

More Options, Better Outcomes: Increasing Deep Retrofit Participation and Savings with Expanded Measures

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ABSTRACT

Residential deep energy retrofits present an enormous opportunity for energy savings and emissions reductions. However, increasing adoption has been a challenge for program administrators, policymakers, and the contractors that deliver efficiency services. Program and project complexity, high costs, and uncertainty over savings present barriers to participation and scaling. While the number of deep retrofit projects—those cutting energy use by 50% or more—continues to grow, only a small fraction of single-family homes has received any type of whole-building retrofit, much less a deep retrofit. Achieving savings of 50% or more requires attention to space-conditioning and water-heating loads, but targeting these loads alone is rarely enough. Other strategies are needed, particularly in mild and moderate climates.

Alternative and supplemental efficiency measures (e.g., window attachments, ceiling fans, drain water heat recovery, consumer electronics, etc.) provide opportunities for meaningful savings at lower cost, increase energy savings in the near term, facilitate electrification, and deliver nonenergy benefits. This paper examines alternative and supplemental measures that provide savings at lower cost, with less disruption and greater appeal to consumers. We present analysis of deep retrofit packages that incorporate these measures, with details on up-front cost, energy savings, and other benefits and recommendations for each climate zone. We also discuss opportunities to increase program participation and savings by incorporating expanded deep retrofit packages, introducing more flexible program delivery approaches, and improving alignment with customer needs and interests.

Introduction

Deep retrofits rely on building envelope improvements and major equipment upgrades as core strategies for achieving energy savings of 50% or more. As the emphasis on decarbonization grows, more and more projects are incorporating electrification along with energy efficiency measures. Recent project experience and modeling studies suggest the cost of deep retrofits, ranging from \$35,000 to more than \$60,000, are prohibitive for most homeowners without significant rebates and financing support (Amann, Srivastava, and Henner 2021). Considering the cost barriers and the ongoing challenges of scaling up home retrofit activity, we opted to explore opportunities to reduce initial costs and increase consumer appeal by expanding the set of measures included in retrofit packages presented to homeowners.

Technology Selection

First, we developed a list of efficiency measures with the potential to deliver energy and carbon savings and narrowed it down to options that might also reduce project costs and/or meet a broader set of consumer needs and interests. We looked to emerging technologies and new

opportunities as well as measures that have been available for some time but have limited adoption. While deep retrofits typically focus on improving thermal performance and installing high-efficiency HVAC and water-heating equipment—critical components of a deep retrofit in all climates—we selected measures from additional end-use categories. As Figure 1 shows, retrofits incorporating a broader set of end uses are more likely to achieve energy use reductions of 50% or more.

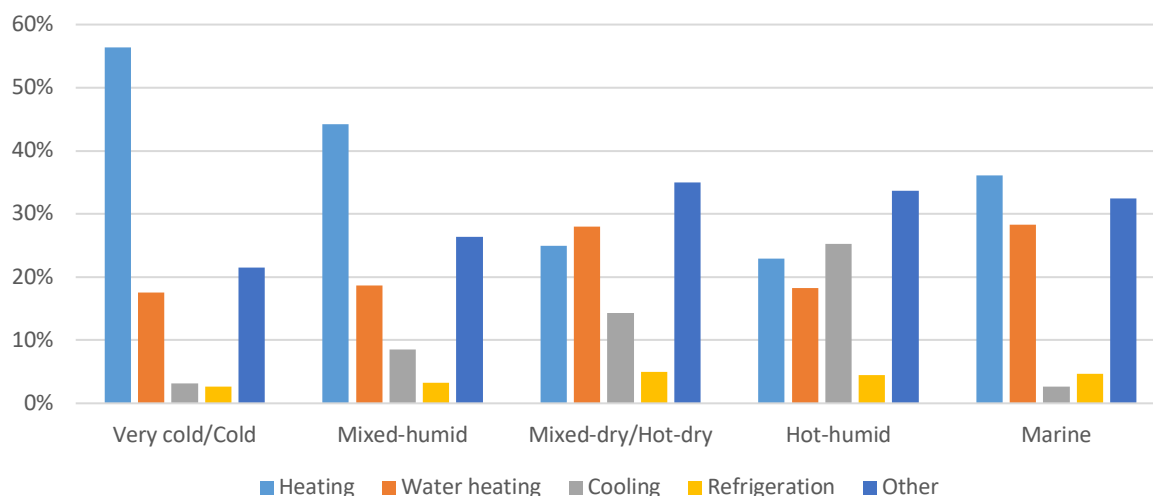


Figure 1. Household site energy consumption by end use for each climate region. Source: EIA 2018

