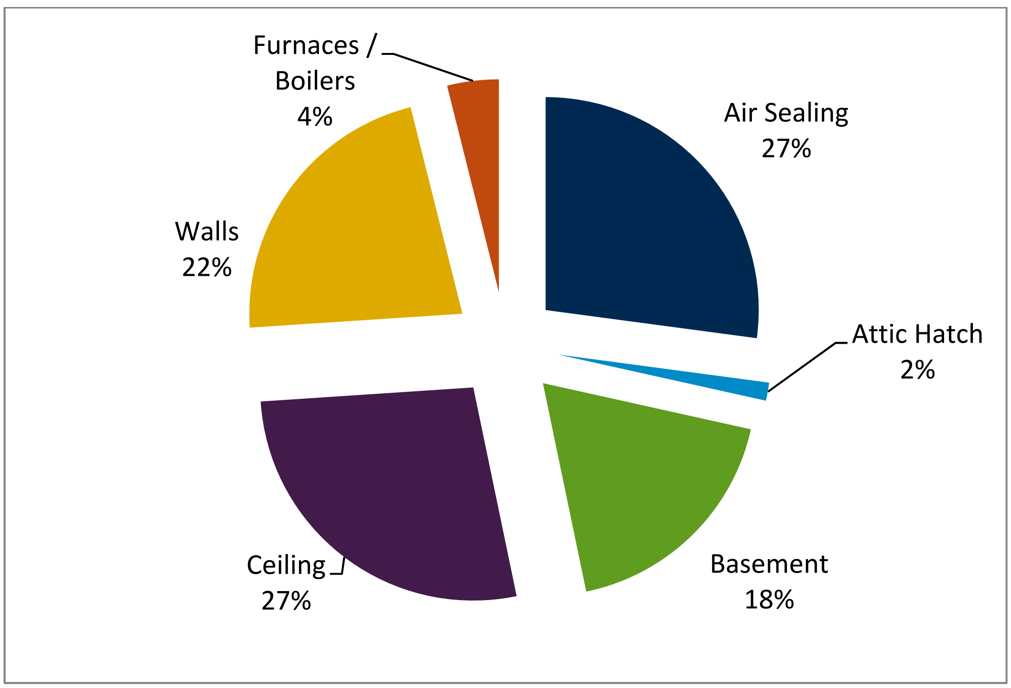
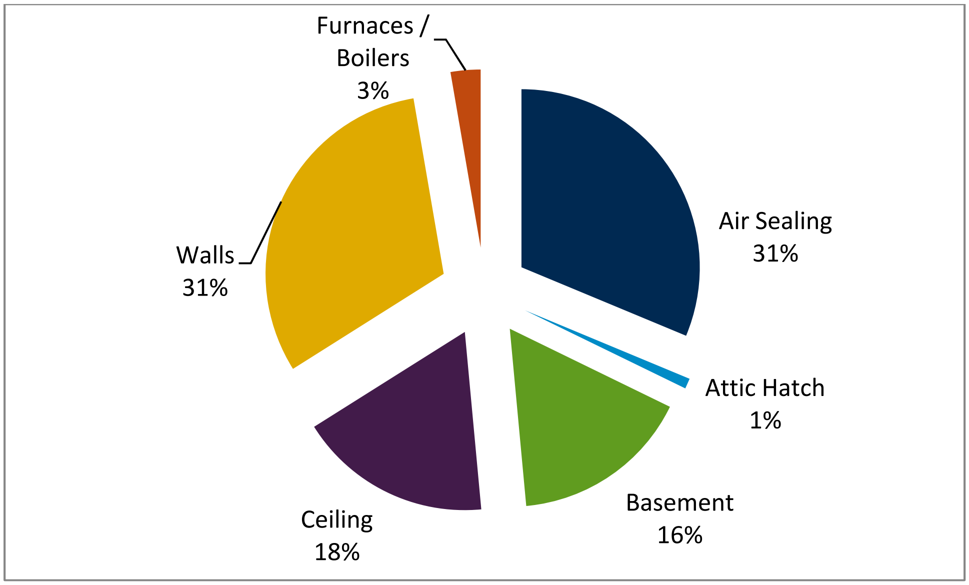


Figure 40. 41 Site Total Energy Savings: Cadmus Observations



The proportion of boiler savings is small in the charts above because there were a small number of retrofits in the sample. The proportion in the population is roughly twice as high.

