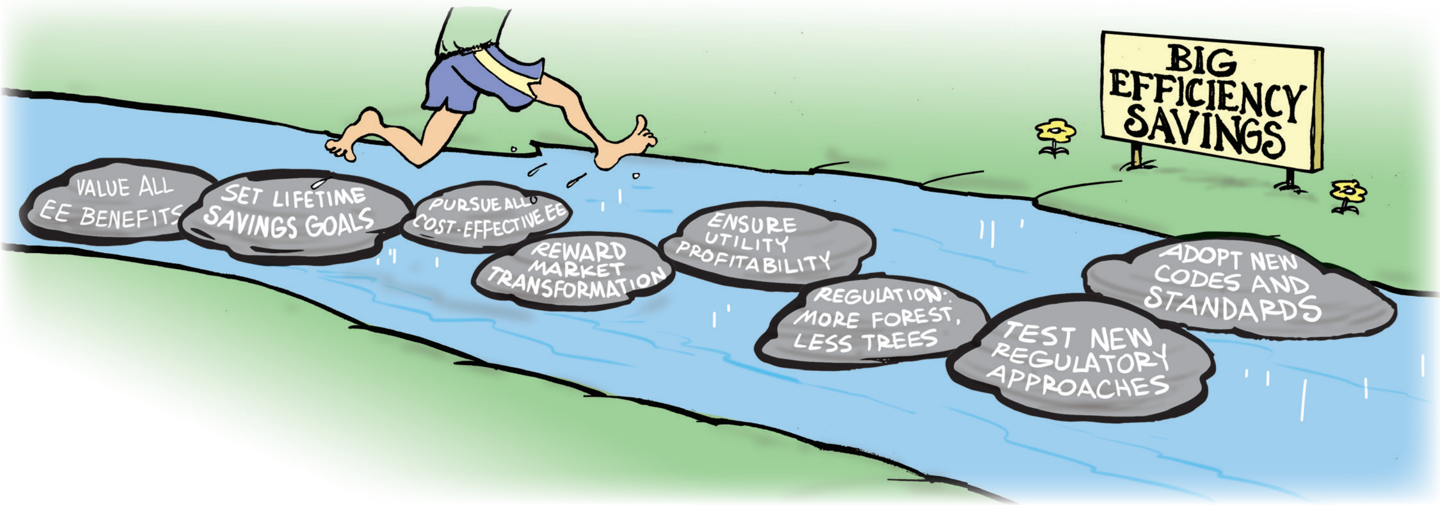
The Next Quantum Leap in Efficiency:



30 Percent Electric Savings in Ten Years

Authors

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Acknowledgments

The authors would like to thank the Regulatory Assistance Project (RAP) for sponsoring this project. It forced us to think expansively about what might be possible. We hope the resulting report also helps readers to "think big."

We also want to thank RAP for helping us navigate our way through a challenging project. RAP senior associate David Farnsworth, who managed this project, deserves particular thanks for being an invaluable "sounding board" and providing excellent guidance at various stages of the project.

We would also like to specifically thank the nine "thought leaders" that we interviewed for this project: Tom Eckman, Northwest Power and Conservation Council; Rafael Friedman, Pacific Gas and Electric (PG&E); David Goldstein, Natural Resources Defense Council (NRDC); Fred Gordon, Oregon Energy Trust; Marty Kushler, American Council for an Energy-Efficient Economy (ACEEE); Mike Messenger, Itron; Phil Mosenthal, Optimal Energy; Steve Nadel, ACEEE; and Steve Schiller, Schiller Consulting. Each of these individuals gave us insightful feedback regarding our initial ideas on opportunities for accelerating the acquisition of cost-effective electricity savings. They also collectively provided a range of interesting ideas we had not initially considered.

A number of other individuals provided important data and input on a variety of topics addressed in this report. We would particularly like to thank Phil Mosenthal (Optimal Energy) for data on efficiency potential studies presented in Appendix A; Dan Mellinger, (Vermont Energy Investment Corporation, or VEIC) for the analysis of LED troffer costs and savings presented in Appendix E; and Jay Pilliod (VEIC), Alan Hebert (VEIC), and George Lawrence (Optimal Energy) on the Efficiency Vermont snowmaking gun case study presented in Appendix G.

Finally, we would like to thank a number of individuals who reviewed earlier drafts of the report: Riley Allen, David Farnsworth, Camille Kadoch, Jim Lazar, Rich Sedano, Rick Weston, Becky Wigg, Donna Brutkoski, and Deborah Stetler, RAP; Marty Kushler and Steve Nadel, ACEEE; Mike Messenger, Itron; David Goldstein, NRDC; Eric Belliveau and George Lawrence, Optimal Energy; Fred Gordon, Oregon Energy Trust; Rafael Friedman, PG&E; and Steve Schiller, Schiller Consulting.

Though we could not have completed this report without the help of those identified above, it is important to note that some of the feedback we received was conflicting. In addition, in some cases, we disagreed with and therefore elected not to make some specific changes suggested by one or more reviewers. We make these points to underscore that we, the authors, are ultimately solely responsible for the information presented and the conclusions drawn in the report.

How to Cite This Paper

Neme, C., & Grevatt, J. (2016, February). *The Next Quantum Leap in Efficiency: 30 Percent Electric Savings in Ten Years.* The Regulatory Assistance Project: Montpelier, VT. Available at: http://www.raponline.org/document/download/id/7944.

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February 2016

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The Next Quantum Leap in Efficiency: 30 Percent Electric Savings in Ten Years

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Acronyms

ACEEE	American Council for an Energy-Efficiency Economy
CHP	Combined heat and power
CVR	Conservation voltage reduction
EERS	Energy efficiency resource standard
EM&V	Evaluation, measurement, and verification
kWh	Kilowatt-hour
SEM	Strategic energy management
T&D	Transmission and distribution
TRC	Total resource cost
US EPA	US Environmental Protection Agency

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I. Introduction

Energy efficiency is the cheapest electricity resource. As Figure 1 shows, the cost of savings from electric ratepayer-funded efficiency programs is currently only one-half to one-third of the average cost of electricity from new power plants. Energy efficiency also provides substantial economic benefits to the electric utility system resulting from reduced investments in transmission and distribution (T&D) infrastructure,[1] reduced exposure to fuel price volatility and other forms of risk,[2] price suppression effects,[3] and reductions in environmental compliance costs,[4] which will become even more important in the future given the US Environmental Protection Agency's (EPA) recently-issued Clean Power Plan regulations. There are also substantial additional benefits to homeowners and businesses (e.g., gas savings, water savings, and improvements to comfort, health and safety, building durability, and business productivity) as well as environmental, public health, low income energy affordability, local economic development, and other societal benefits.[5]

Recognition of the value of energy efficiency has grown considerably over the past decade. In 2006, annual spending on US electric ratepayer-funded efficiency programs was just $1.6 billion[6] and only three states' ratepayer-funded electric efficiency efforts were achieving first year electric savings of greater than 0.8 percent of annual sales.[7] By 2014, spending on ratepayer-funded electric efficiency programs had nearly quadrupled to $5.9 billion and 18 different states achieved

1 For example, the New England Independent System Operator recently identified over $400 million in previously planned transmission system investments in just Vermont and New Hampshire that it is now deferring beyond its ten-year planning horizon as a result of those states' efficiency programs; see Neme, C., & Grevatt, J. (2015). *Energy Efficiency as a T&D Resource: Lessons from Recent US Efforts to Use Geographically Targeted Efficiency Programs to Defer T&D Investments.* Lexington, MA: Northeast Energy Efficiency Partnerships. Many jurisdictions now routinely include avoided T&D costs in efficiency program screening, with values averaging about $70 per kW-year; see The Mendota Group. (2014). *Benchmarking Transmission and Distribution Costs Avoided by Energy Efficiency Investments.* Prepared for Public Service Company of Colorado. Moreover, a growing number of jurisdictions are now deploying geographically targeted efficiency programs specifically for the purpose of cost-effectively deferring upgrades to specific elements of their T&D systems; see Neme, C., & Grevatt, J. (2015); and Neme, C., and Sedano, R. (2012). *US Experience with Efficiency as a Transmission and Distribution System Resource.* Montpelier, VT: The Regulatory Assistance Project.

2 For example, Vermont regulators require that the costs of efficiency measures be reduced by ten percent to account for their risk mitigating advantages relative to supply-side investments.

3 In regions with competitive wholesale markets, reductions in demand lower market-clearing prices for electric energy and/or capacity, at least in the short to medium term. A number of studies have found this effect to initially be on the order of a one to three percent drop in prices for every one percent drop in demand; see Chernick, P., & Griffiths, B. (2014). *Analysis of Electric Energy DRIPE in Illinois.* Memo to Chris Neme, Energy Futures Group; Rebecca Stanfield, Natural Resources Defense Council; and David Farnsworth, Regulatory Assistance Project. This is sometimes called the demand reduction-induced price effect (DRIPE).

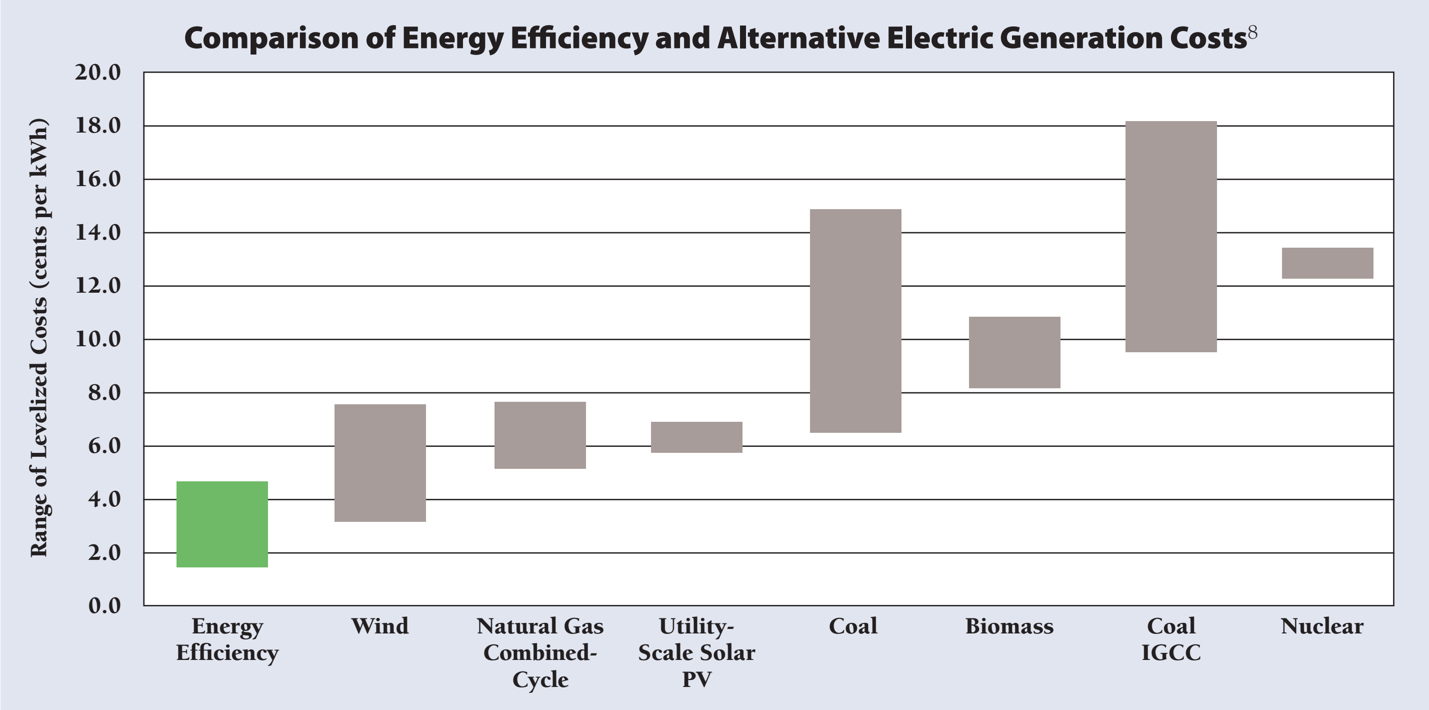
4 For example, see Woolf, T., Steinhurst, W., Malone, E., & Takahashi, K. (2012). *Energy Efficiency Cost-Effectiveness Screening: How to Properly Account for 'Other Program Impacts' and Environmental Compliance Costs.* Montpelier, VT: The Regulatory Assistance Project.

5 For a full discussion of the benefits of efficiency, see Lazar, J., & Colburn, K. (2013). *Recognizing the Full Value of Energy Efficiency.* Montpelier, VT: The Regulatory Assistance Project.

6 Gilleo, A., Nowak, S., Kelly, M., Vaidyanathan, S., Shoemaker, M., Chittum, A., & Bailey, T. (2015). *The 2015 State Energy Efficiency Scorecard.* (ACEEE Report U1509).

7 Connecticut and Rhode Island achieved 1.2 percent savings; Vermont achieved 1.1 percent.

Figure 1



electric savings of more than 0.8 percent of sales. Two states—Massachusetts and Rhode Island—were at or above 2.5 percent.[9] Five others—Arizona, California, Connecticut, Maryland, and Vermont—have policies in place that will require 2.0 percent annual savings or better in the coming years.[10]

This study examines whether the bar could be raised substantially again. Specifically, we examine whether it would be possible to meet 30 percent of electricity system needs in ten years. Though very aggressive—requiring 50 percent to 100 percent more savings than what even the leading states are pursuing today—we conclude that this goal is likely to be achievable, but only with both an unwavering commitment to promoting efficiency whenever it is cost-effective and with innovative thinking and approaches to a variety of topics, including:

- the range of efficiency measures which are considered appropriate to promote;
- the currently strong regulatory emphasis on short-term resource acquisition in the context of long-term goals;

8 See http://aceee.org/topics/energy-efficiency-resource. For efficiency, the costs shown are the utility costs. Under the total resource cost and societal cost tests, one must also consider both additional costs and additional benefits experienced by efficiency program participants. Experience suggests that the net effect of considering both additional participant costs and additional participant benefits will be to reduce the net levelized resource cost of electric efficiency programs. For example, for 2014, Efficiency Vermont reported its levelized utility cost of acquiring savings as 4.6 cents/kWh, but its levelized net resource cost—i.e., after adjusting for both participant costs and savings—was only 0.9 cents/kWh. Efficiency Vermont. (2015). *Savings Claim Summary 2014.*

9 Gilleo et al., 2015.

10 Note that the comparisons here are just for savings from ratepayer-funded efficiency programs. Substantial additional savings have been achieved nationally through federal equipment efficiency standards. States also produce savings through building codes and, in some cases, additional equipment efficiency standards. Over the past decade, there have also been significant efforts in a number of states (perhaps most notably in California) to increase savings from such regulatory mechanisms. However, the data necessary to provide state-by-state comparisons of savings from codes and standards are not readily available.

- the type of metrics being employed to measure efficiency program effectiveness;
- alternatives or additions to current utility-run approaches that are funded by system benefit charges; and
- other regulatory and non-regulatory policy changes.

Needless to say, that range of topics is enormous. Each one of them could be the sole subject of a substantial report, so this study does not purport to provide the "final word" on any of these issues. Rather, it provides a high-level assessment of what is possible and makes preliminary recommendations on some of the policy and program changes that may be necessary to realize another quantum leap in the levels of electric efficiency savings being achieved.

In section II, we summarize the approach we have taken to address the questions raised in this study. In section III, we discuss the current best practice and estimate the ten-year impact of simply continuing that practice. That analysis illustrates how much further we need to go to achieve 30 percent savings in ten years. In section IV, we consider what could be done—technologically and programmatically—to increase savings. In section V, we address what policymakers would need to do to enable those savings to be achieved. Our concluding section VI briefly summarizes key "takeaways" from the report. More detailed discussions of a range of issues raised in the main body of the report are provided in several technical appendices.

What Do We Mean By "30 Percent Savings In Ten Years"?

Savings targets can be defined in many ways, with significantly different economic and policy implications. The "30 percent savings in ten years" target considered in this study is defined as follows:

- Only savings in homes and businesses. We do not consider reductions in line losses, power plant heat rate improvements, or other changes on the utility's side of the meter.
- Just efficiency. We do not consider impacts of customer-sited renewables that generate rather than reduce consumption of electricity.
- Affecting electricity consumption ten years from now. Our focus is on savings that will be in effect at the end of a ten-year period. For example, savings from measures installed in 2016, but that last for only a few years, would not count. Thus, our target is expressed in the form of a much longer-term objective than the "first-year savings" goals currently used in most states.
- Relative to a "business as usual" baseline. We focus on incremental savings that would result from new policies or program interventions. We do not count, for example, savings from federal lighting efficiency standards that have already been promulgated. Nor do we count savings that are forecast to occur "naturally" as markets evolve. In the parlance of the efficiency industry, our focus is on "net savings."

II. Study Approach

It is important to make clear at the outset that this is not an efficiency potential study, at least not in the way that term is commonly used in the energy efficiency industry in North America. That is, we do not conduct a bottoms-up analysis of savings potential from hundreds of individual efficiency measures, assess which of those measures' savings potential is cost-effective based on today's estimates of costs and savings, and then forecast how many of each of those measures consumers would purchase and install under current efficiency program designs. Many such studies already exist. Moreover, while they can provide some useful insights, such traditional potential studies are inherently poor tools for assessing the limits of what is possible, typically grossly understating maximum achievable efficiency potential. (See Appendix A for a discussion of the limitations of traditional potential studies.)

Traditional potential studies are inherently poor tools for assessing the limits of what is possible.

Thus, we approach the question from a more "top down" perspective. As the ensuing discussion will demonstrate, this still involves substantial analysis. However, the analysis is focused more on macro-level trends, lessons learned from past attempts to push the envelope, and strategic or targeted analysis of selected new ideas that have the potential to have big impacts.

