SECTOR-BY-SECTOR APPROACHES

Making Energy Efficiency Work

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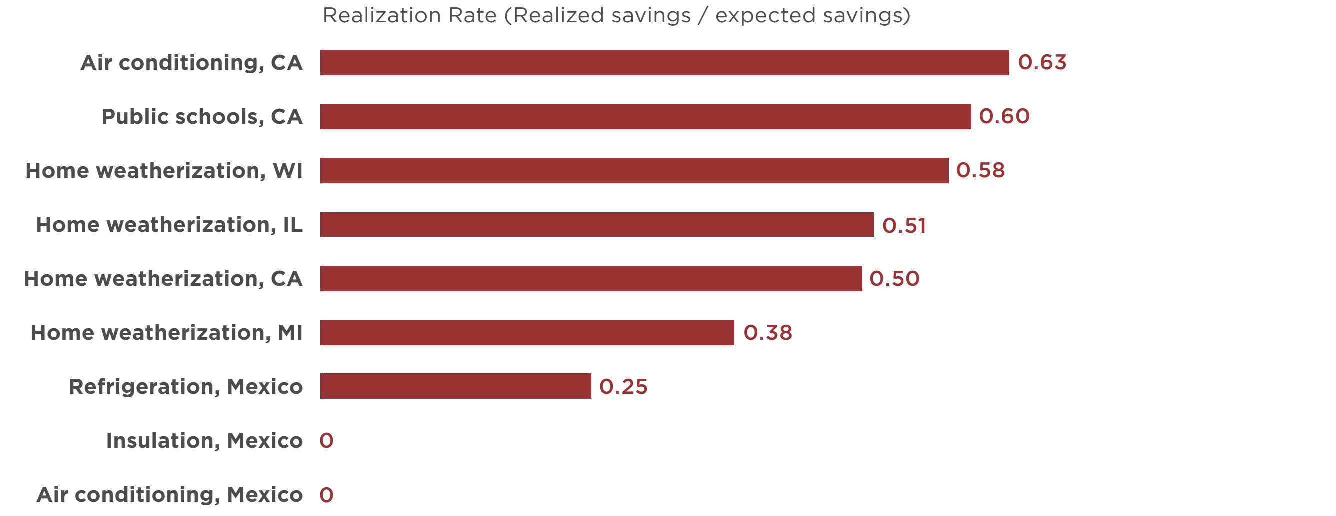
Energy efficiency is often touted as a win-win approach to the global climate problem. Customers that install energy efficient appliances win by reducing their electricity bills enough to cover the cost of the new appliance, and the planet wins as reducing electricity consumption means lower greenhouse gas (GHG) emissions. Policymakers have therefore made energy efficiency a cornerstone of climate policy. In order to meet the Paris Agreement's target of limiting average warming in 2100 to no more than 2^0 C, the International Energy Agency estimates that energy efficiency will be required to deliver nearly 30 percent of global emissions reductions.[1] In the United States, the Department of Energy (DOE) alone spent $14.5 billion on a wide range of energy efficiency investments from 2000 to 2019, including early stage research funding, technology evaluation, compliance monitoring, and retrofit programs.[2]

1 International Energy Agency, "CO_2 Emissions Reductions by Measure."

2 Gallagher and Anadon, "DOE Budget Authority for Energy Research, Development."

FIGURE 1 - CHAPTER IN A CHART

Energy Efficiency Delivers Lower than Expected Savings



Sources: Boomhower & Davis, "Do Energy Efficiency Investments Deliver;" Burlig, Knittel, Rapson, Reguant, and Wolfram, "Machine Learning from Schools;" Allcott and Greenstone, "Measuring the Welfare Effects;" Christensen, Francisco, Myers, and Souza, "Decomposing the Wedge;" Graff-Zivin and Novan, "Upgrading Efficiency and Behavior;" Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver;" Davis, Fuchs, and Gertler, "Cash for Coolers;" Davis, Martinez, and Taboada, "How Effective is Energy-Efficient Housing;" Davis, Fuchs, and Gertler, "Cash for Coolers."

