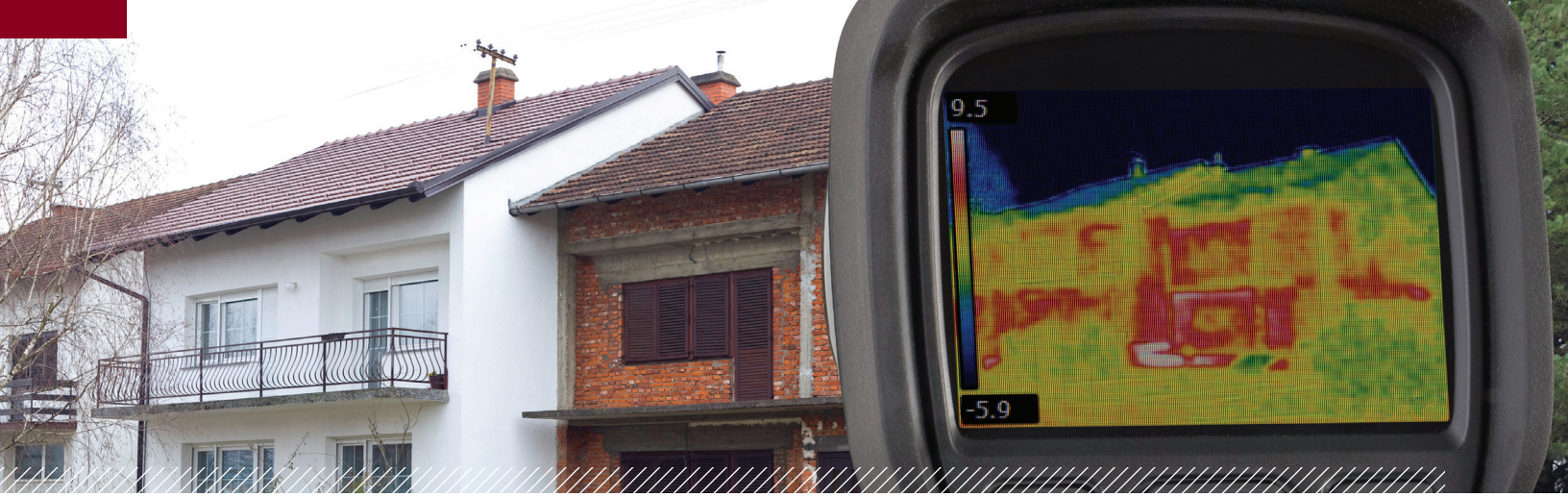


RESEARCH SUMMARY

Measuring the Welfare Effects of Residential Energy Efficiency Programs

by Hunt Allcott and Michael Greenstone

KEY TAKEAWAYS

1. Energy-efficiency programs offer tremendous potential to save consumers money by conserving energy, while also reducing pollution and greenhouse gas emissions. However, past studies of residential energy efficiency programs have revealed that some programs may not be delivering as promised.

2. The authors conduct a randomized experiment evaluating two large federally-funded residential energy-efficiency programs in Wisconsin. The experiment across more than 100,000 households was paired with administrative data to assess informational and behavioral barriers and other market failures.

3. The study finds that when it comes to deciding whether to participate in an energy-efficiency program, audit costs are an important factor for households—with a higher subsidy to encourage audits increasing the take up of audits. While some have proposed that consumers don't participate in such programs because they are incapable of or unwilling to weed through all of the information, the study did not find any evidence that consumers are poorly informed or suffer from behavioral biases.

4. While the audit subsidies encouraged more households to participate in the audits, these households were not very likely to take up the recommended improvements. This in turn lessened the impact the program had on reducing energy consumption, pollution and greenhouse gas emissions.

5. Ultimately, the study finds that households decide whether to make energy efficiency investments based on both monetary and non-monetary factors. For example, the households studied chose not to take up 40 percent of the investments that would have yielded a 20 percent or greater return, and did take up 36 percent of investments that yielded negative returns. This demonstrates that non-monetary factors like hassle costs, aesthetics, and the warm glow of having done something that benefits the environment contribute to the decision-making process.

6. Overall, instead of providing Wisconsin residents net energy benefits, the residential audit program evaluated had the opposite effect—the costs exceeded the value of the energy savings and the environmental benefits. This is because the realized energy savings were only 58 percent of what was projected and the subsidies were not well targeted at investments with the highest environmental benefits.

