

# The Effectiveness and Cost of Energy Efficiency Programs

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**E**NERGY EFFICIENCY PLAYS A CRITICAL ROLE in energy policy debates because meeting our future needs really boils down to only two options: increasing supply or decreasing demand.

However, in light of a range of energy issues—such as climate change, air pollution, and energy security—focusing exclusively on increasing supply is probably not the best way to go. Currently the United States emits approximately 1.58 billion metric tons of carbon equivalent (MMtCE) a year, and this number is rising steadily, presenting a daunting challenge to policymakers. Increasing energy efficiency holds the promise of providing a relatively inexpensive response to this challenge and other environmental effects of energy use, while continuing to meet demand.

The effectiveness and cost of government energy efficiency programs have, however, been the subject of a long-standing debate. To move beyond this point, two key questions need to be addressed. First, what types of energy efficiency programs have been implemented, and how much energy has been saved as a result? And, second, how much have these programs cost the public and private sectors, and how cost-effective have they been?

To look for answers, we evaluated the literature on a broad range of U.S. energy efficiency programs, with a focus on the adoption of energy efficient equipment and building practices (as opposed to transportation energy efficiency). Applicable programs and policies tended to fall into four general categories: appliance standards; utility-driven financial incentives — also referred to as energy demand-side management, or DSM; information and voluntary programs; and management of energy use by the federal government,

the nation's largest energy consumer.

Measuring the effectiveness or total energy savings from a conservation initiative or program can be difficult for a number of reasons and can lead to overly optimistic (or pessimistic) estimates. One problem is defining the baseline energy efficiency improvement that would occur in the absence of any program and avoiding double counting of the same energy savings attributed to multiple government programs. Another is accounting for “free riders,” people who receive rebates for energy efficient equipment that they would have purchased anyway. There is also the rebound effect, where people increase their utilization of equipment (for example, leaving their fluorescent lights on) because it costs less to operate. Another consideration is whether all of the salient costs (costs to the government, business, and consumers and losses due to quality changes) and the benefits of the programs (including otherwise unaccounted-for spillovers to energy savings in other areas) are being accounted for.

Our review reveals a lack of detailed independent *ex post* analyses of conservation programs, with almost all available quantitative estimates coming from institutions either administering or advocating the programs themselves. Independent analyses are key to understanding the robustness of the effectiveness and cost-effectiveness estimates reported here. Detailed analysis is particularly important for classes of programs, such as appliance standards or utility DSM, that policymakers may use more widely in the future.

Despite these caveats, the balance of evidence suggests that these programs are delivering positive net benefits and are likely to be a relatively inexpensive part of the overall solution to climate change mitigation.

## *Appliance Standards*

**M**INIMUM ENERGY EFFICIENCY STANDARDS FOR appliances in the United States first appeared in response to the energy crises of the 1970s and early 1980s. Many states, particularly California and New York, implemented appliance standards to cut the growth in energy demand. Leading manufacturers responded by putting pressure on the federal government to develop national standards that would supersede those of the states. Since 1987, the federal government has enacted a series of laws and regulations mandating minimum appliance energy efficiencies.

National standards have been established for an array of household appliances, including refrigerators, kitchen ranges and ovens, dishwashers, washers, dryers, and air conditioners. Standards have also been established for lighting fixtures and residential and commercial heating and cooling equipment. Cumulative federal government expenditures for the appliance efficiency program totaled \$61 million in 2002 dollars in the period 1979 to 1993. The effectiveness and overall benefits and costs of standards are discussed below.

## *Demand-side Management*

**U**TILITY-BASED PROGRAMS COVER A VARIETY OF ENERGY conservation and load management policies that allow utilities to better match demand with their generating capacity. Federal regulators and state public service commissions began implementing policies that led to the creation of utility DSM programs after the energy crises of the 1970s. Initially most were information-and-loan programs, designed to educate consumers and businesses about the cost-effectiveness of energy efficiency measures and to provide low-cost subsidized financing for investments in those measures.

Utilities gradually learned that education alone produced limited energy savings. In addition, most consumers were not interested in subsidized loans. As a result, utilities moved toward programs with stronger financial incentives to convince consumers to make energy saving choices, typically rebates for purchasing designated energy efficient equipment, such as fluorescent light bulbs. Load management programs, another consistent element of utility DSM, aim to limit peak electricity loads, shift them to off-peak hours, or encourage consumers to change demand in response to changes in utilities' cost of providing power at different times of the day.

In the 1990s, utilities turned to market transformation strategies, whereby an attempt is made to change the market for particular types of equipment or energy services so that

more efficient practices become the norm. This process usually consists of a coordinated series of demonstrations, training, or other information and financial incentives, with the hope that once a market is completely transformed, there will be substantially greater energy savings as the participation or market penetration rate approaches 100 percent.