The final list of measures in our analysis fall into two main categories: alternatives to traditional measures addressing heating, cooling, water heating, and lighting (e.g., drain water heat recovery, ceiling fans); and supplemental measures that save energy in other end-use categories (e.g., consumer electronics, appliances). While few of these measures offer the same order of savings as the core measures in our deep retrofit packages, they provide opportunities to capture meaningful savings at lower cost, help consumers increase energy savings in the near term, and appeal to consumers by offering a range of nonenergy benefits.

Technology Profiles

Profiles of each measure include a brief description and data on energy savings and installed costs. The profiles also address increased amenity or other nonenergy benefits to homeowners and decarbonization impacts. Each profile notes whether the measure is better suited to particular climates or housing types. We compare costs and energy savings to more typical measures in the same energy end use.

High-Performance Window Attachments

High-performing window attachment products, including low-e storm windows (interior and exterior), cellular shades, awnings, and solar screens, can improve existing windows and achieve energy performance on par with ENERGY STAR-qualified windows at less than one-

third of the cost.¹ Published U-value and solar heat gain coefficient (SHGC) data allow comparison of window attachment performance to replacement windows. Table 1 shows the range of performance for several categories of window attachment products.

Table 1. Energy performance of window attachment products

Product	U-value		SHGC		AEP heating		AEP cooling	
	Min	Max	Min	Max				
ENERGY STAR Windows v6.0	≤0.27	≤0.40	≤0.25	≤0.40	n/a	n/a	n/a	n/a
Storm window	0.24	0.32	0.29	0.57	44	112	9	47
Cellular shade	0.17	0.37	0.14	0.48	4	26	11	48
Roller shade	0.31	0.39	0.15	0.49	-24	8	9	49

Notes: ENERGY STAR minimum and maximum values reflect the range of performance requirements across climate regions (e.g., northern climate specification requires U-value ≤0.27 and SHGC ≤0.40). AEP represents the reported Annual Energy Performance in heating or cooling season as determined by Attachments Energy Rating Council's AERC 2 test method (AERC 2020).

High-efficiency window attachments are available to meet the needs of homes in different climates. Exterior storm windows and interior storm panels are suitable for cold and mixed-cold climates. Cellular shades may be optimized for cold, mixed, or hot climates. Awnings and solar screens provide warm season energy savings. Research by Pacific Northwest National Lab finds heating savings of 6.5 to 22.0% and cooling savings of 3.5 to 16.5% when installed over a typical double-pane window (Petersen et al 2016). The addition of automation to optimize attachment position and operating schedule can increase savings.

Costs for high-efficiency window attachments range from \$50 to more than \$500 per window and many products can be installed by the consumer (ACEEE 2019). Window attachments deliver several other benefits including improved visual and thermal comfort, reduced noise, and enhanced aesthetics and privacy. The number of efficiency programs offering incentives for window attachments is growing; examples include the Public Service Electric and Gas rebate for ENERGY STAR-certified low-e storm windows (PSEG 2021) and the Xcel Energy Colorado rebate for cellular shades with an AERC Cool Climate Rating of at least 5 and a warm climate rating of at least 35 (Xcel Energy Colorado 2021). Baltimore Gas & Electric is running a pilot study to determine savings from automated cellular shades. A dozen states include low-e storm windows in their Technical Resource Manuals (TRMs), paving the way for greater program support.

ENERGY STAR Most Efficient Dehumidifiers

Stand-alone dehumidifiers improve indoor air quality (IAQ) and address moisture issues that may pose health concerns, exacerbate pest problems, and compromise durability. Installing a new dehumidifier or replacing an existing unit with a high-efficiency model can remedy these issues while reducing latent load demand on the air conditioner. Dehumidifiers are most common in cold and mixed-humid climate homes (EIA 2018).

¹ The [Attachments Energy Rating Council](#) (AERC) provides rating, certification, and labeling of window attachment products with energy performance scores to simplify consumer comparisons of heating and cooling season performance across products and categories.