However, new research suggests that energy efficiency substantially underdelivers on its promises to reduce energy consumption, putting global climate goals at risk. In a series of empirical studies comparing projected energy savings from energy efficiency retrofits to real-life energy use after they were installed, economists have demonstrated that energy efficiency savings fall short of expectations. In the largest American residential energy efficiency program, the Weatherization Assistance Program (WAP), retrofits delivered less than 40 percent of expected savings,[3] ultimately rendering the costs of the program substantially higher than its societal benefits. These disappointing savings results have also been found in other energy efficiency retrofit programs outside of the residential sector.[4]

What does this mean for future energy efficiency policy? Though existing energy efficiency retrofit programs do not live up to expectations, there are still avenues for these kinds of policies to play an important role in addressing climate change. The next administration should consider two core policy recommendations for reforming energy efficiency policy in the United States. First, setting energy prices correctly will incentivize customers to invest in the appropriate level of energy efficiency on their own, without requiring additional subsidies. Second, rigorous *ex post* evaluation should be built into energy efficiency programs, in order to direct spending to projects that do deliver energy savings at low cost .

Heart of the Problem

The American economy consumes more than 100 quadrillion British thermal units (Btu) of energy every year,[5] or approximately 305 million Btu per person, for lighting, telecommunications, transportation, and industrial production and other everyday uses.[6] For comparison, this is triple China's per capita consumption (98 million Btu), and approximately double that of Germany (170 million Btu) and Japan (150 million Btu).[7] U.S. energy consumption has grown rapidly over time: in 1950, total primary energy consumption in the United

3 Fowlie, Greenstone, and Catherine Wolfram, "Do Energy Efficiency Investments Deliver?"

4 Burlig, Knittel, Rapson, Reguant, and Wolfram, "Machine Learning from Schools about Energy Efficiency."

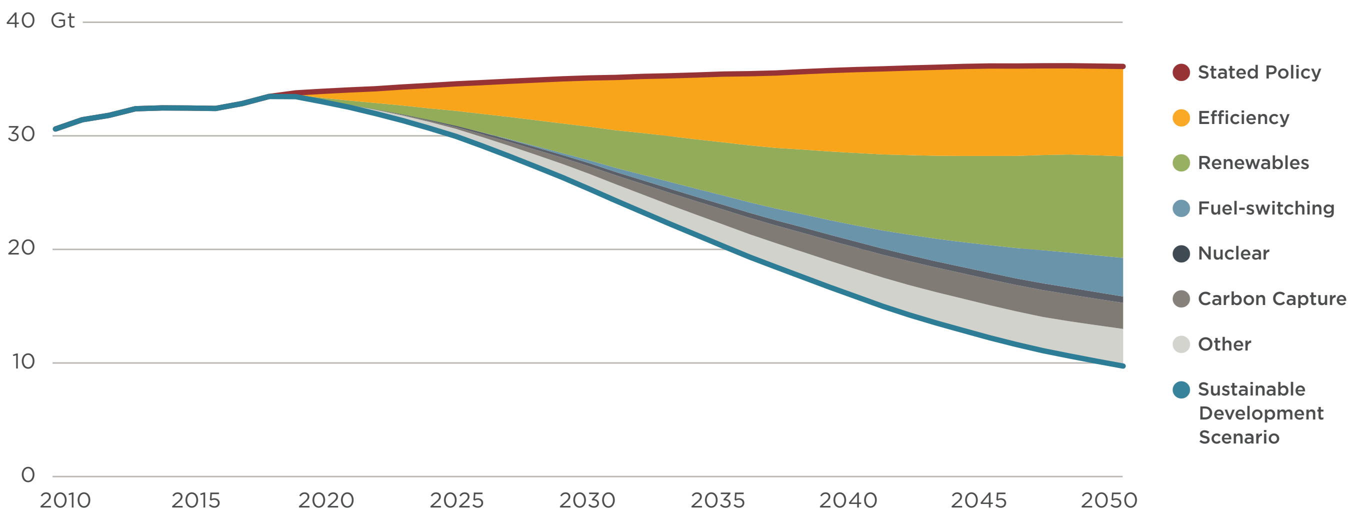
5 U.S. EIA "U.S. Energy Facts Explained."