We started this project by trying to better understand what the states that are achieving two percent (or close to two percent) incremental annual savings are doing today. Based on both the high-level findings from that analysis and our own past experience (particularly in such leading states), we developed a list of both program and broader policy ideas for how savings levels in even the most aggressive states might be further increased. We then conducted interviews with nine national "thought leaders" from across the country,[11] to get their feedback on our initial ideas and to solicit any additional ideas that they might have. With that input, we conducted additional research into several promising ways to leverage additional savings. What follows is a synthesis of the results of that work.

11 Tom Eckman, Northwest Power and Conservation Council; Rafael Friedman, Pacific Gas and Electric; David Goldstein, Natural Resource Defense Council; Fred Gordon, Oregon Energy Trust; Marty Kushler, American Council for an Energy-Efficient Economy (ACEEE), Mike Messenger, Itron; Phil Mosenthal, Optimal Energy; Steve Nadel, ACEEE; and Steve Schiller, Schiller Consulting.

III. Current Best Practice

A. What Leading States Are Achieving

In 2014, the two states achieving the greatest level of electricity savings from ratepayer-funded programs were Massachusetts and Rhode Island. Massachusetts' investor-owned utilities achieved savings equal to nearly 2.8 percent of sales in 2014, 2.75 percent if one excludes a few small combined heat and power (CHP) projects.[12] National Grid in Rhode Island achieved savings equal to approximately 3.5 percent of sales in 2014.[13] However, roughly one-quarter of those savings were from a uniquely large CHP project, without which the annual savings would have been about 2.5 percent of sales.[14] With the exception of the major CHP project impacts in Rhode Island, these are not unpredicted, one-off results. Rather, they represent a continuation of a steady upward trajectory in savings over the past several years in both states. Moreover, both states are projecting slightly higher annual savings levels in the coming years.

It is important to note that the savings any jurisdiction will experience after ten years of running efficiency programs will be less than the sum of its annual savings over that period because every efficiency program portfolio includes measures that last less than ten years. Massachusetts and Rhode Island are no exception. If they were to replicate their 2014 savings every year for the next ten years, the result (excluding CHP impacts) would be annual savings at the end of the tenth year of about 23 percent in Massachusetts and 19 percent in Rhode Island, or an average of 21 percent.

There are undoubtedly many factors that have contributed to the success of both Massachusetts and Rhode Island in acquiring groundbreaking levels of electric energy savings. We have not investigated the issue in the depth required to comprehensively identify all of the factors. However, several jump out as particularly important. Perhaps the most basic and most important is that both states endeavor to treat efficiency as a resource that should be acquired whenever it is less expensive than supply alternatives. In other words, there are no arbitrary budget limits that prevent program administrators from maximizing the amount of efficiency being acquired as long as it is cost-effective. That mandate to pursue all cost-effective efficiency resulted in 2014 electric utility efficiency program spending of more than $500 million in Massachusetts and $80 million in Rhode Island.[15] That translates to between 6 percent and 7 percent of revenues in both states. Vermont (5.95 percent) was the only other state with comparable spending levels; no other state spent more than 4.3 percent of revenues on ratepayer-funded electric efficiency programs.[16]

Other key policy factors include the presence of sophisticated performance mechanisms to reward utility shareholders for meeting or exceeding goals,

12 Note that this is higher than the 2.5 percent reported in the *2015 ACEEE State Scorecard.* The difference is that the ACEEE uses total state sales in its denominator, including sales by municipal utilities who do not run programs.

13 Gilleo et al., 2015.

14 Narragansett Electric Company (d/b/a National Grid). (2015). *2014 Energy Efficiency Year End Report.* RI PUC Docket No. 4451.

15 The Massachusetts electric utilities are required, by policy, to fund efforts to improve the efficiency of oil and propane heated homes. We estimate that on the order of 15 percent of the total 2014 electric efficiency spending could be allocable to such efforts.

16 Gilleo et al., 2015.

cost-effectiveness screening frameworks that come close to fully valuing all of the benefits of efficiency, consideration of spillover effects as well as free rider effects, and a long history of working with non-utility stakeholders to explore new opportunities for savings and develop consensus plans and goals.

Programmatically, both states have very comprehensive and sophisticated program portfolios. The composition of those portfolios is summarized in Appendix B.

Energy efficiency measures aren't static. As opportunities for some measures decrease over time, opportunities for others increase.

B. The Effect of Product Efficiency Standards on Future Savings Potential

A significant portion of the savings that Massachusetts and Rhode Island achieved in 2014 was from measures that will be affected (in some cases effectively mandated) by new federal product efficiency standards. Because such standards apply to all consumer purchases,[17] whereas utility program participation is voluntary and therefore only affects a portion of the market, the standards will increase the level of savings actually experienced on the electric grid. However, in this study we are examining whether it is possible to achieve 30 percent savings in ten years relative to a baseline that includes the effects of laws, regulations, or other policy interventions that are already "on the books."[18] Thus, for the purposes of this study, we consider future savings from already adopted product efficiency standards to be part of the baseline. Put another way, a portion of Massachusetts' and Rhode Island's 2014 savings could not be replicated with the identical efficiency measures over the next ten years and still count as "new savings" relative to the ten-year savings goal that is the subject of this study.

Of course, one would never expect the mix of efficiency measures in a portfolio of programs to remain static year to year, let alone for ten years. As opportunities for some measures decrease over time, opportunities for others increase. The real question is whether the opportunities for new savings that become available over the study period will be greater than, equal to, or less than the savings that can no longer be claimed toward the goal due to the already adopted product efficiency standards. If new savings opportunities will not make up for the savings that can no longer count toward the goal, then a discounting of (i.e., a downward adjustment to) a ten-year extrapolation of the Massachusetts and Rhode Island 2014 results would be warranted.

On the one hand, it could be argued that the adoption of product efficiency standards has always been followed by the introduction by manufacturers of new products with efficiency levels that exceed the standards. Under this line of reasoning, an efficiency program administrator's pursuit of savings from the new products could be used to offset the "loss" of savings from the products which they used to promote and are now (or will soon be) mandated and therefore considered part of the baseline sales forecast. We believe that conclusion is appropriate, at least in aggregate, for most product standards. We reach a different conclusion with respect to changes to efficiency standards for residential light bulbs and linear fluorescent light fixtures, which account for most of the lighting in commercial buildings. This is both because these measures account for such a large portion of current efficiency program portfolios and because, especially in the case of residential lighting, the increment of efficiency improvement is so large that it could not be offset by the introduction of new, more efficient lighting products. Our analysis suggests that it is

17 This is virtually always the case for product efficiency standards. It is a little less clear for building codes, as there is often less than universal compliance with new requirements.

18 An alternative approach might have been to examine the achievability of a larger savings level (i.e., 35 percent or 40 percent), but include the effects of equipment efficiency standards that are already adopted but yet to go into effect in the assessment (i.e., measuring relative to a less efficient baseline). We have chosen to assess savings potential relative to a baseline that includes savings from laws or regulations than are already "on the books" for two reasons. First, that is the baseline against which most program administrators' efficiency program performance is typically measured. Second, it enables us to more clearly communicate that all of the savings we estimate to be achievable would be the result of new policies; we include in "new" the continuation of existing policies, such as utility energy efficiency resource standards (EERS).

appropriate to reduce the ten-year effect of continuing the Massachusetts and Rhode Island 2014 savings levels by about one-fifth, or to a total of about 17 percent persisting savings in ten years. This effect is discussed in some detail in Appendix C.

C. Transferability of Leading States' Results to the Rest of the Country

Massachusetts and Rhode Island are different from some other parts of the country in a number of ways that could affect electricity savings potential both positively and negatively. For example, both states have higher than average electric rates, higher than average avoided costs, colder than average climates, and longer than average histories of promoting electric efficiency. We are unaware of any analysis that could offer definitive insights into the extent to which these or other differences would affect the transferability of their savings levels to the rest of the country. Our qualitative assessment in Appendix D suggests that the net effect of all these factors is likely to be fairly small. The results of dozens of efficiency potential studies also suggest that achievable cost-effective savings potential does not vary considerably (if at all) from region to region (see Appendix A). Thus, our conclusion is that the principal reason Massachusetts and Rhode Island are achieving much greater levels of savings today than most of the rest of the country is that their policy commitment to pursuing cost-effective efficiency is considerably stronger.

IV. Going Beyond Current Best Practice

In this section we explore several ways in which savings levels in even the most aggressive states could be increased in the coming decade. This includes defining efficiency technology more broadly, promoting emerging or new technology, and improving current efficiency program designs in ways that can increase market penetration rates of efficiency measures.

A. Expanding the Definition of End-Use Efficiency Technology

Two "measures" that are not typically included in efficiency program portfolios—combined heat and power (CHP) and conservation voltage reduction (CVR)—could play important roles in providing additional savings and helping to bridge the gap between the 17 percent that current best practice efforts could achieve over the next decade and a more ambitious project target of 30 percent savings.

1. Combined Heat and Power

CHP systems simultaneously generate (1) electricity and (2) thermal energy that is used for process or space heating, water heating, space cooling, and other needs. There is an inherent energy trade-off with such systems. Specifically, they typically consume a little more gas (or other fuel) on-site than would be consumed by a boiler or furnace that only meets a building's or facility's thermal energy needs. In exchange, the building or facility can produce electricity, eliminating the need to purchase that electricity from the grid. Generally, the amount of electricity produced on-site is considerably more than the average central station power plant would produce with the amount of additional gas consumed on-site. As a result, the combined electric and thermal efficiency of CHP systems can reach or exceed 80 percent, which can be 50 percent greater than the combined efficiency of grid delivered electricity and a boiler operated to meet the building's thermal energy needs.[19]

Massachusetts and Rhode Island are achieving much greater levels of savings today than in most of the rest of the country not because of geographic, climatic or economic conditions, but because their policy commitment to pursuing cost-effective efficiency is considerably stronger.

One of the challenges in treating CHP as an electric efficiency measure is determining how much "savings credit" to assign to it. One could treat all of the electricity generation as "savings."[20] However, that ignores the reality that, unlike other efficiency measures, additional gas (or other fuel) must be consumed to produce those savings. One option for addressing this is used by the American Council for an Energy-Efficiency Economy (ACEEE) to calculate what it calls "effective electric savings." In this approach, the electricity output is "de-rated" by the amount of electricity that would have been produced on the grid had the extra gas been burned in a typical grid-connected power plant. There are other approaches to address this as well.[21] Under the ACEEE approach, we estimate that

19 York, D., Nadel, S., Rogers, E., Cluett, R., Kwatra, S., Sachs, H., Amann, J., & Kelly, M. (2015). *New Horizons for Energy Efficiency: Major Opportunities to Reach Higher Electricity Savings by 2030.* ACEEE Report Number U1507.

20 This is how Massachusetts and Rhode Island currently treat CHP generation when counting its contribution toward electric savings goals. However, the increase in gas consumption is considered an added cost when performing cost-effectiveness screening.

21 One additional alternative, which is currently in use in Illinois, is to "de-rate" the electricity output by the amount of electricity that would be produced on the grid with a carbon emissions allowance equal to the carbon emissions associated with the additional on-side gas consumption. Under that approach, the savings credit will decline as the marginal emissions rate on the grid improves. *Illinois Statewide Technical Reference Manual for Energy Efficiency.* Version 4.0. (2015). Prepared by the Illinois Energy Efficiency Stakeholder Advisory Group (SAG).

aggressive promotion of CHP systems, where cost-effective, could achieve effective electricity savings equal to 2 percent of national electricity sales in ten years.[22,23]

2. Conservation Voltage Reduction

In the US, regulations require that voltage be delivered to homes and businesses within 5 percent of the nominal 120 volts that electricity-consuming equipment is designed to use—i.e., between 114 and 126 volts. Because voltage levels drop along the length of distribution feeders, utilities often maintain higher voltage levels at the beginning of feeders in order to ensure that at least 114 volts will be delivered to the last home or business served by a feeder. The result is that many homes and businesses receive higher voltages than they need. Because many types of electricity-consuming devices use more electricity at higher voltages, better controlling voltage levels will provide end-use electricity savings. CVR is the term typically used to describe enhanced management of voltage levels by distribution utilities to enable such end-use energy savings, while still meeting minimum voltage standards and other utility operating requirements. Several studies suggest that deployment of CVR where it is most cost-effective could produce national savings of about 2.3 percent.[24]

It should be noted that some—including the authors of this report—have argued that savings from CVR should not be allowed to count towards utility efficiency savings targets; rather, distribution utilities should pursue CVR wherever it is cost-effective under their existing obligations as regulated monopolies to minimize costs to their customers. We still believe that is a reasonable argument under the existing design of typical efficiency resource standard requirements. If utilities are not being required to capture all cost-effective energy efficiency (e.g. because of insufficiently aggressive targets or spending caps), then it would be inappropriate to count efficiency improvements resulting from investments on their own distribution systems towards their savings targets. However, in the context of much more aggressive savings targets that are explicitly designed to encompass, support, and promote multiple ways of achieving more aggressive levels of electricity savings, CVR deployment can be viewed as a

"Low-Hanging Fruit" Grows Back

While it is true that the "low-hanging fruit" of linear fluorescent lighting upgrades—i.e., replacing very inefficient T12s with T8s or high performance T8s (HPT8s)—will disappear from ratepayer-funded efficiency programs because of recent and upcoming federal efficiency standards, new opportunities are emerging to take their place. LED troffers with integrated controls are already capable of nearly 70 percent savings relative to the new T8 baseline. They are also already cost-effective. Moreover, their efficiency is forecast to continue to improve while their costs are forecast to continue to decline. Put simply, they should become one of the next major reservoirs of electricity savings. Even if one assumes a baseline of an HPT8, they could potentially provide another 2.2 percent savings over the next decade. This new opportunity is discussed in greater detail in Appendix E.

22 This estimate is based on ACEEE's estimate of CHP savings potential (Hayes, S., Herndon, G., Barrett, J., Mauer, J., Molina, M., Neubauer, M., Trombley, D., & Ungar, L. (2014). *Change is in the Air: How States Can Harness Energy Efficiency to Strengthen the Economy and Reduce Pollution.* ACEEE Report E1401.), adjusted up by about 15 percent to account for the limitations of their analysis (e.g., only systems between 100 kW and 100 MW, no export to the grid, only gas-fired systems—no other fuels or waste-to-energy systems, no consideration of biogas, such as methane produced from waste water treatment systems, etc.). Savings were then divided by the US Energy Information Administration's "Annual Energy Outlook 2015" which forecasts 2025 sales of 4078 TWh. Available at: http://www.eia.gov/beta/aeo/#/?id=8-AEO2015).

23 As noted earlier, the 2014 savings levels presented for Massachusetts and Rhode Island excluded each state's CHP savings because the anomalously high level of CHP savings in Rhode Island that year—equal to about 1.0 percent of total state sales—is not likely to be representative of average annual CHP savings in the future. It is perhaps worth noting that though the Massachusetts CHP savings in 2014 were quite modest, from 2011 to 2013 the state's utilities averaged nearly 80,000 MWh of CHP savings annually, or close to the 0.2 percent of total electricity sales that we are assuming to be achievable on average each year for the next decade.

24 Schneider, K.P., Tuffner, F.K., Fuller, J.C., & Singh, R. (2010). *Evaluation of Conservation Voltage Reduction (CVR) on a National Level.* Prepared for the US Department of Energy under contract DE-AC05-76RL01830; and York et al., 2015.

complement to, rather than a substitute for, other demand-side efficiency improvements.

B. Promoting New Technologies

There are a variety of emerging technologies that offer new opportunities for additional electricity savings. In the residential sector, for example, heat pump water heaters, heat pump dryers, new generations of ultra-efficient and cold climate compatible ductless heat pumps for heating and cooling, and smart thermostats all offer substantial new savings potential. In the commercial and industrial sectors, substantial new savings can be achieved through LED alternatives to linear fluorescent fixtures, particularly when integrated with controls; advanced rooftop HVAC systems; and "smart" systems that use advanced sensors, controls, communications protocols and interconnectivity to optimize performance of a variety of building systems or manufacturing processes. All of these technologies are commercially available today (and in some cases, have been for several years), but generally with very low current levels of market penetration, even in leading states. A recent report by ACEEE that characterizes these and several other measures with currently very low levels of market penetration suggests that all such emerging technologies could collectively save between 18 percent and 19 percent of estimated electricity sales over the next 15 years.[25]

We can also say with virtual certainty that *additional* new efficiency technology advances that we cannot identify today will surface in the next decade. Others that are recognized today, but are now too expensive to be cost-effective, will likely see costs decline to the point where they become economically attractive. Technological advancements that had not been foreseen even a few years ahead of time have consistently made large contributions to reported savings. For example, nearly half of the achievable electric energy savings identified in the Northwest Power and Conservation Council's recently published Draft Seventh Power Plan are from efficiency measures not included in the Council's Sixth Plan produced just five years earlier.[26] Put simply, when assessing how much savings could be achieved in the future, we need to account in some way for the savings potential from new technology that we cannot specifically identify today.

Beyond new technology, there may be important new opportunities for efficiency that emerge as patterns of electricity use change. For example, as the market penetration of electric cars increases, there may be important new opportunities for promoting the purchase of the most efficient vehicles. Similarly, to the extent that there is increased electrification of electric space heating, either as a result of natural market forces or government policy designed to address concerns about climate change, opportunities for acquiring additional cost-effective electric heating savings will grow.