In homes with existing dehumidifiers, upgrading to an ENERGY STAR Most Efficient model will improve performance and reduce energy use. When the time comes to upgrade the home's HVAC system, the dehumidifier may no longer be needed, particularly with installation of a variable-speed system. However, a deep envelope upgrade that achieves a very low cooling load may require ongoing use of a dehumidifier to adequately control humidity.

Homes without dehumidifiers may benefit from installation of a unit if there are moisture or high-humidity issues that are not addressed with envelope upgrades. Post-retrofit, a dehumidifier may be needed if humidity control becomes an issue or continues, particularly if the HVAC is not upgraded or if the project achieves a very low cooling load that the new or existing HVAC cannot address.

We analyzed the energy and cost impacts of installing an ENERGY STAR Most Efficient-qualified (ESME) portable dehumidifier with a water removal capacity of 50 pints per day or less. Table 2 provides energy use and cost data for minimum standard and baseline ESME products. We considered two scenarios: the addition of a dehumidifier in a home without one; or replacement of an existing baseline dehumidifier, selecting ESME instead of a typical new model at end-of-life replacement. Other benefits include reduced incidence of mold, allergens, and other IAQ issues, and improved occupant comfort and health.

Table 2. Energy use and costs of dehumidifiers

Product	kWh/year		Cost
	≤25 pints/day	25.01–50 pints/day	
Existing stock baseline	950		n/a
2019 Federal standard	511	771	\$148-\$469
ES Most Efficient 2022	372	582	\$165-409

Source: EPA 2018, EPA 2022b, Enervue 2022a

Dehumidifiers are a relatively common target for efficiency programs,² often targeted for buyback (i.e., trade-in) incentives and rebates on high-efficiency models. While many programs offer incentives based on ENERGY STAR, there are more than 190 portable units from dozens of manufacturers certified to the 2022 ESME specification offering sufficient selection to limit incentives to the more stringent requirements.

ENERGY STAR Most Efficient Ceiling Fans

Ceiling fans can curtail or even eliminate the need for air-conditioning in milder climates and in regions with short summers and reduce the need for air-conditioning in shoulder seasons in other regions. They also may allow occupants to maintain comfort with a warmer thermostat set point when air-conditioning is used. In recent decades, builders have routinely included ceiling fans in new homes; they are also relatively common in older homes and a simple addition in homes where they are not present. According to the Residential Energy Consumption Survey (EIA 2018), ceiling fans are most common in cold, hot-humid, and hot-dry climates. Hot-climate homes with ceiling fans typically have three fans. While cold-climate homes with fans average two per home just like mixed-humid and marine climates; homes in colder climates tend to use their fans for a more significant portion of the year.

² The [DSIRE database](#) lists close to 100 rebate programs for dehumidifiers.

New high-efficiency ceiling fans with improved controls present a savings opportunity in new installations and as upgrades to older fans. Energy savings depend on the number of fans per home, annual operating hours, and proper use (i.e., operating a fan only when a room is occupied, increasing the air-conditioning set point when fans are in use). Additional benefits include improved airflow, improved controls, smart home integration, higher lighting efficacy and performance (for fans with lighting).

We analyze fan-related energy savings for 52-inch-diameter (the most common size) ESME-qualified ceiling fans. The 2022 ESME criteria is twice the energy efficiency of the base ENERGY STAR specification and yields energy saving of 67% relative to the minimum standard (EPA 2022b). As of June 2022, EPA lists a total of 186 ceiling fan models from 13 manufacturers meeting the 2022 ESME recognition criteria. Table 3 provides information on energy use and cost of ceiling fans.

Table 3. Energy use and costs of ceiling fans

Product	kWh/year		Cost	
	Per fan	Per household		
Existing stock	90–300	180–900		
New models	25–283	50–849	\$60	\$1,400
ES Most Efficient 2022	25–55	50–165	\$185	\$1,400

Source: DOE 2016; EPA 2022b

Drain Water Heat Recovery

Drain water heat recovery (DWHR) utilizes a copper heat exchanger to capture waste heat from a shower’s drain line. The reclaimed heat is used to preheat cold water as it is delivered to the showerhead or the water heater. By capturing and using waste heat, DWHR reduces energy used for water heating by 20–45% (Buchalter 2019). DWHR devices are available in both horizontal and vertical configurations for use in most housing types. DWHR is a feasible retrofit technology in homes where drainpipes are accessible without too much disruption, or at the time temperatures throughout the year, but adoption in more moderate climates is increasing.³ Energy savings are dependent on inlet water temperature, DWHR device efficiency, the number of fixtures, and configuration (“equal flow” units direct preheated water to the water heater *and* shower; “unequal flow” units direct it to one or the other).