7. Energy-efficiency programs do offer significant potential to reduce pollution and emissions and save consumers money. However, in order for their potential to be realized, it appears that changes in their design are necessary. Specifically, this research suggests that subsidies for energy audits should be reduced or even removed. And, subsidies for energy efficiency investments should be better targeted towards investments that will deliver the greatest cuts in pollution and greenhouse gas emissions.

Introduction

Improvements in energy efficiency are often touted as win-win investments for consumers, businesses, and society at large. Energy users save money without sacrificing comfort or productivity (win number one). And, society as a whole benefits from reduced pollution and greenhouse gas emissions, and even enhanced energy security and reliability (win number two).

Global data on energy-efficiency investments suggest that significant progress has been made over the past several decades. The International Energy Agency (IEA) estimates that while over the last 15 years our economies have grown, our populations have risen, and vehicle use has increased, energy-efficiency improvements have reduced energy demand in IEA member countries by 12 percent. In 2015, such improvements left 870 million barrels of oil, 205 million tons of coal and 224 billion cubic meters of natural gas in the ground—altogether reducing greenhouse gas emissions by 13 percent (IEA, "Energy Efficiency Market Report," 2016).

For these reasons, in the United States and around the world, energy-efficiency investments play a key role in efforts to confront climate change. But despite its potential, some programs have fallen short of expectations. For example, a past analysis by one of this study's authors, Michael Greenstone, and Meredith Fowlie and Catherine Wolfram evaluated the impact of the U.S. Federal Weatherization Assistance Program using a sample of more than 30,000 households in the state of Michigan ("Do Energy Efficiency Investments Deliver? Evidence from the Weatherization Assistance Program," 2015). The evaluation revealed that the costs of the energy-efficiency investments were about double the households' energy savings, and that the projected savings were roughly 2.5 times the actual savings.

The findings underscored that projection models needed to be improved and further real-world analysis needed to be conducted. However, that study did not account for the unobserved costs and benefits of undertaking energy efficiency investments that are a real part of individuals' decision-making.

Research Design

This study provides additional real-world evidence of the impacts of energy efficiency. The authors worked with the Wisconsin Energy Conservation Corporation to evaluate two large energy-efficiency programs in Wisconsin: the Green Madison and Milwaukee Energy Efficiency programs. The residential energy audit component of the programs were funded with $2.4 million and $732,000 grants, respectively, as part of the national Better Buildings Neighborhood Program through the Energy Efficiency and Conservation Block Grant program. The programs subsidized home energy audits, during which homeowners would learn about recommended steps they could take (e.g., improving insulation, installing a new heating system). They also provided an Energy Advocate service to help consumers understand and act on the audit results, and subsidized some of the energy-efficiency investments the households ultimately decided to make.

The authors conducted a randomized experiment across more than 100,000 households. The experiment included informational letters sent to a subset of owner-occupied, single-family households eligible for the two programs in Madison and Milwaukee, Wisconsin. A significant portion of households were randomly assigned to receive two letters, while the rest were put into a control group. The letters varied along six dimensions meant to address informational and behavioral failures, such as descriptions of the various non-monetary benefits (i.e. reducing emissions, having a more comfortable home, etc.). Some households were also randomly assigned to receive audit subsidies.

The study paired the randomized experiment with administrative data to assess two market failures. First, the authors assessed how imperfect consumer information or behavioral barriers might distort a consumer's decision to have an audit. Second, they assessed how energy price distortions cause the private benefits from the investments to be different from the social benefits.