Table 37 shows the overall, annual program-level savings by verified measure type.

Table 37. Annual Energy Savings by Measure Type in MMBTUs

Measure Type	Reported Gross MMBTU Savings	Verified Gross MMBTU Savings	Gross Realization Rate	NTG	Verified Net Savings (Verified Gross x NTG)	Verified Net Savings	Measures (n)
Air Sealing	42,993	44,467	103%	0.86	38,242	89%	1,846
Attic Access: Existing (Hatch)	2,107	1,310	62%	0.86	1,127	53%	1,248
HVAC: System (Furnace/Boiler)	14,649	9,139	62%	0.86	7,859	54%	730
Insulation: Attic	30,732	17,756	58%	0.86	15,270	50%	2,849
Insulation: Basement/Floors	20,353	16,309	80%	0.86	14,026	69%	2,656
Insulation: Walls	18,394	23,271	127%	0.86	20,013	109%	967
Remaining Measures	12,257	12,257	100%	0.86	10,540	86%	2,765
Total (1780 Sites)	141,485	124,509	88%	0.86	107,077	76%	13,061

Overall program-reported savings and Cadmus-verified energy savings were similar, resulting in an 88% gross realization rate and a 76% net realization rate. The verified program savings are slightly different from the verified measure-level savings due to a slightly different measure mix.

Cadmus draws the following conclusions and makes the following recommendations, based on the HESP evaluation:

1. **Reported savings from air sealing measures were corroborated by Cadmus' analysis (103% realization rate). Efficiency Maine should continue to emphasize the importance of thorough air sealing practices.** Air sealing and wall insulation measures made up the majority of the energy savings among homes reviewed by Cadmus. Stopping air leakage is arguably the most important energy conservation action, as leaky insulation does not impede heat. Also, in heating season, houses tend to breathe in through their basements and out through their top floor ceilings; so these two areas are important areas to air seal.

2. **Efficiency Maine should work with its energy advisors to ensure they target areas within the home that will lead to the greatest energy savings achievements (e.g., empty wall cavities).** Improving the product of (the lowest R-value) times (largest area) has the most benefit, as insulation experiences diminishing returns—a little insulation, added to an area with none and over a large area, provides a substantial benefit, while a great deal of insulation added to existing insulation over a similar or smaller area has lower benefits. Filling existing empty wall cavities tends to show greater savings than ceilings, as ceilings most often have some insulation as a starting point, and, therefore, lower savings relative to walls.

3. To allow future comparisons with actual bills, **we recommend Efficiency Maine collect customer billing data as part of the application process, both to assess the need for efficiency upgrades, and to obtain pre- and post-participation information on a larger set of homes**. Due to the difficulty of obtaining utility billing data after the fact, Cadmus was ultimately unable to compare our modeling results with billing data for most sites.

    a. Additionally, resident responses and our observations indicate around half of inspected residences burned wood.

4. **Cadmus recommends, in future evaluations, Efficiency Maine consider placing temperature loggers in homes to see how homes are actually heated, and to obtain accurate data on heating and water temperatures**. We suspect residents may set temperatures lower on their HVAC and hot water systems than reported.

6.2 Program Recommendations

1. **Promotion**: Efficiency Maine's program outreach efforts have successfully reached residents. Program materials were cited as the primary source of program awareness, and the Website was identified as a primary source for identifying energy advisors. **Cadmus recommends the Trust continue using the effective marketing methods currently in place to promote HESP related efforts**. As contractors provide another primary program gateway, **Cadmus also recommends the Trust continue building partnerships, and supplying contractors with information they can use to help promote program offerings**.

2. **Motivations:** The HESP rebate and the potential to reduce home energy bills served as the primary motivators for program participation during the evaluation period. While federal tax credits (available in 2011 for energy improvements) provided added incentives, most HESP participants reported they would have participated had only the program rebate been offered but not the tax credit. This was further evidenced by the 99% satisfaction rate for the rebate amount. While the Trust's ARRA funding for HESP rebates has been exhausted, rebate amounts provided offer a good benchmark for future rebates, if additional funding becomes available.