DWHR is particularly beneficial when used with a heat pump water heater. Effectively increasing the amount of hot water that can be provided in heat pump mode means there is less need for the backup electric resistance unit and the efficiency of the heat pump water heater is maximized. Additional benefits include faster water heater recovery and the potential to extend water heater life. The units themselves use no energy and require no maintenance providing 30 or more years of performance.

We analyze savings for a DWHR unit with efficiency of 42% with an existing gas water heater and a heat pump water heater to account for near-term and post-retrofit energy savings and lifecycle cost-effectiveness. Table 4 summarizes estimated energy savings and cost.

³ Canada has been the largest market for DWHR. The inclusion of DWHR in California’s Title 24 residential building code reflects growing interest in the technology in more moderate climates.

Table 4. Energy savings and cost of drain water heat recovery

Installation type	Annual savings	Cost
With existing gas water heater	25–95 therms 2.5–9.5 MMBtu	\$650 to \$1,000
With heat pump WH	95–1051kWh 0.7–3.6 MMBtu	

Source: CASE 2017; Amann, Srivastava and Henner 2021.

DWHR has been adopted in building codes in Canada and California. Rebates are offered by many utilities and efficiency programs in Canada; program activity is more limited in the US.⁴ Incentive levels may increase as system size and number of showers connected increases.

Demand Recirculation Pumps

Long piping runs between the water heater and home fixtures are common in many large homes, single-story homes, and in homes where pipes run underneath the foundation (typical of much slab-on-grade construction). The lengthy piping runs lead to significant water waste during the long wait time for hot water to reach fixtures, and energy waste as heat is lost from hot water moving through the pipes and from heated water remaining in the pipes after fixtures are turned off. Conventional recirculation pumps are used to deliver hot water to home fixtures without the lag time and, while they do eliminate water waste, they use a lot of energy for pumping and waste it through heat loss from the pipes.

Demand recirculation systems address both water and energy waste from long piping runs. A small pump installed at the water heater or at the furthest fixture is activated when a tap is turned on or by a push button, remote, or occupancy sensor. The cool water standing in the hot water pipe is pumped back to the water heater using the cold-water pipe or a separate line, pulling hot water to the tap.

Energy savings range from 12% to 17% of hot water energy use. Product costs range from \$300 to \$500 plus installation costs, although this is a straightforward project for a handy consumer. Other benefits include water savings of up to 7,200 gallons per year, convenience, and time savings (Campbell 2019). Table 5 summarizes estimated energy savings and cost.

Table 5. Energy use and cost of demand recirculation pumps

Installation	Annual savings	Cost
With existing gas WH	20–32 therms 1.9–3.2 MMBtu	\$300 to \$500
With heat pump WH	140–350 kWh 0.5–1.2 MMBtu	

Source: Sachs et al 2011; Koeller and Klein 2007

Thermostatic Tub/Shower Diversion Valves

Tub spout diverters (TSDs) and thermostatic restrictor valves (TSVs) present energy and water savings opportunities above and beyond low-flow showerheads. Faulty TSDs are a

⁴ Representative examples of US rebates include [Minnesota Energy Resources](#)' 2022 offer of \$150 for customers with gas water heaters and [Minnesota Power](#)'s 2020 offer of \$400 for customers with electric water heaters.

common source of energy and water waste in combination bathtub-showers, with leaky units wasting an average of 0.8 gallons of hot water per shower. Replacements can save 100–400 kWh or 5–15 therms per fixture each year (Taitem Engineering 2011). Costs for TSD replacement range from \$35 to \$45 parts and labor.

TSVs deliver savings by eliminating energy and water wasted in the lag time between hot water reaching the fixture and the user beginning to shower. We analyzed savings for TSVs integrated with a high-efficiency showerhead or tub spout diverter. Additional benefits include significant water savings of 1,800 to 2,520 gallons per year, convenience and time savings, and improved showerhead water pressure. TSV installation costs run from \$100 to \$200 for equipment and labor. TSDs and TSVs are included in several direct install programs. Table 6 summarizes annual energy savings associated with these technologies.

