



Energy Efficiency Programs for Large Savings in the Next Decade

Steven Nadel and Jasmine Mah

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Research Report



About ACEEE

The **American Council for an Energy-Efficient Economy** (ACEEE), a nonprofit research organization, develops policies to reduce energy waste and combat climate change. Its independent analysis advances investments, programs, and behaviors that use energy more effectively and help build an equitable clean energy future.

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Executive summary

Expanded utility-funded energy efficiency programs can significantly slow rising electricity demand and reduce electricity bills; this report explains how. Growing electricity demand and rising electricity prices are a concern across the United States. Average rates have increased 29% since 2020 and utilities are proposing many billions of dollars in new and upgraded generation, transmission, and distribution systems to meet increased consumption, which will increase rates even more. Energy efficiency not only lowers utility bills, it is almost always less expensive to implement than new generation, transmission, and distribution per kilowatt hour (kWh). Thus, substituting energy efficiency for some of the planned grid investments can reduce costs and slow down rate increases. By contrast, other grid investments do not reduce consumption and rarely reduce bills. Efficiency efforts also can be ramped up in less time than it takes to build new power plants and expand transmission and distribution, creating “headroom” for new loads. Furthermore, expanded programs can reduce use of polluting fuels, including natural gas, fuel oil, and propane.

A substantial portion of past efficiency savings were driven by more efficient lighting, such as lighting from LEDs. While some potential lighting savings remain, much greater opportunities are found elsewhere, so programs need to diversify to take advantage of these other money-saving efficiency measures. This report provides many examples of more diversified programs. We examine 13 program areas with opportunities for both large energy savings and large reductions in peak electric demand in summer and winter. While we focus on programs that reduce electricity use, we also highlight where many of these programs reduce fuel use for space and water heating as well as industrial process loads.

Key findings

- By 2035, expanded utility-funded electric efficiency efforts across 13 program areas can reduce U.S. electricity consumption by 12% relative to projected 2035 electricity consumption, and generally do so at a substantially lower cost per kilowatt hour than new power plants.
- The expanded electric efficiency programs would simultaneously reduce projected consumption of gas, propane, and oil for space heating and other end uses by 6%.
- These programs can also substantially reduce growth in peak electricity demand, providing about 173 GW of summer peak demand reductions and about 108 GW of winter peak savings, not counting the fuel switching programs. This is more than the power output of 100 large nuclear power plants in the winter, and even more power plants in the summer.
- Replacing expensive sources of energy such as fuel oil and propane heat with efficient heat pumps can reduce fuel use by an additional 2%. This reduces the annual electricity savings resulting from electric efficiency programs by 1.3 efficiency points. This fuel switching also increases winter peak electricity demand by 36 GW.
- The programs with the largest electric energy savings are industrial programs, commercial building retrofits, and distribution efficiency improvements.
- The programs with the largest peak demand savings are smart thermostat and HVAC programs, followed by the same ones that deliver the largest overall savings.
- Only a few leading utilities are presently using energy efficiency programs at this level. Most utilities need to dramatically expand their energy efficiency and demand reduction programs to capture available efficiency savings and thereby help serve growing loads and better assist customers in controlling their energy bills. Policymakers should accelerate this adoption by requiring implementation of these programs where utilities continue to lag.

Programs with opportunities for large savings

We look at the following program areas with opportunities for large savings, and they are ordered by potential electric savings, from largest to smallest, as analyzed in this report:

1. **Industry.** We discuss strategic energy management, energy management information systems, energy studies, energy manager support, and several emerging approaches.
2. **Commercial retrofits.** We discuss buildings over 25,000 sq. ft. and cover assisting with enactment and implementation of Building Performance Standards (BPS), supporting building renovations, strategic energy management, monitoring-based commissioning, and automated demand response.
3. **Distribution efficiency.** We address voltage optimization and amorphous core distribution transformers.
4. **Heating, ventilation, and air-conditioning (HVAC).** We discuss midstream market programs, residential and commercial heat pump market transformation programs, advanced rooftop unit control programs, and chiller programs.
5. **Lighting.** This includes both controls and LED lighting.
6. **New construction.** We cover both residential and commercial.
7. **Single-family home retrofits.**
8. **Low-income household retrofits.**
9. **Small business retrofits.** We discuss retrofits in buildings 25,000 sq. ft. and smaller, primarily using a direct installation approach.
10. **Smart thermostats.** We address both energy savings and peak demand reduction.
11. **Multifamily building retrofits.**
12. **Appliances and equipment.** We focus on affecting future minimum efficiency standards.
13. **Water heating.** We emphasize demand-response controls, but also discuss heat pump water heater programs in the years before new federal efficiency standards take effect, as well as products not covered by the Department of Energy (DOE) standard.

We identified these program areas through discussions with program experts and analysis of energy savings achieved by leading utilities and other program implementers. For each program area, we identified leading programs and compiled case studies on these programs including participation rates, savings, costs, and lessons learned.

Energy savings and demand reduction

Overall, excluding the fuel switching programs that we discuss below, the programs we profile reduce projected 2035 electricity use by about 574 TWh and reduce fuel use by about 1,700 trillion Btu (Tbtu). To put these figures in perspective, the U.S. Energy Information Administration's *2026 Annual Energy Outlook* estimates that in 2035, U.S. utilities will sell 4,937 TWh; therefore, implementing our suggested energy efficiency programs would reduce U.S. electricity sales by about 12%.¹ The commercial savings represent 39% of the total electricity savings, industrial 29%, residential 16%, and grid programs 17% (figure ES-1). Because these programs emphasize electricity savings, the 2035 fuel savings from these programs are smaller, about 8% of projected fuel sales to residential, commercial, and industrial customers. Additional savings are likely possible from programs that focus on these fuels, but that is

¹ These figures do not include the additional electricity use of heat pumps from programs that spur replacement of fuel-fired furnaces, boilers, and water heaters with heat pumps. We discuss the energy use of these heat pumps on the next page.

outside the scope of this report. The estimated annual electricity savings are more than the total 2024 electricity consumption of Texas, the state with the highest electricity use.

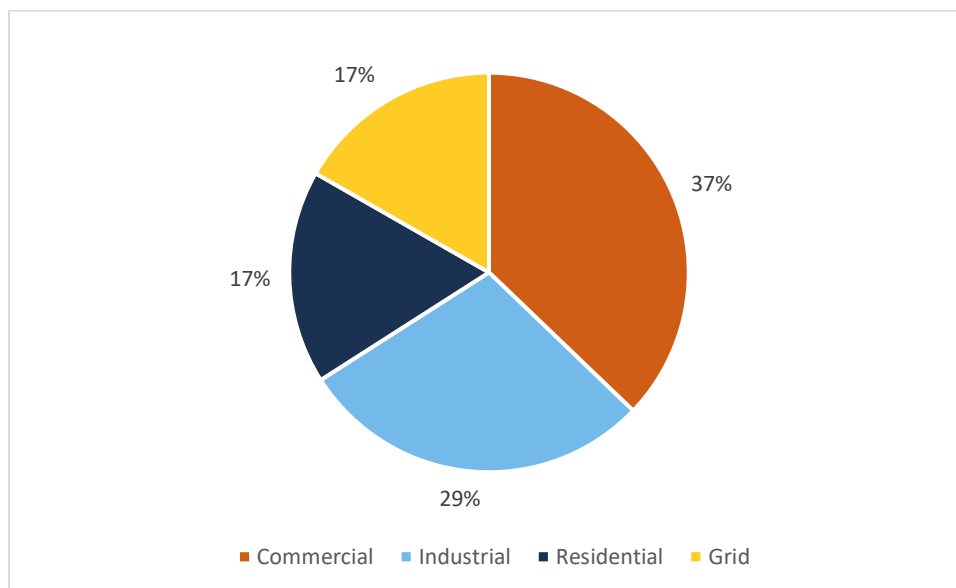


Figure ES-1. Division of 2035 electricity savings (without fuel switching) by sector

The electricity savings free up some capacity for new loads from data centers, electrification with heat pumps, and electric vehicles. The fuel savings include some replacement of oil- and propane-fueled space and water heating with electric heat pumps, and use of heat pumps to complement natural gas heat. This increased use of heat pumps saves energy because heat pumps are about twice as efficient as the systems they displace. These additional heat pumps will increase electricity use by approximately 64 TWh per year, offsetting about 11% of the 574 TWh of total electricity savings that would be achieved with just electric efficiency measures (lowering the projected reduction in 2035 from about 12% to about 10%).

The programs we profile also have large peak demand savings, totaling about 173 GW in the summer and about 108 GW in the winter. To put these demand savings in perspective, a typical large nuclear power plant is about 1 GW, and typical new gas combined-cycle power plants range in size from about 0.7–1.25 GW. Thus, these programs will defer the equivalent of more than 100 large nuclear or gas combined-cycle power plants serving winter peak loads and even more serving summer peak loads. Another way to interpret these demand savings is relative to the demand of large new data centers. The largest operating data centers are 250–750 MW (0.25–0.75 GW), and several planned data centers are over 5 GW. Savings by program are summarized in figure ES-2.

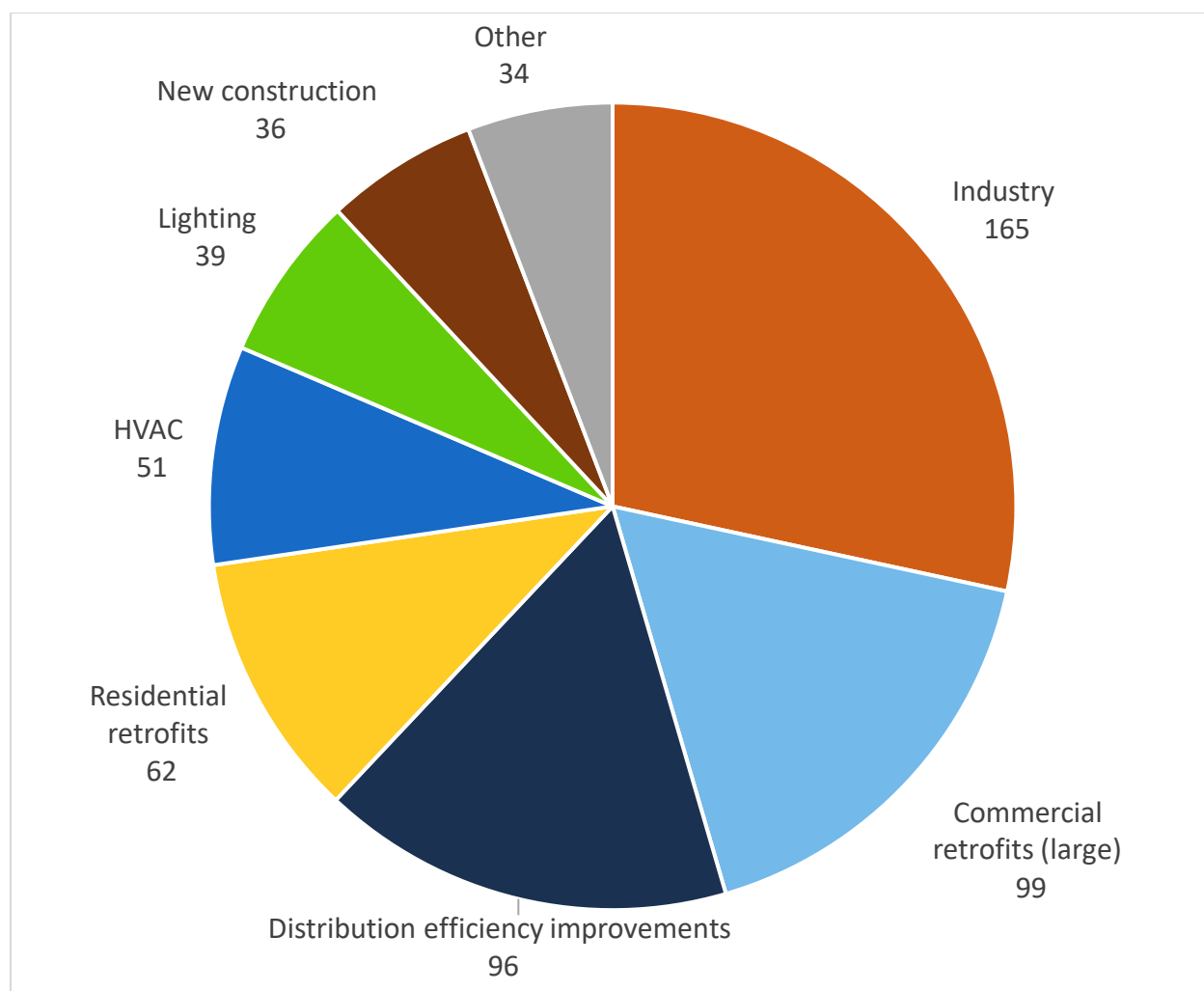


Figure ES-2. Estimated electricity savings by program without fuel switching (TWh)

Cost of saved energy

For most program types, we were able to collect information to calculate the cost per kWh saved over the measure lifetime, also known as the cost of saved energy. We find that for most of the programs, the cost per kWh saved is less than \$0.05 and for a majority it is less than \$0.03. Only a few program types, all addressing homes, have costs that are greater than about \$0.08 per kWh. These costs are substantially less than retail electric rates (which in 2025 averaged \$0.17 per kWh for residential sales, \$0.13 for commercial, and \$0.09 for industrial). These energy efficiency costs per kWh will also generally be less than utility avoided costs, with the possible exception of a few of the residential programs.

Discussion and recommendations

A few utilities are advancing savings at the rate we show is possible, including much of the top third in ACEEE's *Utility Scorecard*. They are helping customers lower their bills, maximizing cost-effective savings, and reducing long-term utility costs. But most utilities do not prioritize efficiency and have much smaller programs. To achieve the large savings needed to slow load growth and help customers control their energy bills, energy efficiency needs to be a high priority for utilities and regulators. Utility energy efficiency program administrators should carefully review each of the program approaches we

detail in Part 2 of this report, add programs where they are lacking, and analyze current programs to identify opportunities for improvement.

Utility regulators should ask utilities under their jurisdiction to review these program concepts, then report back on which program changes they propose to make and which approaches they do not think are appropriate for their service area and customers. Governor's offices, energy offices, and other policymakers beyond regulators should require regulators and utilities to pursue these program ideas when utilities lag behind their peers. In addition, these policymakers should adopt complementary energy-saving policies that will also reduce load growth, such as updated building codes, appliance and equipment efficiency standards, and building performance standards.

Part 1: Overall results

Introduction

Over the past several decades, energy efficiency programs achieved substantial savings in the United States. Average annual new electricity savings have averaged about 25 TWh (billion kWh) in recent years (Kresowik et al. 2025) and have been the backbone of supporting economic growth without driving up electricity demand. The benefits of efficiency measures last an average of about 12 years, and the total savings achieved each year have been growing (figure 1).

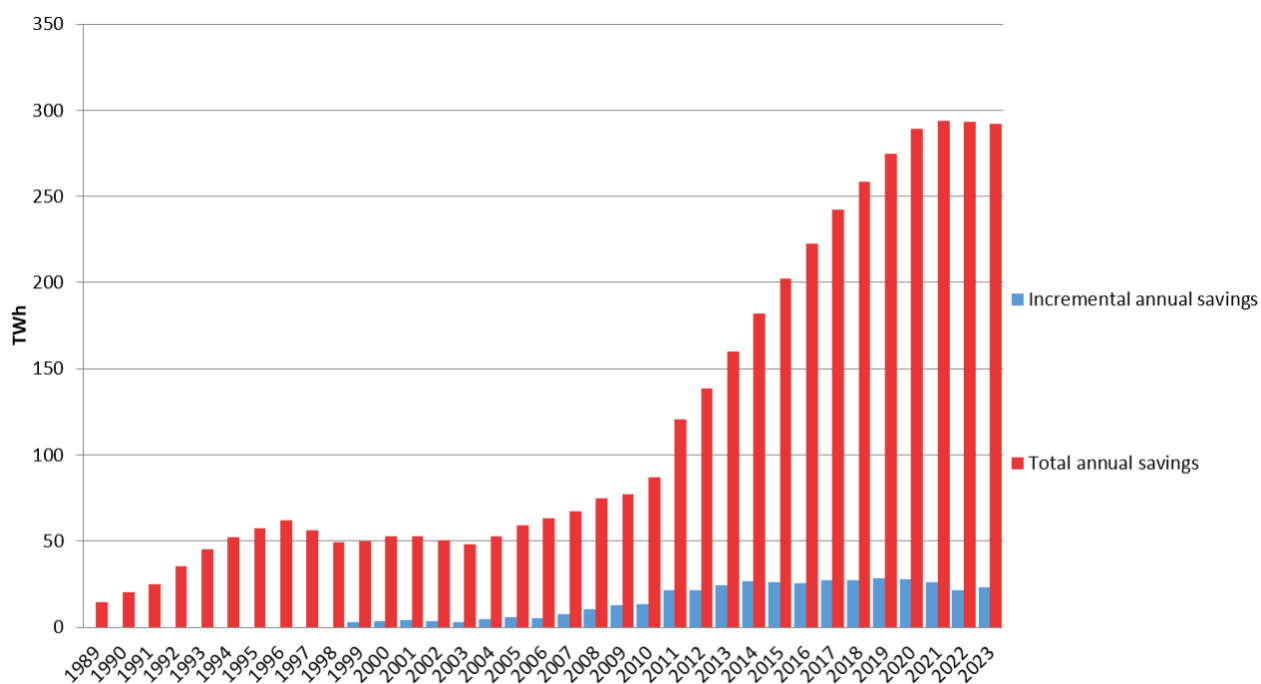


Figure 1. Incremental annual and total annual electricity savings from utility-funded energy efficiency programs. Total annual assumes measures on average provide savings for 10 years. In recent years, incremental annual savings and loss of savings from measures reaching end of life have offset each other.
Source: ACEEE State Energy Efficiency Scorecards, e.g., Kresowik et al. 2025.

Efficiency programs are at least as crucial today, with electric loads growing rapidly and utilities across the country proposing many billions of dollars in new and upgraded generation, transmission, and distribution systems. Expanded energy efficiency programs could help to reduce the size of grid investments, slowing electricity rate increases. While past success now limits potential future savings from traditional efficiency measures such as lighting and appliances, new approaches and new measures can achieve substantial savings.

To do this, we must refresh our understanding of where to find large energy efficiency savings.

The urgency is apparent in the electricity consumption data. While U.S. electricity sales barely grew from 2005 to 2020, due in part to substantial improvements in energy efficiency, since 2020 sales have again started increasing (figure 2). Forecasts are that electricity consumption will increase even more rapidly

in the coming decade, driven by new data center and industrial loads and increasing electrification of vehicles and buildings (EIA 2026a). In substantial part due to the grid investments being made, average electric rates have increased 29% since 2020 (EIA 2026b). Further increases are also likely: consulting firm ICF projects that residential retail rates will increase 15–40% by 2030 from 2025 levels and could double by 2050 (Batra et al. 2025).

U.S. electricity consumption (1990–2026)

billion kilowatthours

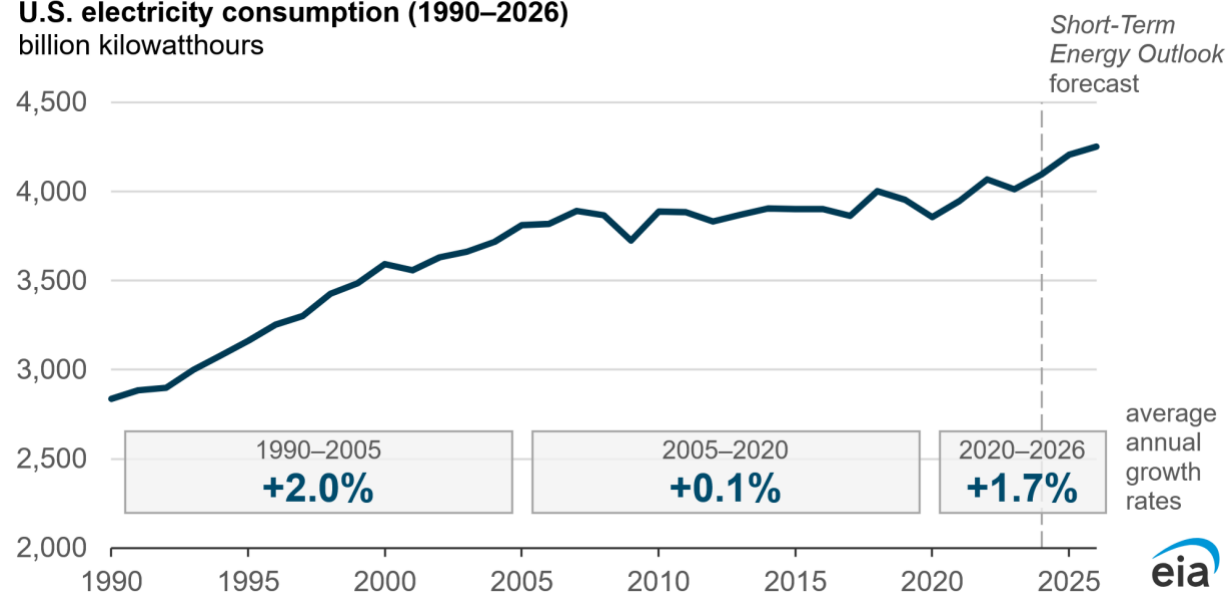


Figure 2. U.S. electricity consumption, 1990–2026. Source: EIA 2025a.

Achieving large efficiency gains in the coming decade will be critical. Energy efficiency programs can be ramped up in just a few years, and help to quickly lower utility bills, slow load growth, and reduce emissions. As discussed in ACEEE’s 2026 *Faster and Cheaper* report (Specian and Aquino 2026). In contrast, most investments in the grid take time. For example, gas combined-cycle turbines now need to be ordered three or four years in advance for high-price, expedited delivery and five to seven years in advance if using normal delivery without a price premium (Wang 2025). If work started today on a new nuclear power plant in the United States, it would not be completed until the 2030s (Brown 2025).

Methodology

This report is a deep-dive examination of ways that energy efficiency could substantially reduce load growth and help limit rate increases. Our work is divided into 13 program areas, all of which emphasize electricity savings. We arrived at these 13 after doing preliminary analysis of available data and gathering input from project sponsors. We chose programs with large energy savings and demand reductions that can build on current program approaches and experience. We discuss each of these program areas in detail in Part 2. They are presented here and in Part 2 in descending order of total potential estimated savings:

1. *Industry* – strategic energy management, energy management information systems, energy studies, energy manager support, and several emerging approaches.²
2. *Commercial retrofits* – for buildings over 25,000 sq. ft., including assisting with enactment and implementation of Building Performance Standards, supporting building renovations, strategic energy management, monitoring-based commissioning, and automated demand response.
3. *Distribution efficiency* – voltage optimization and amorphous core distribution transformers.
4. *Heating, ventilation, and air-conditioning (HVAC)* – midstream market programs, residential and commercial heat pump market transformation programs, advanced rooftop unit control programs, and chiller programs.
5. *Lighting* – lighting controls and LED lighting.
6. *New construction* – residential and commercial.
7. *Single-family home retrofits* – for middle- and higher-income households.
8. *Low-income household retrofits*
9. *Small business retrofits* – for buildings 25,000 sq. ft. and smaller, and primarily a direct installation approach.
10. *Multifamily building retrofits*
11. *Smart thermostats* – for both energy savings and peak-demand reduction.
12. *Appliances and equipment* – focused on affecting future minimum efficiency standards.
13. *Water heating* – mainly focused on demand-response controls but we also include heat pump water heater programs.

For each program type, we identified examples of successful programs based on recommendations from experts and by reviewing evaluation reports and identifying programs that stood out for large and cost-effective savings. We did not look at all potential programs in each area, and likely some equally good programs are not included. The program design and marketing features we highlight at the end of each section are taken from the lessons learned by program administrators and documented in both our case studies and our analysis results.

Methods overview

For each program area, we researched, analyzed, and wrote about the following. See the appendix for additional details of the approach.

- Technologies and program approaches
- Examples of successful programs
- Participation rates
- Energy savings
- Peak demand reduction
- Typical costs and the cost of saved energy
- Exemplary program design and marketing features
- Recommendations for program managers

There are many assumptions in the national energy savings calculations. While the key assumptions are documented with citations throughout the report, these calculations are uncertain and approximate. Furthermore, in constructing our programs and savings estimates, we sought to minimize overlap between programs and adjusted in a few cases to eliminate counting the same savings twice.³ Finally,

² Programs to improve data centers are sometimes part of industrial programs and sometimes part of commercial programs. These programs are nascent; ACEEE plans to focus on these programs in a 2027 project.

³ Specifically, we (1) separated large commercial building retrofits from small commercial building retrofits, because building performance standards only apply to large buildings; (2) reduced lighting and HVAC program savings to account for overlap with retrofit programs; and (3) included appliance standards mostly for products not included in retrofit programs.

we use the cost of saved energy as our primary economic metric because utility avoided costs vary widely and it is very difficult to calculate a national benefit-cost ratio. Because costs and savings vary between individual programs, our energy saving estimates and cost of saved energy estimates should be considered approximate—somewhat higher and lower values are also possible. Further information on the methodology is provided in the “Appendix—Methodology” section.

Overall results

Energy savings

Over the 2026–2035 period, the programs we profile would reduce 2035 electricity use by 574 TWh and reduce fuel use by about 1,700 TBtu. This does not count the fuel switching programs. The U.S. Energy Information Administration (EIA 2026a) estimates that in 2035, U.S. utilities will sell 4,937 TWh, and thus **our estimated savings are about 12% of U.S. electricity sales in 2035**. The programs emphasize electricity savings, and as a result the 2035 fuel savings from these programs are smaller—about 6% of projected fuel sales for residential, commercial, and industrial customers. Additional fuel savings are likely possible from programs that focus on these fuels. These annual electricity savings are more than the total 2024 electricity consumption of Texas, the state with the highest electricity use (EIA 2025b).

The electricity savings free up some capacity for new loads from data centers, heat pumps, and electric vehicles. Programs to promote replacement of expensive sources of energy (fuel oil and propane for space and water heating), plus use of heat pumps to complement natural gas heat during moderate temperature periods, save an additional 2% of fuel use. This increased use of heat pumps saves energy because heat pumps are significantly more efficient than the systems they displace. These additional heat pumps will lower the electricity savings achieved by the 13 programs by 1.3% of total electricity use.

The programs we profile also have large peak demand savings, totaling about 173 GW in the summer and about 108 GW in the winter (not counting the impact of fuel switching). These savings will reduce the need for new power plants and transmission and distribution infrastructure. A typical large nuclear power plant is 1 GW, and typical new gas combined-cycle power plants range in size from about 700–1,250 MW (0.7–1.25 GW) (EIA 2022). Thus, the programs we profile will defer the equivalent of more than 100 large nuclear or gas combined-cycle power plants. Since the largest operating data centers are 250–750 MW (0.25–0.75 GW) and several planned data centers are over 5 GW (Cleanview 2026), these peak demand reductions are also enough to serve many large data centers.

Savings by program are summarized in table 1 and figure 3. Industrial programs have the largest electricity savings, followed by commercial retrofit programs and distribution system measures. Together, these three programs account for over 60% of the savings from all 13 programs.

While a few programs dominate the savings, the programs with smaller savings are also very important because they help to benefit all customer groups, including low-income households, single-family homeowners, and renters.

The 13 programs include one industrial program, two commercial programs (for large and small businesses), five residential programs (smart thermostats, water heating, and single-family and low-income retrofit programs), one program that reduces grid losses, and four programs that address both residential and commercial energy use (HVAC, lighting, new construction, and appliances). The commercial savings are 37% of the total savings, industrial 29%, residential 18%, and grid programs 17% (see figure 4).

The industrial programs reduce sector electricity use by 15% over 10 years. The commercial and residential programs reduce their sector's electricity use by 12% and 5%, respectively. The modest savings from residential programs are primarily due to modest participation rates in many residential programs. For example, over 10 years, the three residential retrofit programs only serve about 21% of homes and apartments across the country. Higher participation rates have been achieved by focused, community-based programs that provide free or nearly free retrofits (e.g., 85% in a program in Hood River, Oregon; 72% in a program in Espanola, Oregon), but these higher participation rates and savings come at a cost (York et al. 2015). Also, the challenges of residential retrofits illustrate the importance of federal and state appliance standards for achieving residential energy savings (Neill, Dias, and Meyers 2025).

Note that for commercial retrofit, new construction, and appliance programs, we allot some credit to program administrators for their role helping to support and implement new building codes, appliance standards, and building performance standards. We credit one-third of the energy savings from these policies to program implementers, based on policy in Arizona, as detailed in the new construction chapter.⁴ The other two-thirds, which total about 110 TWh (about 2% of projected 2035 electricity consumption), will also reduce energy use but are not included in our figures on savings credited to program implementers.

Table 1. Summary of savings and peak demand reduction by program

Program	TWh	Peak MW		Fuels TBtu
		Summer	Winter	
Industry	165	17,520	17,520	1,156
Commercial retrofits	99	27,740	7,630	181
Distribution efficiency	96	16,430	11,500	-
HVAC (excluding fuel switching)	51	34,950	20,740	
Lighting	39	3,280	2,260	-
New construction	36	9,460	2,310	94
Single-family home retrofits	27	7,890	7,950	79
Low-income household retrofits	26	9,380	7,210	85
Small business retrofits	12	3,350	920	24
Multifamily building retrofits	9	1,760	3,260	21
Smart thermostats	8	35,470	20,520	54
Appliances and equipment	6	4,200	2,330	2
Water heating (excluding fuel switching)	0	1,910	3,510	
Subtotal	574	173,340	107,660	1,695

⁴ We chose Arizona's approach because of its simplicity and ease of use. The one-third ratio chosen in Arizona was based on evaluation results from other states at the time Arizona adopted its approach.

Program	TWh	Peak MW		Fuels TBtu
		Summer	Winter	
Savings as % of sales per AEO26	12%			6%
Fuel switching (HVAC and water heating)	(64)	-	(76,990)	445
Total	510	173,340	30,670	2,140
Savings as % of sales per AEO26	10%			8%

Note: Peak savings for HVAC and residential weatherization are based on averaging peak factors for the north and south in order to provide a rough picture of national impacts. Peak impacts will be higher in the summer in the south, higher in the winter in the north, and vice versa.

Electricity Savings in 2035 (TWh) from Programs Analyzed (without fuel switching).

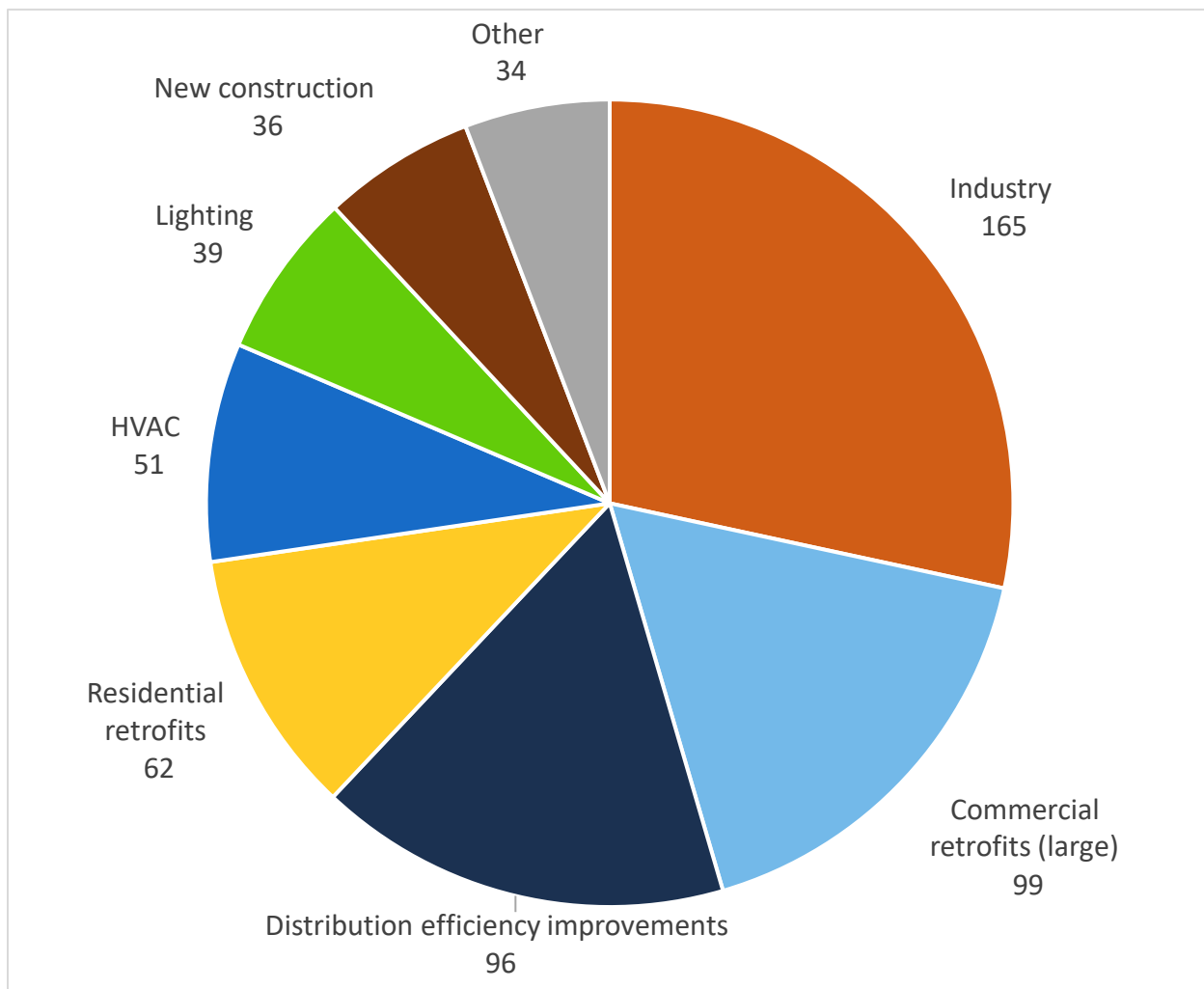


Figure 3. Estimated electricity savings by program (TWh; without fuel switching). The residential retrofit wedge includes the low-income, single-family, and multifamily programs. "Other" includes small business retrofits, smart thermostats, appliances and equipment, and water heating.

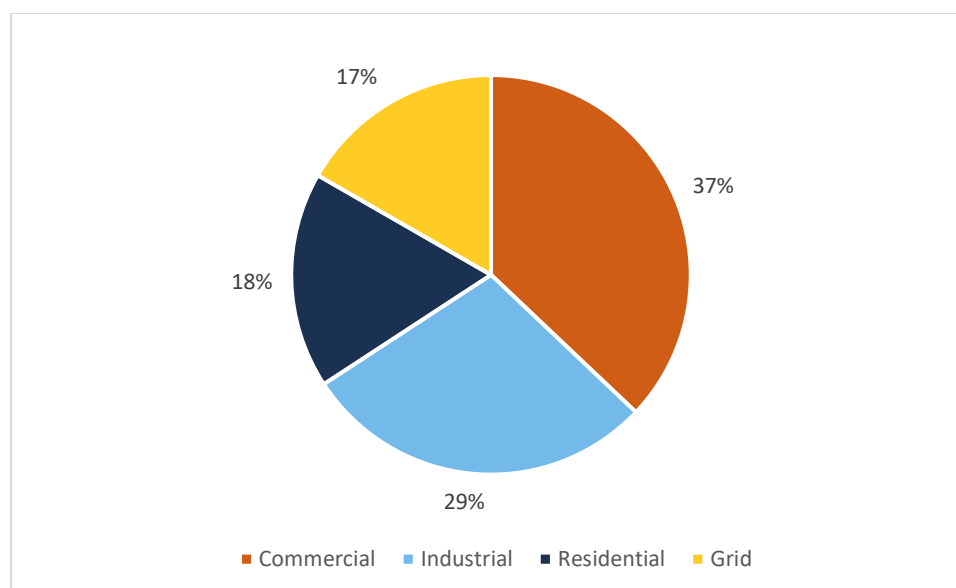


Figure 4. Division of 2035 electricity savings (without fuel switching) by sector

Peak demand reductions

Smart thermostats, HVAC, and commercial retrofits account for the largest summer peak savings. The large savings from smart thermostats come mostly from using them in demand-response mode and changing temperature setpoints by a few degrees, with customer permission and subject to customer override. Together, these three programs account for 63% of the summer peak demand reductions estimated.

Smart thermostats and HVAC have the largest impact on winter peak electric demand, followed by industrial programs. These three together account for 57% of winter demand reductions (without fuel switching). Industrial process and HVAC programs have by far the largest fuel savings, with the latter including some displacement of fuel-fired systems with heat pumps. These two programs together account for 72% of the total fuel savings of our 13 programs (including fuel switching).

Cost of saved energy

For most of the program types, we were able to collect information to calculate the cost per kWh saved over the measure lifetime, also known as the cost of saved energy (CSE). Our results are summarized in figure 5. We find that for most programs, the cost per kWh saved is less than \$0.05, and for a majority, it is less than \$0.03. Only a few program types, all related to existing homes, have costs over about \$0.08. These costs are generally substantially less than retail rates, which in 2025 averaged over \$0.13 per kWh for all customers and over \$0.17 per kWh for residential customers (EIA 2026b). They are also generally less than the levelized cost to build and operate new power plants: A typical new gas combined-cycle power plant costs about \$0.08 per kWh generated over its life (see details in the “Methodology” appendix at the end of Part 1). Acquiring these low-cost efficiency resources will reduce the amount of generation, transmission, and distribution that must be built, and thus reduce utility costs and the rates they must charge. Energy efficiency can be a key component of a utility bill affordability strategy.

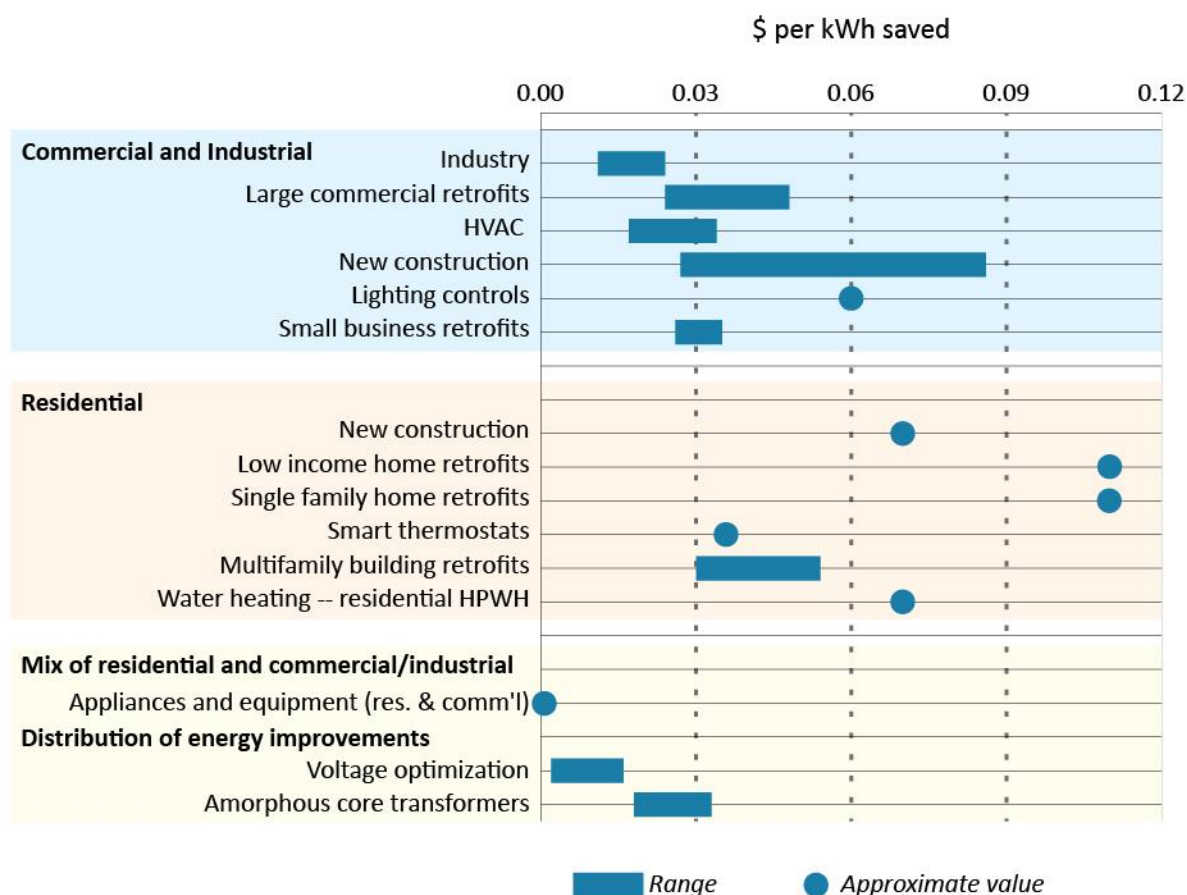


Figure 5. Cost of saved energy for different types of programs. *Note:* Residential HVAC not shown because it varies depending on climate and household energy use. Details discussed in HVAC chapter.

Efficiency efforts need to be prioritized

Our findings of 574 TWh available energy savings and 108–173 GW of peak demand savings over the next 10 years (without fuel switching) average to about 60 TWh and 11–17 GW of additional peak load reductions each year. These are substantially greater than the savings rate that has been achieved in recent years. For example, in 2024 utilities reported a total of about 24 TWh of new energy savings from measures installed that year and about 6.2 GW of peak demand savings (EIA 2025c). That is less than one-half of what we find is possible. While we report savings in peak demand, demand savings can also be impactful at other times because they reduce the need for new power distribution capacity, reduce use of power plants that are expensive to operate, and decrease pollution from the dirtiest power plants.

A few utilities are saving at the rate we show as possible, including much of the top third in ACEEE's *Utility Scorecard* (Specian et al. 2023). But most utilities have much smaller programs, many of which do not explicitly prioritize energy efficiency. To achieve the large savings necessary to slow load growth, energy efficiency needs to be a high priority for utilities and regulators. Slowing load growth can, in turn, limit investments in energy infrastructure, slowing the growth in electric rates. Based on the large, cost-effective savings we find, we make the following three recommendations:

1. **Energy efficiency program administrators** should review each of the 13 program approaches we detail in Part 2 and incorporate missing components in their program portfolios. This process can help to add new programs and to improve existing programs, based on our case studies of some of the best programs in each program area.

2. **Utility regulators** should encourage and consider requiring that utilities under their jurisdiction review these program concepts and report back on which changes to their programs they propose to make. While there may be some suggestions in this report that certain utilities deem inappropriate for their service area and customers, our program savings estimates are based on maximizing cost-effective efficiency savings.

Fully implementing these programs will often require higher budgets than current programs. These larger budgets will save utilities money and reduce customer bills in the long term because these programs are almost always less expensive per kWh of electricity or therm of gas⁵ than building and operating new generation plants and expanding and maintaining electric and gas distribution systems. In some cases, short-term rates might increase modestly to pay for programs before the cost savings from avoided generation, transmission, and distribution begin to kick in—rate impacts of energy efficiency programs and ways to reduce them are discussed extensively by Gold, Nadel, and Neme (2026). To advance these efforts, regulators should establish mechanisms to avoid unduly rewarding utilities for rising sales; this can be achieved by decoupling profits from sales and providing incentives to utilities and their shareholders for aggressively maximizing cost-effective energy efficiency and load-shifting savings (e.g., see Molina and Kushler 2015; LeBel et al. 2023; RMI 2025).

3. **Governor’s offices, energy offices, and policymakers** other than regulators should encourage regulators and utilities to pursue these program ideas, and require them to do so if they are consistently lagging. Policymakers should also adopt complementary policies to achieve energy savings, including strengthened building codes, new and updated equipment efficiency standards, and building performance standards (e.g., Nadel and Gruen 2026; ASAP 2025; Nadel and Hinge 2023).

As utilities work to both meet new demand coming online and help customers struggling with energy bills, it is important to compare the scale of potential identified here with the supply costs that get locked in when these efficiency savings are not captured. Power rates are increasing across the country, and energy efficiency is generally less expensive per kWh of power or Btu of fuel. A low-cost resource that decreases emissions, energy efficiency also reduces the need for expensive investments in supply side resources.

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⁵ At retail, natural gas use is sold by the *therm*. A therm has a heat value of 100,000 Btu.

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Appendix—Methodology

Participation rates

Participation rates, the percentage of the eligible market that participates each year, are a key factor in the depth of program savings. Achieving large savings requires reaching many customers. Participation rate assumptions are summarized for each program in Part 2. These are generally based on the achievements in recent years of the programs discussed in each chapter. For different types of programs, participation rate is multiplied by eligible customers, as described in table A1.

Table A1. Participation rate basis

Equipment sales	Percentage of annual equipment sales: For equipment with more than a 10-year life, we also factor in the percentage of equipment that will be replaced over our 10-year analysis period
Retrofit programs	Percentage of targeted customers, annually and/or cumulatively, depending on the data available ⁶
New construction	Percentage of new homes and apartments or new commercial building floor area

Energy savings

Energy savings are estimated per participant and for the United States as a whole in 2035 (the latter based on the best participation rates that have been achieved by programs). Per-participant savings are the net savings excluding likely measure adoption without programs and are based on evaluation results of the programs described in our case studies. In a few cases, we did not have program-specific estimates of net savings. In these cases, we took gross savings, which includes some savings that would happen without programs, and applied a net-to-gross ratio of 82% for electric savings and 89% for gas savings, where this was a national average in 2023 as estimated by Kresowik et al. (2025).

We recognize that local conditions will vary. For this reason, we present our national calculations in ways that make it relatively easy for program planners, implementers, and regulators to substitute local values. Additionally, we generally provide savings estimates in percentage terms that are easy to apply to local consumption averages. National energy savings are shown in TWh (billion kWh) for electricity, and for programs that save fuels, in terms of trillion Btu (TBtu).⁷ Reductions in peak electricity demand are generally based on the ratio of energy to peak demand savings from leading programs and are

⁶ In the case of the industrial program, instead of looking at participation rate and energy savings separately, we combine them and look at program annual energy savings as a percentage of industrial electric sales.

⁷ For those used to thinking in “therms,” a therm is 100,000 Btu and therefore there are 10 million therms in a TBtu.

expressed in MW (million watts) or GW (billion watts). We also specify when results include or do not include fuel switching.

Costs

Costs vary widely across programs and customers. Our estimates should be considered rough averages, as the costs of specific programs will often be lower or higher. We calculate average cost per kWh saved—this is often called the cost of saved energy, or CSE—based on program costs amortized over the measure lifetime, divided by annual energy savings. For amortization we assume that program costs are financed over the measure lifetime, using a 3% real discount rate as the loan rate; 3% is a common discount rate used for public policy assessments based on the cost of federal government debt (CEA 2017; Cohen 2024). In a few cases, the data to calculate cost of saved energy were not available, and we instead report benefit-cost ratio for those programs.

As an example of CSE, if a program has an up-front cost of \$10 million, saves 100 GWh per year, and the average measure life is 10 years, the annualized cost is \$1.17 million, and this is found using the “PMT” function in a spreadsheet. In dividing that by 100 million kWh, the CSE is \$0.012 per kWh.