3. **Barriers:** Concerns about upfront costs of home energy improvement projects and timing issues (availability of contracts to perform work) present potential barriers to partial participants making recommended improvements to their homes. Given the high level of full participants' satisfaction with the program, success stories from full participants completing the process could be used to address these types of concerns. As the program's Website already features participant experiences through the "Homeowner Stories" section**, Cadmus recommends Efficiency Maine consider using these stories in program promotional channels beyond the Website**.

4. **Application Materials:** As full and partial participants indicated the forms very easy to fill out, preassessment concerns about paperwork and "too many hoops" appear to have been assuaged. Efficiency Maine should **consider developing marketing messages that inspire trust with residents, and highlight participants' very positive experiences with program paperwork.**

5. **Measures**: Most energy advisors recommended—and full participants completed—improvements associated with insulation, HVAC equipment, and air sealing. Very few participants, however, reported installing low-cost measures, such as CFLs and low-flow showerheads, as part of the HESP project. We recommend Efficiency Maine **consider enhancing the "ROI" appeal for low-cost measures to increase uptake on these recommended improvements.** This approach may be particularly effective when federal tax credits become unavailable for higher-cost measures.

6. **Satisfaction**: Based on survey results for program satisfaction, it appears program design and implementation was effective for participants. Higher satisfaction levels among full participants suggest that, when something less than satisfactory occurs in the participation process, participants may be less likely to follow through with completing improvements and submitting required paperwork to receive the rebate. **We recommend Efficiency Maine consider addressing causes of participant dissatisfaction by providing an additional Website FAQ and/or pre-assessment information about "how to prepare for an energy audit**." This will help set expectations, and help residents prepare for the energy audit or assessment. As some participants expressed concerns about waiting on contractors and trusting them to complete paperwork, Efficiency Maine should consider adding additional information to the Website, or providing information for call center staff to assist participants on how to follow-up with contractors.

7. **Value**: Participants who made home energy improvements under HESP highlight increased comfort in their homes as a program benefit. They also cite lower bills and lower energy usage. As these benefits mirror motivations for participating in the program, most participants indicated their expectations have been met. **We recommend Efficiency**

Maine consider using customer reported energy and cost saving benefits to provide testimonial endorsements for program promotions.

Appendix A: Net-to-Gross Evaluation Overview

Net-to-gross (NTG) estimates serve as a critical part of demand-side management (DSM) program impact evaluations as they allow utilities to determine the portion of gross energy savings influenced by and attributable to their DSM programs, free from the result of other influences. Freeridership and spillover comprise NTG's two components. Freeriders are customers who would have purchased the measure without any program influence. Spillover is the amount of additional savings obtained by customers investing in additional energy-efficient measures or activities due to their program participation. Various methods can be used to estimate program freeridership and spillover. Our baseline evaluation approach uses self-reports through participant surveys to estimate freeridership for the HESP program. We did not quantify spillover because the responses received did not indicate a high incidence of spillover.

Survey Design—Freeridership

Cadmus designed survey questions to determine why customers installed a given measure and the program's influence over those decisions. The survey goal was to establish what the decision maker might have done in the program's absence. Five core freeridership questions are used to address this:

- Would the participant have installed the measure without the program incentive?
- Would the participant have installed the same quantity of measures without the program incentive?
- Would the participant have installed the measure to the same efficiency level without the program incentive?
- In the absence of the program incentive, when would the respondent have installed the measures?
- Before they requested the energy audit, had the participant ever previously had an energy audit done on their home?

Freeridership Survey Questions

Five specific questions were included in the HESP survey instrument's freeridership portion to capture the four core freeridership concepts listed above:

1. If only the federal tax credit was available and the HESP rebate was not, would you have made the same improvements?
2. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?
3. And would any of the improvements you would have made been less energy efficient?
4. And when would you have made the improvements? (timing)
5. Before you requested the energy audit, had you ever previously had an energy audit done on your home?