6 U.S. EIA, "Frequently Asked Questions."

7 U.S. EIA, "Energy Intensity."

FIGURE 2

To Achieve IEA Sustainable Development Scenario, Energy Efficiency Expected to Contribute 30 percent of CO_2 Reductions by 2050



Source: IEA, "CO_2 emissions reductions by measure in the Sustainable Development Scenario relative to the Stated Policies Scenario, 2010-2050."

States was only 34.6 quadrillion Btu[8]—just over one third of today's levels. At present, U.S. energy primarily comes from fossil fuels: 80 percent of primary U.S. energy consumption is supplied by petroleum, coal, and natural gas.[9] These are the same fuels driving anthropogenic climate change. The primary challenge facing the U.S. energy system, then, is how to ensure Americans continue to enjoy a high standard of living while reducing the costly consequences of burning fossil fuels.

What makes energy efficiency attractive?

Energy efficiency, the practice of reducing the amount of energy required to generate services, appears to be an attractive way of addressing this challenge. Energy efficiency is seen as a rare example of an environmental and economic "win-win": when a household upgrades from an old, inefficient air conditioning unit to a state-of-the-art EnergyStar model, for example, the household "wins" with a lower electricity bill, and the environment "wins" because the household is using less overall energy—and therefore demanding less fossil fuel-fired power. In a highly influential 2009 report, McKinsey and Company went a step further, suggesting that many

8 U.S. EIA, "Monthly Energy Review October 2020."

9 U.S. EIA, "U.S. Energy Facts Explained."

energy-efficient technologies even pay for themselves over the lifetime of the upgrades, with an overall negative cost per ton of CO_2 saved.[10] This report and others like it[11] have generated substantial enthusiasm around energy efficiency subsidies at the local, state, and federal levels. As Figure 3 shows, the United States has already devoted significant funding to energy efficiency: between 2000 and 2019, DOE alone spent $14.5 billion on energy efficiency research, technology evaluation, and program implementation.[12]

Energy efficiency has also been highlighted as an important route to achieving international climate goals. Figure 2 shows two International Energy Agency (IEA) scenarios for future climate policy worldwide: the Stated Policies Scenario, which reflects emissions reductions if current policy is sustained, and the Sustainable Development Scenario, which is designed to align with the United Nations' Sustainable Development Goals and the targets set out in the Paris Agreement. The wedges between the two scenarios illustrate the projected sources of emissions reductions needed to achieve the Sustainable Development Scenario. By 2050, the IEA projects that

10 Granade et al., *Unlocking Energy Efficiency in the U.S. Economy.*

11 Tonn et al., *Health and Household-Related Benefits;* Nadel and Ungar, *Halfway There.*

12 Gallagher and Anadon, "DOE Budget Authority for Energy Research."

Programs focused on retrofitting buildings with energy efficiency measures (including insulation and HVAC systems, seen here) have not always delivered expected energy savings.

energy efficiency will need to account for eight gigatons of energy reductions relative to present policy, or nearly 30 percent of all reductions, to meet the 2°C target.

Energy efficiency does not work as well as expected

If energy efficiency upgrades are as effective as they seem, it suggests that customers are leaving money on the table. The McKinsey analysis, for example, reports that more than 1.2 gigagtons of CO_2 (equivalent) savings could be attained at negative cost—that is, the efficiency investments would more than pay for themselves. The fact that consumers have not made these investments yet suggests that there may be an "energy efficiency gap" between how much energy efficiency consumers have invested in and the level of investment that would make them privately better off.[13] Potential explanations for this gap have included market failures such as lack of consumer information about available energy efficiency policies or products, as well as behavioral biases that cause consumers to make mistakes, such as inattentiveness (failing to consider the benefits of action), short-sightedness (overweighting the present relative to how much they would value the future in the future), and reference point dependence (overweighting the status quo).[14]

However, a large body of research has substantiated an alternative explanation: energy efficiency upgrades are not nearly as cost-effective as engineering projections

