

The Brattle Group



ENERGY EFFICIENCY AND DEMAND RESPONSE IN 2020 – A SURVEY OF EXPERT OPINION

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EXECUTIVE SUMMARY

The European Union hopes to reduce energy consumption by 20 percent by the year 2020.¹ While the United States as a whole does not have any such targets, some states such as Connecticut, Maryland, and Pennsylvania have established specific numerical targets while other states such as California have made energy efficiency and demand response part of their energy action plan, provide regulatory incentives for utilities to undertake such programs, and institute stringent codes and standards to promote efficient energy use.

It is clear that efforts to reduce growth in energy consumption are beginning to take hold. According to a recent article in a Colorado paper:

A plan for a new coal plant in Michigan is being mothballed. Wind-energy developers in Oregon are cutting back on projects. And in Colorado, Xcel Energy says it may no longer need a proposed high-tension power line to the San Luis Valley. All these projects are being hit by a shift in the utility industry created by increased energy efficiency, small generation projects, such as rooftop solar, and changes in public policy, industry analysts and executives say.

To be sure, the recession and a weak economy have contributed to a slowdown in the demand for electricity, but analysts say there also is a fundamental change afoot. “We are entering a new era,” said Douglas Larson, executive director of the Western Interstate Energy Board, adviser to governors of 12 Western states. “I think we’ll see fewer transmission lines and power plants built.” In its seven-year resource plan filed Oct. 31, Xcel cut the estimated need for additional generation to 292 megawatts by 2020 — down from the 1,000 megawatts forecast in 2010.²

What is the likely impact of energy efficiency and demand response going to be on customer usage by the year 2020? The answer depends on who you ask. To get a robust response, we asked not one but almost 200 experts in in the U.S. and Canada representing all facets of the industry – from academics to consultants, utilities to regulators, and from consumer activists to environmentalists. A total of 50 experts responded, giving us a wide cross section of views.

The survey was carried out by economists at *The Brattle Group*, in conjunction with Global Energy Partners, an Enernoc company.³ Specifically, we asked the experts to tell us what they expected would happen in terms of energy efficiency and demand response during the next decade relative to each respondent’s view of what energy usage would have been in the absence of these new activities.⁴ It is important to note that we did not ask them to tell us what should happen, a normative question, or what is the economic or technical potential for energy efficiency and demand response. Instead, we asked them to simply tell us what they thought was likely to happen, a positive question. We included questions about natural gas as well as electricity.

¹ http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

² Mark Jaffe, “Utilities Power Down on Building Plans,” *The Denver Post*, November 6, 2011.

³ This survey was conducted as part of an energy efficiency potential study for the New Mexico Energy, Minerals and Natural Resources Department. Copies of this work can be found online at: <http://www.emnrd.state.nm.us/ecmd/Multimedia/PublicationsandReports.htm>

⁴ Each respondent’s forecast is assumed to include, in net, growth in overall energy consumption and reductions in energy use due to current and planned future programs.

Key Findings

Overall, the experts expect that U.S. electric consumption will decline by between 5 and 15 percent by the year 2020, compared to what it would have been absent additional energy efficiency measures. The range of savings in U.S. natural gas consumption due to energy efficiency improvements is between 5 and 10 percent, compared to what it would have been otherwise. Demand response programs are expected to lower U.S. peak demand for electricity by 7.5 to 15 percent, compared to what it would have been otherwise.

Regional Variation

There is considerable regional variation (the regions are the same as the U.S. census) in the results. For example, the West North Central region of the U.S. is expected to only see electric energy savings in electricity consumption in the 1.5 to 2.5 percent range while the Mountain region is expected to see savings in the 5 to 16 percent range. On the natural gas front, the lowest savings of under 1 percent are expected from the West South Central region. Much higher numbers of up to 12 percent are expected in the New England, Middle Atlantic, and East North Central regions.

Sectorial Variation

There is also variation across the sectors. For example, the residential sector is expected to see electric savings in the 10 to 12 percent range. It is expected that 40 percent of consumers will buy high efficiency air conditioners and 60 percent will buy high efficiency lighting systems. Some 50 percent of commercial and industrial consumers will buy high efficiency HVAC systems and approximately 70 percent of large commercial and industrial consumers will buy high efficiency electric motors.

Demand Response

In the demand response domain, the U.S. is forecasted to have total system peak demand savings in the range of 7.5 and 15 percent. Within this broad domain, direct load control programs are expected to reach 10 to 15 percent of residential consumers. However, dynamic pricing programs, which currently reach less than one percent of residential consumers, are expected to garner between 7.5 to 20 percent of residential consumers in the U.S. as a whole and the range could be as high as 12.5 to 45 percent in the East North Central region of the country. Participation rates for commercial and industrial consumers in dynamic pricing programs will be higher than in residential markets, as one would expect, ranging from 10 to 30 percent.

While the experts were not explicitly asked what factors would drive improvements in energy efficiency and peak demand, it is quite likely that these reductions are going to be brought about by factors such as (a) long-standing policy drivers such as rising fuel and capital costs, (b) rapid advances in appliance and building technology, brought on partly by government mandates and partly by competitive economics, and (c) cultural shifts in American values which encourage behavioral change.

The survey results confirm that the age of increasing energy efficiency has not yet come to an end. In fact, they herald a period of acceleration for energy efficiency. Furthermore, the surveyed experts anticipate that demand response will become a valuable resource, with much higher participation rates than today, to manage peak demand.

INTRODUCTION

Efficiency pessimists contend that there is little potential for further improvements in energy efficiency, since all the low-hanging fruit has been harvested. Ergo, the solution to meeting the nation's future energy needs in a carbon-constrained future is to build more power plants (preferably those that don't burn coal), transmission lines, and distribution systems.

Efficiency optimists, on the other hand, contend that energy efficiency is essentially an inexhaustible well and we have a long ways to go before the bottom is reached. Their viewpoint suggests that enhancements in energy efficiency may eliminate the need to make investments in the power supply system, except for routine maintenance and upgrades.

The truth is probably somewhere in between. The question of how much energy efficiency is available continues to come up, since we in the United States have been encouraging energy efficiency in one form or another ever since the first oil shock of 1973. The first wave of programs involved moral exhortations (as in the famous call to put on a sweater by President Jimmy Carter), information dissemination, and energy audits. The actors were government agencies and community organizations and the slogan was "energy conservation." Federal legislation was passed in 1978 to give an impetus to conservation. National efforts at cutting back use were redoubled when the second oil shock hit in 1979.

The second wave was led by the utilities and gifted the somewhat clunky term demand-side management (DSM) to future generations. The focus of DSM was on improving energy efficiency and not on asking consumers to make do with less, *i.e.*, energy conservation. Conservation was frowned upon because it meant that consumers would have to change their behavior, which might be perceived as an unwelcome intrusion into their lives and even considered un-American by some. Incentives in the form of rebates and low-interest financing were used to encourage consumers to buy more efficient equipment and buildings. Utility spending on DSM programs peaked in 1993 as the industry prepared for restructuring, which arrived in the mid-to-late 1990s.

The energy crisis that plagued California's energy markets in the years 2000 and 2001 set in motion a third wave of programs that revolved around the concept of demand response. Customers would be provided incentives either through dynamic pricing or cash payments to curtail their usage during times when the power system was stressed, typically because of a shortage of capacity caused by extremely hot weather. Some of these programs could be instituted with existing meters while others required the deployment of smart meters. As of this writing, some 22 million smart meters have been deployed in the U.S. and there is an evolving consensus that the number will rise three-fold in the next five years. Demand response programs represented a major change in the industry's conception of customers as a resource.

Changing consumer behavior, along with behavioral economics, is in now in vogue and appealing to an increasingly widening circle of folks who are active in the energy domain. A fourth wave of programs, sometimes called integrated DSM (iDSM), is upon us.

This new wave of iDSM programs include those that inform consumers about how their energy spending compares with a group of peers and helps them to establish targets for optimizing use. These types of consumer-focused programs are finding widespread acceptance, saving one or two percent of energy consumption simply by inducing consumers to change behavior. Consumer-focused programs may save even more by enhancing consumers' awareness about where their energy dollar goes and by directing consumers toward rebates and low-interest financing that may be available from utility DSM programs.

As a result of iDSM programs, Energy Star labels on appliances are almost ubiquitous in "big box" stores, steering consumers toward efficient purchases. Zero-energy homes are being constructed that produce enough energy through renewable sources to meet their own needs.

Aggressive codes and standards are making an impact on the appliance manufacturing and building construction industries, especially in states such as California which have their own supplemental codes and standards that push the envelope beyond federal requirements.

Nowhere is this transformation in consumer buying habits more visible than in the imminent phase out of incandescent bulbs, called upon by the Energy Independence and Security Act of 2007. Compact fluorescent lamps are expected to get a substantial boost from this legislation, but light-emitting diode (LED) lamps may lead to even greater savings. A recent issue of *Wired* magazine features them on the cover.⁵ They are expensive, but prices are expected to come down as scale grows.

And this fourth wave, iDSM, is not confined to the residential sector. It is not uncommon to see full page ads in the mainstream media by companies such as Johnson Controls and Schneider Electric touting projects in which they helped large commercial and industrial facilities reduce their energy bill by 30 percent.

Finally, it is important to note that electric rates are now being redesigned to incentivize efficient energy use, with inclining block rates and time-varying rates being two concepts that are receiving increasing interest by utilities and policy makers. So the fourth wave, more comprehensive than the first three, is built around five policy instruments: (a) information, (b) codes and standards, (c) technological change, (d) rebates and low interest financing, and (e) rate design.

⁵ http://www.wired.com/magazine/2011/08/ff_lightbulbs/

THE SURVEY

The European Union has set a target of 20 percent savings in energy consumption by 2020.⁶ In the same timeframe, how much energy and peak demand will be saved in the United States through the pursuit of energy efficiency and demand response, respectively?

We posed these questions to some of the nation’s leading energy experts.⁷ Specifically, we asked them to tell us what they expected would happen during the next decade; not what could happen or what is technically feasible, which is often how the question is posed.⁸

A total of 50 of the polled experts responded to the survey. They are spread out across North America, though the majority (42 percent) is located in the western United States (see Figure 1). Responding experts represent a variety of institutions including universities, governments, utilities, research laboratories, and consulting firms. The majority, 46 percent, of the survey respondents are employees of electric utilities. Nonprofit (21 percent) and government (17 percent) employees make up the majority of the other experts that responded (see Figure 2).

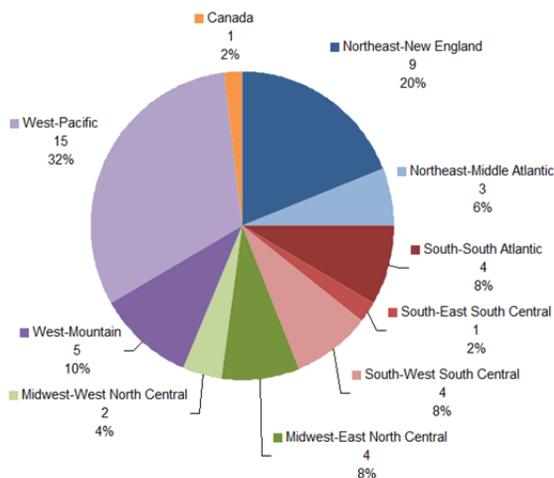


Figure 1 - Location of survey respondents, by census division⁹

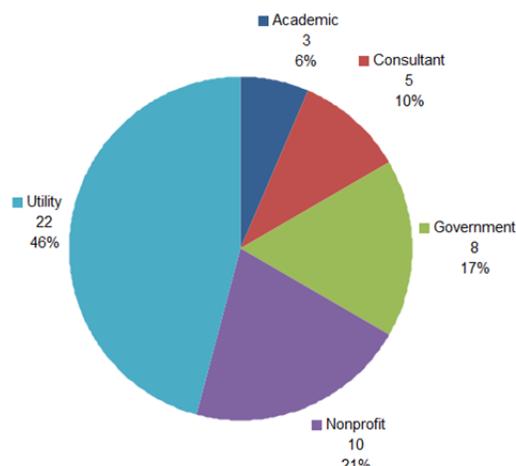


Figure 2 - Profession of survey respondents¹⁰

Each expert was asked three questions in three categories: electric energy efficiency, gas energy efficiency, and demand response.¹¹

⁶ http://ec.europa.eu/energy/efficiency/action_plan/action_plan_en.htm

⁷ This survey was conducted by staff of *The Brattle Group* and Global Energy Partners, an Enernoc company, as part of an energy efficiency potential study for the New Mexico Energy, Minerals and Natural Resources Department. Copies of this work can be found online at: <http://www.emnrd.state.nm.us/ecmd/Multimedia/PublicationsandReports.htm>

⁸ The estimates provided only reflect the savings associated with new, incremental iDSM programs and therefore do not reflect savings that have accrued from programs that have been in operation for long durations. For example, a forecast for a low expectation for energy savings could be because either the savings have already been achieved through long-standing programs or that there is potential energy savings, but the expectation is that there will be low interest in achieving those savings.

⁹ The number of respondents adds up to 48, not 50, because two respondents provided their response anonymously.

¹⁰ *Id.* 9

ELECTRIC ENERGY EFFICIENCY

The questions on electric energy efficiency were asked relative to each respondent's baseline forecast for electricity use in the future, which, in net, is assumed to include growth in overall electricity consumption and reductions in electricity use due to current and planned future building codes, appliance standards, and naturally-occurring efficiency (including price responsiveness and purchases by early adopters).