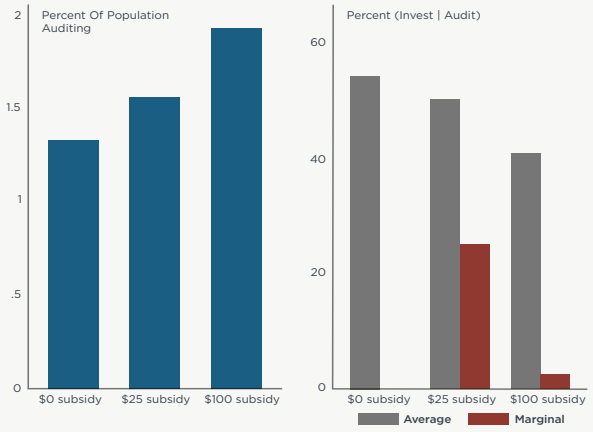
This method is different from most other evaluations of energy-efficiency programs in that it measures non-monetary investment costs and uses empirical evidence rather than simulated predictions. Importantly, this study also expands from the previous energy efficiency study conducted by Michael Greenstone and his colleagues in key ways: It uses a larger sample size that expands beyond low-income households; participants must pay a portion of the costs in order to participate unlike the wholly-subsidized Federal Weatherization Assistance Program; and the energy-efficiency investments expand beyond weatherization improvements. Still, the results are similar in many respects. Together, the two studies provide an increasingly clear picture of the effects of residential audit energy efficiency programs.

Findings

1. When it comes to deciding whether to participate in an energy-efficiency program, the study found that audit costs matter but there isn't evidence that consumers are poorly informed or suffer from behavioral biases. A $100 subsidy given to households to encourage them to participate in the audit increased the take up of audits by 32 percent. Additionally, some have proposed that consumers don't participate in such programs because they are incapable of or unwilling to weed through all of the information. The study did not find any evidence that consumers are poorly informed or suffer from behavioral biases. (Note: The program evaluated did employ Energy Advocates who provided households with helpful information and guidance. This service is not a standard feature of residential energy efficiency programs.)

2. The greater the audit subsidy to encourage households to participate, the less likely households are to make an efficiency investment. Subsidizing home energy audits caused more households to participate in the audits, but these households were not very likely to take up the recommended improvements. The households responsive to these subsidies appear to be "tire kickers" who are unlikely to make investments, indicating low returns to subsidized energy audits.

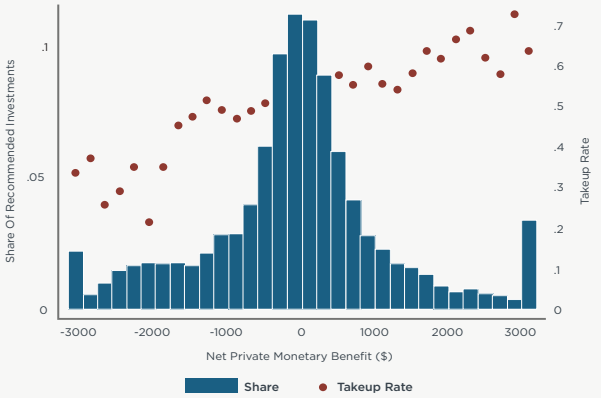
Figure 1 · Audit and Investment Take-Up Rates by Audit Subsidy Level



Note: The blue bars on the left describe the percentage of the population who signed up for an audit, for each amount of subsidy listed. The grey bars on the right describe, among those who audited under each subsidy amount, what percentage signed up for an efficiency investment. One can see that as the subsidy amount increases, the percentage of those who signed up for an investment decreases. The red bars show the percentage of people who took up an efficiency investment among people who took up the audit due to the $25 subsidy, relative to no subsidy, and took up the audit due to the $100 subsidy, relative to the $25 subsidy, respectively.

3. Households make decisions about energy efficiency based on monetary and non-monetary factors. Each $1,000 increase in the net present value of an efficiency measure increases the probability of an investment by 5 percent, but it is evident that households also care about non-monetary factors like hassle costs, aesthetics, and the warm glow of having done something that benefits the environment. For example, they chose not to take up 40 percent of the investments that would have yielded a 20 percent or greater return, and did take up 36 percent of investments that yielded negative returns.

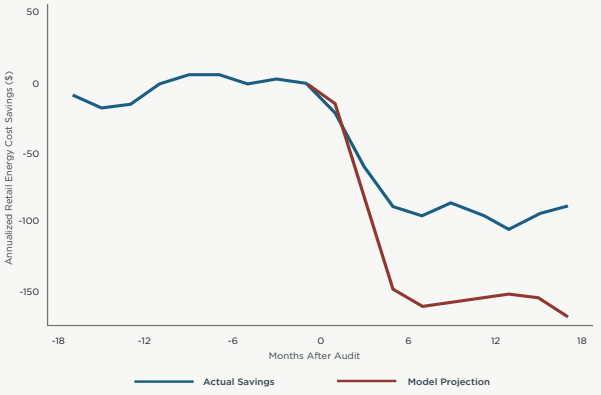
Figure 2 · Histogram of Net Present Value of Recommended Investments and Take-Up Rates



Note: The bars report the share of efficiency investments recommended (left axis) by the private net present value of each investment. For each bar, the red dot shows the fraction of these recommendations (right axis) that were actually taken up.