Cadmus developed a transparent, straightforward matrix approach to assign a score to participants, based on their objective responses to these targeted survey questions. Question response patterns were assigned freeridership scores using a rules-based approach that decremented a respondent's freeridership score if a response to a question was not indicative of freeridership. This specific approach is cited in the NAPEE Handbook on DSM Evaluation, 2007 edition, page 5-1.

The response patterns and scoring weights remain explicit: they can be discussed, changed and results shown in real time. Our approach provided other important features, including:

- Derivation of a partial freeridership score, based on the likelihood of a respondent taking similar actions in the incentive's absence.
- Use of a rules-based approach for consistency among multiple respondents.
- The ability to change weightings in a "what if" exercise, testing the response set's stability.

The Cadmus method offers a key advantage by introducing the concept of partial freeridership. Experience has taught us that program participants do not fall neatly into freerider and not-freerider categories. For example, partial freeridership scores were assigned to participants with plans to install the measure; though the program exerted some influence over their decision, other market characteristics beyond the program also proved influential. In addition, with partial freeridership, we could utilize "don't know" and "refused" responses by classifying them as partial credit, rather than removing the entire respondent from the analysis.

Freeridership was assessed at three levels. First, each participant survey response was converted into freeridership matrix terminology. Each participant's combination of responses was then assigned a score from the matrix. Finally, all participants were aggregated into an average freeridership score for the entire program category.

Convert Responses to Matrix Terminology

We independently evaluated each survey question's response to assess participants' freeridership level for each question. Each survey response option was converted into a value of "yes," "no," or "partial," which refers to whether the respondent's answer for the question was indicative of freeridership or not.

Table 38 lists five survey questions, their corresponding response options, and the value which we converted them to (in parentheses). "Don't know" and "refused" responses were converted to "partial" for all questions.

Table 38. Assignments of HESP Survey Response Options into Matrix Terminology

28. And, how about if only the federal tax credit was available and the program rebate was not, would you have made the same improvements?	33. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?	30 / 34. And would any of the improvements you would have made been less energy efficient?	31 / 35. And would you have made the improvements: [Read list]	32 / 36. Before you requested the energy audit, had you ever previously had an energy audit done on your home?
Yes (Yes)	Would not have made any (Yes)	Yes (No)	At the same time or within three months of when you actually made the upgrades (Yes)	Yes (Yes)
No (No)	Only some (No)	No (Yes)	Within three to six months (Partial)	No (No)
Don't Know (Partial)	Don't Know (Partial)	Don't Know (Partial)	Six to 12 months (Partial)	Don't Know (Partial)
Refused (Partial)	Refused (Partial)	Refused (Partial)	More than a year (No)	Refused (Partial)
			Never (No)	
			Don't Know (Partial)	
			Refused (Partial)	

Participant Freeridership Scoring

After converting survey responses into matrix terminology, we created a freeridership matrix, so the combination of each participant's responses to the four questions could be assigned a freeridership score. To create the matrix, we determined every combination of possible responses to the four survey questions, and then assigned a freeridership score of 0 to 100% to each combination. Using these matrices, every participant combination of responses was assigned a score of 0 to 100%.

Program Category Freeridership Scoring

After assigning a freeridership score to every survey respondent, Cadmus calculated an average freerider score for the program category. For the purposes of this analysis, a simple average was taken of the individual respondent level freeridership scores to arrive at the program freeridership estimate. If accurate program savings information becomes available for these surveyed participants, the individual freeridership scored can be weighted by measure savings to arrive at a savings weighted freeridership estimate.

The Cadmus Freeridership Scoring Model

Cadmus has developed an Excel-based model to assist with freeridership calculation and improve consistency and quality of results. Our model translates raw survey responses into matrix terminology, and then assigns each participant's response pattern a score from the matrix.

Program participants in the sample can be then aggregated by program category to calculate the average freerider score.

The model incorporates the follow inputs described in this methodology:

- Raw survey responses for each participant, along with the program category for their rebated measure, and energy savings from that measure, if applicable.
- Table A2 above represents the converting of the raw survey responses into scoring matrix terminology ("Yes", "No", "Partial") for each program category.
- Custom freeridership scoring matrices for each unique survey type.