To roughly estimate benefits to the average program participant, CSE can be compared with the average price of electricity, which was \$0.1363 per kWh in 2025 (EIA 2026a). CSE can also be compared with the avoided cost of electricity, to approximate the benefits from the program administrator’s perspective. For example, Lazard (2026), in its annual compilation of new generation plant costs, estimated a cost of \$0.051–0.129 per kWh with a midpoint of about \$0.09 for a new gas combined-cycle plant; gas peaking plants and nuclear plants were substantially higher, at \$0.144–0.276 per kWh. Per Lazard, utility-scale solar and onshore wind without storage are slightly less expensive per kWh than combined-cycle gas, but when storage is added, the costs per kWh are roughly similar. These generation costs do not include transmission and distribution costs, which can add several cents per kWh. For example, CPUC (2025) estimates \$0.01–0.05 per kWh.

Part 2: Priority program areas

Industry

Synopsis

Improving existing industrial facilities is one of the largest energy savings opportunities available to program implementers. Savings are available not only from operations and maintenance measures, but also from process upgrades, particularly those undertaken when process lines are refreshed. This chapter discusses the following types of utility engagement approaches with industry to improve energy efficiency: strategic energy management, applying energy management information systems, providing energy studies, and energy manager support. We also highlight some emerging opportunities.

Data summary

Available savings in 2035 from 2026–2035 programs:

165 billion kWh (TWh) of electricity (first of 13)

1,156 trillion Btu of fuels (first of 13)

17,500 MW of summer peak demand reductions (fourth of 13)

17,500 MW of winter peak demand reductions (third of 13)

Cost per kWh saved: \$0.011–0.024

Introduction

In 2024 the U.S. industrial sector consumed just over 31 quadrillion Btu of energy, or 33% of total U.S. energy use. Of this, about 32% was natural gas; 27% was electricity, including losses in power generation, transmission, and distribution; and 27% was petroleum products (EIA 2025a). That same year, the U.S. industrial sector consumed 1,035 TWh of electricity, or 26% of total U.S. electricity consumption (EIA 2025b). While these figures are for the entire industrial sector—including manufacturing, mining, construction, and agriculture—manufacturing was a substantial majority of this consumption.

Manufacturing uses electricity to drive electric motors and for many other uses, as illustrated in figure IND 1. Machine drive is more than half of manufacturing electricity use; figure IND 2 provides a breakdown. Most industrial electricity is purchased from electric distribution utilities, but some large customers purchase directly from generation and transmission companies.

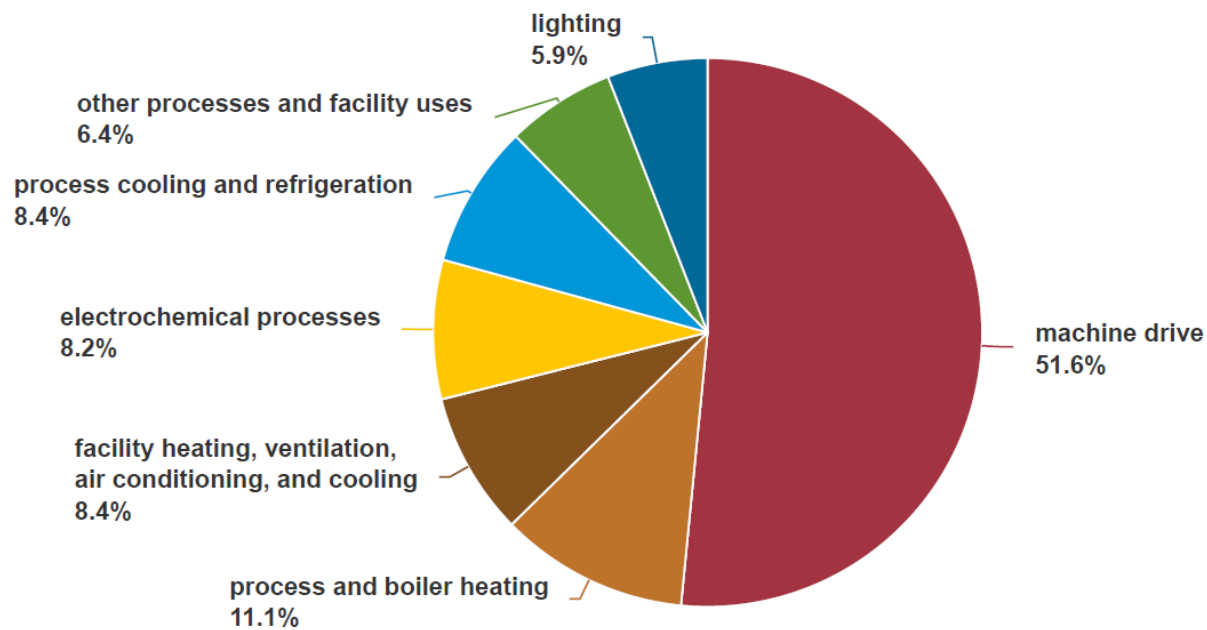


Figure IND 1. Use of electricity for motors in manufacturing, 2018. *Source:* EIA 2023.

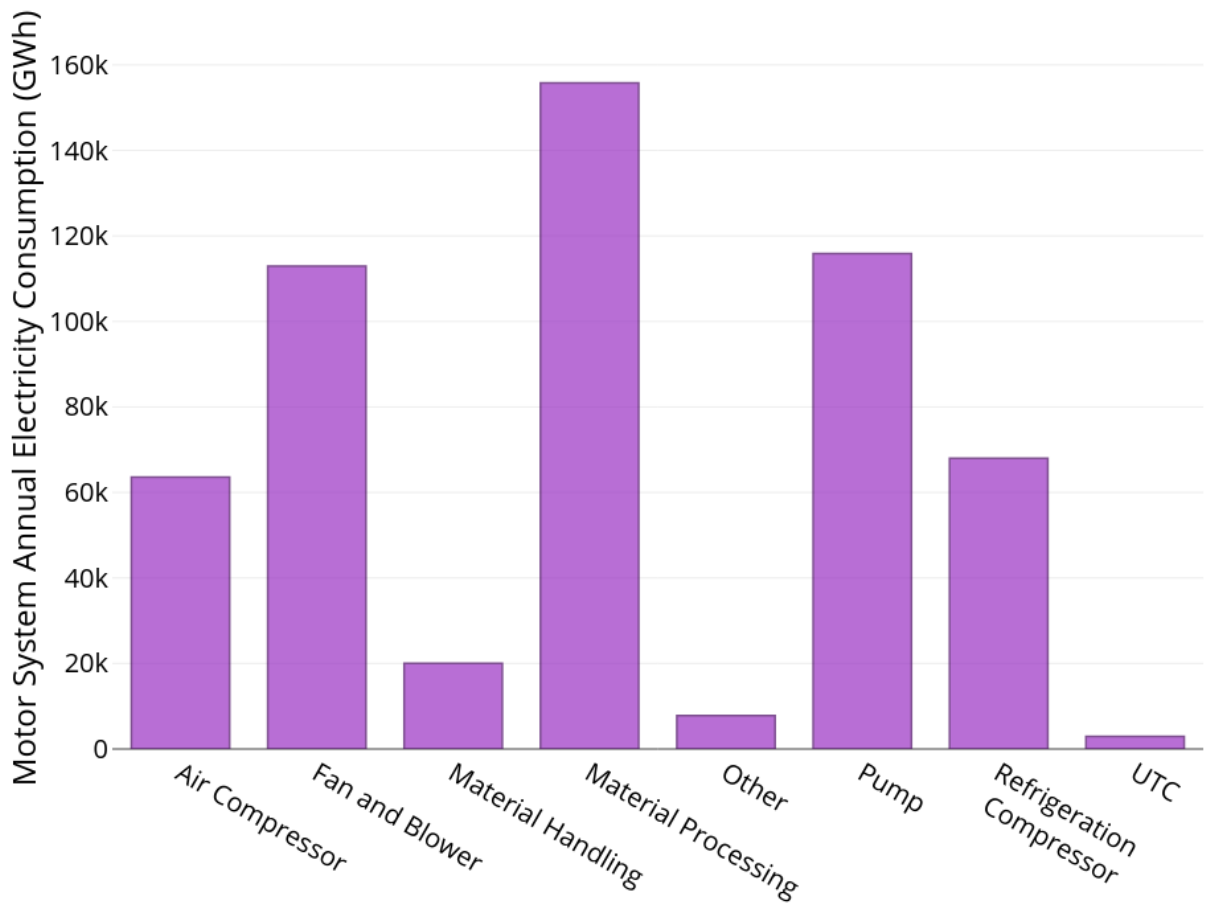


Figure IND 2. Motor system annual electricity consumption for major system types. UTC indicates that the system driven by the motor could not be identified. *Source:* Rao et al. 2021.

Industry uses natural gas for steam generation and other process heating applications, to generate electricity onsite, and as a chemical feedstock. Some of this gas is provided by local natural gas distribution utilities, but a substantial proportion of it is purchased directly from natural gas pipelines by large industrial users.

Many industrial firms pay attention to energy use and have steadily invested in energy efficiency. Because energy productivity—energy use per unit of value added—is easier to track than many other productivity measures, it has sometimes been used as a proxy for broader productivity improvements. As shown in figure IND 3, energy productivity in the industrial sector has steadily improved since the 1973 oil crisis.

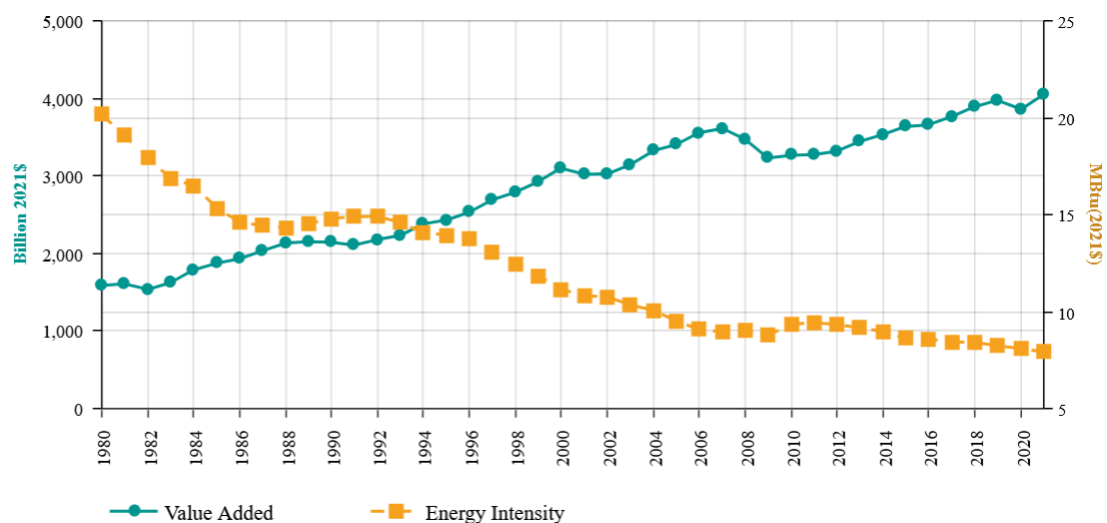


Figure IND 3. Industrial energy intensity relative to value added, 1980–2021. *Source:* Alliance to Save Energy et al. 2022.

These efforts continue: In the most recent edition of the Manufacturing Energy Consumption Survey, 42% of firms indicated they undertook a variety of specific energy management activities (EIA 2025c).

Technologies and approaches

As industry uses energy in thousands of ways, there are thousands of ways to reduce energy use. While equipment such as boilers, motors, fans, and pumps can be improved a little, the big energy savings opportunities are in optimizing systems—including fan, pump, compressed air, steam, and refrigeration systems—to minimize the amount of energy they need. To illustrate, for a process that uses hot water, optimizing the system means examining what temperatures are actually needed and reducing temperatures to these levels. Optimization also involves examining how the flow needed varies over time and can most efficiently be serviced, and whether a different type of pump could provide the needed service. For a process that uses steam, the first question is whether steam is necessary or if hot water could be substituted to save energy; this approach is sometimes referred to as *desteaming* and is practiced by specialists in particular types of processes. There are also often opportunities to revamp processes to use the latest technical approaches, particularly when new production lines are being installed or when existing production lines undergo substantial overhaul. One example is submerged

combustion melting, an improved technique for melting glass and direct reduction steelmaking that is starting to replace basic oxygen furnaces. Finally, production line changes can be an opportune time to think about smart manufacturing, including use of artificial intelligence (AI), and this is discussed further below under “Additional and emerging opportunities.”

To capture industrial opportunities, many utility programs engage industry using *strategic energy management* (SEM). This approach involves assisting and supporting customers in a multiyear process to systematically review energy use in a facility, commit staff to implement operations and maintenance measures to reduce this energy use, and develop and implement a plan to undertake a series of capital improvements that are sometimes linked to when existing equipment needs to be replaced. The SEM construct offers numerous approaches. Some programs help with cost-share studies that examine specific energy-saving opportunities, and a few programs encourage companies to hire energy managers by sharing the costs of adding these employees. The examples in the next section provide a more complete overview of SEM and related approaches.

As a complement to these energy-saving programs, some utilities also conduct research, development, and demonstration projects on industrial processes and technologies. For example, Southern Company, which serves parts of Alabama, Georgia, and Mississippi, is conducting a variety of research and demonstration projects, including on industrial heat pumps, alternative fuels, demand flexibility like thermal energy storage, and using AI to examine industrial customer data and determine the most advantageous applications for various measures (I. Ahmed, senior research engineer, Southern Company, pers. comm., February 2026).

Examples of successful programs

To help readers track the program types and examples, table IND 1 briefly summarizes the information in this section. After we discuss these four types of programs, we much more briefly discuss a few emerging program types.

Table IND 1. Summary of program types and examples

Program type	Brief description	Customers commonly targeted	Example programs
Strategic energy management (SEM)	Training and technical assistance on operations and maintenance measures and establishing a long-term plan, including capital measures, to manage energy use	Large customers	Energy Trust, Focus on Energy (FOE), Xcel Colorado, BPA, PacifiCorp
Energy management information systems (EMIS)	Subset of the above with a particular focus on tracking and using data	Very large customers	Efficiency Nova Scotia, California, and New Brunswick utilities

Energy studies	Cost-shared studies that examine potential projects that a customer is interested in pursuing	Medium and large customers	NYSERDA ⁸ FlexTech, many of the SEM programs
Energy manager	Cost sharing so that a customer can hire a dedicated energy manager (or sometimes an energy manager shared among several firms)	Medium customers and some large customers	NYSERDA, Detroit Edison (DTE) Energy, BPA

Strategic energy management (SEM)

This section summarizes a few of the leading SEM programs, particularly those that have achieved significant adoption of capital measures, such as custom measures proposed by customers that are not prescriptively described by the program. Most programs include both commercial and industrial customers. The commercial retrofit chapter discusses several programs with many commercial participants, and this chapter discusses programs with a lot of industrial participants. While the lines between these two groupings blur, the programs featured in this chapter generally do good commercial sector work and vice versa. The case studies below were selected because they had the highest electricity savings as a percentage of eligible customer sales in the programs for which we could obtain data. These programs typically combine multiple components, going well beyond basic SEM services. One reviewer suggested calling these programs something besides SEM, such as “wraparound energy management” or “holistic energy savings.”

Energy Trust of Oregon: Energy Trust runs a “production efficiency” initiative with four tracks: SEM, custom capital and custom operations and maintenance (O&M), lighting, and standard measures that are prescriptive incentives beyond lighting. The SEM program uses a cohort strategy where over the course of 12–14 months, participants attend training sessions together and receive one-on-one consulting. A 2026 evaluation of the SEM Program found an average energy savings of 2.7% in the first year (Cadmus 2026), and they have found additional average savings of 1.5% for sites that continue after the first year (E. Braddock, senior technical manager, and A. Bartini, sector lead, Energy Trust of Oregon, pers. comm., February and March 2026). In 2026, the custom program offers incentives on annualized savings of \$0.45 per kWh saved and \$5 per therm of gas saved, both up to 90% of project cost for custom capital projects; the O&M and SEM programs have different incentive rates. In addition, the program offers no-cost scoping of energy efficiency opportunities and no-cost technical studies on specific potential custom projects (Energy Trust 2026b).

For 2025, preliminary data indicate the breakdown of the program’s kWh savings were as follows:

- Custom measures, 40% of savings
- Lighting measures, 30%
- Other prescriptive incentives, 19%
- SEM 11%

⁸ New York State Energy Research and Development Authority.

Program staff note that SEM can help to get customers engaged in other program tracks and to consider custom measures (Rubado, Batmale, and Harper 2015). Energy Trust requires and pays for studies on potential custom projects, but some studies do not result in installations. Custom projects take time to reach fruition; in approximate order of electric savings, common custom projects address compressed air, process, pumps, refrigeration, HVAC, air abatement, secondary process, chillers, controls, and wastewater. Program staff also note that in recent years, they had some success identifying upcoming renovation projects through contacts with economic development agencies and engineering firms (E. Braddock, senior technical manager, and A. Bartini, sector lead, Energy Trust of Oregon, pers. comm., February and March 2026).

As detailed in table IND 2, measures installed since 2018 have saved over 1,200 GWh of electricity and over 1,300 billion Btu of natural gas. The gas savings are only for customers served by local gas distribution utilities. Much of the gas used in large industrial facilities is purchased wholesale and is thus not eligible for Energy Trust assistance; Energy Trust receives ratepayer funding from gas distribution utilities and not from gas wholesalers. The electricity savings are 17.9% of 2023 industrial electricity sales in the areas served by Energy Trust (from EIA 2025b). This is an average of 2.2% per year. Energy Trust reported a benefit-cost ratio using the utility cost test of 4.3 for the 2024 program and 3.8 for the 2023 program (Energy Trust 2025). Assuming a 13-year average life of a measure and a 3% real discount rate, the cost for the 2024 program is \$0.022 per kWh saved.

Table IND 2. Energy Trust of Oregon Production Efficiency Program annual energy savings and expenditures

Year	Electric savings (GWh)	Gas savings (billion Btu)	Expenditures (\$millions)
2025	150.8	192.5	52.2
2024	206.4	210.7	54.1
2023	161.1	172.0	43.6
2022	172.0	128.6	31.8
2021	126.3	130.1	
2020	142.0	243.3	
2019	153.4	83.9	
2018	149.5	171.9	
Total	1,261.2	1,333.2	

Source: Energy Trust of Oregon evaluation data and annual reports. This includes only production efficiency spending and savings, and not spending and savings from Northwest Energy Efficiency Alliance programs. Figures for 2024 and 2025 are preliminary pending final evaluation results.

Focus on Energy (FOE): Focus is a statewide initiative in Wisconsin that began in 2001. It is funded by investor-owned utilities—legislation requires their participation—and some municipal utilities that voluntarily participate. They offer a broad array of programs, one of which is the Large Industrial program, which has been run by Leidos for many years. This program offers a variety of incentives,

including prescriptive and custom incentives, cost sharing of 50% for energy-saving project studies, staffing incentives for hiring staff to manage projects, and special SEM operational incentives. The heart of the program is a network of industrial energy advisors; each large company is assigned an advisor who is a regular point of contact. Advisors are generally engineers, and many of them have previously worked as energy managers at industrial companies. The state has 10 advisors, each assigned 100–150 customers. This includes some specialized advisors, including two assigned to pulp and paper manufacturers. Many of these advisors have been with the program for more than 10 years and know their customers well. They are a trusted resource for their customers, understand capital planning in companies, and encourage the inclusion of energy management projects in capital plans. For example, Focus runs periodic requests for proposals (RFPs) in which customers compete for incentives for large projects by bidding based on energy savings, how much incentive they require, and justification for their requested incentive. These RFPs help to gain the attention of senior management at industrial firms. At least one RFP is released each summer, and decisions are made in September, in time to influence capital budgeting for the upcoming calendar year, which often takes place in the fall. The program managers emphasize the importance of having a single point of customer contact for all customers, having some flexibility to best meet customer and program objectives (for example, RFP responses can exceed annual spending caps per customer), and committing to incentive amounts to support project planning and not varying the incentive based on actual savings performance.⁹ In addition to the energy advisors on staff, the program has found national subject matter experts and brought them to customer sites; these individuals have provided great value in identifying process energy-saving opportunities in the pulp and paper, metal casting, industrial refrigeration, and water/wastewater sectors (Cadmus 2025b; J. Nicol, program director, and N. Altfeather, program manager, Leidos, pers. comm., March 2026).

In 2024 Focus's large industrial program had 233 participants out of about 1,200 sites eligible; eligible customers have peak electric demand greater than 1 MW.¹⁰ These 233 participants saved 160 GWh of electricity and 4.3 million therms of gas from projects implemented in 2024 (Cadmus 2025b). The electric savings are about 1.1% of the annual electricity use of eligible customers (ACEEE calculation using data in EIA 2025b and assuming 80% of industrial energy use is by large customers). Incentives totaled \$8.2 million and together with another 61% for contractor and administrative costs (Cadmus 2025b), total program cost was about \$14 million. Table IND 3 summarizes Focus's energy savings and incentive spending over the past 10 years. The number of participating customers each year has varied from 233 to over 400, with an average of 344 per year; many customers participate in multiple years. Across the 10 years, the electric savings are about 8% of the electricity use of targeted customers.¹¹

Table IND 3. Focus on Energy Large Industrial Program annual energy savings and expenditures

⁹ They note that adjusting for actual savings erodes customer trust and willingness to participate in the future. They suggest that the program accept the risk that not all projects will reach expected savings because across many projects they will come close.

¹⁰ Or use 100,000 therms of natural gas per month and their combined utility bills were at least \$60,000 in any month of the preceding year.

¹¹ ACEEE calculation using data in EIA 2025 and assuming 80% of industrial energy use is by large customers.

Year	Electric savings (GWh)	(MW)	Gas savings (billion Btu)	Incentive expenditures (\$millions)
2024	160	17.96	433	8,225,894
2023	99	11.48	953	9,955,975
2022	70	8.32	296	
2021	113	12.22	584	
2020	90	9.97	842	
2019	127	14.74	1,206	12,105,098
2018	104	12.58	735	9,964,658
2017	138	17.29	845	9,118,075
2016	107	12.33	1,139	10,423,365
2015	131	17.32	1,207	13,920,708
Total	1,140	134.21	8,241	\$73,713,773

Source: Focus on Energy annual evaluations. For 2015 to 2019, the numbers include some large commercial customers; they are generally less than 20% of the savings.

Xcel Colorado: In this program, customers generally make a three-year participation commitment. They agree to set up an internal energy management team and meet with a designated Xcel industrial energy consultant at least six times a year. Consultants are industrial efficiency experts contracted by Xcel. The consultants provide advice and technical analyses on specific projects that customers want to explore, help establish program goals, and facilitate the energy team. They then advise the energy team on operational improvements, capital upgrades, project tracking, and reporting mechanisms.

Consultants are first paid on enrollment and then paid additionally based on the energy savings achieved, which incentivizes them to maximize energy savings. Customers can also earn additional incentives for custom measures, with incentives paid per kW saved and much higher incentive rates for peak-coincident kW saved.

Xcel Energy began incorporating SEM elements into its other programs in 2017, and then filed SEM as a program in 2019. The SEM program achieved about 70 GWh per year of incremental savings over the 2021–2024 period. This is about 1.2% per year of total annual consumption of industrial customers (EIA 2025b), and an even higher percentage if data centers, which are not targeted for SEM, are excluded from the calculations. In 2024 about 90% of the program’s industrial electricity savings were from capital measures and about 10% from operational measures (S. Warkentin, senior program manager, Xcel Energy, pers. comm., February 2026).

Bonneville Power Administration (BPA) and PacifiCorp: Both BPA and PacifiCorp work with Cascade Energy on large industrial programs. BPA, which serves substantial portions of Washington, Oregon, Idaho, and Montana, runs the Energy Smart Industrial program, which works with the industrial customers served by BPA’s public utility customers. All industrial customers are eligible, including municipal water and wastewater systems. As in the Focus program discussed above, a dedicated energy advisor is assigned to each customer; this person is a single point of contact who serves as a long-term strategic advisor. Advisors are often experts in particular industries. BPA’s Energy Smart Industrial

program includes SEM, energy project managers, custom, and streamlined programs. Incentives are available in each of these subprograms. In fiscal year 2022–2023, the BPA program saved 265 GWh of electricity at a cost of about \$28.5 million (BPA 2024), and in fiscal year 2024–2025, it saved about 277 GWh (BPA 2025). Eligible customers consume about 15,200 GWh per year (S. Martin, senior director, Cascade Energy, pers. comm., March 2026) and thus the electricity savings in fiscal year 2024–2025 year were about 1.8% of the eligible customer electricity use.

PacifiCorp, which serves a substantial portion of Utah, medium-sized portions of Oregon and Wyoming, and small portions of California and Washington, is achieving more than 1% electricity savings per year with its largest customers; it is less with somewhat smaller customers. In 2024, PacificCorp's C&I program spent about \$38.6 million, including commercial, and saved 194 GWh (Rocky Mountain Power 2025). Annual sales to C&I customers in 2024 were about 19,185 GWh (PacifiCorp 2026) and thus the 2024 savings were about 1% of sales.

An important lesson from these programs, according to Cascade, is that a single point of contact is very useful, particularly one with expertise in the customer's industry. They also note the value of understanding what each customer cares about and orienting assistance around their concerns. A key service they provide is helping customers make the business case to their management, based on the customer's own key concerns. Furthermore, they note that good energy consumption data help with identifying energy consumption problems (Z. Podell-Eberhardt, director of strategy and products, Cascade Energy, pers. comm., March 2026).

Energy management information systems (EMIS) programs: This subset of SEM programs is much more data intensive and includes deep dives into energy use patterns and opportunities for savings among the very largest customers: those with annual electricity use generally greater than 30 GWh per year. The first such program was offered by Efficiency New Brunswick in 2007 (Flannigan, Bujold, and Bassett 2009) and Efficiency Nova Scotia started an EMIS Program in 2012. For these programs, participants demonstrate the commitment of senior management prior to enrollment through a letter of intent that commits them to completing all stages of an EMIS project, provided it meets their predetermined financial criteria. Program participants complete a three-step process: EMIS Audit, EMIS Implementation Plan, and Implementation. EMIS includes meters for energy measurement, data collection, and storage infrastructure. Software is used to convert data into easily understood information, with the expectation that the organization will systematically convert information into action. After Implementation, participants benefit from a customized 12-month support plan. This structure allows for energy savings that do not just persist but also grow over time (Henwood and Bassett 2015).

An example of the EMIS approach integrated into a SEM model is an effort applied by Stellantis at eight of its vehicle manufacturing plants. The initial emphasis is on minimizing energy use when the plant is shut down. Through data collection and analysis via weekly and monthly reports, sources of waste are identified and corrective actions were taken. This progression is illustrated for one plant in figure IND 4 (Lawlee, Baslock, and Karim 2023).

Plant-8 Excellent Plant Shutdown Total Site Elec CUSUM

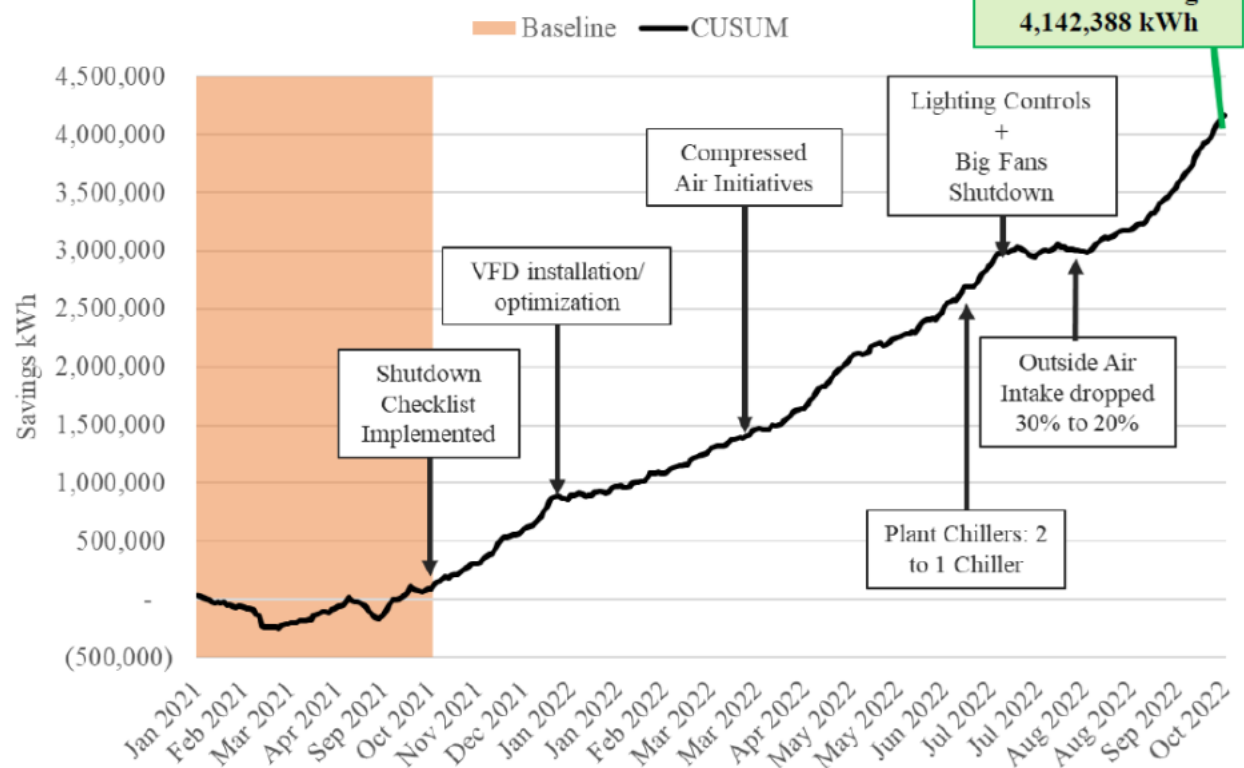


Figure IND 4. Cumulative electricity savings over time at plant-8. *Source:* Lawlee, Baslock, and Karim 2023.

Consulting firm Energy Performance Services has helped implement EMIS on a standalone basis and as part of SEM in programs in conjunction with New Brunswick, Nova Scotia, Quebec, DTE, ComEd, Focus on Energy, and PG&E. Across five programs with a total of about 80 customers, they estimate total annual electric savings of about 88 GWh, amounting to an average of about 1.33% of participating customer annual electricity use (P. Bassett, president, Energy Performance Services, pers. comm., April 2026).

Energy studies and energy managers

New York State Energy Research and Development Authority (NYSERDA): NYSERDA, a state authority, operates several technical assistance programs for industrial, commercial, agricultural, and multifamily customers, as a complement to utility programs. These include the FlexTech energy study program and the On-Site Energy Manager (OSEM) program.

For eligible measures, FlexTech shares the cost of energy studies with customers. NYSERDA has consulting engineers with various areas of expertise on contract, or a customer can choose their own consultant; NYSERDA pays 50–75% of the cost of the study, and the customer pays the rest. The program has operated since the 1990s. While an evaluation of the program is now underway, a prior evaluation found that over the 2007–2009 period, 303 studies were completed that recommended 2,452 measures. Eventually, 68% of the savings associated with the recommended measures were implemented by study recipients, and about two-thirds of these savings were realized within three years of the study completion. Based on this finding and other evaluation adjustments, they estimated that the 2007–2009 studies resulted in annual savings of about 107 GWh of electricity, summer peak

demand reductions of about 16.8 MW, and natural gas savings of about 360 billion Btu (Moray et al. 2012).

The OSEM program assists participants by assigning a dedicated energy manager to operationalize an energy management process. Rather than having a third-party energy coach, as in FlexTech and other SEM programs, the OSEM program offers cost sharing with sites to embed part- or full-time energy managers—either staff or consultants—in their facilities and operations. These energy managers are responsible for identifying measures, calculating potential energy savings, securing management approval, and tracking projects to completion. An evaluation of 11 industrial OSEM projects that were implemented over the 2017–2020 period verified 40 GWh of annual electric savings and 323 billion Btu of annual fuel savings, with these savings averaging 6.4% of baseline electricity use and 16.4% of baseline fuel use (Michaels Energy 2024).

Detroit Edison: As part of its commercial and industrial programs, Detroit Edison (DTE) helps fund energy managers at each Ford and GM plant in its service area, and conducts energy assessments for other medium and large customers. DTE found that many assessments were not acted on due to lack of staff time to pursue implementation. To address this, the company first piloted and then fully launched its On-Site Energy Manager (OSEM) program, separate from its work with the large auto manufacturers. The OSEM program offers two paths: The utility either fully funds a part-time energy manager who is shared with other customers, or a customer hires a dedicated full-time energy manager and the costs are split between the customer and DTE. In the pilot, DTE found that participating customers increased their applications to DTE energy efficiency programs about sixfold relative to the four years prior to OSEM. Over the 2022–2025 period, DTE estimates that OSEM has saved 7–12 GWh per year and reduced customer bills by about \$0.8–1.2 million annually. The program manager recommends enlisting utility account managers to help market the program, monetizing benefits for customers, and identifying early on the metrics that will be needed to encourage customers to remain in the program (T. Banks, principal supervisor—energy partnership, DTE, pers. comm., March 2026).

Additional and emerging opportunities

Some program implementers devote special attention to subsectors that are particularly prominent in their service area. For example, as noted above, Focus on Energy has a specialized advisor for the paper and pulp industry. Southern California Edison has a specialized program focused on water and wastewater utilities¹² and Pacific Gas & Electric has focused resources for food processing, biotech, and high tech.¹³

Below we briefly describe two emerging program approaches, new construction and midstream incentives. We then discuss two emerging technology program opportunities, industrial heat pumps and smart manufacturing, including AI.

New construction: In addition to running traditional programs focused on existing industrial customers, a few utilities and states with significant new industrial loads are looking to influence the energy efficiency of equipment and systems installed at these new facilities. This decade has seen a surge in major new industrial facilities being built in some regions of the United States due to macroeconomic drivers and government policies, among them pharmaceutical, semiconductor, battery, automotive, and

¹² www.sce.com/sites/default/files/inline-files/Water%2B-%2BWastewater%2BIS%2Br1_WCAG.pdf.

¹³ www.pge.com/en/save-energy-and-money/rebates-and-incentives/business-energy-efficiency-rebates.html.

steel. New installation of measures such as process heating electrification using industrial heat pumps or other electric heating technologies is far more cost effective than retrofits. Utilities in electricity constrained markets are interested in reducing these new loads while still attracting new customers, together with their attendant economic benefits. Since these programs are nascent, there is not yet published information on program details and impacts. Such programs are often combined with commercial new construction programs and may have similar technical assistance and incentive structures. But a key for success for industrial new construction is having expert engineers on retainer who are familiar with the state-of-the-art measures in the type of plant that is being built.

Midstream programs for equipment: For many years, utilities have operated prescriptive rebate programs for electric motors, lighting, and other types of equipment used in factories. As an example, Energy Trust offers incentives to industrial customers for measures that address compressed air systems, heating and cooling equipment, industrial battery chargers, building and pipe insulation, motors and drives, refrigeration, insulation, water and wastewater systems, and welding equipment (Energy Trust 2026). Most of these incentives are paid to end users for qualifying equipment they purchase.

As discussed in the HVAC chapter, many HVAC programs use a midstream model and pay incentives to product distributors for the efficient products they sell. They enlist distributors to help sell their programs to contractors, which results in a direct discount on the price charged to contractors. This midstream model is starting to move to industrial equipment, and the first programs are offered by Southern California Edison (SCE) and Duke Energy, which serves much of the Carolinas and parts of Indiana and Kentucky. The SCE program thus far includes air compressors, pumps, and variable speed drives, and they plan to add additional products. As well as midstream incentives, the program also includes some customer-level and custom incentives. Over the 2025–2029 period, the program has a budget of \$13.5 million and a goal to save about 26 GWh of electricity in its final year (Energy Solutions and Cascade Energy 2025). Duke’s program includes pumps and fans rated with a fan efficiency index (Duke Energy 2026). Both programs started in fall 2025 and do not have results yet. Thus, while these are programs to watch, they are not included in our estimates of savings by 2035.

Industrial heat pumps (IHPs): IHPs can offset a significant share of the industrial process heat demand that is currently met largely by natural gas–fired boilers. Many of these boilers are aging, oversized, and inefficient relative to electric alternatives, but remain in use because of reluctance to explore new approaches and the upfront costs of electrified technologies. IHPs are not new, and their technical performance has been demonstrated over decades. They operate by moving heat from a lower-temperature source to a higher-temperature sink where it is useful. Efficiency is highest when sources of waste heat can be tapped. Today’s IHPs are efficient, commercially available, and continue to improve. They can operate independently or as part of hybrid systems that retain fossil backup. Current systems can reach temperatures of up to 160°C and reduce reliance on steam systems, thereby avoiding associated maintenance and infrastructure costs (EHPA 2022). Broad deployment across applicable industries could reduce energy use for process heat by up to one-third (Rightor et al. 2022). Realizing this potential will depend on programs and policies that address upfront capital costs and electricity rate designs that reward early adopters. Some utilities and states are promoting IHP through demonstration programs, technical assistance, and financing (Hoffmeister, Chen, and Omotesho 2025).

Smart manufacturing: Smart manufacturing can unlock new avenues in process efficiency by connecting siloed measures such as electrification and demand flexibility. Rather than focusing on isolated equipment, smart manufacturing uses data, sensors, controls, and analytics to optimize production processes and energy use.

Automation, data collection, and waste-reduction practices, for example, can increase the efficacy of electrification while shaping energy use, reducing peak demand, and alleviating grid strain. Intelligent motor and drive systems, which are another example, have been shown to reduce system energy consumption by more than 30% while technologies such as smart-metering, digital twins, and advanced process controls have the potential to deepen savings even further (Gray 2024; Siemens 2024). Many of these technologies and strategies are commercially available, but adoption remains relatively nascent due to the need to upskill the workforce and establish a standardized approach to quantifying process-level improvements. Reaching the full savings potential of smart manufacturing will require programs and policies that support workforce development, technical assistance, and connected data infrastructure.

Participation rates

As noted by the Focus on Energy experience, about 20–35% of eligible customers may participate in a large industrial program in any given year, and many customers participate in multiple years with different projects each year. Perhaps a better way to estimate participation is to look at energy savings as a percentage of targeted customer demand.

- Energy Trust: 2.2% average savings per year over the past 10 years
- BPA: 1.8% average savings per year
- EMIS programs: 1.3% average savings
- Focus and Xcel Colorado: 1.1–1.2% average savings

Energy savings and peak demand reduction

To estimate national savings from a comprehensive program, we use 15% over 10 years; this is a little less than the programs with the highest savings noted above but more than the 1.1–1.2% per year saved by Focus on Energy and Xcel Colorado in recent years. We estimate summer peak demand savings based on Focus data and absent any other data, assume that winter peak savings are the same as summer peak savings. We estimate gas savings based on the ratio of gas to electric savings in the Focus program and do not use Energy Trust because it does not target extensive gas savings. We find a 10-year savings potential of about 165 TWh of electricity and about 1.56 trillion Btu of gas, with peak demand reductions of about 17,500 MW. Industrial programs have the largest electricity and fuel savings of the programs examined in this report and among the largest peak demand savings. Our calculations are shown in table IND 4.

Table IND 4. Potential energy and peak demand savings from industrial programs

("x" designates multiplication)	Value	Units	Comments
	1,101	TWh	2035 industrial electricity use (EIA 2026)
x	15%		Average savings (based on ETO and BPA, as discussed in text)
=	165	TWh	Savings in 2035
x	106		Ratio MW/TWh savings for Wisconsin large industrial program in 2023 (Cadmus 2025)

("x" designates multiplication)	Value	Units	Comments
=	17,520	MW	Summer peak demand savings
=	17,520	MW	Winter peak demand savings (assume same as summer demand savings)
x	7		Ratio of gas savings (billion Btu) to electric savings (GWh) in Focus program
=	1,156	TBtu	Rough estimate of potential gas savings

Typical costs and cost of saved energy

We collected data on program costs and energy savings from four programs: 2024 data from Energy Trust, Focus, and Xcel Colorado, and data on fiscal year 2022–2023 from BPA. We assumed a 12.2-year average measure life, which is the weighted average for the Energy Trust program, and a 3% real discount rate. We assigned costs to electric and gas savings proportional to Btus saved, using 10,000 Btu/kWh of source to convert electric savings to Btus.¹⁴ Results are shown in table IND 5. Costs are no more than \$0.024 per kWh and \$0.24 cents per therm saved. These are very cost-effective programs: An evaluation of the 2024 Focus program estimated a benefit-cost ratio from the total resource perspective of 4.3 (Cadmus 2025b).

Table IND 5. Program costs and cost of saved energy

Program	GWh	Savings				
		Gas (billion Btu)	Total Btu (billions)	Cost (\$million)	\$/kWh	\$/therm
Energy Trust 2024	207	211	2,278	54.1	0.024	0.235
FOE 2024	160	433	2,033	14.2	0.007	0.069
Xcel Colorado 2024	73	NA	NA	10.5	0.014	NA
BPA FY 2022–2023	265	NA	NA	28.5	0.011	NA

Note: Sources for savings and costs noted in text. A therm is 100,000 Btu and is the commonly used unit for pricing gas to end-use customers.

Exemplary program design and marketing features

The following lessons emerge from some of the leading programs discussed above:

¹⁴ We use source energy in order to look at fuel savings for both natural gas end uses and for power generation. When electricity is saved there are substantial fuel savings in power generation and this approach includes these fuel savings, allowing electric and gas savings to be combined on a Btu of fuel basis.

- *Hire expert energy advisors and assign each large customer an energy advisor* to act as their point person for all energy efficiency programs. Use these experts as key program marketers. This has worked very well for Focus; BPA, PacifiCorp, and Xcel Colorado also use this approach.
- *Encourage and assist customers in undertaking a multiyear energy management effort* that starts with O&M measures and then extends into periodic capital projects, as Xcel Colorado and many of the other programs do.
- *Document successful projects* and encourage firms undertaking these projects to share experiences with other industrial firms in their region.
- *Share the cost of conducting more detailed analyses* of specific efficiency measures that interest customers. NYSERDA does this with FlexTech and so do many of the other programs.
- *Periodically hold special competitions* where expenditure caps per customer are dropped and the best projects are chosen to advance program objectives, as Focus does. In general, some flexibility helps to build long-term relationships with these large customers.
- *Share in the cost of dedicated and shared energy managers* to assist customers with their energy management efforts, as NYSERDA and Detroit Edison do.
- *Have experts available, either on staff or under contract*, who know about the specific issues and opportunities facing key industries in a service area. Consider special initiatives targeting these industries.
- *Evaluate and incorporate emerging energy efficiency opportunities* such as smart manufacturing and industrial heat pumps.

In addition, John Nichols (2026), a long-time industrial program manager at Leidos, includes a few other recommendations in a paper he wrote:

- Recognize that most industrial customers are understaffed. The energy champion often wears multiple hats (hence they have limited time) and they are generally looking for highly technical information.
- Manufacturing processes often have substantial energy saving opportunities, but changes to process are seen as risky. To reduce this risk, build trust with the energy team and also with process engineers.
- Marketing materials should be short, targeted to specific industries, and aimed at profitability.
- Use industrial trade allies and industrial trade associations to help connect with customers and market programs.

Summary and recommendations

Large industrial customers have large energy-saving opportunities, but the specific measures will vary from plant to plant. Most of the work will be in custom projects and in developing an ethos of regular projects and continuous improvement. Programs need to hire experts and develop long-term, trusted partnerships with key accounts.

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Commercial retrofits

Synopsis

Retrofitting existing commercial buildings is one of the largest energy-saving opportunities available to energy efficiency programs. This chapter discusses how utilities can assist with enactment and implementation of Building Performance Standards (BPS), building renovations, strategic energy management, monitoring-based commissioning, and automated demand response. It concentrates on medium and large buildings over 25,000 sq. ft. of floor area. Smaller buildings are discussed in the small business chapter.

Data summary

Available savings in 2035 from 2026–2035 programs:

99 billion kWh (TWh) of electricity (second of 13)

181 trillion Btu of fuels (third of 13)

27,700 MW of summer peak demand reductions (third of 13)

7,600 MW of winter peak demand reductions (fifth of 13)

Cost per kWh saved: \$0.024–0.048

Cost per kW year of demand reduction: ~\$44.

Introduction

Most of the buildings in the United States that will be standing in 2050 have already been built. The Energy Information Administration (EIA) estimates that 73% of commercial floor area in 2050 will be in buildings built in 2025 and earlier (EIA 2026). Thus, a key strategy to achieve large savings will be efficiency retrofits in existing buildings.

Many utility-funded energy efficiency programs offer rebates for purchasing and installing high-efficiency equipment and other measures in commercial buildings. Many programs also encourage custom measures proposed by customers, who then receive an incentive per kWh or therm of savings achieved in their building. Such programs offer steady but not large savings. For example, a study of Massachusetts business customers conducted on behalf of the state's program administrators found that over the 2013–2022 period, energy efficiency programs reduced the average business customer's consumption by 2.25%; the reduction was slightly more, 2.49%, for large customers (DNV 2024). To achieve large savings on average, much more substantial retrofits will be needed.

Technologies and approaches

Here we discuss four approaches that have been used to achieve energy use reductions of 15% or more per building. Achieving this level of savings typically involves eliminating waste through O&M measures, improved control over energy-using systems, and upgrades to higher efficiency equipment when equipment needs to be replaced. We also discuss automated demand-response programs, which have the potential for large reductions in summer and winter peak demand.

Building Performance Standards

Building Performance Standards (BPS)¹⁵ are mandatory energy consumption limits established by states and local governments. These limits are specified in terms of energy consumption and/or carbon emissions per square foot of floor area, with the initial target typically set at the average consumption or emissions for different building types. This means that buildings using or emitting more than this average need to upgrade. BPS typically cover large- and medium-sized commercial and multifamily buildings with a floor area of 25,000 sq. ft. or more. Buildings are given several years to retrofit before the standards take effect; Nadel and Hinge (2023) describe these standards in detail. Program administrators can provide data and support for establishing BPS, educate customers, help identify and implement measures to meet BPS, and assist with workforce training and other support functions. In many cases, program administrators can earn credit from regulators for the savings achieved (Sims and Malinowski 2026).

Renovations

Commercial buildings (e.g., offices, retail, and schools) need to be periodically renovated to stay competitive in rental markets, to meet updated health and safety codes, and to replace aging systems. While minor renovations may be made every few years, replacement of major systems such as boilers and chillers typically only happens every 20–25 years, and other major renovations only once every 30–50 years (RDH Building Science undated). During equipment replacement and more major renovations, substantial energy can be saved. Some of these improvements are covered by utility HVAC programs and those are discussed in the HVAC chapter. Additionally, major renovations like “gut rehabs” are often included in new construction programs and are discussed in that chapter. But the substantial renovations that happen while a building is still occupied often fall through the cracks between programs. Such renovations might involve moving some walls; adding insulation; installing new lighting, heating, and cooling equipment; and modifying but not removing and replacing the HVAC distribution system. More can be done to capture energy savings during these renovations.