13 Allcott and Greenstone, "Is There an Energy Efficiency Gap?"

14 Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

suggest. Figure 1 shows realization rates from nine empirical evaluations of energy efficiency programs in the United States and Mexico. A realization rate compares realized savings caused by an energy efficiency upgrade, measured in the field, with the expected energy savings, typically derived from an engineering model. A realization rate of one implies that the energy efficiency upgrade delivered 100 percent of expected energy savings; a realization rate of zero implies that the upgrade delivered no savings. While the majority of this research focuses on residential retrofits such as installing insulation or energy-efficient appliances, one study demonstrates similar results in public schools in California. In all of these studies, the estimated realization rate is below one. Even the most optimistic study only finds a realization rate of 0.63: energy efficiency upgrades delivered only 63 percent of expected savings.[15]

The remainder of the studies are even less optimistic, with estimates ranging from 0.6 (in California schools)[16] to zero (on insulation and housing upgrades, and on air conditioning, both in Mexico).[17,18] Several studies of the flagship U.S. residential energy efficiency program, WAP, have likewise found low realization rates across

15 Boomhower and Davis, "Do Energy Efficiency Investments Deliver at the Right Time?"

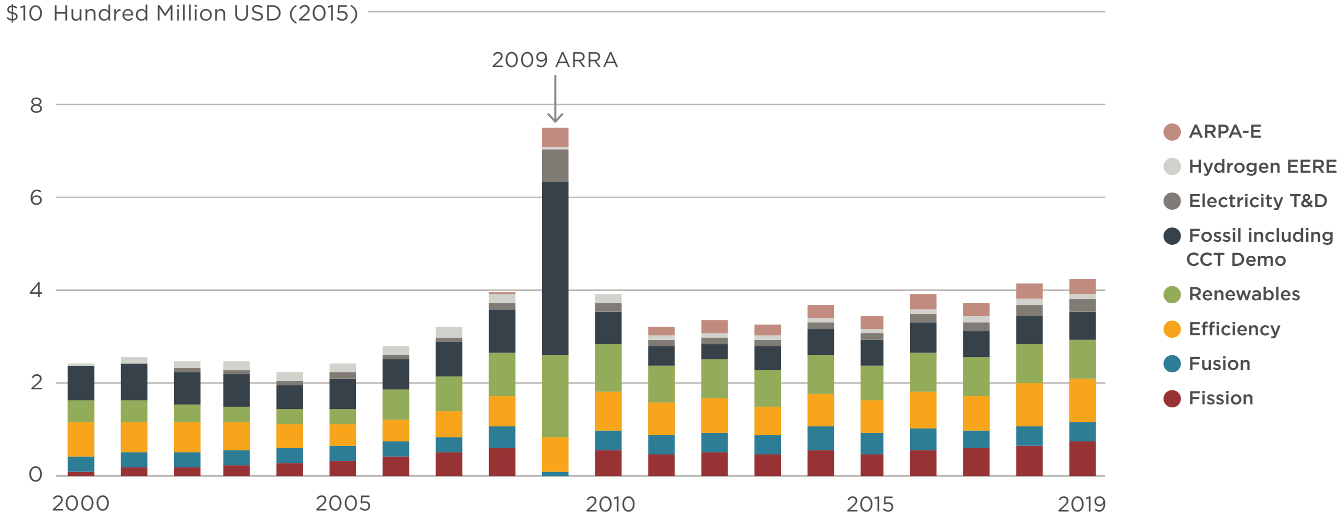
16 Fiona Burlig et al., "Machine Learning from Schools about Energy Efficiency."

17 Davis, Martinez, and Taboada, "How Effective Is Energy Efficient Housing?"; Davis, Fuchs, and Gertler, "Cash for Coolers."

18 In the air conditioning study, households actually increased their overall energy use as a result of the energy efficiency upgrades. They appear to have replaced old, dysfunctional, expensive-to-operate AC units with new ones and used them more.

FIGURE 3

$14.5 billion in DOE Funds Spent on Energy Efficiency from 2000 to 2019



Source: Gallagher, K.S. and L.D. Anadon, "DOE Budget Authority for Energy Research, Development, and Demonstration Database," The Fletcher School, Tufts University; Department of Land Economy, University of Cambridge; and Belfer Center for Science and International Affairs, Harvard Kennedy School; March 21, 2018. Note: DOE is just one source of federal spending for energy efficiency.

the country: 0.58 in Wisconsin,[19] 0.51 in Illinois,[20] 0.5 in California,[21] and 0.38 in Michigan.[22] In other words, this research demonstrates that energy efficiency upgrades are much less effective than expected. Several of these studies conclude that the *ex ante* engineering projections of energy savings from technologies were simply too high. These empirical results call into question the idea that similar energy efficiency programs will be as cost-effective as expected.