C. New Efficiency Program Approaches

There are also opportunities to achieve deeper levels of savings and greater market penetration of efficient technology—old and new—within the construct of electric ratepayer-funded efficiency programs. Several approaches that have shown great promise merit greater consideration:

- **Upstream product rebates:** Several program administrators, including Pacific Gas & Electric (California), Efficiency Vermont, and the Connecticut utilities have tested upstream program models—where incentives are aimed at distributors rather than end-use purchasers—for a variety of HVAC products. As Figure 2 illustrates, such programs have seen large, sometimes dramatic, participation increases compared to traditional downstream models. A more detailed description of these experiences is presented in Appendix F. The EPA is currently coordinating the launch of a national "mid-stream" program, with incentives provided to retailers for air purifiers, freezers, clothes dryers, and possibly other products.[27] Upstream approaches may not be the best approach for all efficient products, but they can significantly increase participation and savings for the products for

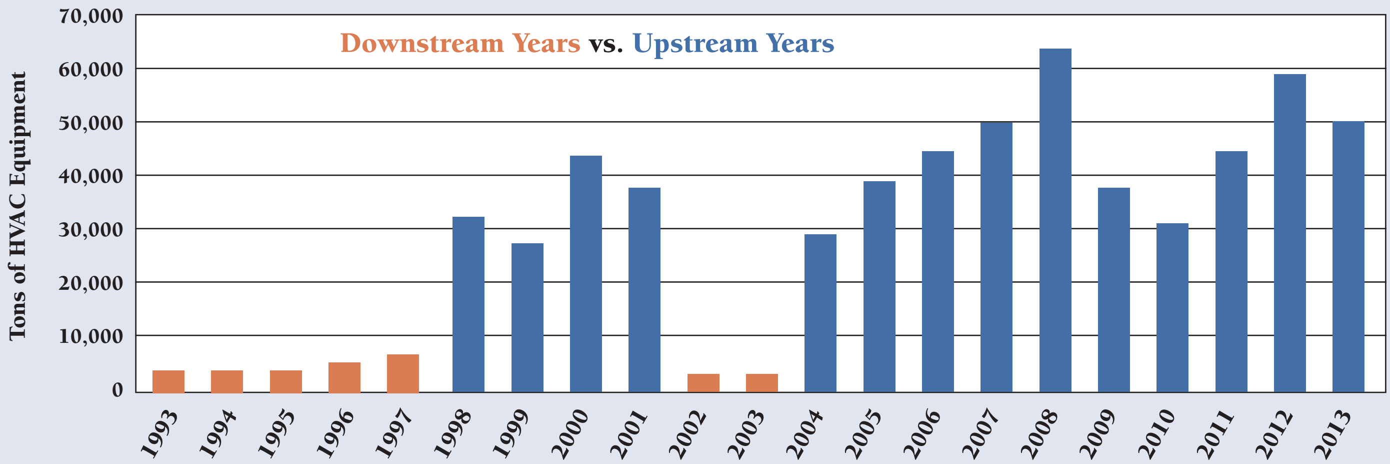
25 The report gives a mid-point savings estimate of 22 percent, including savings from CHP and CVR. The 18-19 percent figure referenced here excludes those two technologies, since we discuss them separately. York et al., 2015.

26 Data provided by Charlie Grist, Northwest Power and Conservation Council, October 14, 2015.

27 See Energy Star. (2015). Retail Products Platform. Available at: http://www.energystar.gov/sites/default/files/asset/document/ESRPP_1pager_10-07-15.pdf.

Figure 2

PG&E Commercial HVAC Program Participation Increases with Upstream Incentive[28]



which they are best suited.[29]

- **Strategic Energy Management (SEM):** SEM is aimed at improving operational efficiency in industrial, commercial, and institutional settings in a systematic and sustained manner, and is increasingly being supported by energy efficiency program administrators. ACEEE recently estimated that aggressive adoption of SEM in the industrial sector could lead to a 1.0 percent reduction in US electric consumption, and that adoption of SEM in the commercial/institutional sector could lead to an additional 0.1 percent-0.3 percent reduction.
- **Market-specific "deeper dives":** Many industries and market segments use energy in ways that are highly specific, and in some cases are even unique when compared with other energy users in their rate class. For instance, hospitals use energy differently than manufacturing facilities, and they are also likely to have very different decision-making processes when it comes to planning for energy efficiency improvements. Leading programs recognize that getting deep savings requires sustained engagement with large customers through "account management" approaches, and that specific intelligence about the business needs of different market sectors is critical to successful engagement. In several cases, industry-specific "deep dives" have identified ways to produce enormous savings. An illustrative case study of how Efficiency Vermont helped transform the market for "snow guns" sold to ski resorts to products that provide more than 95 percent electricity savings relative to standard products is provided in Appendix G. We offer this example not because savings potential from snow guns is substantial nationally (though it is in Vermont and some other states), but rather to illustrate that savings in many niche markets—which *collectively* could be very substantial on a national scale—are potentially much larger than one might imagine.

Just as we have not quantified the potential from all possible new technology, we have not attempted to quantify the savings potential from new or enhanced efficiency program approaches. Indeed, just as with new technology that has not yet emerged, the potential savings from some enhanced efficiency program strategies (e.g., industry-

28 Mosenthal, P. (2015). *Do Potential Studies Accurately Forecast What Is Possible in the Future? Are we Mislabeling and Misusing Them?* Presented at the ACEEE Efficiency as a Resource Conference, Little Rock, AR. Graphic provided to Mr. Mosenthal by Jim Hanna, Energy Solutions.

29 Upstream approaches appear to be most beneficial when either (1) the incremental cost or per unit savings of measures is small (making the transaction costs of the alternative of customer-specific rebates both comparatively expensive and challenging to implement, given the potentially limited value provided to retailers or other trade allies); or (2) when the current market share for a product is relatively low (mitigating potential net-to-gross concerns).

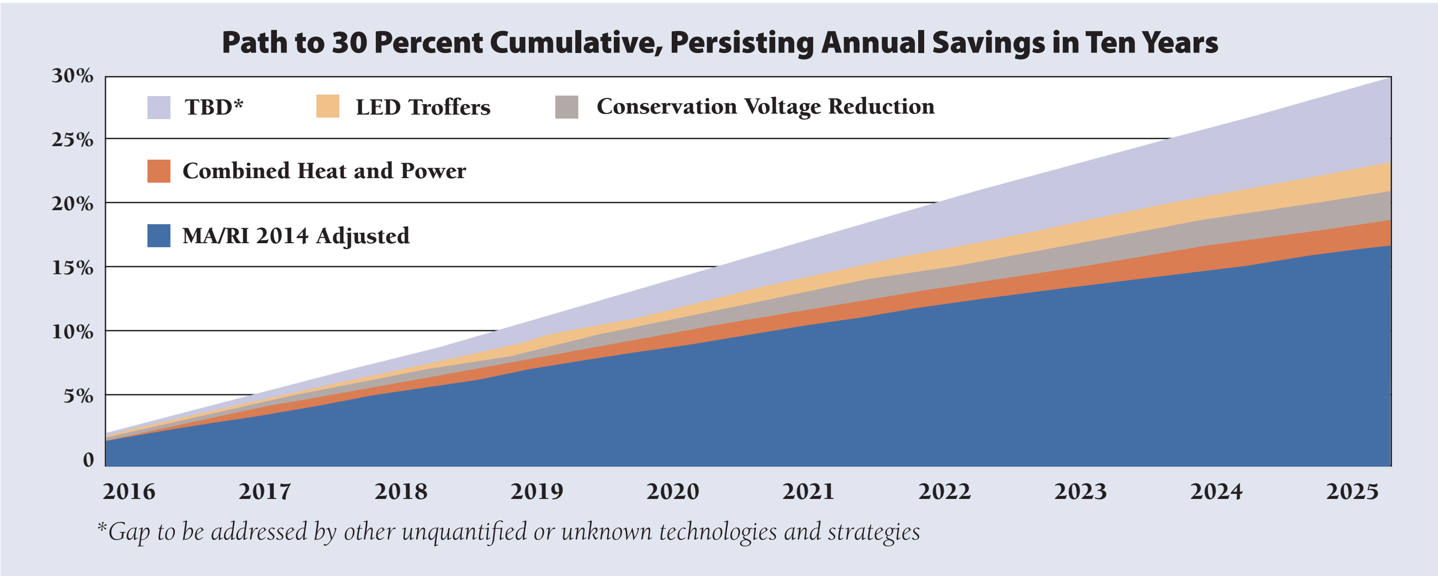
specific deeper dives) are challenging, at best, to forecast.

D. Bridging the Gap to 30 Percent Savings in Ten Years

We estimate that extending the Massachusetts and Rhode Island 2014 savings levels for the next ten years, after downward adjustments to remove anomalous CHP savings and to reduce lighting savings to account for the effect of new federal standards, would produce cumulative persisting annual savings of a little over 17 percent. In the discussion in this section of the report, we identify a number of potential sources of savings that could be tapped to go beyond the adjusted Massachusetts and Rhode Island 2014 savings levels. We have only quantified three of those opportunities—CHP, CVR, and LED alternatives to linear fluorescent lighting. As Figure 3 shows, adding those three opportunities to the adjusted current Massachusetts/Rhode Island savings levels could bring cumulative persisting annual savings levels to almost 24 percent over ten years. ACEEE has identified a number of other technologies with substantial additional potential. The combination of those technologies, others that will emerge in the coming years, and improved program strategies that we have discussed only qualitatively would need to be able to produce an additional 6 percent savings in order for the 30 percent savings target to be achieved.

Given the range of options for filling that gap, as well as historic experience with the emergence of new technology, new market approaches, and what happens when efforts to significantly ramp up savings are undertaken, we believe it is possible to cost-effectively achieve 30 percent cumulative savings over ten years.

Figure 3



V. Policy Needs and Considerations

Cost-effective electricity savings potential, with all of the enormous economic and other benefits it can provide, will only be fully realized if policies are carefully designed to encourage least-cost approaches to meeting long-term electricity demands. Specifically, significant changes will be necessary to address common policies and practices that:

- Artificially cap efficiency program spending;
- Inadequately address utility profitability concerns;
- Over-reward short-term savings;
- Limit investment in market transformation efforts;
- Under-value the diverse benefits of efficiency; and
- Discourage innovation and appropriate levels of risk-taking.

In this section, we discuss key policy changes that are either already clearly essential or warrant serious consideration as options for addressing these issues.

A. Increase Spending on Cost-Effective Efficiency Programs

As noted above, perhaps the most important factor underlying Massachusetts' and Rhode Island's recent success in achieving high levels of savings is that they operate under a mandate to pursue all cost-effective efficiency. They do not artificially constrain spending on efficiency; if it is cost-effective, it is funded. That perspective will be absolutely essential if savings goals are to grow beyond what has been achieved to date in these best practice states.

While a portion of additional savings could be achieved through other policy instruments (e.g., more stringent equipment efficiency standards or building codes—see discussion below), it is hard to imagine how a target of 30 percent savings in ten years could be met without greater savings from ratepayer-funded initiatives. As discussed below, the form of such ratepayer funding could be different than the mechanisms funded by system benefit charges that are common across the United States today. However, whatever the vehicle for collecting the funds, the *magnitude* of the funding will almost certainly have to grow.

That will require changes in jurisdictions in which efficiency program spending is currently capped at some level less than "all cost-effective." One reason for such caps is that ratepayer-funded efficiency programs are often viewed more as social programs than as vehicles to acquire resources that cost-effectively meet system needs. That perspective ignores the reality that cost-effective efficiency investments—by definition—reduce utility system costs (both operating costs and capital investments). The total resource cost (TRC) and societal cost test benefit-to-cost ratios for the 2014 Massachusetts and Rhode Island program portfolios demonstrate this, at approximately 3.5-to-1 and 2.7-to-1, respectively.[30] In other words, efficiency is an economic bargain.

A second related reason many states currently cap efficiency program spending is that they are concerned that it will increase electric rates too much or too fast. However, such concerns typically fail to adequately consider several important realities regarding efficiency programs:

- Many benefits of efficiency programs put downward pressure on rates. Examples include capacity savings, T&D system savings, environmental compliance cost savings, and price suppression effects. Depending on local circumstances, these downward pressures can be greater than the upward pressure caused by efficiency

30 For Massachusetts, see the electric statewide summary spreadsheet for 2014 at http://ma-eeac.org/results-reporting/; for Rhode Island, see Narragansett Electric Company (d/b/a National Grid). (2015).

program spending.[31]

- Efficiency programs reduce utility system risks, such as lowering exposure to fuel price volatility. This benefit has value to consumers.
- Bills matter more than rates. Even if rates go up as a result of efficiency program spending, consumers who participate in efficiency programs will be better off because their consumption will typically go down by a much greater amount.
- The best way to address impacts on non-participants is to expand efficiency programs so that more customers can participate and benefit.

One of the rare analyses of bill and rate impact trade-offs recently estimated that an aggressive efficiency strategy in Vermont would produce an average 7 percent reduction in electric bills (net of rate increases) for the more than 95 percent of residential customers who would be expected to participate in programs. The corresponding average increase in bills would be 4 percent to 5 percent for the fewer than 5 percent of customers who would not participate.[32] While policymakers in different states might reach different conclusions regarding whether that trade-off would be worth making, very few are ever able to make informed decisions because they do not see data in this way. That needs to change.

B. Make It Profitable to Pursue All Cost-Effective Efficiency

Policymakers have long recognized that greater energy efficiency can have adverse effects on the profitability of electric utilities due to reductions in sales volumes. That barrier must be addressed if we are to reach 30 percent cumulative savings over ten years. Regulators must implement critical policy changes such as providing utilities the opportunity to earn shareholder incentives for meeting savings targets, decoupling (i.e., removing) the link between utility profitability and increased electricity sales, or simply collecting funds from the utilities and giving the job of running efficiency programs to independent third parties.[33] Numerous reports on these topics provide more detail on the nature of the barriers and options for addressing them.[34]

C. Align Goals with Long-Term Objectives

Most utility system investment decisions are made with long-term economic, reliability, environmental, and other objectives in mind. If efficiency is to be treated as a resource comparable to supply-side alternatives, then policymakers should also focus not just on how much it can deliver in the next year or two, but for at least the next decade as well. Strategies to address climate change may demand consideration of even longer-term time horizons. However, energy efficiency goals are rarely—if ever—structured to consider impacts more than a few years into the future. Instead, they are often very short-term focused. Moreover, credit is commonly given only for savings that are easily "counted" at the individual measure (or building) level. As a result, most efficiency goals today reward and likely lead to efficiency investment decisions that are less (sometimes far less) than optimal. Several changes to the approach to typical efficiency goal-setting practices are warranted.

31 We found that to be the case in an unpublished 2014 analysis of Commonwealth Edison's (ComEd) efficiency programs in Illinois (primarily using Com Ed's own estimates of savings and avoided costs). The one additional factor that can put upward pressure on rates is lost revenue—i.e., the impact of spreading utility fixed costs across a smaller pool of consumption. However, allowing concerns about the impacts of lost revenues on rates to drive decisions on the level of ratepayer investment in efficiency is tantamount to saying that you would not want greater efficiency even if it could be acquired for free.

32 Analysis of "high case" in Woolf, T., Malone, E., & Kallay, J. (2014). *Rate and Bill Impacts of Vermont Energy Efficiency Programs (from Proposed Long-Term Energy Efficiency Scenarios 2014-2034)*. Snyapse Energy Economics. Prepared for the Vermont Department of Public Service.

33 Where the third party route is taken, part of the compensation for such third parties should be tied to their performance.

34 For example, see Hayes, S., Nadel, S., Kushler, M., & York, D. (2011). *Carrots for Utilities: Providing Financial Returns for Utility Investments in Energy Efficiency.* (ACEEE Report Number U111). Lazar, J., Shirley, W., & Weston, F. (2011). *Revenue Regulation and Decoupling: A Guide to Theory and Application.* Montpelier, VT: The Regulatory Assistance Project; Cappers, P., Goldman, C., Chait, M., Edgar, G., Schlegel, J., & Shirley, W. (2009). *Financial Analysis of Incentive Mechanisms to Promote Energy Efficiency: Case Study of a Prototypical Southwest Utility.* Berkeley, CA: Lawrence Berkeley National Laboratory (LBNL-1598E).

1. Increase Focus on Longer Measure Life

Today, most efficiency savings targets are defined in terms of annual savings—i.e., how much savings the measures installed will produce in their first year. Under this approach, annual savings from measures that have a one-year life, five-year life, ten-year life, or longer are treated as if they are all of equal value. The result has been, in part, an over-emphasis on efficiency measures and programs that produce shorter-lived savings because many shorter-lived measures have lower costs per first year kilowatt-hour (kWh) saved. There are a variety of ways to fix this problem.[35] Perhaps the easiest and most straightforward is to shift to a lifetime savings goal.

2. Focus on a Longer Time Horizon

In most states, program administrators' performance is measured annually, against annual savings goals. Thus, program administrators focus most of their attention on "this year" rather than on the medium or longer term. As a result, there is an inherent disincentive to make investments in efficiency technology or program strategies that will take several years or more to begin to bear fruit, even if the longer-term payoff could be very large. Several states—including Vermont, Illinois, and California—have attempted to address the problem by moving to three-year performance goals, though this may still not be long enough to adequately promote investments that will take longer to pay off. Three-year goals may also be insufficient to motivate program administrators to invest in potentially valuable long-term market transformation efforts.

3. Consider Goals Based on Actual Sales, Rather than Evaluation-Based Calculations

Policymakers should explore the possibility of establishing total electricity sales goals, or perhaps goals framed in terms of sales per unit of gross domestic product or other measure of energy intensity. The performance of program administrators could be assessed relative to such targets, rather than by summing up estimates of savings from thousands of efficiency measures as is currently done. Basing goals on actual sales levels would have a number of advantages, including elimination of discord over evaluation of gross savings;[36] elimination of debate over net-to-gross adjustments;[37] explicitly rewarding market transformation effects; and explicitly rewarding non-incentive programs, information or education efforts, and savings from both operational efficiency improvements and capital investments—provided they actually produce savings. To be sure, there would be challenges with this kind of shift. For example, regulators would need to establish mechanisms for weather-normalizing sales, adjusting for increased electrification of vehicles and buildings where deemed beneficial, and potentially adjusting for other factors, such as changes in demographics or economic activity relative to forecasts at the time sales goals were set. However, the potential benefits are large enough to warrant further exploration.