Strategic energy management

Strategic energy management (SEM) is a systematic, long-term approach for organizations to continuously reduce energy use and costs by integrating energy efficiency into daily operations, culture, and business practices. It results in sustained savings, improved competitiveness, and lower carbon footprints that are analogous to ongoing quality or safety programs. Once a customer commits to SEM, the discussion can move from “Should we do anything next year?” to “What should we do next year?” SEM involves data analysis, employee training and engagement, process optimization, and establishing policies to make energy savings persistent, rather than one-time fixes or new equipment. Although early SEM efforts emphasized industrial facilities, large commercial customers are increasingly also included.

Monitoring-based commissioning

Monitoring-based commissioning (MBCx) is a process that maintains and continuously improves building performance over time (Kramer, Crowe, and Granderson 2017) and it is sometimes also called continuous commissioning® or ongoing commissioning. MBCx typically begins with properly commissioning a building so systems operate as intended, either through new building commissioning or retro-commissioning of an existing building. After that, continuous monitoring and analysis of large

¹⁵ Sometimes called Building Energy Performance Standards or BEPS, they are referred to as BPS throughout this report.

amounts of data are used to improve operations and spot and address problems, like a stuck damper, as they occur. Savings of 10–15% are typical, and they sometimes reach over 20% (Kramer et al. 2020).

Automated demand response

Loads that can be shed during periods of critical peak demand can be identified and enrolled in automated demand-response programs, sometimes as part of a commissioning process. In these programs, the loads are preprogrammed to be shed during critical peaks, particularly if payments are available for load reductions during these periods. Such a load-reduction program is not a way to reduce energy use. Sometimes energy use decreases a little and other times it does not, as energy use rebounds after the control period.

Examples of successful programs

Table CR 1 summarizes each type of program and highlights the examples that we detail below.

Table CR 1. Summary of program types and examples

Program type	Brief description	Customers commonly targeted	Example programs
Building Performance Standards	Legislative requirement to meet a certain energy or emissions performance; sometimes program implementers can receive savings credit	Medium and large commercial and multifamily residential buildings, which are typically over 25,000 sq. ft. of floor area	Utility roles illustrated by Commonwealth Edison and Evanston BPS; Eversource and Cambridge BPS; District of Columbia and Washington State utility “accelerator” programs
Renovations	Technical assistance and incentives to optimize building renovations for energy efficiency	Buildings undergoing substantial renovation	Efficiency Vermont
Strategic energy management	Training and technical assistance for operations and maintenance measures and establishing a long-term plan, including capital measures, to manage energy use	Customers large enough to have a dedicated energy management person on staff	ComEd and Energy Trust SEM programs; Eversource MOU; Efficiency VT Key Accounts
Monitoring-based commissioning	Technical assistance and incentives for continuous monitoring and commissioning	Primarily large buildings with more than 100,000 sq. ft. of floor area	ComEd’s monitoring-based commissioning
Automated demand response	Assistance identifying measures that can be automatically shifted upon	Buildings able to shift some loads out of peak period; these are	PG&E’s ADR

Program type	Brief description	Customers commonly targeted	Example programs
	signal; incentives to install needed equipment	primarily large customers, but some are medium-sized	

Building Performance Standards (BPS)

Utilities and other program implementors can sometimes get credit for energy savings that result from policies they help to enact and/or implement. These savings could come from appliance and equipment efficiency standards, building codes, and BPS. We discuss some specifics in the chapter on new construction. Program implementor support can include research, technical assistance, and advocacy leading to the adoption of standards and technical and program support for standard implementation (Simms and Malinowski 2026).

Commonwealth Edison: Commonwealth Edison, with partners Slipstream, the Midwest Energy Efficiency Alliance, the Illinois Green Alliance, and the Metropolitan Mayor’s Caucus are providing education and technical assistance to Evanston, Illinois, and other Illinois jurisdictions on building energy benchmarking and BPS adoption and implementation. They help develop a list of covered buildings, and assist building owners with submitting benchmarking data, reviewing policy language, and answering questions from city staff (Simms and Malinowski 2026).

Eversource Massachusetts: Eversource Massachusetts has worked with the City of Cambridge to set up a “concierge service” to help buildings covered by the city’s benchmarking law improve their energy efficiency. Eversource staffs the program and provides technical assistance and financial incentives, all covered by its energy efficiency budget (Shemkus 2019). These efforts contributed to adoption of a BPS by the Cambridge City Council in 2023.

DC Sustainable Energy Utility (DCSEU): In Washington, DC, the DCSEU works with the city’s Department of Energy & Environment and the DC Green Bank to administer the Affordable Housing Retrofit Accelerator. The Retrofit Accelerator offers qualified affordable housing buildings technical and financial assistance to identify energy upgrades, access financing sources, and find approved contractors, all to support compliance with the city’s BPS (DCSEU 2025).

Puget Sound Energy (PSE), Seattle City Light, Snohomish County PUD, and Pacific Power: These four Washington State utilities offer “Accelerator” programs that target the requirements of the Washington BPS and, local to Seattle, the Seattle BPS. They use a SEM-like approach, but focus on quick, immediate savings that support early compliance with BPS requirements. They also use a lighter touch that requires less customer commitment and a lower budget per customer than a typical SEM program; this alleviates budget strain for the utility by accommodating the larger number of customers the program aims to engage but returns lower savings per customer for each program engagement. In addition to delivering energy savings, the Accelerator programs allow utilities to strengthen customer relationships and often act as on-ramps to other utility program offerings that generate additional savings. For example, approximately two-thirds of PSE’s Accelerator participants moved into another PSE program after completing the Accelerator; other programs included its commercial SEM, capital projects, and commissioning programs (Simms and Malinowski 2026). Programs like these Accelerators can play an

important role in addressing challenges faced by buildings with limited staff capacity to manage compliance with BPS requirements.

Renovations

For major renovations, most program implementers refer project teams to their new construction program. For example, Mass Save includes existing building projects in its new construction program when the use of the space is changed (such as a building that was previously a hotel being renovated as a college dormitory); when there is a complete gut renovation of a space in the building, such as a complete removal, replacement, or redesign of the HVAC system, including distribution; when there is reconstruction of a vacant building; and for projects so extensive that the space cannot be occupied during the work period (Mass Save undated). Energize Connecticut has similar procedures. For renovations that are not this extensive, program implementors generally refer them to their retrofit programs. However, retrofit programs do not typically include any special attention or services targeting renovations, and sometimes the incentives per measure or per kWh saved are smaller than for new construction programs. Without attention to assisting and optimizing renovations, programs can miss opportunities for substantial savings.

Efficiency Vermont: Efficiency Vermont appears to pay more attention to renovations that are not substantial enough for new construction programs, as it has assigned eight key account managers to help approximately 375 of its largest customers capture opportunities and receive services under Efficiency Vermont programs. Two additional account managers can provide more focused services to the next tier of customers when there appear to be substantial savings opportunities. For example, when Mach's Market was planning a substantial renovation, an Efficiency Vermont engineering consultant helped it implement a series of retrofit projects, including insulation and air sealing that reduced energy use by 30%, and upgraded lighting, refrigeration, and HVAC systems (Efficiency Vermont undated).

Strategic energy management (SEM)

Although SEM programs come in a variety of forms, they most commonly provide training and technical assistance that allows customers to identify and implement a set of no and low-cost operations and maintenance measures that bring modest energy savings. For example, an evaluation of the SEM program operated by the Energy Trust of Oregon found 4–6% electricity and gas use reductions among participating customers (DNV-GL 2016).

To achieve more comprehensive savings, SEM requires a multiyear commitment to make regular improvements year after year, including some capital measures. Two examples are programs offered by Commonwealth Edison (ComEd), a large electric utility that serves Northern Illinois, including Chicago, and Xcel Colorado. Both programs include commercial and industrial customers; ComEd has more commercial participants while Xcel has more industrial participants. We discuss ComEd's program here and Xcel's program in the industry chapter.

ComEd SEM: This program involves cohorts of customers who meet regularly for educational presentations and to share experiences. ComEd contractors facilitate the groups and provide follow-up services and referrals to other ComEd programs. The program targets customers who use more than 500 MWh of electricity per year. ComEd has about 17,300 of these customers, of which about 400

participate in SEM each year. Customers sign on for a year at a time, and most participate for many years. Every year, some customers drop out and other customers join. About half the participants are publicly owned entities such as schools and wastewater plants, and half are private, mainly industrial. ComEd establishes an energy use baseline for each customer and then documents savings relative to this baseline.

On average, the offering saves customers about 2% per year. Customer savings range 0–21% from baseline energy usage in a year. Using the 2% per year average, a customer who participates for five years on average will reduce energy use by about 10%. Of the approximately 400 customers participating each year, about 65 will also participate in other ComEd programs. The SEM cohorts saved a total of about 43 GWh from the program in 2025, and an additional 7.5 GWh from other programs.

Regarding lessons learned, the program manager notes that it is important to coordinate with implementation contractors on what to prioritize, to establish rigorous baseline energy models, to innovate and provide new information to keep customers engaged, to emphasize building long-term relationships with customers, and to try to recognize customer achievements both within companies and externally (M. Jacobson, senior program manager, Commonwealth Edison, pers. comm., February 2026).

The next couple of program examples have achieved substantial multiyear commitments. While not officially labeled SEM, they achieve the strategic long-term objectives of SEM efforts.

Eversource Memorandum of Understanding (MOU): Eversource pioneered the MOU approach as a structured way to build multiyear partnerships with some of its largest customers. Through these MOUs, Eversource commits to providing technical assistance and financial incentives, and the customers commit to meeting certain energy goals and targets. The message is very straightforward: “If you are willing to step up and reach, we will do it with you.”

Some customers are more than ready for this level of ambition, and Eversource continues to work with those who are not through its regular programs. To date, Eversource has entered into about 30 MOUs with large institutional, municipal, commercial, and industrial customers in its Massachusetts, Connecticut, and New Hampshire service areas. Other utility companies, including National Grid and RI Energy, have adopted similar MOUs, following the Eversource model.

Customers that have partnered with Eversource to develop MOUs have achieved notable energy-saving outcomes, including

- *The University of Connecticut (UConn)* and Eversource worked together for over a decade to reduce the school’s energy usage by half, which has resulted in over 6.1 million kWh savings to date. These reductions have continued even while the university redevelops older buildings and constructs new ones to support the growing needs of its student body. The MOUs with Eversource have provided a framework for identifying opportunities, setting target energy goals, and executing well-planned projects across a campus with diverse building stock.
-
- *Boston Medical Center (BMC)* reduced its energy consumption by one-third while its patient volume increased by nearly one-third. This proves that it is possible to grow as an organization while pursuing ambitious energy efficiency and carbon mitigation goals. In its most recent MOU with Eversource, BMC outlined a strategy that would reduce electric use by over 4 million kWh over three years. BMC engaged Eversource early in the design of new construction and major

renovations, and advanced deep energy efficiency, decarbonization, and demand reduction strategies across its campus.

In recent years, Eversource has also formalized strategic MOUs with cities and municipalities that take a different approach to similar goals. One example is the recent agreement with the City of Boston, which launched the Boston Energy Savers initiative. Highlighted by the mayor in her State of the City address in March 2025, this agreement outlines how both utilities involved, Eversource and National Grid, will coordinate with various city departments and defines specific, measurable outcomes on weatherization and heat pump adoption.

In developing MOUs, Eversource and its MOU partners work together to address three questions:

1. What is the opportunity?
2. How do we finance it, factoring in the customer's financial criteria?
3. How do we execute it and get out of our own way?

Alignment across the customer's organization is important, from the C-suite down through operations, and while the MOU document is a moral commitment, it is not a legally binding contract. It establishes a shared direction, accountability, and momentum (T. Subrahmanian, vice president, Eversource, pers. comm. February 2026).

Efficiency Vermont key accounts: Efficiency Vermont employs key account managers to regularly work with its largest customers and those one tier below that have substantial projects. In 2025, Efficiency Vermont completed 444 custom projects for its largest customers and saved about 25 GWh of electricity. Of these savings, 46% came from retrofit projects, 44% came from replacing equipment that reached end-of-life, and 10% came from new construction projects (D. Corliss, director customer engagement, Efficiency Vermont, pers. comm., February 2026).

Monitoring-based commissioning

ComEd: ComEd has operated a Retro-Commissioning Program that commissions existing buildings since 2009. In the early years, it targeted large commercial buildings, primarily offices, and had a focus on kWh savings. Over time, the focus broadened to other building types, including hospitals, schools, universities, and government buildings. Beginning in 2013, ComEd added a Monitoring-Based Commissioning (MBCx) component to drive deeper savings. Some buildings have now been enrolled in this MBCx program for up to seven years. In 2015 a simplified Retro-Commissioning Tune-Up program was added for smaller buildings, and in 2017 an entirely remote Virtual Commissioning® pathway was also added to reach smaller buildings; the latter particularly focuses on groups of similar buildings where lessons learned in one building can be applied in other buildings under the same management.

In the early years, the program emphasized the value to the customer of the retrocommissioning study funded by the utility. This focus expanded to how customers can benefit from incentives for implementing the recommended measures and from measure verification after studies are completed. The incentives mostly go to service providers so that they can provide the services at no cost to the customer, but there is also an incentive to the customer for savings achieved: It is \$0.04 per kWh in 2026. At inception, the program had five stages with a review at each stage. This was later simplified to four stages: application, investigation, implementation, and verification. The number of participating customers has gradually increased, from just a few in 2013 to over 250. In recent years, three gas utilities whose service areas overlap with ComEd have helped to fund the program, and the costs can be

shared between the utilities based on electricity and gas savings (E. Pauli, senior energy efficiency program manager, Commonwealth Edison, pers. comm., March 2026).

Presently, there are three project types: Monitoring-Based Commissioning for large buildings; Retro-Commissioning Flex, which is primarily for medium-sized buildings, though larger buildings are eligible; and Virtual Commissioning, which includes smaller buildings. These represent an evolution from the programs originally offered. More details are in table CR-1.

Table CR-1. Commonwealth Edison retrocommissioning program

	Retro-Commissioning Flex (RCx)	Monitoring-Based Commissioning (MBCx)	Virtual Commissioning (VCx)
Building size	Any	> 150,000 sq. ft.	Any
Building annual energy usage	> 0.5 GWh	> 3 GWh	Any
Peak demand	> 100kW		< 500 kW
Energy savings	5–10% of annual usage	10–15% of annual usage	5–15% of annual usage
Incentives	Fully funded RCx Flex study covering the costs of engineering services Performance-based incentive up to implementation cost (\$0.04/kWh)	Fully funded MBCx study covering the costs of monitoring software and engineering services Performance-based incentive up to implementation cost (\$0.04/kWh)	Fully funded remote analysis of energy usage and technical assistance
Implementation commitment	Lesser of cost for measures with <1.5 year payback or \$1,000–15,000 based on project size	None	None
Project payback period	< 1.5 years for implemented energy improvements		< 6 months
Minimum customer staff requirement	3–6 hours per month	10 hours per month	None
Average project duration	6–15 months	18+ months	3 months

Source: www.comed.com/WaysToSave/ForYourBusiness/Pages/FactSheets/RCxOptions.aspx

Since inception, the program has served commercial buildings with more than 500 million sq. ft. of floor area. Based on estimates for 2025, first-year program participants reduced electricity use 35 GWh at a total program cost of \$11.86 million (ComEd 2026). The program also has natural gas savings, and these costs and savings are assigned to natural gas utilities.

Automated demand response (ADR)

These programs target demand reductions, typically measured in kW. Many more examples are provided in a forthcoming ACEEE report (Traynor and Aquino 2026).

Pacific Gas & Electric Company (PG&E): This ADR program provides funding to customers to install demand-reducing equipment that can receive a signal from PG&E to initiate a series of automatic, customer-defined, and preauthorized actions during demand-response (DR) events. Rebates of up to \$200 per kW of preprogrammed demand reductions help customers offset either 75% (Standard program) or 100% (FastTrack program) of the purchase and installation costs of new behind-the-meter technologies and controls. This equipment also makes it easier for customers to participate in various other PG&E DR programs, including Peak Day Pricing, which offers discounted rates for most of the summer but higher prices on 9–15 peak days, and Capacity Bidding, which pays for load reductions during DR events with bidding handled by aggregators. ADR signals trigger preprogrammed and automated energy management and curtailment strategies; this automation reduces the burden on customers who would otherwise have to manually reduce their energy use, and makes the expected load reduction more reliable.

The ADR program offers two application processes, the Standard Application and the FastTrack Application. The Standard Application is primarily for large commercial, industrial, and agricultural customers and it requires a robust calculation of curtailment kW prepared by PG&E's ADR program engineers and analysts. The FastTrack Application process is available for certain building types that have under 500 kW average peak summer demand per service account and employ limited, common HVAC and lighting curtailment measures. This prescriptive approach provides a streamlined incentive calculation process for projects (Energy Solution 2024).

Each customer can choose from a variety of ADR strategies. Some precool their buildings when a DR event is likely, and others use various thermal energy storage techniques such as ice storage. Agricultural customers send signals to stop pumps and some customers program their building energy management systems to make a variety of modifications during the few hours of a DR period, including higher temperature setpoints, lower fan speeds, and reduced intake of fresh air.

In 2024 PG&E's ADR program included 41 customers and 420 service accounts; many customers have more than one participating site. ADR-attributed load reductions totaled 24 MW and agricultural, retail, and grocery customers accounted for the largest committed reductions, with restaurants a distant fourth. Load reductions from offices used to be higher when PG&E had a summer afternoon peak period, but reductions declined when PG&E moved to a summer evening peak of 4–9 pm, after the workday for most offices. For commercial customers—such as retail, restaurants, and grocery—ADR reduced peak demand by 13% on average among buildings that participated during event periods (K. Wang, technical director, Energy Solutions, pers. comm., February 2026).

Other approaches

Srivastava and Mah (2022) discuss custom retrofit packages, for which they estimate 10–20% savings, and performance-based programs, including pay for performance, efficiency as a service, and Energy Savings Performance Contracts (ESPCs), for which they estimate 15–40% savings. The Mach's Market

project in Vermont is an example of custom incentives. For performance-based programs, Srivastava and Mah note that the General Services Administration entered into long-term ESPCs with energy service companies for deep retrofit packages that were financed via long-term energy-service agreements at large facilities that averaged 19 years. In round 1, 23 projects were undertaken in buildings totaling 14.7 million sq. ft., and energy savings averaged 38%. These were very large federal buildings and entering into such long-term contracts with private companies may be difficult.

Participation rates

Because BPS are required by law, the participation rate approaches 100% but will not be perfect. We assume 90% based on initial experience in New York City (NYC 2026). A few buildings will pay penalties instead of meeting the standards, but most will eventually comply.

The other programs have lower participation rates. For instance, Efficiency Vermont estimates that about half of its large customers undertake projects each year (D. Corliss, director customer engagement, pers. comm., February 2026). Likewise, in Focus on Energy's SEM program (discussed in the industry chapter), 20–35% of eligible large commercial and industrial customers participate each year.

Energy savings and peak demand reduction

Webb and McConnell (2023) estimate 25–45% energy savings based on analyzing how BPS policies that have been adopted in 10 cities will affect office buildings, schools, and multifamily buildings. We estimate that on average, program implementers might be able to claim one-third of these savings, based on the experience in Arizona that is discussed in the new construction chapter. For our calculations of claimable savings from BPS adoption and implementation, we use the 35% BPS savings, the midpoint of the range discussed above, and divide by three for the program implementer claim.¹⁶ We further assume that BPS policies will affect 30% of commercial building floor area in the United States by 2035 and that 90% of buildings comply (as explained in the participation rate section).¹⁷ For the other 70% of large commercial buildings, we assume that customers accounting for half of kWh sales in this group participate in some type of enhanced SEM program, based on the Efficiency Vermont custom program experience for large customers. We assume 15% average energy savings from SEM and monitoring-based commissioning. Thus, we estimate that 65% of commercial customers are affected: 30% by BPS, and half of the remaining 70% with SEM. We further estimate about 12.9% average savings: 11.7% for the program implementer share of BPS savings that apply to 30% of buildings times a 90% compliance rate, and 15% for SEM that applies to 35% of buildings. These savings are applied to the 69% of commercial building floor area that is in buildings with floor area of 25,000 sq. ft. or more. Buildings under 25,000 sq. ft. are covered by the Small Business program discussed later in this report.

¹⁶ A modest portion of the BPS savings may come from replacing old equipment with new equipment that meets current equipment and building code standards. These savings would happen without BPS policies and we assume they are part of the two-thirds of savings that are not credited to program implementers. Savings beyond current equipment and building code standards are covered in other chapters such as HVAC and lighting.

¹⁷ Currently about 10% of commercial building floor area is covered by BPS (C. Majersik, senior advisor, Institute for Market Transformation, pers. comm., May 2026) and another 20% will be adopted and implemented by 2035. Over half of the new adoptions are likely to be in California, where the legislature has asked for a report and recommendations on a statewide BPS. The remaining new adoptions will be in other states and cities, such as from the more than 30 states and cities currently without a BPS but that have committed to the National BPS Coalition to adopt a BPS (National BPS Coalition 2025).

We estimate peak demand savings based on the ratio of commercial sector energy savings (kWh) to summer peak electric demand reduction (kW) from commercial sector energy efficiency programs, both as reported to EIA (EIA 2025). Winter peak savings are estimated based on the ratio of summer to winter peak savings for commercial retrofits in the Mass Save 2025–2027 Three-Year Plan (Mass Save 2025).

Assumptions and national savings are summarized in table CR 2. Given the highly approximate nature of key assumptions, this is only a rough estimate of potential savings. Still, savings are substantial, totaling about 100 TWh after 10 years with summer peak reductions of over 27,000 MW. Commercial retrofits are the source of some of the largest energy and peak demand savings estimated in this report.

Table CR 2. Energy and peak demand savings from commercial retrofit programs

("x" designates multiplication)

	Value	Units	Comments
	1,715	TWh	2035 commercial electricity use (EIA 2026)
x	69%		Percentage of floor area in buildings over 25,000 sq. ft. (EIA 2020)
x	65%		Proportion affected by new policies and programs (explained in text)
x	12.9%		Average savings (average of BPS and large customer programs as explained in the text)
=	99	TWh	Savings in 2035
x	279		Ratio of summer peak savings (MW) to annual savings (TWh) for commercial utility programs in 2024 (EIA 2025)
=	27,739	MW	Summer peak savings
x	0.27		Ratio of winter peak to summer peak savings for commercial retrofit programs (Mass Save 2025)
=	7,627		Winter peak savings
	3,379	TBtu	2035 commercial natural gas use (EIA 2026)
x	69%		Percentage of floor area in buildings over 25,000 sq. ft. (EIA 2020)
x	60%		Proportion affected by new policies and programs
x	12.9%		Average savings
=	181	TBtu	Savings in 2035

The BPS will achieve additional savings for which we do not assume utility credit. At a national level, given our assumptions, an additional 75 TWh of electricity can be saved in 2035. These additional savings are a significant reduction in loads beyond those included in our primary analysis.

Typical costs and cost of saved energy

For its large customer energy-management program, Efficiency Vermont estimates savings of about 25.4 GWh from measures installed in 2025. These are preliminary estimates before evaluation. The program paid incentives of about \$5.5 million (D. Corliss, director customer engagement, Efficiency Vermont, pers. comm., February 2026). If we add 45% for other program costs (Opinion Dynamics and ACEEE 2026) and assume a 15-year average measure life and 3% real discount rate, the program costs about \$0.026 per kWh saved.

For retrocommissioning, measure lives are shorter because these emphasize controls adjustments. For the ComEd retrocommissioning program, using the 2025 program costs and savings discussed above and

assuming an average measure life of 8.13 years (ComEd 2025) and a 3% real discount rate, the average cost per kWh saved is \$0.048.

For BPS upgrades, Webb and McConnell (2023) estimate upgrade costs will average a little over \$1 million per building and will have a median simple payback period of 10–20 years, varying by city and building type. If we assume a 20-year measure life and a 3% real discount rate, life-cycle savings will approximately equal the costs.¹⁸ However, actual costs are likely to be significantly lower, as these cost estimates assume full measure costs and not incremental measure costs at the time of equipment replacement. Additionally, these costs are based on New York City, a very expensive place for construction work.

Finally, for the PG&E ADR program, using figures on demand reductions and incentive cost from Energy Solutions 2024 and assuming a seven-year average measure life and a 3% real discount rate, the cost of avoided demand is about \$44 per kW-year. This is the cost of a kW of capacity available throughout the year. In comparison, Specian and Aquino (2026) report that a peaking gas turbine costs \$52–86 per kW year and other types of plants cost even more.

Exemplary program design and marketing features

The following lessons emerge from our case studies:

- *Encourage comprehensive retrofits* involving multiple measures that address major building systems. Sometimes these can happen during building renovations, but more often measures will be steadily adopted in a continuous improvement process, and many of the SEM programs we profile encourage this.
- *Focus on the very largest customers* within the large customer class, as they use the most energy and generally have staff that focus on building energy systems. The Eversource MOU and Efficiency Vermont Key Account programs illustrate this approach.
- *Encourage and assist customers in moving beyond O&M to capital measures.* SEM is a useful construct, but often just results in O&M measures. The best programs sustain long-term customer interest and include capital measures. This is shown by the ComEd SEM program, the Eversource MOU, and Efficiency Vermont's Key Account programs.
- *Support customers in committing to continuous improvement* to achieve large energy savings and other benefits in the long term. To sustain these long-term relationships, programs need to keep providing fresh information, be flexible and willing to innovate, and engage with multiple staff at each customer's organization so the relationship is not dependent on one person. A good example is the ComEd SEM program.
- *Monitoring-based commissioning can be a complementary approach*, as illustrated by the ComEd program by this name. It can achieve significant energy savings that can often be a useful first step in reaching building energy performance standard targets, and it can provide a foundation for automated demand response.
- *Understand customer priorities* so that customers can make deeper commitments and programs can assist in reaching these goals. This has been a key consideration in the Eversource MOU program.
- *Recognize customer achievements*, both internally at the customer's organization and externally, to help motivate customers to undertake additional projects. The ComEd SEM program does this.

¹⁸ In other words, assume a simple payback of 15 years. This results in a savings of $\$1,000,000/15 = \$66,666$ per year. Now accumulate that for 20 years ($PV(0.03, 15, 66,666)$) which is \$991,822, which is 99% of \$1,000,000.

- *Keep in regular touch with owners of large buildings* to understand when renovations are likely to occur and help with renovation planning. Building renovations can provide opportunities for substantial savings. Efficiency Vermont does this.
- *Assist with adoption and implementation of BPS*, which provide a mechanism for reaching all large buildings. ComEd, Eversource, and Washington State utilities have done this.

To this list of good practices, Read, Honeychuck, and Zheng (2025) add two more:

- *Target an initial anchor participant to help scale new programs*. For example, Eversource worked with MIT as the first participant in its MOU program.
- *Focus on customers that have multiple eligible sites*. Sometimes key decision-makers can enroll multiple sites, but either way, good experiences at one site can often help to enroll additional sites.

Summary and recommendations

To achieve large energy savings, programs need to move beyond a single measure approach and promote retrofits that involve multiple measures. This will often be by a multiyear, continuous-improvement process. Two ways to get multiyear commitments are SEM and adoption of a BPS. In addition, periodic building renovations provide an opportunity to include multiple energy measures in a project. Achieving the very large energy savings possible from these approaches will require a strong commitment by policymakers to adopt BPS and to push program implementers to pursue large savings during building renovations and through multiyear SEM programs. Commercial retrofits have among the largest potential energy and peak demand savings of all the programs examined in this report.

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Distribution efficiency improvements

Synopsis

This chapter discusses two ways to improve distribution systems by reducing energy losses. One is voltage optimization (VO), which involves optimizing and often reducing voltage and other power parameters. The other is use of amorphous core distribution transformers, which have less loss than the more commonly used transformers that use grain-oriented steel cores.

Data summary

Available savings in 2035 from 2026–2035 programs:

96 billion kWh (TWh) of electricity (third of 13)

16,400 MW of summer peak demand reductions (fifth of 13)

11,500 MW of winter peak demand reductions (fourth of 13)

Cost per kWh saved: \$0.002–0.016 for VO; \$0.018–0.033 for amorphous core transformers

Introduction

In the United States, about 5% of electricity generated is lost in the transmission and distribution system due to line and other system losses (EIA 2023). The losses are smaller in some areas and larger in others; for example, they are larger in most rural areas. Losses during critical times, such as on hot days when systems peak, are higher than the average due to additional inefficiencies at high temperatures (EPRI 2022). One of the best ways to reduce power losses is conservation voltage reduction (CVR), which heavily overlaps with Volt/Var control. In addition to voltage control, Volt/Var addresses control of reactive power and thus improves the power factor.¹⁹ Together, these approaches are sometimes called voltage optimization (VO).

Another way to reduce distribution system losses is to install high-efficiency transformers when new transformers are purchased. Federal minimum efficiency standards ensure all new transformers are fairly efficient, but even more efficient transformers are available, and they often use amorphous metal cores.

In this chapter, we only discuss the distribution system and not the transmission system. There are also large opportunities to improve transmission systems (Le Mueller and Mendel 2025). We focus here just on distribution systems as energy efficiency program budgets sometimes include distribution system efficiency improvements, but we are not aware of any instances where these budgets extend to transmission systems.

Technologies and approaches

Conservation voltage reduction (CVR) and voltage optimization (VO)

CVR has been in use in the United States since the 1970s, before modern grid technologies were widely available. While modern technologies are not necessary for CVR implementation, use of advanced smart

¹⁹ Reactive power increases losses on the system. It is caused by certain loads, including electric motors and other equipment with a low power factor.

grid systems can help with CVR implementation by automating processes for managing voltage and enabling finer control that is quicker and more localized.

In the United States, electricity is supplied to residential and small commercial users at 120 volts nominal. However, under American National Standards Institute (ANSI) standards, voltage at the meter can range between 114 and 126 volts at all times and between 106 and 127 volts for brief periods. CVR involves measuring and analyzing voltages on distribution feeders to find ways to reduce voltages while maintaining service requirements; this includes voltage levels and phase balance at levels that allow equipment to operate without problems. Lower voltages can improve end-use equipment efficiency and reduce line losses on both the customer and the utility side of the meter. Voltage optimization can also improve the effective capacity (kW) and help with reactive power management (NWPCC 2009). Voltage is often regulated using voltage regulators or load tap changers at the substation. Other, less common methods include controlling the distribution voltage level from the transmission system or using switched capacitors. Voltage control needs to be automatic and can be done via line drop compensation settings, switched capacitor banks, excitation on the generator, or voltage feedback signals from the extremities of the distribution system. At times, distribution system improvements will be needed on some circuits to optimize voltages across the circuit. Best methods for voltage control will often vary from circuit to circuit—there is no one-size-fits-all approach (Schwartz 2010).

Several recent technology developments can contribute to distribution system efficiency. First, there are improved ways to optimize voltage. Several companies, including General Electric, Cooper, Utilidata, and Hitachi, are now marketing integrated volt/VAR controls (IVVC) that provide automated adjustment of substation-level voltage based on end-of-line voltage and predictive algorithms. Some of these products can also control switchable capacitor banks to regulate reactive power compensation. Second, smart meters with two-way communication are being installed in many areas and can provide utilities with a way to measure service voltage for each customer. These data can aid in voltage control. Dominion Voltage, a subsidiary of the utility Dominion Energy, has a set of software products that use this smart meter data for not just customer voltage control but also grid planning and energy savings validation.²⁰

Starting around 2008, major CVR pilot projects were undertaken in the Pacific Northwest by the Northwest Energy Efficiency Alliance (NEEA); the results showed average energy savings from voltage control of 2.07% of the consumption on the circuit, with savings higher in summer and lower in winter (NEEA 2007; NWPCC 2009). If voltage is carefully controlled to be above minimum thresholds, they found that most customers will not notice any difference. Similarly, the Electric Power Research Institute (EPRI) sponsored the *Green Circuits* project, which worked with 22 utilities to characterize 66 circuits across many states, with a concentration in the Southeast. The project found 2.34% average savings across the 66 circuits. The project also included a field test on nine circuits and in these, energy savings averaged 2.01%. Across all 66 circuits there were almost no complaints about circuits operating at reduced voltage. There were initial complaints on two circuits, but these were resolved by less aggressive voltage reduction (EPRI 2011). More recent and broader-scale applications of CVR and VO are discussed in the section on program examples below.

Amorphous core distribution transformers

Nearly all power around the world passes through distribution transformers that step down power voltage from the high voltage used in distribution systems to the lower voltage used in homes and

²⁰ See www.dvigridsolutions.com/.

businesses. Distribution transformers consist of a steel core and wire windings around the core, typically copper wire. These transformers are generally about 98–99.5% efficient, meaning that roughly 99% of the energy is passed through the transformer and 1% is lost. While 1% is not large, it adds up. This number essentially applies to all electricity consumed in the United States, as nearly all electricity passes through a transformer, and a substantial amount of electricity passes through more than one transformer.

Transformers have two types of major losses—core losses and winding losses. Core losses apply around the clock, even when there is no load on the transformer. Winding losses occur when the transformer carries load, and the losses are approximately proportional to the load. Most transformers have steel cores made of a special low-loss steel, but core losses can be reduced further using amorphous metal cores. These are solid, noncrystalline alloys with a disordered atomic structure that are created by rapidly cooling molten metal to prevent crystallization. Amorphous cores were commercialized in the 1980s and using them can reduce energy losses by about 40% in utility distribution transformers (DOE 2024a).²¹ About 2% of transformers sold in the United States in 2023 used amorphous cores, whereas in Canada that figure is about 65% (Metglas 2023). Until recently, amorphous cores cost more, and most U.S. utilities used steel cores to reduce transformer purchase costs; this was despite the reality that the energy savings over the approximately 30-year life of the transformer more than justified the additional purchase price (see more in the costs section below). However, in the past year, the cost of the low-loss, grain-oriented steel used in most transformers has increased such that amorphous core transformers are sometimes competitive on cost, particularly for three-phase transformers (D. Nathasingh, global business development consultant, Metglas, pers. comm., March 2026).

Another factor affecting the market is new DOE transformer efficiency standards that will take effect in April 2029. For single-phase transformers greater than 100 kVA (kilovolt amperes, roughly similar to kW) and for three-phase transformers less than 500 kVA, the new standards will in most cases require use of amorphous metal cores. For single-phase transformers less than or equal to 100 kVA and three-phase transformers greater than or equal to 500 kVA, the highest efficiency grain-oriented steel cores will meet the standards (DOE 2024b), with higher efficiency amorphous core transformers available for purchasers who want higher efficiency and lower losses. Increased use of amorphous core transformers by utilities in the next 10 years can have an impact on the next DOE transformer standard, which might be set in the early 2030s and take effect near the end of that decade.

Distribution transformers are generally funded out of distribution budgets and not energy efficiency budgets. We list them here because they provide substantial savings that are often overlooked during distribution planning. Such purchases should continue to be financed out of distribution budgets.

Examples of successful programs

CVR/VO

Commonwealth Edison (ComEd): ComEd has run a VO program since 2017. The program includes both CVR and volt/VAR control. Through 2025, ComEd has addressed 281 substations; it plans to address 32 more substations in 2026 and approximately 80 additional substations from 2027 to 2031. These 400

²¹ This is for liquid-immersed transformers, the predominant type used by utilities (DOE 2024b).

substations are about one-sixth of their total substations. A feasibility report that ComEd conducted at the beginning of the effort identified eligible feeders based on voltage level and a high portion of residential loads. Further analysis was conducted to estimate benefits and costs for these feeders. After the VO activation of a new substation, the substation and feeders are run on the VO test cycle for four days on and four days off, to obtain the necessary data to calculate the actual energy savings achieved by VO for that feeder. Based on this approach, the company estimates that by the end of 2024, the VO program achieved energy savings of 1,086 GWh per year and reduced peak demand by 195 MW. Across the circuits involved, the average customer energy use reductions averaged about 2%. The program has cost ComEd about \$550 million through 2025 and the company now estimates a 50-year measure life. At a 3% real discount rate, that means a cost of \$0.002 per lifetime kWh saved.

In terms of lessons learned, the program manager noted that not all transformers have the taps needed to get the voltage reduction they want, so sometimes they had to settle for lesser reductions. Systems are monitored and controlled remotely at substations, voltage regulators, capacitor banks, and advanced customer meters. They particularly keep an eye on voltage at the end of a circuit, to make sure it does not dip too low. The VO team has worked with internal and external stakeholders to resolve various issues with the software and the VO centralized system. The VO centralized system utilizes GIS mapping data that contain all the equipment and lines controlled by the system; this allows it to dynamically control the feeder lines efficiently and help crews to find equipment when onsite work is needed (J. Pozen, manager of distribution automation, Commonwealth Edison, pers. comm., March and September 2026).

Baltimore Gas and Electric (BG&E): BG&E has run a CVR program since 2013. The company has an old distribution system and most of its substation transformers do not have taps that can be used to adjust voltage while energized. Instead, BG&E developed a system whereby it briefly deenergizes a circuit to manually adjust the voltage and uses capacitor banks along the circuit to maintain the desired voltage. This requires correctly sizing capacitor banks; if banks are mis-sized, they may not be able to maintain the desired voltage. This system is not as flexible as the one implemented by ComEd and energy savings have averaged only about 1.2%. By 2024, BG&E had installed this system in all of its circuits, and in 2025, the program saved 230 GWh. The program cost about \$56 million in capital costs and has annual costs of over \$1 million to cover software, staff costs, and the cost of sending trucks out to address communication problems with the capacitor banks. With these costs and savings, the cost per kWh saved is about \$0.016 (assuming a 30-year capacitor life and a 3% real discount rate). The program manager noted that the program took 10 years to deploy, twice as long as originally hoped, and recommended planning for reasonable ongoing costs (Independent Evaluator et al. 2024; J. Picarelli, manager emerging grid technologies, BG&E, pers. comm., March 2026).

Dominion Energy: Serving the majority of the load in Virginia, Dominion is pursuing VO as the largest component of its energy efficiency program. The company is using smart meters to help monitor voltage at many points on a circuit and controlling voltage using load tap changers and voltage regulators that ensure the system is above the minimum required voltage at all points. As of early 2026, 128 substation nodes had been set up for VO: About 30 were set up in 2024, 70 in 2025, and the remainder in early 2026. Dominion ultimately wants to outfit about 1,000 nodes by 2033, which would be about 90% of the load on its system. Dominion is not using VO on circuits that primarily serve large customers, such as data centers, although it is planning an initial pilot on one circuit with a data center. The company estimates savings in a sample of circuits by turning VO on for one day and then off the next. In 2024 it estimated energy savings of about 100 MWh and peak load reductions of about 36 kW. Additionally,

Dominion program managers recommend starting VO with circuits that are easy to implement and then gradually progressing to circuits that have more challenges. A subsidiary, Dominion Voltage, markets VO services to other utilities, including Ameren Illinois (E. Hall, S. Tyler, and R. Christian, Dominion Energy, pers. comm., March 2026).

Ameren Illinois: Ameren employs both volt/VAR optimization (VVO)²² and CVR in its VO program. VVO improves the power factor and reduces system losses, and CVR controls and reduces voltage using load tap changers, voltage regulators, and capacitors. In 2024, VO was made operational in 224 circuits; it saved 77 GWh that year and reduced peak by 13.7 MW. For these circuits, Ameren reduced voltage by an average of 3.49% and energy savings averaged 2.79% of energy flows on those circuits. In addition, 699 circuits were made operational in earlier years. Ameren originally planned to implement VO on 1,047 circuits but now expects to implement it on more than 1,200 circuits (Opinion Dynamics 2025).

Transformer purchases

The Los Angeles Department of Water and Power (LADWP) has been purchasing and using amorphous core transformers for more than a decade. It has been satisfied with the quality and sees no differences compared with conventional transformers. Like many utilities, LADWP evaluates total owning cost using A and B factors, where A is the cost to the utility of no-load losses and B is the cost to the utility of load losses, both expressed in dollars per watt. LADWP presently uses about \$9.60 per watt for A and \$2.00 per watt for B.²³ Recently, it finds that amorphous core transformers cost about 10% more than transformers with low-loss steel cores, and sometimes even less. With these A and B factors and costs, most of LADWP's purchases are transformers with amorphous metal cores. It does not purchase amorphous cores for small pole-mounted transformers (100 kVA and below) because when the utility looked into this issue several years ago, it found a significant weight difference in these sizes.²⁴ LADWP also does not purchase amorphous cores for transformers installed in underground vaults because the vaults are generally not big enough (P. Wei, electrical engineer, LADWP, pers. comm., March 2026).

Participation rates

As discussed above, Dominion estimates that it can implement VO on about 90% of its circuits. Ameren Illinois is pursuing a similar penetration rate and BG&E has already outfitted nearly all of its circuits. Our case studies show that implementing VO on a full system takes about 10 years.

Energy savings and peak demand reduction

CVR/VO

In our case studies, energy savings ranged from a low of 1.2% (BG&E) to 2.8% (Ameren Illinois). ComEd is saving about 2%. As also noted above, a study by NEEA study found 2.09% average savings from CVR (NEEA 2007) and EPRI found 2.34% average savings in its analysis (EPRI 2011). A study by Pacific

²² Essentially the same as volt/VAR control referred to earlier in this chapter.

²³For a full explanation, see EEP (2018). The A factors are higher than the B factors because no load losses happen 24 hours a day and load losses vary with loads; the average transformer is loaded less than 50% of its full rated load. LADWP has two A factors, one at rated voltage and one at 105% of rated voltage; these are weighted equally and total about \$9.60 per watt.

²⁴ Some manufacturers recently claimed that new alloy development and process improvements have significantly reduced the size and weight of amorphous core transformers (Metglas 2023).

Northwest National Laboratory (PNNL) on a nationwide program that optimized the 40% of circuits where CVR has the highest value found average savings of 2.4% (Schneider et al. 2010). For our analysis we use 2% average energy savings, which is likely conservative.²⁵

A few other points regarding energy savings are worth noting. First, the vast majority of savings from CVR are on the customer side of the meter. Based on its detailed modeling of 24 prototypical feeders, PNNL estimates that 98–99% of the energy savings are on the customer side of the meter (Schneider et al. 2010). EPRI (2011) found that that overall, 95.6% of the kWh savings were at the end-use level.

Second, it appears that energy savings and peak load reductions, on a percentage basis, are similar. For example, PNNL's results indicated 0.5–3% reductions in both summer peak load and annual energy use, depending on the feeder, with results for these two metrics nearly the same in percentage terms (Schneider et al. 2010). This said, savings tend to be higher in the summer when air conditioners are running and lower in the winter on circuits with substantial electric resistance heat. When voltage is reduced, the amount of heat produced by electric resistance heat is also reduced and equipment needs to run a little longer. Data from the Northwest show that winter savings are about one-third lower than summer savings, with summer savings higher than the annual average across seasons and winter savings lower than the annual average (NWPPC 2009).

Based on these findings, we estimate national impacts from CVR/VO in table Distribution 1. We find available energy savings of over 80 GWh, summer peak savings of nearly 15,000 MW, and winter peak savings of about 10,000 MW.

Table Distribution 1. Energy and peak demand savings from CVR/VO

("x" designates multiplication)	Value	Units	Comments
	4,640	TWh	Electricity sales in 2035 (EIA 2026)
x	90%		Percentage of circuits that can implement CVR/VO (see text)
x	2%		Average energy savings (see text)
=	84	TWh	Annual energy savings in 2035
x	178.7		Ratio of summer peak savings (MW) to annual savings (TWh) for ComEd and Ameren programs (see text)
x	14,927	MW	Summer peak savings
x	0.7		Ratio of winter peak savings to summer peak savings (NWPPC 2009)
=	10,001	MW	Winter peak savings

²⁵ Note, however, that if the other programs reduce electricity use by about 10%, savings from this program will be about 10% (8 TWh) lower than we show here.

Amorphous core distribution transformers

In 2024, the U.S. Department of Energy (DOE) established new minimum efficiency standards for distribution transformers that take effect in 2029. As discussed above, amorphous cores are implicitly required for two product classes. DOE (2024) estimated that use of amorphous cores will reduce losses 36–42% relative to transformers just meeting the 2029 standard for classes where amorphous cores are not implicitly required. We recommend that utilities voluntarily purchase amorphous core transformers to reduce transformer energy losses. Savings will be on the utility side of the meter.

DOE (2024) also estimated that if amorphous core transformers were the norm for most transformers, not including transformers used in underground vaults, nine years of transformer shipments would reduce site energy use by 1.4 quadrillion Btu (quads) over the 32-year life of these transformers and result in annual savings of 0.044 quads (1.4/32). Converting to TWh hours using 3,412 Btu per kWh means **annual savings of 12.8 TWh**. We use this figure for 10-year savings, as a couple of years will be needed to ramp up to full use of amorphous core transformers.

We did not find information on peak demand savings from amorphous core distribution transformers. As an approximation, and because amorphous cores reduce losses every hour of the year, we spread the energy savings over the 8,760 hours in a year; that resulted in peak demand reductions of approximately 1,500 MW.

Costs and cost of saved energy

CVR/VO

For CVR/VO, we examined the costs and savings of the ComEd and BG&E programs. Data and results are shown in table Distribution 2. The ComEd calculation only includes capital cost and is low because the company was able to mostly use load tap changers. The BG&E cost is substantially higher due to the expense of capacitor banks, ongoing maintenance costs, and lower savings as a percentage of distribution system load. Still, even the BG&E program costs less than \$0.02 per kWh saved.

Table Distribution 2. CVR/VO savings, costs, and cost per kWh saved

Program	Annual savings (GWh)	Capital cost (\$million)	Cost per kWh saved	Notes
ComEd	1,086	55	\$0.00197	Used 50-year life, as approved by ICC
BG&E	230	56	0.01629	Included \$1 million/year operating cost; used 30-year life for capacitors

Amorphous core distribution transformers

For amorphous core transformers, we use costs and savings by transformer class from DOE (2024). Results are summarized in table Distribution 3.

Table Distribution 3. Amorphous core transformer average savings, costs, and cost per kWh saved

Transformer class	Annual savings (kWh)	Incremental cost	Cost per kWh saved
1 phase < 100 kVA	421	\$ 151	\$0.018
1 phase > 100 kVa	1,491	1,003	0.033

3 phase < 500 kVA	1,366	773	0.028
3 phase > 500 kVA	8,340	3,502	0.021

Notes: 32-year transformer life and 3% real discount rate assumed. Savings, costs, and life from DOE (2024a).