Several of these studies go beyond the realization rate and calculate cost-benefit measures. WAP, for example, was found to have an annual rate of return of -4.1 percent in Wisconsin[23] and -7.8 percent in Michigan, even when accounting for the benefits of emissions reductions.[24] That is: these weatherization programs did not pay for themselves, but instead cost states more than the private and social benefits they generated. This is in part because the emissions reductions these programs deliver come at a very high cost: in Mexico, residential energy efficiency upgrades cost $547 per ton of CO_2 saved—far higher than the best existing estimates of the social cost of carbon (for more information, see "Updating the United States Government's Social Cost of Carbon," page 20).

In short, energy efficiency policies consistently over-promise and under-deliver on energy savings. Instead of being a win-win, today's energy efficiency programs appear to be an expensive way of generating environmental benefits. Doing more with less energy, however, is an intuitively appealing way to reduce emissions, so the fact that these programs fall short of meeting their savings targets has important implications for both U.S. and global climate policy. Finding ways to improve energy efficiency retrofits, therefore, should be a key policy goal for the Biden administration.

How We Got Here

In the wake of the 1973 energy crisis sparked by the Arab oil embargo, in 1975 Congress passed the Energy Policy and Conservation Act (P.L. 94–163) to expand federal energy policy. This included increasing energy production and reserves to mitigate future supply chain disruptions and fostering energy conservation through fuel economy and energy efficiency standards for home appliances. The following year, the Energy Conservation and Production Act (P.L. 94–385) established energy standards for new buildings; provided grants, low-interest loans, and loan guarantees to improve energy conservation in existing buildings; provided oversight, proposals, and state funding to improve electric utility rate design; and created financial incentives for domestic energy production. Together, these acts created several energy efficiency programs under DOE, including WAP and the State Energy Conservation Program, which later became known as the State Energy Program (SEP).

19 Allcott and Greenstone, *Measuring the Welfare Effects of Residential Energy Efficiency Programs.*

20 Peter Christensen et al., *Decomposing the Wedge.*

21 Zivin and Novan, "Upgrading Efficiency and Behavior."

22 Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

23 Allcott and Greenstone, *Measuring the Welfare Effects of Residential Energy Efficiency Programs.*

24 Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

WAP provides funding to states for home weatherization, and was designed in part to reduce energy costs for low-income households, for whom energy expenditures often make up a large fraction of total spending. One study found, for instance, that low-income households with electric heat spend 12 percent of annual income on electricity. An average household with electric heat, by contrast, spends just 3 percent of its total expenditure on energy.[25] For the tens of millions of Americans living below the poverty line, home weatherization investments could have a meaningful impact on their household's bottom line. However, it is critical that these programs actually deliver real energy savings to low-income households.

WAP initially focused on measures thought to produce the most energy savings per dollar spent, such as air sealing and insulation improvements.[26] These measures eventually expanded to include sealing damaged doors, windows, pipes, and ducts; tuning, fixing, and installing heating and cooling units; and addressing potential gas leaks and electrical hazards.[27] Under the American Recovery and Reinvestment Act (ARRA), WAP's scale and scope increased dramatically. Funding increased from $450 million in 2009 to nearly $5 billion in 2011-12. Eligibility was extended to all owner-occupied households at or below 200 percent of the poverty line.[28] Over 7 million households have been provided weatherization assistance through the program since its inception in 1976.[29]

By rigorously testing energy efficiency programs and focusing funding on those that deliver real savings, policymakers can get the most out of every dollar spent.