Is it time to start using the ultimate metric of efficiency program performance: electricity sales levels?

D. Recognize the Full Value of Energy Efficiency

Energy efficiency investments should only be pursued when they are cost-effective—that is, when they are less expensive than supply alternatives. That perspective is already widely-held across the US. However, in most jurisdictions, cost-effectiveness screening fails to fully value the benefits that efficiency provides. To begin with, most jurisdictions do not fully value the electric system benefits of efficiency because they do not fully account for avoided T&D costs, reductions in environmental compliance costs, the value of reduced risk, the value of price suppression effects, or the full magnitude of reductions in T&D line losses.[38] Also, most jurisdictions which use the societal test or the TRC test include the portion of efficiency measure

35 Optimal Energy and Energy Futures Group. (2013). *Final Report: Alternative Michigan Energy Savings Goals to Promote Longer Term Savings and Address Small Utility Challenges.* Lansing, MI: Michigan Public Service Commission.

36 Such evaluations would still have value, but for informing program design rather than for "bean counting."

37 Again, evaluation of free ridership and spillover would still have value, but only for informing program administrators on what is working and what is not.

38 Lazar, J., & Baldwin, X. (2011). *Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements.* Montpelier, VT: The Regulatory Assistance Project.

costs borne by program participants in screening but do not assign value to the often very large non-energy benefits that many efficiency measures provide to those participants. In addition, many jurisdictions inappropriately under-value future benefits of efficiency by using discount rates based on utilities' weighted average cost of capital—a measure of utility shareholders' time value of money—rather than lower discount rates that better reflect the time value of money to utility consumers or society as a whole.[39] As a number of recent papers and reports make clear,[40] the end result of these screening errors and omissions are cost-effectiveness results that are biased—often dramatically so—against efficiency investments. Such biases may not be critical when only a modest portion of cost-effective efficiency is being pursued. However, they become very important when the goal is to acquire all cost-effective efficiency. Thus, it is vital that states review the way they conduct cost-effectiveness screening of efficiency to ensure that the practices treat efficiency and supply alternatives in a balanced way.[41]

E. Recognize and Reward Market Transformation

Since the mid- to late-1990s, utility ratepayer-funded efficiency programs have been overwhelmingly focused on short-term resource acquisition. Achieving 30 percent savings in ten years will require significantly greater emphasis on longer-term market transformation, both because transformed markets produce greater levels of savings (e.g., everyone buys a more efficient product because doing so is the new status quo, rather than just those who voluntarily participate in a program) and because they create new platforms for the development of the next generation of efficient technologies and processes.

The biggest barrier to increased investment in market transformation is that efficiency program administrators are rarely given credit for market transformation effects of their efficiency programs. Instead, as Figure 4 shows, regulators and many stakeholder groups tend to narrowly focus on savings that are easily counted, which usually means savings for which financial incentives have been paid. Although such "resource acquisition" programs often still produce some market transforming effects, greater savings would be possible if the way savings are counted was better aligned with longer-term energy efficiency policy goals. There are at least three ways this could be done:

1. **Establish longer-term savings goals.** This point was discussed in subsection C above.
2. **Assign credit to success in advancing the adoption or increasing the enforcement[42] of more efficient building codes or equipment standards.** Several states—including California, Arizona, Massachusetts, and Rhode Island—have begun to at least partially address this opportunity.[43]
3. **Estimate and count market transformation effects of other programs.** Even short-term resource acquisition programs often have some long-term market transformation effects. The effect that many years of promotion of compact fluorescent light bulbs had on recent federal lighting efficiency standards exemplifies this. It is ironic that once an efficiency

39 For an excellent discussion of how to select an appropriate discount rate, see Chapter 5 of: Woolf, T. (2014). *Cost-Effectiveness Screening Principles and Guidelines: For Alignment with Policy Goals, Non-Energy Impacts, Discount Rates and Environmental Compliance Costs.* Lexington, MA: Northeast Energy Efficiency Partnerships.

40 For example, see Lazar, J., & Colburn, K. (2013). *Recognizing the Full Value of Energy Efficiency (What's Under the Feel-Good Frosting of the World's Most Valuable Layer Cake of Benefits).* Montpelier, VT: The Regulatory Assistance Project; and Neme, C., & Kushler, M. (2010). *Is it Time to Ditch the TRC? Examining Concerns with Current Practice in Benefit-Cost Analysis.* Proceedings of the 2010 ACEEE Summer Study on Energy Efficiency in Buildings, Volume 5.

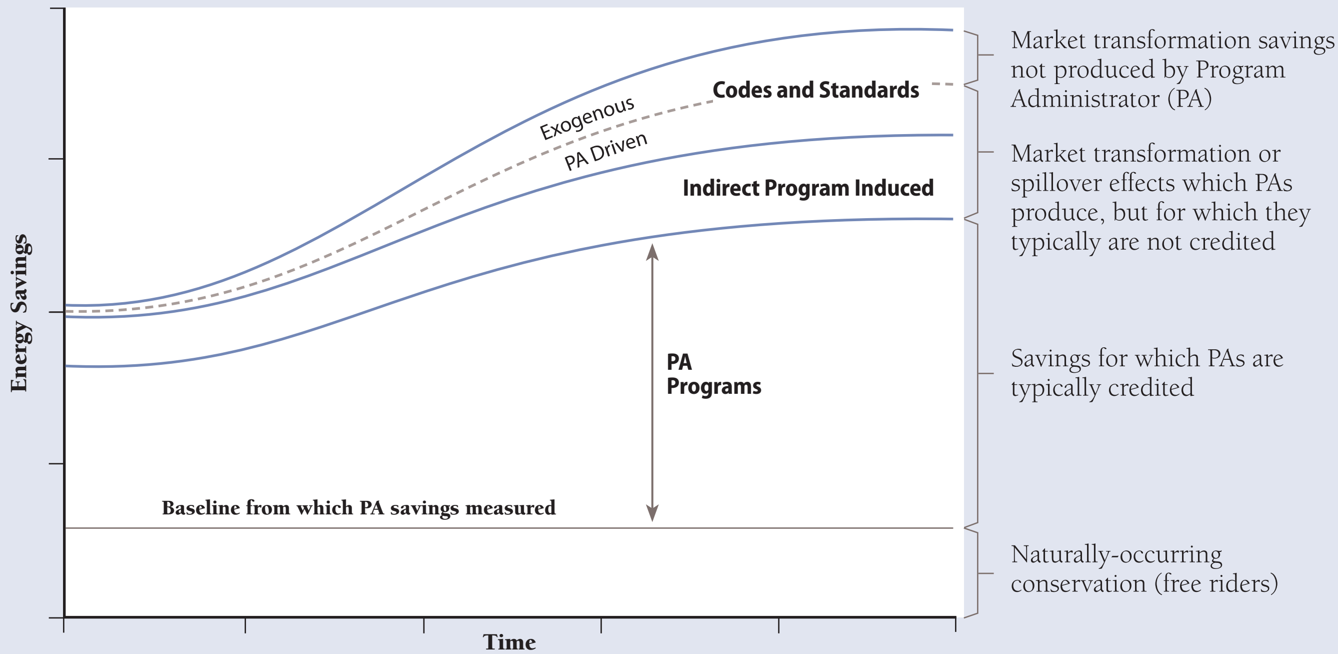
41 The Resource Value Framework recently developed by the National Screening Project offers a useful framework for such assessments. See Woolf, T., Neme, C., Stanton, P., LeBaron, R., Saul-Rinaldi, K., & Cowell, S. (2014). *The Resource Value Framework: Reforming Energy Efficiency Cost-Effectiveness Screening.* Prepared for the National Efficiency Screening Project.

42 The Institute for Market Transformation notes that there is "significant and widespread" lack of compliance with state building codes. In many places compliance is as low as 50 percent. It similarly reports that "every dollar spent on code compliance and enforcement returns $6 dollars in energy savings, an impressive 600-percent return on investment." See http://www.imt.org/codes/code-compliance.

43 For more information on this topic, see Lee, A., Groshans, D., Schaffer, P., Rekkas, A., Faesy, R., Hoefgen, L., & Mosenthal, P. (2013). *Attributing Building Energy Code Savings to Energy Efficiency Programs.* Prepared for Northeast Energy Efficiency Partnerships, Innovation Electricity Efficiency, and Institute for Market Transformation.

Figure 4

Common Divergence Between Savings Generated and Credit Given[44]



program accelerates the market adoption of an efficient technology, it is no longer able to claim credit for the resulting savings. Regulators typically require the program to treat the customers who are part of the increased baseline that the program produced as free riders. We are not suggesting that it is smart or prudent to continue to offer efficiency programs to promote efficiency measures for which the market has already changed, or where the cost per unit of additional savings that would be produced by additional program efforts is too high to justify. However, credit could be given for past program efforts for moving the market, at least for a certain period of time. Put simply, we need to create a set of rules that provides incentives for more intentional efforts to more effectively transform markets. Any concern about making goals easier to reach by changing "savings accounting practices" could be addressed by adjusting goals further upward so that they are just as hard to reach as today. To be sure, it is challenging to estimate these kinds of market effects. As a result, there will probably always be a tendency to be conservative in such estimates. However, that is better than ignoring them altogether and, by extension, not providing incentives for program administrators to try to produce them.

F. Reorient Regulatory Scrutiny to Focus More on the "Forest," Less on the "Trees"

The regulatory processes governing both efficiency program planning and approval of energy savings claims have become increasingly complex and rife with conflict. To some degree, that may reflect perceptions that increased scrutiny is necessary and commensurate with significant increases in both efficiency program spending and reliance on savings as an increasingly substantial portion of the electricity resource portfolio. However, one could argue that the result has been regulatory constructs and cultures that undermine our ability to maximize acquisition of cost-effective efficiency savings. Examples include:

- Not valuing savings from long-term market transformation (as discussed above);
- Placing greater emphasis on quantifying and adjusting for free rider effects than on quantifying spillover effects; and
- Discounting or ignoring altogether savings produced from changes in the way customers operate their buildings or production facilities (i.e., operational efficiency improvements).

44 Figure adapted from a graphic in Lee, A., & Faesy, R. (2011). *Supporting Energy Efficiency Codes and Standards through DSM/EE Programs.* Webinar. Montpelier, VT: The Regulatory Assistance Project.

These kinds of practices do not just result in giving less "credit" for current efficiency programs. They also effectively remove potentially valuable types of efficiency programs from consideration, provide false conclusions that other programs are not cost-effective, discourage community-based and other collaborative approaches to promoting efficiency, and discourage creativity and innovation in the design and delivery of programs. In other words, the focus on ensuring that efficiency program administrators do not "get away with something" or do not get to claim any savings that they did not create can produce an unintended effect of leading to far fewer savings than might otherwise be achieved. Ironically, because efficiency savings are typically so much less expensive to acquire than the alternative supply-side investments, reductions in "waste" by utility efficiency programs that result from some aspects of current regulatory constructs may simultaneously produce far more wasteful or unnecessary supply-side investment. This type of approach to regulation of efficiency investments will need to change if we are to reach 30 percent savings over ten years.

Some current regulatory approaches to ensuring utilities are not rewarded for "over-claiming" savings are likely to be causing significant unnecessary investment in supply resources.

G. Consider New Models for Acquiring Efficiency Resources

Today, electric efficiency resources are almost universally acquired through a combination of (1) government codes and standards; and (2) efficiency programs that are funded through surcharges on electric bills, delivered by utilities or alternative administrators chosen by regulators, and based on designs that are scrutinized and approved by regulators. In this section, we consider alternatives to the utility-centric nature of program design and delivery and direct regulation of efficiency programs. We also explore the concept of rewarding acquisition of non-electric energy savings.

1. Competitive Procurement

Several of the thought leaders interviewed at the outset of this project suggested that a key to achieving another "step function" increase in the level of electric efficiency is spurring innovation, and that one way to do so would be to promote greater competition to the identification and delivery of energy savings by potentially engaging a much wider array of market actors. Such competition could come in a variety of forms, including efficiency program bidding, new forms of the "standard offer" programs much more commonly offered across a number of jurisdictions in the 1990s, and efficiency feed-in-tariffs.

Experience with variations on some of these types of mechanisms suggests that they also pose a number of challenges.[45] For one thing, they have mostly ended up paying for standard forms of energy savings—and sometimes at a cost that was much greater than if those savings had been acquired through more traditional program administrator models. That is particularly true with mechanisms in which the same fixed price is offered for all savings (i.e., the most simple standard offer or efficiency feed-in-tariff approach).[46] Other challenges include increased administrative complexity, a likely need for greater investment in evaluation, measurement, and verification (EM&V),[47] and the potential for some market confusion. There are certainly ways to reduce any such adverse consequences.[48] However, it is not clear whether the benefits outweigh the costs of doing so. Thus, it may

45 Current examples include the Illinois Power Agency's annual procurement of energy savings for residential and small business customers through a competitive solicitation for new programs (not competing with existing utility programs), New Jersey's "Pay for Performance" programs, and both the New England and PJM capacity markets (which permit efficiency savings to compete with generation alternatives).

46 For example, Public Service Electric & Gas' standard offer program in New Jersey in the 1990s and early 2000s—arguably the largest such program of its kind to date (PSE&G spent over $1 billion on it)—got 83 percent of its savings from commercial lighting retrofits at a levelized cost of 3.9 cents per kWh. See Edgar, G., Kushler, M., & Schultz, D. (1998). *Evaluation of Public Service Electric and Gas Company's Standard Offer Program.* Prepared for PSE&G. That is roughly twice the cost at which similar types of savings were being captured through more standard utility program interventions.

47 One would need to verify the savings claims of a much larger range of savings delivery agents.

48 Neme, C., & Cowart, R. (2013). *Energy Efficiency Feed-in Tariffs: Key Policy and Design Considerations. Proceedings of the 2013 ECEEE Summer Study on Energy Efficiency in Buildings, Volume 2;* and Cowart, R., & Neme, C. (2013). Can Competition Accelerate Energy Savings? Options and Challenges for Efficiency Feed-in Tariffs. *Energy & Environment,* 24(1&2).

be prudent to explore the use of competitive mechanisms in more targeted ways—i.e., to address certain challenging efficiency opportunities or to solicit new ideas or market approaches that have not been tested.

2. New Regulatory Paradigms

There is growing interest across the country in exploring new approaches to regulating electric utilities in order to better respond to a number of emerging industry trends, such as: increasing deployment of rooftop photovoltaics and other forms of distributed generation; consumers' and utilities' growing ability to collect, analyze, and use data on energy usage patterns and costs to inform operations and investment decisions; and growing acknowledgement of the significant opportunities to better optimize investments in T&D infrastructure. The state of New York's "Reforming the Energy Vision" proceeding is perhaps the most prominent and far-reaching example. Among other things, it would aim to both make promotion of energy efficiency by distribution utilities a more integral and integrated part of the way they do business and endeavor to simultaneously "animate" the private market to help deliver cost-effective demand-side alternatives (including efficiency) to more traditional distribution system investments.

In our view, the key to making this work for efficiency—in other words, the key to capturing all the cost-effective efficiency potential—will be to (1) include explicit customer efficiency metrics against which utilities will be judged and upon which their financial rewards will be based; and (2) adopt specific values for such metrics that ensure utility profitability is maximized only when it has truly captured all cost-effective efficiency. Since the effectiveness of this new regulatory paradigm in promoting acquisition of all cost-effective efficiency has not yet been tested, it will be important to regularly review the effectiveness of the performance metrics in encouraging efficiency investment. It may also be prudent to simultaneously establish minimum efficiency savings requirements as a "failsafe," as part of a transition to a new and untested regulatory paradigm.

3. Counting Acquisition of Some Fossil Fuel Savings Towards Electric Savings Targets

Studies in both the United States and Europe suggest that substantial electrification of both building energy use (particularly space heating and water heating) and cars will likely be necessary if we are to affordably reduce greenhouse gas emissions by 80 percent by 2050, the level commonly seen as necessary to stabilize the global climate.[49] In this context, it is worth considering whether to allow improvements, for example, to the insulation levels and air tightness of buildings that are currently heated with natural gas or other fossil fuels to count towards electric savings targets (e.g., translating gas savings to kWh equivalents). From a long-term perspective, if buildings are going to ultimately have to become electrically heated, the savings will ultimately become electric savings anyway.

It is also worth noting that new generations of electric heat pumps can be more efficient, even after accounting for losses in generating and distributing electricity, than the most efficient gas furnace; similarly, electric cars can be inherently more efficient than combustion engine-driven vehicles. In such circumstances, one could argue that fuel-switching these end uses to electricity can increase energy efficiency. In that context, it may also be worth considering whether to allow energy savings that result from increases in efficient electrification to count toward electric savings targets as well. However, such allowance may also justify consideration of increasing savings goals because of the increase in savings opportunity.

These are obviously controversial ideas. However, they are consistent with a need that we see for a more holistic or integrated approach to thinking about energy efficiency (rather than narrowly focusing on the efficiency of just one fuel in isolation).

H. Additional and More Effective Codes and Standards

Achieving 30 percent savings in ten years may also require policy changes beyond the world of electric ratepayer-funded efficiency programs. Indeed, additional policy changes may be necessary to enhance the effectiveness of such programs. Among those that could be of significant value are:

- Adoption of more aggressive building codes for new construction;
- Adoption of building codes for existing buildings. For example, several jurisdictions[50] have adopted

49 For example, see European Climate Foundation. (2010). *Roadmap 2050: Practical Guide to a Prosperous, Low Carbon Europe*; and Energy and Environmental Economics, Lawrence Berkeley National Laboratory, & Pacific Northwest National Laboratory. (2014). *US 2050 Report: Pathways to Deep Decarbonization in the United States.*

50 Examples include Boulder, CO; San Francisco and Berkeley, CA; and Burlington, VT.

rental energy ordinances. Deepening the efficiency requirements (in some cases) and expanding them to other jurisdictions could both provide substantial cost-effective savings and create platforms for helping building owners to move to even higher levels of efficiency. A Boulder, Colorado ordinance appears to have had some success in that regard.[51]

- Mandatory building efficiency benchmarking, labeling, and disclosure requirements. Nearly 20 different cities[52] and two states (Washington and California) have adopted such requirements for at least some types of buildings.[53]
- Adoption of additional or more aggressive federal and state product efficiency standards.
- Adoption of the SAVE Act or other legislation that requires the efficiency of homes to be considered in mortgage underwriting, allowing buyers of more efficient homes to be eligible to purchase more expensive properties and possibly to be eligible for lower interest rates.[54] Such requirements could create greater market demand for more efficient buildings.

