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Residential Efficiency Retrofits:

A Roadmap for the Future

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Residential Efficiency Retrofits:

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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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.

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.

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.

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

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.

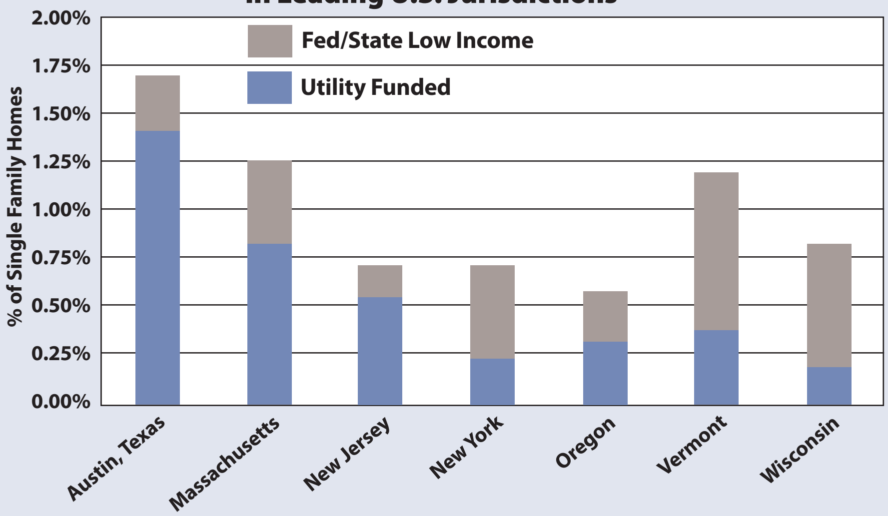
26 Cavity wall insulation was also installed in 1.1 million homes over the same two year period. In addition, subsidized prices on insulation from do-it-yourself stores led to enough sales to benefit over a million homes, though there are questions about the extent to which such sales overlap with the 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]



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 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

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			■ (red)	■ (red)	■ (red)					■ (grey)
• Difficult to differentiate good contractors from bad		■ (red)			■ (grey)				■ (grey)	
• Access to capital						■ (red)	■ (red)			
• Split incentives (renters)						■ (red)	■ (red)	■ (grey)		
• Risk – Are savings real? Is cost recoverable at sale?			■ (grey)	■ (grey)	■ (grey)	■ (red)		■ (red)	■ (grey)	
• Transaction/Hassle costs		■ (red)	■ (red)	■ (grey)	■ (grey)	■ (red)				
• Efficiency not visible or "sexy"				■ (grey)	■ (grey)	■ (red)		■ (red)		
Contractors										
• Lack technical tools/skills	■ (red)									■ (grey)
• Difficult to differentiate good contractors from bad		■ (red)			■ (grey)				■ (grey)	
• Weak sales skills			■ (red)	■ (red)						■ (grey)
• Inadequate numbers, infrastructure	■ (red)	■ (red)			■ (grey)	■ (grey)	■ (grey)	■ (grey)		
Others										
• Lenders don't value efficiency in appraisals								■ (red)		■ (red)

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]

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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)