As noted above, however, recent research has shown WAP's effectiveness to be vastly overstated, finding that the program's costs outweigh its benefits. Like many energy efficiency programs,[30] WAP uses engineers' estimates of a technology's energy-saving potential to estimate savings prior to determining which upgrades to install. These estimates can overstate savings threefold, with upfront weatherization costs typically double actual savings.[31] Even after accounting for the societal benefits of emissions reductions derived from installing more energy efficiency upgrades, WAP's average annual rate of return is approximately -7.8 percent.[32] These findings highlight the need to base resource allocation decisions on rigorous evaluations of real-world energy efficiency programs rather than engineering projections alone, by using existing empirical analyses where possible, conducting ongoing evaluations as new technologies are deployed, and revising funding guidelines in line with these real-world results.

The SEP provides funding and technical assistance to U.S. states and territories to promote energy efficiency. These funds are used in over eighteen project areas, including energy standards and audits, retrofits, grants

25 Environmental Defense Fund, *Low-Income Energy Efficiency*

26 Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, Weatherization Assistance Program Timeline."

27 Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, "Q&A: The Weatherization Assistance Program."

28 111th U.S. Congress, *American Recovery and Reinvestment Act of 2009* (P.L. 111–5), 2009.

29 Office of Energy Efficiency & Renewable Energy, U.S. Department of Energy, "Weatherization Assistance Program."

30 Kushler, Nowak, and Witte, *A National Survey of State Policies and Practices.*

31 Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

32 Ibid.

FURTHER READING

Energy Efficiency Policies

Machine Learning from Schools about Energy Efficiency

Journal of the Association of Environmental and Resource Economists

Energy efficiency improvements lowered electricity consumption on average by 3 percent, but the energy savings was only 24 percent of what was projected before officials invested in the upgrades.

and loans, and education and training.[33] As it did for WAP, ARRA significantly increased SEP's funding. From just $33 million in 2008, SEP was afforded $3.1 billion for 2009-11.[34] This grant also came without fund-matching requirements, allowing states to receive support without having to first raise money themselves. A 2015 review by Oak Ridge National Laboratory found SEP cost-effectively reduces energy consumption, increases renewable power generation, and avoids carbon emissions.[35] These estimates, however, are also based on engineering estimates, which as noted above significantly overstate the cost effectiveness benefits of WAP. The findings should therefore be interpreted with caution.

In addition to funding programs designed to retrofit private homes, like WAP, the federal government itself is also a major participant in energy efficiency programs. In 1973, the Federal Energy Management Program was established as part of the DOE to encourage the federal government to adopt more energy-efficient practices, such as improving utility management, adopting renewable energy technologies, and conserving energy.

The federal government's experience has been fairly similar to those of state agencies and private homeowners, however, as energy efficiency upgrades have not delivered cost savings in the expected timeframe. In 2011, the General Services Administration (GSA) published a national study comparing the environmental performance and financial metrics of twenty-two representative green buildings in its portfolio to commercial and GSA baselines.[36] Although the green buildings did use 25 percent less energy, GSA spent an estimated $172 million to achieve these reductions, with guaranteed savings amounting to just $10.8 million in the first year.[37] Even after ignoring potential operating and replacement costs and assuming

33 Schweitzer and Tonn, *An Evaluation of State Energy Program Accomplishments.*

34 Oak Ridge National Laboratory, *National Evaluation of the State Energy Program.*

35 Ibid.

36 Public Buildings Service, U.S. General Services Administration, *Green Building Performance.*

37 Shonder, *Energy Savings from GSA's National Deep Energy Retrofit Program.*

that future years would produce similar levels of savings, this investment would take sixteen years to pay off. This is a significantly lower payoff compared to gains typically achieved through investing in other energy efficiency endeavors, namely research and development. Ultimately, across a suite of federal programs, there is clearly room for improvement in the effectiveness of energy efficiency investments.

What To Do

Current energy efficiency programs in the United States have been shown to be expensive and relatively ineffective. The remainder of this chapter lays out two principles aimed at improving the existing suite of American energy efficiency programs to ensure that future policies generate tangible benefits at a reasonable cost.

PRINCIPLE

Correctly setting energy prices empowers consumers to make the best decisions

The vast majority of Americans currently face energy prices that are below the true cost of energy consumption.[38] When a household uses a kilowatt hour (kWh) of electricity, it does not pay the full cost that the production of that kWh imposes on society, because damage caused by energy-related global and local pollution is not reflected in the electricity price. This leads consumers to overuse energy relative to a scenario in which consumers actually paid for the pollution damages caused by electricity generation. In other words, without a price on pollution, the United States is implicitly subsidizing the use of fossil fuel energy. It also means that consumers will underinvest in energy efficient technologies, compared to a world with higher energy prices that reflect the true cost of electricity use, because there is less financial pressure to do so.