51 See Gichon, Y., Cuzzolino, M., Hutchings, L., and Neiger, D. (2012). *Cracking the Nut on Split-Incentives: Rental Housing Policy.* Proceedings of the 2012 ACEEE Summer Study on Energy Efficiency in Buildings, Volume 8, pp. 92-101; (2012). Lawrence Berkeley National Laboratory. (2012). *Boulder, Colorado's SmartRegs: Minimum Performance Standards for Residential Rental Housing.* Clean Energy Program Policy Brief.

52 Boston, Cambridge, New York, Philadelphia, Washington DC, Atlanta, Chicago, Minneapolis, Kansas City, Austin, Boulder, Seattle, Portland, San Francisco, and Berkeley.

53 See Institute for Market Transformation: http://www.buildingrating.org/graphic/us-benchmarking-policy-landscape.

54 See Institute for Market Transformation. The SAVE Act. Summary. Available at: http://www.imt.org/finance-and-real-estate/save-act; Cardwell, D. (2013). Bill Would Sweeten Loans for Energy-Efficient Homes. *The New York Times.* Available at: http://www.nytimes.com/2013/06/07/business/senate-bill-sweetens-loans-for-energy-efficient-homes.html?_r=0.

VI. Conclusions

This report addresses whether it is possible to achieve 30 percent electricity savings in ten years. That is a very ambitious target, requiring far greater savings than efficiency potential studies typically suggest is possible or than leading states are currently on the path to achieving. However, efficiency potential studies are inherently poor tools for assessing the boundaries of what is possible. And though the most aggressive states have dramatically increased savings in recent years, they are not yet fully addressing all currently known technological, programmatic, or policy-driven opportunities for capturing cost-effective savings, let alone new opportunities that we know with virtual certainty will surface over the next decade.

A high-level examination of additional opportunities, including consideration of historic patterns in emerging technology and new market interventions, suggests that it should be possible to achieve 30 percent savings in ten years. That said, it is abundantly clear that such an achievement will only be possible if fundamental enabling policies are put in place. Among these are:

- **Increasing efficiency program funding to whatever level is necessary to capture all cost-effective efficiency.** If efficiency is less expensive than supply alternatives, it should be pursued. That paradigm is an essential prerequisite for achieving 30 percent savings in ten years. Since efficiency program costs replace more expensive utility system options, it is also an essential prerequisite for minimizing total electricity costs.
- **Eliminating utilities' financial disincentives to support efficiency.** The utility business model needs to be aligned with the objective of pursuing all cost-effective efficiency. That includes, but is not limited to, decoupling profits from the volume of throughput on the system.
- **Fixing the way savings goals are structured.** The current emphasis on bottoms-up estimation of annual savings achieved from one to three years of program implementation runs counter to long-term objectives. At a minimum, goals should be expressed in terms of lifetime savings generated over a multi-year period and serious consideration should be given to more sweeping changes such as setting long-term electricity sales goals or electricity intensity goals instead.
- **Fully valuing all of the benefits of efficiency.** The manner in which cost-effectiveness screening of efficiency resources is conducted is fundamentally flawed because it compares only a portion of the benefits of efficiency to its full cost. This misapplication of common cost-effectiveness tests will significantly hinder efforts to cost-effectively achieve 30 percent savings in ten years.
- **Encouraging and rewarding market transformation efforts.** This will require changes in the way savings goals are structured and the way savings are counted. However, such changes are absolutely essential if market transformation efforts are to be undertaken at the scale necessary to reach savings targets on the order of 30 percent in ten years.
- **Striking a better balance in the regulation of utility efficiency programs.** In some states, regulators' approaches to ensuring utilities are not rewarded for "over-counting" savings are likely to be causing greater "waste" by reducing cost-effective efficiency investment, thereby increasing investment in more expensive supply resources. Of particular concern are failures to value market transformation effects, spillover effects, and savings from customer operational efficiency improvements—all of which can provide valuable contributions to meeting aggressive long-term savings targets.

- **Exploring new regulatory approaches to acquisition of efficiency resources.** Such efforts might include new competitive procurement processes or new forms of utility regulation and compensation. Such approaches should be tested in pilot forms or with "backstops" to ensure that the adverse effects of any unexpected failures are minimized.

- **Broadening, accelerating, and improving the effectiveness of efficiency codes and standards.** These tools have been shown to be very effective in capturing significant levels of savings. There are a variety of ways they could be expanded, including through disclosure and performance requirements for existing buildings and potentially for regulation of the efficiency of existing buildings (especially rental properties).

Appendix A:

The Limitations of Traditional Efficiency Potential Studies

Efficiency potential studies have become very detailed endeavors that build up estimates of future savings potential based on literally thousands of individual assumptions, including:

- The list of efficiency measures to be analyzed—typically hundreds if not a thousand or more measures or measure permutations;
- The savings, expected life, incremental cost, load shape, and other features of each measure;
- The size of the market for each measure for each year of the analysis horizon;
- The various components of utility avoided costs, forecast for 30 to 40 years into the future. Depending on the jurisdiction and how comprehensively it assesses benefits, these can include avoided energy costs, avoided transmission and distribution system costs, avoided generation costs, price suppression effects, avoided carbon emissions and other avoided environmental compliance costs, and line loss rates;
- Forecasts of the value of other benefits such as avoided gas or other fossil fuel costs (needed for measures that save multiple fuels), avoided water costs (needed for measures that save water as well as energy), and sometimes other non-energy benefits;
- Estimates of the portion of the technical or economic potential of each measure that is "achievable"—or the portion of their customers that efficiency program administrators could convince to invest in each measure through their efficiency programs. Such estimates are typically developed using models of "adoption curves" that are based on estimates of customers "willingness to pay" studies.

Much can be learned from these studies. They provide useful insights into which measures are cost-effective and which are not—at least at today's savings levels and prices, and today's estimates of avoided costs. They can also provide useful insights into the relative magnitude of savings potential of different measures—at least among measures that are known today. That, in turn, can shed light on the relative effectiveness or ineffectiveness of current programs.

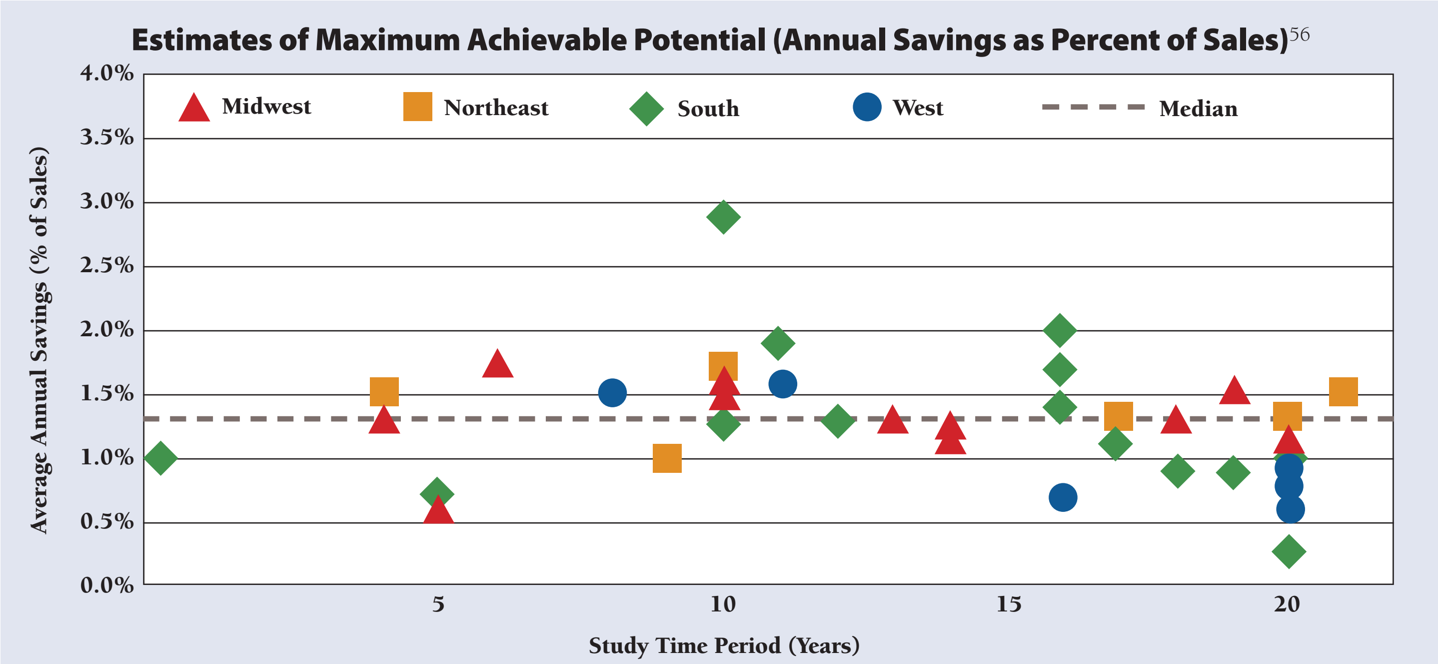
That said, efficiency potential studies have not proven to be very useful at providing insight into the bigger question that they are commonly undertaken to address: How much savings can be cost-effectively achieved over the next decade (or more)? Indeed, it has become clear that they routinely underestimate longer-term savings potential. As Figure A1 shows, the average "maximum achievable" annual savings estimated by nearly 40 different recent efficiency potential studies is about 1.3 percent of annual sales (black line). Interestingly, there do not appear to be any large regional differences in these estimates. Even for the Northeast, the region that has arguably been most aggressive in pursuing efficiency in recent years, the average across six different studies is only slightly higher—about 1.5 percent—with no study suggesting more than about 1.8 percent was possible.

In contrast, the Massachusetts utilities have ramped up to the point where they achieved 2.8 percent in 2014; National Grid in Rhode Island reached almost 3.5 percent in 2014.

A variety of papers and reports have documented many of the reasons that detailed, bottom-up potential studies appear to underestimate what is achievable, particularly in the long term.[55] We will not repeat all of the reasons here.

55 For example, see: Goldstein, D. (2008). *Extreme Efficiency: How Far Can We Go If We Really Need To?* 2008 ACEEE Summer Study on Energy Efficiency in Buildings. Volume 10, pp.44-56; and Kramer, C., & Reed, G. (2012). *Ten Pitfalls of Potential Studies.* Montpelier, VT: The Regulatory Assistance Project.

Figure A1



However, a few are worth highlighting:

- There is an almost universal focus on efficiency measures that are known and documentable today. Even when attempts are made to identify and quantify potential savings from emerging technologies, such efforts are limited to technologies that are known and for which some analysis of savings potential and cost already exists. We are unaware of a potential study that has attempted to account for the truly unknown and unknowable. That is a big omission, particularly as the time horizon for potential studies extends out a decade or more. For example, nearly half of the achievable electric energy savings identified in the Northwest Power and Conservation Council's recently published Draft Seventh Power Plan are from efficiency measures not included in the Council's Sixth Plan produced just five years earlier.[57]
- The potential savings from truly custom measures—particularly for industrial applications—are rarely (if ever) addressed comprehensively. This is a function of the fact that most potential studies build up savings at the measure level. It is impossible, almost by definition, to identify and characterize all possible custom measures.
- Studies rarely attempt to account for increasing savings (as some existing technologies evolve) or decreasing costs (driven economies of scale of production, product familiarity, and other factors) of some measures over time.
- Assessments of the portion of economic potential that are "achievable" are typically based on overly simplistic and inherently conservative assumptions about how customers react to cost vs. savings trade-offs (e.g., payback periods). When efforts are made to benchmark such assumptions, the benchmarking is typically against the "average program" or against other potential studies that approached the question in the same way. Program participation rate assumptions are rarely calibrated against actual experience of the leading or most aggressive programs.
- Studies rarely attempt to account for long-term market transformation effects.

The regulatory context in which potential studies are developed and considered is probably responsible for many of their inherent limitations. First, every one of the

56 Graphic courtesy of Phil Mosenthal of Optimal Energy. See his presentation—*Do Potential Studies Accurately Forecast What is Possible in the Future? Are We Mislabeling and Misusing Them?*—for the ACEEE Energy Efficiency as a Resource Conference in Little Rock, AR, September 21, 2015.

57 Data provided by Charlie Grist, Northwest Power and Conservation Council, October 14, 2015.

literally thousands of assumptions in these studies must be able to withstand intense regulatory scrutiny. Second, the contractors performing the studies must be able to develop and use the thousands of assumptions in a reasonably affordable way or they will not be competitive when bidding on such projects. The tendency is, therefore, to ensure that each assumption is defensible as "mainstream" based on data currently at hand, and can be used over and over again in multiple places without being continually re-examined and revised. That leads to the use of conservatisms whenever there are any potential questions.

It is not surprising that the compounding effect of conservatisms across thousands of assumptions significantly dampens projections of what can be achieved. While that might be acceptable for some types of analyses for some purposes, it is not helpful in exploring the boundaries of what is possible ten years (or more) into the future, especially—as is the case with this project—if such inquiry intentionally assumes no policy constraints and is designed to be a "best estimate" of what is possible (meaning the probability of overestimation and underestimation of savings potential is roughly equal).

Appendix B:

Massachusetts and Rhode Island Utilities' 2014 Efficiency Program Savings

A. Massachusetts and Rhode Island 2014 Results by Program

Both Massachusetts' and Rhode Island's utilities have very comprehensive portfolios of efficiency programs that promote a wide range of efficiency measures to both residential and business customers. Significant efforts are made to serve low-income customers, so there are several programs focused solely on that group of customers. As Table B1 shows, roughly half of the savings come from business customers, both from new construction and equipment replacement projects and from retrofitting of existing buildings. An additional 15-20 percent of savings are produced by residential lighting programs, while an additional 10 percent (MA) to 19 percent (RI) are from residential behavior programs.

Table B1

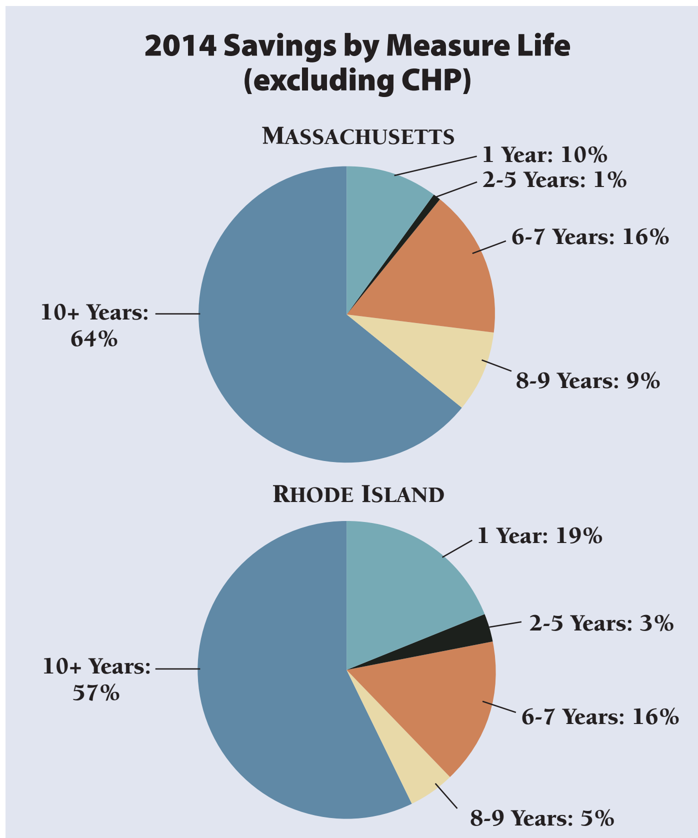
Massachusetts and Rhode Island Electric Savings by Program (excluding CHP)

Sector/Program	MA	RI
Residential New Construction	1%	0%
Residential ENERGY STAR HVAC	1%	1%
Residential Single Family Retrofits	6%	7%
Residential Multifamily Retrofits	2%	2%
Residential Behavioral	10%	19%
Residential ENERGY STAR Lighting	18%	16%
Residential ENERGY STAR Products	1%	3%
Low-Income New Construction	0%	0%
Low-Income Single Family Retrofit	1%	3%
Low-Income Multifamily Retrofit	2%	2%
C&I New Construction/Equip. Replacement	24%	18%
C&I Retrofit	26%	19%
C&I Direct Install	8%	10%

B. Massachusetts and Rhode Island 2014 Results by Measure Life

As Figure B1 shows, roughly 60 percent of the first year savings from both Massachusetts and Rhode Island's electric efficiency programs come from measures with estimated savings lives of ten years or more.[58] On the other hand,

Figure B1



58 Savings by measure life were estimated for Massachusetts by analyzing measure level data for both NSTAR and National Grid. (See Appendix 2 of filings by each utility with the Massachusetts Department of Public Utilities in

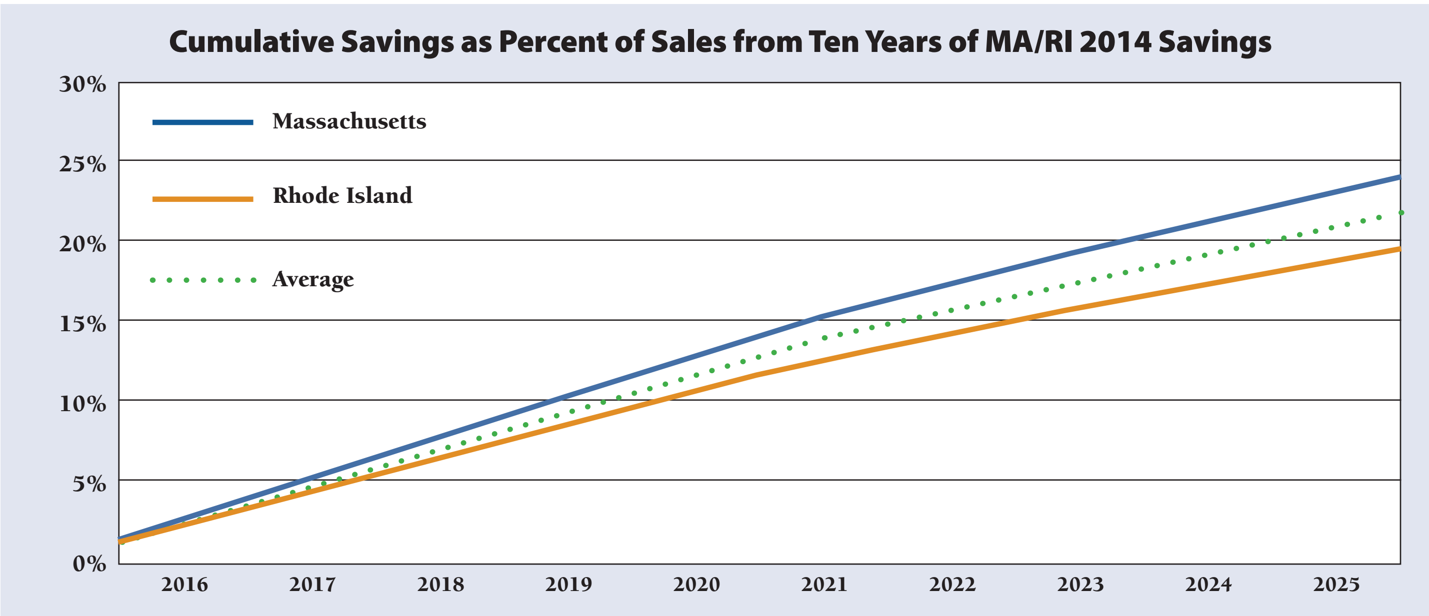
continued on next page

ten percent of the Massachusetts savings and 19 percent of the Rhode Island savings had a life of only one year; virtually all of those one-year savings are from their residential behavior programs.[59] Most of the rest of the shorter-lived savings—primarily from CFLs and a portion of commercial LED applications—have lives of six to eight years.