Exemplary program design features

For CVR/VO:

- *First, assess the distribution system and look for opportunities* to reduce voltage and improve power factor. Consider also whether current equipment can be used to make voltage changes—for example, do most transformers have load tap changers?—and how much new equipment, such as voltage controllers and capacitor banks, will be needed. Circuits also need to be assessed, including how many are appropriate. Many utilities avoid circuits used by their very largest customers but include most other circuits.
- *Use voltage data from smart meters* where available, as Ameren Illinois and Dominion are doing.
- *Prepare a plan and submit to regulators for approval.* CVR/VO is quite different from other programs and will need to be explained, including how most of the energy savings are on the customer side of the meter.
- *Start with a few of the easiest circuits,* to develop procedures and refine software, and then steadily ramp up. Some utilities are now doing as many as 180 circuits per year.
- *Budget for some ongoing staff and maintenance costs.*

For amorphous core transformers:

- *Reexamine cost-benefit procedures for transformer purchases* and adjust A and B factors to reflect the cost of losses on the system. Avoid a “band of equivalence” that overrides life-cycle cost, because this reduces initial costs at the expense of long-term savings.
- *Get bids from multiple manufacturers* as they differ in cost and ability to deliver amorphous core products.
- *Examine size and weight issues for current products* and determine whether these need to be a factor for some pole-mounted transformer sizes. Leave vault transformers out of initial efforts; revisit procedures for these transformers in a few years, after more experience has been gained and technologies have perhaps further improved.

Summary and recommendations

CVR/VO and amorphous core transformers both provide significant opportunities for energy savings and demand reduction. CVR/VO savings average about 2% of power flows, and amorphous core transformers somewhat less than 1%. Over a 10-year period, savings from CVR/VO are the larger of the two. Full savings from CVR/VO can be realized in a decade. For amorphous core transformers, generally less than one-third of the transformer stock will turn over in a decade, so the savings we show can be at least tripled over the subsequent two decades. Both approaches are very cost effective, with CVR/VO costing less than \$0.02 per kWh saved. The extra cost of amorphous core transformers relative to low-loss steel cores generally works out to less than \$0.03 per kWh saved. Both approaches are fully within the utility’s control and do not depend on marketing. Both approaches should be aggressively pursued.

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Heating, ventilation, and air-conditioning (HVAC)

Synopsis

HVAC systems are improved through better equipment and controls. This chapter discusses midstream market programs that work with HVAC distributors and contractors, residential and commercial heat pump market transformation programs, advanced rooftop unit control programs, and chiller programs. Some of the largest savings come from improved controls for commercial rooftop packaged HVAC systems and from replacing electric resistance heat with heat pumps.

Data summary

Available savings in 2035 from 2026–2035 programs:

51 billion kWh (TWh) of electricity savings without fuel switching (fourth of 13); with fuel switching electricity use increases 11 TWh

418 trillion Btu of fuels (second of 13); these savings come from installing heat pumps in homes heated with oil or propane.

35,000 MW of summer peak demand reductions (with and without fuel switching) (second of 13)

21,000 MW of winter peak demand reductions without fuel switching (second of 13); fuel switching increases winter peak by 56,000 MW

Cost per kWh saved: commercial \$0.017–0.034, residential ~\$0.20

Introduction

Heating and cooling of homes and apartments accounted for about 42% of U.S. residential energy use in 2025. In the commercial sector, HVAC accounted for about 32% of sector energy use in 2025 (EIA 2026a). There are opportunities to improve the efficiency of equipment and to better control and optimize heating and cooling systems. A big savings opportunity for the coming decade is to move steadily toward variable speed heat pumps, which perform significantly better during the many hours of the year when peak heating or peak cooling output is not needed. At these times, variable speed is much more efficient than repeatedly starting and stopping single-speed equipment to match heating and cooling output to building needs. Variable speed operation can also increase heating capacity at low temperatures. Likewise, a heat pump is more efficient than a furnace or boiler in all but the coldest temperatures, and heat pumps often have slightly higher cooling efficiencies than air conditioners because their year-round operation makes it easier to justify the cost of measures to improve equipment efficiency.

The next section explores residential central systems, commercial rooftop units, and commercial chillers, the three most common HVAC system types, and briefly discusses other major systems. Industrial process heat is addressed in the industry chapter and water heating is discussed in the water heating chapter.

Technologies and services

Residential central systems

Central air conditioners, including both cooling-only ACs and central heat pumps, are used for cooling in about 67% of homes and apartments in the United States, and central heat pumps provide heating in about 13% of homes and apartments (EIA 2023). Residential-style systems also serve 19% of commercial building floor area (EIA 2022). Currently, system cooling efficiency is rated using the SEER2 metric.²⁶ In southern states, the federal minimum efficiency is 14.3 for split systems, which are separate indoor and outdoor units joined with piping containing refrigerant; in northern states, the requirement is 13.4. The latter is also the nationwide requirement for single-package systems where all the components are in a single unit and not split. The ENERGY STAR specification for heat pumps generally requires a SEER2 of 15.2, about a 6% energy use reduction relative to the minimum standard in the south.²⁷ Both the federal minimum and ENERGY STAR can be met with single-speed equipment. The Consortium for Energy Efficiency (CEE), whose membership is primarily efficiency program implementers, also has a higher efficiency tier. For 2026, CEE's "tier 1" calls for SEER2 of 17.0 for split systems and 16.0 for single package systems. This reduces energy consumption about 16% relative to federal standards for split systems and nearly triples the energy savings from ENERGY STAR-rated equipment. This tier generally requires use of variable speed or multiple compressors.

For heat pumps, there are also ratings for heating performance at 17 °F and 47 °F, and for equipment designed for use in cold climates, also at 5 °F. ENERGY STAR has a specification for products that manufacturers choose to classify as "cold climate heat pumps." Among the various criteria, this requires a Coefficient of Performance (COP) at 5°F of 1.75, and a heating output at 5°F of at least 70% of full load, with the rest supplied by electric resistance backup; this means about 34% energy savings at 5°F relative to pure electric resistance heat, which has a COP of about 1.0.²⁸ As we discuss later under program examples, some programs provide rebates only for heat pumps and not for cooling-only air conditioners, to capture some heating energy savings with the cooling savings. Installing heat pumps in homes with electric resistance heating can also save energy. For example, a study in Texas found that homeowners who installed a heat pump to replace central air conditioners with electric resistance heat at end-of-life reduced electricity consumption by an average of 2,535 kWh per home annually and earned a return on investment (ROI) of 49% with a simple payback of two years. These energy savings are about 50% relative to the annual power consumption of electric resistance heat in Texas (Nadel, Amann, and Chen 2024). Heat pumps can also save energy relative to gas heating, due to much higher heat pump efficiencies. At temperatures above freezing, heat pumps are always more efficient and often less expensive to operate than gas furnaces (see ComEd undated). In states with cold climates and high electricity rates, the economics are more challenging but can be improved by separate rates for heat pump customers, based on the cost of service for these customers when separated from general use customers (Malinowski et al. 2025).

²⁶ SEER is Seasonal Energy Efficiency Ratio. The 2 notes a different test procedure with different ratings than under the now retired SEER metric.

²⁷ $(15.2 - 14.3)/15.2 = 6\%$.

²⁸ Weighted COP $(1.75 * 70\%) + (1.0 * .3) = 1.525$. Savings $= (1.525 - 1)/1.525 = 34\%$.

Commercial rooftop units

In the commercial sector, about 42% of building floor area is heated and cooled by rooftop units (RTUs; EIA 2022). Efficiency levels and requirements vary by system size and the type of heating system incorporated—electric resistance, heat pump, or gas—and the primary efficiency metric used today is the Integrated Energy Efficiency Ratio (IEER). For a typical 10-ton unit with 120,000 Btu/hour of cooling capacity and gas heating, the federal minimum efficiency standard is 14.6 IEER and the ENERGY STAR requirement is 17.8 IEER. The federal minimum standard will increase in January 2029 and there will be new efficiency metrics. For a 10-ton unit, ENERGY STAR reduces energy use 18% relative to the current federal minimum. To achieve the ENERGY STAR specification, either variable speed or multiple compressors are generally needed. The federal minimum that will take effect in 2029 is similar to the current ENERGY STAR for 7.5-ton and 10-ton equipment but less stringent than the ENERGY STAR for larger equipment.

For heat pumps, the required cooling IEER is a little lower in most specifications, but a heating Coefficient of Performance (COP) or other heating metric is added. Most heat pump RTUs are not designed for high efficiency at low temperatures. To help fill this gap, DOE is running a Commercial Building HVAC Technology Challenge to work with manufacturers to develop rooftop heat pumps with better cold climate performance (DOE 2025). Initial products have been certified by DOE and are now undergoing field tests. Table HVAC 1 summarizes efficiency levels and metrics for RTUs.

Also, the Northwest Energy Efficiency Alliance (NEEA) has an initiative to encourage RTU manufacturers to incorporate cabinet insulation, tighter cabinet construction, low-leakage dampers, and energy or heat recovery ventilators in designs. The Alliance would eventually like to see these measures better incorporated into test procedures, but in the interim has developed prescriptive requirements for the efficient RTU program, and products from a few manufacturers meet the specification (Van Clock 2025). A nationwide analysis commissioned by NEEA found that in most of the United States, RTU heating energy use is substantially greater than cooling energy use, and thus heating-oriented measures such as heat pumps, heat recovery, and cabinet insulation can be important (Dimeo et al. 2025).

Table HVAC 1. Rooftop efficiency levels under several standards and specifications

Metric	Cooling capacity		
	65–134k Btuh	135–239k Btuh	240–760k Btuh
Current DOE efficiency std.			
IEER	14.8	14.2	13.2
COP 47	3.4	3.2	NA
Current Energy Star			
IEER	18.0	17.0	NA
COP 47	3.5	3.4	NA
COP 17	2.4	2.1	NA
DOE Tech Challenge			
IVHEc (for heating)*	7.1	6.9	6.7
COP 5	1.7	1.7	1.7

Metric	65–134k Btuh	135–239k Btuh	240–760k Btuh
2029 DOE standard			
IVEC (for cooling)	14.3	13.8	12.9
IVHE (for heating)	6.2	6.0	5.8
Approx. IEER**	18.0	15.0	13.5

Notes: Values shown are for units with electric resistance heat or no heat. Units with gas heat are often 0.2 efficiency points lower. COP varies with outdoor temperature, and COPs at 47°F, 17°F, and 5°F are shown; kBtuh is cooling capacity in thousands of Btu per hour. Minimum IEER and IVEC shown are for cooling-only systems. For heat pumps the values are slightly different.

*The IVHEc value shown for the DOE Tech Challenge is for cold climates and is not directly comparable with the IVHE metric for warmer climates.

**IEER values for the 2029 standards are approximate and based on how the average unit complying with the new metrics compares with the old metrics.

In addition to improved efficiency equipment, improved controls can also provide energy savings. For example, the Minnesota Center for Energy and the Environment conducted a field study of three types of controls that varied the speed of the RTU fans and found RTU annual electricity savings of 33–43%, depending on the brand of control (Haynor, Miller, and Schoenbauer 2023). Likewise, a program in New York State that retrofitted variable speed controls on RTUs found average savings of 35% for electricity and 5% for natural gas, which was generally the space heating fuel (Energy Solutions 2019). We discuss this program further later in this section.

Commercial chillers

Although chillers serve only about 3% of commercial buildings, these are large buildings that account for about 16% of commercial building floor area and an even higher percentage of commercial building energy use (EIA 2022).²⁹ There are both air- and water-cooled systems and these can be designed for centrifugal, screw, scroll, and reciprocating compressors. Centrifugal compressors are used in the largest chillers and are generally the highest efficiency. Reciprocating compressors are often used in the smallest chillers and are commonly the lowest efficiency. Screw and scroll chillers are in the middle in terms of typical size and efficiency. While precise data are not available, it appears that most new chiller sales are variable speed (Mordor Intelligence 2025). In most of the country, state and local building codes specify minimum efficiency levels for the major types of chillers. Some efficiency improvements are possible within classes, but the bigger efficiency opportunities appear to be in choice of chiller type and system design. For example, Nugent (1993) discusses the large efficiency savings potentially available from looking at the entire system and not just the chiller; this includes running the chiller under distribution water temperatures and optimizing other system setpoints for the application and climate, which may mean different setpoints than those used in a laboratory testing.

Adding thermal or cool storage can also help to improve system efficiency and manage peak energy demands. DOE (2024) provides an introduction to these systems.

²⁹ According to EIA 2022, buildings over 100,000 sq. ft. of floor area account for 34% of cooling energy use of all commercial buildings. While not all of these buildings use chillers, many do.

Other system types

In addition to the three most common system types, other major equipment types have efficiency opportunities that are therefore worth discussing briefly.

Ductless mini-split heat pumps: These typically heat and cool individual rooms. Most units sold in the United States are variable speed and have high efficiency.

Variable refrigerant flow (VRF) heat pumps: These ductless systems typically serve multiple rooms in commercial and multifamily buildings. While there are some efficiency differences between systems, the big opportunities are in sizing and the quality of installation. Recent studies of installed VRF systems show that low energy performance compared with rated efficiencies was due to system oversizing, losses from long refrigerant lines, pressure drops at fittings, and continuous refrigerant flow even when there is no call for heating or cooling (Steven Winter Assoc. 2025; Taitem Engineering 2020).

Water source heat pumps: These systems can work well in buildings that need simultaneous heating and cooling because cooling in some zones can create opportunities for heat recovery to heat other zones. Good system design is important.

Ground source heat pumps: These are generally very efficient because ground temperatures are higher than air temperatures on cold days; the higher input temperatures make for higher efficiency, and this reduces both energy use and peak electric demand. However, these systems are generally more expensive than other types because they require vertical or horizontal heat exchange loops in the ground. While residential system economics can be challenging (Nadel and Fadali 2024), higher loads—such as in schools, medium-sized and large commercial buildings, and multihome residential development—can better cover the ground-loop costs (Petroy and Kolway 2024).

Packaged terminal air conditioners (PTACS) and heat pumps (PTHP): These through-the-wall systems are common in hotel rooms and some multifamily buildings. They are generally lower efficiency than other system types, and no units are yet designed for cold climates. The New York State Energy Research and Development Authority (NYSERDA) is currently sponsoring a project to cost-share development of cold climate PTHP systems (NYSERDA 2024).

Controls and commissioning

Good monitoring and control of HVAC systems can save substantial energy. Srivastava (2025) found building energy management systems provide energy savings of 10–25%. Data from the EIA Commercial Building Energy Consumption Survey indicate that approximately two-thirds of buildings with over 100,000 sq. ft. of floor area have such systems (EIA 2022). For buildings without these systems, installing them can be a good investment. For buildings that already have such systems, the best approach, with the most energy savings and buildings operation benefits, is continuous monitoring and commissioning. But if that is not possible, buildings should be periodically retrocommissioned. We discuss retrocommissioning programs in the commercial retrofit chapter because the savings extend beyond HVAC.

Fuel-fired equipment

The efficiency of natural gas, propane, and oil furnaces and boilers can be improved by moving to condensing systems and gas-fired heat pumps.³⁰ Condensing systems have large heat-exchange areas to recover heat from exhaust gases; they reduce their temperature below the boiling point of water and recover the heat released when that steam is condensed. For furnaces, a condensing unit will typically have an efficiency of about 95%. Starting December 18, 2028, federal efficiency standards will require new residential furnaces to have an efficiency of at least 95% and programs to promote condensing furnaces will no longer be needed. Even now, condensing furnaces account for roughly 60% of furnace sales nationwide, though that figure is higher in the north and lower in the south (DOE 2023). Some program administrators are no longer providing rebates for condensing furnaces because the market share is already high, and others because of concerns about the CO₂ emissions from these units. Many commercial buildings and a limited number of homes use boilers to provide space heating via hot water, and here condensing boilers are an option. In addition, some gas utilities are undertaking demonstration projects and providing rebates for gas-fired heat pumps, which have efficiencies of 120% or more. However, these units are expensive and other system types typically have lower life-cycle costs, except in very cold climates like in northern Canada (Nadel and Fadali 2024).

Examples of successful programs

This section discusses multiple types of programs that are being used to improve HVAC system efficiency.³¹ A summary of these program types and the examples we detail below is in table HVAC 2.

Table HVAC 2. Summary of program types and example

Program type	Brief description	Customers commonly targeted	Example programs
Midstream market	Incentives to distributors to reduce the cost to contractors and customers of improved efficiency equipment	Distributors and contractors for the benefit of end users	Focus on Energy for residential, Mass Save for RTUs
Residential heat pump market transformation	Address market barriers through training and support of trade allies, incentives, and policy support	Residential customers and their contractors	Efficiency Maine, Vermont and Pacific Northwest programs
Commercial RTU heat pump market transformation	Similar to the above but for RTUs	Commercial customers and their contractors	NEEA and META

³⁰ Efficiency improvements are limited for oil boilers, with maximum technologically feasible (max-tech) efficiency of about 88 (DOE 2022).

³¹ While HVAC is often also prominent in retrocommissioning programs and automated demand-response programs, those are discussed in the commercial retrofit chapter because they address other systems beyond HVAC.

Program type	Brief description	Customers commonly targeted	Example programs
Advanced RTU controls	Education, training, and incentives for retrofit controls that vary fan speed and activate economizer cycles	Commercial customers and their contractors	Energy Solutions (NY) and Center for Energy and Environment (MN)
Chillers	Incentives for improved efficiency equipment and system design	Building owners and system specifiers	Mass Save

Midstream market programs

Midstream programs provide incentives to equipment distributors for each qualifying unit they sell. Distributors can subtract the value of the rebate from the purchase price and then invoice the program administrator for the rebate plus a handling fee. This saves contractors and homeowners the hassle of applying for a rebate and tends to result in higher participation (EPA undated; NEEP 2025).

Focus on Energy residential program: A midstream program for residential equipment is operated by a contractor for Wisconsin's Focus, which covers most of the state. Focus includes furnaces, heat pumps, boilers, thermostats, and water heaters. It offered consumer rebates in 2023 and earlier, and switched to midstream incentives in 2024 to expand reach; by 2025, participation had matched annual participation under the prior consumer rebates, and they hope it will continue to grow. The midstream rebates have been particularly effective with furnaces and reached about 25% of furnace sales;³² there was lower participation for other products due to limited overall sales of heat pumps and boilers and the low energy savings credited for water heaters, which limits rebate amounts. The program manager notes that because distributors and contractors prefer continuity between program years, they try to make as few changes as possible. Any changes require an extensive education effort. Additionally, as distributors want to be paid quickly, they have been working to reduce approval and payment times. Keeping the incentive claim form as simple as possible helps (E. Kapadia, senior manager, Energy Solutions, pers. comm., March 2026).

Mass Save commercial program: The Mass Save partners hired a firm that specializes in midstream programs to run a commercial midstream program on behalf of all the Massachusetts utilities, with billing and reporting to individual utilities. The program enrolls distributors, provides training and marketing information to their staff, and reaches out to the contractors who buy from the distributors to educate them about the program and high-efficiency equipment. When a contractor buys an eligible high-efficiency model, the distributor reduces the purchase price by the amount of the utility rebate. The distributor then bills the program for the rebate plus a fee for the distributor. Program staff note that it is important to design programs and paperwork to fit into distributor processes as much as possible and to pay distributors quickly; they aim to pay within two weeks of receipt of invoice. After several years, the program was providing incentives for about 75% of RTU sales in Massachusetts.

³² Over 21,000 furnaces were incented in 2025. Wisconsin has about 1.87 million homes heated with gas furnaces (EIA 2023). Assuming a 21.5-year average equipment life (DOE 2023), annual sales are about 86,700. $21,500/86,700 = 24.8\%$ of annual sales. This calculation ignores modest levels of new home construction in the state.

In 2024 regulators limited the program to all-electric equipment and thus RTUs with built-in gas furnaces were no longer eligible. These “gas-pak” units are the majority of RTU sales in Massachusetts, and since then, the program’s market share has declined to about 25%. While some commercial heat pump sales are aided by supplemental rebates of \$2,000/ton provided directly by the utilities, the limited range of rooftop heat pump models and contractor comfort with gas-paks have combined to limit the heat pump market share (A. Gutkowski, associate director, Energy Solutions and R. Willingham, senior energy efficiency consultant, Eversource, pers. comm., March 2026).

Residential heat pump market transformation programs

Probably the most impactful heat pump programs in North America are in Maine, Vermont, and in or near the Pacific Northwest in Washington, Oregon, Idaho, and Montana. Despite the cold climate in these regions, heat pumps are 15–20% of annual space heating equipment sales. All have combined consumer incentives with ambitious programs to assist trade allies and supportive policies.

Maine: Trade-ally support in Maine includes a steady flow of online advertising and earned media; a searchable, online registry of heat pump installers; and extensive installer training programs, including scholarships for training programs at community colleges (Nadel 2024).

Maine’s efforts have been aided by a statewide goal established by the legislature to install 100,000 heat pumps by 2025; for context, Maine has about 615,000 households (Census 2026). This goal was exceeded in 2023, and the state set a new goal of 175,000 additional heat pumps by 2027. As of late 2025, 143,000 heat pumps had been installed under this new target (Nadel 2024; Tilton 2025). Efforts in Maine are also supported by special heat pump electric rates offered by the state’s two major electric utilities. Under these rates, homes with heat pumps pay a higher fixed monthly charge but are charged less per kWh during the winter (Yim and Subramanian 2023; Malinowski et al. 2025).

Vermont: In Vermont, heat pump sales are aided by a three-tier renewable portfolio standard. Tier 1 applies to renewable electricity generation procured by the state’s utilities, tier 2 assists customers with distributed generation systems such as photovoltaics, and tier 3 is a requirement for utilities to assist customers in reducing fossil-fuel use. Under tier 3, utilities must either procure additional renewable distributed generation eligible for tier 2 or acquire fossil-fuel savings from energy transformation projects that reduce fossil fuel consumed by a utility’s customers. Transformation projects include heat pumps, heat pump water heaters, electric vehicles and charging equipment, battery storage, and custom projects. For tier 3, the required amount of savings is 2% of a distribution utility’s annual retail sales in 2017, and that will increase by two-thirds of a percentage point each year until it reaches 12% in 2032. In 2023 about 65% of the tier 3 savings were from heat pumps (Vermont DPS 2026).

To assist distribution utilities in meeting tier 3 requirements, Efficiency Vermont, a statewide energy efficiency utility financed primarily through electric and natural gas rates, administers a midstream heat pump program that provides rebates to contractors on behalf of the electric distribution utilities. The utilities and Efficiency Vermont share the cost of incentives for heat pump installations. Efficiency Vermont also assists local contractors with training and technical assistance and helps administer supplemental incentives offered by some utilities (Efficiency Vermont 2023).

Northwest Energy Efficiency Alliance (NEEA): In the Northwest, NEEA has been a leader in heat pump deployment. The Northwest has a high proportion of electric resistance heat: about 32% in Oregon and 46% in Washington (EIA 2023). NEEA and local utilities have promoted ductless heat pumps to displace some of this electric resistance heat, with NEEA leading regional market transformation efforts and the utilities providing incentives. The effort has included extensive efforts to enlist and train local contractors and a variety of promotion and research activities (Driscoll and Diamond 2024). A 2022

study of market influences on heat pump adoption in the Northwest credited incentives, contractor recommendations, and consumer interest as the biggest drivers, while also noting the importance of contractor training, coordination of utility incentives, efforts to increase consumer and contractor awareness of heat pumps, and a desire for air-conditioning driven by hotter summers (Kirsznier, Hogan, and Pitt 2022). Because hydropower is dominant, the Northwest states have among the lowest electric rates in the United States (EIA 2026b), which improves heat pump economics.

In all three regions, heat pump incentives are relatively modest. They are \$1,000–2,000 per heat pump in Vermont, varying by size, and \$1,000 per outdoor unit in Maine (Efficiency Vermont 2025; EMT 2025). The emphasis is on market development and not incentives. In all three regions, sales are aided by rising temperatures and an increasing need for air-conditioning; except for Idaho, the majority of homes in these regions do not have air-conditioning (EIA 2023) and installing heat pumps provides both air-conditioning and heating. In all three regions, the initial program focus was on ductless mini-split units that typically heat a single room and lack controls that integrate with a home's main heating system. These units are easier to sell and install than whole-home systems, but analysis of heating bills in several states found that these units generally only serve a minority of space heating loads (EMT 2023). Thus, all three regions are now shifting their focus to whole-home heat pumps. When Maine shifted focus, the number of rebates declined at first but then recovered to previous levels by 2025 (EMT 2025). A recent evaluation for Efficiency Maine suggests how to minimize fossil-fuel use with whole-home heat pumps that retain a fossil-fuel backup (Jaskwicz 2026). In Maine and Vermont, most homes are heated with fuel oil or propane. As these fuels are expensive, the economics of electric heat pumps are often attractive to consumers (Nadel 2024).

California, Massachusetts, and New York also have extensive residential heat pump programs and they combine efforts to educate contractors with much higher incentives than the programs discussed above. Still, these larger states have been unable to match the market share achieved in the states discussed above. Nadel and Rosenow (2026) provide information on the California, Massachusetts, and New York programs and on heat pump programs in Europe.

Commercial rooftop unit market transformation

Several program operators are seeking to move current RTU programs to higher levels of performance using a market transformation approach. These efforts typically focus on rooftop heat pumps that have good heating performance.

NEEA: NEAA has an Advanced Performance RTU initiative that targets efficiency improvements not captured in the current test procedure. It targets low-leak dampers, cabinet insulation, and, in a second tier, either a condensing furnace or heat or energy recovery ventilators. They now list 7 models that meet tier 1 and 10 models that meet tier 2 (NEEA 2026).

Minnesota Efficient Technology Accelerator (META): META is running a Next Gen RTU program to promote rooftop heat pumps designed for the cold Minnesota climate. This includes dual fuel units with gas backup and units with energy recovery ventilators. The program works with manufacturers to increase product offerings, including by coordinating with the DOE HVAC Technology Challenge; it also helps to increase field tests and contractor training and education, and works with utilities to improve and align utility incentives. Since the program began in 2024, the number of qualifying product lines has increased from three to seven, and 20 sites are working on pilot installations (META 2026; L. Guenter, initiative manager, pers. comm., January 2026).

California Market Transformation Administrator: This program is also developing an advanced rooftop initiative that emphasizes variable speed supply fans (CalMTA 2026).

DOE HVAC Technology Challenge: This initiative is promoting air source heat pump RTUs with at least a 1.7 COP at 5°F and full heat output at that temperature (based on the equipment’s heating and cooling rating) (DOE 2024b). Multiple manufacturers are participating: Aeon, Carrier, Lennox, and Rheem have been certified as meeting the program’s requirements in laboratory tests and are now undergoing field tests. Commercialized products are expected in the next few years.

These initiatives all indicate that more advanced RTUs are likely to be available in the next few years and thus programs should consider how best to include them in their offerings. The Consortium for Energy Efficiency (CEE) is developing a new set of specifications for RTUs that might incorporate some of the high-efficiency levels and features discussed above. CEE is targeting publication in early 2027, with the new specification likely to take effect 18 months later (B. Jensen, senior program manager, Consortium for Energy Efficiency, April 2026).

Advanced rooftop unit control programs

The New York State Energy Research and Development Authority (NYSERDA) and Energy Solutions: NYSERDA has a history of funding innovative programs selected through an RFP process. One program selected this way was a project to promote and install advanced rooftop unit controls on single-speed rooftop systems. This program was implemented from 2015–2018 by consulting firm Energy Solutions and sought to demonstrate and validate the savings opportunity. Information on this program comes from the project final report (Energy Solutions 2019).

The program installed a specific type of control and variable speed drive that converted the supply fan from single-speed to variable speed operation. It included “Intelligent Controls 101” webinar training sessions for contractors, end users, and utility staff and “Contractor and Customer Engagement” webinars for the targeted contractor network on the specific control selected, its deployment, and benefits. The program also offered a \$2,400 incentive to contractors for each control installed to help cover the costs of the control and installation.

Over the course of the program, 186 controls were installed at 24 sites. Monitoring found 35% average electricity savings and 5% natural gas savings across these sites. Electricity savings included large fan energy savings and some cooling savings from operating in economizer mode. The controls were found to be particularly well suited to buildings with long operating hours, large capacity units, and sites with proportionately large HVAC loads and variable occupant loads like restaurants and retail. Overall, Energy Solutions estimates that the benefit-cost ratio from the customer perspective averaged 2.6.

Based on their program experience, Energy Solutions recommends that utilities incorporate advanced controls in their programs, either as a large pilot program or a regular program measure. Another key finding is that successful implementation of advanced controls requires a focus on workforce education and training.

Chiller programs

Many programs offer prescriptive incentives for chillers of various types if they exceed building code requirements by 5–10%. However, as noted above, much larger savings are often possible with careful system design, including consideration of how to best design for and stage multiple chillers.

Mass Save for Massachusetts' utilities: This program includes both prescriptive and custom incentives. The custom program is for systems over 1,000 tons of cooling capacity, for applications with more than one chiller, for industrial process applications, and for comprehensive retrofits and new construction where the system is being designed or redesigned (Mass Save 2026). From January 2019 to March 2026, the custom program accounted for 84% of the incentives and 86% of the energy savings of the overall chiller program (see figure HVAC 1). The custom projects reduce chiller system energy use by 5–25% relative to a new chiller system that just meets building code requirements (R. Willingham, senior energy efficiency consultant, Eversource, pers. comm., March 2026).

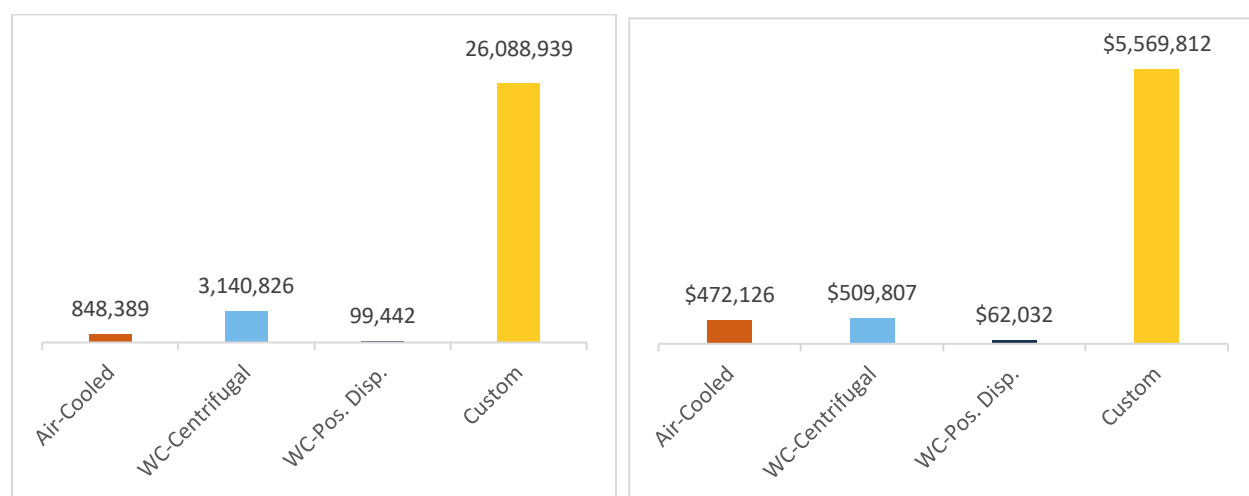


Figure HVAC 1. kWh savings (left) and incentive spending (right) for chiller projects in the Eversource Massachusetts service area from 2019 to March 2026. WC=water cooled. *Source:* Eversource.

Participation rates

Data on program participation as a percentage of annual sales are limited. For midstream programs, Focus on Energy achieved a 25% participation rate for residential furnaces. Mass Save achieved a 75% participation rate with a midstream program for RTUs including units with heat pumps and gas furnaces. They recently dropped units with gas furnaces from the program and participation declined to about 25%, despite hefty additional incentives for heat pumps. For our energy savings calculations for midstream commercial programs, we use 50% participation, a midpoint between these two figures. While heat pump participation is presently lower, we assume that it will steadily increase over the next 10 years. In the next section, based on these limited data, we make assumptions for potential participation rates in different types of programs. In general, we assume 25% for the residential midstream program (based on the Wisconsin furnace program), 50% for the commercial RTU and chiller programs (based on the midpoint of the two RTU participation rates), and 50% for fuel switching from high-cost energy sources such as electric resistance, fuel oil, and propane heat. For RTU controls, due to their low cost (about \$0.01 per kWh saved), we assume that 75% will participate over 10 years.

Energy savings and peak demand reduction

It is complicated to estimate HVAC savings because there are many different types of equipment and multiple program approaches. Based on the program descriptions above, we estimate savings separately for the residential and commercial sectors and separately for heating and cooling. We include the following programs:

Residential

1. Midstream heat pump incentives for ENERGY STAR units and more efficient variable speed units for cooling, and for standard ENERGY STAR units and ENERGY STAR cold climate units for heating.³³
2. Central heat pumps replace electric furnaces when the existing equipment needs to be replaced. Nadel, Amann and Chen (2024) examined such a program and found large savings and attractive economics.
3. Mini-split heat pumps replace electric resistance baseboard heat.
4. Central heat pumps replace oil and propane furnaces and boilers when the existing equipment needs to be replaced.³⁴

We did not include replacement of natural gas with heat pumps in this analysis because the economics of such a change vary from state to state, based on the relative prices of electricity and natural gas and on climatic differences (Malinowski et al. 2025). Such programs will make sense in some states, but not in others.

Commercial

1. More efficient RTUs reduce energy use by 10% relative to baseline units.
2. Advanced RTUs are expected to be available in the next few years, with additional energy savings of at least another 5%.
3. As part of the above two items, efficient heat pumps often displace electric resistance heat and some gas heat; this is due to the efficiency gains of heat pumps, particularly at moderate temperatures.³⁵
4. RTU controls vary the speed of the supply fan and often make better use of cool outdoor air through economizer cycles; these substitute cool outdoor air, when available, for compressor cooling.
5. More efficient chillers.

Our assumptions about the portion of heating and cooling energy use covered by each of these options, participation rates, and savings are summarized in table HVAC 3. These are generally based on the results of programs covered in the case studies above. At the bottom of each section, we indicate total potential energy savings as a percentage of baseline 2035 energy use for that sector and end use. For residential, the largest percentage savings are on the heating side, including replacing electric resistance heat with heat pumps and partially replacing fuel heating with heat pumps. For commercial, large percentage savings come from RTU controls and partial displacement of gas heating with heat pumps.

For programs promoting more efficient equipment when existing equipment needs replacement, we included a net to gross savings ratio of 0.82, based on the average for electricity-saving programs as reported by Kresowik et al. (2025). For controls and chillers, our savings estimates are based on

³³ For heating and cooling, for our calculations we divide estimated participation evenly between ENERGY STAR and more efficient units. For cooling, we include some variable speed units that are not designed for cold climates. Where a home has both a heat pump and a space heating system, we assume that the heat pump provides 67% of space heating (Guidehouse 2024), but with gas systems still in place to provide heat when temperatures are cold. Some states have restrictions on programs promoting heat pumps in homes using other fuels. As states with these restrictions periodically make changes, we do not explicitly account for this in our calculations and instead note that this could affect calculations in individual states. We handle displacing electric resistance, oil, and propane heat with the next few items.

³⁴ Ibid.

³⁵ Ibid.

evaluations of net savings. For fuel switching programs there is not much data on free-rider levels and we did not make any free-rider adjustments.

These options do not include demand response, which shift loads out of peak periods. We include one such program in the commercial retrofits chapter, but much more demand response is possible.

Based on the percentage savings for each sector and end use in table HVAC 3, along with baseline energy use from the Energy Information Administration's Annual Energy Outlook (EIA 2026a), we project total potential savings in 2035 in tables HVAC 4 (residential) and HVAC 5 (commercial). To avoid double counting, we exclude from these savings calculations the one-third of the 21% of customers who participate in the three residential retrofit programs addressed in this paper (one-third as an estimate of the percentage of retrofit projects that include new HVAC systems) and the estimated 5% of customers who participate in the small business program.³⁶ For electricity, we estimate potential 2035 savings of 13 TWh (billion kWh) in the residential sector and 39 TWh in the commercial sector. Thus, commercial savings are much greater than residential savings. We roughly estimate peak demand savings using data from Massachusetts and Texas. The largest peak demand savings are summer peak savings of nearly 34,000 MW in the commercial sector followed by over 11,000 MW of winter peak savings in the commercial sector. Residential peak demand savings are much lower, but are dominated by winter peak savings, which are over 9,000 MW (not counting the impact of fuel switching, which we discuss below).

We also estimate fuel savings, including natural gas from partial displacement with heat pumps and replacing oil and propane in the residential sector with heat pumps. Savings in 2035 are a little larger in the commercial sector, 353 trillion Btu, than in the residential sector, 271 trillion Btu; the residential savings are primarily from replacing oil and propane.

³⁶ These are customers who we estimate receive new HVAC systems through these programs. In the Minnesota CEE program, it is 1% of participants as noted in table HVAC 5, but we assume 5% as some programs may install more new HVAC systems.

Table HVAC 3. Weighted savings as a percentage of baseline energy use from improved HVAC equipment

Measure	Affected % of homes	% of equip. over 10 yrs	Participation		Weighted % savings			Notes
			rate over 10 yrs	% savings Electric				
					Gas and oil	Electric	Gas and oil	
Residential cooling								
Energy Star heat pump	76%	56%	10%	5%	0%	0.2%	0%	Per EIA 2023, 76% of homes with air-conditioning (AC) have central AC. Savings are based on Energy Star. We apply a net to gross savings ratio of 0.82 (Kresowik et al. 2025).
Variable speed heat pump (CEE tier 1)	76%	56%	15%	13%	0%	0.8%	0%	Same as above but savings are based on CEE tier 1. Participation is split between two levels.
Total						1.03%	0%	
Residential heating								
Energy Star HP	38%	56%	15%	3%	0%	0.1%	0%	Per EIA 2023, 38% of homes use electricity as the main source of heat use HPs. Savings based on Energy Star.
Cold climate HP	38%	56%	10%	6%	0%	0.1%	0%	Same as above but we use the Energy Star cold climate spec; split participation with line above

Participation								
	Affected	% of equip.	rate over	% savings	Weighted % savings			
Measure	% of homes	over 10 yrs	10 yrs	Electric	Gas and oil	Electric	Gas and oil	Notes
Partial heating with HP	43%	56%	15%	See text	67%	See text	2.4%	Include natural gas furnaces here; oil and propane are below. Partial heating fraction is from Guidehouse 2024.
HP to replace electric furnace	32%	56%	25%	50%	0%	2.2%	0%	Per EIA 2023, 32% of homes using electricity as main source of heat have an elec. furnace. Estimate seasonal COP of 2.
Mini-split HP to replace baseboard electric	18%	100%	50%	40%	0%	3.6%	0%	Per EIA 2023, 18% of homes using electricity as main source of heat have elec. baseboard. 100% potential replacement is mostly early replacement. Estimate seasonal COP of 2 and displacing 80% of baseboard heat.
HP to replace oil furnace	100%	47%	50%	See text	67%	See text	16%	21.5-yr. avg. Life; reduction in fuel use from Guidehouse 2024
HP to replace propane furnace	100%	47%	50%	See text	67%	See text	16%	Same as above
Total						6.1%	33.6%	
Commercial cooling	% of sq. ft.							

Participation								
	Affected	% of equip.	rate over	% savings	Weighted % savings			
Measure	% of homes	over 10 yrs	10 yrs	Electric	Gas and oil	Electric	Gas and oil	Notes
More efficient RTU	42%	48%	25%	8%	0%	0.4%	0%	As noted in text, ENERGY STAR is 18% beyond minimum std. We split this into two steps, 10% and 8%, then apply an 82% net to gross savings ratio and use 21-yr. avg. life.
Advanced RTU	42%	48%	25%	15%	0%	0.7%	0%	ENERGY STAR performance as explained in text but then apply 82% net to gross savings ratio
RTU controls	42%	75%	75%	35%	0%	8.3%	0%	Net savings from Energy Solutions 2019. They note that it is not worth installing controls on equipment nearing end-of-life.
More efficient chiller	16%	47%	50%	15%	0%	0.6%	0%	21.5-yr. avg. life; 15% savings is midpoint of range from Eversource program; includes both better equipment and improved system optimization
Total							10.0%	0%
Commercial heating								
Advanced RTU								

Measure	Participation				Weighted % savings			Notes
	Affected	% of equip.	rate over	% savings				
	% of homes	over 10 yrs	10 yrs	Electric	Gas and oil	Electric	Gas and oil	
RTU controls	42%	75%	75%	35%	5%		2%	Not worth installing on equipment nearing end of life. Wang et al. (2018) found similar electric savings for AC and HPs. Gas savings from Energy Solutions 2019 and apply to units with gas heating.
HP to replace electric resistance in RTUs.	44%	48%	50%	43%	0%	4.5%	0%	Per EIA 2022, about 44% of heating electricity use in in packaged systems. 50% of systems upgrading to HPs is an aggressive ACEEE estimate. Estimate seasonal COP of 1.75.
HP to provide partial heating, reducing gas use	32%	48%	50%	See text	67%	0%	21%	Remaining 76% of RTUs not covered in row above. 50% of systems upgrading to HPs is an aggressive ACEEE estimate. Use same gas savings as for residential partial heat.
Total						4.5%	23.5%	

Note: Participation rates are assumptions informed by case studies discussed above.

Table HVAC 4. Energy and peak demand savings from residential HVAC programs

(“x” designates multiplication)	Value	Units	Comments
	314	TWh	2035 residential electricity use for cooling (EIA 2026a)
x	1.03%		Savings by 2035 from table HVAC 3
x	93%		Does not include participants in residential retrofit programs that sometimes include some HVAC. Retrofit programs serve 21% of households per the residential retrofit chapters of this report. Of these retrofits, about 1/3 of participants install new heating and cooling equipment (e.g., Opinion Dynamics 2020).
=	3	TWh	Residential cooling savings in 2035 from improved AC
x	0.000354		Peak kW/annual kWh: average of data for Texas (Nadel, Amann, and Chen 2023) and Massachusetts (Guidehouse 2024)
=	1,066	MW	Summer peak demand savings
	158	TWh	2035 residential electricity use for heating (EIA 2026a)
x	6.1%		Savings by 2035 from table HVAC 3.
x	93%		Does not include participants in residential retrofit programs that sometimes include some HVAC. Retrofit programs serve 21% of households per the residential retrofit chapters of this report. Of these retrofits, about 1/3 of participants install new heating and cooling equipment (e.g., Opinion Dynamics 2020).
=	10	TWh	Residential electric heating savings in 2035
x	0.000981		Peak kw/annual kWh: Average of data for Texas (Nadel , Amann, and Chen 2024) and Massachusetts (Guidehouse 2024)
=	9,386	MW	Winter peak demand savings
	657	TBtu	2035 residential propane and fuel oil use for heating (EIA 2026a)
x	31.2%		Savings by 2035 from table HVAC 3
=	205	TBtu	Residential oil and propane heating savings in 2035
	2,730	TBtu	2035 residential natural gas use for heating (EIA 2026a)
x	2.4%		Savings by 2035 from table HVAC 3
=	66	TBtu	Residential natural gas heating savings in 2035

Table HVAC 5. Energy and peak demand savings from commercial HVAC programs

	Value	Units	Comments
	312	TWh	2035 commercial electricity used for cooling and cooling share of ventilation (EIA 2026a). As a rough approximation, we split ventilation evenly between heating and cooling.
x	10.0%		Savings by 2035 from table HVAC 3.
	99%		This does not include participants in small business program (77%) plus 22% who participate in small business program (from small business chapter) but do not receive new HVAC. For Minnesota CEE small business program, electric HPs installed for 1% of customers (CEE 2026). Other programs did not provide data, but to be more conservative we round up to 5%.
x			
=	31	TWh	Commercial cooling and ventilation savings in 2035
x	0.0011		Annual kWh to maximum kW (DNV 2024)
=	33,882	MW	Summer peak demand savings
	175	TWh	2035 commercial electricity use for heating and heating share of ventilation (EIA 2026a); as a rough approximation, we split ventilation evenly between heating and cooling
	96.5%		Same assumption as above
x			
x	4.5%		Savings by 2035 from table HVAC 3
=	8	TWh	Commercial electric heating and ventilation savings in 2035
x	0.0015		Annual kWh to maximum kW (DNV 2024)
=	11,353	MW	Winter peak demand savings
	1,501	TBtu	2035 commercial natural gas use for heating (EIA 2026a)
x	23.5%		Savings by 2035 from table HVAC 3
=	353	TBtu	Commercial gas heating savings in 2035

These savings do not include the impact of electrification on electricity use. If we take all of the electrification fuel savings from tables HVAC 4 and 5 and convert them to electricity use, and assume on average that a furnace with an 85% efficiency is replaced with a heat pump with a seasonal COP of 2.5, this partial electrification will increase 2035 electricity use by about 62 TWh and winter peak demand by roughly 77 GW. These heat pumps will save a substantial amount of energy because they are more efficient than the furnaces they replace, and they will increase electricity use by a little more than the HVAC 51 TWh of electricity savings we estimate from other aspects of the HVAC program.

Typical costs and cost of saved energy

For each of the major equipment and control options, we estimated costs and costs per kWh saved based on program results and other data in the literature. These are generally consumer costs and do not include utility administration costs and the costs of free riders who contribute to costs but do not provide additional energy savings. The figures we provide can be considered approximate averages, because there will be substantial variation around this midpoint. Results of this analysis are provided in table HVAC 6. In general, the commercial costs per kWh saved are \$0.03 per kWh saved or less based on consumer costs. If we assume net savings are 82% of total savings (average from Kresowik et al. 2025) and that marketing, administrative, and evaluation costs add 45% (from Opinion Dynamics and ACEEE 2026), then commercial program costs range from \$0.017–0.034 per kWh saved. For residential heat pumps, the costs are higher (consumer costs of about \$0.142 per kWh saved and total utility costs of about \$0.20 per kWh saved, including free-rider and administrative costs). This figure is based on the national average for space heating and cooling. Savings will be higher and costs per kWh saved lower in regions with above average heating and/or cooling energy use. In service territories where retail rates are below \$0.20 per kWh, programs may want to target households with above-average heating and cooling energy use.

Table HVAC 6. Costs, energy savings, and cost per kWh saved from HVAC measures

Program	Cost (\$)	kWh Saved	Life (yrs)	\$/kWh Saved	Notes
Energy Star residential HP	372	191	18	0.142	Costs and life from DOE 2016 adjust to 2025\$ using FRED 2026. Base use is from EIA 2023. Percentage saved from savings section but reduced by 18% to exclude savings from free riders (per average net to gross savings in Kresowik et al. 2025).
RTU controls	244	3,283	7	0.012	Net savings and costs come from CEE 2023, averaging 3 supply fan controls covered. ³⁷ Life comes from Energy Solutions 2019, which is based on remaining life of RTU.
Commercial midstream program for RTU+	387,104	1,063,342	21	0.024	Costs and savings come from Mass Save program; 26% added to costs to account for non-incentive direct expenses (estimate from Eversource). Life comes from DOE 2024c.
Chiller program	6,613,777	30,177,596	21.5	0.014	Costs and savings are from Eversource Massachusetts program. Life from ASHRAE 2019.

Notes: First row covers consumer costs (100% of installed costs) but not program costs. Last three rows cover program administrator direct program costs. None of these figures include overall program administration costs. A 3% real discount rate is assumed.

³⁷ We use CEE for costs and not Energy Solutions because CEE is a much more recent study.