Table 6. Energy savings of tub-spout diverters and thermostatic restriction valves

Installation type	TSD annual savings		TSV savings kWh/year	
	Min	Max	Min	Max
With existing gas water heater	1.5 therms .15 MMBtu	15.5 therms 1.55 MMBtu	9.7 therms .97 MMBtu	22.3 therms 2.2 MMBtu
With electric resistance WH	38 kWh 0.13 MMBtu	382 kWh 1.31 MMBtu	176 kWh 0.6 MMBtu	406 kWh 1.4 MMBtu
With heat pump WH	15 kWh 0.05 MMBtu	155 kWh 0.53 MMBtu	71 kWh 0.24 MMBtu	165 kWh 0.56 MMBtu

Source: CPUC 2013; Amann, Srivastava and Henner 2021.

Room Air Cleaners

There is a growing market for air cleaners (air purifiers) as the frequency of wildfires increases and expands to a larger portion of the country, as a response to airborne disease, and as people become more aware of the impacts of indoor air pollution on occupant health. As of 2020, 36% of U.S. households owned an air cleaner (Evergreen Economics 2021). Penetration is expected to grow as more than 7 million units were sold in the U.S. from October 2020 to October 2021 (Evergreen Economics 2022). The number of products on the market is also expanding rapidly. Products from 76 brands have been identified; the top 25 models, representing 38% of national sales, are from 11 manufacturers (Evergreen Economics 2021 and 2022).

Energy use and air-cleaning performance varies widely. According to EPA, standard air cleaners use an average of 450 kWh/year when operated continuously (EPA 2019). ENERGY STAR v2.0 qualified models save an average of 20%, using 37 to 729 kWh/year depending on air cleaning capacity.⁵ Newer models offer improved performance and generally provide more information on their ability to remove dust, smoke, and pollen allowing consumers to select products optimized for the particles of most concern to them.

Product prices range from less than \$50 to more than \$1,000 (Enervee 2022b). In general, price increases with product efficiency, although ENERGY STAR-qualified products in the \$100–\$199 range have the highest average efficiency (Evergreen Economics 2022). At these

⁵ ENERGY STAR Qualified Products List as of June 15, 2022.

<https://www.energystar.gov/productfinder/product/certified-room-air-cleaners/results>

price points, replacing old, inefficient air cleaners with new high-efficiency models can be a good investment, particularly for the 40% of owners that have multiple air cleaners (Evergreen Economics 2021) and those that operate their air cleaners for a significant number of hours throughout the year. Table 7 provides energy efficiency and energy consumption data on ENERGY STAR air cleaners.

Table 7. Energy efficiency and energy use of ENERGY STAR v2.0 air cleaners

	30 ≥ CADR < 100	100 ≥ CADR < 150	CADR ≥ 150
Smoke CADR/W	Min: 1.9 Max: 10.3	Min: 2.4 Max: 13.8	Min: 2.8 Max: 14.8
Dust CADR/W	Min: 1.1 Max: 11.1	Min: 2.0 Max: 12.9	Min: 2.8 Max: 13.2
Pollen CADR/W	Min: 0.9 Max: 9.9	Min: 2.1 Max: 13.9	Min: 2.7 Max: 14.7
Annual energy consumption (kWh/yr)	Min: 37 Max: 264	Min: 53 Max: 334	Min: 132 Max: 514

Source: ENERGY STAR Air Cleaners Qualified Products List

Incentives can encourage purchase of high-efficiency models for both replacements and new installations. A number of efficiency programs around the country have introduced consumer rebates for air cleaners and/or midstream incentives for retailers through the ENERGY STAR Retail Products Platform. In Massachusetts, Mass Save offers a \$40 instant or mail-in rebate for ENERGY STAR-certified models. Others offering rebates up to \$50 include Appalachian Power, Baltimore Gas and Electric, Consumers Energy. EPA has proposed to add room air cleaners to the 2023 ESME product portfolio with proposed levels estimated to save 314 kWh/year or 72% relative to ENERGY STAR v1.2, the level adopted as minimum standard in DC, MD, NV, and NJ (EPA 2022b).

Induction Cooktops and Ranges

Induction cooking is a critical technology to enable the full electrification of housing. The improved operating efficiency relative to gas and conventional electric cooktops reduces energy use, while the cool cooking surface reduces heat load in the kitchen providing additional energy savings and a safer workspace. Induction also eliminates the health issues associated with direct combustion of fossil fuels in the living space. What makes induction particularly attractive and critical for electrification is its cooking performance. The technology heats very quickly and offers the temperature control and responsiveness of cooking with gas, making induction an option for many cooks that would never have considered conventional electric cooktops.