The model uses a simple interface, allowing users to quickly reproduce a scoring analysis for any program category. It displays each participant's combination of responses and corresponding freeridership score, and then produces a summary table, providing the average score.

Table 39 contains the full freeridership scoring matrix developed for the HESP program.

Table 39. Full HESP Freeridership Scoring Matrix

28. And, how about if only the federal tax credit was available and the program rebate was not, would you have made the same improvements?	33. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?	30 / 34. And would any of the improvements you would have made been less energy efficient?	31 / 35. And would you have made the improvements …	32 / 36. Before you requested the energy audit, had you ever previously had an energy audit done on your home?	Combo	Freeridership Score
Yes	x	Yes	Yes	Yes	YesxYesYesYes	100.00%
Yes	x	Yes	Yes	Partial	YesxYesYesPartial	100.00%
Yes	x	Yes	Yes	No	YesxYesYesNo	75.00%
Yes	x	Yes	Partial	Yes	YesxYesPartialYes	75.00%
Yes	x	Yes	Partial	Partial	YesxYesPartialPartial	75.00%
Yes	x	Yes	Partial	No	YesxYesPartialNo	50.00%
Yes	x	Yes	No	x	YesxYesNox	0.00%
Yes	x	Partial	Yes	Yes	YesxPartialYesYes	75.00%
Yes	x	Partial	Yes	Partial	YesxPartialYesPartial	75.00%
Yes	x	Partial	Yes	No	YesxPartialYesNo	50.00%
Yes	x	Partial	Partial	Yes	YesxPartialPartialYes	50.00%
Yes	x	Partial	Partial	Partial	YesxPartialPartialPartial	50.00%
Yes	x	Partial	Partial	No	YesxPartialPartialNo	25.00%
Yes	x	Partial	No	x	YesxPartialNox	0.00%
Yes	x	No	Yes	Yes	YesxNoYesYes	50.00%
Yes	x	No	Yes	Partial	YesxNoYesPartial	50.00%
Yes	x	No	Yes	No	YesxNoYesNo	25.00%
Yes	x	No	Partial	Yes	YesxNoPartialYes	25.00%

28. And, how about if only the federal tax credit was available and the program rebate was not, would you have made the same improvements?	33. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?	30 / 34. And would any of the improvements you would have made been less energy efficient?	31 / 35. And would you have made the improvements…	32 / 36. Before you requested the energy audit, had you ever previously had an energy audit done on your home?	Combo	Freeridership Score
Yes	x	No	Partial	Partial	YesxNoPartialPartial	25.00%
Yes	x	No	Partial	No	YesxNoPartialNo	12.50%
Yes	x	No	No	x	YesxNoNox	0.00%
Partial	x	Yes	Yes	Yes	PartialxYesYesYes	75.00%
Partial	x	Yes	Yes	Partial	PartialxYesYesPartial	75.00%
Partial	x	Yes	Yes	No	PartialxYesYesNo	50.00%
Partial	x	Yes	Partial	Yes	PartialxYesPartialYes	50.00%
Partial	x	Yes	Partial	Partial	PartialxYesPartialPartial	50.00%
Partial	x	Yes	Partial	No	PartialxYesPartialNo	25.00%
Partial	x	Yes	No	x	PartialxYesNox	0.00%
Partial	x	Partial	Yes	Yes	PartialxPartialYesYes	50.00%
Partial	x	Partial	Yes	Partial	PartialxPartialYesPartial	50.00%
Partial	x	Partial	Yes	No	PartialxPartialYesNo	25.00%
Partial	x	Partial	Partial	Yes	PartialxPartialPartialYes	25.00%
Partial	x	Partial	Partial	Partial	PartialxPartialPartialPartial	25.00%
Partial	x	Partial	Partial	No	PartialxPartialPartialNo	12.50%
Partial	x	Partial	No	x	PartialxPartialNox	0.00%
Partial	x	No	Yes	Yes	PartialxNoYesYes	25.00%
Partial	x	No	Yes	Partial	PartialxNoYesPartial	25.00%
Partial	x	No	Yes	No	PartialxNoYesNo	12.50%
Partial	x	No	Partial	Yes	PartialxNoPartialYes	12.50%
Partial	x	No	Partial	Partial	PartialxNoPartialPartial	12.50%
Partial	x	No	Partial	No	PartialxNoPartialNo	0.00%
Partial	x	No	No	x	PartialxNoNox	0.00%
No	Yes	Yes	Yes	Yes	NoYesYesYesYes	50.00%
No	Yes	Yes	Yes	Partial	NoYesYesYesPartial	50.00%
No	Yes	Yes	Yes	No	NoYesYesYesNo	25.00%
No	Yes	Yes	Partial	Yes	NoYesYesPartialYes	25.00%
No	Yes	Yes	Partial	Partial	NoYesYesPartialPartial	25.00%
No	Yes	Yes	Partial	No	NoYesYesPartialNo	12.50%
No	Yes	Yes	No	x	NoYesYesNox	0.00%
No	Yes	Partial	Yes	Yes	NoYesPartialYesYes	25.00%
No	Yes	Partial	Yes	Partial	NoYesPartialYesPartial	25.00%
No	Yes	Partial	Yes	No	NoYesPartialYesNo	12.50%
No	Yes	Partial	Partial	Yes	NoYesPartialPartialYes	12.50%
No	Yes	Partial	Partial	Partial	NoYesPartialPartialPartial	12.50%
No	Yes	Partial	Partial	No	NoYesPartialPartialNo	0.00%
No	Yes	Partial	No	x	NoYesPartialNox	0.00%