The chart above does not include programs that switch some fuel use to electricity because analysis of such programs depends on both electric and fuel prices. As an indication of the economics of such programs, Efficiency Maine estimates that its 2024 heat pump program had a benefit-cost ratio of 1.3 from the Total Resource Cost (TRC) perspective, including all direct costs and benefits, regardless of whether the program administrator or customer pays these costs (EMT 2025).

Exemplary program design features

The following key features of successful programs emerge:

- *A key opportunity for savings is when existing equipment fails and must be replaced.* This includes opportunities to promote higher efficiency equipment and to install heat pumps when an existing central air-conditioning system must be replaced. Heat pumps provide heating energy savings because they are more efficient than electric resistance heat and fuel-fired furnaces.
- *Midstream incentives to distributors for high-efficiency equipment will result in higher participation and savings* than end-user programs, in general. Such programs should be as easy as possible for distributors, with simple forms and minimal data requirements. Prompt payment to distributors is also important.
- *Should midstream programs require distributors to pass on rebates to contractors?* Without such a requirement, distributors tend to profit and are therefore more likely to enroll. However, one program that does not require distributors to pass on the rebate has found some contractor dissatisfaction as a result. If they had to make the decision again, this program might require applying the rebate as a deduction on contractor invoices.
- *Adopt a market transformation perspective and identify and address market barriers.* Such barriers include the need to train contractors to be comfortable selling and installing high-efficiency heat pumps, as has happened in Maine, Vermont, and the Northwest.
- *Promote advanced RTUs by emphasizing a market transformation approach*, as NEEA and Minnesota are doing. Currently available RTUs often provide only modest energy savings. *For RTUs, controls that vary the speed of air-supply fans and harvest savings from economizer cycles can result in large energy savings.* The New York State program profiled above is a good example.
- *Efficiency opportunities in chiller system design need to be captured with custom programs* and not just incentives for higher efficiency equipment at standard rating conditions. This is illustrated by Eversource's experience.

Summary and recommendations

HVAC programs have among the largest energy savings of the programs analyzed in this report and some of the largest winter and summer peak electric savings. Big savings opportunities include displacing electric resistance heat with heat pumps, RTU controls, and partially displacing fuel heating with heat pumps, particularly at moderate temperatures. RTU controls can be a retrofit measure, but the other large savings opportunities are when existing equipment needs to be replaced. Just upgrading to slightly higher equipment efficiencies produces only modest energy savings. Programs need to emphasize training contractors and distributors to be comfortable selling and installing heat pumps and to look at programs from a long-term, market-transformation perspective.

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Lighting

Synopsis

With LED lighting now common, available savings are smaller than in the past. This chapter discusses several remaining lighting opportunities, including networked lighting controls in new fixtures and upgrading aging LEDs to more modern and efficient products.

Data summary

Available savings in 2035 from 2026–2035 programs:

39 billion kWh (TWh) of electricity (fifth of 13)

3,300 MW of summer peak demand reductions (11th of 13)

2,300 MW of winter peak demand reductions (12th of 13)

Cost per kWh saved: ~\$0.03 for luminaire level lighting controls

Introduction

Lighting measures dominated energy efficiency programs for many years due to their substantial energy savings and moderate cost. These programs emphasized lamps, ballasts, and lighting fixtures, but also sometimes included lighting controls. Recent years have seen enormous growth in the use of LED lighting. Controls have also gained market share, but not nearly as much. Below we discuss where the market is today regarding these two classes of lighting efficiency opportunities.

Technologies

Lamps and fixtures

The growth in LED lighting was driven by declining costs, large energy savings, and federal minimum efficiency standards that require efficiency levels for many product types that only LEDs can meet. Relative to fluorescent lamps, savings range from 18–44%, depending on the type of lamps being installed and replaced (Atherton 2023). Relative to incandescent lamps, LED lamps typically reduce energy use 75–90% (DOE undated). Relative to high-intensity discharge (HID) lamps, which are used in parking lots and other areas where high levels of light are needed over a large area, LEDs can reduce energy use 50–75% (Braun 2025).

In Massachusetts, which has been aggressively promoting LEDs and other efficient lighting options for many years, LEDs accounted for 73–80% of commercial building interior lighting in 2023 (DNV 2024). A national study that used contractor and program implementor interviews to develop a model estimated that in 2023, LEDs accounted for about 68% of sales, and projected that the share would reach 82% in 2026 and 88% in 2030 (DNV 2025). In the residential sector, in 2020, 47% of U.S. households reported that most or all of their lamps were LEDs (EIA 2022), and that percentage has almost certainly increased since then. These figures are in line with DOE projections from 2019, which showed LED market share continuing to increase steadily through 2035; this is illustrated in figure LTG 1.

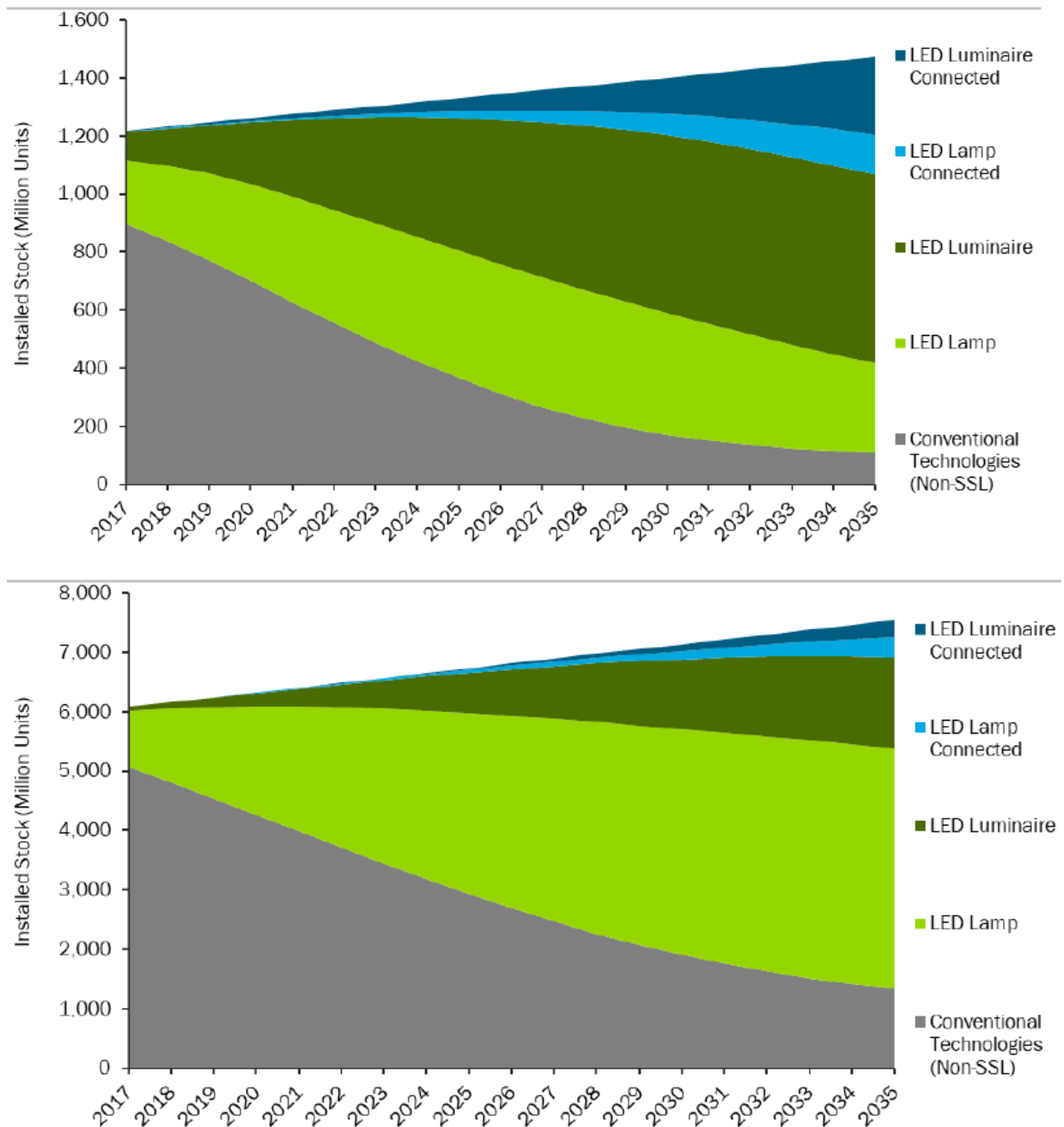


Figure LTG 1. DOE projections of LED saturation by year for the commercial sector (top) and residential sector (bottom). Source: DOE 2019.

From the recent sales numbers and projections we summarize, it appears that the market is steadily transforming without further energy efficiency program intervention. Opportunities to promote LED lamps and fixtures are greater in portions of the market that are transforming more slowly, such as small commercial facilities and low-income housing. For example, in Massachusetts, the saturation of LEDs was slightly higher in large buildings over 10,000 sq. ft. than small buildings of 10,000 sq. ft. or less in 2023 (DNV 2024). In the residential sector, EIA (2022) found that 55% of the highest income households primarily use LEDs, while for the lowest income groups, the figure was 39%. As a result,

some programs are still providing incentives for LED lighting in small commercial buildings and for low-income households, and these include free bulbs as part of home energy inspections or weatherization and efforts to improve stocking of LEDs in retail outlets that serve low-income customers. However, as saturation levels increase in these market segments, these efforts may be dropped.

Seifert (2025) noted that as LED systems installed a decade or more ago are replaced, there will be some additional energy savings because the current LED systems are more efficient than those a decade ago. The efficiency gain relative to 2015 ranges from 20% to more than 50%, depending on the product. For example, here is how the Design Lights Consortium (DLC) standard specification (not the premium specification) from v.3.1 (2015) compares with v.6.0 (2026) for a few common products:

- TLED replacement lamps: 100lpw to 130lpw (23% energy savings)
- Troffers: 85lpw to 120lpw (29% energy savings)
- High-bay fixtures: 80lpw to 135lpw (41% energy savings)

Much of these savings will naturally occur as old fixtures are replaced and will not need assistance from energy efficiency programs.

Lighting controls

Lighting controls include occupancy sensors and various types of dimming controls that adjust lighting levels in response to daylight availability, lamp light output over time, and user preferences. A 2023 Massachusetts study on commercial buildings found that 27% of customers reported having dimmer switches, 20% occupancy sensors, 11% daylight dimming systems, and 3% advanced/network controls (DNV 2024). These systems combine in multiple ways to reduce energy use, including light-level sensing, which adjusts the amount of light emitted by the lighting system as a function of the amount of daylight in a space as well as adjustments to light levels in response to user preferences. Many energy efficiency programs have emphasized these integrated network lighting controls in recent years.

A study for the Northwest Energy Efficiency Alliance (NEEA) examined 194 buildings with networked lighting controls, where sensors and controls are connected via Wi-Fi or Bluetooth, and found 49% average lighting energy use savings. Savings averaged 63% when controls are part of individual fixtures, and 35% when controls work with groups of fixtures (Wen et al. 2020). Many fixture manufacturers sell fixtures prewired with networked controls in individual fixtures. DLC certifies LED fixtures relative to a variety of safety and quality criteria, and this includes a program to certify fixtures with networked lighting controls. Many programs make DLC certification a requirement for rebates.

Examples of successful programs

Programs from Ameren Illinois, Commonwealth Edison, Energy Trust of Oregon, and Mass Save feature somewhat similar designs with up to three paths:

1. Midstream incentives paid to distributors
2. Downstream incentives paid to customers that do not go through a distributor program
3. A direct installation program for small commercial and industrial (C&I) customers

Some programs pay per fixture installed, with much higher incentives if the fixtures include networked lighting controls. Some programs pay incentives based on the difference in wattage between the old and new fixture, again with much higher incentives if the fixture includes networked lighting controls with a minimum number of implemented control strategies; such strategies include high-end trim, occupancy sensing, daylight sensing, and scheduling. This latter approach provides some incentive for replacing

first-generation LED fixtures with new, more efficient LEDs, since when combined with incentives per fixture for lighting controls, it can attract customer interest.

Ameren Illinois

Ameren offers \$0.50 per watt controlled for interior fixtures with networked lighting controls and \$1.50 per watt controlled for interior fixtures with luminaire level lighting controls (LLLC) that include sensors and controls on every fixture. There are also control incentives for exterior lighting fixtures. In 2025 Ameren had 496 applications for networked lighting controls and paid about \$4.1 million in incentives; estimated annual savings were about 9 GWh and summer peak reductions of about 17 MW. For the majority of participants, incentives and savings were from the direct installation program (N. Crowder, manager energy efficiency, Ameren Illinois, pers. comm., February 2026).

Ameren emphasizes the importance of training for lighting distributors and installers that educates them on the virtues of networked and luminaire level lighting controls. The company does this through a “LLLC University.” Originally this was a two-day course, but participants asked Ameren to streamline and it is now just six hours. The training includes discussion of procurement, code compliance, commissioning, and hands-on practice with programming controls. LLLC demo boards are used for installer training and customer education. Program staff note that installers are concerned about the cost of callbacks related to software controls commissioning. They find that installers prefer the LLLC controls because of the higher incentive and because the controls come preinstalled in some fixture types, which reduces both the work required and the chance for installation and operational problems.

Ameren Illinois is approaching advanced lighting controls as a market transformation program and plans to claim some savings from increases in market share once it can collect data to support the claim (N. Crowder, manager energy efficiency, Ameren Illinois, pers. comm., February 2026).

Energy Trust

The Energy Trust of Oregon program also illustrates direct installation. Energy Trust runs a commercial and industrial program with a specific direct installation lighting component that targets schools, local governments, and community centers. The program starts with a free facility assessment to determine which eligible measures could be used, and then contractors complete the direct installation of these measures. New fixtures with luminaire level controls are installed for free. Energy Trust is exploring whether these controls can also be used to control HVAC, which would increase energy savings (K. Hughes, senior program manager business programs, Energy Trust, pers. comm., February 2026). As Nock et al. (2024) documented in more than a dozen case studies of integrating lighting controls with HVAC, this could be a substantial source of energy savings in the future.

Commonwealth Edison

Across programs from different utilities, savings from lighting controls are rising but are still a minority of business lighting program savings. For example, in 2025, 77% of Commonwealth Edison’s lighting program savings were from lighting controls (R. Tonielli, senior energy efficiency program manager, ComEd, pers. comm., October 2026), up from 20% in 2023 (Calderson, Swaroop, and Tonielli 2025). Most of the program managers with whom we spoke expect this share to increase as controls become more popular and incentives for LED lighting continue to be scaled back. In general, savings from midstream programs are substantially greater than from downstream programs. Figure LTG 2 illustrates savings from controls in Commonwealth Edison’s midstream and downstream programs.

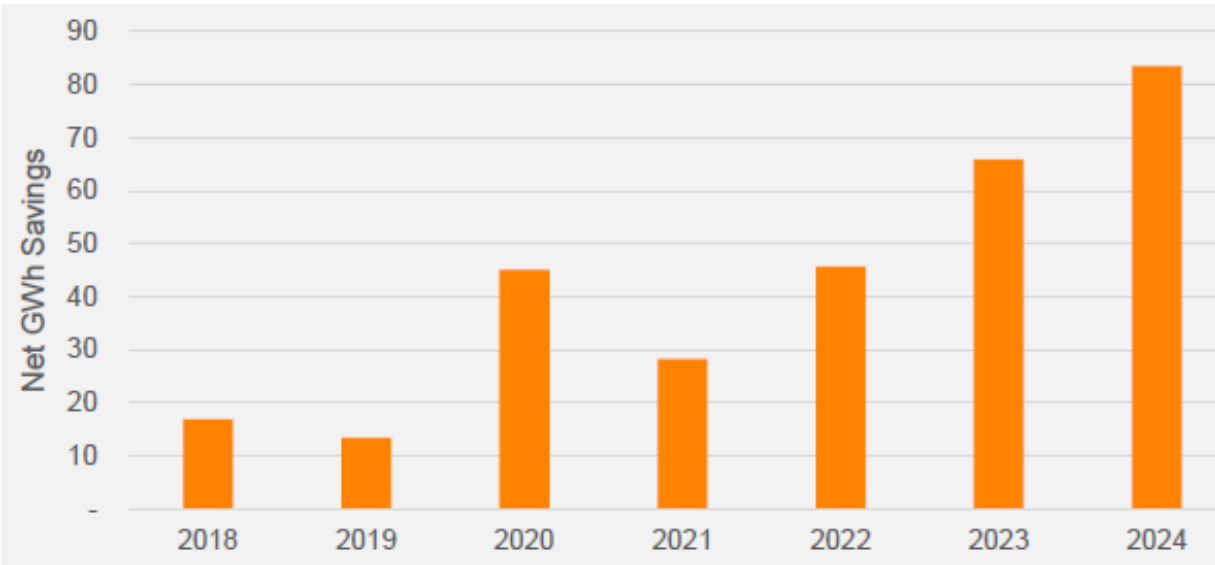


Figure LTG 2. Energy savings from lighting controls in Commonwealth Edison’s midstream and downstream programs. *Source:* Calderon, Swaroop, and Tonielli 2025.

Participation rates

A study prepared for Ameren Illinois estimated that about 1.5% of their business customers have installed luminaire level lighting controls as of 2024 (Opinion Dynamics 2024). As noted earlier, a 2023 Massachusetts study estimated a 3% market share for advanced lighting controls.

Energy savings and peak demand reduction

The 2025 Annual Energy Outlook published by the Energy Information Administration estimates that in 2035, U.S. commercial buildings will consume 153 TWh for lighting and residences will consume 102 TWh. The projections in figure LTG-1 estimate that by 2035, about 7% of commercial lighting will not be LED and about 18% of residential lighting will not be LED. Many of these remaining non-LED lights will have low hours of use, so we only include half the remaining lamps in our calculations. Based on the discussion in the above section on lamps and fixtures, we assume 25% average energy use reductions for commercial and 50% for residential; this assumes half are incandescent and can save 75% and half are fluorescent and can save 25%. We also make adjustments to eliminate overlap with other program savings.³⁸ Converting the higher use half of the remaining non-LED lighting to LED would then reduce commercial lighting energy use by about 1 TWh and reduce residential lighting energy use by about 7 TWh. Our calculations are shown in table LTG 1. These figures are highly approximate. We do not attempt to estimate peak savings, as these remaining non-LEDs will have, on average, lower hours of operation and may not be in use during peak periods.

Table LTG 1. Available potential energy savings from converting non-LED lighting in 2035 to LED

³⁸ Specifically, we exclude from the savings calculations the 23% of business customers that we estimate participate in the small business program and the 21% of residential households that we estimate participate in the low-income, single-family, and multifamily retrofit programs.

("x" designates multiplication)	Value	Units	Comments
	143	TWh	2035 commercial electricity use for lighting (EIA 2026)
x	9%		Percentage of total baseline energy use from non-LEDs based on 7% of the 2035 stock being non-LEDs (per figure LTG-1) and non-LEDs using 33% more energy on average as LEDs, as discussed in text
x	25%		Average savings as discussed in text
x	50%		Converted; remaining applications will be low use or highly resistant to change
x	77%		Do not participate in the small business program, which includes lighting retrofits
=	1.3	TWh	Commercial lighting savings from converting all remaining non-LED lights
	55	TWh	2035 residential electricity use for lighting (EIA 2026a)
x	31%		Percentage of total baseline energy use from non-LEDs based on 18% of the 2035 stock being non-LEDs (per figure LTG-1) and non-LEDs using twice as much energy on average as LEDs, as discussed in text
x	50%		Average savings as discussed in text
x	79%		Do not participate in residential retrofit programs, which often include some lighting
=	7	TWh	Residential lighting savings from converting non-LED lights

For upgrades of aging LED lighting systems, a moderate amount of savings is available, as shown in table LTG 2. Savings are about 5 TWh. DNV (2025) suggests moderate midstream incentives, such as for lighting distributors to encourage purchasers to buy the best products.

Table LTG 2. Available potential energy savings from upgrading aging LED lighting to improved products

("x" designates multiplication)	Value	Units	Comments
	143	TWh	2035 commercial electricity use for lighting (EIA 2026)
x	25%		Proportion that needs replacement by 2035; an ACEEE estimate of aging LED systems based on the data in figure LTG-1
x	30%		Average energy savings; the average of examples discussed in text
x	50%		Estimated participation rate in 2035; an ACEEE estimate, similar to what we estimate for controls below
=	5	TWh	Annual energy savings

("x" designates multiplication)	Value	Units	Comments
x	106.7		Ratio of summer peak savings (MW) to annual savings (TWh) for commercial lighting systems; derived from Mass Save 2024
=	574	MW	Summer peak savings
x	73.3		Ratio of winter peak savings (MW) to annual savings (TWh) for commercial lighting systems; derived from Mass Save 2024
=	394	MW	Winter peak savings

For controls, national impacts are approximated in table LTG 3. We estimate potential savings of 26 TWh of electricity in 2035, with summer peak savings of nearly 3,000 MW and winter peak savings of nearly 2,000 MW. Only some of the lights will be on at peak times and the controls will turn off only some of them at these times.

Table LTG 3. Electricity savings and electric peak load reductions in 2035 from networked lighting controls in the commercial sector

("x" designates multiplication)	Value	Units	Comments
	143	TWh	2035 commercial electricity use for lighting (EIA 2026)
x	75%		Proportion that can use networked lighting controls; an ACEEE estimate
x	49%		Average energy savings (Wen et al. 2020)
x	50%		Estimated participation rate in 2035; an ACEEE estimate based on a Massachusetts survey of commercial customers
=	26	TWh	Annual energy savings
x	106.7		Ratio of summer peak savings (MW) to annual savings (TWh) for commercial lighting controls; derived from Mass Save 2024
=	2,811	MW	Summer peak savings
x	73.3		Ratio of winter peak savings (MW) to annual savings (TWh) for commercial lighting controls; derived from Mass Save 2024
=	1,932	MW	Winter peak savings

Typical costs and cost of saved energy

This section considers only lighting controls. LED lighting is highly cost effective (e.g., Reliant 2025) and the big question is the ratio of net savings to gross savings, since the number of *free riders* (customers who participate in a program but would have taken action without it) will be high.

A 2023 study prepared for the Northwest Energy Efficiency Alliance (NEEA) estimated an average cost of \$43-60 per fixture for luminaire level lighting controls, with the smartest controls at the upper end of

the range and more basic controls at the lower end. NEEA reports that in the time since a similar study was conducted two years earlier, costs came down an average of 33% for the smartest controls and 12% for the less sophisticated controls (Buck, Hannigan, and Wen 2023). NEEA plans to conduct a new study in 2026, but from the anecdotal information received, are expecting similar costs in 2026 to those in the 2023 study, with continued improvements in controls and sales quantities approximately offsetting inflation (C. Wolgamott, product manager, NEEA, pers. comm., January 2026).

The cost of saved energy for luminaire level lighting controls is about \$0.04 per kWh saved. This assumes a \$60 incremental cost per fixture, the upper end of the range above; 49% energy savings, also discussed above; a 40-W fixture—office fixtures may be a little less, and warehouse and other high bay fixtures more; 5,000 operating hours per year, per Wen et al. (2020); and a 20-year lifetime and 3% real discount rate. Adding 45% for program planning, marketing, implementation, and evaluation (Opinion Dynamics and ACEEE 2026) raises the cost of saved energy to about \$0.06 per kWh saved.

Exemplary program design and marketing features

From these case studies and a variety of other sources (e.g., Nock et al. 2024), we note the following key features of programs for advanced lighting controls and other measures:

- *Approach the popularization of advanced lighting controls as a market-transformation initiative* by understanding and addressing issues such as distributor and installer concerns about how to sell and install the controls and market their benefits. Training distributors and contractors, as Ameren has done, will be critical.
- *Luminaire level controls have higher savings and are easier to install.* While they are more expensive than networked lighting controls, the benefits are generally greater than the costs; they have a cost of saved energy of about \$0.02/kWh, and the price difference between network and luminaire level controls is likely to keep declining. These controls can also be a low-risk point of entry to lighting controls because they come preinstalled; however, they must still be set up.
- *Midstream incentives to distributors can result in substantial savings.*
- *Downstream consumer incentives can provide additional savings,* but if both midstream and downstream incentives are offered, applications need to be carefully screened to prevent double-dipping incentives for the same installation.
- *Significant incentives are needed to encourage distributors and installers to promote advanced lighting controls.* Energy Trust decided to increase many control incentives in February 2026. As an example, the per-fixture incentive for interior fixtures with integrated controls was increased from \$50 to \$90 for fixtures using 40–90 W of power (Energy Trust 2025).
- *Some energy can still be saved in converting non-LED fixtures to LEDs,* but at some point continuing incentives for uncontrolled LEDs will no longer be worthwhile. Massachusetts utilities have stopped offering incentives for uncontrolled fixtures, but those utilities and many other programs still offer incentives for controlled fixtures; these incentives are primarily based on the controls, but they include a little credit for upgrading from non-LEDs. Several of the programs we talked with indicated that they are heavily marketing LED incentives in 2026 and LED-only incentives (i.e., without controls) will likely sunset at the end of the year. Several other programs said they hope to continue LED-only incentives in 2027 and perhaps beyond.

Summary and recommendations

Lighting measures have been a cornerstone of energy efficiency programs since the 1980s. In recent years, LED lighting has grown dramatically in market share, driven by efficiency programs and policies such as building codes and equipment efficiency standards. Today, approximately half of residential lighting and roughly 80% of commercial lighting uses LEDs. In this environment, the largest lighting energy saver is advanced lighting controls, particularly controls that are built into individual commercial lighting fixtures; these are often called luminaire level lighting controls. Such controls can reduce lighting energy use by 50% or more and have an average cost on the order of \$0.02 per kWh saved. Programs can approach use of these controls as a market-transformation initiative and combine training for distributors and installers with incentives for fixtures with these controls. Midstream incentives provided to distributors have been particularly effective. Some savings remain from converting the remaining non-LEDs to LEDs, but given high market shares for LEDs, free-rider levels will often be substantial. A few programs have already ended LED incentives and many others plan to phase out these incentives in the next few years. Another opportunity is to work with distributors to promote the highest efficiency LEDs when aging LEDs need to be replaced.

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New construction

Synopsis

Building new homes, apartments, and commercial buildings for high efficiency is easier and less expensive than building inefficiently and retrofitting the buildings later. This chapter discusses residential and commercial new construction programs and opportunities for utilities to assist with updates to building codes and receive credit for a portion of the energy savings achieved.

Data summary

Available savings in 2035 from 2026–2035 programs:

36 billion kWh (TWh) of electricity (sixth of 13)

94 trillion Btu of fuels (fourth of 13)

9,500 MW of summer peak demand reductions (sixth of 13)

2,300 MW of winter peak demand reductions (11th of 13)

Cost per kWh saved: ~\$0.07 for residential, \$0.027–0.086 for commercial

Introduction

Nearly 1.5 million homes were built in the United States in 2024 and 2025 (Census 2026). If this rate of construction continues, about 15 million new homes will be built by 2035, and these will be about 10% of the projected housing stock that year (EIA 2025a). EIA also projects that 32 billion sq. ft. of commercial floor area will be added between 2026 and 2035, which is about 27% of the projected 2035 commercial building floor area (EIA 2025a).

In most of the United States, state and local building energy codes specify minimum efficiency requirements for new buildings. These codes have steadily increased in stringency (see figure NC 1) and thus new buildings are generally more energy efficient than old buildings. While enforcement of these codes is uneven, as some buildings exceed the codes and some fall short, on average these efficiency requirements are likely to be met.

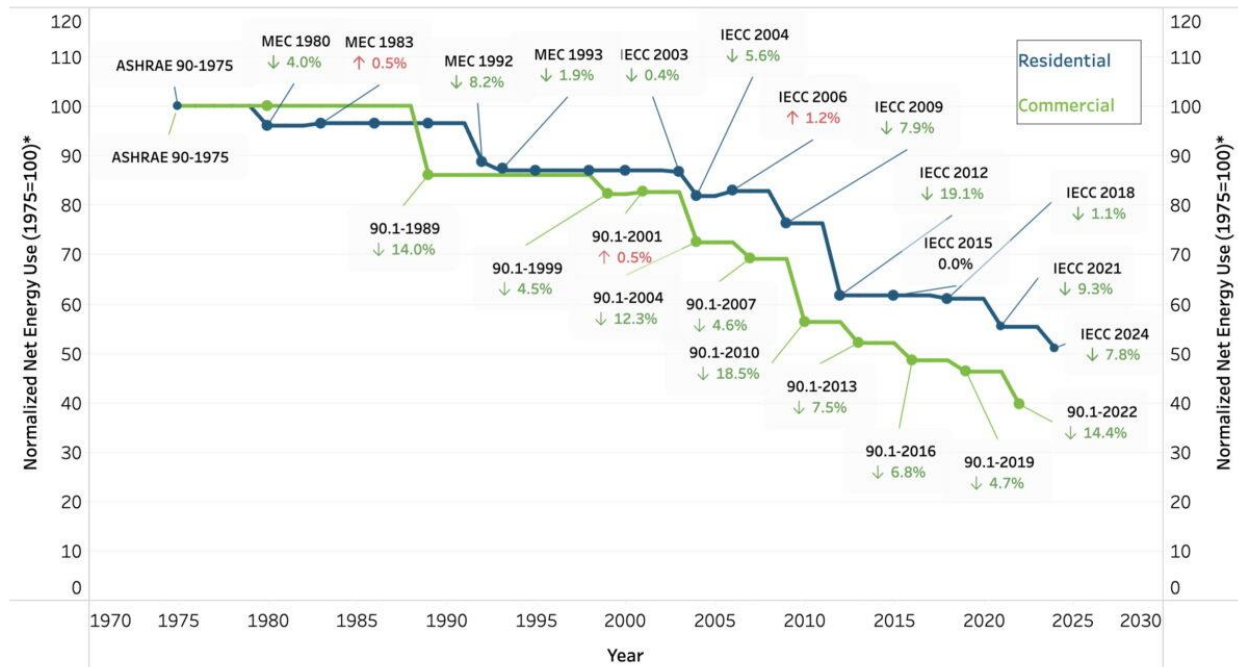


Figure NC 1. Average energy use of buildings just meeting model energy codes for residential and commercial buildings. Model codes in 1975 are calibrated to 100 on the y-axis, with newer codes gradually reducing energy use on average. *Source:* DOE 2025a.

Even with these codes in place, many program implementers offer new construction programs that further improve new home and commercial building energy efficiency.

New construction specifications and technologies

Residential

For new homes and apartments, programs commonly choose two or three tiers of specifications, and these are discussed here in order of increasing efficiency. Meeting these standards generally requires higher levels of insulation, improved windows, and tighter air and duct sealing; additionally, more efficient heating, cooling, and water heating equipment are often installed. The highest tier typically includes onsite solar.

ENERGY STAR: The ENERGY STAR new homes specification lists a variety of efficiency measures that exceed model building code requirements to reduce annual energy use by about 10–15% relative to the 2024 International Energy Conservation Code (IECC). There are separate specifications for single-family and multifamily buildings (Energy Star 2025).

DOE Efficient New Homes (ENH): Previously called Zero Energy Ready Homes, this specification requires ENERGY STAR certification and additional insulation, window, and equipment efficiency requirements. There are also water efficiency and indoor air quality provisions, and requirements that homes be ready for solar, electric vehicles, and heat pumps, meaning that wires and other provisions are installed during

new home construction to make it easy to retrofit these systems in the future (DOE 2025b). This specification reduces energy use about 20% beyond the 2024 IECC.³⁹

Passive House: This specification was originally developed in Europe for tight and high-efficiency construction, but has been adapted to U.S. homes and construction practices. It reduces energy use roughly 30% beyond the 2024 IECC.⁴⁰

Near-Zero: This is another tier used in some programs that commonly requires high efficiency, in other words, one of the other specifications, and solar photovoltaic systems that provide much of a home's energy use. For example, the highest tier of the Connecticut Residential New Construction Program specifies a Home Energy Rating System (HERS) index of 15 (Energize Connecticut 2026).

Commercial

Commercial new construction programs commonly have two tiers, a basic tier that achieves 10–20% energy savings relative to current state and local energy codes, and a high-efficiency tier that achieves 25–30% energy savings (sometimes even more) relative to current codes. Achieving these savings requires carefully designing how to integrate high-efficiency equipment and components.

Examples of successful programs

This section discusses examples of new construction programs that promote various levels of energy efficiency to save energy and, in some cases, promote electrification as a decarbonization strategy. The next section discusses some efforts for which utilities have received credit for advancing building energy code changes. Effective programs can help increase builder understanding of high-efficiency construction practices, increase the market share of higher efficiency building, and potentially inform future building code updates.

Mass Save (residential and commercial)

In Massachusetts, all investor-owned utilities work together under the Mass Save® brand to develop and deliver a common set of residential and commercial programs. These programs are centered on market transformation and developed to work in tandem with energy codes. The goal is not to just reach individual projects, but to elevate the experience of the entire design/build community so that over time, regulators can incorporate energy efficiency, zero/low carbon, electric vehicle (EV) ready, solar ready, and grid interactive measures into the state's base codes/policies and require them for everyone (K. Cullinane, manager new construction energy efficiency, Eversource, pers. comm., August 2026).

For residential single-family and low-rise multifamily new construction, there are presently three tiers, all of which require the services of RESNET™ credentialed Home Energy Rating Systems (HERS) raters.⁴¹ Multifamily high-rise projects similarly utilize a three-tiered structure; however, these projects often utilize the services of a building energy modeling professional to assess whole building energy

³⁹ Percentage savings based on Home Energy Rating System (HERS scores)—typically about 55 for the 2024 IECC and 45 for ENH. The HERS system compares a home to the minimum requirements of the 2006 IECC code. Thus, a score of 45 means the home uses 55% less energy than a home built to the 2006 IECC.

⁴⁰ Percentage savings based on Home Energy Rating System (HERS scores)—typically about 55 for the 2024 IECC and 38 for Passive House.

⁴¹ RESNET, the Residential Energy Services Network, establishes standards for homes, systems, and energy professionals.

performance. Since July 2024, only all-electric⁴² homes are eligible for the Mass Save Residential New Construction Program, in line with the state’s decarbonization objectives. There is a Base tier for homes with energy performance that exceeds the base energy code by 15%, an ENERGY STAR tier,⁴³ and a Passive House tier. The ENERGY STAR tier requires participation in the ENERGY STAR NextGen program, which includes electric ready requirements, or the ENERGY STAR Multifamily High Rise program—and in either case requires 30% energy savings relative to the base code or a HERS score of 45 or less. Incentives per home vary by tier and the number of dwellings in the home. For single-family homes, incentives per home start at \$7,500 for the base tier and go up to \$25,000 for Passive House dwelling units. There are also several “add-on” incentives for additional efficiency measures such as Wi-Fi thermostats, heat pump water heaters, and more that can be layered on to these base incentives (Mass Save 2026a). These incentives, along with new electric rates for dwelling units with heat pumps, are designed to help overcome production-builder hesitancy to use electric heat, which is driven in part by the high cost of electricity in the state.

In 2025, 4,750 dwelling units were completed through the Mass Save initiative; 76% were in the base tier, 1% were tier 2 ENERGY STAR, and 23% were at the Passive House tier level (N. Jones, senior energy efficiency consultant, Eversource, pers. comm., February 2026). To put this in perspective, about 18,600 new homes are built annually in the state and thus Mass Save 2025 participants are just over 25% of this annualized number.⁴⁴

Mass Save launched a supplementary program to promote multifamily new construction meeting Passive House standards in July 2019. This effort began with training for builders in Passive House design and construction techniques, and it helps pay for a project feasibility study of up to \$5,000 and for 75% of the cost of Passive House energy modeling, up to \$20,000. Certification incentives are also available for meeting Passive House standards. Precertification incentives are offered at \$750 per unit with an additional \$3,000 per unit available upon completion of construction and final certification. According to program staff, the feasibility studies have been helpful: Builders appreciate knowing up front the per-unit incentive, and program leaders have found it possible to exceed the Passive House standards. As of February 2026, more than 250 Passive House feasibility studies have been completed and 49 buildings with more than 2,300 units have been certified. An additional 30,000 dwelling units are on track for Passive House certification over the next five to six years (N. Jones, senior energy efficiency consultant, Eversource, pers. comm., February 2026).

The Mass Save program has also made substantial progress toward its market transformation goals. As of August 2026, 302 of the 351 municipalities in Massachusetts have adopted stretch codes voluntarily. The rate of stretch code adoption would arguably not be nearly so high without Mass Save’s long-standing technical and financial commitment to new construction initiatives and the intentional effort to grow the workforce, including help with code implementation. For example, Mass Save offers code trainings for municipal building departments and funds technical trainings for the design community to help meet stretch code requirements (E. Richer, supervisor, energy efficiency, New Construction &

⁴² There is one exception to these all-electric requirements, for multifamily domestic hot-water systems, where gas equipment is still allowed given the constraints of current electric domestic hot-water technologies. While labeled ENERGY STAR, the savings requirements are similar to DOE’s Efficient New Homes specification.

⁴³ The ENERGY STAR specification often results in 10–15% energy savings, but for the Massachusetts residential new construction program, 30% savings is required.

⁴⁴ There were 97,656 units completed in the state in the 5.25-year period ending July 2025 (Boston Foundation 2025), and that equates to an annual average of 18,600.

Major Renovations, Eversource, pers. comm., August 2026). Massachusetts has gone from one HERS rater in 2007 to dozens today who are the foundation of both the Mass Save program and Massachusetts' stretch codes (K. Cullinane, manager new construction energy efficiency, Eversource, pers. comm., August 2026).

The Mass Save Sponsors relaunched the commercial and industrial (C&I) New Construction Program in 2020 with several pathways, including a new net-zero-energy/low energy-use-intensity (EUI) pathway (Path 1) that assists with net-zero and zero-energy-ready buildings. This program targets EUIs of 22–40 or less, depending on building type. Buildings of 10,000 sq. ft. or more of conditioned space are eligible. The program's 2026 incentives are either \$2.25 or \$2.75 per sq. ft. of floor area, depending on the tier, with a portion paid out at the end of construction and the rest paid out at the end of a mandatory monitoring period if the building's operating EUI, adjusted for weather, meets its target. The program also includes a heat pump adder of \$800 per ton for air source heat pumps, \$1,200 per ton for variable refrigerant flow (VRF) systems, and up to \$3,600 per ton for ground source systems.⁴⁵ In addition, it requires predictive energy modeling and offers early technical assistance at multiple design milestones and incentives for verification contractors to help assess building performance 2, 6, and 12 months into building operation and correct operational issues to ensure performance to target EUIs. The concept is comprehensive assistance from design all the way into operation: communicating with and educating everyone including owners, designers, contractors, and facilities managers, and giving them all some stake in the outcome and rewards (E. Richer, supervisor, Energy Efficiency, New Construction & Major Renovations, Eversource, pers. comm., August 2026) .

As of January 2026, 84 projects had enrolled in Path 1, and they represented over 9.6 million sq. ft. of building floor area. More than 6.6 million sq. ft. were in K–12 schools. A key for this program is reaching design teams as projects begin and ensuring they set energy-performance targets early in the design process. Starting January 1, 2025, new buildings must be all-electric to be eligible for participation in any Mass Save initiative; there are very limited exceptions for hospitals with hot-water considerations for health and laboratories with high ventilation rates.

Several projects initiated in 2020 are either in or have recently completed their post construction monitoring periods, and Mass Save Sponsors are seeing great value in holding projects accountable to their predicted EUIs. The program's required EUI monitoring and resulting corrective action has reduced initial operating EUIs substantially and saved hundreds of thousands of dollars in customer utility bills for the first few participating projects (K. Cullinane, manager new construction energy efficiency, Eversource, pers. comm., February 2026). Richer et al. (2026) discuss the post-construction monitoring and its impact in more detail. The program continues to evolve. For example, Mass Save is preparing to launch a new Grid-Interactive Efficient Buildings (GEB) offer in their C&I new construction program that will provide technical support to design teams for integrating load shedding and shifting and overall demand management strategies into the design phase considerations and plans.

Programs in Connecticut, Rhode Island, and Vermont are similar to the Massachusetts program (Nadel 2024).

⁴⁵ For this program, heat pump incentives are based on heating “tonnage” such that one ton is equal to 12,000 Btu per hour.

Energy Trust of Oregon (commercial)

Energy Trust of Oregon's Path to Net Zero is probably the most advanced of the commercial programs, having completed 73 projects with a total of 5.3 million sq. ft. The program began with an eight-building pilot in 2009, which found that focusing on the early stages of design leads to more net-zero buildings. Lessons from this pilot were incorporated into a full-scale Path to Net Zero relaunch in late 2014. Since 2020, buildings must target 80% energy use reductions relative to the average existing building in Oregon of its type; this target comes from the Architecture 2030 initiative.⁴⁶

According to Energy Trust, the program's design strategy has two key elements: (1) early target setting, to position building owners and teams to set and achieve net-zero goals, and (2) "build a community around net zero," to support broad market adoption. Energy Trust finds that the greatest opportunity to identify and influence deep savings is preschematic design, and the program supports shoebox modeling with simple models, often with only one zone; EUI targeting; and energy-related studies that inform final energy modeling and savings calculations such as daylighting studies and computational fluid-dynamic modeling of natural ventilation. About halfway through the preparation of construction documents, the program conducts a project review and makes final recommendations to keep projects on track to achieve their original savings target.

The program also provides free training that is critical to developing net-zero experts in the local market and building a community around net-zero design. The program offers Continuing Education Units (CEUs) to design professionals that highlight the latest net-zero technologies and strategies. This work has grown in recent years as the program increases its focus on helping design teams make cost-informed decisions.

Currently, the program offers early design assistance that includes a project kickoff meeting, up to \$6,500 for a design charrette, and construction document review; technical assistance equal to 60% of the cost to conduct energy studies such as shoebox modeling, computational fluid-dynamics analysis, daylighting studies, energy modeling, and commissioning design review, up to \$40,000; installation incentives of \$0.40 per first-year estimated kWh savings and \$1.20 per therm; solar-ready incentives up to \$2,000 to determine solar potential, up to \$10,000 for a solar system, and up to \$9,000 for battery storage; assistance with energy metering up to 50% of the cost up to \$20,000; and \$2,000 for net-zero certification by the International Living Future Institute (Energy Trust 2026). Energy savings of 80% of average existing building EUI are required for participation. For multifamily, the program's Market Solutions offer has modeled and precalculated packages of measures that use a whole building approach, with incentives paid per sq. ft. based on "good," "better," or "best" packages for efficiency.

Energy Trust estimated that a few years ago, about three-quarters of eligible commercial new construction projects were participating in the Path to Net Zero program and a companion program for less ambitious building upgrades (S. Carlton, senior program manager, Energy Trust of Oregon, pers. comm., March 2026).

Architecture 2030 tightened its savings target in 2025 to 90% energy savings relative to the average existing building of its type, and Energy Trust is finding this very challenging. The program is reviewing possible changes and developing offers that incorporate new grid-interactive components to efficient buildings (S. Carlton, senior program manager, Energy Trust of Oregon, pers. comm., March 2026).

⁴⁶ www.architecture2030.org/2030_challenges/2030-challenge/.

The New York State Energy Research and Development Authority (NYSERDA)

NYSERDA has offered the Buildings of Excellence competition for carbon-neutral multifamily buildings since 2019 and provides two funding opportunities: Early Design Support (EDS) and the Competition. By offering funding for both early exploration and later design phases, the program effectively supports projects across soft and hard cost investments. EDS ensures that carbon-neutral solutions are integrated into project designs from the start, when design choices are most impactful. The EDS funding helps designers to try new design solutions and tools, integrate new systems and third-party standards, identify innovative materials and products, and work with specialized consultants and publicly share key findings.

The Competition has gone through five rounds and distributed \$83 million to 74 projects that received up to \$1.5 million each to support design and construction. These projects will deliver over 9,600 housing units, the majority serving low- to moderate-income households. An ongoing cost analysis of winning projects from the first three rounds found that most projects were designed using Passive House principles. NYSERDA anticipates achieving energy savings of 30% or more on average, with many projects achieving far greater net purchased energy reductions through the use of renewable generation. The analysis also found that incremental costs without incentives ranged from less than 1% to just over 10%, depending on building type; with incentives, the average incremental costs ranged from 0% to 5% (NYSERDA 2025, 2023; IEI 2023; I. Wechsler, director of neighborhood-scale transformation, NYSERDA, pers. comm., February 2026).

Energy savings credits

Garfunkel and Waite (2024) identified 14 states plus the District of Columbia that allow program administrators to claim energy savings credit for building codes. Many of these states also give credit for appliance efficiency standards, and they found five additional states that are considering such credits. These states are illustrated in figure NC 2.

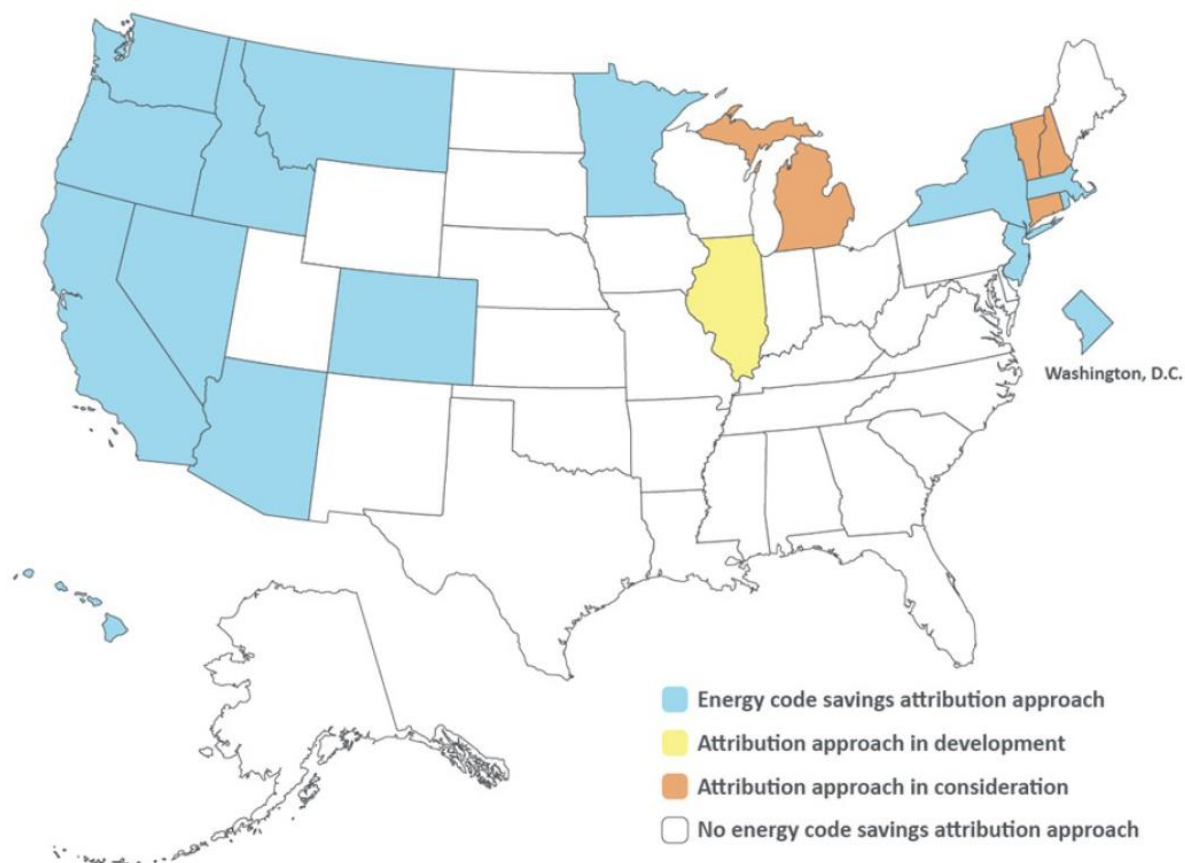


Figure NC 2. States with code and standard savings credit in place or under development. *Source:* Garfunkel and Waite 2024. In Illinois, as of August 2026, an attribution framework for code advancement has been approved while one for BPS has been developed and is awaiting approval.