With this baseline in mind:

Electric Energy Efficiency Question 1

What percent of total electricity use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

Overall, the experts expect that national electric consumption will decline by between 5 and 15 percent by the year 2020, compared to what it would have been without incremental improvements in energy efficiency. The experts expect regional variation in total energy savings with the Northeast and Western regions to have the highest expected energy savings, ranging between 5 and 16 percent. On the other hand, the Southern and Central regions of the United States are expected to have a maximum of 7 percent total energy reductions due to electric energy efficiency (see Figure 3).

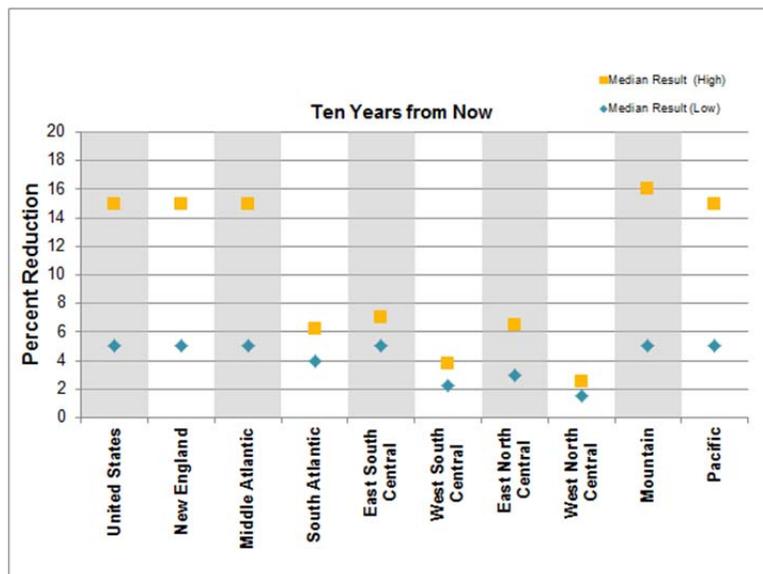


Figure 3 - Total electric energy efficiency savings

The second and third electric energy efficiency questions, answered together in the section below, focus on expectations of energy use in four consumer sectors: residential, commercial, industrial, and agricultural.

¹¹ Full details of the response to each question are found in the appendix.

Electric Energy Efficiency Question 2

What percent of each sector's total electricity use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?

Electric Energy Efficiency Question 3

What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?

The residential sector in the United States is expected to see overall electric savings in the 10 to 12 percent range. However, there is regional variation in the expected outcomes with high estimates ranging from 5.5 to 15 percent (see Figure 4).

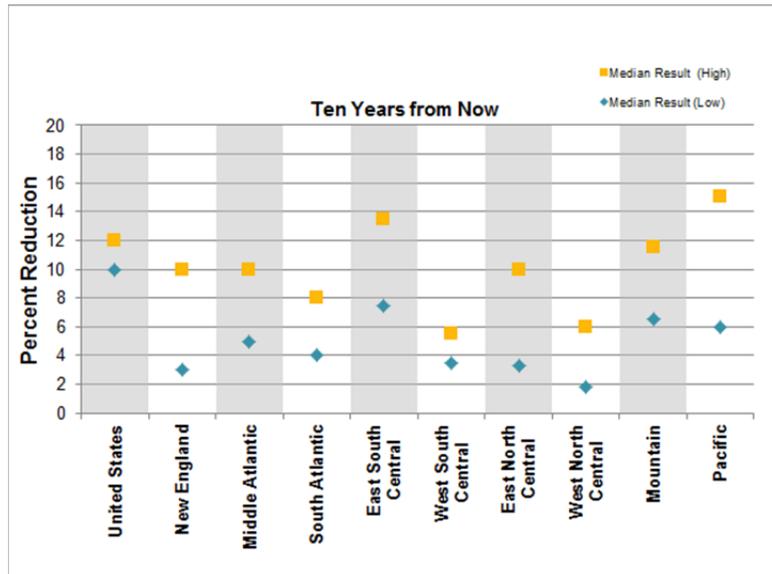


Figure 4 - Residential sector electric energy efficiency savings

Residential customers will be able to achieve these energy savings by adopting high-efficiency options in the future. The experts expect that, overall, 60 percent of customers will choose high-efficiency lighting systems and 40 percent of customers will choose high-efficiency air conditioners and refrigerators (see Figure 5).

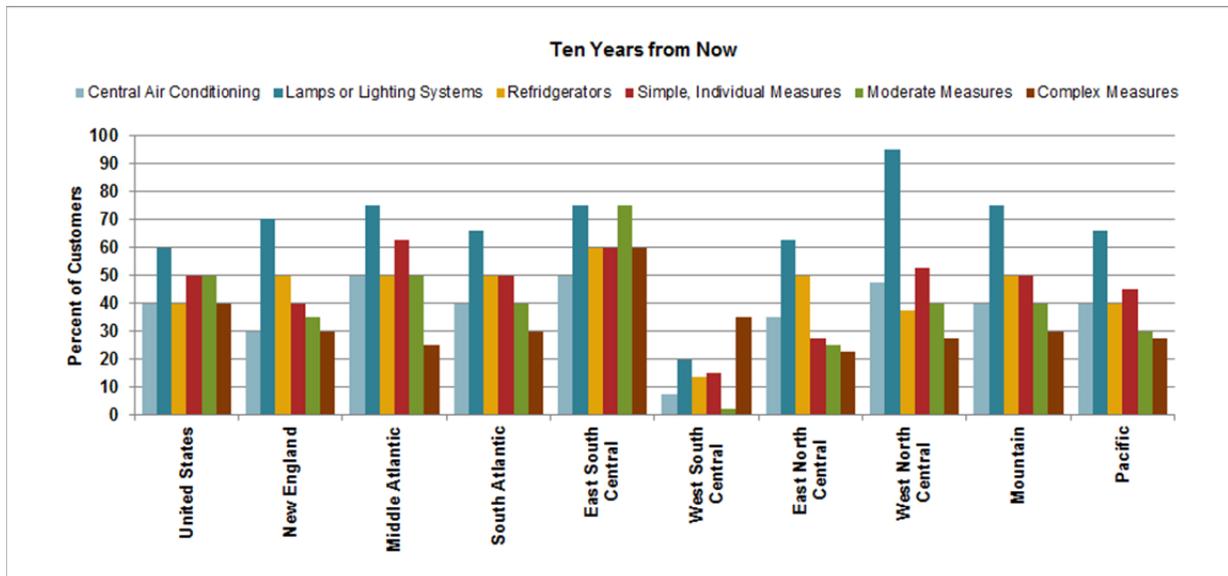


Figure 5 - Percent of residential high-efficiency electric equipment purchases

For the commercial and industrial sectors, the United States is expected to see overall electric savings in the 5 to 15 percent range. The experts expect that, overall, these savings will come from 70 percent of customers choosing high-efficiency motors, 60 percent choosing high-efficiency lighting systems, and 50 percent choosing high-efficiency HVAC systems. Agricultural sector savings are expected to be the lowest of the four sectors, ranging nationally from 5 to 10 percent.

NATURAL GAS ENERGY EFFICIENCY

The questions on natural gas energy efficiency were very similar to the questions on electric energy efficiency. The questions on natural gas energy efficiency were asked relative to each respondent's baseline forecast for natural gas use in the future, which, in net, is assumed to include growth in overall natural gas consumption and reductions in electricity use due to current and planned future building codes, appliance standards, and naturally-occurring efficiency (including price responsiveness and purchases by early adopters).

With this baseline in mind:

Natural Gas Energy Efficiency Question 1

What percent of total natural gas use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

Overall, the experts expect that national natural gas consumption will decline by between 5 and 10 percent by the year 2020, compared to what it would have been without incremental improvements in energy efficiency. The experts expect regional variation in total energy savings with the high estimates ranging from 0.65 to 12 percent (see Figure 6).

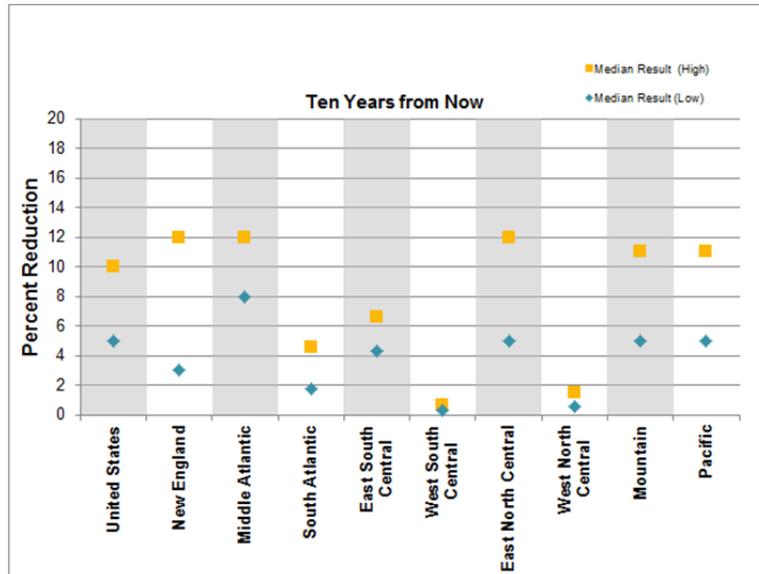


Figure 6 - Total natural gas energy efficiency savings

The second and third natural gas energy efficiency questions, answered together in the section below, focus on expectations of energy use in four consumer sectors: residential, commercial, industrial, and agricultural.

Natural Gas Energy Efficiency Question 2

What percent of each sector's total natural gas use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?

Natural Gas Energy Efficiency Question 3

What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?

All regions of the United States are expected to have residential natural gas energy efficiency savings of at most 11 percent except for the Middle Atlantic region, which is expected to have between 10 and 16 percent savings (see Figure 7).¹²

¹² There were no survey responses for national estimates of residential natural gas energy efficiency savings, so the “United States” column of the chart is blank.

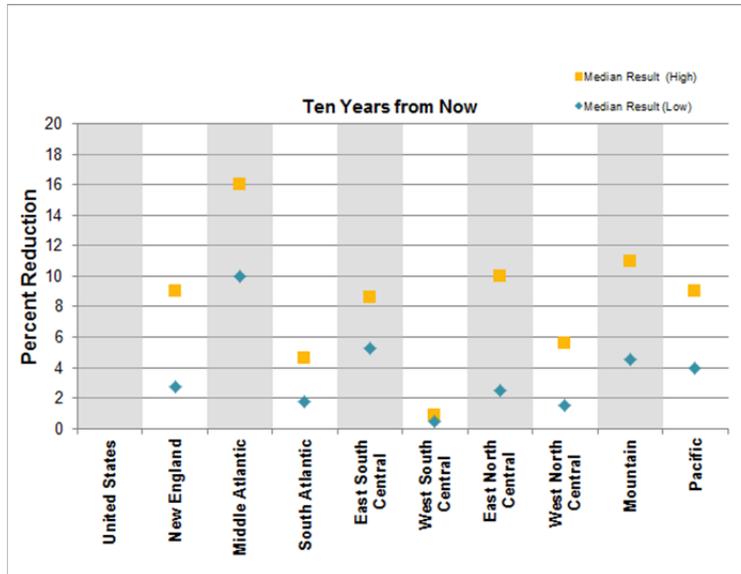


Figure 7 - Residential sector natural gas energy efficiency savings

Residential customers will be able to achieve these energy savings by adopting high-efficiency options in the future. While there is regional variation in the experts' forecasts, none of the measures are expected to have more than a 50 percent adoption rate in the future (see Figure 8).

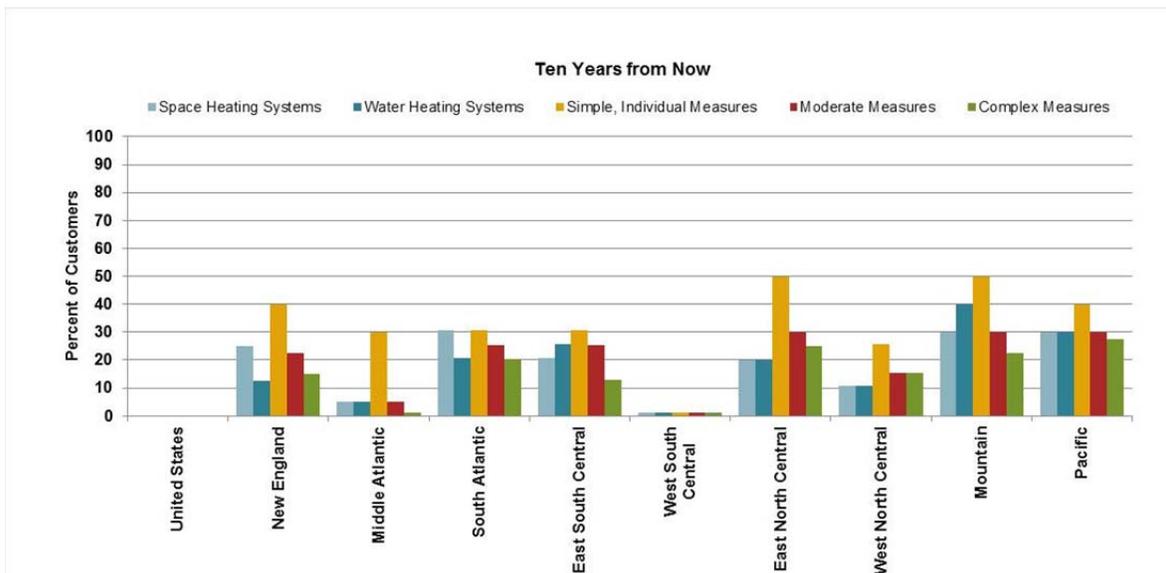


Figure 8 - Percent of residential high-efficiency natural gas equipment purchases

For the commercial and industrial sectors, all regions of the United States are expected to see natural gas energy efficiency savings range between 1 and 11 percent. In every case except one, experts expect no more than 35 percent of commercial and industrial customers to adopt high-efficiency options 10 years from now. Agricultural sector savings are expected to have regional savings ranging between 2 and 9 percent.