C. Ten-Year Implications of Massachusetts and Rhode Island 2014 Results

Figure B2 shows what the cumulative persisting savings would be if both the magnitude and the mix of savings lives in the Massachusetts and Rhode Island 2014 programs were repeated each year for ten years. As noted above, because some of the measures being installed each year have lives that are less than ten years, the cumulative persisting savings in ten years would be less than the annual savings multiplied by ten. Specifically, the cumulative persisting annual savings in year ten would be about 23 percent for Massachusetts and 19 percent for Rhode Island. The two-state average of about 21 percent serves as the foundation for the balance of our analysis of what would be required to achieve 30 percent savings in ten years.

Figure B2



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Docket 15-49.) NSTAR and National Grid are the two largest program administrators in Massachusetts. Together they accounted for nearly 90 percent of the state's reported 2014 electric savings. National Grid also serves virtually all of Rhode Island. Thus, the mix of measure lives within each type of program were assumed to be the same in Rhode Island as for National Grid in Massachusetts. Those program level mixes were then multiplied by the slightly different profile of savings by program in Rhode Island to produce a portfolio mix for that state.

59 There is evidence to suggest that savings from residential behavior programs would persist for more than a year—declining by only about 20 percent annually—if the programs were stopped. (Khawaja, S., & Stewart, J. (Winter 2014/2015). Long-Run Savings and Cost-Effectiveness of Home Energy Report Programs. Cadmus.) However, such programs are not designed to be one-off investments. Rather, utilities typically run them every year to both eliminate any erosion of savings and support marketing of their other programs. Thus, there are ongoing debates in several states regarding how to deal with measure life assumptions for such programs. If a life of longer than one year were to be adopted, the annual savings claimed each year would have to be reduced. That is probably the most accurate way to reflect the impact of such programs. However, it is a somewhat complicated approach to put in place because one needs to carefully tease out of each year's evaluated savings the portion that was attributable to the previous year's funding of the portion attributable to the current year's efforts. This distinction becomes less important in the context of the ten-year savings goal analyzed in this report (as all that matters is how much total savings the program can deliver after ten years).

Appendix C:

The Impact of Federal Lighting Efficiency Standards

In 2012, new federal efficiency standards for general service fluorescent lamps effectively banned the sale of new T12s, as well as the first generation (known as 700 series) of T8 lamps.[60] The new minimum requirements are on the order of 25 percent more efficient than a typical T12.[61]

Utility efficiency programs that have claimed linear fluorescent lighting savings relative to a T12 baseline will be affected by the recent change in minimum efficiency standards. At a minimum, it would appear necessary to assume that any light fixtures that are replaced during a normal stock turnover cycle would have been at least as efficient as an 800 series T8; any new savings from more efficient products would be measured relative to that baseline. While one could theoretically argue that efficiency programs could still generate savings relative to a T12 baseline with retrofit programs that cause such existing inefficient fixtures to be replaced before they otherwise would have been (i.e., outside of the "normal stock turnover cycle" referenced earlier), it is likely a stretch to argue that such "early retirement" savings would still be persisting ten years from now (i.e., within the timeframe of interest to this project) as most such existing T12s would likely have been replaced during natural replacement cycles by then. Again, that does not mean that electric grids will not see substantial savings as a result of businesses replacing very inefficient T12s with T8s (or better). It only means that such savings would not "count" toward the savings target we are examining in this report.

The magnitude of the effect that the current linear fluorescent efficiency standard will have on utility program savings will ultimately depend primarily on the portion of the utility's current commercial and industrial (C&I) lighting savings that are based on an assumed T12 baseline. Public data on the magnitude of Massachusetts and Rhode Island business electricity savings that are derived from linear fluorescent lighting for which the baseline was assumed to be a T12 are not available. However, only about four percent of linear fluorescent light fixtures currently in use in Massachusetts businesses are T12s.[62,63] Similarly,

Fluorescent Lamp Comparisons

The T12, T8, and T5 designation for fluorescent lamps refers to how many eighths of an inch in diameter the light measures. For example, a T12 lamp is 1.5 or 12/8 of an inch in diameter.

The Retrofit Companies Blog (2013, March). When Are Your Fluorescent Lights Being Discontinued?

60 The 800 Series of T8s require significant quantities of several rare earth minerals that were recently subject to supply constraints. As a result, a number of manufacturers applied for and were granted two-year extensions for compliance, during which time they could continue to manufacture 700 Series T8s.

61 For further description of lighting fixtures, see The Retrofit Companies Blog (2013, March). When Are Your Fluorescent Lights Being Discontinued?

62 DNV-GL. (2015). Massachusetts Commercial and Industrial Customer On-Site Assessments: Interim Results Report. Prepared for the Massachusetts Program Administrators and Energy Efficiency Advisory Council Consultants.

63 It is also worth noting that, even for the likely rare cases in which T12s are retrofitted, both the Massachusetts and Rhode Island utilities stopped claiming savings relative to the full T12 wattage after 2012. By agreement with their respective state Advisory Councils, the baseline wattage of T12 retrofits is being "de-rated" by an increasing amount every year between 2013 and 2017, such that by 2017 it is effectively assumed that the baseline is equivalent to an 800 Series T8 (i.e., about 88 Watts for a four-foot, three-lamp fixture).

low levels of existing T12s have been documented in some of the other states with aggressive efficiency programs and/or standards.[64] Thus, it appears reasonable to assume that the impact of the most recent linear fluorescent fixture efficiency standards on the Massachusetts and Rhode Island utilities will be very small—too small to warrant adjusting our estimates of the impact of continuing 2014 levels of savings into the future.

Standards for linear fluorescent fixtures will be modified again in 2018, when the minimum efficiency requirements for T8s will be increased by about another four percent.[65] That will likely affect virtually every utility's estimates of commercial lighting savings because utilities today typically do not assume a baseline efficiency that is greater than an 800 series T8. The magnitude of the impact will depend on the portion of commercial lighting savings associated with linear fluorescents. It will also depend on the mix of linear fluorescent measures. The new standards will reduce savings associated with upgrades to high performance T8s by about 25 percent. It will have much smaller effects on savings associated with T5s (i.e., fluorescent lamps that are 5/8 of an inch in diameter), LED troffers (i.e., typically a trough-shaped reflective box fluorescent lamps), de-lamping, and controls. It is difficult to say precisely how much of an impact this increasing baseline would have on the Massachusetts and Rhode Island utilities because detailed data on the portion of their commercial lighting savings coming from linear fluorescent lighting measures—let alone the portion coming from different efficiency measures affecting linear fluorescent electricity consumption—are not publicly available. Based on limited data that are available, we estimated that the effect will be to reduce the Massachusetts and Rhode Island utilities' commercial lighting savings by between five percent and ten percent beginning in 2018.[66]

A. Impact of Residential Lighting Standards

Section 321 of the 2007 Energy Independence and Security Act (EISA) established minimum efficiency standards for general service lamps. The standards were intended to eliminate the then typical 40W, 60W, 75W, and 100W screw-based incandescent light bulbs.

EISA had two phases. In the first phase, starting in 2011 for 100W bulbs and concluding by 2013 for 40W bulbs, maximum wattages of light bulbs were required to go down by 25-30 percent (e.g. the lighting output of an old 75W incandescent would be required to be met with a maximum of 53W). One key impact of those requirements was that manufacturers shifted significant production to halogens that just met the new efficiency standards. Though more efficient than the old incandescent bulbs that they replaced, the new halogens are still much less efficient than compact fluorescent light bulbs (CFLs) or LEDs, but they are the same size and have very high color rendition which makes them attractive to some buyers. Utility programs that currently promote screw-based CFLs or LEDs—particularly for residential applications—typically already reflect the change in baseline, from incandescent to halogen, in the way savings were estimated or "counted" in 2014.

Under the second phase of EISA's general service screw-based lighting requirements in 2020, the US Department of Energy is to put in place a new standard requiring all general service lamps to produce at least 45 lumens per watt. That would have the effect of cutting the current (EISA phase 1) maximum wattage in half, or effectively mandating efficiency levels that begin to approach those of current CFLs. Thus, if this second phase of standards goes into effect as anticipated when the law was passed,[67] there would be substantial savings on the grid, but little room

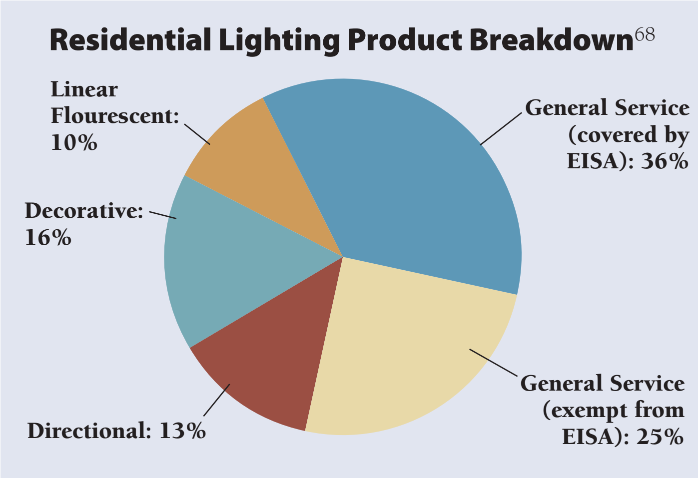
64 For example, see slide 18 in: Mellinger, D. (2015). State of the Commercial Lighting Market in Vermont. Presented at Efficiency Vermont's 2015 Better Buildings by Design conference.

65 For a summary description of recent and planned future changes in general service fluorescent lamp standards, see: http://www.appliance-standards.org/node/6802.

66 That is consistent with the following assumptions: 50 percent of C&I lighting savings are from measures affecting linear fluorescent electricity consumption; 50 percent of the linear fluorescent savings are from HPT8s; savings from HPT8s are 25 percent lower under the new 2018 standard than under the current standard; savings from other non-HPT8 measures affecting linear fluorescent lighting consumption (e.g., T5s, LED troffers, de-lamping, and control) are five percent lower under the new 2018 standard.

67 There has been significant political opposition to the lighting standards since they were enacted, including attempts to either weaken or completely repeal them. A federal bill with a rider that will prohibit the US Department of Energy from enforcing the 2020 standards has already become law, though it is unclear whether that will have any significant effect on the market as manufacturers may still be loath to violate the law and states and private parties could still sue to enforce the law through the courts. For the purposes of this project, we assume that the standards will go into effect as passed and that manufacturers will abide by their requirements.

Figure C1



for additional savings to be generated by utility ratepayer-funded efficiency programs.[69]

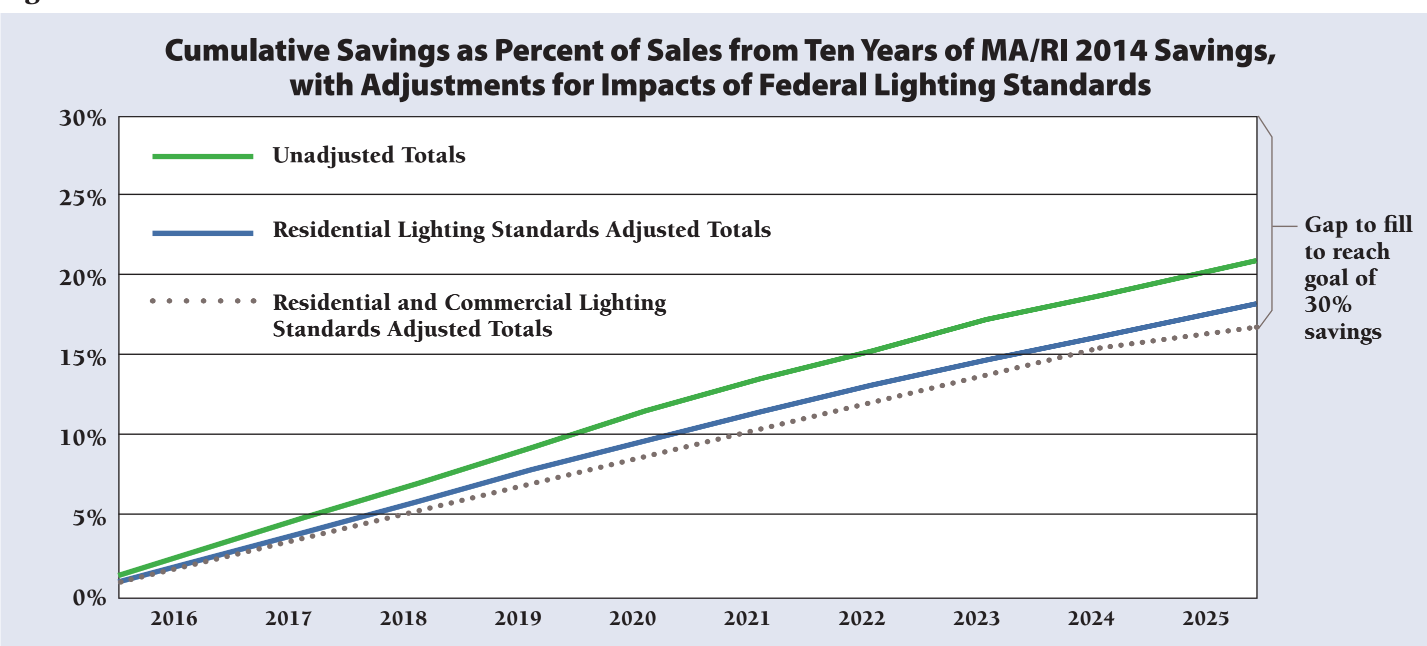
That said, as Figure C1 illustrates, the EISA standards only cover about one-third of products in residential light sockets. A number of general service lamp types—including three-way and incandescent bulbs with less than 40W or greater than 150W—are exempt from the standards. Also exempt are incandescent reflector (directional) lamps, "candelabra-based" (decorative) lamps, and a variety of others serving niche applications.

Current utility residential lighting programs are getting savings from both EISA-covered products and non-EISA products. We assume that about half of the residential lighting savings being produced by all of the Massachusetts and Rhode Island residential and low-income efficiency programs are associated with EISA-covered products. Put another way, we assume that about half of the Massachusetts and Rhode Island 2014 residential and low-income lighting savings should not be able to contribute to a 2025 cumulative persisting annual savings goal. That is a significant adjustment, not only because both states' residential lighting programs produce a significant portion of the total portfolio savings, but also because lighting savings are an important part of many of their other residential and low-income programs (particularly whole building retrofit programs).

B. Adjusting MA/RI 2014 Savings to Account for Future Impact of Lighting Standards

Figure C2 shows the cumulative persisting annual savings over the next ten years assuming that the average of the 2014 results for Massachusetts and Rhode Island were realized each year, but with downward adjustments

Figure C2



68 Miziolek, C., Wallace, P., & Lis, D. (2015). *The State of Our Sockets: A Regional Analysis of the Residential Lighting Market.* Northeast Energy Efficiency Partnerships.

69 Though LED technology may provide some additional savings potential, the increment will be relatively small compared to the change in wattage utility programs currently claim relative to an EISA phase 1 halogen baseline.

to account for the portion of residential and commercial lighting savings that will become part of the "baseline" condition as a result of federal efficiency standards discussed above. The green line is the unadjusted average for the two states, ending at just under 21 percent in 2025. The blue line is the savings if adjustments are made only to the account for the impacts of residential lighting efficiency standards. It ends at slightly under 18 percent in 2025. The dotted grey line is the net impact of adjusting for both residential and commercial lighting standards. It ends at a little over 17 percent. That is the adjusted point from which the discussion in the rest of this paper builds.