The appliances chapter discussed programs in California, and below we summarize efforts in Massachusetts and Arizona. Programs in the remaining states are discussed by Garfunkel and Waite (2024).

Massachusetts: Efficiency program administrators began the Code Compliance Support Initiative (CCSI) in 2014 and expanded it in 2022 with the Codes and Standards Compliance and Support (CSCS) Initiative. Evaluation of the initiative has evolved over time and differed for residential and C&I efforts, and for compliance and support/advancement efforts. The initial efforts for code compliance savings generally relied on a Delphi panel⁴⁷ to determine savings based on the difference between actual building practices and a counterfactual building practice baseline with naturally occurring market adoption, or NOMAD. California follows a similar process. More recently, savings from code compliance efforts have been bundled with savings from the new construction initiatives instead of being broken out separately; in other words, the counterfactual baseline assumed no program administrator support for new construction, including code compliance support. Savings for the code advancement efforts, as well as

⁴⁷ A Delphi panel is a panel of experts each asked to answer specific questions. Typically, results are then compiled and reported to panel participants, and they are then asked if they want to change any of their answers after learning what other panelists answered.

for the standards advancement efforts, are determined by first estimating an attribution factor for the program administrator's efforts in passing the new codes/standards, based on input from a small group of market experts and stakeholders, and then applying the attribution factor to a gross savings estimate (J. Martell, lead analyst, New Construction & Major Renovations, National Grid, pers. comm., February 2026).

Arizona: For many years, investor-owned utilities could get credit for up to one-third of the savings from new building codes and standards. As noted in an Arizona Corporation Commissions energy efficiency decision, and affirmed in subsequent utility-specific cases, an “affected utility may count toward meeting the standard up to one-third of the energy savings resulting from energy efficiency building codes that are quantified and reported through a measurement and evaluation study undertaken by the affected utility” (ACC 2010). Since then, the same treatment has been afforded to appliance efficiency standards. The Salt River Project, a public utility, is not regulated by the ACC and can claim up to 50% energy savings from adoption of new codes and appliance standards (E. Zuckerman, senior associate, Southwest Energy Efficiency Project, pers. comm., July 2020). These provisions were used by utilities to claim credit for their role in building codes enacted by local municipalities (there is no statewide code) and a pool pump efficiency standard enacted by the state in 2010 (T. Hines, principal, Tierra Resource Consultants, pers. comm., February 2026). The advantage of this approach is its simplicity—it provides a projection of code and standard impacts without a complex process. Instead, 33% or 50% attribution is implicitly assumed. In recent years, Arizona has been scaling back energy efficiency efforts due to political changes at the state level, and these provisions have not been used.

Participation rates

As discussed above, the Energy Trust commercial new construction program is reaching an estimated 75% of new construction in Oregon and the Mass Save residential new construction program is reaching about 25% of new construction in Massachusetts. If stronger building codes were adopted with program administrator assistance, participation would approach 100% because these codes are mandatory.

Energy savings and peak demand reductions

We estimate potential nationwide energy savings in tables NC 1 (residential) and NC 2 (commercial). For participation rate, based on the section above, we assume 25% from voluntary programs in all states from 2026–2030, based on Mass Save residential. Starting in 2030, we assume 100% participation from codes in half the states 50% from voluntary programs in the other half, based on the average of Mass Save residential and Energy Trust for commercial. Of the savings from codes, we assume that programs get credit for one-third, based on the Arizona experience discussed in this chapter. Other key assumptions in these calculations are contained in the tables. We find that commercial program energy and demand savings are substantially greater than those for the residential program—7,900 MW of summer peak savings for commercial and 1,600 MW for residential. Electricity savings for which program administrators can get credit total about 12 TWh for both codes. There are additional building code savings of 24 TWh for which program administrators do not get credit.

Table NC 1. Energy savings and demand reductions for residential new construction programs

("x" designates multiplication)	Value	Units	Comments
	15	new homes	Millions of new homes, 2026–2026, based on U.S. Census data on housing starts in 2025
x	10,927	kWh/home	Based on average consumption per home in 2035 (EIA 2026)
x	81%		Newest homes use 19% less energy per unit than the overall stock (EIA 2023)
x	20%		Estimated average energy savings from participating buildings: For states with strong codes, this is based on homes built to DOE Efficient New Homes levels; for states with weaker codes, still assume 20% savings relative to their weaker codes, but these will not reach Efficient New Homes levels
x	33%		25% in 2026–2030 from voluntary programs, 100% in half the states starting in 2030 from codes of which programs get credit for 1/3; 50% from voluntary programs after 2030 in remaining states, all as discussed in text
x	82%		Average net to gross savings ratio from Kresowik et al. 2025.
=	7	TWh	Annual energy savings in 2035
x	215		Ratio of summer peak savings (MW) to annual savings (TWh) for residential utility programs in 2024 (EIA 2025)
=	1,560	MW	Summer peak savings
x	1.1		Ratio of winter peak savings to summer peak savings for Massachusetts residential new construction program (Mass Save 2024)
=	1,676	MW	Winter peak savings
	32	mBtu/home	Gas consumption per home, based on average consumption in 2035 (EIA 2026)
=	26	Trillion Btu	Annual natural gas savings (applying same assumptions as for electricity)

Note: We use Massachusetts because it is one of the few states that reports both summer and winter peak savings.

Table NC 2. Energy savings and demand reductions for commercial new construction programs

("x" designates multiplication)	Value	Units	Comments
	28	Billion sf	New construction, 2026–2035
x	414	TWh	Electricity consumption in 2035 from these buildings based on overall stock
x	100%		New buildings relative to average building energy use/sq. ft. (EIA 2022)
x	25%		Estimated average energy savings from participating buildings (based on comprehensive services provided under Oregon and Mass Save programs)
x	33%		25% in 2026–2030 from voluntary programs, 100% in half the states starting in 2030 from codes of which programs get credit for 1/3; 50% from voluntary programs after 2030 in remaining states, all as discussed in text
x	82%		Average net to gross savings ratio from Kresowik et al. 2025
=	28	TWh	Annual energy savings in 2035
x	279		Ratio of summer peak savings (MW) to annual savings (TWh) for commercial utility programs in 2023 (EIA 2025)
=	7,899	MW	Summer peak savings
x	0.08		Ratio of winter peak to summer peak savings for commercial new construction program (Mass Save 2025)
=	635	MW	Winter peak savings
	816	Trillion Btu	Natural gas consumption in 2035 from these buildings based on overall stock
=	68	Trillion Btu	Annual natural gas savings (applying same assumptions as for electricity)

Typical costs and cost of saved energy

Nadel (2024) examined 14 residential new construction programs and 8 commercial new construction programs. For the residential programs that provided program costs and energy savings, the average cost of saved electricity was \$0.070 per kWh saved and the average cost of saved gas was \$0.700 per

therm (100,000 Btu) . For the commercial programs, the figures were \$0.086 for electricity and \$0.86 for gas savings.⁴⁸

Energy Trust of Oregon in 2024 had a total commercial new construction program cost of \$17.2 million. It estimates a levelized cost of saved energy for the program of \$0.027 per kWh saved and \$0.445 per therm of natural gas saved (Energy Trust 2025).

For the NYSERDA Buildings of Excellence program, nearly \$7 million of awards were made for nine projects in the most recent round of the competition (round 5). These projects ranged in size from 25,000 sq. ft. to 648,000 sq. ft. The cost to NYSERDA averaged about \$0.50 per sq. ft. On average, the NYSERDA awards were only 0.1% of total project costs, which are mostly the base construction costs but also include the extra costs of the energy-saving features (NYSERDA 2025).

Exemplary program design and marketing features

Nadel (2024) reviewed 22 new construction programs that target high levels of energy efficiency, including most of the programs profiled in this chapter, and observed and concluded the following:

- Many of the programs focus on zero-energy-ready new construction, but several have zero-energy paths.
- Several programs explicitly target affordable housing, and some give higher incentives for affordable housing.
- Some new construction programs require electric space and water heating. Also, some programs that allow fossil-fuel heating provide extra incentives for electrifying these end uses.
- *For residential programs, train builders on how and why to build to zero-energy/carbon.* Make special efforts to target the largest builders, as they can have the greatest impact.
- *For commercial programs, build a community of practitioners, and intervene early in the design process.* Use this early intervention to set and follow through on energy design goals. Post-occupancy monitoring, as in the Mass Save program, also helps ensure that energy savings are achieved.
- *Use simple incentive structures that are easily understood by builders, designers, and developers.*
- *Highlight the multiple benefits of high-efficiency homes and buildings.* In addition to operating cost savings, these benefits include impacts on comfort, health, building resilience, and employee satisfaction.
- *Some utilities can receive credit for energy savings from helping to improve building codes.* Utility efforts can include code advocacy and incentive programs that help to show that specific efficiency levels can be achieved in-state.

Summary and recommendations

New construction programs are important because it is much easier and less expensive to build for energy efficiency than to retrofit buildings later. Leading programs combine target setting, design assistance, and incentives to reduce new building energy use by 20% or more. Program implementers should include both residential and commercial new construction programs in their portfolios and

⁴⁸ These calculations assume a 30-year measure life and a 3% real discount rate. We divided program costs between electric and gas savings based on primary energy savings, valuing electric savings at source energy consumption of 10,000 Btu/kWh. See footnote 7 for further explanation.

emphasize achieving high levels of energy efficiency from integrated design approaches. These programs greatly contribute to efforts to transform new construction markets and can ultimately lay the groundwork for building codes that make net zero-energy and net zero-carbon common practice.

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Single-family home retrofits (middle- and higher-income households)

Synopsis

This chapter discusses programs to assist with retrofits to middle- and higher-income single-family homes through technical assistance and incentives. This section emphasizes whole-home, comprehensive retrofits over single upgrades.

Data summary

Available savings in 2035 from 2026–2035 programs:

27 billion kWh (TWh) of electricity (seventh of 13)

79 trillion Btu of fuels (sixth of 13)

7,900 MW of summer peak demand reductions (eighth of 13)

7,900 MW of winter peak demand reductions (fifth of 13)

Cost per kWh saved: ~\$0.11

Introduction

In 2023, nearly 70% of American households lived in single-family residences, and the average home was about 2,000 sq. ft. (Center for Sustainable Systems, University of Michigan 2025). The large size of typical American homes means that they consume a lot of energy, especially on a per-capita basis (Mah et al. 2025a). To help households save energy, utilities and third-party program administrators run residential retrofit programs to improve a home's building envelope and install energy-efficient equipment. Such programs often target owners of single-family homes.

As with commercial buildings, most residential buildings that exist today will still be here in 2050. As discussed in the new construction chapter, 90% of the homes in the United States in 2035 are projected to be homes built in 2025 or earlier. Retrofitting homes can help save money on utility bills and some program administrators encourage “comprehensive” or “deep” retrofits that can achieve energy savings of more than 20% and 40%, respectively (Sussman, Lewallen, and Conrad 2024). However, such retrofits can be costly and briefly disrupt daily life in a household. Lack of knowledge of available offerings is another barrier that program administrators must overcome to bring the benefits of residential retrofits to more households.

Technologies

Although residential retrofit offerings can vary greatly, some common measures contribute to large energy savings. Below we describe upgrades that program administrators should promote to unlock the deepest savings.

Building envelope upgrades: insulation and air sealing

Weatherization is a suite of building energy upgrades that save energy and improve indoor comfort (Farrell et al. 2025). Weatherization typically involves updating HVAC systems and strengthening a building's envelope. Adding insulation to a building's envelope and sealing air gaps between the building and outside and unheated spaces such as attics and basements/crawl spaces helps prevent

unconditioned outside air from entering the house; this maintains more comfortable indoor temperatures and reduces the strain on heating and cooling systems (Sealed 2020). Air sealing is often done with the aid of a blower door that temporarily pressurizes a home to make air leaks easier to spot. These upgrades can also increase occupant comfort, as homes are less drafty and the temperatures of the walls and windows are higher, which reduces radiant heat losses from people to these cold surfaces. A stronger building envelope also blocks exposure to outdoor air pollutants and moisture, which improves indoor air quality, limits mold growth, and protects residents' respiratory health (Tonn et al. 2014; Fisk, Singer, and Chan 2020; R2E2 2024). Implementing envelope improvements prior to heat pump installation can reduce heating and cooling loads and allow for a smaller and less expensive heat pump that better meets heating needs during very cold weather.

Heating and cooling systems

Space heating and cooling were 42% of residential energy use in 2025 (EIA 2026). Compared with multifamily homes, single-family homes require more energy for heating and cooling due to their larger square footage and higher proportion of walls exposed to the outside. Heat pumps that provide both heating and cooling are more energy efficient than separate air conditioners and furnaces (DOE 2026). High-efficiency models like those certified under the ENERGY STAR program increase savings relative to baseline models. Other useful measures include sealing ducts so that conditioned air does not leak into attics, basements, and walls and making sure that heating and cooling ducts and hot-water pipes are well insulated. Installing heat pumps can cost thousands of dollars at the lower end and tens of thousands of dollars at the higher end (Mah et al. 2025b), and program administrators may provide rebates or connect customers with financing options that help with the upfront costs. Mass Save programs, discussed below, are a notable example.

Electrification

Despite the climate and efficiency benefits of installing heat pumps and heat pump water heaters, home electrification can be physically and financially difficult to implement. Roughly 40% of American homes have electric panels with capacity below 200 amperes, and they may need upgrades to accommodate higher electric loads from heat pumps and electric appliances (Gul and Meier 2025). To help more households benefit from the health and climate benefits of electrification, program administrators can provide financial incentives for panel upgrades or emerging technology options such as smart circuit splitters⁴⁹ that reduce the need for additional panel capacity. They can also assist residents in the permitting process and connect them to qualified electricians (Bastian and Cohn 2022).

Examples of successful programs

DOE and EPA's Home Performance with ENERGY STAR

Since 2001, DOE and EPA have administered Home Performance with ENERGY STAR to promote whole-home retrofits. External organizations that run energy efficiency programs can apply to become program sponsors, and that allows them to use the ENERGY STAR brand in their work and access technical assistance from DOE. To become eligible, a prospective sponsor must complete a Home Performance with ENERGY STAR Implementation Plan and submit it to DOE. Once approved, sponsors are required to submit annual and quarterly reports to DOE that document a list of participating

⁴⁹ Smart circuit splitters allow loads to share a circuit, with a computer chip deciding which loads to prioritize so as not to overload the circuit. There are also additional options as discussed by Amann and Aquino 2026.

contractors, number of completed projects, summary results, summary goals, and other data (DOE BTO 2014).

Home Performance with ENERGY STAR was the first major national energy efficiency program that emphasized whole-home retrofits rather than single upgrades. Although single upgrades like lighting or water heater replacements are initially cheaper and less disruptive, comprehensive retrofits lead to lower operating costs overall due to the different upgrades complementing each other (Sussman, Lewallen, and Conrad 2024). Almost 90% of Americans recognize the ENERGY STAR label as an indicator of deep energy savings (EPA 2023). The ubiquity of the ENERGY STAR brand is a likely factor in the program’s large energy savings (M. Plog, home energy score and Home Performance with ENERGY STAR manager, U.S. DOE, pers. comm., March 2026).

New Jersey Whole Home Energy Solutions

Various utilities in New Jersey administer the state’s Whole Home Energy Solutions program, a market-rate residential retrofit program. Contractors use the software SnuggPro to conduct an energy assessment and estimate total energy savings. Participants can receive up to \$7,500 in rebates, depending on their estimated energy savings.⁵⁰ They can also pay back the cost of upgrades through interest-free on-bill financing up to \$25,000 (PSE&G undated). As of January 1, 2026, the program requires attic air sealing, water heater insulation, and duct sealing as mandatory upgrades. Additional measures include heating and cooling replacement and basement upgrades (K. Konarski and A. Khalil, PSE&G, pers. comm., April 2026). The program also offers separate building decarbonization incentives that encourage heat pump adoption.

Whole Home Energy Solutions has served roughly 50,000 households since it first launched in October 2006. In the most recent program year, 2,336 customers participated. An average project costs \$15,735 and achieves 19.6% average energy savings. Like many other high-performing retrofit programs, Whole Home Energy Solutions attributes its whole-home approach to its high energy savings. The program’s multiple financial incentives for energy efficiency and building decarbonization plus optional on-bill financing plan have resulted in zero out-of-pocket consumer costs for 95% of projects (K. Konarski and A. Khalil, PSE&G, pers. comm., April 2026). Participants are encouraged to get quotes from three different trade allies before choosing one to hire; this helps the program stay cost effective.

Efficiency Vermont’s Home Performance with ENERGY STAR

Efficiency Vermont sponsors its own Home Performance with ENERGY STAR program. It is open to all income levels, with separate incentive levels for high-income, moderate-income, and low-income customers.⁵¹ Table SF 1 shows the available incentives for each income level.

Table SF 1. Financial incentives for different income levels

Income level classification	Percentage of project costs covered	Maximum rebate amount
Low	90%	\$9,500

⁵⁰ The first 5% of savings are worth \$2,000, and every percentage point beyond that is worth an additional \$700 (K. Konarski and A. Khalil, PSE&G, pers. comm., April 2026).

⁵¹ Income level classifications vary by county.

Moderate	75%	\$9,500
High	75%	\$4,000

Table adapted from Efficiency Vermont (undated)

Efficiency Vermont maintains the Efficiency Excellence Network of contractors who carry out relevant projects related to weatherization, HVAC, heat pumps, and lighting. Contractors who join Efficiency Vermont's network must meet minimum requirements, including Building Performance Institute certification. Customers choose which contractor they would like to implement their home upgrades (J. Bortz, program manager, VEIC, pers. comm., April 2026). The contractor then submits a project plan to Efficiency Vermont for approval. If approved, the contractor can make the upgrades and submit proof of work to Efficiency Vermont so that the customer can receive their rebate (Efficiency Vermont undated).

The program previously used custom modeling to estimate energy savings, but now uses a prescriptive model. While this change in methodology has resulted in lower reported savings, it has allowed Efficiency Vermont to serve a greater number of customers. Vermont residents have demonstrated greater demand for weatherization due to the comfort, energy bill savings, and air quality benefits (J. Bortz, program manager, VEIC, pers. comm., April 2026). Efficiency Vermont still guarantees substantial energy savings per project due to the requirement for minimum air leakage of 10% (Efficiency Vermont undated).

Mass Save

Six Massachusetts utilities and other program implementers come together to run Mass Save, the state's primary energy efficiency initiative. Like many other retrofit programs, Mass Save offers free home energy assessments to identify areas for improvement. Participants can also speak to a decarbonization consultant who can share best practices for transitioning from fossil-fuel heating to an efficient heat pump (Mass Save 2026c). After a no-cost home assessment, participants can receive standard weatherization in addition to financial incentives and financing for more significant upgrades such as heat pumps, battery storage, and EV charging. Mass Save offers particularly generous rebates for heat pump installation that range from \$8,500–16,000 for air source heat pumps and \$13,000–25,000 for ground source heat pumps (Mass Save 2026a, 2026d).

In 2025 Mass Save's 1–4 Unit Turnkey program weatherized 22,288 non-income-eligible dwelling units (Mass Save 2026b). The program's total expenditures were more than \$90 million, and more than \$67 million was spent on participant incentives (Mass Save 2026f). The 1–4 Unit Turnkey program achieved 11,802 MWh in annual electric savings during that time (Mass Save 2026e).

Mass Save is a long-standing program that has benefited from brand recognition. The initiative has a dedicated team for brand awareness marketing that highlights the bill savings and comfort benefits of energy efficiency, which is a particularly salient message in Massachusetts, where the housing stock is older and the cold climate motivates households to invest in efficient heating (M. Coen, principal analyst, National Grid, pers. comm., March 2026). The program has also engaged and educated contractors about the importance of heat pump installation and how to best teach participants about their new home upgrades. A heat pump quote analysis tool helps homeowners evaluate contractor proposals and select the best system and contractor for their home. Since contractors interact face-to-face with households, it is important for them to be knowledgeable about heat pump technology and address any concerns that participants may have. Like many of the other program examples, Mass Save offers a "one-stop shop," or a single point of entry where participants can access a range of services

such as energy assessments, weatherization, and rebates. This setup contributes to a more positive experience for current customers and removes barriers to participation for prospective households.

Participation rates

The International Energy Agency's (IEA) Net Zero Energy scenario assumes that 50% of existing buildings receive retrofits by 2040. Globally, this translates to a consistent annual retrofit rate of 2.5% until 2050, which is when many countries have set net-zero targets (IEA 2021). New Jersey's Whole Home Performance has served nearly 4% of eligible homes since its inception 20 years ago; this translates to an average annual retrofit rate of 0.2% (A. Khalil, program support manager, PSE&G, pers. comm., April 2026). Mass Save measures the number of weatherization jobs completed and reported 22,288 completed projects from Q1 to Q4 of 2025 (Mass Save 2026b). Based on the state's survey of existing housing stock, about 77% of Massachusetts' housing stock consists of 1–4-unit homes (Commonwealth of Massachusetts 2025). Mass Save's retrofits thus work out to an annual participation rate of about 1.0%.

Energy savings and peak demand reductions

Sussman, Lewallen, and Conrad (2024) define “comprehensive” retrofits as those that achieve energy savings of 20% or more. Among the programs we profile, the New Jersey program has saved an average of 19.6% per home; this value represents electric and gas savings together. Based on these findings, we use 20% for electric savings and 20% for gas savings for our national savings estimate.

To estimate peak winter and summer demand, we averaged estimates from Texas, a hot climate state, and Massachusetts, a cold climate state. The Texas values represented peak demand savings from attic insulation, sealing, and duct sealing as a proxy for weatherization (Nadel, Amann, and Chen 2023). The Massachusetts data came from Mass Save's Turnkey Solutions program for 1–4-unit buildings, the initiative's primary single-family retrofit program (Mass Save 2025). We then measured the ratio of peak demand savings to annual energy savings to estimate summer and winter peak savings, respectively. Our calculations are summarized in table SF 2. We find potential electricity savings in 2035 of 27 TWh plus substantial peak demand and fuel savings.

Table SF 2. Savings and peak demand reductions from single-family retrofits

“x” designates multiplication)	Value	Units	Comments
	1,577	TWh	2035 residential gross end-use electricity consumption (EIA 2026)
x	73%		Percentage of residential housing stock not covered by Low Income program
x	85%		Single-family homes in 2035 as percentage of total building stock electricity use (based on analysis of 2020 RECS microdata)
x	14%		Estimated percentage of homes that receive comprehensive retrofits from 2026 to 2035, based on Mass Save's average annual participation rate of 1.4%

("x" designates multiplication)	Value	Units	Comments
x	20%		Average per-home energy savings from high-performing programs, based on PSE&G's average savings of 19.6%
=	27	TWh	Annual energy savings
x	288		Ratio of summer peak savings (MW) to annual savings (TWh) for single family retrofit programs (avg. of Texas and Massachusetts; Nadel, Amann, and Chen 2023; Mass Save 2025)
=	7,887	MW	Summer peak savings
x	290		Ratio of winter peak savings (MW) to annual savings (TWh) for single family retrofit programs (avg. of Texas and Massachusetts; Nadel, Amann, and Chen 2023; Mass Save 2025)
=	7,951	MW	Winter peak savings
	4,562	TBtu	2035 residential natural gas delivered energy (EIA 2026)
x	73%		Percentage of residential housing stock not covered by Low Income program
x	85%		Single-family homes in 2035 as percentage of total building stock natural use (based on analysis of 2020 RECS microdata)
x	14%		Estimated percentage of homes that receive comprehensive retrofits from 2026 to 2035, based on Mass Save's average annual participation rate of 1.4%
x	20%		Average per-home energy savings from high-performing programs, based on PSE&G's average savings of 19.6%
=	79	TBtu	Annual energy savings (other assumptions same as for electricity)

All data from New Jersey Whole Home Energy Solutions provided by A. Khalil from PSE&G

Typical costs and cost of saved energy

In 2021, Lawrence Berkeley National Lab conducted a national survey of average home upgrade costs from projects over the 2010–2020 period. The survey collected data from 1,739 single-family projects and found total costs of \$24,689,213. This amounted to a median project cost of \$8,740, although the report notes that not all homes received significant retrofits. The most expensive upgrades were solar installation, which had a median cost of \$27,184, and heat pump installation, with a median cost of \$8,027; the least expensive upgrades were health and safety measures, which had a median cost of \$109, and lighting installation at a median cost of \$143. Assuming a discount rate of 3% and a measure

life of 15 years, these measures saved \$0.11 per kWh (Less et al. 2021). In recent years, inflation has been high and costs have increased.

There was insufficient data from PSE&G and the other programs we profiled to calculate the costs of saved energy.

Exemplary program design and marketing features

From our case studies, we can attribute multiple program design and marketing features that led to success. We also include additional recommendations from Amann, Srivastava, and Henner (2021), R2E2 (2024), Sussman, Lewallen, and Conrad (2024), and Amann and Aquino (2025).

- *Apply a whole-home approach to maximizing energy savings.* Understand how upgrades to multiple systems complement each other.
- *Offer more advanced energy upgrades like heat pumps, solar installation, and EV charging,* in addition to weatherization, to the extent budgets permit.
- *Tailor marketing to customers' needs and preferences,* and account for factors like service area demographics, climate zone, and typical behaviors.
- *Market retrofits to homeowners when they are open to making changes,* such as a planned renovation or HVAC replacement, or after they recently purchased a home.
- *Offer a one-stop shop or concierge program* that features a single point of entry. This setup is easier for customers to navigate and thus improves program participation.
- *Consider making retrofits in stages* to spread costs over multiple years.
- *Offer technical assistance at all stages of the program* to help customers navigate projects from beginning to end.
- *Set aside funding for evaluation, measurement, verification, quality assurance, and control.* Adjust practices accordingly based on data.
- *Minimize the high upfront costs of upgrades* by packaging multiple financial incentives—such as grants, rebates, and tax credits—and financing options such no- or low-interest loans.
- *Engage contractors and ensure that they are up to date on the latest energy-efficient technologies.* Contractors often get the most face-to-face interaction with participants, so it is important for them to be knowledgeable and educate customers.

Summary and recommendations

Residential retrofits for single-family homes occupied by middle- and higher-income households need to be significantly scaled to maximize energy savings. The long-standing Home Performance with ENERGY STAR provides a model for whole-home retrofits that can be adapted to multiple contexts. Programs that offer weatherization, heat pump installation, and other advanced upgrades can help achieve energy savings of 20% or more. To ensure high participation rates, program administrators should design a process that is user friendly for participants and contractors. A one-stop-shop with a single point of entry, technical assistance throughout the entire process, and an educated contractor network that can effectively engage participants are vital to a positive customer experience. Retrofit programs will need to integrate more of these design features to quickly serve the millions of existing single-family homes in need of weatherization.

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Low-income household retrofits

Synopsis

Home retrofits can reduce home energy use by about 20%. This chapter discusses programs targeting single-family homes occupied by low-income households. Low-income retrofit programs tend to offer free or low-cost services, especially since households frequently lack the ability to cover upfront costs. In-home health and safety hazards are common among these households and often need to be addressed before weatherization can begin. Many programs have worked with community-based organizations to build trust, recruit participants, and carry out work. Other chapters discuss single-family retrofits for middle- and higher-income households and multifamily retrofits, including for low-income residents.

Data summary

Available savings in 2035 from 2026–2035 programs:

26 billion kWh (TWh) of electricity (eighth of 13)

85 trillion Btu of fuels (fifth of 13)

9,400 MW of summer peak demand reductions (seventh of 13)

7,200 MW of winter peak demand reductions (sixth of 13)

Cost per kWh saved: ~\$0.11

Introduction

Many low-income Americans live in older, inefficient homes that consume a lot of energy (Hayes et al. 2022). Such households tend to experience high energy burdens, meaning they spend more than 6% of their annual household income on energy bills (Drehobl, Ross, and Ayala 2020). High energy burdens can lead to health risks, as some low-income individuals will forego food and medicine or set their thermostats to uncomfortable, and potentially unsafe, temperatures to afford energy bills (Hernández and Laird 2022). An unpaid utility bill can result in disconnection and further put vulnerable households at risk. As a result, many utilities and government agencies run bill assistance programs to help low-income households pay their energy bills. One notable example is the federal Low Income Home Energy Assistance Program (LIHEAP), which provides money to states to support both bill assistance and weatherization for income-eligible households (Mah and Sussman 2023).

Although bill assistance programs can temporarily prevent a utility disconnection, residential retrofits that reduce energy consumption and bills on a long-term basis are a more durable solution to inefficient housing. The Department of Energy's (DOE) Weatherization Assistance Program (WAP) is the nation's most prominent low-income weatherization program. It provides income-eligible households with no-cost energy upgrades, including health and safety measures, insulation and air sealing, and heating and cooling improvements. It has served more than 7.2 million households since it launched in 1976 (DOE 2023). Despite WAP's extensive reach, governments, utilities, and third-party program administrators will need to significantly scale their low-income retrofit programs to fully serve the 36.8 million Americans living in poverty (Census Bureau 2024).

Specifications and technologies

There is considerable overlap between low-income retrofit programs and broad residential retrofit programs. Here we discuss some elements that differentiate low-income programs.

Health and safety measures (weatherization readiness)

In addition to funding constraints, health and safety hazards prevent WAP and other low-income programs from serving more income-eligible households. Energy inefficient homes tend to be older and commonly have leaky roofs, unsafe electrical wiring, faulty plumbing, mold, lead, and other hazards (Hayes et al. 2022). Such issues need to be addressed prior to weatherization, but utilities and third-party program administrators frequently lack the funds to remediate hazards. As a result, 19% of WAP-eligible households were deferred from service in 2023 due to preexisting health and safety hazards (Farrell et al. 2025).

To reduce deferrals and ensure more low-income households receive the health and bill savings benefits of weatherization, program implementers often braid funding from multiple sources for health and safety repairs. For example, the Philadelphia Energy Authority's Built to Last program combines resources from local utility, home repair, and social service programs to support extensive health and safety repairs (Philadelphia Energy Authority undated). Other utilities allocate a maximum percentage of program funding specifically for health and safety repairs. For example, TVA's Home Uplift program caps health and safety repairs at 10% of project budget, or \$1,000 per home, assuming an average project budget of \$10,000 (S. Harrell, program manager, TVA, pers. comm., March 2026).

Some governments and utilities run designated programs specifically for addressing health and safety issues that lead to deferrals. In Virginia, the Weatherization Deferral Repair Program supports households that have been deferred from WAP. Local weatherization subgrantees can receive funding strictly for repairing issues that cause deferrals (Virginia DHCD 2026). In San Antonio, local utility CPS Energy runs the Weatherization Repair Assistance Program for the roughly 30% of households that get deferred from the utility's primary weatherization program. Qualified households can receive up to \$2,000 to fix common issues like broken ceilings or faulty electrical wiring (CPS Energy undated).

Income eligibility thresholds

Retrofit programs vary greatly based on how they determine income eligibility. Common thresholds include below 200% of the federal poverty level or 60% or 80% of area median income. Other programs allow customers to use categorical eligibility for other assistance programs like Medicaid or Supplemental Nutrition Assistance Program (SNAP) to prove eligibility for energy retrofit assistance. Although these thresholds are beneficial for prioritizing customers with the most need, they may leave out moderate-income customers whose incomes are just above the maximum limit. These moderate-income customers have limited funds and may struggle to afford the high upfront costs of energy upgrades (Mah et al. 2025). Thus, program administrators seeking to accommodate moderate-income households should either expand their eligibility thresholds to serve more customers or include provisions that target moderate-income households.

Financial incentives and financing options

DOE's WAP offers weatherization at no cost to the customer if they meet income requirements. Some utility programs replicate this model, such as TVA's Home Uplift. Others, like NYSERDA's EmPOWER+, cover 100% of upgrade costs up to a maximum of \$12,000 or \$14,000, depending on region, for low-income households and 50% of costs for moderate-income households. Utility budgets for

weatherization measures can vary greatly. Unfortunately, there is little public information on how low-income energy efficiency programs allocate funding for different categories of measures.

Different state policies can greatly affect the extent to which utilities can offer free upgrades for low-income customers. States that limit utilities on energy efficiency spending would need new legislation that allows utilities to offer more advanced upgrades, such as comprehensive retrofits (Johnson et al. 2026). For programs that do not offer completely free upgrades, rebates can offset some of the upfront costs, especially if the program offers higher rebate amounts for customers below a certain income. However, they could still be inaccessible to households that cannot afford initial upfront costs (Mah et al. 2025). Using tax credits to fund upgrades poses the same issue, and it is more acute now after the expiration of the Energy Efficient Home Improvement Credit in December 2025 (IRS 2025).

Tariffed on-bill (TOB) programs are a financing option that can cover upfront costs. In TOB programs, the utility pays for upgrades using its own capital or other sources. Customers then repay the costs of upgrades through a line item on their utility bills. Some TOB programs like Pay as You Save tie the tariff to a specific meter rather than a specific customer. They often use utility bill payment history to help determine eligibility. As with traditional loans, TOB programs should be designed to minimize financial risks to consumers.⁵² For example, a significant buffer between modeled energy savings and expected costs can ensure that the monthly tariff is lower than energy savings, thus saving consumers money (Mah et al. 2025).

Traditional loans could be an option for moderate-income customers who are more likely to qualify than low-income customers. Effective loans for moderate-income customers have zero or very low interest rates and robust consumer protections against predatory lending practices. For example, the utility should not disconnect service if a customer misses a loan payment (Mah et al. 2025).

Examples of successful programs

CPS Energy's Casa Verde program

CPS Energy's Casa Verde program serves San Antonio and provides weatherization and rebates for energy-efficient products. Households are eligible if they make below 200% of the federal poverty level, receive income-based government assistance, or report energy burdens higher than 10%. Beginning in October 2025, the program incorporated vetted contractors as "registered trade allies." Customers can now choose their own trade allies to access rebates for upgrades like smart thermostats and HVAC tune-ups (unless otherwise noted, information about this program is from F. Kostusyk, manager, CPS Energy, pers. comm, March 2026). For homes with health and safety issues, CPS Energy offers the Weatherization Repair Assistance Program, which provides free repairs and prevents deferrals from Casa Verde; common repairs include gas stove replacements, roof repairs, and minor electrical work (CPS Energy 2026).

CPS Energy launched Casa Verde in 2010 and it has weatherized more than 40,000 homes. In FY 2025, the program served 2,455 customers and reported average gross savings of 2,468 kWh per household. Participation dipped after the COVID-19 pandemic, but it has been steadily increasing since FY 2022

⁵² Although the classification of tariffed on-bill financing is open to debate, some organizations like the National Consumer Law Center argue that it is a type of loan and needs to be regulated as such (Cohen and Wein 2024). See www.nclc.org/wp-content/uploads/2024/09/Final-letter-on-TOB.09092024-Alys-Cohen.pdf.

(Frontier Energy 2025). Approximately 97,295 households in San Antonio are eligible for the program and thus the annual participation rate is about 2.9%.⁵³

CPS Energy attributes Casa Verde’s high energy savings to its focus on insulation, air sealing, and duct repair. In addition to insulating attics, the program encourages insulation of a home’s foundation if there is adequate clearance, such as in pier and beam homes or homes built on a slab. CPS Energy also runs a technical product innovation group to learn about new technologies and pilot new ideas for Casa Verde. Generally, the program encourages trade allies to implement the greatest number of upgrades possible in each home. Blower door tests after project completion help verify energy savings and contribute to quality assurance and quality control.

TVA Home Uplift

TVA’s Home Uplift serves households in the Tennessee Valley whose incomes are below 200% of the federal poverty line or 80% of area median income. TVA partners with local power companies to fund no-cost retrofits up to \$10,000. The program sets aside 10% of its budget to address any health and safety issues that would prevent weatherization. If repairs are more costly, then TVA defers the work to local organizations. In addition to weatherization, available repairs and upgrades include duct work, HVAC installation, water heaters, windows, and doors (all information about this program is from S. Harrell, program manager, TVA, pers. comm., March 2026).

Launched in October 2019, TVA’s Home Uplift had upgraded 8,374 homes by February 2026 and 451 homes had received service in the most recent fiscal year. Average savings per home amounted to 3,000 kWh.

TVA’s partnerships with local organizations are a key factor in Home Uplift’s significant energy savings. Local partners who conduct significant health and safety repairs are vital for serving homes that would otherwise have been deferred from weatherization. Community partners can also help earn residents’ trust, especially in rural areas where prospective customers may be skeptical about a program that offers free home upgrades. In these areas, word-of-mouth referrals from satisfied customers have been effective for recruiting new participants.

NYSERDA’s EmPOWER+ program

NYSERDA’s EmPOWER+ program provides free and reduced-cost home energy upgrades for low- and moderate-income households in New York State. All customers can receive energy assessments and direct installation measures for free, but funding for more advanced upgrades such as heat pump installation, air sealing and insulation, and electrical wiring upgrades depends on income level. Low-income⁵⁴ households can receive no-cost upgrades of up to \$12,000–14,000, depending on their home county—downstate counties offer higher incentives than upstate counties—and moderate-income⁵⁵ households are eligible for incentives that cover 50% of project costs (NYSERDA undated). Although the program originally focused on electric baseload measures, it now prioritizes weatherization first and building electrification second, to mitigate possible bill increases that could result from electrification

⁵³ San Antonio has a total of 568,979 households, and according to the U.S. Census Bureau (2024), 17.1% of the population lives in poverty.

⁵⁴ Defined as income levels 60% or below area median income.

⁵⁵ Defined as income levels between 60–80% of area median income.

(unless otherwise noted, information is from C. Moriarta, director of residential programs NYSERDA, pers. comm., March 2026).

In 2023 the program served more than 22,000 income-eligible customers and achieved annual savings of 630,000 million Btu. The annual budget was approximately \$160 million (ACEEE 2024), which means it invested roughly \$7,273 for each customer served.

EmPower+ emphasizes strong contractor relationships and robust quality assurance to guarantee large energy savings. NYSERDA partners with qualified contractors and collaborates with them on program design changes. NYSERDA also reviews projects as they begin, conducts field inspections at the end, and aims for continuous improvement. To encourage further savings, the EmPower+ program aims to connect manufacturers to heat pump installation training, to ensure proper sizing for cold climate heat pumps (C. Moriarta, director, NYSERDA, pers. comm., March 2026).

Illinois Home Energy Savings

Electric utility ComEd works with Nicor Gas, Peoples Gas, and North Shore Gas to deliver the Home Energy Savings program to income-eligible residents of one- to three-unit homes. These utilities all contribute funding to the program, which allows it to serve more customers. As of 2026, the program is only open to households that make 80% of area median income or below; previous years had a separate market-rate track. The program has two components: a home energy assessment and weatherization. An energy advisor conducts the no-cost home assessment, asks the participants behavioral questions, including about bill payments and energy usage, and provides low-cost direct installation upgrades such as LED light bulbs and smart thermostats. At least 15% of the Home Energy Savings budget is set aside for health and safety measures that need to be addressed prior to weatherization (K. Jonas, L. McKeon, and E. Connolly, ComEd, pers. comm., March 2026).

By the end of the fourth quarter of 2025, Home Energy Savings achieved net energy savings of 7,442 MWh; this exceeded its original approved net energy savings goal of 6,438 MWh and its implementation plan savings goal of 7,068 MWh (ComEd 2026).

Multiple program design features contribute to the Home Energy Savings program's high savings. The program not only pools funding from the four partner utilities but also braids funding from DOE's WAP and other federal and state grants to help community action agencies provide health and safety repairs. Such funding has been helpful for reducing weatherization deferrals. In addition, ComEd has a utility-wide research and development budget to test new technologies and best practices. The Home Energy Savings program also runs topical focus trainings for energy service providers on subjects like health and safety and building science to further support high-quality work (K. Jonas, L. McKeon, and E. Connolly, ComEd, pers. comm., March 2026).

Participation rates

According to Morales and Nadel (2022), the average annual participation rate for low-income energy efficiency programs is 5%. However, as this value includes low-cost measures like efficient light bulb distribution, participation in comprehensive weatherization programs that generate deep savings is likely even lower. Generally, participation rates for retrofit programs are higher for wealthier households than low-income households (Amann, Tolentino, and York 2023). Thus, many utilities and even some states set minimum participation goals for low-income energy efficiency programs. For example, Rhode Island Energy planned to serve 3,636 unique customers for its income-eligible residential program in 2025 (Rhode Island Energy 2024). Meanwhile, a 2026 bill approved by the Virginia

General Assembly requires utilities to provide energy efficiency upgrades for at least 30% of income-qualified customers by December 31, 2031 (Virginia General Assembly 2026).⁵⁶

As stated earlier, many income-eligible energy efficiency programs use 80% of area median income or below 200% of the federal poverty level to identify low-income customers. For our calculations, we used the latter threshold to estimate the number of eligible low-income customers because data from the U.S. Census Bureau were more readily available. For program participation data expressed as number of households, we multiplied such values by the average number of people per household to estimate the number of people served. For example, the Casa Verde program reaches about 2.9% of eligible customers each year. Although TVA's Home Uplift only reaches 0.4% of eligible customers each year, it achieves high energy savings per household, as detailed below. This trade-off between achieving high participation rates or deep energy savings per household is common for low-income programs (Morales and Nadel 2022).

Energy savings and peak demand reductions

Many programs report average energy savings as the amount of kWh saved. For example, TVA Home Uplift reported that participating homes annually saved 3,000 kWh on average (S. Harrell, program manager, TVA, pers. comm., April 2026). The average home in Tennessee consumes roughly 1,109 kWh of electricity a month (Reyes 2025), which amounts to 13,308 kWh per year. Thus, Home Uplift achieves electricity savings of roughly 23%. This is similar to the 18% electricity savings reported by CPS Energy's Casa Verde program. Based on these two figures, we assume 20% average savings for these programs in our national savings estimate.

We estimated summer and winter peak savings with averaging data from Texas and Massachusetts⁵⁷ (Nadel, Amann and Chen 2024; Mass Save 2025). We multiplied the ratio of summer and winter peak savings by total annual savings to estimate peak savings. Our calculations are summarized in table LI 1. We estimate a savings potential of 26 TWh by 2035 plus substantial peak demand and fuel savings.

Table LI 1. Energy and Peak Savings from Low-Income Retrofit Programs

("x" means multiplication)	Value	Units	Comments
	1,577	TWh	2035 residential gross end-use electricity consumption (EIA 2026)
x	27%		Percentage of low-income households, defined as 200% below federal poverty level (KFF 2024)
x	30%		Estimated percentage of homes that receive comprehensive retrofits from 2026 to 2035, based on Casa Verde's 2.9% average annual participation rate for CPS Energy's San Antonio customers
x	20%		Average per-home energy savings from high-performing programs, based on TVA Home Uplift's 22.5% average and CPS Casa Verde's 18.4%
=	26	TWh	Annual energy savings

⁵⁶ The bill classifies utilities as Phase I or Phase II utilities. Phase I utilities can serve 30% of customers or 2,000 households, whichever value is less, and Phase II utilities can serve 30% of customers or 8,400 households, whichever value is less.

⁵⁷ Although we did not feature Mass Save's programs in this section, we used peak energy savings data from Massachusetts due to its availability and due to the need to represent a warm climate state and a cold climate state.

("x" means multiplication)	Value	Units	Comments
x	367		Ratio of summer peak savings (MW) to annual savings (TWh) for single family retrofit programs; we use an average of Texas and Massachusetts (Nadel, Amann, and Chen 2023; Mass Save 2025).
=	9,382	MW	Summer peak savings
x	282		Ratio of winter peak savings (MW) to annual savings (TWh) for single family retrofit programs; we use an average of Texas and Massachusetts (Nadel, Amann, and Chen 2023; Mass Save 2025).
=	7,208	MW	Winter peak savings
	4,562	TBtu	2035 residential natural gas delivered energy (EIA 2026)
x	27%		Percentage of low-income households, defined as 200% below federal poverty level (KFF 2024)
x	30%		Estimated percentage of homes that receive comprehensive retrofits from 2026 to 2035, based on Casa Verde's 2.9% average annual participation rate for CPS Energy's San Antonio customers
x	23%		Average per-home energy savings from high-performing programs, based on TVA Home Uplift's average annual savings of 22.5%
=	85	TBtu	Annual energy savings (other assumptions same as for electricity)

Typical costs and cost of saved energy

Low-income retrofit programs commonly have higher costs than market-rate retrofit programs, often because they provide health and safety measures (ACEEE 2021). As a result, some utilities and regulatory commissions exempt low-income programs from cost-effectiveness testing or modify rules to more effectively capture the non-energy benefits of low-income energy efficiency (Berg and Mah 2023). Utilities that are not required to meet cost-effectiveness tests for low-income programs can still work toward cost-effective operations by verifying energy savings, investing in deep retrofit measures that produce large savings, and monitoring spending caps and cost shares per project. For example, the maximum project cost per home for TVA's Home Uplift is \$10,000. TVA typically contributes \$5,000 and local power company partners contribute the remaining \$5,000; this helps reduce costs for each organization (S. Harrell, program manager, TVA, pers. comm., March 2026).

At the household level, retrofits are effective for significantly reducing energy burdens for low-income households. WAP participants save an average of \$372 a year on their energy bills after receiving weatherization. When accounting for non-energy benefits like reduced health costs and fewer missed days of work, WAP produces \$2.78 in benefits for every program dollar invested (Nadel 2025). Participants of CPS Energy's Casa Verde reported similar bill savings: The average customer saves \$30–40 a month on energy bills (ACEEE 2024), or \$360–480 a year.

We calculated an average cost per kWh saved from the TVA data. If a program costs \$10,000 per household, measures have an average life of 20 years, and a 3% real discount rate is assumed, the annualized cost is about \$670 per year. If we divide this by 3,000 kWh savings per year, the average cost per kWh is about \$0.22. Note, however, that this assigns all costs to electricity savings, and most programs also reduce fuel use, such as natural gas. If half the savings are electricity and half are fuel—as

is the case in Massachusetts, where 55% of savings came from electricity and 45% came from gas—then the cost per kWh saved is \$0.11.

Exemplary program design and marketing features

From our case studies, we find multiple program design and marketing features that help lead to success. Additional recommendations come from Mah and Sussman (2023); Amann, Tolentino, and York (2023); Morales and Nadel (2022); and Johnson et al. (2026) .