The textbook economics approach to closing the gap between the energy price a consumer pays and the true cost of that energy is a price on pollution (including carbon pollution), in the form of a pollution tax or other market-based instrument like cap-and-trade (for more information, see " Put a Price on It: The How and Why of Pricing Carbon", page 50). If Congress were to impose such a price, it would be more costly for an average household or firm to use energy, so consumers would find ways to reduce their overall energy use either by lowering consumption of energy services, or by turning to more efficient technology. Without such a price on carbon or other pollutants, consumers are missing an important incentive for energy conservation. As a result, government subsidies for energy efficiency continue to be a useful policy tool—provided that these subsidies are targeted towards cost-effective upgrades.

38 Borenstein and Bushnell, *Do Two Electricity Pricing Wrongs Make a Right?*

POLICY

Energy efficiency programs should be subject to rigorous *ex post* evaluation

Unless and until energy prices reflect the true cost of energy use, policymakers should continue to promote energy efficiency through other approaches. As noted above, the biggest challenge facing existing energy efficiency programs in the United States is that they are extremely costly, but do not appear to deliver promised energy savings or climate benefits. Across a variety of contexts and programs, research in this setting demonstrates two common themes, both of which highlight the importance of *ex post* evaluation in energy efficiency programs.

First, engineering projections for energy efficiency upgrades have been found to be overly optimistic.[39] Though current energy efficiency programs typically do require upgrades to pass a cost-benefit test of some kind, these metrics only use expected savings to determine which measures are eligible for installation. These expected savings metrics are often based on laboratory, rather than real-world conditions, which leave them susceptible to producing unrealistically high expected savings estimates. In contrast, *ex post* analysis has shown that energy efficiency upgrades deliver far lower savings than promised up front. For every 100 kWh in expected savings, large-scale North American energy efficiency retrofit programs provided substantially fewer

39 Burlig et al., "Machine Learning from Schools about Energy Efficiency;" Davis, Fuchs, and Gertler, "Cash for Coolers;" Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

savings: between 0[40] and 78[41] kWh, with WAP delivering approximately 24 kWh.[42]

Applying these realized savings estimates in place of engineering expectations, many energy efficiency retrofits that appeared to pass a cost-benefit test would no longer do so. Regulators should therefore require that proposed programs that are similar or identical to past initiatives use real-world results, rather than engineering estimates, in any cost-benefit analysis prior to launch. All ongoing programs should also be reviewed regularly and have a mechanism to accommodate new evidence. Measures that pass a cost-benefit review on the basis of realized savings should continue to be funded; measures that fail to do so should be excluded or amended in line with those findings.[43]

For new technologies, where possible, state and federal agencies planning to implement new approaches should begin with small-scale trials to generate rigorous evidence. Where this is not feasible, *ex ante* engineering programs can be used to begin with, but should be replaced by real-world analysis as part of a regular review process. Importantly, these *ex post* analyses must be rigorous and conducted independently. Randomized controlled trial evidence should be the standard.

A second reason for *ex post* evaluation of energy efficiency programs is that these analyses can go beyond simply identifying a difference between anticipated and real-world energy savings in energy efficiency programs to identifying the design flaws that account for these gaps. One important step in this process is identifying which of a program's individual energy efficiency measures, if any, are capable of efficiently reducing energy use in the real world.[44] For instance, a home weatherization program could fall short of expectations because the insulation technology underperformed, because the program failed to attract sufficient participation, the type of properties enrolled in the program were disproportionately energy efficient to begin with, or a host of other reasons. *Ex post* evaluations can tease out the specific components that contributed to program failure to improve future implementation or program design.