The main barriers to adoption of induction include up-front product cost, the lack of familiarity with the technology, and the need for compatible cookware. Manufacturers are introducing lower-cost induction cooktops and ranges to meet the growing demand. EPA has awarded the 2021–2022 Emerging Technology Award to residential induction cooktops (EPA

2022a) to increase consumer and manufacturer interest and establish initial efficiency criteria for the technology. A growing number of professional chefs and cooking personalities are demonstrating the performance benefits of induction cooking. Further consumer education efforts are focused on cookware compatibility; while induction requires the use of ferrous cookware, many common pots and pans are suitable including stainless steel, cast iron, and enameled cast iron. Table 9 provides energy efficiency, use, and cost information.

Table 9. Energy efficiency, use and cost of induction cooktops

Product	Efficiency (%)	AEC (kWh/yr) *	Cost	
			Cooktop	Range
Smooth element electric	75–80%	144	\$360–2,599	\$566–2,399
Gas	32%	376	\$389–2,399	\$498–8,300
Induction	85%	109	\$476–3,000	\$1,098–4,588

* Energy consumption of cooktop only for both standalone cooktops and ranges and includes standby energy consumption. Gas cooktop annual energy use 1,282 kBtu Source: EPA 2022a; DOE 2020

Efficiency programs and local governments are promoting adoption of induction cooktops through incentives and consumer education strategies. For example, Sacramento Municipal Utility District (SMUD) offers a \$100 rebate for a conventional electric-to-induction cooktop or range replacement; the rebate increases to \$750 for a gas-to-induction replacement (SMUD 2022). Pacific Gas & Electric's (PG&E) Induction Cooktop Loaner Program offers customers the opportunity to test out a portable induction cooktop in their own home for two weeks (PG&E 2022). Appliance retailers and local libraries are offering borrowers single-burner portable induction cooktops and compatible cookware (William J Worthen Foundation 2022).

Video Streaming Devices

Stand-alone video streaming devices (e.g., Roku, AppleTV) are an energy-efficient alternative to set-top boxes. Many pay-TV service providers now offer their customers the option to select a streaming device instead of a dedicated STB to access subscriber programming. Since most subscriber homes use more than one set-top box—an average of two boxes per household (D&R International 2021)—household energy consumption for subscribers exceeds 200 kWh/year. In homes with multiple DVRs, set-top energy use exceeds 300 kWh/year.

Unlike set-top boxes, streaming devices are owned by the customer. They may be provided free of charge by the service provider, or the customer may purchase their own unit for a cost of \$25 to more than \$100. Table 10 compares energy use of streaming devices and various types of set-top boxes.

Table 10. Energy use of various streaming devices

Product	Average annual energy use per box (kWh/year)
DVR set-top box	154.0
Non-DVR set-top box	93.4
Thin client	45.6
Streaming device	18.5

Source: D&R International 2021

Contribution to Energy Savings and Decarbonization

To evaluate the contribution of these measures to deep retrofit energy savings and decarbonization goals, we compare energy savings and costs to those of traditional measures based on findings of ACEEE's recent study of deep retrofit packages, *Pathways for Deep Energy Reductions and Decarbonization in Homes* (Amann, Srivastava, and Henner 2021). Table 11 summarizes specifics on the energy savings, costs, and primary benefits of each technology.

Space Conditioning

Modeled retrofit packages included a comprehensive set of envelope upgrades, including insulation, air sealing, and window replacements tailored to each U.S. climate region. Existing fossil-fuel heating systems and existing cooling equipment (central air conditioners or room air conditioners) were replaced with high-efficiency air-source heat pumps.

Window attachments are a promising option for homes with clear, double-pane windows in all climates. ENERGY STAR-certified storm windows and high U-value cellular shades are attractive in cold, mixed-humid, and marine climate homes. In hot-humid and hot-dry climates, high-performance cellular shades offer year-round HVAC savings. Window attachments offer meaningful savings at a much lower cost than window replacements, which were the most expensive measure in our modeled scenarios, ranging from \$9,000 to \$14,600. The significant cost savings can impact a homeowner's ability to move forward with a project.