- *Conduct equitable community engagement.* Engaging marginalized communities and co-designing a program to best meet their needs can lead to greater participation and deeper energy savings.
- *Provide upgrades at little to no cost for eligible households.* High upfront costs are a common barrier to low-income retrofits, so covering all or most of these costs can make it easier for households to participate.
- *Partner with community-based organizations and leaders* to build trust among vulnerable households. Employing trusted messengers is important for educating participants and reducing skepticism toward program administrators.
- *Also target moderate-income customers* who fall just short of income eligibility thresholds. Flexible financing options like on-bill repayment or loans with strong consumer protections can make significant energy upgrades more affordable.
- *Braid funding from multiple sources*, such as federal income eligibility programs (e.g., WAP, LIHEAP), state funds, and utilities. Additional funding helps program administrators address common health and safety issues plus serve more customers.
- *Reduce weatherization deferrals by prioritizing health and safety measures.* Establish a designated program for repairs, partner with external organizations to implement measures, or allocate a portion of the program’s budget to health and safety.
- *Create clean energy workforce development programs* that train members of underserved communities. These programs should offer wraparound services (e.g., transportation stipends) to meet workers’ immediate needs and teach skills for deploying more advanced clean energy technologies (e.g., heat pumps, rooftop solar, battery storage).
- *Link retrofit programs with energy bill assistance services.* Both services together can significantly reduce high energy burdens for vulnerable households.
- *Complement electrification with upgrades that mitigate electricity bill increases* (e.g., weatherization and solar installation).

Summary and recommendations

Low-income households stand to benefit greatly from energy-efficient retrofits, but they face significant barriers to program participation. Program administrators can remove barriers by meeting low-income customers where they are. Addressing health and safety issues that lead to weatherization deferrals not only allows households to participate in retrofit programs but also makes their indoor environments less hazardous and more comfortable. Once a household is eligible for weatherization, program administrators must minimize or eliminate upfront costs for efficiency upgrades for customers with limited incomes. Throughout the program, it is also important for administrators to continuously engage customers, build trust, and ensure that they are satisfied with the home upgrades. Such practices will lead to larger energy savings from low-income retrofit programs. More importantly, they will also help vulnerable households afford their energy bills while enjoying better health and comfort in their own homes.

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Small business

Synopsis

This chapter discusses programs that target efficiency retrofits for small businesses. These primarily use a direct installation approach, in which the program handles the energy audit and installs the recommended measures; simply needs to agree to the retrofit package. Various programs define “small” differently, and while this is often based on energy use, it is sometimes based on building floor area.

Data summary

Available savings in 2035 from 2026–2035 programs:

12 billion kWh (TWh) of electricity (ninth of 13)

24 trillion Btu of fuels (ninth of our 13 programs)

3,350 MW of summer peak demand reductions (10th of 13)

900 MW of winter peak demand reductions (13th of 13)

Cost per kWh saved: \$0.026–0.035 per kWh and \$0.26–0.50 per therm

Introduction

Among commercial and industrial customers (collectively “business customers”), large customers are more likely to participate in energy efficiency programs than small customers. For example, a 2024 study on participation by business customers in programs funded by Massachusetts utilities found that 17% of “micro” customers, those with annual electricity use less than 110,000 kWh, participated in programs over the 2013–2022 period, while 73% of “small” customers, those with 110,001–1.5 million kWh, participated. Most large customers, those with more than 1.5 million kWh per year, participated in programs, and many more than once (DNV 2024).

Small customers generally have limited staff and other resources; this leaves little time to dedicate to evaluating energy efficiency investments. To address this, as early as 1986, utilities began experimenting with direct installation programs that provided free energy assessments and free installation of recommended measures, with an emphasis on lighting efficiency improvements (Nadel 1986).

Technologies and approaches

Historically, small business programs have emphasized lighting, but as LED lighting has become common, even for small businesses, most have added other measures. These include HVAC system measures such as thermostats, tune-ups, and replacement; refrigeration system measures; advanced lighting controls; and building envelope and other weatherization measures.

Examples of successful programs

Commonwealth Edison (ComEd)

The Small Business program was one of ComEd’s first and largest programs. For many years, the program offered services to customers with a billing demand under 100 kW, but it was recently

expanded to include customers with demand of 101–500 kW. The program began in 2010 and while early records are not currently available, the program has completed over 100,000 assessments and is estimated to have provided completed projects to between 90,000 and 110,000 customers. The midpoint of the range is 44% of the approximately 225,000 customers targeted by the program.

Services are offered by a network of about 75 authorized service providers. Providers conduct free energy assessments, develop lists of recommended measures, and then install measures after obtaining customer agreement. Incentives that cover a portion of the costs of the measures are provided for various measures based on an appropriate metric for that measure. For example, the incentive for lighting measures is \$0.80 per watt reduction in connected lighting load. Incentives typically cover up to 75% of the measure cost, including installation, and the customer pays the balance. ComEd periodically offers short-term campaigns during which incentives may cover as much as 100% of measure costs.

Most savings in the early years were from lighting measures. While lighting remains a core component, its savings opportunities are declining and the program is ramping up other measures such as air-conditioning tune-ups and replacements; advanced rooftop controls, thermostats, and other space conditioning controls; and building envelope and refrigeration system measures. There are nearly 140 measures included in the program and about half of them involve lighting.

In 2025 ComEd estimated that annual average savings per customer were about 33,900 kWh and that program measures reduce customer energy use by a little over 10%. Between 5,000 and 6,000 customers per year receive retrofits and the program budget is about \$80 million per year, including incentives, administration, and marketing. ComEd’s annual savings goal for 2026 is 181 GWh; in 2024, program savings were higher, at 220 GWh. The company estimated a weighted average measure life of about 14.5 years. In 2025, about one-third of projects and spending were in communities designated as underserved (C. Allen, senior energy efficiency program manager, ComEd, pers. comm., March 2026; Guidehouse 2025).

The program manager emphasized the importance of high-quality, ongoing training for program contractors. ComEd conducts a half-day training annually, hosts a monthly webinar for contractors on different subjects, and periodically hosts more in-depth training sessions on specific technologies like thermostats, networked lighting controls, and refrigeration measures. Additionally, the company regularly interviews customers and contractors to learn how well the program is working and uses this input to make improvements. For example, when interviewees shared problems with thermostat installation, ComEd introduced a kit to help with installation (C. Allen, senior energy efficiency program manager, ComEd, pers. comm., March 2026).

State programs in Massachusetts and Connecticut

Massachusetts and Connecticut have direct installation programs for small business customers along the same lines as the ComEd program discussed above. In Massachusetts, the program is operated by Mass Save on behalf of the state’s investor-owned utilities and other utility-funded program implementors. In Connecticut, the program is marketed under the Energize Connecticut banner; the state’s two major utilities, Eversource and United Illuminating, coordinate implementation.

In both states, program administrators contract with vendors who provide free audits, develop a list of eligible measures, including the savings and incentives for each, and offer to install these measures. In Massachusetts, the incentive is the lesser of 70% or what is called the *savings gap*: the net lifetime savings times the value to the utility, which is currently \$0.125 per kWh for electricity and \$1.97 per therm. On-bill loans are available for the customer cost-share. In Connecticut, for “micro” businesses that have annual consumption of no more than 100,000 kWh, the savings gap cap is dropped.

Outreach is conducted by the utility and the vendors and includes digital marketing, phone solicitation, and segmented outreach such as working with restaurant associations, retail associates, and chambers of commerce. In Connecticut, a special outreach program to nonprofit organizations and houses of worship is planned; both have been identified as underserved.

Both states also have a “Main Streets” program in which vendors spend multiple days in a town conducting door-to-door outreach and scheduling services. The uptake is much higher through face-to-face engagement, and grouping jobs in the same town reduces travel time and costs.

The program managers noted that small business owners have many demands on their time and it is hard to get their attention. Program staff try to get the owner to agree to participate in the first contact, as second conversations often do not happen. They also seek to provide the most comprehensive package of energy-saving measures to which the customer will agree. Door-to-door marketing and working with organizations the customers trust are the most useful marketing strategies. The programs regularly work with vendors to train their staff and improve both the measures that can be offered and the services provided (Z. Lippert, lead analyst, National Grid, pers. comm., March 2026; A. Lungren, senior energy efficiency consultant, Eversource, pers. comm., February 2026).

In Massachusetts, savings and spending data are combined with large business programs, which makes it difficult to isolate results for small businesses. However, an online tool provides breakdowns of participation, spending, and savings by customer size, such as “micro” and “small,” as defined in the introduction to this section. For the 2024 program, this tool reports that 4,090 unique micro and small addresses participated in their programs statewide, and that is about 2.3% of micro and small addresses. Incentive costs totaled \$43.6 million that year and electric savings were 77 million kWh. These figures include participation in other utility programs by micro and small customers and not just the Small Business program (DNV 2025). In Connecticut, the budget is smaller. In 2025, Eversource audited 692 out of about 60,000 eligible customers—an annual participation rate of about 1.15%. Of these customers, 376 installs were completed during the year; for the remaining 316, some decided to do the work themselves, some are completing the work in 2026, some completed the work through another program, and for some, the audit did not find savings opportunities (A. Lungren, senior energy efficiency consultant, Eversource, pers. comm., February and May 2026).

Minnesota Center for Energy and Environment’s One-Stop Efficiency Shop

The One-Stop Efficiency Shop (One-Stop) is different from the programs discussed above in that it is operated by the nonprofit Center for Energy and Environment (CEE⁵⁸) under contract with the local utility, Xcel Energy. One-Stop began in 2000 when CEE proposed this program to the Minnesota Division of Energy Resources and Xcel Energy under a regulatory provision for third parties to propose alternative programs. The program is offered in Xcel Energy’s Minnesota service territory. The 2025 Annual Status Report (CEE 2026) provides a wealth of information. It is the primary source for this section, and is supplemented by details from a conversation with the program manager (K. Funk, senior director of small and medium business programs, CEE, pers. comm., March 2026).

Under One-Stop, CEE provides small and midsized commercial customers with a free energy assessment, a report with actionable cost-saving recommendations, substantial rebates and financing options, assistance finding qualified contractors and reviewing bids, and start-to-finish oversight of the entire

⁵⁸ Sometimes also called Minnesota CEE in order to differentiate it from the Boston-based Consortium for Energy Efficiency.

retrofit project. Commercial customers with a billing demand of 400 kW or less are eligible, and the program targets customers with billing demand under 50 kW with specific services like direct install of lighting. CEE has developed long-term relationships with many local contractors and community organizations that help with outreach and support. Financing is provided by an in-house financing department; in 2025, loans were offered for up to 5 years and had a 5.75% interest rate.

The program originally focused on lighting measures, but HVAC services—with a focus on rooftop unit optimization—were added in 2017 and refrigeration measures and efficient fuel-switching were added in 2024. By 2025 the HVAC and refrigeration measures listed in Table SB-1 were included.

Table SB 1. HVAC and Refrigeration Measures Included in the Minnesota CEE Program.

HVAC	Refrigeration
Thermostat upgrades	Anti-sweat heater controls
Fin combing	No heat case doors
Improved economizer controls	Evaporator fan motor controllers
Demand-controlled ventilation	Enclosed reach-in cases—add doors or new case
Economizer install and repair	Retrofit of open multi-deck cases with solid glass doors
Electronically commutated motors on supply and condenser fans	Walk-in freezer defrost controls
Optimized RTUs	Floating head pressure controls
Exhaust fan control	Aerators
RTU replacement	LED refrigerated case lighting and screw-ins for walk-in coolers and freezers
Boiler replacement	Refrigeration fans—electrically commutated motors (ECM) and permanent magnet synchronous motors (PMSM)
Boiler tune-ups	Strip curtains
Boiler controls	Auto closers for doors
Steam traps	Custom projects
RTU tune-ups	
Water heater replacement	
Minisplit AC	

In 2025 the most common measures were as follows:

- HVAC measures:
 1. Smart thermostat, 43% of all HVAC measures installed
 2. Variable frequency drives, 35%
 3. Replacing rooftop units, 14%
- Refrigeration measures:
 1. Anti-sweat heater controls, 41%
 2. LED lighting for display cases, 12%
 3. New fan motors for display cases, 12%.

In 2025 the program provided incentives up to 75% of measure cost; there were 1,827 participants and a total project budget of \$19.0 million. In addition, \$71,400 of financing was arranged. First-year savings for measures installed in 2025 were 64 GWh (million kWh) of electricity and 4,202 million Btu of natural gas. The program mostly serves small customers—since inception, 60% of participants have had a billing demand of 50 kW or less and 77% have had a billing demand of 100 kW or less. It also includes a special focus on environmental justice areas, and in 2025, these areas represented 45% of participants.

Since inception in 2000, the program has served nearly 36,000 customers, including some that participated more than once, out of approximately 104,000 eligible customers. Also, since inception, the average rebate per project has been \$6,277, annual electricity savings have been 1,034 GWh, and the program has reduced summer peak electric demand by 252 MW. CEE estimated annual customer energy savings to be \$3,505.

Pacific Gas & Electric Business On-Bill Financing

Instead of offering incentives, the Pacific Gas & Electric (PG&E) Business On-Bill Financing program finances small business efficiency retrofits with zero-interest loans that presently range from \$5,000 to \$6 million per project. Loan repayments are made through customers' monthly energy bills.⁵⁹

The program began in 2011 and is available to all nonresidential customers. It is marketed by implementers of other PG&E programs and a Trade Pro Network of approximately 30 contractors that develop and install energy efficiency projects. Members of the Network range from small independent contractors to large energy service companies. The implementers work with customers to identify projects. Since 2021, implementers and Network members must submit project prescreening information to PG&E to ensure that projects they work on are eligible, apply to the appropriate one of three program paths, and meet cost-effectiveness criteria. There is also a preinstallation review prior to financing. The program has three paths: one for relatively small and somewhat homogenous projects that determine energy savings with a regression-based model that compares participants with the eligible population at large; one for larger, more complex projects that determine energy savings through a site-level regression model; and one for complex custom projects for which regression models do not work well. The program includes extensive contractor training and quality control components (Kialashaki and Knight 2024).

From 2015 to 2025, the program provided \$477 million in loans to 5,622 projects. This equates to an average project size of about \$85,000 and reflects a mixture of both small and larger customers and projects. Included in the total are \$179 million of loans to 3,617 small- and medium-sized businesses, defined as those with electricity use less than 500,000 kWh per year or gas use less than 25 billion Btu annually. The average small- and medium-sized business loan was about \$49,000. Other major customer classes receiving loans are government agencies, which received 1,300 loans during this 11-year period, large commercial/industrial/agriculture projects, which received 696 loans, and multifamily projects, which received 9 loans (P. Thompson, principal, EE Finance, PG&E, pers. comm., April 2026).

Approximately 70% of the projects have only addressed lighting and about 85% include at least some lighting. To increase use of the program for non-lighting measures, various efforts are underway, including recently expanding the program to include battery storage and electric vehicle charging. As of 2026, lighting-only projects are no longer eligible, except for loans under \$400,000 and for "critical infrastructure" such as schools. To improve savings results and cost effectiveness, the program now

⁵⁹ PG&E also has some other incentive programs for small business customers, but we do not cover these in this case study.

requires projects over \$400,000 to meet a utility benefit-cost ratio of at least 1.5, including program costs. The savings from the large projects help to keep a simpler program available for small customers.

PG&E is finding that larger projects typically reduce customer energy use by 15–20% and the program seeks to ensure that all projects save at least 5%, as savings smaller than that are difficult to discern in regression models. Presently, the program operates with a revolving loan pool of \$210 million funded by ratepayers. As loans are repaid, that capital goes back into the pool and can be re-lent to other customers. To ensure cost effectiveness, projects must generally generate projected energy savings with a value equal to or exceeding loan payments over a period of no more than 10 years, though there are exceptions for EV charging and battery storage. Creditworthiness is based on customer bill payment history over the prior year. The default rate for On-Bill Financing since program inception, defined as projects that are written off, is 0.09% of the total funds lent to date (P. Thompson, principal, EE Finance, PG&E, pers. comm., March and April 2026).⁶⁰

The program manager emphasized the importance of keeping these programs simple so it is easy for customers to participate. He noted that flexibility is also important, including the option to modify procedures where possible to accommodate customer requests. For local governments and some other customers, structuring loans for repayment through utility bills, rather than carrying them on their balance sheets, can be very helpful.⁶¹ Zero-interest financing has proved very attractive to customers and does not need to be supplemented with other incentives (P. Thompson, principal, EE Finance, PG&E, pers. comm., March and April 2026).

Participation rates

Of the case studies, ComEd has the largest budget and has reached about 44% of eligible customers over 15 years, an average of 2.9% per year (discussed in the ComEd section above). The Minnesota CEE program has had 35,928 participants since inception, which is about 34% of the 105,000 eligible customers,⁶² an annual rate of 2.1% over the program's 16 years. For the Massachusetts Small Business program, as noted earlier, a study on participation over 10 years finds that 17% of "micro" customers have participated and 22% of "micro" plus "small" customers participated. Some of these will have participated in other utility programs and not the small business program, but the number of participants in other programs is somewhat offset by the fact that many small and medium-sized customers participate in the small business program.

Energy savings and peak demand reduction

While all the programs we feature in case studies report energy savings, they are hard to compare as some programs are primarily small customers (Minnesota CEE), some a mixture of small and large custom customers, with many customers large (PG&E) and some in between. As discussed above, ComEd estimates just over 10% average energy savings from its program, while PG&E estimates about 15–20% for its larger projects and at least 5% for smaller projects. For our national savings estimate, we assume an average of 10%. For participation rate, we average the annual participation rates achieved by

⁶⁰ This does not include projects that were in arrears but were later paid off, or in arrears but are expected to be eventually paid off.

⁶¹ Customers need to check with their accountants on this issue.

⁶² The 100,000–120,000 eligible include multiple meters for some customers. We take the midpoint of the range and then round down to reflect that some customers have more than one meter.

ComEd, Massachusetts, and Minnesota CEE. We apply these assumptions to national data on commercial energy use and the share of small customers (where we define *small* as buildings of 25,000 sq. ft. or less). Our calculations are shown in table SB 2. We estimate potential national energy savings from small business programs in 2035 of about 12 TWh, along with fuel savings of about 24 trillion Btu. Summer peak savings are based on commercial energy efficiency program kWh and kW data reported to EIA (2025b). Based on these data, summer peak savings are about 3,350 MW and winter peak savings about 9,000 MW. These savings are relatively small because we only include buildings less than 25,000 sq. ft. Savings would be substantially greater if we drew the line at a higher value such as 50,000 sq. ft.

Table SB 2. Estimated national energy and peak demand savings in 2035 from small business programs
("x" designates multiplication)

	Value	Units	Comments
	1,715	TWh	2035 commercial electricity use (EIA 2026)
x	31%		Percentage of floor area in buildings under 25,000 sq. ft. (EIA 2022)
x	22.6%		10 yr participation rate from average of ComEd, Mass., and MN CEE; figures in text
x	10%		Average savings (see text)
=	12	TWh	Savings in 2035
x	279		Ratio of summer peak savings (MW) to annual savings (TWh) for commercial utility programs in 2024 (EIA 2025b)
=	3,353	MW	Summer peak savings
x	0.27		Ratio of winter peak to summer peak savings for commercial retrofit programs (Mass Save 2025)
=	922		Winter peak savings
	3,379	TBtu	2035 commercial natural gas use (EIA 2026)
x	31%		Percentage of floor area in buildings under 25,000 sq. ft. (EIA 2022)
x	22.6%		10-year participation rate, average of ComEd and Mass.; figures in text
x	10%		Average savings
=	24	TBtu	Savings in 2035

Costs and cost of saved energy

In 2024 ComEd's total program expenditures were \$81 million and 5,509 customers were served, for an average cost per participant of \$14,714. ComEd estimates a weighted average measure life of 13.2 years for electric measures and 8.6 for gas measures (ComEd 2025⁶³). Based on these figures, their reported

⁶³ While the cite is to a ComEd spreadsheet, the gas measures are paid for by gas utilities and not ComEd.

electricity and energy savings, and a 3% real discount rate, we estimate an average cost per kWh saved of \$0.035 and an average cost per therm saved of \$0.50.⁶⁴

As noted above, over the life of the Minnesota CEE program, incentives have averaged about \$6,300 per participant. In 2025, their incentive per participant averaged \$6,288 (the average customer in this program is smaller than the average customer in the ComEd program discussed in the prior paragraph). These do not include CEE non-incentive costs, which in 2025 added 4.4% (CEE 2026). Based on the 2025 program costs and savings, and assuming a 14-year average measure life (K. Funk, senior director of commercial and industrial programs, CEE, pers. comm., March 2026), the average cost per kWh saved is \$0.0261 and the average cost per therm saved is \$0.261.

There is not sufficient savings or spending data to calculate the cost of saved energy for the Connecticut and Massachusetts programs, nor is there sufficient data on loan costs to calculate a cost of saved energy for the PG&E program.

Exemplary program design and marketing features

Based on the case studies above, key program features include the following:

- *Offer one-stop-shop services:* Small business customers have limited time and programs need to make it as easy as possible for them to participate. *Recruit via trusted organizations such as restaurant and retailer associations.* Door-to-door recruitment is promising, as is shown by the Massachusetts and Connecticut Main Street program.
- *Direct more attention to non-lighting measures.* There are many different measures that should be included. ComEd has a list of more than 100 measures; about half are lighting. Additionally, the Minnesota CEE case study includes a list of some specific HVAC and refrigeration measures.
- *Ongoing, high-quality training for program contractors is important* and helps them to learn about the latest savings opportunities and how to install them. All of the case study programs do this.
- *Regularly interview customers and contractors* about how the program is working and use this input to improve programs, as the ComEd program is doing.
- *Special efforts may be needed to target the smallest customers and environmental justice communities* so that these customers are not underserved. Examples include the Massachusetts and Minnesota programs.
- *For costs not covered by incentives, financing is sometimes needed.* Zero-interest loans can be particularly attractive if a source of free capital such as from electric rates, or funds to subsidize interest rates, can be found.

Summary and recommendations

Small business customers have limited time and can be difficult to reach. They tend to under participate in programs relative to larger customers, as shown by the Massachusetts data summarized in the introduction to this chapter. Reaching these customers generally requires a direct-installation approach where the customer simply has to say “yes.” The most effective programs have reached more than one-third of eligible customers and reduced energy use by these customers by 10% or more. We recommend

⁶⁴ We allocated total program costs to electricity and gas based on total Btu savings, and valued electricity at 10,000 source Btu per kWh.

that all program implementers offer these programs and build on the lessons from the leading programs.

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Multifamily building retrofits

Synopsis

Compared to single-family homes, multifamily buildings face additional challenges when pursuing retrofits. Program administrators serving multifamily buildings will need to consider competing priorities between landlords and tenants as well as common area versus in-unit upgrades. This chapter discusses examples of successful strategies for multifamily retrofit programs for all income levels.

Data summary

Available savings in 2035 from 2026–2035 programs:

9 billion kWh (TWh) of electricity (11th of 13)

21 trillion Btu of fuels (10th of 13)

1,800 MW of summer peak demand reductions (13th of 13)

3,300 MW of winter peak demand reductions (11th of 13)

Cost per kWh saved: \$0.030–0.054

Introduction

Residents of multifamily buildings—those with five or more residential units—are generally harder to reach for energy efficiency programs than residents of single-family homes. There is frequently a split incentive between the landlords who pay for energy upgrades and the tenants who reap the benefits of lower utility bills, and overcoming this is necessary for deploying more residential retrofits in multifamily buildings.

Multifamily retrofit programs can offer upgrades for both common area spaces and individual units. Such improvements can lower energy burdens for vulnerable households and operating costs for building owners (Samarripas and Tanabe 2020; Taylor, Searcy, and Jones undated). Program administrators typically engage building owners and managers for program enrollment (Johnson 2013; Ross, Jarrett, and York 2016); some programs allow individual tenants to enroll after gaining their landlord's permission. Maximizing energy savings requires a whole-building approach that upgrades common areas and individual units.

Technologies and approaches

Multifamily program offerings can range from simple direct installation measures such as efficient lamps and showerheads to energy-efficient consumer appliances and financial incentives for more advanced upgrades such as heating and cooling upgrades and electrification.

Direct installation measures

Direct installation measures such as LED lighting, faucet aerators, and low-flow showerheads are common in multifamily programs because they are easy and inexpensive to provide to multiple units at once. These upgrades typically result in modest savings, but they offer an opportunity for contractors to directly engage residents and steer them toward deeper energy savings (Mah and Sussman 2023). More importantly, direct installation measures are almost always offered at no cost to the customer, which means they avoid the split incentive problem and contribute to a building's overall savings.

Energy-efficient appliances

Installing energy-efficient appliances or providing rebates for such appliances can also help multifamily buildings save energy. ENERGY STAR refrigerators, cooking equipment, washing machines, and dryers are some appliances that a program can provide. Energy bill savings are most apparent over the lifetime of a product. For example, an ENERGY STAR refrigerator can save \$260 over its lifetime and an ENERGY STAR washing machine can save \$360 (ENERGY STAR 2022). Combining direct installation measures with appliance rebates can make building owners open to more advanced upgrades that produce deep, whole-building savings (Drehobl, Ross, and Ayala 2020).

Weatherization

Weatherization is beneficial for market-rate multifamily buildings because adding insulation and air sealing reduces heat loss and gain and thus minimizes heating and cooling costs. For multifamily residents, these upgrades are also helpful for blocking outdoor noise (Efficiency Maine 2026). Additionally, weatherization can reduce costs for multifamily residents whose buildings lack central air-conditioning and rely on inefficient window air conditioners (Samarripas and Tanabe 2020). Such improvements are vital to implement before a building pursues more advanced upgrades like building electrification.

Additionally, air sealing and insulation block air pollutants from entering the home, which improves indoor air quality. Thus, residents have fewer exposures to respiratory health risks and can save money on their healthcare costs (Norton et al. 2016). Improvements to the building envelope also help ensure indoor temperatures stay cool during the summer and warm during the winter. These upgrades often result in greater tenant satisfaction and willingness to renew a lease, and can even inspire residents to ask about energy efficiency when considering new housing (Philbrick, Scheu, and Evens 2014).

Advanced upgrades

Although advanced energy upgrades such as building electrification and solar installation can produce multiple health and bill savings benefits for multifamily residents, providing them can be difficult. For example, some multifamily buildings have one central water heating system, and others have many water heaters that serve individual units. To install a heat pump water heater, contractors need to overcome unique retrofitting challenges. Central water heaters require accurate sizing and intricate design configurations, and in-unit water heaters need adequate ventilation and space (Dombrovski et al. 2024). Educating contractors to handle the different obstacles of multifamily electrification can increase the deployment of upgrades.

Connecting multifamily residents with community solar programs can bring solar power to renters who cannot install panels on their roofs (DOE 2026). Programs can include special accommodations for renters who may not remain in their homes for a long period of time: For example, programs that allow subscription transfer or termination without penalty can protect renters from steep cancellation fees if they need to relocate before their subscription ends (Hausman 2022).

Implementing energy efficiency upgrades before pursuing electrification or solar installation is important for maximizing cost savings and resilience benefits. Weatherization improves the performance of HVAC systems due to the systems not needing to expend as much energy to heat or cool a room to a comfortable temperature. Weatherizing an electrified home can help save between \$150 and \$1,200 a year on utility bills (Specian and Aquino 2026). Additionally, in case of a power outage, solar PV installations with battery back-up systems can provide energy (Samarripas and York 2018).

Examples of successful programs

Rocky Mountain Power and Resource Smart's Wattsmart Multifamily Program

The Wattsmart Multifamily program serves multifamily buildings with at least four units. Eligible customers include market-rate properties, affordable housing properties, and mixed-use buildings. Customers first receive a free energy audit and then a report that documents their eligible rebates. To encourage high energy savings, the rebates are given as dollar amount per kWh saved, with higher rebates for income-eligible properties. Incentives are based on estimated first-year annual savings; eligible upgrades include windows, HVAC, heat pump water heaters, appliances, and lighting (Rocky Mountain Power undated).

The program has grown rapidly since inception in 2018. In 2025 it achieved 38 million kWh of savings across 15,537 households, an average of 2,446 kWh saved per home. Many of these savings are due to widespread heat pump adoption, as the program installed 6,739 heat pumps across 123 properties that year (N. Grahf, program manager, Resource Smart, pers. comm., April 2026). The program's operations have remained cost effective even when devoting more than 50% of its budget to low-income customers (ACEEE 2024).

Targeted communication is key to large energy savings. The program administrators acknowledge that a challenge of retrofitting multifamily buildings is identifying the correct decision-makers. As a result, they seek to engage with retrofit organizations promoting heat pump adoption, contractors with experience combining financial incentives to reduce upfront costs, and even large property developers looking to construct new projects in the Southwest. Program administrators have also used word-of-mouth references from local trade allies to recruit new potential customers. Ultimately, they work to convince property owners that energy efficiency investments are sound investments (N. Grahf, program manager, Resource Smart, pers. comm., April 2026).

California Department of Community Services and Development's Low Income Weatherization Program for Multifamily

California's Low Income Weatherization Program (LIWP) for Multifamily offers energy efficiency upgrades, solar installation, and building electrification for multifamily buildings where at least 66% of residents are at or below 80% of area median income. Program participants first receive free technical assistance and then are eligible for financial incentives. Eligible energy efficiency measures include weatherization, water heating upgrades, and efficient appliances. Participants receive financial incentives after installing upgrades that result in a least 15% modeled energy savings (LIWP-Multifamily 2026). The program offers tiered incentives for both residents and building owners, depending on who pays for utilities. Incentives are given as a dollar amount per greenhouse gas (GHG) emissions saved (\$/tonne CO₂e), which encourages building owners to pursue deep decarbonization.

The LIWP Multifamily program started in 2014 and has since completed 15,828 projects, serving more than 39,570 households. On average, they estimate that properties achieve energy savings of 58%⁶⁵ (California Housing Partnership, Association for Energy Affordability, and California Climate Investments 2026). Thus, this program emphasizes deep energy savings on a limited number of projects each year. As

⁶⁵ This value represents a modeled energy savings calculation. In addition to efficiency measures, the model counts PV installation toward energy savings, which explains the high percentage (A. Rodriguez, senior sustainability program associate, California Housing Partnership, pers. comm., May 2026).

of February 2025, the program has achieved annual energy savings of 19.3 million kWh and annual GHG emissions reductions of 13,845 MT CO₂e (Hill 2025).

The funding comes from California's Cap-and-Invest (previously known as Cap-and-Trade) program. Tying LIWP's goals to GHG reduction rather than direct energy savings allows for non-prescriptive measures: Building owners choose from a menu of options that lead to significant energy savings. As a state-funded program, LIWP can partner with utilities or local programs to supplement funding and existing resources. The program's wide range of available upgrades, free technical assistance, and tiered incentives have contributed to its large energy savings; some projects have even achieved near net-zero energy (S. Hill, director of low-income programs, Association for Energy Affordability, pers. comm., March 2026).

Maryland Department of Housing and Community Development's Multifamily Energy Efficiency and Housing Affordability Program

The Maryland Department of Housing and Community Development (DHCD) runs the Multifamily Energy Efficiency and Housing Affordability (MEEHA) Program to serve affordable multifamily rental housing. Customers can apply to the program directly or through DHCD's rental lending program. The EmPOWER track awards grants to buildings where at least 20% of the units are affordable for residents who make 80% or below area median income. Other buildings, such as naturally occurring affordable housing, can receive 0% deferred loans to supplement grants (S. Falvey and N. Tran, Maryland DHCD, pers. comm., April 2026). After completing an energy audit, participants receive funding for mandatory air sealing and insulation. Additional funds can support appliances, hot water, HVAC, lighting, windows and doors, electrification, and health and safety measures (Maryland DHCD 2026).

Since the program's launch in 2012, it has served 28,100 residential units and 3,700 participants on a commercial meter. DHCD spends about \$5,100 per unit; average energy savings per home are 10–12% (S. Falvey, senior energy program manager, Maryland DHCD, pers. comm., April 2026).

Like many other multifamily retrofit programs, MEEHA has encountered obstacles related to the landlord-tenant split incentive. To help mitigate this, program administrators have highlighted benefits like improved property value, improved comfort and lower utility costs for tenants, and lower tenant turnover. Since MEEHA only covers 85% of project costs, building owners often need to be persuaded to cover the remaining 15% for upgrades. However, Maryland has a statewide Building Performance Standard (BPS) that requires multifamily and commercial buildings over 35,000 square feet to minimize their energy consumption and GHG emissions by 2040 (Maryland Energy Administration undated). Compliance with the BPS has been another motivator for customers to enroll in MEEHA (S. Falvey and N. Tran, Maryland DHCD, pers. comm., April 2026).

Austin Energy and CLEAResult's Multifamily Rebate Program

Multifamily properties in Austin can earn rebates for attic insulation, HVAC improvements, smart thermostats, and other energy-saving upgrades. Rebate amounts are calculated based on dollars per kWh saved, with different program tracks setting maximum limits. The Multifamily Standard offering limits the rebate payment to 80% of project costs and the Multifamily Income Qualified track covers 100% of project costs (Austin Energy 2026a). When a property is enrolled in the program, a meeting is scheduled that includes Austin Energy, CLEAResult, and contractors to determine eligibility. If eligible, the property receives upgrades and subsequent quality assurance and quality control. The program caps expenditures at \$300,000 per property, which will often cover all costs for midsized, income-qualified properties (J. Galloway and J. Teng, Austin Energy, pers. comm., April 2026).

In FY 2024, the program served 11,614 housing units—8,063 standard and 3,551 income-qualified—and achieved 10,797 MWh of energy savings, 8,229 MWh from the standard offering and 2,568 from the income-qualified track. Austin Energy distributed \$4,055,353 in rebates to market-rate customers and \$1,513,135 to income-qualified customers (Austin Energy 2025).

The Multifamily program receives dedicated funding every year, but it attributes its high savings to strong relationships with contractors. Austin Energy and CLEAResult vet contractors and favor those with at least three years of experience. They also allow new contractors to enter the program slowly, by taking on smaller projects before advancing to larger properties; this gives them the opportunity to observe the new hires' work. The program administrators run criminal background checks and allocate budgets for contractor training and reimbursement. The Multifamily program's model depends on contractors forming relationships with participating buildings, and this allows scalability because the program is not tied to one provider (J. Galloway and J. Teng, Austin Energy, pers. comm., April 2026).

Participation rates

Multifamily programs often present their participation data by number of projects completed, which can refer to either buildings completed or number of units (households) served. California's LIWP for Multifamily served 15,828 households from 2014 to 2025 (California Housing Partnership, Association for Energy Affordability, and California Climate Investments 2026). Additionally, Maryland's MEEHA program has retrofitted 28,100 residential units and served 3,700 participants on a commercial meter since it launched in 2012 (S. Falvey, senior energy program manager, Maryland DHCD, pers. comm., April 2026).

Rocky Mountain Power and Resource Smart's Wattsmart Multifamily Program has served 81,451 multifamily units since it launched in 2018 (N. Grahf, program manager, Resource Smart, pers. comm., April 2026). Table MF 1 shows the yearly breakdown of number of customers served.

Table MF 1. Yearly participants from Rocky Mountain Power and Resource Smart's Wattsmart Multifamily Program

Year	Number of households served
2018	4,431
2019	6,906
2020	12,293
2021	9,965
2022	10,749
2023	9,987
2024	11,583
2025	<u>15,537</u>
Total	81,451

Source: N. Grahf, program manager, Resource Smart, pers. comm., April 2026

The Wattsmart program is only available to Rocky Mountain Power's Utah customers, but it has been successful in retrofitting the state's multifamily housing stock. Since launch, it has retrofitted 43.2% of

available multifamily units in Utah.⁶⁶ That is an average annual retrofit rate of 5.4%, which is incredibly ambitious. For comparison, Maryland’s MEEHA program has an annual retrofit rate of 1.3%.

For the other programs in our case studies, there were insufficient data to calculate their participation rates.

Energy savings and peak demand reductions

Samarripas and Tanabe (2020) estimate that retrofitting the top quartile of high energy-consuming multifamily buildings can produce multifamily residential energy savings of 17% nationally. As noted above, though, the California Weatherization Program claims nearly 60% savings.

We estimate summer and winter peak savings with data from Mass Save’s Residential Turnkey Solutions (5+ Units) (Mass Save 2025). To estimate peak savings, we multiply the ratio of summer and winter peak savings by total annual savings. Our calculations are summarized in table MF 2. We find 9 TWh of potential electricity savings in 2035 and substantial peak demand and fuel savings. Savings are relatively small compared with other programs due to the modest size and energy use of many apartments.

Table MF 2. Energy and peak demand savings from multifamily retrofit programs

("x" designates multiplication)	Value	Units	Comments
	1,577	TWh	2035 residential gross end-use electricity consumption (EIA 2026)
x	73%		Percentage of residential housing stock not covered by low-income program
x	15%		Multifamily (MF) homes in 2035 as percentage of total building stock electricity use, based on analysis of 2020 RECS microdata
x	40%		Estimated percentage of MF units that receive comprehensive retrofits, based on rounding Wattsmart Multifamily Program's annual retrofit rate of 5.4% down to 4%, as the higher level of participation will be hard to maintain for a decade
x	13%		Average per-unit annual energy savings for Wattsmart Multifamily Program
=	9	TWh	Annual energy savings
x	196		Ratio of summer peak savings (MW) to annual savings (TWh) for multifamily retrofit programs; average of Texas and Massachusetts (Nadel, Amann, and Chen 2023; Mass Save 2025)
=	1,759	MW	Summer peak savings

⁶⁶ Utah contained 235,897 occupied multifamily units in 2024 (Census Bureau 2024). A Rocky Mountain Power serves roughly 80% of the state (N. Grahf, program manager, Resource Smart, pers. comm., April 2026), this translates to 188,718 units eligible for Wattsmart. This number may slightly overestimate the number of eligible homes due to the American Community Survey counting three-unit and four-unit apartments in a single category; Wattsmart requires apartments to have at least four units.

("x" designates multiplication)	Value	Units	Comments
x	363		Ratio of winter peak savings (MW) to annual savings (TWh) for multifamily retrofit programs; average of Texas and Massachusetts (Nadel, Amann, and Chen 2023, Mass Save 2025)
=	3,258	MW	Winter peak savings
	4,562	Trillion Btu	2035 residential natural gas delivered energy (EIA 2026)
x	73%		Percentage of residential housing stock not covered by low-income program
x	13%		Multifamily homes in 2035 as a percentage of total building stock gas use, based on analysis of 2020 RECS microdata
x	40%		Estimated percentage of homes that receive comprehensive retrofits, based on rounding Wattsmart Multifamily Program's annual retrofit rate of 5.4% down slightly, as this level of participation will be hard to maintain for a decade
x	12%		Average per-unit annual energy savings for Maryland DHCD's MEEHA program
=	21	TBtu	Annual energy savings (other assumptions same as for electricity)

All data from Wattsmart Multifamily Program provided by N. Grahf at Resource Smart; all data from Maryland DHCD's MEEHA program provided by S. Falvey at Maryland DHCD.

Typical costs and cost of saved energy

In 2025 Rocky Mountain Power and Resource Smart's Wattsmart Multifamily Program spent \$13.44 million (N. Grahf, program manager, Resource Smart, pers. comm., April 2026). This amounted to roughly \$865 spent per household. Assuming an average measure life of 15 years and a 3% real discount rate, the cost of saved energy was \$0.030 per kWh. For cost-effectiveness testing, Rocky Mountain Power blends its multifamily projects into a broader residential portfolio. The utility conducts program-level cost-effectiveness testing before making significant changes to the program.

For FY 2025, Austin Energy distributed \$4.38 million in rebates for its multifamily program. Assuming the utility spends 45% of its energy efficiency budget on administrative costs,⁶⁷ the total program costs amounted to roughly \$6.35 million. The multifamily program achieved 9,811 MWh of savings (Austin Energy 2026b), and thus the cost of saved energy is about \$0.054.

California's Low Income Weatherization Program for Multifamily reported program funding of \$124.89 million by the end of 2024. The program is not required to meet cost-effectiveness rules but has conducted analyses of bill impacts for individual properties. For example, benchmarking results from

⁶⁷ This estimation comes from an average of non-incentive spending across three statewide energy efficiency programs between 2015 and 2024 (Opinion Dynamics and ACEEE 2026).

one Sacramento apartment complex showed that the building saved \$214,373 after accounting for total electricity and gas savings (Hill 2025).

Exemplary program design and marketing features

Program administrators can learn many program design and marketing lessons from our case studies. We list some examples below. Additional recommendations come from R2E2 (2024), Tanabe (2021), and Ross, Jarrett, and York (2016).

- *Identify the key decision-maker for each project.* Depending on the property, that person could be the building owner, the building manager, the property developer, or another stakeholder.
- *Offer free technical assistance to walk the customer through the whole project.* This is especially important if working with customers who have very different roles, for example a building owner and a building manager.
- *Engage decision-makers when they are planning other capital improvements and are more open to pursuing retrofits.*
- *Make the business case to building owners to pursue upgrades.* In addition to lower operating costs, energy upgrades can lead to better tenant satisfaction and retention.⁶⁸
- *Integrate financial models that avoid the landlord-tenant split incentive.* For example, a program can offer incentives for both common area spaces, to benefit landlords, and in-unit upgrades, to benefit tenants.
- *Continuously vet and train contractors* to ensure they can do high-quality work and navigate challenges that may arise from upgrading multifamily buildings.
- *Serve both homeowners and renters* and make it easy for renters to gain their landlord's permission to install upgrades.
- *Engage renter groups* to learn about tenants' needs and their ideas to improve rental housing.
- *Minimize temporary disruptions and create relocation plans if necessary* when conducting upgrades. Be transparent about how upgrades will affect tenants' day-to-day life and provide funds or referrals for temporary relocation if needed.
- *Offer higher incentives and special services to multifamily affordable housing.* Establish an eligibility threshold that can include many properties: For example, a program could require at least 20% of the units to serve households that make 80% or below area median income.
- *Preserve affordability after upgrades through affordability covenants* that limit rent increases for a set amount of time after upgrades.⁶⁹
- *For multifamily affordable housing, partner with utilities, advocacy groups, local public housing authorities, and state housing finance agencies* to consolidate resources and funding.

⁶⁸ As one example, in a study by Philbrick, Scheu, and Evens (2014) that surveyed residents of a Chicago apartment complex that received retrofits, 70% said "they were likely or very likely to renew their lease" (p. 12).

⁶⁹ For example, Knoxville's Rental Rehabilitation Program awards loans for energy conservation measures and other upgrades. Depending on the loan amount, landlords must maintain minimum affordability periods of 5–15 years after rehabilitation (City of Knoxville 2026).

Summary and recommendations

Multifamily buildings can be difficult to retrofit, but multiple programs across the country address the common tenant-landlord split incentive while delivering large energy savings. Programs that combine direct-install measures for individual units and advanced, systemwide upgrades like weatherization, HVAC, and solar installation for the entire building can benefit both tenants and landlords. Intentional, targeted communication is essential for gaining buy-in from building owners and hiring contractors who can perform high-quality work. Offering higher financial incentives for multifamily affordable housing can make upgrades more accessible, attract more participants, and generate more energy savings. These practices can help the multifamily building sector move toward its potential to substantially reduce energy consumption.

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Smart thermostats

Synopsis

Smart thermostats can reduce heating and cooling energy use by an average of about 8%. They can also be used in demand-response programs to reduce summer and winter peak home energy demand by nearly 1 kW per home. This program has among the highest peak demand and fuel savings of the programs we examine.

Data summary

Available savings in 2035 from 2026–2035 programs:

9 billion kWh (TWh) of electricity (seventh of 13)

64 trillion Btu of fuels (fourth of 13)

36,000 MW of summer peak demand reductions (first of 13)

22,000 MW of winter peak demand reductions (first of 13)

Cost per kWh saved: ~\$0.036.

Introduction

Smart thermostats provide energy savings and demand reduction by simplifying residents' control and management of air-conditioning and heating systems, and by adjusting to variations in home occupancy patterns. Like programmable thermostats, smart thermostats save energy by raising cooling temperature setpoints and lowering heating setpoints when the home is unoccupied or while occupants are sleeping. Smart thermostats have the potential to save more energy than programmable thermostats because they automate setpoint changes, respond to actual home occupancy, and allow for remote operation and control.

Smart thermostats can also be used to reduce peak electric demand by automatically adjusting interior temperatures by a few degrees during critical peak periods. Residents need to give permission for these adjustments—typically by enrolling in a program that provides a seasonal or annual payment for participation—and residents can override the automatic adjustment if they are uncomfortable. Due to this remote control, it is also possible to adjust the thermostat to precool or preheat a home by a few degrees prior to the critical peak period, so that the home can glide through the critical peak period with no or reduced HVAC system operation. Due to these various control options, and the substantial savings that we estimate can be achieved, smart thermostats are a key component of many virtual power plant initiatives.

While many homes can use a smart thermostat, there are some exceptions. For example, smart thermostats are not designed for use with zonal heating systems like baseboards and built-in wall heaters, or ductless heat pumps. Consumer Reports (McCabe 2023) notes that for homes with low heating and cooling energy use, energy and bill savings will be small. They also note that in homes where the thermostat is regularly turned down at night and when the home is unoccupied, savings will be smaller. The same applies to homes that are generally occupied during the day. Finally, they note that older HVAC systems without a “C-wire,” a dedicated power line for the HVAC system, will only work with some smart thermostats. The *New York Times* (Quaglia 2025) quotes engineers who note that smart thermostats are less effective with systems that take a long time to heat up, such as radiant

floors. ENERGY STAR (2026) suggests that the very highest efficiency heating and cooling equipment like an air conditioner rated at 20 SEER or higher may require a controller from the same company, as many of these products are optimized for use with a matching thermostat. Major manufacturers such as Google Nest and Ecobee have online compatibility check tools.

Smart thermostats were first commercialized in 2011 (Snell and Valentine 2020) and since then have gradually been adopted by American homeowners. Parks Associates (2025) estimates that as of mid-2025, 16–17% of U.S. households with internet have a smart thermostat. Ramirez (2025) estimates a higher percentage—28% of U.S. homes as of mid-2025. An ENERGY STAR survey of partners estimates that 4.3 million connected thermostats were shipped in 2023, representing 48% of thermostat shipments that year (Energy Star 2024). An industry expert told us that sales peaked a few years ago, when many young homeowners were attracted to the features of smart thermostats. Following these early adopters, sales have been steady but not quite as high. Parks Associates (2025) estimates that in 2030, U.S. sales will reach 8.1 million units, with annual revenues of over \$1.1 billion. This implies a substantial increase in sales relative to the 2023 ENERGY STAR data. The sales and revenue estimates from Parks make for an average 2030 price of about \$140 per thermostat.

Technologies

We define a smart thermostat as a device that meets the specification of the ENERGY STAR connected thermostat program (Energy Star 2026). This requires demonstrating at least 8% heating and cooling energy savings in a sample of homes and having a Wi-Fi connection.

This chapter focuses on smart thermostats that are certified by EPA to meet the ENERGY STAR smart thermostat specification. As of early 2026, over 100 thermostat models were listed from 29 manufacturers (Energy Star 2026). According to Parks Associates (2025), the top brands in terms of ownership are Google Nest, Honeywell Home, Ecobee, and Amazon. In 2020, E Source found 168 demand-side programs that had smart thermostats, including 49 with marketplaces selling smart thermostats (Snell and Valentine 2020). Below we profile two of these programs.