Appendix D:

Representativeness of Massachusetts and Rhode Island

Massachusetts and Rhode Island are different from some other parts of the country in a number of ways. Since this report is meant to address electric efficiency potential across the United States, it is important to consider whether the differences between Massachusetts and Rhode Island and other parts of the country have implications for achievable cost-effective savings potential and, to the extent possible, either adjust for such differences or qualify our conclusions. To that end, we consider several factors that could theoretically affect electricity savings potential. Where possible, we analyze relevant data on each of these factors. However, in many cases our conclusions are necessarily qualitative as there has been relatively little (or no) empirical research on the relative importance of each of the factors.

A. Costs of Electricity

Average retail electricity prices in Massachusetts (14.5 cents/kWh) and Rhode Island (13.7 cents/kWh) were above the national average (10.1 cents/kWh) in 2013.[70] In theory, that could make customers in the region more willing to make investments in energy efficiency. However, we are unaware of empirical analysis that would support such a conclusion. While it is true that all four of the states that produced the greatest levels of electricity savings in 2014 had higher than average electric rates, it is also true that seven of the next 12 highest ranking states had average rates at or below the national average,[71] in some cases well below average.[72] Also, the two Northeastern states with the highest average electric rates—New York and Connecticut—had electricity savings levels in 2014 that were one-half to one-third the levels achieved in neighboring Massachusetts and Rhode Island. In short, it is not clear that there is a significant correlation between costs of electricity and achievable savings potential.

B. Magnitude of Avoided Costs

Anecdotally, it appears as if the avoided costs use for cost-effectiveness screening of efficiency measures and programs in New England are higher than those used in many other states. One might hypothesize that such differences could make more energy efficiency measures and programs cost-effective, leading to greater savings potential. However, while some such effect is possible, we do not believe it is substantial. One reason for differences in avoided costs between New England and many other regions of the country is that the New England states endeavor to more comprehensively assess avoided supply costs, particularly avoided transmission and distribution costs. Secondly, and perhaps more importantly, most of the electricity savings being acquired in Massachusetts and Rhode Island passes cost-effectiveness screening easily. In fact, the average TRC benefit-cost ratio for Massachusetts' 2014 programs was 3.49 to 1; only one non-low-income program,[73] which accounted for about one percent of portfolio savings,[74] had a benefit-to-cost ratio of less than 2 to 1. In other words, even if avoided costs were cut in half, it would have had a negligible impact on the level of savings pursued.

70 US Energy Information Administration. (2015). *Electric Power Annual.* Table 2.10.

71 For state rankings in delivery of electricity savings see Table 13 in Gilleo, A., Nowak, S., Kelly, M., Vaidyanathan, S., Shoemaker, M., Chittum, A., and Bailey, T. (2015, October). *The 2015 State Energy Efficiency Scorecard.* ACEEE Report U1509.

72 Iowa, Illinois, Oregon, and Washington all had average electric rates below 8.5 cents/kWh in 2013.

73 All the low-income programs had a benefit-to-cost ratio of at least 1.7 to 1.

74 The Residential HVAC equipment program had a benefit-to-cost ratio of 1.45 to 1.

C. Climate

The climate in southern New England is certainly different than in many other parts of the country. It is colder than many other places in the winter and, though peak cooling days can be quite hot, the cooling season is shorter and considerably less severe than in the South or the desert Southwest. One implication of those differences is that heating savings may be more likely to be cost-effective and cooling savings may be less likely to be cost-effective than in many other parts of the country.

That said, there is relatively little electric heat in New England, so—despite more heating hours—the magnitude of heating savings potential is quite low. Indeed, it is probably lower than in many milder climates. Though central cooling is almost ubiquitous in commercial buildings, it is not in residential homes, which rely on a mix of central and window air conditioning.

The upshot is that New England probably has a higher proportion of its electric savings potential in non-space conditioning end uses. It is difficult to say exactly what that might mean in terms of the ability to save large portions of baseline electricity use. It is possible that it makes it a little easier to achieve higher percentage savings, as the history of efficiency programs suggests that thermal envelop improvements (which are an important way to reduce heating and cooling loads) are among the most difficult of the efficiency measures to effectively promote.

D. History of Investment in Energy Efficiency

Massachusetts and Rhode Island have among the longest histories of aggressive state efforts to promote energy efficiency. On the one hand, one might argue that this experience will make it easier to achieve deep levels of savings because the states have helped build an extensive and increasingly sophisticated infrastructure of efficiency service providers and increased the awareness and sensitivity to efficiency opportunities among customers and the product supply chains that sell to them. On the other hand, one could also argue that their experience will make it more difficult to achieve deep levels of savings because they have already captured a lot of the easiest savings. Intuitively, both arguments have merit. It is not clear what the net effect of these two factors is.

E. Summary

We are unaware of any analysis that could offer definitive insights into the extent to which the success of leading states in acquiring electricity savings is transferable. Our qualitative assessment suggests that there are some factors that might suggest that savings percentages in the southern New England states of Massachusetts and Rhode Island would be expected to be a little larger than in some other parts of the country, and other factors which push in the opposite direction. Our professional judgment is that the net effect of all these factors is likely to be fairly small. As noted above, the results of dozens of efficiency potential studies also suggests that achievable cost-effective savings potential does not vary considerably (if at all) from region to region.

Appendix E:

LED Alternatives to Linear Fluorescent Lighting

Nationally, commercial customers currently account for approximately 36 percent of total electricity consumption. Between 35 percent and 40 percent of commercial electricity use is for lighting; the majority of that consumption is associated with various forms of linear fluorescent fixtures, particularly T12s and T8s. Linear fluorescent fixtures also play important, though less substantial, roles in residential and industrial lighting.

As discussed above, many program administrators have historically achieved substantial portions of their lighting savings by persuading business customers to install high performance T8s and other measures that reduce linear fluorescent lighting consumption (e.g., T5s, de-lamping, controls). Both because of the effects of new federal efficiency standards and, in some jurisdictions, success in helping a substantial portion of business customers to install more efficient linear fluorescent technology, it is sometimes argued that the "low-hanging fruit" of C&I lighting is or will soon be largely "picked." However, that argument ignores the evolution of technology. In particular, it ignores the emergence of LED alternatives to linear fluorescent fixtures, or what are often called LED troffers.

As Table E1 shows, high performance T8s currently save 11 percent to 22 percent relative to the current federal minimum efficiency standard for linear fluorescent lighting. In contrast, an LED troffer provides 45 percent savings on its own (or two to four times as much savings as an HPT8) and 66 percent if installed with integrated controls (or three to six times as much savings as an HPT8). These savings are already cost-effective ($0.06 to $0.11 per kWh saved, depending on the situation). Moreover, both because their performance is improving and their cost is declining, their cost-per-unit of savings is forecast to improve by 50-80 percent (down to $0.01 to $0.05 per kWh saved) by 2025. Put simply, LED alternatives to linear fluorescent lighting fixtures offer a massive reservoir of new and very cost-effective savings potential that most efficiency programs—even most efficiency potential studies—have not even considered tapping.

Because their savings potential is so substantial even compared to an HPT8 baseline, the emergence of LED troffers will permit utility programs to revisit and re-serve virtually every single business customer they have already treated with HPT8s. Moreover, because utility programs already have valuable data for those customers (e.g., numbers of existing light fixtures, typical run hours, etc.), they will be able to develop estimates of savings potential and strategies for reaching out to the customers before revisiting them, saving time and money while increasing marketing effectiveness. Indeed, even relative to an HPT8 baseline, we estimate that the conversion of 75 percent of linear fluorescent fixtures to LED troffers with integrated controls over the next ten years would produce savings equal to approximately 2.2 percent of national electricity sales in 2025.[75,76]

75 This is an estimate of just the lighting savings. We have not adjusted the estimate for additional cooling energy savings or heating energy penalties.

76 We are not suggesting that fixtures first get converted to HPT8s and then again (later) to LED troffers. It would obviously be ideal to just promote the most efficient technology. We are only suggesting that when assessing how much further beyond what Massachusetts and Rhode Island 2014 savings levels one can go, one needs to account for the fact that the 2014 Massachusetts and Rhode Island savings levels already account for the next major increment in linear fluorescent savings potential (i.e., to very high market penetrations of HPT8s) over the next decade.

77 Table E1 was developed by Dan Mellinger, Vermont Energy Investment Corporation Lighting Strategy Manager. It is an expanded and updated version of one he developed for a 2013 business lighting white paper: Mellinger, D. (2013, July 15). *A New Dawn in Efficient Lighting: The Future of Efficiency for Businesses.* Burlington, VT: Vermont Energy Investment Corporation.

Table E1

Comparison of LED Troffer Savings to HPT8 Savings[77]

	Lighting Technology[i]	Typical System Watts[v]	Savings		Estimated Upgrade Cost[vi]					
					Total Cost		Cost/Watt Saved		$/kWh Levelized	
			Watts Saved vs. 2014 Baseline	% Saved vs. 2014 Baseline	Time of Natural Replace-ment	Early Retirement Retrofit	Time of Natural Replace-ment	Early Retirement Retrofit	Time of Natural Replace-ment	Early Retirement Retrofit
2012 Baseline[ii]	3-lamp F32 T8 (89 lpW) w/ 0.88 Ballast	88	--	--	--	--	--	--	--	--
2014 Baseline[iii]	3-lamp F32 T8 (89 lpW) w/ 0.88 HE Ballast	84	--	--	--	--	--	--	--	--
2018 Baseline[iv]	3-lamp F32 T8 (92 lpW) w/ 0.88 HE Ballast	81	--	--	--	--	--	--	--	--
HPT8	3-lmap F32 T8 High Lumen w/ 0.77 HE Ballast	75	9	11%	$15	$100	$1.67	$11.11	$0.03	$0.23
	3-lamp F28 Reduced Watt w/ 0.77 HE Ballast	66	18	21%	$15	$100	$0.83	$5.56	$0.02	$0.11
LED	2015 LED 2x4 Troffer, 5200 lumens[vii] 112 lpW[viii]	46	38	45%	$115	$200	$3.06	$5.32	$0.06	$0.11
	2020 LED 2x4 Troffer, 5200 lumens[vii] 131 lpW[ix]	40	44	53%	$62	$147	$1.40	$3.32	$0.03	$0.07
	2025 LED 2x4 Troffer, 5200 lumens[vii] 156 lpW[x]	33	51	60%	$30	$115	$0.60	$2.28	$0.01	$0.05
LED + Integrated Controls[xi]	2015 LED 2x4 Troffer, 5200 lumens[vii] 112 lpW[viii]	28	56	66%	$190	$275	$3.41	$4.94	$0.07	$0.10
	2020 LED 2x4 Troffer, 5200 lumens[vii] 131 lpW[ix]	24	60	71%	$114	$199	$1.91	$3.33	$0.04	$0.07
	2025 LED 2x4 Troffer, 5200 lumens[vii] 156 lpW[x]	20	64	76%	$69	$154	$1.09	$2.42	$0.02	$0.05

i A 3-lamp T8 configuration was selected based on Efficiency Vermont projects from 2000 — 2015 where the average number of lamps per fixture is 2.9

ii 2009 General Service Fluorescent Lamp DOE Rule (effective 2012) established 89 ipW efficacy standard for 4' T8 fluorescent lamps. http://www.appliance-standards.org/node/6802

iii 2011 Fluorescent Ballast DOE Rule (effective 2014) established efficiency standards fluorescent ballasts. http://www.appliance-standards.org/node/6811

iv 2015 General Service Fluorescent Lamp DOE Rule (effective 2018) establishes 92.4 ipW efficacy standard for 4' T8 fluorescent lamps. http://www.appliance-standards.org/node/6802

v Fluorescent wattages based on Xcel Energy Input Wattage Guide. http://www.xcelenergy.com/staticfiles/xe/Marketing/MN-Bus-Lightning-Input-Wattage-Guide.pdf

vi Equipment costs based on Efficiency Vermont past projects; labor costs assume ½ hour per fixture at $50/hour; future LED costs are based on 2014 DOE Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. http://energy.gov/sites/prod/files/2015/05/f22/energysavingsforecast14.pdf

vii 5200 lumens is approximately equivalent to a 3-lamp "800 series" 89 ipW T8 (3 lamps x 2710 means lumens x 0.88 ballast factor x %72 fixture efficiency)

viii Average efficacy of DesignLights Consortium Premium Tier LED 2x4 Troffers as of Nov. 2015. http://www.designlights.org/qpl

ix 2020 efficacy forecast per 2014 DOE Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. http://energy.gov/sites/prod/files/201505/f22/energysavingsforecast14.pdf

x 2025 efficacy forecast per 2014 DOE Energy Savings Forecast of Solid-State Lighting in General Illumination Applications. http://energy.gov/sites/prod/files/2015/05/f22/energysavingsforecast14.pdf

xi Wireless integrated controls (occupancy, daylight, task tuning) can save 39% of lighting energy per LBNL Wireless Advanced Lighting Controls Retrofit Demonstration. http://www.gsa.gov/portal/mediald/227615/fileName/Wireless_Advanced_Lighting_Controls_Retrofit_Demo_FINAL_508-0629

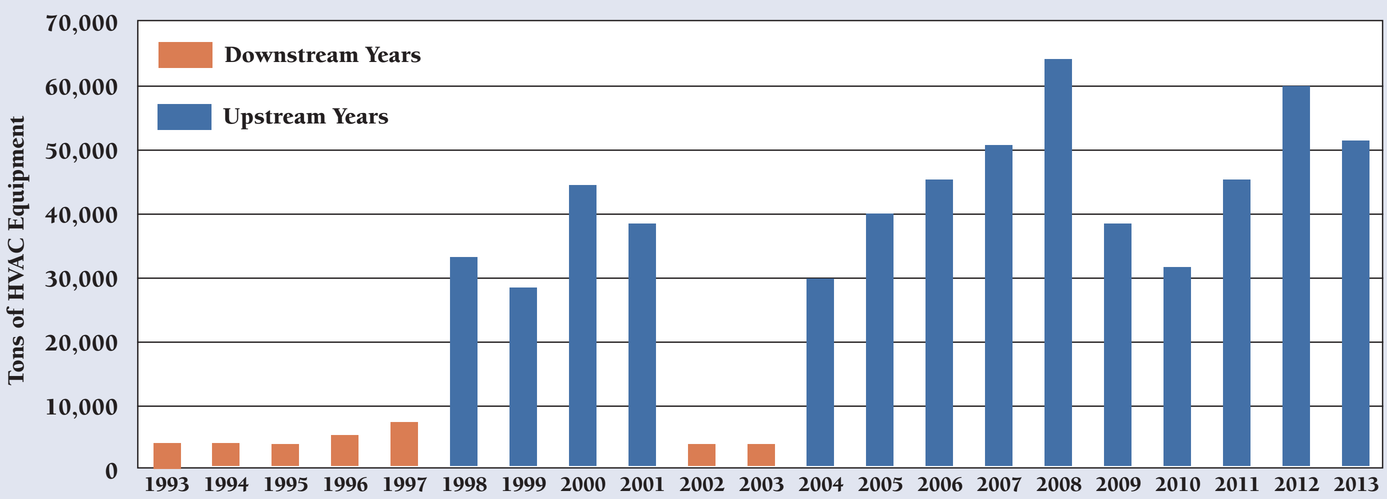
Appendix F: Expanding Consideration of Upstream Product Rebates

Upstream incentives—that is, incentives paid to manufacturers, distributors, contractors, and other key players in the supply chain rather than to the end use customers—can have several advantages. Most importantly, they typically lead to much higher market penetration rates for efficient equipment. That can be seen in Figure F1, which shows that a commercial cooling equipment upstream incentive program (blue bars) run by Pacific Gas and Electric in California achieved nine times the level of participation that its former downstream customer rebate program design (red bars) achieved. Notably, when the program design was changed back to a customer rebate after four years of the upstream model, participation plummeted again. After two years of that much lower participation rate, the upstream incentive approach was re-initiated and participation skyrocketed again. Very similar results have been achieved in California for commercial gas boilers and other products.[78]

Similarly, in September 2013 Efficiency Vermont launched an upstream incentive for high efficiency circulator pumps for boilers and saw the market share (from one of the leading HVAC wholesalers) for those products increase from two percent or less to about 50 percent in the span of just one year. It took about six months to get the program off the ground, but it has continued to grow steadily.[79] Today, the program is producing as many participants every 2.5 days as it did

Figure F1

Pacific Gas & Electric Commercial HVAC Program Participation Increases with Upstream Incentive[81]



78 Personal communication between Jim Hanna (Energy Solutions) and Jim Grevatt, July 2015.

79 Personal communication with Jake Marin, Efficiency Vermont, July 2015.

80 Personal communication with Howard Merson, Efficiency Vermont, August 27, 2015.

81 Mosenthal, P. (2015). Do Potential Studies Accurately Forecast What Is Possible in the Future? Are we Mislabeling and Misusing them? Presented at the ACEEE Efficiency as a Resource Conference, Little Rock, AR. Graphic provided to Mr. Mosenthal by Jim Hanna, Energy Solutions.

in an entire year before moving to an upstream strategy.[80] Moreover, it has had documentable market transformation effects. For example, when the upstream program was initially launched, Taco, the largest manufacturer of circulator pumps, did not have a product on the market that met Efficiency Vermont's program specifications. They subsequently modified their equipment to produce a new product that did. Moreover, they even appear to have named the product after the Vermont program: VT 2218.