4. The amount of energy saved is substantially less than predicted. The estimated energy savings from energy-efficiency investments are only 58 percent of predicted savings—pointing to flaws in the engineering models that predict energy savings. The discrepancy in the realized versus actual savings was not caused by temporary weather patterns or a "rebound effect," in which households choose to use more energy in response to a decrease in energy costs.

Figure 3 · Actual and Predicted Energy Savings, by Months Since the Audit



Note: The blue line shows the actual energy cost savings in the months after the audit, relative to before. Time is normalized so that zero is the month of the audit. The red line shows the projected energy cost savings according to the models. The actual savings are just 58 percent of the projected savings.

5. Overall, the programs' costs exceeded its benefits. The programs reduce welfare by about $0.20 per subsidy dollar. This is because the subsidies attract households that do not ultimately make improvements to reduce emissions and the subsidies are not well-calibrated to target the energy-efficient investments that would deliver the largest reductions in pollution and greenhouse gas emissions. Consequently, the programs have a negative rate of return of roughly 4 percent.

However, energy-efficiency programs do have great potential to improve welfare if the subsides are better targeted. Namely, the study found that perfectly-calibrated subsidies could increase welfare by about $2.50 per subsidy dollar. For example, if an insulation improvement is projected to reduce climate damages and local air pollution by $500 more than what is internalized into retail energy prices, the optimal subsidy would be $500.

Policy Implications

The study clearly illustrates the vast potential of energy-efficiency programs to deliver on their promise to reduce pollution and emissions and save consumers money. However, reaching this potential requires restructuring policies to more precisely target the market failures that motivate them. Even subtle-seeming design issues can have very large implications for a policy's welfare impacts.

The design of the subsidies is especially important. The evaluation of the Wisconsin programs showed that subsidizing audits may be particularly ineffective because they draw in consumers who are unlikely to make efficiency investments. This leaves a significant amount of potential energy savings on the table.

The importance of subsidy design becomes even more critical outside of the Wisconsin programs, as many programs across the nation offer investment subsidies that scale as a percentage of investment costs. This type of subsidy design encourages high-cost investments without regard for either energy savings or environmental benefits.

To properly design energy-efficiency programs, the evaluation of current programs must be improved. The finding, consistent with past analyses, showing that some residential energy-efficiency investments yield savings that are substantially less than predicted ex ante by engineering models underscores the need for improved models. These models play a central role in helping consumers decide if they should have a home energy audit, and in helping policymakers and regulators decide whether to keep funding energy-efficiency programs.

While these models need to be improved, they must also not be the sole means of evaluating energy-efficiency programs. Instead, they should be paired with real-world field studies and look-back analyses using state-of-the art evaluation techniques, such as those used in this study. Routine retrospective evaluations of energy-efficiency programs at the state and federal levels using energy bill data would help to inform the projection models, as well as inform the design of future energy-efficiency programs to ensure the programs deliver the greatest energy savings at the least cost.

Energy-efficiency programs have great potential as methods to reduce energy consumption, pollution, and greenhouse gas emissions. Unfortunately, the programs evaluated are not meeting this potential. This research suggests that subsidies for energy audits should be reduced or even removed. And, subsidies for energy efficiency investments should be better targeted towards investments that will deliver the greatest cuts in pollution and greenhouse gas emissions.

> "This study confirms past studies finding that the costs of some residential energy efficiency programs exceed their benefits. But importantly, it also reveals vital lessons for how such residential programs can be improved. Doing so requires close coordination with policy partners who can help implement these lessons learned."
>
> **MICHAEL GREENSTONE**
> **DIRECTOR, ENERGY POLICY INSTITUTE AT THE UNIVERSITY OF CHICAGO**

The E2e Project unites top researchers in economics, engineering, and other fields to close the energy efficiency gap using transparent and state-of-the-art analyti-cal techniques. E2e is a joint initiative of University of California – Berkeley, the Massachusetts Institute of Technology, and the University of Chicago: three rec- ognized leaders in energy research.

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