Examples of successful programs

CPS Energy WiFi Thermostat and smart thermostat programs

CPS Energy, a municipally owned utility serving San Antonio, Texas and the vicinity, has operated various thermostat programs for more than a decade. Presently it offers the Bring Your Own Thermostat program (BYOT) in which a customer purchases and installs an eligible thermostat from more than 30 eligible models and enrolls in the WiFi Thermostat Rewards program. Customers receive an \$85 bill reduction when they enroll, plus an annual participation fee of \$30 that is payable each fall. Enrolling gives the utility permission to modify thermostat settings during critical peak periods, but customers can override the utility control. During these events, the utility will make small temperature changes of around 3°F, precool the home prior to the event, and then allow the temperature to gradually rise during the three-hour event. At times, special offers are made; one example is a special winter demand reduction program during the winter of 2025–26, in which customers who enrolled in late 2025 received a \$150 bill credit and an additional \$20 bill credit in the spring if their thermostat was controlled by the utility during the winter (CPS Energy 2025b). CPS Energy is discussing potential expansion of its winter program in future years as the Texas power grid increasingly looks for both summer and winter demand reductions.

Since 2017, CPS Energy has also offered a Direct Install Thermostat program through its weatherization and Home Energy Assessment programs. This provides free thermostats and installation for customers as part of these other services. To receive a free thermostat, customers need to enroll in CPS Energy's WiFi Thermostat rewards program. For Direct Install, the average cost to the utility is about \$190 per thermostat, including installation. For several years, the company also operated a Mail Me a Thermostat program that provided free thermostats to customers who enrolled in the WiFi Thermostat Rewards program. This last program is no longer enrolling new customers because evaluations found that only 40–50% of customers felt comfortable installing their own thermostats. Though CPS Energy mostly helped the Mail Me a Thermostat customers who had installation and maintenance issues over the phone, they sometimes had to send a technician to address problems, and that added expense. For this reason, among others, they prefer the BYOT program (A. Lozano, director of technology & product innovation, CPS Energy, pers. comm. January 2026).

Since 2003, CPS Energy has offered pager-style thermostats through its Peak Saver program and these would cycle air conditioners on and off during load-control events. The program is still operational, but customers are gradually being converted to Wi-Fi thermostats through a Smart Thermostat Upgrade program (CPS Energy 2025b).

A spring 2025 program evaluation listed nearly 46,000 devices in the WiFi Thermostat Rewards program plus another 17,000 through the Direct Install program. There were also 86,500 devices in the legacy load-control program (CPS Energy 2025a). CPS Energy has about 900,000 residential customers and thus about 7% of these customers are participating in the Wi-Fi and direct installation programs, and an additional 10% in the legacy load-control program. CPS Energy estimates a benefit-cost ratio of 7.99 for its BYOT program, based on a utility cost test, and 4.91 for the direct install program (A. Lozano, director of technology & product innovation, CPS Energy, pers. comm. January 2026).

Commonwealth Edison smart thermostat program

Commonwealth Edison (ComEd), the utility that serves Northern Illinois, including Chicago, has one of the largest smart thermostat programs in the country. Launched in 2016, it was designed to accelerate the adoption of smart thermostats across ComEd's service territory and ensure that income-eligible customers could also benefit from the technology. As of mid-2025, ComEd had provided incentives for about 640,000 smart thermostats (ComEd 2025). This is about 17% of ComEd's 3.75 million residential customers.

Currently, the program features multiple paths: rebates for qualifying thermostats purchased and installed by the customer, midstream incentives for qualifying thermostats purchased and installed by a participating Heat Pump Trained Contractor, and thermostats installed as part of a single or multifamily assessment visit. For the rebates, customers can purchase from a participating retailer and have the rebate deducted from the purchase price—this is an instant coupon that is only available at a limited number of retailers—or they can purchase the thermostat and apply for the rebate afterward. The ComEd rebate is presently \$75, and additional incentives may be available from local gas utilities. In the past, the company tried higher and lower incentives and has determined that \$75 best balances participation and costs. ComEd periodically also runs targeted limited-time offers that provide higher incentives to a preselected group of income-eligible customers. These offers typically apply to the first 10,000 or 20,000 eligible customers who respond, and ComEd often partners with manufacturers who support these limited-time offers by providing preferential pricing, marketing assistance, and/or free C-wire adapters, all of which help to further reduce barriers to participation.

Heat Pump Trained Contractors may apply a \$75 incentive to a customer's invoice when installing a qualified ENERGY STAR smart thermostat with the installation of a qualified heat pump (air source or

ductless). In 2025 approximately 3% of midstream heat pump invoices included an incentive for a smart thermostat (R. Tonielli, senior energy efficiency program manager, ComEd, pers. comm., August 2026).

For thermostats installed through an assessment visit, ComEd partners with the natural gas utilities in northern Illinois to deliver in-person assessments for income-eligible single-family and multifamily customers through the Home Energy Savings and Multi-Family Energy Savings offerings. During these visits, customers are evaluated for smart thermostat eligibility, and qualifying customers receive a smart thermostat at no cost, including installation. Programmable thermostats are available to these customers as well. (P. Grimyser, residential channels manager, Energy Efficiency Services, Commonwealth Edison, pers. comm., January 2026).

Participation rates

As noted above, CPS Energy reports that 7% of their residential customers are enrolled in their WiFi Thermostat Rewards program, plus another 10% of customers in their legacy load-control program that are gradually being moved into the WiFi Thermostat program. For ComEd, about 17% of their residential customers have received thermostats under their program. As discussed earlier, Parks Associates (2025) estimates 8.1 million smart thermostats sold in 2030, with sales ramping up from 2025 to 2030 and the ramp continuing after 2030. Assuming 8.1 million units is the average annual sale over the 2025–2035 period, this is about 55% of the number of U.S. homes in 2035. We assume that thermostats installed prior to 2025 will be replaced during the 2025–2035 period, based on a conservative estimate of a 10-year average life for smart thermostats (Lennox 2026). These sales will be driven by the growing number of manufacturers and contractors who recommend these thermostats when new equipment is installed.⁷⁰

Energy savings and peak demand reduction

Google Nest (2024) summarizes a variety of independent studies on energy savings with its thermostats, and finds average heating savings of 10% and average cooling savings of 13%. Google adds 1.8% heating savings and 1.5% cooling savings for programs that participate in Google Nest’s Seasonal Savings program, which adjusts thermostat settings on peak days. ENERGY STAR (undated a), *Consumer Reports* (McCabe 2023), and E-Source (Snell and Valentine 2020) also reviewed a variety of energy savings estimates and found 8–10% net savings: ENERGY STAR found 8%, a figure cited by *Consumer Reports*, and E-Source found 10%. To be conservative, we use 8% in the calculations below. This is an average and individual homes will vary. Note that energy savings from smart thermostats can be hard to estimate because smart thermostat adopters tend to be younger than the average consumer; results can be skewed when the comparison group is not similar (Stewart et al. 2023).

Peak demand savings come in two ways. First, some customers participate in demand-response programs. We estimate that by 2035, half of customers with smart thermostats will be enrolled in demand-response programs, either because they opt into these programs or because their utilities run these programs on an opt-out basis. We are not aware of any solid estimates of future demand-response program participation; our 50% estimate is based on the current 17% participation rates in the CPS Energy and ComEd programs relative to a rough estimate of the share of households with smart

⁷⁰ Some manufacturers recommend their own proprietary smart thermostats that are optimized for their systems instead of more generic systems from such manufacturers as Nest and Ecobee.

thermostats.⁷¹ Second, those customers who do not participate in demand-response programs achieve passive demand savings because a portion of their kWh savings are during peak periods. To estimate these savings, we use residential HVAC load shapes as estimated in the HVAC chapter of this report.

Regarding demand-response savings, E-Source (Snell and Valentine 2020) estimated an average peak demand saving from smart thermostats of 0.5–1.5 kW per central air conditioner. Opinion Dynamics published a study estimating average peak demand reductions of 0.97 kW for a four-hour load-control event. Renew Homes (2024) summarizes the results of 10 independent studies on summer peak load savings. Individual programs range from 0.59–1.29 kW per thermostat, with an average of 0.93 kW. One of these studies, on a program operated by Portland General Electric, found that savings were highest in the first hour of the event but then degraded about 30% in each subsequent hour as more customers overrode their controls in search of comfort (Cadmus 2021). Based on these data points, we estimate average summer peak savings from load flexibility of 0.93 kW.

Regarding winter peak demand-response program savings, we found two data points. First, the Portland General Electric study noted above also had cold winter morning demand-response events. In the second year, after a few first-year bugs were worked out, these homes had average winter peak savings of about 0.83 kW per thermostat, the same as the summer peak savings (Cadmus 2021). Second, Renew Home performed several tests of its network of about 12,000 smart thermostats installed in homes with electric heat pumps during a polar vortex affecting the Southeast U.S. in the winter of 2024–25. They found average demand reductions of about 1 kW per home during this two-hour event (Blasnik, Reid, and Lanzisera 2025). The average of these two studies is 0.915 kW per thermostat, a figure we use in our subsequent calculations. However, more data are needed to better estimate winter load shift savings.

These figures allow for the fact that some customers will use their thermostat to override utility control during load-control events. Research by Podolefsky et al. (2019) found that during a full summer, about half of enrolled customers never opt out of a demand-response event (they call them “reliable participants”), about 40% opt out less than half the time (they call them “best-effort participants,” who try to cope but sometimes opt out), and about 10% opt out more than half the time (they call them “comfort seekers,” who opt out as soon as they feel uncomfortable). The study found that opt-outs are more frequent with higher outdoor temperatures and humidity, longer events, and events that last later into the evening. They also found that opt-outs were lower for an incentive structure where the annual customer incentive depended on regular participation, for example at least 75% of the time.

Based on the savings per participant and other data, we can estimate potential national energy and load flexibility savings from smart thermostats. Our calculations are provided in table ST 1. We estimate potential national average energy savings of 16 TWh (billion kWh): 35 GW (1,000 MW) of summer peak load reductions and 21 MW of winter peak load reductions in 2035, after 10 years of program operations. We also estimate 108 TBtu of natural gas savings from reduced gas use for space heating. Our summer peak savings estimate is less than the nearly 70 GW estimated as possible by Renew Homes (2024). In our summary tables that add up savings for all programs, we only include half of the TWh and TBtu saving and half of the passive peak demand reductions, as the other half will be due to increasing market adoption and not due to energy efficiency programs. But we assume that all the demand-

⁷¹ As noted earlier, the Ramirez (2025) estimates that 28% of U.S. households have smart thermostats. We increase this somewhat to allow for an additional year of market growth and for the fact that market share is likely to be higher in areas with active thermostat programs.

response peak load reductions will be due to utility programs, as peak load management will rarely happen without a utility role.

Table ST 1. Electricity and natural savings and electric peak load reductions in 2035 from smart thermostats

("x" designates multiplication)	Value	Units	Comments
	473	TWh	2035 residential electricity use for space conditioning (heating and cooling) (EIA 2026)
x	75%		Estimated percentage of homes with central cooling (67% in 2020; EIA 2023); we estimate that by 2035, 75% of homes will have central AC, and virtually all of these will be controlled by thermostats
x	8%		Average net energy savings as discussed in text
x	55%		Assumption for participation rate in 2035 based on Parks Associates (2025) estimate of sales in 2030 applied over 10 years.
=	16	TWh	Annual energy savings
x	0.000354		Peak kW/annual kWh: Average of data for Texas (Nadel, Amann, and Chen 2024) and Massachusetts (Guidehouse 2024)
x	50%		Percentage of households with smart thermostats who do not participate in demand-response programs (discussed in text); savings from those in demand-response programs are calculated below)
=	2759		Summer peak MW savings without demand response based on HVAC load shape
x	0.00098		Peak kW/annual kWh: Average of data for Texas (Nadel, Amann, and Chen 2024) and Massachusetts (Guidehouse 2024)
x	50%		Percentage of households with smart thermostats who do not participate in demand-response programs (discussed in text); savings from those in demand-response programs are calculated below)
=	7649		Winter peak MW savings without demand response based on HVAC load shape
	144.3	million	Number of homes and apartments in 2025 (EIA 2026)
x	75%		Percentage with central cooling (67% in 2020; EIA 2023), estimate 75% by 2035.

x	33%		Estimate that half of the 65% of homes with smart thermostats ultimately participate via opt-in or opt-out demand-response programs (rationale for "half" is discussed in the text)
x	0.93		Peak summer kW demand-response savings per home as discussed in text
=	32,714	MW	Peak summer demand-response savings
=	35,474	MW	Total summer peak savings (sum of savings with and without demand response)
x	30%		Percentage with central electric heating (24% in 2020; EIA 2023), estimate 30% by 2035
x	33%		Estimate that half of the 65% of homes with smart thermostats ultimately participate via opt-in or opt-out demand-response programs (rationale for "half" is discussed in the text).
x	0.915		Peak winter kW demand-response savings per home as discussed in text
=	12,875	MW	Peak winter demand-response savings
=	20,523	MW	Total winter peak savings (sum of savings with and without demand response)
	2,730	TBtu	2035 residential natural gas use for space heating (EIA 2026)
x	90%		Percentage that can use smart thermostats (ACEEE estimate); exclude space heaters and some very old systems
=	108	TBtu	Annual energy savings (other assumptions same as for electricity)

Typical costs and cost of saved energy

As noted above, Parks Associates (2025) estimates an average cost of about \$140 per smart thermostat. Individual thermostat models can range from roughly \$50–250 (Delaney and Greenwald 2025).

For a rebate program, the cost per participant is the rebate amount plus program marketing and administrative expenses. The most common rebate amounts are \$75–100 per thermostat. Marketing and administration costs average about 45% for a full-scale program, based on results in Oregon, Vermont, and Wisconsin (Opinion Dynamics and ACEEE 2026). For programs that provide and install thermostats, such as those for income-qualified households, the CPS Energy price of about \$190 per installed thermostat is a reasonable estimate (2025\$).

If we assume a cost of \$190, a 10-year measure life, 262 kWh and 15 therms per year in electric and gas savings, respectively, based on figures in table ST 1, and a 3% real discount rate, then the levelized cost per kWh saved is \$0.061—if we assign all the costs to the electric program (as would be the case for an

electric-only utility where the gas utility is not sharing costs). If costs are allocated to both electric and gas savings, the levelized cost is about \$0.036 per kWh, valuing electric savings as 10,000 source Btu per kWh (as would be the case for a dual fuel utility or where the gas and electric utilities share costs).⁷²

Exemplary program design and marketing features

These case studies and a variety of additional sources, including ENERGY STAR (undated b) and Whirtshafter, Peters, and Haeri (2018), support the following recommendations about exemplary program features:

- *Provide multiple assistance paths to install smart thermostats*, including rebates and discount coupons, direct installation as part of energy assessments and weatherization visits, and online marketplaces. This is what CPS Energy and ComEd are doing.
- *For low- and moderate-income customers, offer free or nearly free thermostats* to gain participation. These can be via direct installation programs or as part of higher incentives for low-income customers, as both the CPS Energy and ComEd programs demonstrate.
- *Offer customers multiple options and provide educational information* on the features and capabilities of each model to aid in making a choice. Different brands and models have advantages and disadvantages.
- *Rebates can help encourage purchases, and annual payments can help retain customers in load-control programs.*
- *Installation is key: Choose thermostat models that are easy to install and provide good instructions and how-to videos.* Offer live chat assistance for customers who have questions. For some customers, installation services are important. A thermostat that sits on a shelf does not save energy.
- *For thermostats purchased through the utility, allow customers to spread the cost over several utility bills.*
- *Customers need the option to opt out of specific load-control events* in order to agree to load control.
- *Employ a variety of strategies to minimize overrides*, including shorter control periods, precooling or preheating before load-control events, and optimizing temperature changes for each customer (Blasnick, Reid, and Lanzisera 2025).
- *Marketing and education materials should discuss both the energy savings to the customer and the load-control benefits to the community and utility system*, including how load control can help to reduce utility system costs.
- *Use the ENERGY STAR brand to help build trust.*
- *Incentivize heating and cooling contractors to install smart thermostats when they install new units.* This reduces disruption to consumers as the contractor is already in the home. It also minimizes the administrative burden on contractors.
- *A variety of load-control vendors and platforms can help utilities manage load-control events and analyze and report on results.* Smart thermostats have been a key component of many virtual power plant initiatives.

⁷² See footnote 7 for an explanation of why we use source energy in this calculation.

- For separate electric and gas utilities serving the same homes: Work together on a single program and share costs.

Summary and recommendations

Smart thermostat programs can produce large energy and peak demand savings with very high benefit-cost ratios. Consumers have substantial choice among products. Effective program designs are exemplified by CPS Energy and ComEd. Of the program types covered in this report, smart thermostat programs are among the easiest to implement and have the largest peak demand benefits. Many program implementers include smart thermostats in broad rebate programs, but focused attention results in much higher participation and savings, as demonstrated by CPS Energy and ComEd.

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Appliances and equipment

Synopsis

Although appliances and other equipment have improved substantially in efficiency since the 1980s, additional opportunities remain. A very cost-effective way for utilities to capture substantial savings is to work with federal and state governments to influence minimum efficiency standards and then receive partial credit for those savings. This chapter provides examples and estimates available savings.

Data summary

Available savings in 2035 from 2026–2035 programs:

6 billion kWh (TWh) of electricity (12th of 13)

2 trillion Btu of fuels (11th of 13)

4,200 MW of summer peak demand reductions (ninth of 13)

2,300 MW of winter peak demand reductions (10th of 13)

Cost per kWh saved: ~\$0.002

Introduction

In 2025 home appliances were estimated to use about 225 TWh,⁷³ or about 15% of U.S. residential electricity use (EIA 2025). Many of these products are covered by federal minimum efficiency standards. A variety of commercial equipment is also covered by standards, including commercial refrigerators and freezers, ice makers, and vending machines. In the industrial sector, electric motors, fans, pumps, and air compressors account for more than half of electricity use (Hasanbeigi 2017) and are covered by standards.

As a result of federal legislation passed in 1987, 1988, 1992, 2005, and 2007, about 60 products are currently regulated (ASAP 2026). Standards are periodically reviewed and revised by DOE, and as a result most regulated equipment types have steadily improved in performance. For example, figure A&E 1 illustrates performance improvements for residential refrigerators.

⁷³ This includes refrigerators, freezers, clothes washers, clothes dryers, dishwashers, and cooking equipment. We include furnaces, water heaters, and air conditioners in other sections of this report.

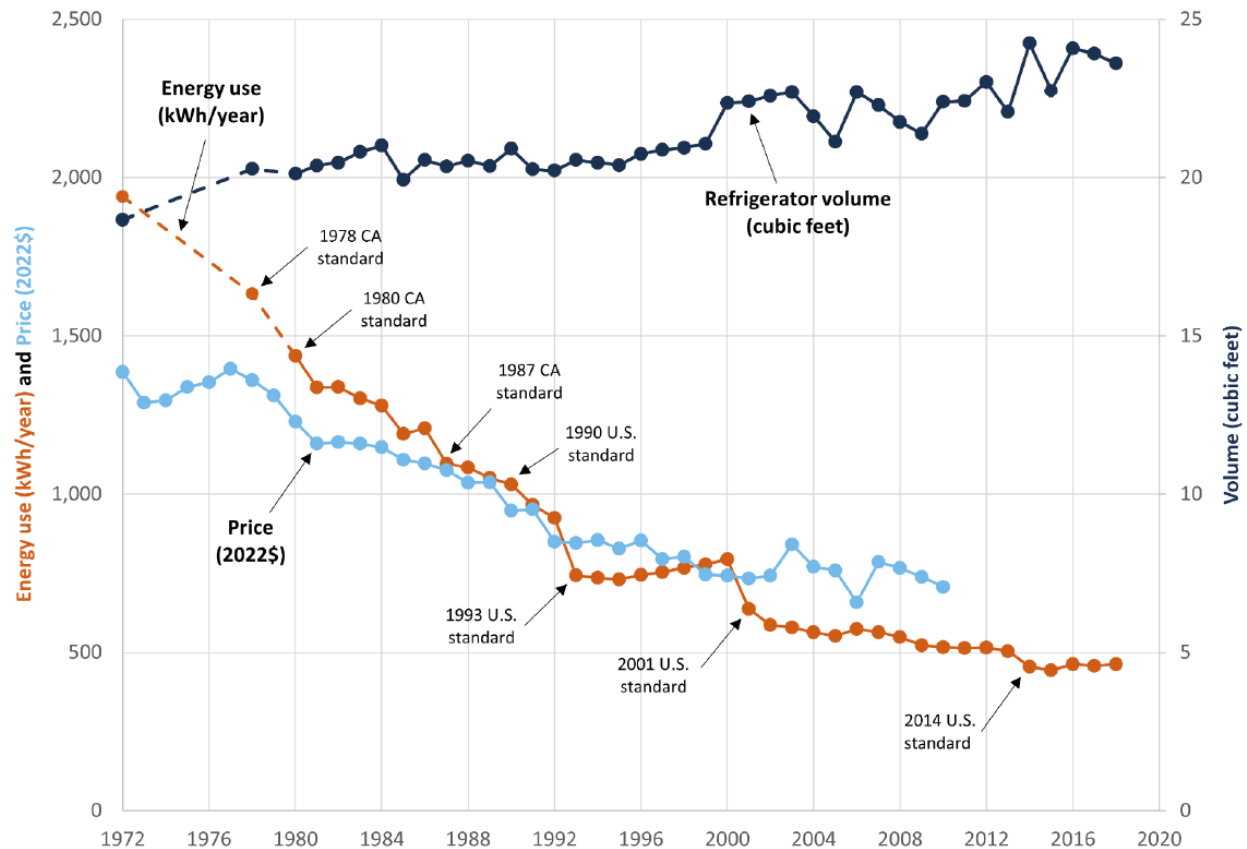


Figure A&E 1. Refrigerator efficiency progress. *Source:* Appliance Standards Awareness Project.

The remaining potential is exemplified by programs like ENERGY STAR: The ENERGY STAR specification for refrigerators generally requires 10% energy savings beyond federal minimum efficiency requirements (Energy Star 2021) and in 2023 an estimated 63% of refrigerators sold met the ENERGY STAR specification (Energy Star 2023). With modest per-unit savings, it is often challenging to design cost-effective programs to influence consumer purchases. To address this opportunity, some states give program implementers credit for the savings obtained through their research and advocacy for new product and building standards.

Examples of successful programs

Fourteen states plus the District of Columbia allow program administrators to claim energy savings credit for building codes and often also for appliance efficiency standards, and an additional five states are considering such credits (Garfunkel and Waite 2024). All 20 of these jurisdictions provide credit for building code savings, and 11 of the states allow credits for appliance standards. Below we discuss the California program because of its focus on appliances. Other states focus on buildings codes and are discussed in the new construction chapter.

California

For more than 20 years, California utilities have received energy savings credit for statewide codes and standards adopted because of their efforts. Utilities' federal standards efforts are also now included. Savings claims are reviewed by California Public Utilities Commission evaluators using a four-step

process: (1) calculating potential savings, (2) adjusting potential savings using survey-based compliance factors to derive gross savings, 3) adjusting gross savings to net savings by estimating through a Delphi panel what would have occurred had the standard not been enacted, and (4) estimating the share of net savings that is attributable to utility efforts, using a second Delphi panel (CPUC 2005). In recent years, the program has also included work on national model building codes, code compliance, and demand-flexible appliance standards that enable demand-response and daily load shifting. They have also increased work on product testing and test procedures to improve the relationship between test procedures and field performance (M. Anderson, principal program manager, PG&E, pers. comm. January 2026). In 2024 PG&E spent about \$35 million on the program, which was about 17% of the company's energy efficiency portfolio budget, not including income-qualified programs. Statewide in 2024, the program saved 3,390 GWh of electricity, not counting continued savings from activities in earlier years, and more than 5 trillion Btu of natural gas; it also reduced summer peak electric demand by about 690 MW. That same year the program accounted for over 75% of PG&E's electric savings (PG&E 2025).

Energy savings and peak demand reductions

In mid-2025, the Appliance Standards Awareness Project (ASAP) published an analysis of potential savings from the next round of federal efficiency standards (Margolis and Mauer 2025). They evaluated 49 product categories—28 residential and 21 commercial and industrial—and found potential energy savings in 2040 of 204 TWh, with summer peak demand reduction of about 32,000 MW. They estimated 2040 natural gas savings of 280 trillion Btu.

These estimates assumed that many new standards would be finalized over the 2025–2028 period. However, the Trump administration is instead working to roll back existing standards and appears unlikely to establish new, stronger standards. Also, since savings steadily mount as additional products are sold, energy savings will be substantially less in 2035, the target year for this report, than in 2040, as analyzed by ASAP.

To address these differences, at our request ASAP revised its appliance standards model to change rulemaking completion dates. Specifically, for products for which DOE previously issued a Notice of Proposed Rulemaking (NOPR) but not a final rule, they assume a revised NOPR in 2030 and a final rule in 2031. For all other products, they assume a NOPR in 2031 and a final rule in 2032. Based on these assumptions, they estimate that in 2035, new appliance and equipment standards will reduce electricity use by 18.3 TWh, summer peak electric demand by 12.6 GW, and natural gas use by 6.6 trillion Btu. We take one-third of these figures to estimate the savings that utility-funded programs might be able to claim, if these utilities are actively involved in the rulemaking. The one-third estimate is based on the Arizona experience as discussed in the new construction chapter. The other two-thirds of the savings total about 12 TWh and are not included in our savings calculations. To roughly estimate winter peak savings, we multiply by the ratio of winter peak to summer peak savings from past appliance standards, as estimated by Mauer and Margolis (2026). Using this ratio, winter peak savings are approximately 7,000 MW and of this, programs might be able to claim one-third.

Typical costs and cost of saved energy

A large utility with a very extensive effort, PG&E spends over \$30 million on its program. If we assume a 15-year average measure life and a 3% real discount rate, the cost of saved energy for PG&E is about

\$0.001 per kWh.⁷⁴ PG&E reports a benefit-cost ratio for its 2024 codes and standards program of over 35, using the program administrator cost test (PG&E 2025). This is a highly cost-effective program.

Other program implementors could have much lower annual spending. It could focus on a more limited number of products and potentially coordinate with and piggyback on the PG&E effort. We would recommend focusing particularly on products for which challenges in setting stronger standards have hindered large potential energy savings, such as residential central air conditioners and heat pumps. Such efforts could include incentives for the highest efficiency products, which would help build product availability and market share so that these higher efficiency levels can potentially be included in future standards.

Summary and recommendations

Appliance and equipment efficiency has steadily increased over the past few decades, driven by federal appliance and equipment efficiency standards and by voluntary programs such as ENERGY STAR. Substantial additional energy savings are available for many products, but the savings per unit are often too low to justify the cost of programs to influence retail purchases. Some program implementers are instead working to influence future efficiency standards at the state and federal levels, enabled in part by state policies that provide program implementers with energy-saving credits for their advocacy. State policymakers and program implementers should apply this approach in additional states, to help achieve the large savings available from efficiency standards that can be established in the next decade. These additional efforts could include political support for new and updated standards, improved incentives for the highest efficiency products, and possibly some limited research. These need not be as extensive as the PG&E effort. Before undertaking such an effort, particularly if commissioned research is included, program implementors are encouraged to talk with and coordinate with PG&E and any other existing programs.

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⁷⁴ This calculation is just for PG&E expenditures and savings, and charges all costs to electric savings, ignoring gas savings.

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Water heating

Synopsis

Many efficiency programs currently promote heat pump water heaters (HPWHs). Leading programs are achieving participation rates of up to 20% of annual water heater sales. In May 2029 new federal water heater efficiency standards will generally require new electric water heaters over 35 gallons to be HPWH. Before 2029, programs should seek to maximize HPWH sales. After 2029, programs can promote load flexibility controls in new water heaters and replacement of oil and propane water heaters with HPWHs. This chapter discusses these and other savings opportunities.

Data summary

Available savings in 2035 from 2026–2035 programs:

We did not calculate electricity savings. There will be some small savings from heat pump water heaters (HPWHs) prior to when the 2029 federal standard takes effect, and even more limited savings after that from small HPWHs.

About 26 trillion Btu of fuel can be saved by 2035 from installing HPWHs instead of oil and propane water heaters when existing water heaters need to be replaced (eighth of 13). The replacement HPWHs will use about 2 TWh of electricity.

3,500 MW of summer peak demand reductions from including demand controls on all new water heaters (eighth of 13)

1,900 MW of winter peak demand reductions from demand controls (eighth of our 13 programs). We did not calculate the impacts of fuel switching on peak demand but much of the impact will be after the peak period.

Cost per kWh saved: ~\$0.07 per kWh saved from HPWHs replacing electric resistance water heaters including program costs.

Cost per kW-year for demand controls: ~\$92 for summer and the same for winter.

Introduction

Roughly half of U.S. homes have electric water heaters (EIA 2023). In 2025 residential electric water heating was estimated to use about 135 TWh, and commercial electric water heating adds another 22 TWh. The other half of U.S. homes have gas water heaters, and in 2025 these consumed about 1,050 trillion Btu of gas. By comparison, the site energy use of electric water heaters was about 460 trillion Btu (EIA 2025). Residential electric and gas water heater efficiency is regulated by federal minimum efficiency standards. The required efficiency varies with storage volume and heating capacity. For a 36-gallon electric water heater, which is a common size, the current standard typically requires a Uniform Energy Factor (UEF) of 0.915.⁷⁵ However, for electric water heaters over 55 gallons of storage capacity, a

⁷⁵ UEF is a measure of efficiency measured according to a specific DOE test procedure. Approximately, a UEF of 0.90 means that 90% of the energy in the electricity is transferred to the hot water and the other 10% is waste heat that warms the surrounding air.

UEF of 1.97 is typically required and this can only be met with an HPWH. HPWHs use a compressor to extract heat out of the ambient air and often achieve efficiencies over 300%.

For a 38-gallon gas water heater, also a common size, the current standard requires a UEF of 0.58. However, for gas water heaters over 55 gallons of storage capacity, a UEF of 0.75 is required and this can only be met with condensing water heaters. In condensing water heaters, there is enough heat exchange surface to reduce the temperature of the exhaust below 212°F and thus condense water in the exhaust (DeMascio 2015).

In May 2029, the required UEF for residential electric water heaters over 35 gallons in storage capacity will increase to 2.3, and the required UEF for water heaters over 55 gallons of storage capacity will increase to 2.5. Thus, the majority of electric water heaters will need to switch to HPWH when the existing water heater reaches end-of-life. Units of 35 gallons or less are commonly used in apartments, vacation homes, and remote bathrooms; these can continue to use electric resistance water heaters. The required efficiency for gas water heaters of 55 gallons or less also increases slightly under the standard (Federal Register 2024). For commercial gas water heaters, a new standard going into effect October 2026 requires a thermal efficiency of at least 95%, which essentially requires condensing gas water heaters (AO Smith undated).

Efficiency programs can and should promote use of residential HPWHs prior to the new federal standard taking effect, for two reasons. First, many water heaters will be replaced during this period. Second, increasing HPWH market share and contractor experience will help to show Congress that the standard is workable and to prevent a rollback. In addition, both before and after the new standard takes effect, programs can promote HPWHs for commercial applications and as a more efficient substitute for oil, propane, and gas water heaters; programs should also explore opportunities to help low-income households to install HPWHs, as the higher cost can be a barrier.

Technologies

The prime technology for water heater programs will be electric HPWHs. Units using 240-V electricity typically have UEFs over 3, meaning they produce more than three units of hot water for every unit of electricity consumed. For homes with gas water heaters, switching to an electric HPWH will generally reduce monthly operating costs because of the much higher efficiency of HPWH, but costs to switch can be substantial. The economics of switching will depend on the characteristics of a home, local gas and electricity prices, availability of rebates locally, and other factors (Rewiring America undated). There are 120-V HPWHs available that can be used without an upgrade to 240-V wiring at the water heater. These typically have UEFs below 3.0 and will also take longer to heat water.

In addition to the efficiency gains of HPWHs, demand-response controls can be installed in new water heaters at the factory that enable easy participation in utility demand reduction programs. The most widely used controls conform to American National Standards Institute (ANSI) and Consumer Technology Association (CTA) Standard 2045-B and/or to Air-Conditioning, Heating and Refrigeration Institute (AHRI) Standard 1430-2022. Several states, including Colorado, Oregon, and Washington, require these controls in new water heaters (Ungar 2023). Many utilities require these controls in HPWHs that receive utility rebates. With the controls installed, it is easier and less expensive for households to sign up for programs that reduce water heater power-draw during peak demand periods.

Programs can consider promoting condensing gas water heaters in residential sizes of 55 gallons or less, as the standard does not require condensing. However, the payback periods for these are typically long, given the substantially higher up-front costs of purchasing and installing a condensing water heater—

venting modifications are sometimes needed—and the moderate energy bill savings due to the somewhat limited efficiency gain (DOE 2024a). In addition, gas heat pump water heaters are entering the market and targeting commercial applications that use a lot of hot water (GTI Energy 2021).

Examples of successful programs

Efficiency Maine

Efficiency Maine operates energy efficiency programs statewide that are funded by utility bills, emissions allowance proceeds, and other sources. Efficiency Maine probably has the most successful HPWH program in the United States. While the market share of HPWHs was approximately 4% nationwide in 2023 (Energy Star 2024), in Maine over 10,000 HPWHs were rebated or installed in FY 2025. This is a market share of about 20% of all residential water heater sales and about 29% of standalone water heater sales; 67% of Maine households have standalone water heaters and 33% heat water off of the main space-heating boiler (NMR Group 2024).

Currently, Efficiency Maine runs two HPWH programs, one offering midstream incentives to distributors and another providing rebates for retail purchases in stores. The program features instant rebates at participating distributors and at participating retailers, including Home Depot, Lowe's, and most local chains. Retail rebates are generally just subtracted from the purchase price, but mail-in rebates are available if a retailer does not provide the instant rebate. Designed to make the cost of HPWHs about the same as an electric resistance water heater, present incentives vary from \$1,050–1,350, depending on sales channel, product price, and sales volume. The program also includes some replacement of oil water heaters, as Maine has the highest proportion of oil water heating in the United States (EIA 2023).

The HPWH program started in 2012 and has built good relationships with distributors, contractors, and retailers. Many educational and training programs have been offered for these audiences, and the program is extensively promoted via many channels, including a variety of special promotions each year. Due to these long-standing relationships with distributors and retailers and the high market share, HPWHs are readily available in Maine (Efficiency Maine 2026a, 2026b).

In the past, Efficiency Maine offered free HPWH installation in low-income homes. The low-income program kept costs low by bulk purchasing water heaters and procuring fixed price installation services, both via bids. It typically completed 850 income-qualified installations each year at a cost of about \$3.5 million annually for the water heaters plus installation. About 15% of the HPWH budget was devoted to the low-income program (AWHI 2024), which was discontinued in 2025 to increase the budget for the other water heater programs. Since HPWHs now cost about the same, after rebates, as electric resistance water heaters, low-income customers are served by the distributor and retailer programs (Efficiency Maine 2026a).

Tennessee Valley Authority

Based on the Efficiency Maine model, the Tennessee Valley Authority (TVA) began a successful midstream program in March 2025, after earlier programs with consumer incentives had limited participation.

The TVA midstream program emphasized ease of participation, initially offering a \$1,300 discount on HPWH purchases. In addition to the product discount, TVA paid distributors \$50 per unit to cover administrative costs and paid contractors \$50 for sending installation details back to TVA. The program

leaders also regularly engage with distributors and contractors about the benefits of HPWHs through newsletters, blogs, and other outreach tools.

The program had moderate participation in its first months, but in the fourth quarter of 2025 it saw increased engagement, providing more than 5,000 rebates in Q1 of FY 26. As of February 2026, the rebate was reduced to \$900 (Moopnar 2026). In March 2026, TVA paused its rebates to distributors and retailers, except for the two \$50 rebates discussed above. Prior to the pause, they had rebated and discounted more than 19,000 water heaters since the start of the midstream program. TVA is planning to restart the program when their new fiscal year begins in October 2026 and is considering updates so the program can operate year-round within the available budget. One option is moving the retail program to an in-store coupon, allowing TVA to track rebate spend in real time. Other potential updates include preapproval for large bulk purchases (e.g., for new housing developments) (B. Kitch, senior program manager, TVA, pers. comm., April 2026).

When asked about lessons learned, the program manager recommended setting up systems to track rebate use regularly, such as requiring high-level weekly reports from retailers. She suggests that when setting up a program, first talk to manufacturers about getting referrals to distributors. Working with distributors, programs can then set up outreach to and training of contractors. Only after these pieces are in place, and contractors are trained and the product is available, does it make sense to open the program and begin marketing to homeowners. This sequencing helps reduce consumer frustration and prevents deterring contractors. If changes need to be made when the program is underway, be transparent with distributors and contractors, and if possible, give them 30 days' notice of program changes so they can adjust their orders (B. Kitch, senior program manager, TVA, pers. comm., April 2026).

Northwest Energy Efficiency Alliance

Another notable effort is the 20-year campaign by the Northwest Energy Efficiency Alliance (NEEA) to promote HPWHs in its four-state region (Washington, Oregon, Idaho, and Montana). The campaign provides data and technical guidance to influence product development for the benefit of Northwest consumers and utilities. It collaborates closely with the entire supply chain, including cultivating awareness and demand among Northwest consumers and installers through training and promotion, and working with regional utilities to offer rebates and other incentives. It has also influenced the advancement of codes and standards to lock in efficiency gains by providing energy, cost, and customer satisfaction data to represent the needs of Northwest customers.

As a result of these efforts, NEEA estimates that HPWHs account for 9% of all water heater sales and 18% of electric water heater sales in the region (NEEA 2024). Meek and Powell (2023) detail many lessons learned by NEEA, including the importance of installer education and training, with the ultimate objective of having installers recommend HPWHs to their customers. The campaign also learned the value of marketing to consumers so they are more receptive to—and even sometimes request—HPWHs. Additionally:

- *Minimize call-backs*, which can be expensive for installers. Among the major consumer complaints are an inadequate amount of hot water and hot water that is not hot enough. HPWHs need to be sized correctly and manufacturers should be encouraged to improve contractor training on unit selection to better address these concerns.
- *Work with installers and manufacturers to explore and pursue paths for reducing costs*, which are a significant barrier.

- *Keep program costs down by first targeting applications that do not require accommodations* (about 30% per NEEA findings). Meanwhile, progress can be made on reducing the need for and cost of accommodations, such as to increase electric service or dispose of condensate.
- *Programs and manufacturers should help retailers to promote HPWHs to their customers.* About half of water heaters are purchased at a retail store (Ciani 2018) and installed either by the homeowner or someone they know.
- *Work with installers to better understand and address their concerns with HPWHs.* Some installers use workarounds to avoid installing HPWHs where they are required by federal standards. .

Vermont Gas

Another potential program model is leasing a HPWH. Vermont Gas has leased gas water heaters for years, and beginning in 2022, it began leasing electric HPWHs; this was spurred by several state laws designed to increase electrification. For an ENERGY STAR certified HPWH, lease program participants pay \$39 per month for a 50-gallon tank and \$46 per month for a 65-gallon tank. After 10 years of payments, the customer owns the water heater. Additionally, low- and moderate-income customers get a \$200 rebate (AWHI 2024). Since spring 2023, Vermont Gas has installed 231 HPWHs, 51 of them leased and the rest paid for either by customers or programs for income-eligible customers (M. Hood, director of product management, Vermont Gas, pers. comm., April 2026).

Finally, several electric cooperatives have been among the leaders in promoting demand response with HPWHs (Ungar 2023).

Participation rates

As discussed above, in Maine, HPWHs have a 29% share of annual standalone water heater sales and about 20% of all water heating system sales. In the Northwest, this rate is 18% of electric water heater sales and roughly 9% of all water heater sales.

Energy savings and peak demand reductions

An independent evaluation prepared for Efficiency Maine submetered 118 sites and estimated gross savings of 1,949 kWh per year and net savings of 1,797 kWh per year; the same study estimated net peak demand reductions of 0.307 kW in winter and 0.212 kW in summer (West Hill Energy and Computing 2019). Savings are slightly lower for the low-income program. These kWh estimates are very similar to the 1,799 kWh of savings estimated for Massachusetts' HPWH program, although the Massachusetts summer peak savings estimate is lower, 0.125 kW (Ringo and Beaman 2021).

The new federal minimum efficiency standards taking effect in 2029 will save a lot of energy—more than any other single DOE standard (DOE 2024b). The Appliance Standards Awareness Project estimates that in 2035, annual electricity savings from these standards will be 34 TWh, summer peak savings will be 4,300 MW, and winter peak savings will be 7,200 MW (from analysis summarized in Mauer and Margolis 2026).

The standards essentially require HPWH levels of performance for water heaters above 35 gallons of storage capacity, although we expect some plumbers to seek and exploit loopholes, such as use of 35-gallon water heaters with hot-water temperatures set very high. Still, a substantial majority of electric water heater sales are likely to be HPWHs starting in 2029. Remaining opportunities to promote HPWH as an alternative to electric resistance heating will likely focus on 30- and 35-gallon units. For example,

General Electric is selling a 30-gallon unit. More data are needed on the baseline energy use and energy savings with these small units.

The new federal efficiency standard does not require installation of demand-response controls. Utilities can promote and rebate HPWHs with these controls, enabling significant peak savings. Ungar (2023) reviewed several studies on the peak savings possible with these controls and estimated average peak savings for demand response with HPWHs of 0.244 kW per controlled water heater in winter and 0.122 kW in summer. This is beyond the savings from switching from electric resistance to heat pumps. Table WH 1 provides an estimate of national peak power savings from electric water heater controls relative to uncontrolled water heaters: about 1,900 MW in summer and about 3,500 MW in winter.

Table WH 1. Peak demand savings from water heater demand controls

("x" designates multiplication)	Value	Units	Comments
	57	million	Number of homes with electric water heaters (EIA 2023)
x	66%		Proportion of stock that turns over during the next 10 years, based on 15.1-yr average life (DOE 2024a)
x	83%		Proportion that can use HPWH with controls; this excludes the 13% of water heaters that are too small to be covered by federal standards (DOE 2024a) and the 4% of homes and apartments with instant water heaters (EIA 2023)
x	50%		Average participation rate by 2035 (from Ungar 2023); programs with high incentives have achieved participation rates as high as 95% for water heater control (Goh and Apt 2004)
=	0.122	kW	Summer peak demand reduction per water heater (Ungar 2023)
=	0.224	kW	Winter peak demand reduction per water heater (Ungar 2023)
=	1,911	MW	Summer peak demand savings
=	3,509	MW	Winter peak demand savings

In jurisdictions that allow credit for fuel switching, substantial energy savings (in Btu) can be achieved by installing an electric HPWH to replace an oil, propane, or gas water heater. For example, if a typical gas water heater uses 182 therms per year (EIA 2023) and has a UEF of 0.64 (the 2029 federal efficiency standard), installing a HPWH with a UEF of 3 results in savings of about 14 million Btu per year.⁷⁶ Further assuming that the electricity is provided by a gas power plant operating at 40% efficiency, a HPWH will save about 8.5 million Btu per year of natural gas per gas water heater replaced.⁷⁷

The economics of fuel switching are best for units that use expensive fuels such as fuel oil and propane (Nadel and Fadali 2024). Given this, we estimate the potential fuel savings from installing a HPWH instead of a new oil and propane water heater when existing equipment needs to be replaced.⁷⁸ Our

⁷⁶ An increase in UEF from 0.64 to 3.0 is about 79% savings $[(3 - 0.64)/3]$. 182 therms times 79% savings is 143 therms, which is about 14 million Btu (there are 100,000 Btu in a therm).

⁷⁷ Same calculations as footnote above except electric water heat has an efficiency of 1.2 $(3.0 \times 40\%)$.

⁷⁸ Some states have restrictions on programs that promote heat pumps in homes that use other fuels. As states with these restrictions periodically change, we did not explicitly account for this in our calculations. Instead, we note that this could affect calculations in individual states.

assumptions and results are provided in table WH 2. About 46 trillion Btu of fuel would be saved, but the replacement HPWHs would use about 3 TWh of electricity.

Table WH 2. Fuel savings and additional electricity consumption from replacing oil and propane residential water heaters with HPWHs

Measure	Fuel use in 2035 (TBtu)	Avg. lifetime (years)	% of stock replaced over 10 yrs.	Participation rate over 10 yrs.	% fuel savings	Fuel savings (TBtu)	Additional electricity (TWh)
Oil to HPWH	23.69	15.5	65%	50%	100%	7.64	0.51
Propane to HPWH	54.54	14.5	69%	50%	100%	18.81	1.25

Sources: Fuel use in 2035 from EIA 2026a. Lifetimes from DOE 2024a. Participation rate is an ACEEE estimate based on professional experience. Additional electricity assumes an average efficiency of 0.68 for propane and oil (the 2029 standard) and an average COP of 3 for HPWH.

Typical costs and cost of saved energy

Efficiency Maine’s rebate of \$1,050 for a HPWH is based on their estimate of the incremental cost of a HPWH relative to an electric resistance water heater. Similarly, market research for the Massachusetts program estimated incremental costs of \$952 in 2021. If we use the more recent Maine incremental cost, the net 1,797 kWh savings, assume a 14.8-year water heater life (DOE 2024a), and assume a 3% real discount rate, the levelized cost of saved energy is about \$0.05 per kWh saved, without including program costs. If we add 45% for program costs, the levelized cost is about \$0.07 per kWh (Opinion Dynamics and ACEEE 2026).

Demand-response controls add about \$30 to the water heater cost, according to Ungar (2023). If we capitalize this cost over the 14.8-year water heater life and assume a \$20 per household annual incentive for participation (also from Ungar 2023), this works out to \$185 per kW-year for both summer and winter demand reductions. Dividing this into summer and winter portions will depend on the relative summer and winter peaks for each utility.

Summary and recommendations

- *Offer midstream incentives to dealers combined with extensive outreach and training for contractors* to achieve high uptake of HPWHs, as shown by the Efficiency Maine and TVA experiences.
- *Require rebated water heaters to include demand-response controls* to lower the costs of enlisting these customers in water heater demand-response programs and achieving additional peak demand savings.
- *Encourage use of HPWHs and provide incentives for water heaters of 55 gallons and below until May 2029 and for 35 gallons and below after May 2029*, when federal efficiency standards change
- *Encourage manufacturers to factory-install a port to make it easy to install demand-response controls.* This can be a requirement for receiving HPWH incentives. For water heater sizes where HPWH are required, separate control incentives can be provided for water heaters over 55 gallons until May 2029 and for those over 35 gallons after May 2029.

Promote conversion of fuel-fired water heaters to HPWHs at the time of equipment replacement wherever the economics are positive for consumers. HPWHs will generally use less energy than gas, propane, and oil water heaters. The economics of installing a HPWH instead of a fuel-fired water heater at time of equipment replacement should be analyzed using local electric and gas rates and fuel prices.

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