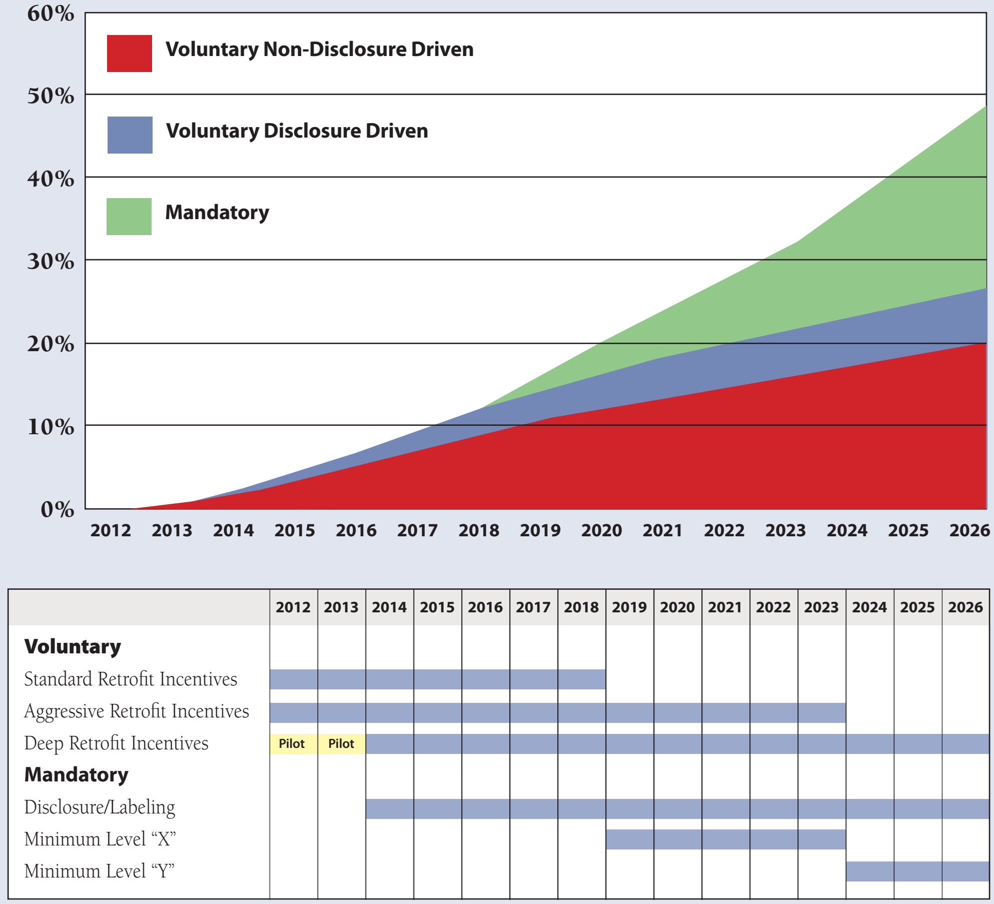
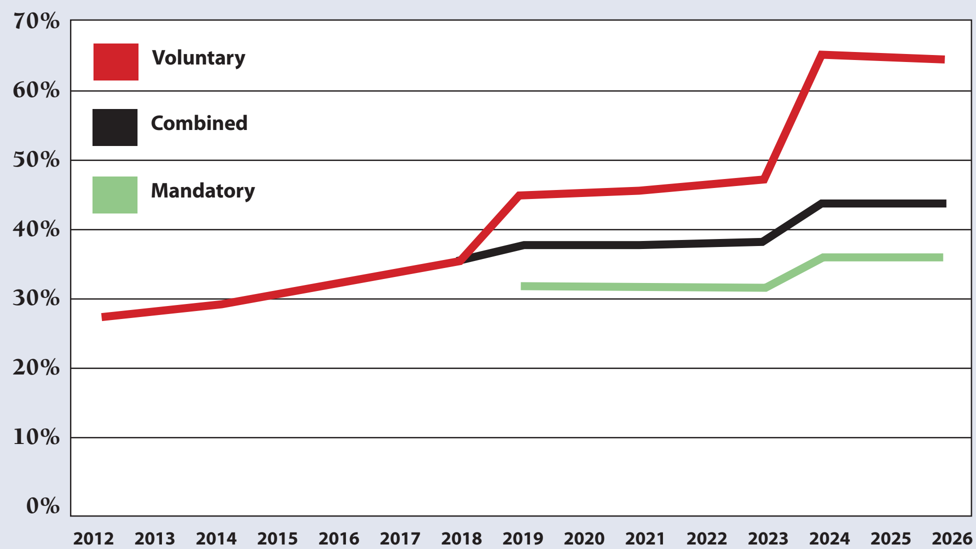


Figure 3: **Conceptual Forecast of Average Savings Per Retrofit**



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.