ELECTRIC DEMAND RESPONSE

The questions on electric demand response were asked relative to each respondent's baseline forecast for electric peak demand in the future, which, in net, is assumed to include growth in overall peak demand and reductions in peak demand due to current and planned future demand response programs.

With this baseline in mind:

Electric Demand Response Question 1

What percent of total system peak demand, relative to a total baseline forecast, will be offset by savings from demand response programs?

Overall, the experts expect that national peak demand will decline by between 7.5 and 15 percent by the year 2020, compared to what it would have been without incremental improvements in demand response programs. The experts expect regional variation in total energy savings with the high estimates ranging from 8 to 15 percent (see Figure 9).

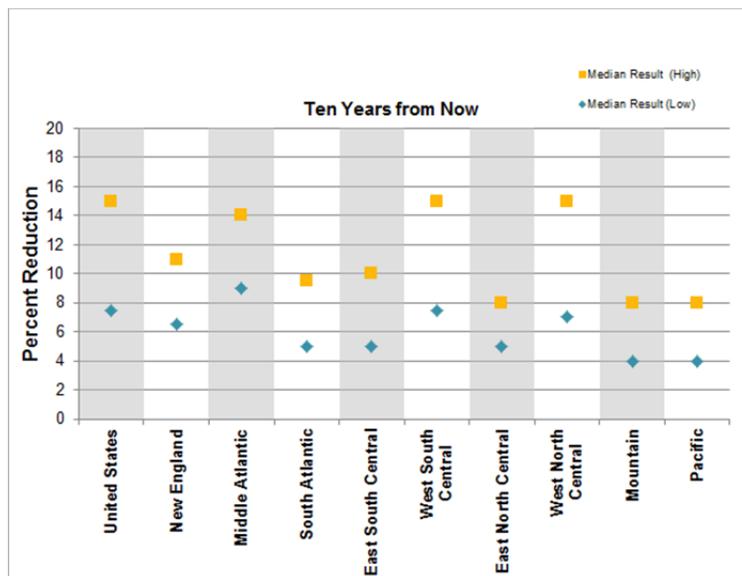


Figure 9 - Total electric demand response peak demand savings

The second and third electric demand response questions, answered together in the section below, focus on expectations of energy use in four consumer sectors: residential, commercial, industrial, and agricultural.

Electric Demand Response Question 2

What percent of each sector's total peak demand, relative to its own baseline forecast, will be offset by savings from demand response programs?

Electric Demand Response Question 3

What percent of customers will be engaged with demand response programs?

At the national level, peak demand reductions are expected to range between 4 and 15 percent for the residential sector. However, there is much regional variation, as high estimates for peak demand reductions range between 6.5 and 20 percent (see Figure 10).

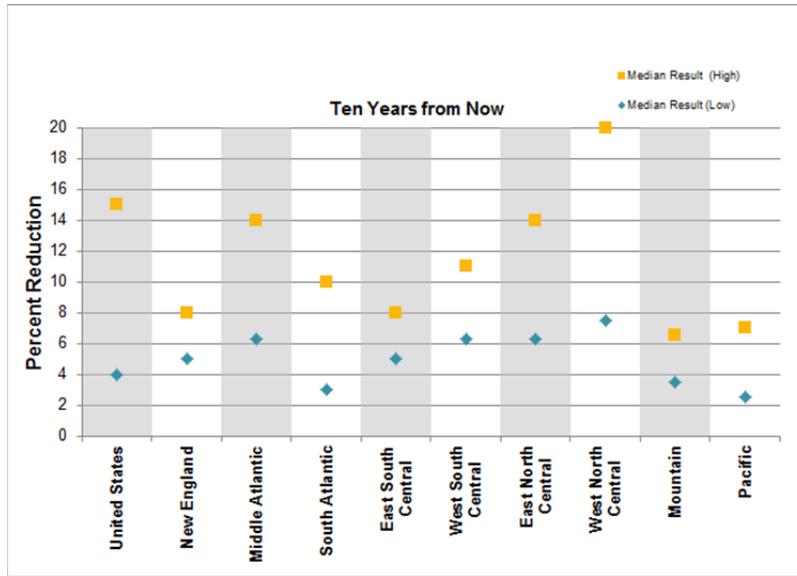


Figure 10 - Residential sector electric demand response peak savings

Ten years from now, experts expect at the national level that more residential customers could be engaged with dynamic pricing (20 percent high estimate) than direct load control (15 percent high estimate). This expectation of potentially higher dynamic pricing participation than direct load control participation also holds true in two-thirds of the regions of the United States (see Figure 11).

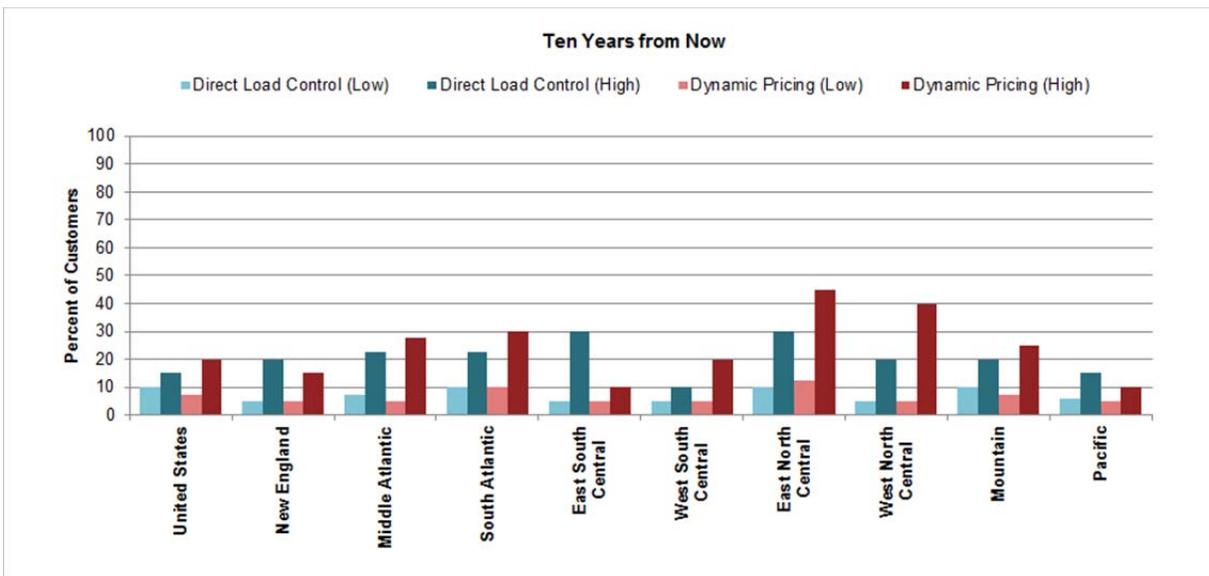


Figure 11 - Percent of residential customers who will be engaged with demand response

Similar to residential customers, commercial and industrial customers, at the national level, could have peak demand reductions ranging between 4 and 15 percent. Furthermore, experts expect higher participation in dynamic pricing than other demand response programs, with a high-end estimate of 30 percent of customers to be engaged with dynamic pricing. High-end estimates for engagement in direct load control, tariffs, and other demand response are all 15 percent of customers. Agricultural sector peak demand reductions are expected to range nationally from 4 to 7 percent.

CONCLUSION

This survey reveals a surprising consensus on the size of the energy efficiency resource, even though there is considerable variation across regions, sectors, programs, and end-uses. Overall, iDSM is expected to lower electricity consumption by 5 to 15 percent, peak electricity demand by 7.5 to 15 percent, and natural gas consumption by 5 to 10 percent, each relative to an assumed baseline forecast. These reductions are being driven by a number of factors including (a) long-standing policy drivers such as rising fuel and capital costs, (b) rapid advances in appliance and building technology, brought on partly by government mandates and partly by competitive economics, and (c) cultural shifts in American values which encourage behavioral change.

The survey results confirm that the age of increasing energy efficiency has not yet come to an end. In fact, they herald a period of acceleration for energy efficiency. Furthermore, the surveyed experts anticipate that demand response will become a valuable resource, with much higher participation rates than today, to manage peak demand.

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- **Hossein Haeri**, The Cadmus Group
- **David Jacobson**, National Grid
- **Val Jensen**, Commonwealth Edison
- **David Kathan**, Federal Energy Regulatory Commission
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- **Bob Lieberman**, Regulatory Assistance Project
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- **Michael Messenger**, Itron
- **Harvey Michaels**, Massachusetts Institute of Technology
- **Lawrence Oliva**, Southern California Edison
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- **Price Robertson**, Oncor
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APPENDIX 1: SURVEY INSTRUMENT

The survey was organized into three sections: electric energy efficiency, gas energy efficiency, and demand response.

ELECTRIC ENERGY EFFICIENCY

The questions on electric energy efficiency were asked relative to a baseline forecast that was assumed to include the impacts of current and future building codes, appliance standards, and naturally-occurring efficiency (including price responsiveness and purchases by early adopters). Furthermore, the baseline forecast was assumed to include savings from programs conducted in past years but not include savings from existing or new programs in the future.

With this baseline in mind, the first question asked:

What percent of total electricity use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now.

The second question in this section asked:

What percent of each sector's total electricity use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now for the following sectors:

- Residential
- Commercial
- Industrial
- Agricultural

The third and final question of this section asked:

What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?

The responding experts were asked to provide estimates to this question both one and ten years from now for the following equipment:

- Residential
 - Central air conditioning
 - Lamps or lighting systems
 - Refrigerators
 - Simple, individual measures that are relatively straightforward (e.g., air conditioner maintenance or home electronics that have an Energy Star option)

- Moderate measures that are usually drop-in replacements, but require some research (*e.g.*, clothes washers, cooking equipment)
- Complex measures that involve structural changes (*e.g.*, windows, HVAC replacement)
- Commercial and Industrial
 - Lighting systems
 - HVAC systems
 - Refrigeration systems
 - Motors
 - Simple, individual measures that are relatively straightforward (*e.g.*, light bulbs or office equipment which have only the Energy Star option)
 - Moderate measures that are drop-in replacements, but require some research (*e.g.*, packaged rooftop HVAC equipment, motors)
 - Complex measures that involve more time and money (*e.g.*, advanced designs, energy management systems, retrocommissioning)

NATURAL GAS ENERGY EFFICIENCY

The questions on natural gas energy efficiency were very similar to the questions on electric energy efficiency. The questions on natural gas energy efficiency were asked relative to a baseline forecast that was assumed to include the impacts of current and future building codes, appliance standards, and naturally-occurring efficiency (including price responsiveness and purchases by early adopters). Furthermore, the baseline forecast was assumed to include savings from programs conducted in past years but not include savings from existing or new programs in the future.

With this baseline in mind, the first question asked:

What percent of total natural gas use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now.

The second question in this section asked:

What percent of each sector's total natural gas use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now for the following sectors:

- Residential
- Commercial
- Industrial
- Agricultural

The third and final question of this section asked:

What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?

The responding experts were asked to provide estimates to this question both one and ten years from now for the following equipment:

- Residential
 - Space heating systems
 - Water heating systems
 - Simple, individual measures that are relatively straightforward purchases (*e.g.*, low-flow showerheads or furnace maintenance)
 - Moderate measures that are usually drop-in replacements but require some research (*e.g.*, clothes dryers, water heaters, cooking equipment)
 - Complex measures that involve structural changes (*e.g.*, windows, solar water heating)
- Commercial and Industrial
 - Boilers for space heating
 - Furnaces for space heating
 - Boilers for water heating
 - Simple, individual measures that are relatively straightforward purchases (*e.g.*, HVAC or water heating maintenance)
 - Moderate measures that are drop-in replacements but require some research (*e.g.*, HVAC equipment, boilers, cooking equipment)
 - Complex measures that involve more time and money (*e.g.*, advanced designs, energy management systems, retrocommissioning, gas cooling)

ELECTRIC DEMAND RESPONSE

The questions on electric demand response were asked relative to a baseline forecast that was assumed to include the impacts of current demand response programs, including peak demand reductions from programs conducted in past years, but not including peak demand reductions from any existing or new programs in the future.

Demand response was assumed to include the following types of programs, but excluded time-of-use rates and permanent load shifting:

- Direct load control
- Dynamic pricing
- Interruptible/curtailable tariffs
- Demand bidding
- Capacity bidding
- Demand response participation in ancillary services markets

With this baseline in mind, the first question asked:

What percent of total system peak demand, relative to a total baseline forecast, will be offset by savings from demand response programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now.

The second question in this section asked:

What percent of each sector's total peak demand, relative to its own baseline forecast, will be offset by savings from demand response programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now for the following sectors:

- Residential
- Small commercial and industrial (less than 20 kW)
- Medium commercial and industrial (20-200 kW)
- Large commercial and industrial (greater than 200 kW)
- Agricultural

The third and final question of this section asked:

What percent of customers will be engaged with demand response programs?