ENERGY STAR Most Efficient dehumidifiers are an attractive measure in some cold and mixed-humid climate homes. Homes in these regions are more likely to have basements and crawl spaces, which can be significant sources of moisture. In cold-climate homes without central air-conditioning, dehumidifiers play an important role in moisture management. The need for a stand-alone dehumidifier can be reassessed with installation of a heat pump (whether ducted or ductless).

ENERGY STAR Most Efficient ceiling fans provide savings, particularly when replacing older, inefficient fans in hot-humid and hot-dry climates. Homes in these climates are more likely to have multiple fans, use the fans for a longer portion of the year, and to run fans with a longer duty cycle. Smart fans that communicate with the thermostat to adjust the setpoint when the ceiling fan is in operation can increase savings since studies show few people take advantage of this savings opportunity.

Water Heating and Distribution

Modeled retrofit packages included replacement of gas-fired storage water heaters with heat pump water heaters and installation of low-flow fixtures (1.5 gpm or less). The *Pathways* study only modeled replacement of gas water heaters, but heat pump water heaters are the recommended replacement for electric resistance and fossil-fuel fired systems.

Drain water heat recovery is a cost-effective measure in cold, mixed-humid, and marine climates. Colder inlet water temperatures increase energy savings; the larger stock of two-story homes and prevalence of basements/crawlspaces makes installation easier and less disruptive. In homes where a water heater replacement is not warranted, DWHR can yield significant near-term gas savings. Even though energy savings decline once the water heater is replaced with a HPWH, the added energy savings can offset the cost of shifting to more expensive electricity, particularly in regions with high electricity rates, such as the Northeast.

Demand recirculation pumps and thermostatic restrictor valves are particularly attractive in homes with significant hot water wait times in all climates. Both technologies provide valuable energy and water savings. TSVs are a lower-cost option, well suited to homes with fewer fixtures or where only one primary shower is used frequently.

Table 11. Summary of energy savings, costs, benefits, and application for alternate measures

Measure	Region	Savings	Cost	Scenario	Low cost	Near-term gas savings	Enable electrification	Consumer appeal
Window attachments	all	H	L-M	N, R, E	X	X	X	X
Dehumidifiers (stand-alone)	C, MH	M	M	N, R, E				X
Ceiling fans	all	L-M	L-M	N, R, E	some			X
Drain water heat recovery	C, MH, M	H	M	N		X	X	
On-demand recirculation	all	M		N, R		X		X
Thermostatic restrictors valve	all	M	L	N	X	X		X
Air purifier/air cleaner	all	L-M	L-H	N, R, E	some			X
Induction cooking	all	L	H	N, R, E		X	X	X
Video streaming devices	all	M	L	R, E	X			X

Region: C=cold, MH=Mixed-humid, HH=Hot-humid, HD=Hot-dry, M=Marine

Savings and Cost: H=high, M=medium, L=low

Scenario: N=new installation, R=replacement, E=early retirement

Incorporating Alternate Measures into Programs

Several of the measures are already included in efficiency program offerings, as discussed above, but rarely as part of comprehensive retrofit programs. Other measures have not been *incorporated* into programs or have only been part of pilot program activity to date. Options to expand program coverage of these measures include leveraging existing offerings through greater coordination with home retrofit programs or developing new mechanisms to incorporate alternate measures into home retrofit programs themselves. Opportunities for further exploration include

- *Marketplace programs*: Program administrators could add appliance and plug-load measures to their online marketplaces. Participants could access instant rebates for purchase of priority measures for their retrofit through custom discount codes.
- *Direct install/energy savings kits*: Lower-cost alternate measures could be incorporated as direct install measures or included in energy savings kits distributed to retrofit program participants. Video streaming devices and TSVs are particularly good candidates.

- *Home performance contractors:* Programs can work with participating home performance contractors to incorporate alternate hot water heating and distribution measures, dehumidifiers, and related measures into retrofit projects.
- *Nontraditional contractors and installers:* Programs can work with window attachment retailers and installers, plumbers, and others to provide their services in coordination with retrofit projects.

Conclusion

Alternative and supplemental efficiency measures provide opportunities for meaningful savings at lower cost, increase energy savings in the near term, facilitate electrification, and deliver nonenergy benefits. While not a one-size-fits-all approach, there are measures that can expand savings and benefits for consumers while helping to meet program priorities for efficiency and decarbonization. Expanding deep retrofit program offerings and introducing more flexible program delivery approaches to incorporate these measures can support efforts to achieve deep energy savings and emissions reductions from the existing building stock.

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