28. And, how about if only the federal tax credit was available and the program rebate was not, would you have made the same improvements?	33. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?	30 / 34. And would any of the improvements you would have made been less energy efficient?	31 / 35. And would you have made the improvements …	32 / 36. Before you requested the energy audit, had you ever previously had an energy audit done on your home?	Combo	Freeridership Score
No	Yes	No	Yes	Yes	NoYesNoYesYes	12.50%
No	Yes	No	Yes	Partial	NoYesNoYesPartial	12.50%
No	Yes	No	Yes	No	NoYesNoYesNo	0.00%
No	Yes	No	Partial	Yes	NoYesNoPartialYes	0.00%
No	Yes	No	Partial	Partial	NoYesNoPartialPartial	0.00%
No	Yes	No	Partial	No	NoYesNoPartialNo	0.00%
No	Yes	No	No	x	NoYesNoNox	0.00%
No	Partial	Yes	Yes	Yes	NoPartialYesYesYes	25.00%
No	Partial	Yes	Yes	Partial	NoPartialYesYesPartial	25.00%
No	Partial	Yes	Yes	No	NoPartialYesYesNo	12.50%
No	Partial	Yes	Partial	Yes	NoPartialYesPartialYes	12.50%
No	Partial	Yes	Partial	Partial	NoPartialYesPartialPartial	12.50%
No	Partial	Yes	Partial	No	NoPartialYesPartialNo	0.00%
No	Partial	Yes	No	x	NoPartialYesNox	0.00%
No	Partial	Partial	Yes	Yes	NoPartialPartialYesYes	12.50%
No	Partial	Partial	Yes	Partial	NoPartialPartialYesPartial	12.50%
No	Partial	Partial	Yes	No	NoPartialPartialYesNo	0.00%
No	Partial	Partial	Partial	Yes	NoPartialPartialPartialYes	0.00%
No	Partial	Partial	Partial	Partial	NoPartialPartialPartialPartial	0.00%
No	Partial	Partial	Partial	No	NoPartialPartialPartialNo	0.00%
No	Partial	Partial	No	x	NoPartialPartialNox	0.00%
No	Partial	No	Yes	Yes	NoPartialNoYesYes	0.00%
No	Partial	No	Yes	Partial	NoPartialNoYesPartial	0.00%
No	Partial	No	Yes	No	NoPartialNoYesNo	0.00%
No	Partial	No	Partial	Yes	NoPartialNoPartialYes	0.00%
No	Partial	No	Partial	Partial	NoPartialNoPartialPartial	0.00%
No	Partial	No	Partial	No	NoPartialNoPartialNo	0.00%
No	Partial	No	No	x	NoPartialNoNox	0.00%
No	No	x	x	x	NoNoxxx	0.00%

Table 40 shows the unique response combinations from the HESP participant survey sample, and the number of responses for each combination.