The responding experts were asked to provide low and high estimates to this question both one and ten years from now for the following programs:

- Residential
 - Direct load control
 - Dynamic pricing (*e.g.*, peak-time rebates, critical peak pricing)
- Commercial and Industrial
 - Direct load control
 - Dynamic pricing (*e.g.*, critical peak pricing, real-time pricing)
 - Interruptible/curtailable tariffs
 - Other demand response (*e.g.*, demand bidding, capacity bidding, demand response participation in ancillary services markets)

APPENDIX 2: DETAILED DATA COLLECTION APPROACH

Each expert was sent an email with a link to an electronic, online survey instrument. The survey began by asking the expert to identify to which geographical segmentations of North America their responses are applicable. Responding experts could choose more than one geographical segmentation. In addition, responding experts were allowed to complete the survey multiple times with answers that are applicable to certain geographical segmentations of North America.

After identifying the geographical segmentations for which their responses are applicable, the responding experts were asked to identify at least one topic for which to provide their input:

1. electric energy efficiency
2. gas energy efficiency
3. demand response

DESCRIPTION OF THE EXPERTS

The Brattle Group contacted almost 200 energy experts from a range of industry sectors across North America to share their opinions on the future potential of energy efficiency and demand response.¹³ The experts contacted for this survey¹⁴ were chosen due to their demonstrated expertise in the areas of energy efficiency and/or demand response via their job title, publications, and/or speaking engagements. Other criteria were also included in developing the list of experts, including geographic and professional diversity.

The geographical location¹⁵ of the surveyed experts is fairly evenly split across the four major United States census regions, with the largest population being located in the West (see Figure 12). A closer examination of location by United States census division shows that almost 40 percent of those surveyed are either on the West coast or in the Southeast (see Figure 13).

¹³ Two of the respondents did not provide their contact information, so they are excluded in this segmentation analysis.

¹⁴ To avoid bias with regards to the work being conducted for the state of New Mexico, government and utility officials from New Mexico were not surveyed.

¹⁵ The geographical classification of surveyed experts is based on the location of their employer in relation to census classifications. United States Census Regions and Divisions are available at http://www.census.gov/geo/www/us_regdiv.pdf.

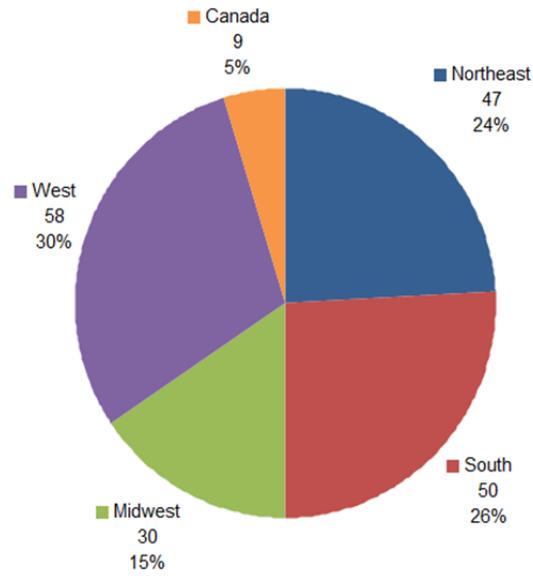


Figure 12 - Location of surveyed experts, by region

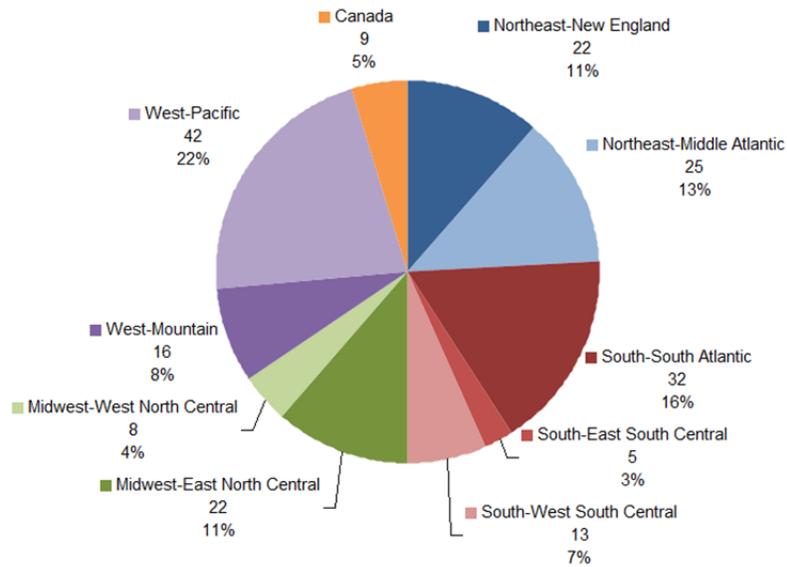


Figure 13 - Location of surveyed experts, by division

The West is the most responsive region of experts, with almost 35 percent of experts providing their opinion (see Figure 14).

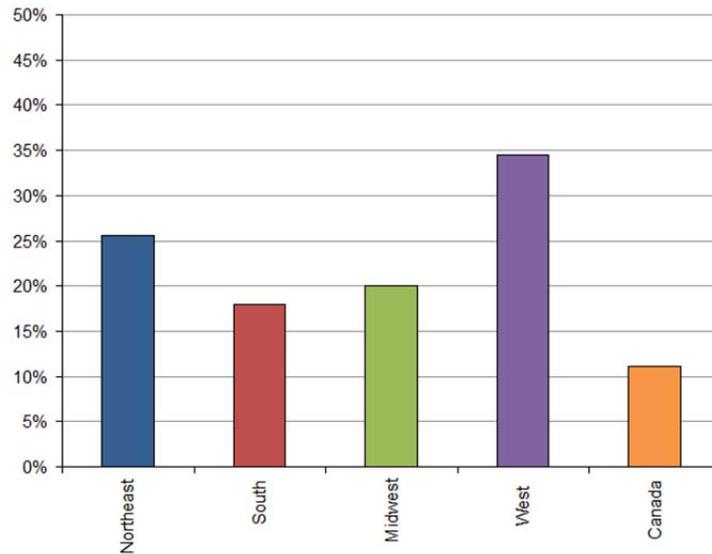


Figure 14 - Response rate of experts, by region

As a result of the high response rate of experts in the West, this group makes up over 40 percent of the survey respondents (see Figure 15). A closer examination of location by United States census division shows that over 50 percent of the respondents are either on the Western coast or in New England (see Figure 16).

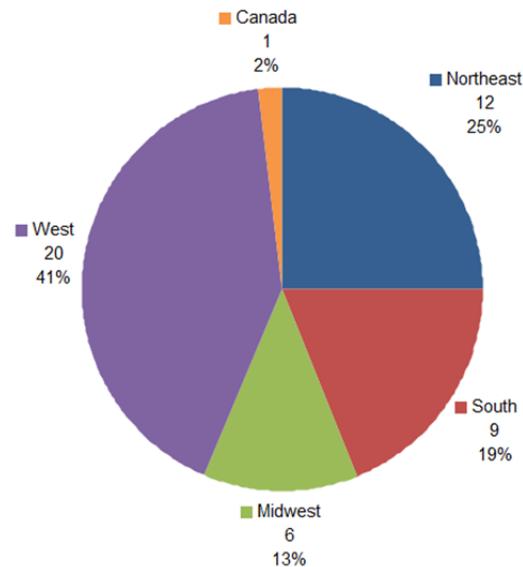


Figure 15 - Location of survey respondents, by region¹⁶

¹⁶ The number of respondents adds up to 48, not 50, because two respondents provided their response anonymously.

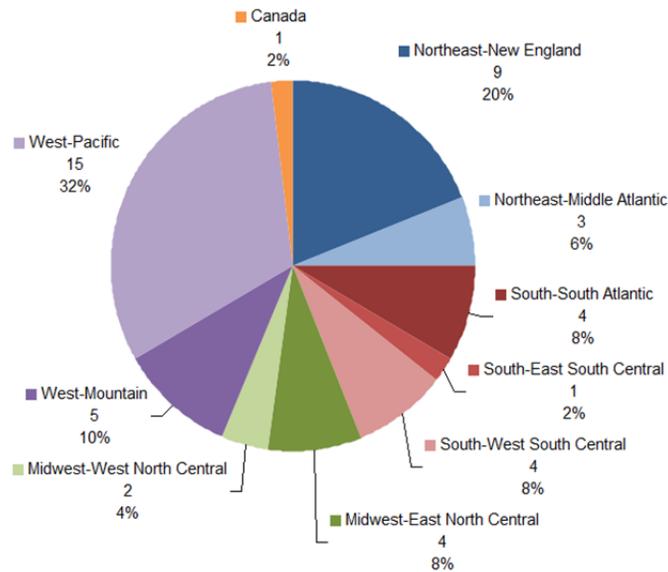


Figure 16 - Location of survey respondents, by division¹⁷

The majority, 54 percent, of the experts surveyed are employees of electric utilities. Nonprofit (20 percent) and government (15 percent) employees make up the majority of the other experts that were surveyed (see Figure 17). The smallest group surveyed, academics, has the highest response rate at 43 percent (see Figure 18).

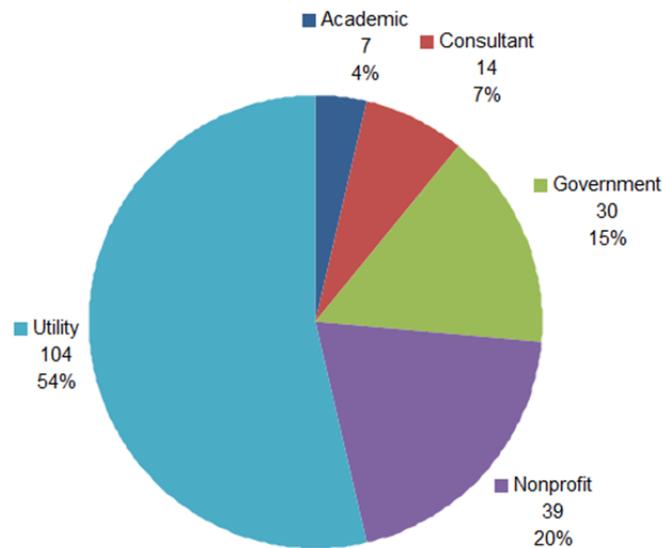


Figure 17 - Profession of surveyed experts

¹⁷ *Id.* 16

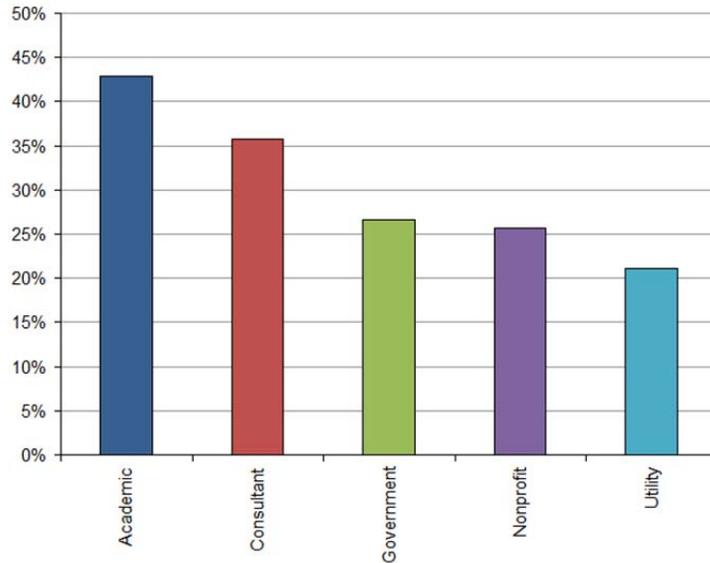


Figure 18 - Response rate of experts, by profession

Though utility employees have the lowest response rate, they make up almost half of the respondents since they are largest group of experts surveyed (see Figure 19).

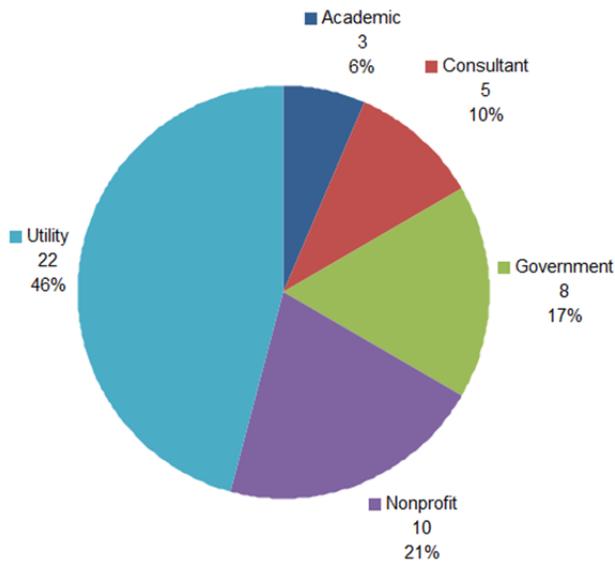


Figure 19 - Profession of survey respondents¹⁸

¹⁸ *Id.* 16

APPENDIX 3: DETAILED RESULTS

All surveyed experts identified the geographic segmentation of the United States, according to the United States census, with which their responses are applicable (see Figure 20).

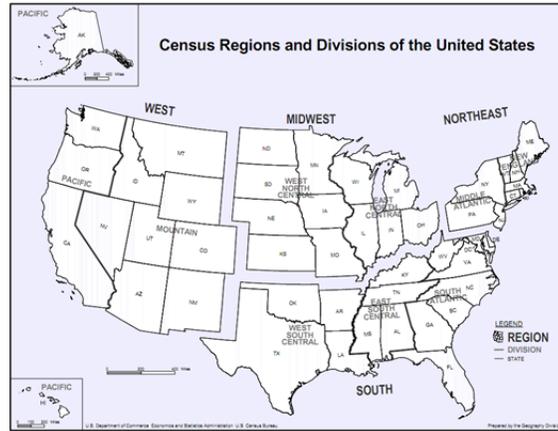


Figure 20 - United States census regions and divisions¹⁹

A total of 52 responses were completed,²⁰ providing 90 divisional responses for the United States.^{21,22} The majority of responses are with regards to the Pacific division (see Table 1).