Ex post analysis can also identify implementation challenges that impede energy efficiency programs from delivering low-cost savings. In WAP, new evidence reveals that differences among contractors can explain up to 43 percent of the difference between expected and realized savings.[45] More effective contractor selection processes and incentives also have the potential to substantially improve energy efficiency retrofit programs. As an example, a new study finds that in California's low-income Energy Savings Assistance (ESA) program, when contractors were paid on a per-retrofit basis, they intentionally misreported program data and replaced relatively new appliances, rather than only the older, inefficient ones officially covered by the program. This lead an otherwise successful program to fail a cost-benefit test: had only the old refrigerators been replaced, the program would have been cost-effective, because these replacements delivered large energy savings. By contrast, replacing newer refrigerators generated little in terms of savings.[46] After this study was released, ESA contractors were required to provide photographic evidence that they were only replacing qualified refrigerators, which should make the program substantially more cost-effective. As state and federal agencies approve spending plans under WAP and other energy efficiency programs, they should bear in mind the clear importance of using careful monitoring and evaluation to update existing energy efficiency programs.

These examples demonstrate the benefits of evaluating energy efficiency programs: ensuring that these policies are re-evaluated using the best available evidence will allow policymakers to identify and eliminate wasteful program spending. The Biden administration and incoming Congress are likely to face historic demands on the federal purse. Rigorously evaluating proposed and ongoing spending will ensure that every penny spent on these programs is delivering real energy savings at low cost. Where they are not, it offers policymakers the opportunity to devote those resources to areas where they are more likely to have a positive return on investment.

One promising place to redirect funding from underperforming efficiency programs is research and development and basic science in the energy sector. Because the benefits to society of innovation tend to be higher than the narrow, private benefits the innovation accrues to the inventor, private firms under-invest in innovation. There is therefore a clear and beneficial role for federal spending in this area.

Closing Argument

Energy efficiency appears to be an attractive solution to America's energy challenge, with its dual promises of reduced local and global pollutants and lower energy bills. However, existing U.S. energy efficiency programs have failed to make good on these promises. Energy efficiency programs in the United States have substantially over-promised and under-delivered, with some, such as WAP, ultimately proving to have a negative return on taxpayers' investment.

That said, there are ample opportunities to improve U.S. energy efficiency spending. In an ideal world, Congress would pass pollution pricing—such as a carbon tax—and obviate the need for federal subsidies for energy efficiency retrofits.

In the absence of pollution pricing, energy efficiency retrofit subsidies can improve overall well-being, but must be targeted towards cost-effective investments. To do so, DOE and, where relevant, state program administrators, should require retrofit programs to incorporate data from rigorous *ex post* evaluation to determine which energy efficiency measures to invest in, and uncover potential flaws in program design. These evaluations should be conducted by independent evaluators using state of the art methods such as randomized controlled trials. Before applying new measures or technologies, these measures should first be piloted with a small sample of real consumers before being deployed at scale. When piloting is not possible, programs should begin with a combination of existing evidence on similar technologies and engineering estimates, and conduct *ex post* analysis after deployment. This approach would help to prevent costly, ineffective investments; help the government discover which energy efficiency retrofits deliver cost-effective energy savings and greenhouse gas reductions; and identify implementation failures that undermine program effectiveness.

This approach to energy efficiency will help the United States reduce carbon emissions and mitigate climate change, while enabling it to maintain high standards of living supported by the American energy system.

Energy efficiency retrofit programs, including those targeting air conditioning (pictured) have not delivered promised energy savings.

40 Davis, Martinez, and Taboada, "How Effective Is Energy-Efficient Housing?"

41 Burlig et al., "Machine Learning from Schools about Energy Efficiency."

42 Fowlie, Greenstone, and Wolfram, "Do Energy Efficiency Investments Deliver?"

43 In response to this research on WAP, its proponents claimed that a negative cost-benefit calculation should not be sufficient reason to suggest the program be reformed, because the program was also providing benefits to low-income households. However, this logic is flawed: it would have been much cheaper to simply provide these low-income households with the per-household cost of the program in cash if the goal were poverty alleviation.

44 Davis, Fuchs, and Gertler, "Cash for Coolers;" Allcott and Greenstone, Measuring the Welfare Effects of Residential Energy Efficiency Programs; Burlig et al., "Machine Learning from Schools about Energy Efficiency."

45 Christensen et al., Decomposing the Wedge.

46 Blonz, The Welfare Costs of Misaligned Incentives.

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