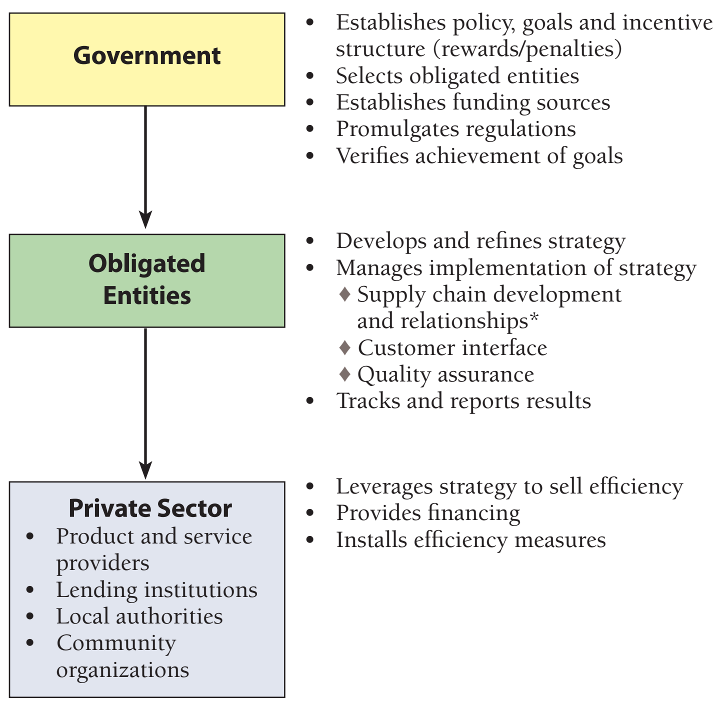
[94] To be sure, there has been some consternation about how some of the targets were met—particularly concern about heavy reliance on compact fluorescent lamps. However, that suggests problems with the initial design of goals given to the obligated entities rather than to any inherent problems with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

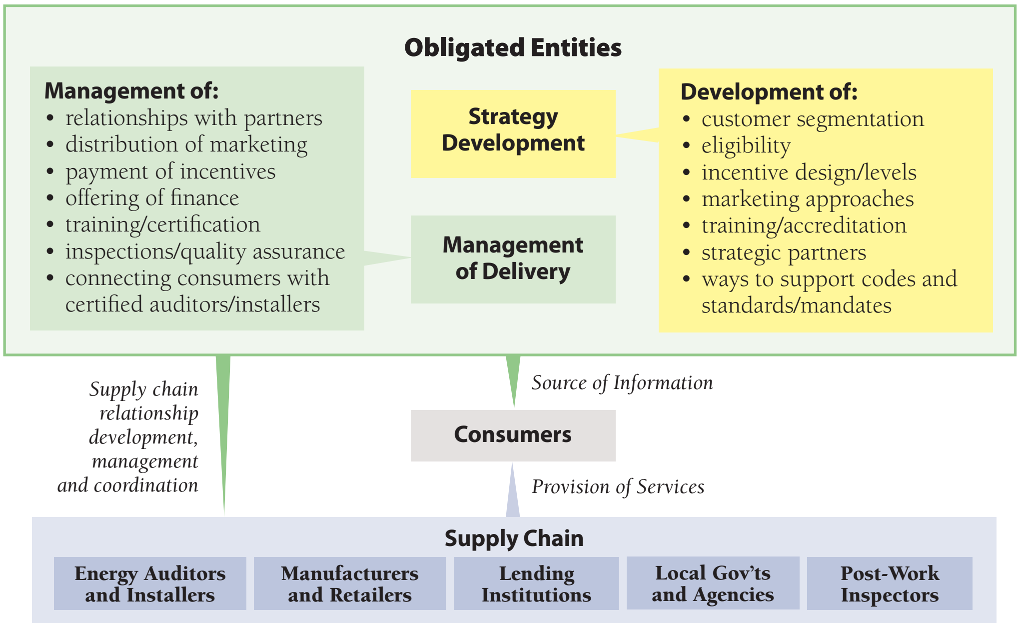
As illustrated in Figure 5, within the confines of high-level policy guidance and funding sources established by government, each obligated entity should be charged with developing, implementing, and continually refining the strategy needed to meet the goals set by government. Obligated entities must 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.

[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.

[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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