Table 1 - United States responses, by region and division

National		Count
United States		6
Region	Division	Count
Northeast	New England	9
	Middle Atlantic	11
South	South Atlantic	6
	East South Central	5
	West South Central	8
Midwest	East North Central	8
	West North Central	7
West	Mountain	9
	Pacific	21
Total		90

For the purposes of analyzing the results of the survey, the median value of survey responses is chosen as the statistic with which to summarize all responses. Furthermore, all answers provided by responding experts, and therefore comparisons across regions, sectors, measures, *etc.*, are in percentage terms. Finally, for the purposes of comparison, the “lowest” division is the division

¹⁹ http://www.census.gov/geo/www/us_regdiv.pdf

²⁰ The number of responses, 52, is greater than the number of experts that responded, 50, because responding experts were allowed to submit more than one survey response if their answers would be different for various regions of North America. Two responding experts submitted two survey responses.

²¹ The number of locations, 99, is greater than the number of responses, 52, because a responding expert’s answers were allowed to be applicable to more than one North American region and division.

²² There were also nine Canadian divisional responses submitted by responding experts. However, due to the limited number of Canadian responses, the results are focused only on United States survey responses.

with the lowest “high” estimate. Similarly, the “highest” division is the division with the largest “high” estimate.

ELECTRIC ENERGY EFFICIENCY

What percent of total electricity use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

The United States is forecasted to have total savings from electric energy efficiency range between 5 and 15 percent. The West North Central division is forecasted to have the lowest total savings from electric energy efficiency, ranging between 1.5 and 2.5 percent. The Mountain division is forecasted to have the highest savings from electric energy efficiency, ranging between 5 and 16 percent (see Figure 21).

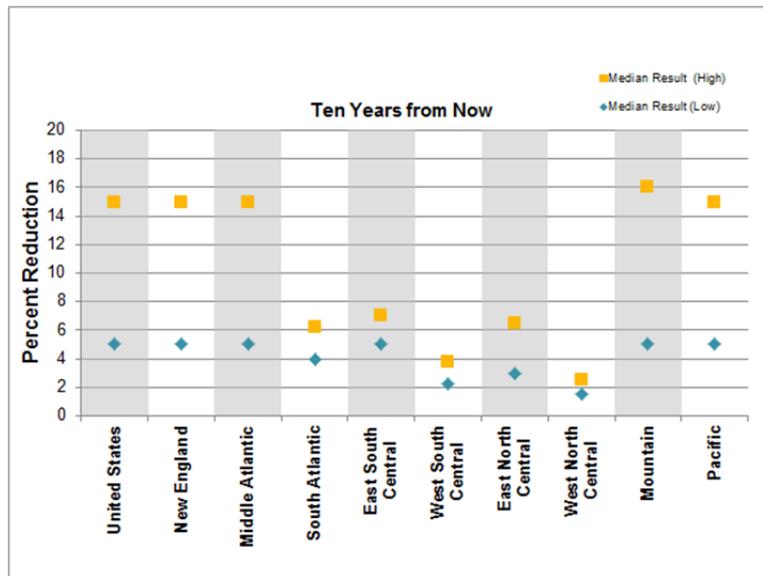


Figure 21 - Total electric energy efficiency savings

What percent of each sector's total electricity use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?

The United States is forecasted to have residential sector savings from electric energy efficiency range between 10 and 12 percent. The West South Central division is forecasted to have the lowest residential sector savings from electric energy efficiency, ranging between 3.5 and 5.5 percent. The Pacific division is forecasted to have the largest residential sector savings from electric energy efficiency, ranging between 6 and 15 percent (see Figure 22).

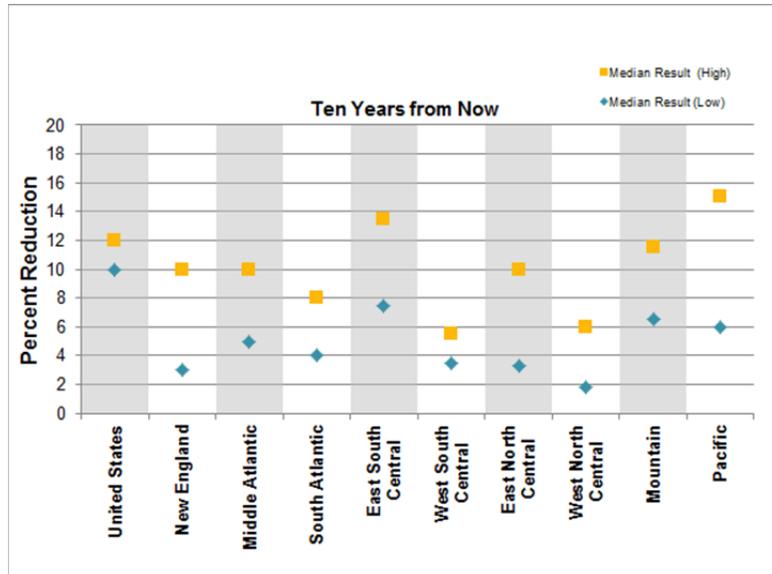


Figure 22 - Residential sector electric energy efficiency savings

The United States is forecasted to have commercial sector savings from electric energy efficiency range between 5.5 and 15 percent. The West South Central division is forecasted to have the lowest commercial sector savings from electric energy efficiency, ranging between 3.5 and 5.5 percent. The Pacific division is forecasted to have the largest commercial sector savings from electric energy efficiency, ranging between 5.5 and 13.5 percent (see Figure 23).

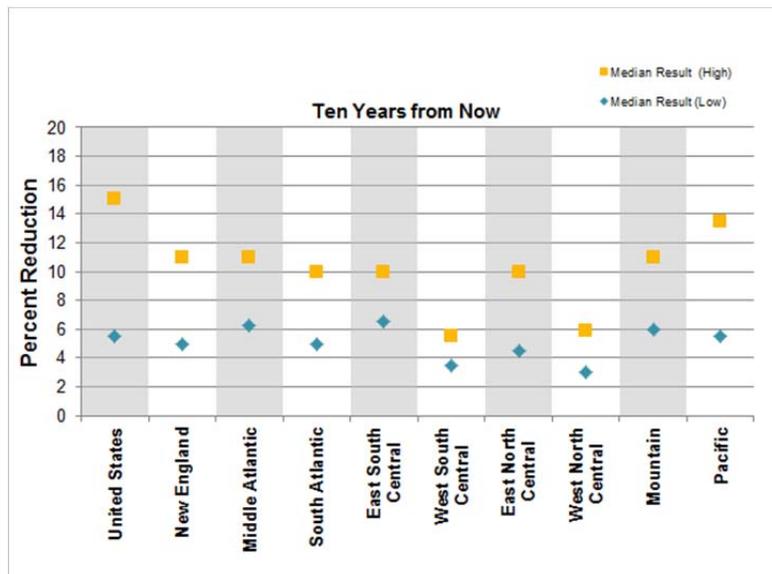


Figure 23 - Commercial sector electric energy efficiency savings

The United States is forecasted to have industrial sector savings from electric energy efficiency range between 5 and 15 percent. The West North Central division is forecasted to have the lowest commercial sector savings from electric energy efficiency, ranging between 1.75 and 6 percent. The Middle Atlantic division is forecasted to have the largest residential sector savings from electric energy efficiency, ranging between 5 and 15 percent (see Figure 24).

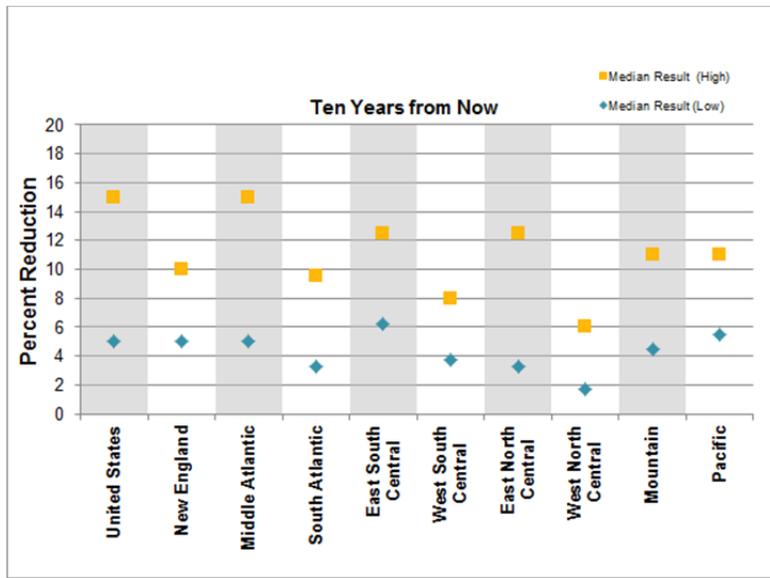


Figure 24 - Industrial sector electric energy efficiency savings

The United States is forecasted to have agricultural sector savings from electric energy efficiency range between 5 and 10 percent. The West South Central division is forecasted to have the lowest agricultural sector savings from electric energy efficiency, ranging between 0.85 and 1.25 percent. The Pacific division is forecasted to have the largest agricultural sector savings from electric energy efficiency, ranging between 4 and 10 percent (see Figure 25).

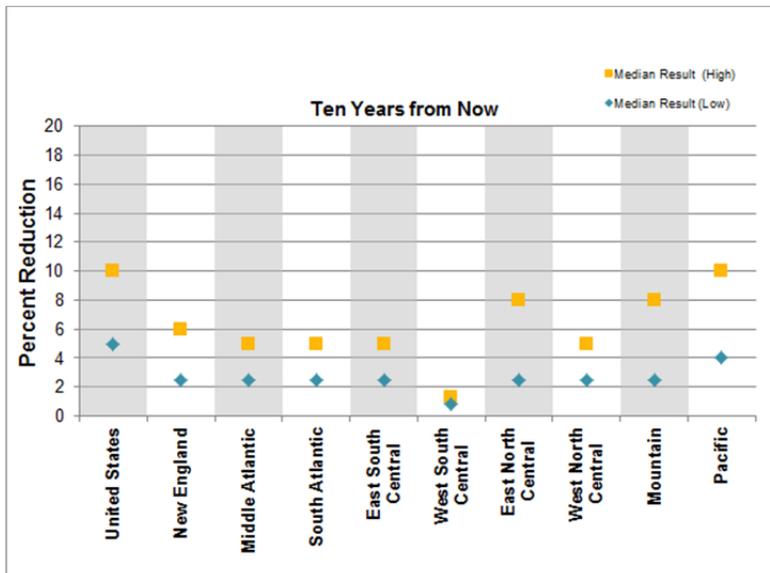


Figure 25 - Agricultural sector electric energy efficiency savings

What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?

The United States is forecasted to have 40 percent of residential customers choose the high-efficiency central air conditioning option. The West South Central division, at 7.5 percent, is forecasted to have the lowest rate of residential customers choosing the high-efficiency central air conditioning option. The Middle Atlantic and East South Central divisions, at 50 percent, are forecasted to have the highest rate of residential customers choosing the high-efficiency central air conditioning option (see Figure 26).

The United States is forecasted to have 60 percent of residential customers choose the high-efficiency lamp or lighting option. The West South Central division, at 20 percent, is forecasted to have the lowest rate of residential customers choosing the high-efficiency lamp or lighting option. The West North Central division, at 95 percent, is forecasted to have the highest rate of residential customers choosing the high-efficiency lamp or lighting option (see Figure 26).

The United States is forecasted to have 40 percent of residential customers choose the high-efficiency refrigerator option. The West South Central division, at 13.5 percent, is forecasted to have the lowest rate of residential customers choosing the high-efficiency refrigerator option. The East South Central division, at 60 percent, is forecasted to have the highest rate of residential customers choosing the high-efficiency refrigerator option (see Figure 26).

The United States is forecasted to have 50 percent of residential customers choose simple high-efficiency measures. The West South Central division, at 15 percent, is forecasted to have the lowest rate of residential customers choosing simple high-efficiency measures. The Middle Atlantic division, at 62.5 percent, is forecasted to have the highest rate of residential customers choosing simple high-efficiency measures (see Figure 26).

The United States is forecasted to have 50 percent of residential customers choose moderate high-efficiency measures. The West South Central division, at 2 percent, is forecasted to have the lowest rate of residential customers choosing moderate high-efficiency measures. The East South Central division, at 75 percent, is forecasted to have the highest rate of residential customers choosing moderate high-efficiency measures (see Figure 26).

The United States is forecasted to have 40 percent of residential customers choose complex high-efficiency measures. The East North Central division, at 22.5 percent, is forecasted to have the lowest rate of residential customers choosing complex high-efficiency measures. The East South Central division, at 60 percent, is forecasted to have the highest rate of residential customers choosing complex high-efficiency measures (see Figure 26).