Table 40. Frequency of Freeridership Scoring Combinations

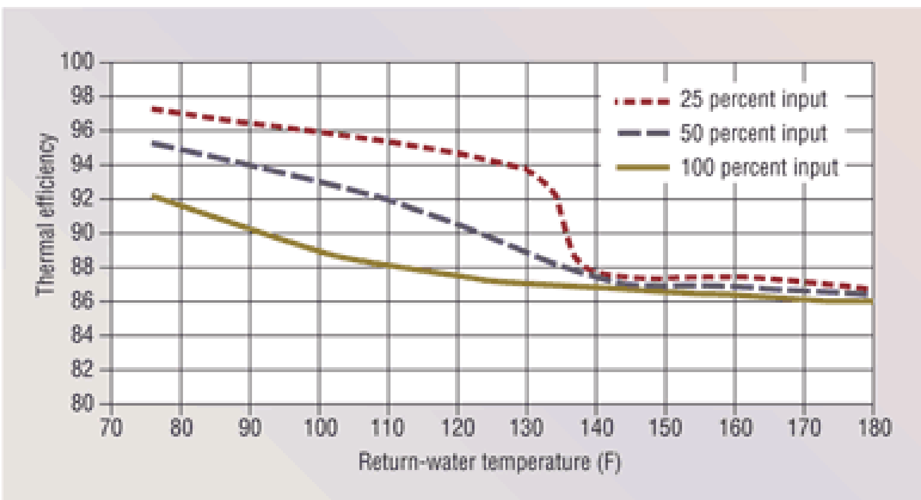
Q28. And, how about if only the federal tax credit was available and the program rebate was not, would you have made the same improvements?	Q33. Let me make sure I understand. When you say you would not have made the same improvements, do you mean you would not have made any of them or you would have made only some?	Q30 / Q34. And would any of the improvements you would have made been less energy efficient?	Q31 / Q35. And would you have made the improvements: [Read list]	Q32 / Q36. Before you requested the energy audit, had you ever previously had an energy audit done on your home?	Freeridership Score	Frequency of Response String
Yes	x	Yes	Yes	No	75.00%	5
Yes	x	Yes	Partial	No	50.00%	6
Yes	x	Yes	No	x	0.00%	7
Yes	x	No	Yes	No	25.00%	5
Yes	x	No	Partial	Yes	25.00%	1
Yes	x	No	Partial	No	12.50%	3
Yes	x	No	No	x	0.00%	6
Partial	x	Yes	Partial	No	25.00%	1
Partial	x	Partial	Partial	No	12.50%	3
Partial	x	Partial	No	x	0.00%	1
Partial	x	No	No	x	0.00%	2
No	Yes	Yes	Yes	No	25.00%	3
No	Yes	Yes	No	x	0.00%	6
No	Yes	No	Yes	No	0.00%	3
No	Yes	No	Partial	Yes	0.00%	1
No	Yes	No	Partial	No	0.00%	3
No	Yes	No	No	x	0.00%	5
No	No	x	x	x	0.00%	9

Appendix B: Limitations of Increasing Heating System Efficiency with Existing Distribution Systems

Replacing mechanical equipment in existing homes can be a simple way to improve efficiency and reduce fuel costs, especially if a heating system is nearing the end of its useful life. However, the overall system efficiency does not necessarily reach the nameplate Annual Fuel Utilization Efficiency (AFUE) rating if the heating appliance is not operating under the same circumstances used during the AFUE testing. AFUE testing conditions are below the condensation temperature of natural gas exhaust streams: therefore, nameplate ratings assume operational conditions are below the condensing point of natural gas, which is in the 135°F range.

High-efficiency condensing gas or propane appliances can reach thermal conversion efficiencies into the mid 90% AFUE range, when operating in a condensing regime, but if return temperatures are above the condensing temperature of the flue gas, the additional efficiency boost of condensing the moisture from the flue gas is not realized. Figure 41 is a typical efficiency curve for condensing boilers.