The Connecticut utilities have also had notable recent success in moving residential HVAC and water heating equipment incentives upstream to distributors. That includes:

- Ten-fold increase in high efficiency gas water heater participation in the first year (and on track for 50 percent greater participation in the second year, or a nearly 15-fold increase over the last year of downstream rebates);
- Six- to seven-fold increase in electric heat pump water heater participation in the first year; and
- 70 percent increase in efficient gas boiler participation in the first year (on track for roughly another doubling in participation in the second year, or a roughly three-fold increase relative to the last year of downstream rebates).[82]

These types of increases in market penetration happen for several reasons. First, it is generally easier to inform and work with a relatively small number of strategic market actors who influence (through their own stocking and sales practices) the purchases of thousands of end use customers. Second, because the cost of products is typically marked up at every step in the supply chain, a financial incentive paid to a distributor will cover a higher fraction of the incremental cost of a product (making it easier to persuade the distributor to stock and promote it) than the same financial incentive paid to an end-use customer. Third, upstream incentives are easy to set up in ways that eliminate the need for filling out of rebate forms and other paperwork that downstream players often hate. To be sure, launching an upstream program requires effort to build relationships with distributors and to reach agreement with them on how the program will work. However, once the relationships are established and the program systems are in place, the program may also potentially enable reductions in marketing and administrative costs. Moreover, once an upstream program for one type of equipment is in place, it is much easier to launch similar initiatives for other products sold by the same distributors (or other upstream market actors).

These days, residential lighting programs are almost universally delivered as upstream programs. However, few jurisdictions have gone upstream in other markets. Some have done so with commercial lighting products with some success and, as noted above, a few leaders have done the same with HVAC and water heating equipment. The dramatic success of these efforts suggests that this type of approach ought to be at least considered for many more types of efficient equipment (e.g., residential appliances, commercial office equipment, food service equipment, and ventilation equipment).

82 Parsons, J., (2015). Dramatically Increase Residential HVAC Program Participation with an Upstream Approach. The United Illuminating Company. Presented at the 2015 ACEEE Efficiency as a Resource Conference.

Appendix G:

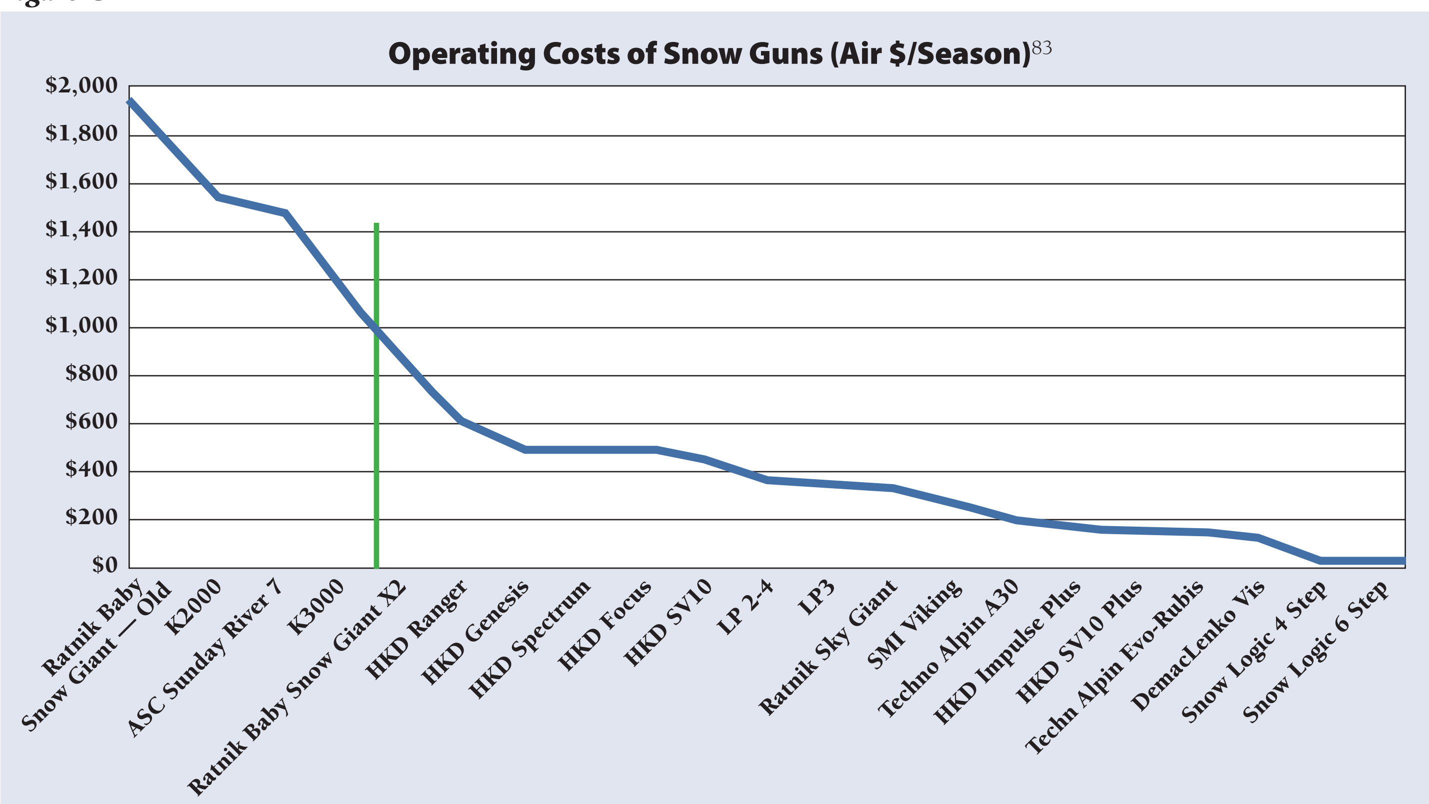
Vermont's Transformation of the Snowmaking Gun Market

Many of the thought leaders that we interviewed for this project suggested one of the defining characteristics of today's leading states is that they are more carefully segmenting their markets and tailoring their efficiency program or service offerings to the unique needs of different types of businesses—whether grocery stores, hospitals, automotive manufacturing, or any other type of customer for which needs and opportunities may be similar. These approaches are married with sophisticated "account management" models in which staff is dedicated to working with specific larger customers and industries.

Some of these leading jurisdictions have begun to advance this concept to another level in which they pursue what we will call industry "deep dives." That can include not only doing extensive assessments of energy savings opportunities at individual facilities, but also investing in efforts to understand the business needs to unearth either unknown barriers or new opportunities to leverage in promoting efficiency investments and, where potentially appropriate, working closely with the supply chains for those businesses to help better position and potentially even modify product offerings to maximize efficiency.

One notable example is Efficiency Vermont's recent work with the state's ski industry. Since its inception in 2000, Efficiency Vermont has worked fairly closely with ski areas

Figure G1



83 McMurry, J., & Lawrence, G. (2014). *Snow Gun Performance, Efficiency, and Operating Costs.* Presented at the Ski Areas Best Practices Exchange. Burlington, VT: Efficiency Vermont

in the state. It has also achieved significant savings from that work, both from the promotion of efficient snow guns and from work to help ski areas with both the design and construction of new and retrofitting of existing hotels, condos, and other buildings. However, a few years ago, it began to go a little deeper in its efforts to promote more efficient snow guns. First, it bought testing equipment and began investing considerable effort to test the efficiency and demonstrate the effectiveness of different snow guns at ski resorts and wherever else they could get an interested audience. From 2012 through 2014, Efficiency Vermont staff spent a day testing snow making equipment at each of the National Ski Areas Association's annual eastern region meetings. Each vendor's guns were lined up on the same trail, with the same test applied to each. The data collected were then presented at the conference the day after the testing—typically to a standing-room-only crowd. As Figure G1 illustrates, the tests clearly demonstrated that there were significant differences not only between the energy efficiency of old snow guns (those to the left of the green line) and new snow guns (those to the right of the green line), but also between the new guns themselves. In fact, the most efficient new guns (the Snow Logics) have operating costs that are more than 95 percent lower than the least efficient new gun on the market (the Ratnik Baby Snow Giant X2).

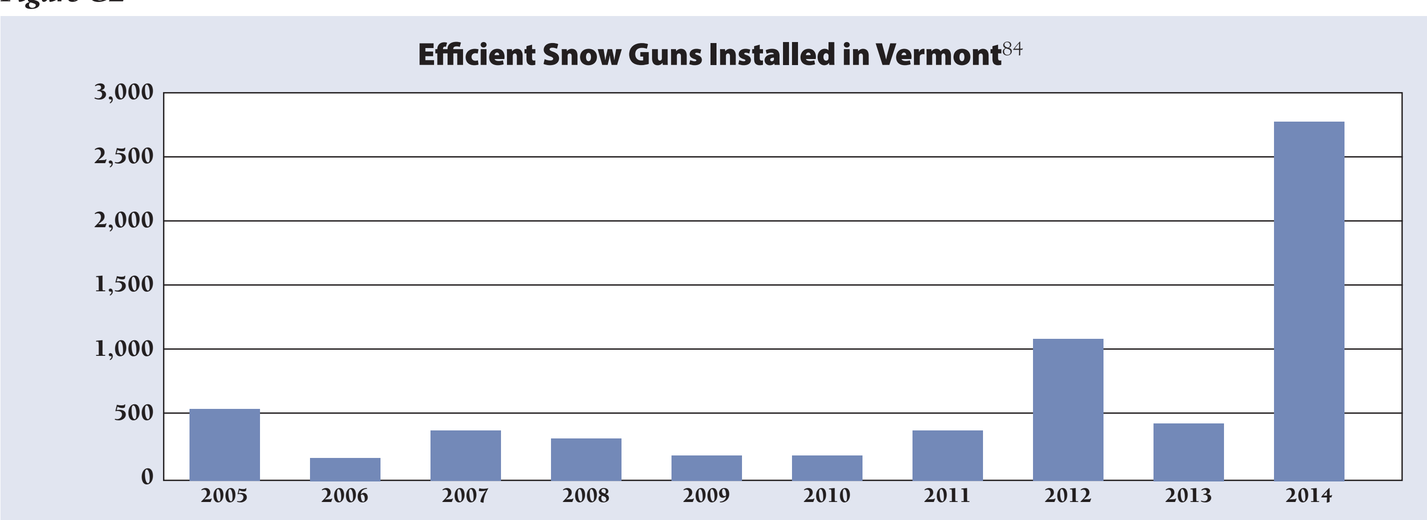
The testing also demonstrated that many of the more efficient guns also functioned at higher air and water temperatures (important for extending the ski season), made better snow, and were quieter than the alternatives.

Prior to Efficiency Vermont's testing, these differences in performance were not fully understood by the industry. Indeed, there was considerable skepticism among ski areas about snow gun efficiency claims. All that has changed.

To take advantage of the great interest in the testing results, Efficiency Vermont launched a major initiative in 2014 called the Great Snow Gun Round Up. It offered financial incentives of up to 75 percent of the cost of the most efficient guns. Ski areas would need to pick up the balance of the cost of the gun plus a variety of other related costs (including pipe repairs, air compressors, new hydrants, new tower mount, etc.). All told, the industry spent nearly $15 million, with a third of that coming from Efficiency Vermont. As Figure G2 shows, the result was more efficient snow guns rebated than in the previous six years combined. In addition, the ski areas donated for scrap four old snow guns for every five new ones that they purchased. Efficiency Vermont pledged to donate the proceeds from the scrap metal to a state program that promotes skiing and snowboarding, in part through massive ski pass discounts for all fifth graders in the state.

There is also anecdotal evidence of some market transformation effects from this effort. For example, some ski areas in competing states have reportedly complained that they are not getting comparable support for investments in better snow guns. Also, some manufacturers are changing product designs to be able to market their products in the highest efficiency tier.

Figure G2



84 Graphic provided by Alan Hebert, Efficiency Vermont, August 31, 2015.

One should not conclude that the Vermont snow gun example is illustrative of the percentage savings that would be possible from deeper dives into savings potential in other industry or business types. Indeed, it is highly unlikely that there are many other business end uses of electricity for which it will be possible to achieve savings on the order of 95 percent or more, even with intensive assessment of opportunities and assistance to the businesses and their supply chains. Rather, the example is meant to illustrate that some additional savings, beyond levels currently envisioned, is likely possible through such industry-specific "deeper dives." The precise magnitude of such increases in savings will undoubtedly vary substantially—from industry to industry and from end use to end use—but cannot be known or even predicted until such efforts are undertaken.

Other RAP Publications on Energy Efficiency Include the Following:

Recognizing the Full Value of Energy Efficiency

Available at: http://www.raponline.org/document/download/id/6739

Energy efficiency provides numerous benefits to utilities, to participants (including ratepayers), and to society as a whole. However, many of these benefits are frequently undervalued, or not valued at all, when energy efficiency measures are assessed. This paper seeks to comprehensively identify, characterize, and provide guidance regarding the quantification of the benefits provided by energy efficiency investments that save electricity. It focuses on the benefits of electric energy efficiency, but many of the same concepts are equally applicable to demand response, renewable energy, and water conservation measures. Similarly, they may also apply to efficiency investments associated with natural gas, fuel oil, or other end-user fuels. This report is meant to provide a comprehensive guide to consideration and valuation (where possible) of energy efficiency benefits. It provides a real-world example that has accounted for many, but not all, of the energy efficiency benefits analyzed herein. We also provide a list of recommendations for regulators to consider when evaluating energy efficiency programs.

Valuing the Contribution of Energy Efficiency to Avoided Marginal Line Losses and Reserve Requirements

Available at: http://www.raponline.org/document/download/id/4537

While utilities and their regulators are familiar with the energy savings that energy efficiency measures can provide, they may not be aware of how these same measures also provide very valuable peak capacity benefits in the form of marginal reductions to line losses that are often overlooked in the program design and measure screening. This paper is the first of two that the Regulatory Assistance Project is publishing on the relationship between energy efficiency and avoiding line losses.

US Experience with Efficiency as a Transmission and Distribution System Resource

Available at: http://www.raponline.org/document/download/id/4765

Transmission and distribution (T&D) investments by investor-owned utilities, which collectively account for approximately two-thirds of the electricity sales in the United States, have averaged about $26 billion annually over the past decade. This paper summarizes US experience to date of efforts to use geographically targeted efficiency programs to defer T&D system investments. It presents several case studies and summarizes lessons learned from those initiatives. Most importantly, it concludes that targeted efficiency programs—either alone or in combination with other demand resources—clearly can be a cost-effective alternative to T&D investments. However, their cost-effective potential as a T&D resource has been grossly under-utilized for a variety of policy and institutional reasons. The paper offers several policy recommendations to address those barriers.

Energy Efficiency Cost-Effectiveness Screening

Available at: http://www.raponline.org/document/download/id/6149

Energy efficiency is widely recognized as a low-cost, readily available resource that offers a variety of benefits to utility customers and to society as a whole. There is a great amount of variation across the states in the ways that energy efficiency programs are screened for cost-effectiveness. Many states apply methodologies and assumptions that do not capture the full value of efficiency resources, leading to under-investment in this low-cost resource, and thus higher costs to utility customers and society. This report addresses the major differences between tests, and is designed to help regulators recognize the important features of these broad cost-benefit tests that are frequently overlooked as the tests are applied. The authors address two elements of energy efficiency program screening that are frequently treated improperly or entirely overlooked—"other program impacts" (OPIs) and the costs of complying with environmental regulations.

Revenue Regulation and Decoupling: A Guide to Theory and Application

Available at: http://www.raponline.org/document/download/id/902

This guide was prepared to assist anyone who needs to understand both the mechanics of a regulatory tool known as decoupling and the policy issues associated with its use. This would include public utility commissioners and staff, utility management, advocates, and others with a stake in the regulated energy system. While this guide is somewhat technical at points, we have tried to make it accessible to a broad audience, to make comprehensible the underlying concepts and the implications of different design choices. This guide includes a detailed case study that demonstrates the impacts of decoupling using different pricing structures (rate designs) and usage patterns.
Other documents on energy efficiency and other topics are available on The Regulatory Assistance Project website at: www.raponline.org.

Energy Efficiency Collaboratives: Driving Ratepayer-Funded Efficiency through Regulatory Policies Working Group

Available at: http://www.raponline.org/document/download/id/7860

Collaboratives for energy efficiency have a long and successful history and are currently used, in some form, in more than half of the US states. Collaboratives can be useful to gather stakeholder input on changing program budgets and program changes in response to performance or market shifts, as well as to provide continuity while regulators come and go, identify additional energy efficiency opportunities and innovations, assess the role of energy efficiency in new regulatory contexts, and draw on lessons learned and best practices from a diverse group. This guide defines and examines four different types of collaboratives based on their origin, scope, decision-making method, membership, duration, available resources, and how they interact with and influence their respective commissions. The guide also highlights common elements and conclusions on the overall effectiveness of specific characteristics of different types of collaboratives. As comprehensive, sophisticated programs have evolved, so too have the purpose, usefulness, and focus of collaboratives. Increasingly, customers as a group are seen as a vital and strategic, demand-side power sector resource with distinct advantages over other resources. States with energy efficiency collaboratives are likely to find themselves better able to respond to these trends and utilize this resource. This guide provides valuable context for decision-makers as they design new or improve existing energy efficiency collaboratives.

Thermal Efficiency for Low Income Households in Vermont

Available at: http://www.raponline.org/document/download/id/7536

Thermal energy efficiency—improvements in the usable heating and cooling performance of buildings—directly lowers energy costs and creates indirect benefits for the household and broader community. These include improved energy affordability, improved work and school productivity, job creation, and reduced greenhouse gas emissions. An estimated 125,000 Vermonters are fuel-poor, a situation that forces them to make difficult decisions between household health and comfort and other basic services. This paper characterizes and quantifies the multitude of benefits associated with investments in thermal energy efficiency initiatives, especially as they relate to reducing the fuel burden on low-income households. The paper also reviews policies for capturing and delivering those benefits in Vermont. The recommendations include strengthening building codes and standards, utilizing integrated resource planning to advance thermal efficiency, establishing binding energy savings targets, enabling new markets for energy efficiency services, and expanding successful existing programs.

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