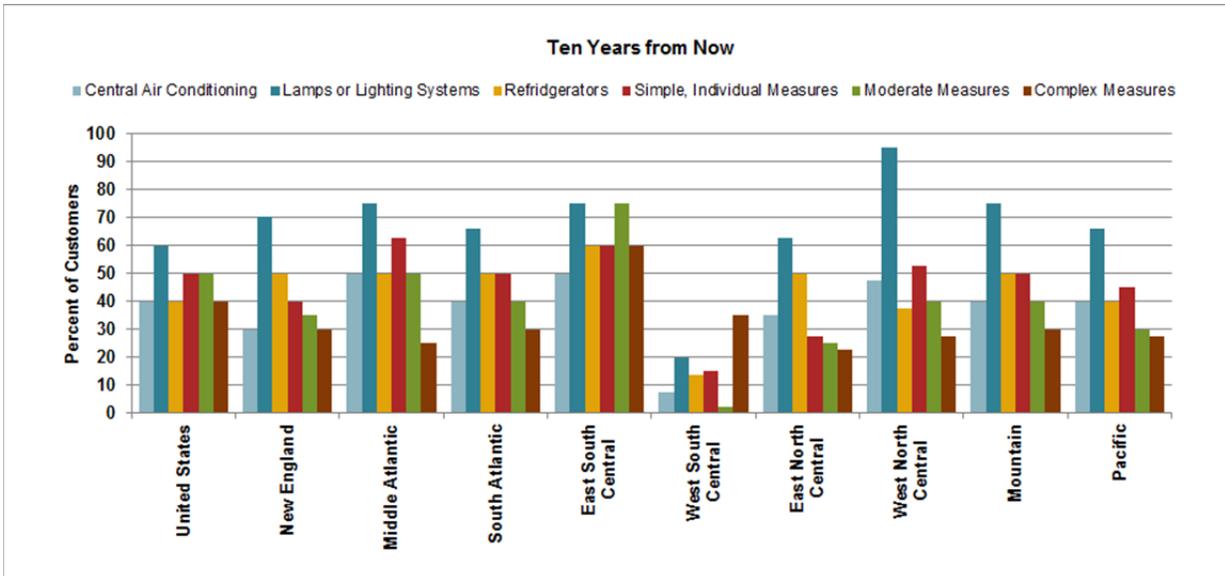


Figure 26 - Percent of residential high-efficiency electric equipment purchases

The United States is forecasted to have 60 percent of commercial and industrial customers choose the high-efficiency lighting system option. The West South Central division, at 15 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency lighting system option. The West North Central division, at 90 percent, is forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency lighting system option (see Figure 27).

The United States is forecasted to have 50 percent of commercial and industrial customers choose the high-efficiency HVAC system option. The West South Central division, at 10 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency HVAC system option. The East South Central division, at 65 percent, is forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency HVAC system option (see Figure 27).

The United States is forecasted to have 20 percent of commercial and industrial customers choose the high-efficiency refrigeration system option. The New England division, at 20 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency refrigeration system option. The East South Central division, at 62.5 percent, is forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency refrigeration system option (see Figure 27).

The United States is forecasted to have 70 percent of commercial and industrial customers choose the high-efficiency motor option. The Pacific division, at 32.5 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency motor option. The Middle Atlantic and East South Central divisions, at 70 percent, are forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency motor option (see Figure 27).

The United States is forecasted to have 50 percent of commercial and industrial customers choose simple high-efficiency measures. The West South Central division, at 50 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing simple high-efficiency measures. The West North Central division, at 90 percent, is forecasted to have the highest rate of commercial and industrial customers choosing simple high-efficiency measures (see Figure 27).

The United States is forecasted to have 50 percent of commercial and industrial customers choose moderate high-efficiency measures. The West South Central division, at 26 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing moderate high-efficiency measures. The South Atlantic division, at 60 percent, is forecasted to have the highest rate of commercial and industrial customers choosing moderate high-efficiency measures (see Figure 27).

The United States is forecasted to have 40 percent of commercial and industrial customers choose complex high-efficiency measures. The West South Central and East North Central divisions, at 25 percent, are forecasted to have the lowest rate of commercial and industrial customers choosing complex high-efficiency measures. The South Atlantic division, at 50 percent, is forecasted to have the highest rate of commercial and industrial customers choosing complex high-efficiency measures (see Figure 27).

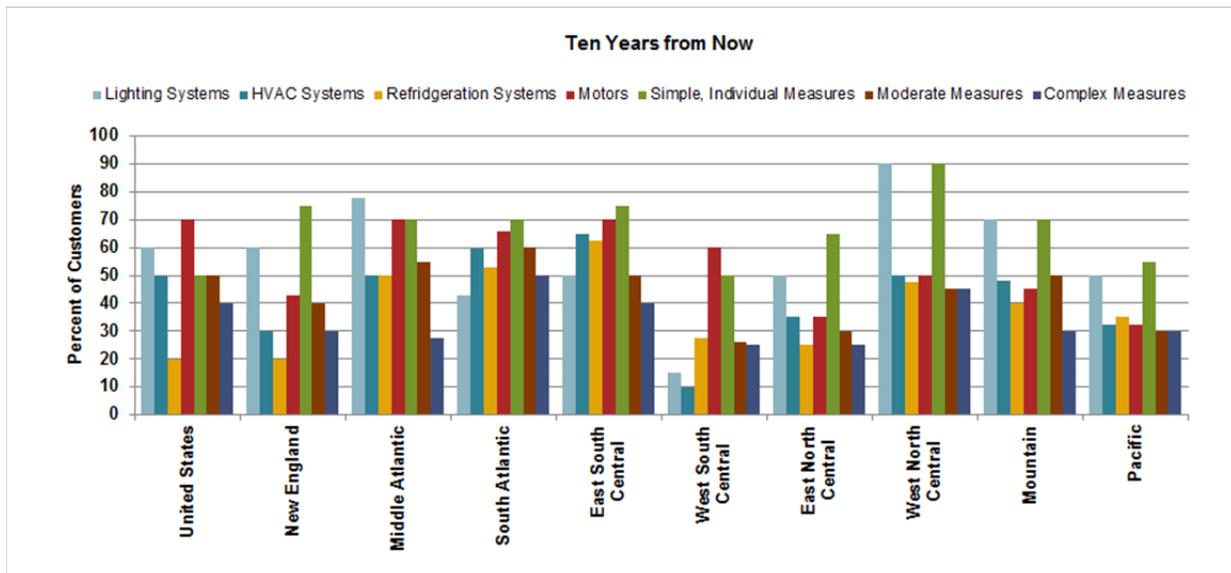


Figure 27 - Percent of commercial and industrial high-efficiency electric equipment purchases

NATURAL GAS ENERGY EFFICIENCY

What percent of total natural gas use, relative to a total baseline forecast, will be offset by savings from energy efficiency programs?

The United States is forecasted to have total savings from natural gas energy efficiency range between 5 and 10 percent. The West South Central division is forecasted to have the lowest total

savings from natural gas energy efficiency, ranging between 0.35 and 0.65 percent. The New England, Middle Atlantic, and East North Central divisions are forecasted to have the highest savings from natural gas energy efficiency, ranging between 3 and 12, 8 and 12, and 5 and 12 percent, respectively (see Figure 28).

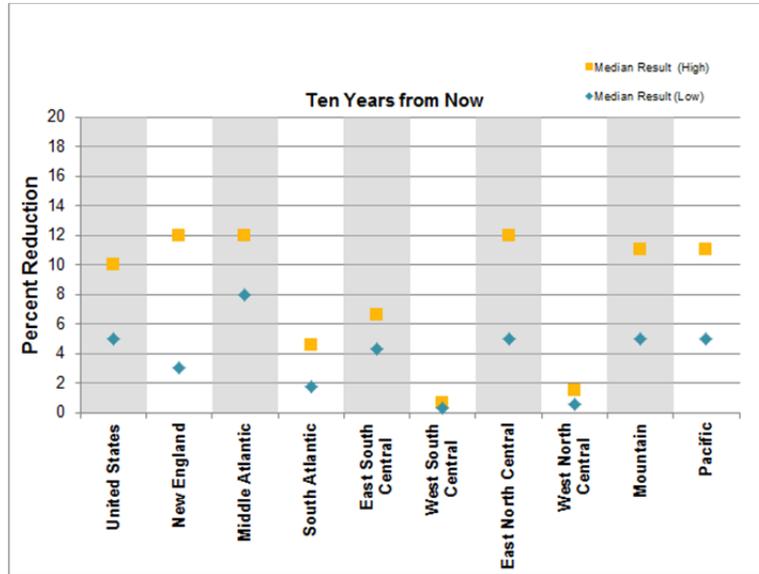


Figure 28 - Total natural gas energy efficiency savings

What percent of each sector's total natural gas use, relative to its own baseline forecast, will be offset by savings from energy efficiency programs?²³

The West South Central division is forecasted to have the lowest residential sector savings from natural gas energy efficiency, ranging between 0.45 to 0.85 percent. The Middle Atlantic division is forecasted to have the largest residential sector savings from natural gas energy efficiency, ranging between 10 and 16 percent (see Figure 29).

²³ There were no survey responses for some geographic segmentations of natural gas energy efficiency. For these cases, no values are included in the respective chart.

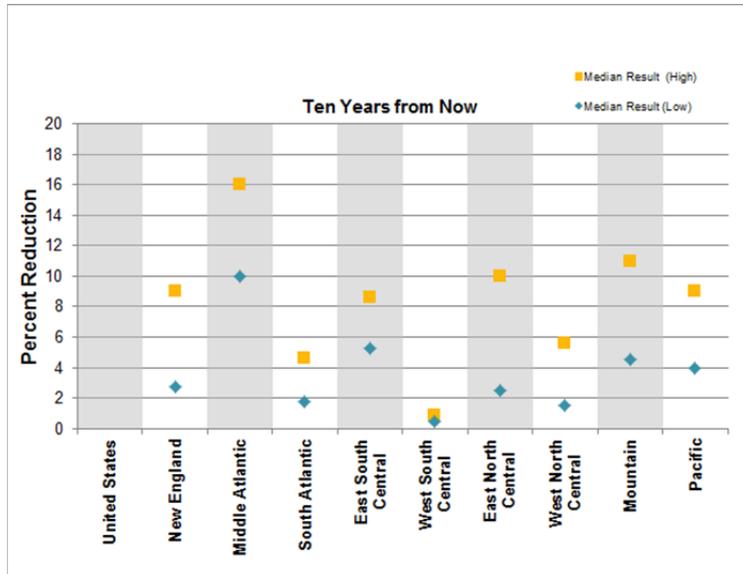


Figure 29 - Residential sector natural gas energy efficiency savings

The West South Central division is forecasted to have the lowest commercial sector savings from natural gas energy efficiency, ranging between 0.4 to 0.75 percent. The West North Central division is forecasted to have the largest commercial sector savings from natural gas energy efficiency, ranging between 2.75 and 10.5 percent (see Figure 30).

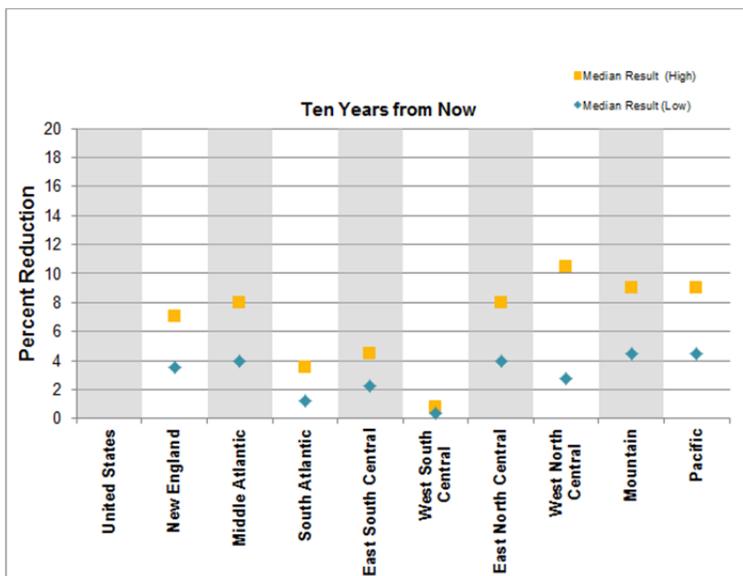


Figure 30 - Commercial sector natural gas energy efficiency savings, ten years from now

The West South Central division is forecasted to have the lowest industrial sector savings from natural gas energy efficiency, ranging between 0.5 to 1.2 percent. The West North Central division is forecasted to have the largest industrial sector savings from natural gas energy efficiency, ranging between 2.75 and 10.6 percent (see Figure 31).

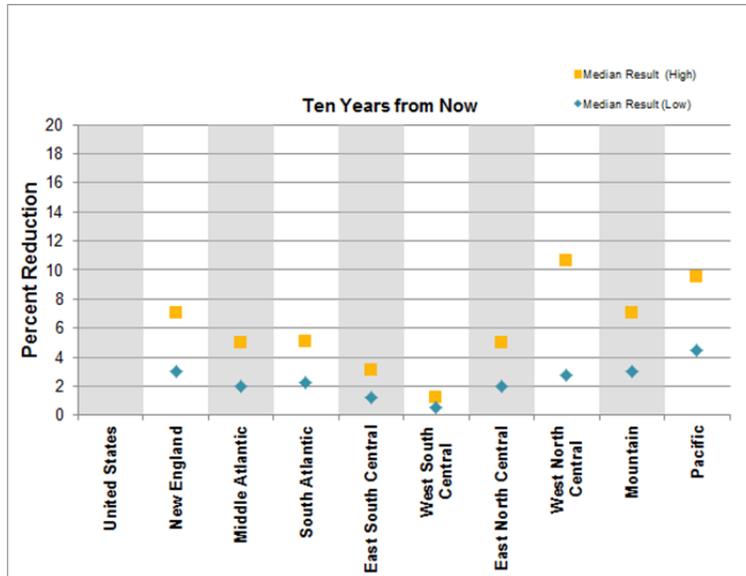


Figure 31 - Industrial sector natural gas energy efficiency savings

The Middle Atlantic, East South Central, and East North Central divisions are forecasted to have the lowest agricultural sector savings from natural gas energy efficiency, ranging between 2 to 5 percent. The South Atlantic division is forecasted to have the largest agricultural sector savings from natural gas energy efficiency, ranging between 4 and 9 percent (see Figure 32).