Figure 41. Condensing Boiler Efficiency Curve



With condensing gas furnaces, the return air temperature is the low end of room temperature, which might be in the 60-70°F range for most of the population of typical residences—obviously well below the condensing temperature of natural gas. Thus, condensing gas furnaces can be relied on to operate in a condensing regime throughout the season.

With gas boilers, the return water temperature is a function of the design of the distribution system and piping, and in the past has typically been designed around temperatures well above the condensing temperature of natural gas, most often 180°F LWT, 160°F EWT. Replacing an 85+/-% AFUE boiler with a condensing boiler without reviewing and/or modifying the distribution system characteristics may mean that the new condensing boiler will condense only under certain conditions (e.g., light loading, which occurs when a boiler has short firing cycles with extended off-periods where boiler return water temperatures do not rise above condensing temperatures), potentially forfeiting the 5-10% AFUE savings being sought.

In some cases, a homeowner may be willing to experiment with boiler water temperatures to empirically determine the lowest functional hot water delivery temperature, and incorporate that information into an outdoor reset controller, but it is more likely settings will be chosen by an installing contractor based on a rule of thumb that does not lead to insufficient heat call-backs, and does not condense for a significant amount of the heating season.

Appendix C. Insulating Basements

From the standpoint of a building enclosure surface area, insulating basement walls increases exterior surface area and total building heat loss over insulating ceilings, but, functionally, attaining an effective air seal and insulation layer at basement walls is typically easier than for basement ceilings. Insulating basement walls makes a quasi-outdoor basement space into a known indoor space, and clarifies the plan for that space, while the typical insulated ceiling does not. Note that when bringing the mechanical equipment into the conditioned space, there is a new concern that combustion products are being properly exchanged with outdoors, and not left to linger indoors.

Basement spaces most often are left to “float” thermally (not directly controlled with a thermostat), and are quasi-indoors and quasi-outdoors, the exact proportion depending on the particular basement under review. While insulating the ceiling of the basement might appear to be a good approach to limit heat loss from upstairs conditioned spaces to the basement, there tend to be many unsealed penetrations through the floor, and the commonly seen fiberglass batting provides no resistance to air flow; so drafts into basements tend to warm up and rise up into the spaces above, bypassing the insulation. Further, most often the heating system resides in the basement, and complicates the question of the basement being indoors or outdoors, since, with few exceptions, the heating system loses a noticeable amount of heat to the basement.

Appendix D. Contacting Fuel Providers

During the Efficiency Maine HESP evaluation, Cadmus contacted the following fuel providers on behalf of Efficiency Maine and HESP participants.

McKusick	Colby & Gale
Dead River	MW Sewall
Ness Oil	Bangor Hydro
RH Foster	Gary's Fuel
Crowley	North Village
Downeast	AmeriGas
Bragdon	Harvest
Mount Blue	Community Energy
Pitt Stop	Atlantic Heating Company
Fielding's	Lampron Energy
Fabian	Deer Pond
J&S Oil	Maritime Energy

Cadmus began by calling the aforementioned fuel providers to locate a contact within the company who could approve of the distribution of energy usage information, and could obtain the necessary energy usage information. Once the connection was made, Cadmus either faxed or e-mailed the participant's signed authorization form to the contact with the hopes of receiving the necessary data in response.

For participants that were customers of Unitil, Cadmus followed a different process. Unitil was unwilling to provide the energy usage information for its customers – even with a signed authorization form. As a result, Cadmus relied on the participants themselves to provide their energy bills. This proved to have a lower than average success rate with two out of five Unitil customers providing complete bills.

Cadmus made multiple attempts to reach out to fuel providers and customers if the fuel usage data was not supplied. In some instances, one participant had multiple fuel providers and, if one fuel provider did not send in the data, that customer fuel usage information was not able to be used in the comparison. Table 41 shows the results of our attempts to receive fuel usage information.

Table 41. Fuel Bill Receipt

Fuel Provider	Received	Not Received	Total
Unitil (only)	2	3	5
Dead River (only)	6	0	6
Downeast (only)	4	1	5
Other/Incomplete	9	7	16
No Viable Form	N/A	N/A	9
Total	21	11	41