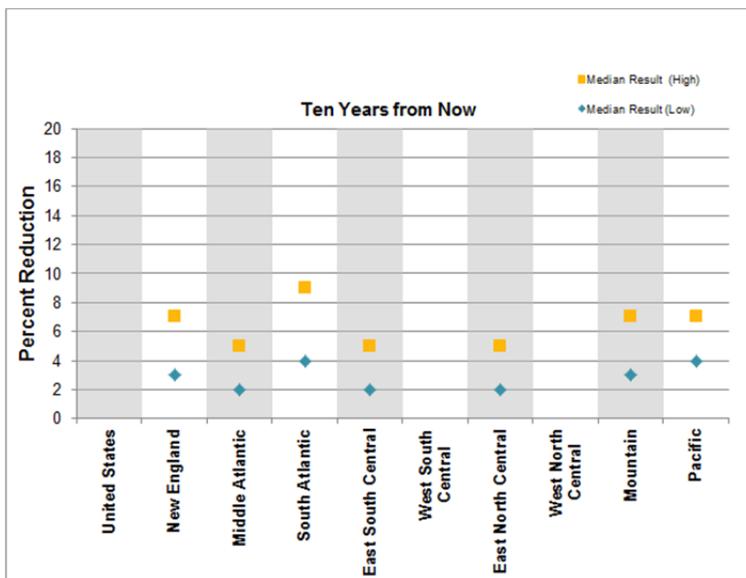


Figure 32 - Agricultural sector natural gas energy efficiency savings

*What percent of customers who need to replace or purchase equipment will choose high-efficiency options offered through programs?*²⁴

²⁴ *Id.* 23

The West South Central division, at 1.2 percent, is forecasted to have the lowest rate of residential customers choosing the high-efficiency space heating system option. The South Atlantic division, at 30.6 percent, is forecasted to have the highest rate of residential customers choosing the high-efficiency space heating system option (see Figure 33).

The West South Central division, at 1.2 percent, is forecasted to have the lowest rate of residential customers choosing the high-efficiency water heating system option. The Mountain division, at 40 percent, is forecasted to have the highest rate of residential customers choosing the high-efficiency water heating system option (see Figure 33).

The West South Central division, at 1.2 percent, is forecasted to have the lowest rate of residential customers choosing simple high-efficiency measures. The East North Central and Pacific divisions, at 50 percent, are forecasted to have the highest rate of residential customers choosing simple high-efficiency measures (see Figure 33).

The East South Central division, at 1 percent, is forecasted to have the lowest rate of residential customers choosing moderate high-efficiency measures. The East North Central, Mountain, and Pacific divisions, at 30 percent, are forecasted to have the highest rate of residential customers choosing moderate high-efficiency measures (see Figure 33).

The Middle Atlantic and West South Central divisions, at 1 percent, are forecasted to have the lowest rate of residential customers choosing complex high-efficiency measures. The Pacific division, at 27.5 percent, is forecasted to have the highest rate of residential customers choosing complex high-efficiency measures (see Figure 33).

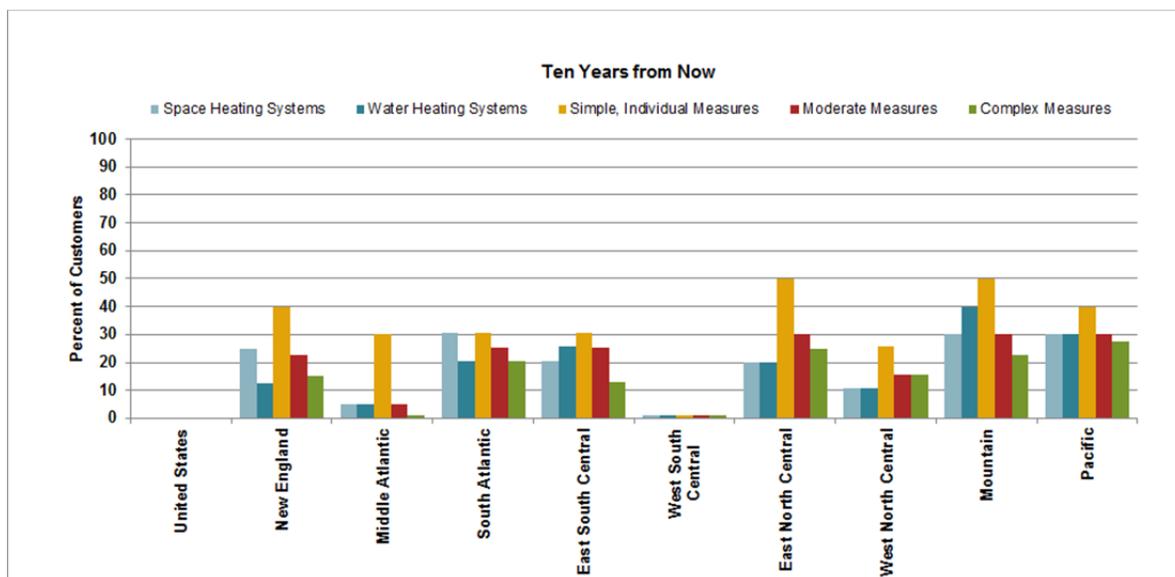


Figure 33 - Percent of residential high-efficiency natural gas equipment purchases

The West South Central division, at 1 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency boiler for space heating option. The South Atlantic division, at 25.5 percent, is forecasted to have the highest rate of commercial

and industrial customers choosing the high-efficiency boiler for space heating option (see Figure 34).

The West South Central division, at 1 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency furnace for space heating option. The South Atlantic division, at 25.5 percent, is forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency furnace for space heating option (see Figure 34).

The West South Central division, at 1.2 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing the high-efficiency boiler for water heating option. The South Atlantic division, at 25.6 percent, is forecasted to have the highest rate of commercial and industrial customers choosing the high-efficiency boiler for water heating option (see Figure 34).

The West South Central division, at 1 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing simple high-efficiency measures. The Mountain division, at 50 percent, is forecasted to have the highest rate of commercial and industrial customers choosing simple high-efficiency measures (see Figure 34).

The West South Central division, at 1 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing moderate high-efficiency measures. The Mountain division, at 35 percent, is forecasted to have the highest rate of commercial and industrial customers choosing moderate high-efficiency measures (see Figure 34).

The West South Central division, at 1 percent, is forecasted to have the lowest rate of commercial and industrial customers choosing complex high-efficiency measures. The Pacific division, at 25 percent, is forecasted to have the highest rate of commercial and industrial customers choosing complex high-efficiency measures (see Figure 34).

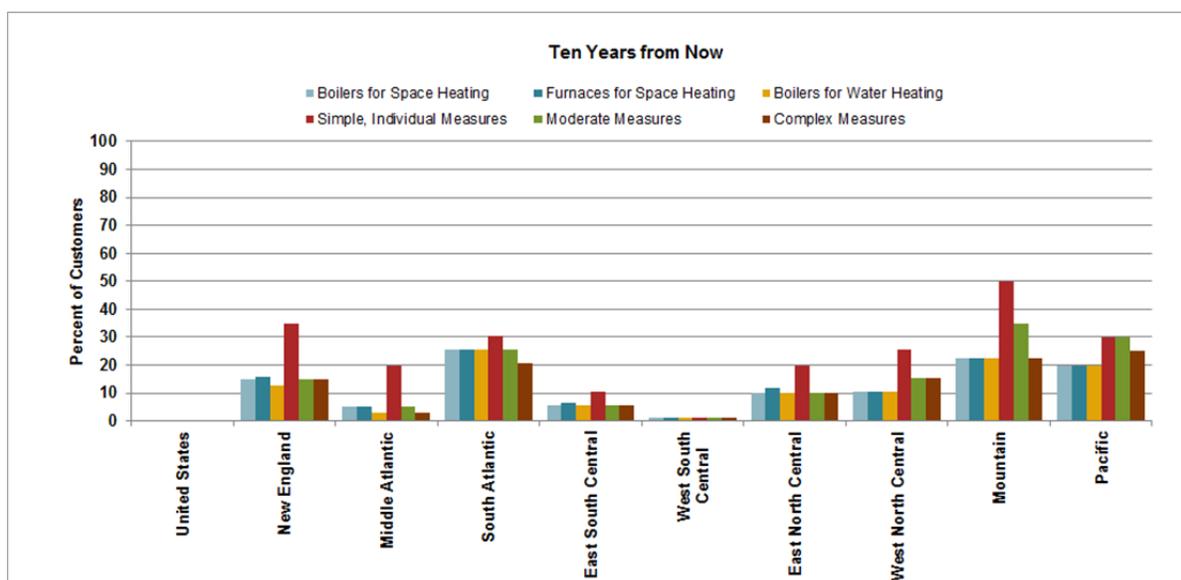


Figure 34 - Percent of commercial and industrial high-efficiency natural gas equipment purchases

ELECTRIC DEMAND RESPONSE

What percent of total system peak demand, relative to a total baseline forecast, will be offset by savings from demand response programs?

The United States is forecasted to have total system peak demand savings range between 7.5 and 15 percent. The East North Central, Mountain, and Pacific divisions are forecasted to have the lowest total system peak demand savings, ranging between 5 and 8, 4 and 8, and 4 and 8 percent, respectively. The West South Central and West North Central divisions are forecasted to have the highest total system peak demand reductions, ranging between 7.5 and 15 and 7 and 15 percent, respectively (see Figure 35).

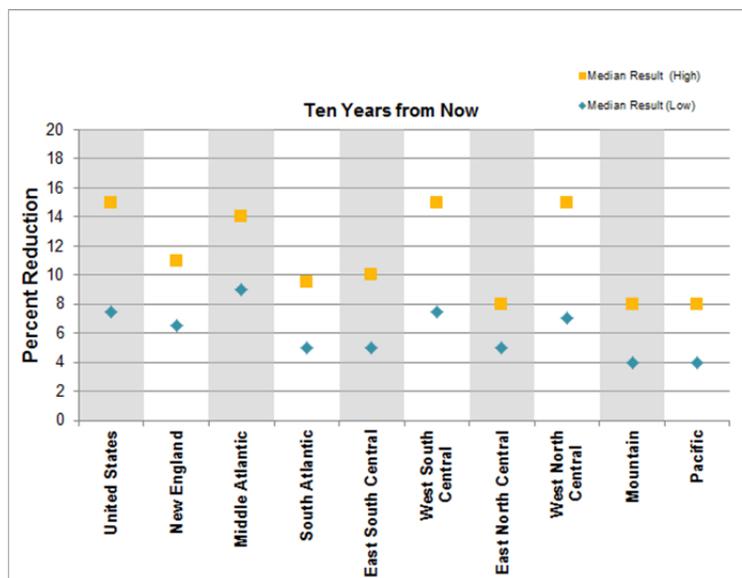


Figure 35 - Total electric demand response peak demand savings

What percent of each sector's total peak demand, relative to its own baseline forecast, will be offset by savings from demand response programs?

The United States is forecasted to have residential sector peak demand savings range between 4 and 15 percent. The Mountain division is forecasted to have the lowest residential sector peak demand savings, ranging between 3.5 and 6.5 percent. The West North Central division is forecasted to have the largest residential sector peak demand savings, ranging between 7.5 and 20 percent (see Figure 36).

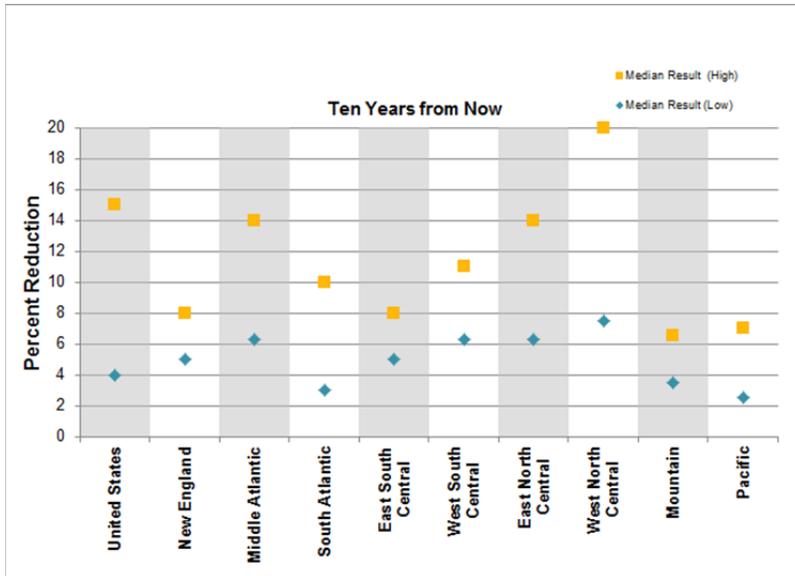


Figure 36 - Residential sector electric demand response peak savings

The United States is forecasted to have small commercial and industrial sector peak demand savings range between 4 and 7 percent. The Pacific division is forecasted to have the lowest small commercial and industrial sector peak demand savings, ranging between 3 and 5 percent. The West North Central division is forecasted to have the largest small commercial and industrial sector peak demand savings, ranging between 7.5 and 20 percent (see Figure 37).

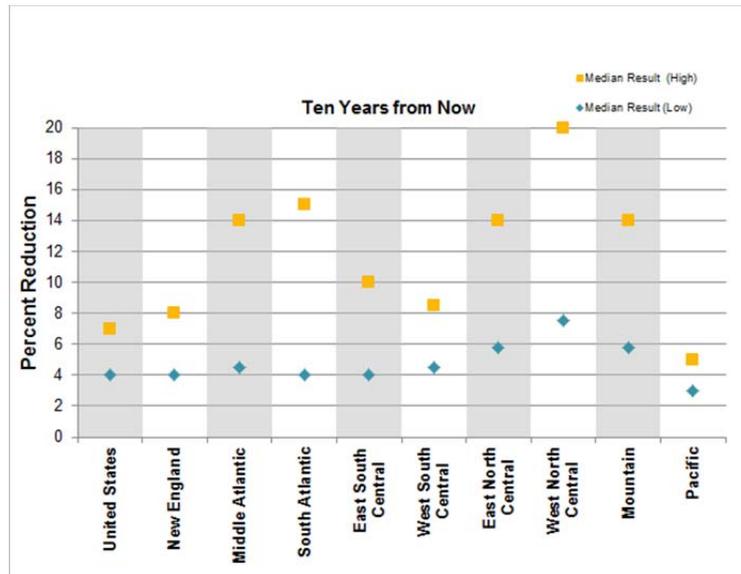


Figure 37 - Small commercial and industrial sector electric demand response peak savings

The United States is forecasted to have medium commercial and industrial sector peak demand savings range between 5 and 12 percent. The New England division is forecasted to have the lowest medium commercial and industrial sector peak demand savings, ranging between 3 and 6 percent. The West North Central division is forecasted to have the largest medium commercial and industrial sector peak demand savings, ranging between 7.5 and 22 percent (see Figure 38).

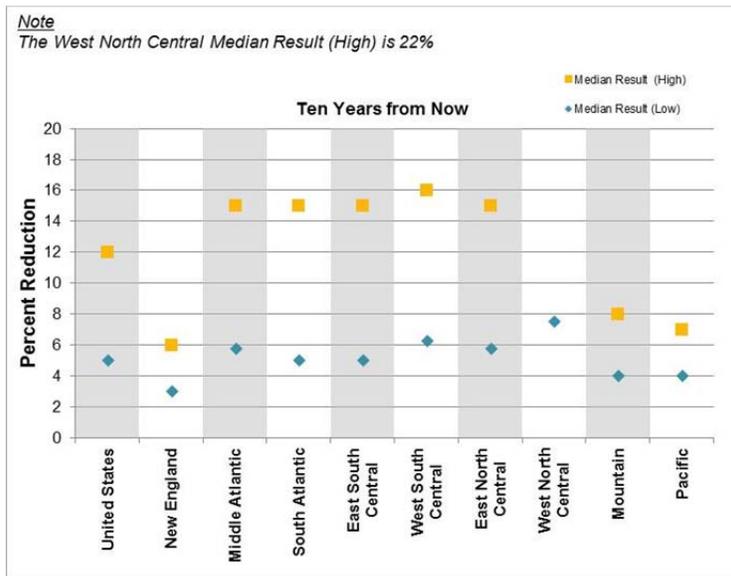


Figure 38 - Medium commercial and industrial sector electric demand response peak savings

The United States is forecasted to have large commercial and industrial sector peak demand savings range between 6 and 15 percent. The East South Central, Mountain, and Pacific divisions are forecasted to have the lowest large commercial and industrial sector peak demand savings, ranging between 5 and 10 percent. The South Atlantic and West North Central divisions are forecasted to have the largest large commercial and industrial sector peak demand savings, ranging between 7.5 and 25 percent (see Figure 39).

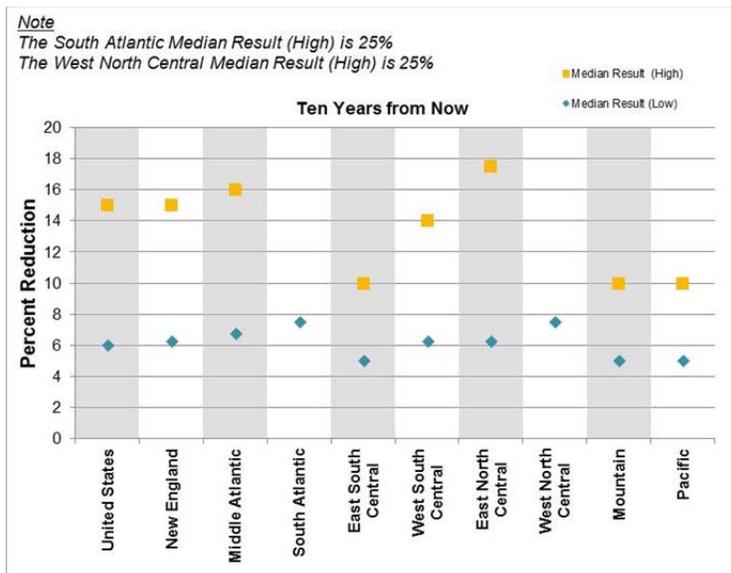


Figure 39 - Large commercial and industrial sector electric demand response peak savings

The United States is forecasted to have agricultural sector peak demand savings range between 4 and 7 percent. The East South Central, Mountain, and Pacific divisions are forecasted to have the lowest agricultural sector peak demand savings, ranging between 5 and 10 percent. The West

North Central division is forecasted to have the largest agricultural sector peak demand savings, ranging between 8 and 25 percent (see Figure 40).

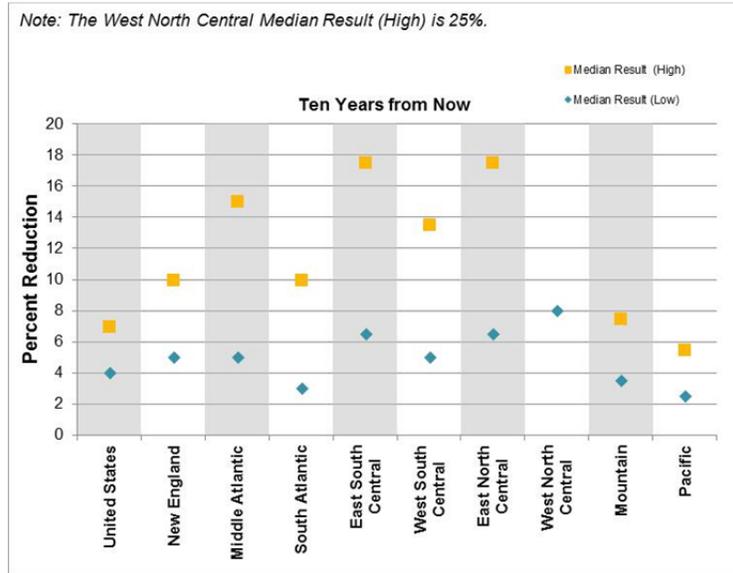


Figure 40 - Agricultural sector electric demand response peak savings

What percent of customers will be engaged with demand response programs?

The United States is forecasted to have residential direct load control participation range between 10 and 15 percent. The West South Central division is forecasted to have the lowest residential direct load control participation, ranging between 5 and 10 percent. The East South Central and East North Central divisions are forecasted to have the highest residential direct load control participation, ranging between 5 and 30 and 10 and 30 percent, respectively (see Figure 41).

The United States is forecasted to have residential dynamic pricing participation range between 7.5 and 20 percent. The East South Central and Pacific divisions are forecasted to have the lowest residential dynamic pricing participation, ranging between 5 and 10 percent. The East North Central division is forecasted to have the highest residential dynamic pricing participation, ranging between 12.5 and 45 percent (see Figure 41).

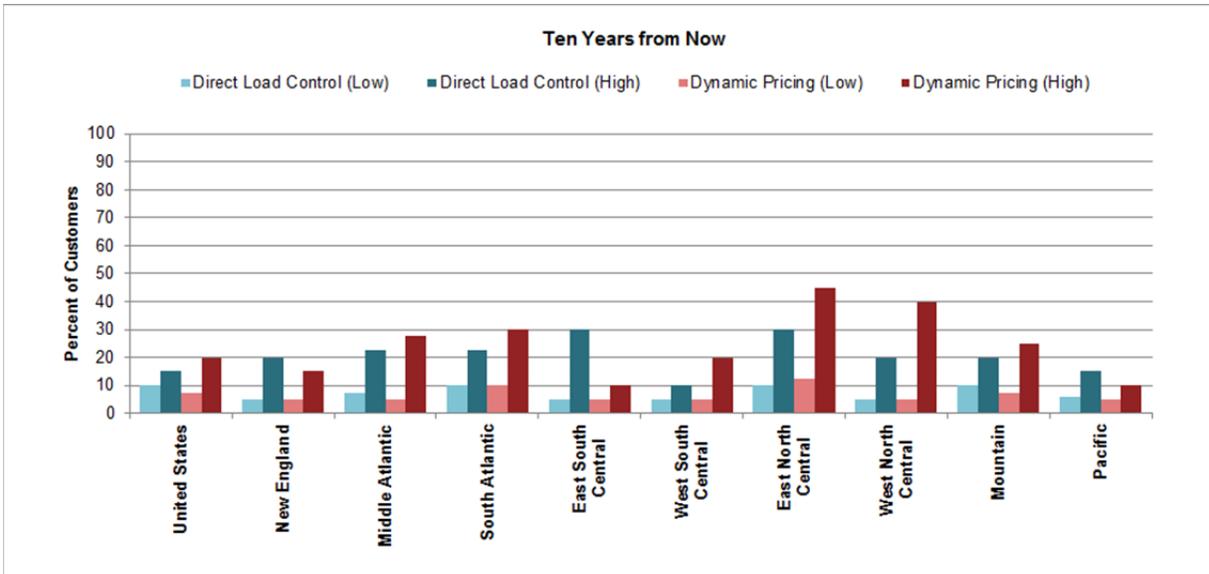


Figure 41 - Percent of residential customers who will be engaged with demand response

The United States is forecasted to have commercial and industrial direct load control participation range between 5 and 15 percent. The West South Central division is forecasted to have the lowest commercial and industrial direct load control participation, ranging between 2 and 10 percent. The West North Central division is forecasted to have the highest commercial and industrial direct load control participation, ranging between 8.5 and 32.5 percent (see Figure 42).

The United States is forecasted to have commercial and industrial dynamic pricing participation range between 10 and 30 percent. The East South Central division is forecasted to have the lowest commercial and industrial dynamic pricing participation, ranging between 3 and 6 percent. The Middle Atlantic, South Atlantic, and East North Central divisions are forecasted to have the highest commercial and industrial dynamic pricing participation, ranging between 7.5 and 40, 10 and 40, and 20 and 40 percent, respectively (see Figure 42).

The United States is forecasted to have commercial and industrial interruptible/curtailable tariff participation range between 3 and 15 percent. The West North Central division is forecasted to have the lowest commercial and industrial interruptible/curtailable tariff participation, ranging between 3 and 4 percent. The East North Central division is forecasted to have the highest commercial and industrial interruptible/curtailable tariff participation, ranging between 40 and 60 percent (see Figure 42).

The United States is forecasted to have commercial and industrial participation in other demand response programs range between 4 and 15 percent. The West South Central division is forecasted to have the lowest commercial and industrial participation in other demand response programs, ranging between 2 and 9 percent. The South Atlantic division is forecasted to have the highest commercial and industrial participation in other demand response programs, ranging between 17.5 and 55 percent (see Figure 42).

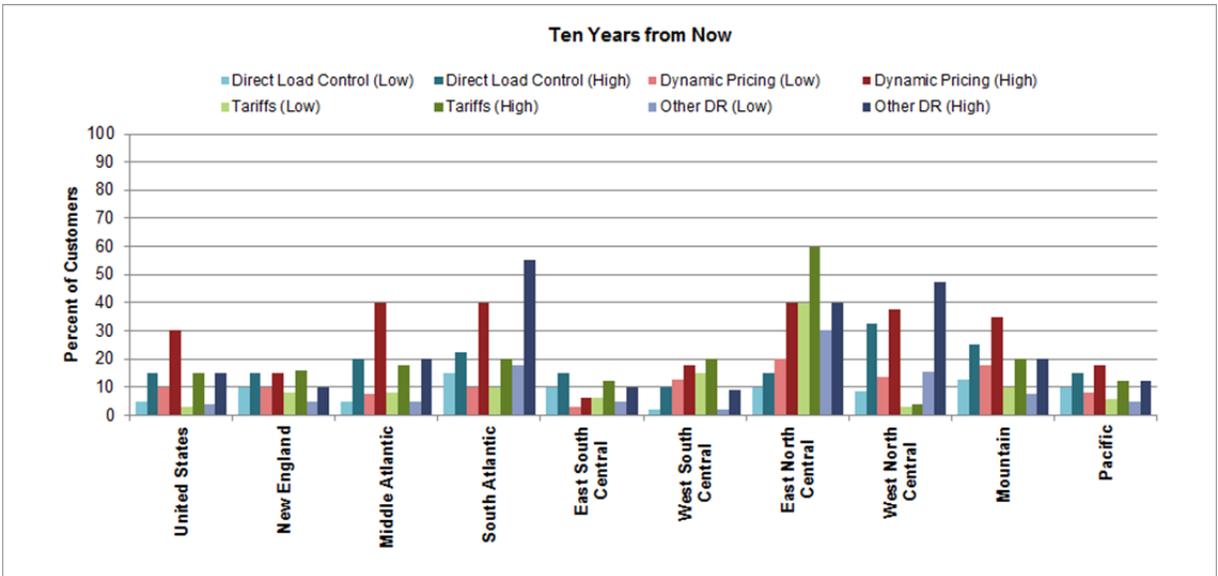


Figure 42 - Percent of commercial and industrial customers who will be engaged with demand response