Utility DSM evolved into standard operating procedure for a large number of power companies. For example, in 1990 over 14 million residential, 125,000 commercial, and 37,500 industrial customers nationwide were involved in DSM programs run by over a thousand utilities, large and small. While DSM policies matured in the mid-1990s, many state governments began to deregulate utilities. Diminished funds resulted in energy companies' suspending or curtailing these programs, although in recent years spending on them has leveled off.

## *Voluntary and Information Programs*

**T**HE ENVIRONMENTAL PROTECTION AGENCY (EPA) and the Department of Energy (DOE) jointly run the voluntary labeling program, Energy Star, which provides information on the relative energy efficiency of products. It was designed to reward manufacturers of the most energy efficient products with positive publicity, thereby encouraging consumers to buy those products and other manufacturers to improve the energy efficiency of their own products. The program now covers a wide array of products, including major appliances, computers and monitors, office equipment, home electronics, and even new residential, commercial, and industrial buildings. In addition to the labeling program, Energy Star also encompasses a range of public-private partnerships (for example, Green Lights), many of which began as separate programs and were moved under the auspices of Energy Star in the late 1990s. EPA spends around \$50 million annually on administering all Energy Star programs.

DOE also runs two voluntary programs to report and reduce greenhouse gas emissions. The 1992 Energy Policy Act mandated the establishment of a national inventory of greenhouse gases and a national database of voluntary reductions in greenhouse gas emissions (commonly referred to as the Section 1605b program). Companies are required to report measures to reduce emissions on a yearly basis. Reductions could come from any of a variety of methods, including fuel switching, forest management practices, use of renewable energy, manufacture or use of low-emissions vehicles, greater appliance efficiency, and even nonvoluntary measures such as facility closings and governmental regulations.

In 2001 alone, 228 different companies or government agencies voluntarily reported reductions in greenhouse gas emissions for 1,705 projects. These reductions totaled 6.1 million metric tons of carbon equivalent from energy efficiency conservation projects not associated with other voluntary or DSM programs. The government administrative costs of the Section 1605b database and inventory system are currently less than \$500,000 annually.

One factor that needs to be accounted for is that most entities reporting tended to be affiliated with one or more of the other government programs, and some percentage of their registered emissions reductions would have occurred anyway, without the Section 1605b program.

DOE also runs a complementary, voluntary program for utilities. The Climate Challenge program is designed to facilitate voluntary emissions reductions that make sense on their own merits. To take part, a utility must report to DOE annually on its progress, be willing to confer with the agency on possible strategies, and agree to one or more of six specified reduction commitments.

### *What Is the Effectiveness and Cost of These Programs?*

**T**AKEN TOGETHER, ESTIMATES INDICATE THAT THE conservation programs we reviewed save up to 4 quadrillion Btus (quads) of energy per year and reduce annual carbon emissions by as much as 63 million metric tons of carbon equivalent. This represents about a 3.5 percent reduction in annual carbon emissions relative to what they would have been in the absence of these programs. These estimates typically reflect the cumulative effect of programs (that is, all appliance efficiency standards currently in effect) on annual energy consumption. These total energy savings—4 quads—represent at most 6 percent of annual nontransportation energy consumption, which has hovered around 70 quads in recent years.

Most of these energy savings come from reduced energy use associated with residential and commercial buildings (as opposed to more efficient industrial processes), so another relevant basis of comparison is total energy use in buildings, which accounts for 54 percent of the 70 quads of nontransportation consumption. Consequently, the 4 quads of energy saved represent approximately 12 percent of all building-related energy use and about a 3.5 percent reduction in current annual carbon emissions.

The table opposite summarizes energy savings, costs, and carbon emissions savings for the largest-scale conservation programs. The programs are listed in an order roughly reflecting

our degree of confidence in the reliability of the estimates. Existing estimates suggest that minimum efficiency standards and DSM programs have provided some of the largest energy savings—about 1.2 and 0.6 quads, respectively, in 2000. Energy savings associated with the Energy Star and 1605b registry programs are also sizable (0.9 and 0.4 quads, respectively, in 2000), but it is less clear what portion of these savings would have occurred in the absence of these programs. Energy savings from other programs are relatively small or unavailable. We emphasize the use of quads for comparison among programs because many of the programs cover nonelectricity reductions, which have a different heat rate than electricity.

Bringing the energy savings and cost estimates together provides our measure of cost-effectiveness, defined as the annual cost of each conservation program divided by the physical energy savings it achieves. Estimates of overall cost-effectiveness are available only for efficiency standards for residential appliances (\$3.3 billion/quad saved in 2000) and DSM (\$2.9 billion/quad, including only utility costs for the energy efficiency portion of DSM). Note that higher dollars-per-quad cost-effectiveness estimates imply the program is *less* cost-effective (that is, it costs more per quad saved). If all energy savings were in the form of electricity, these estimates would translate to 3.8 cents/kilowatt-hour and 3.4 cents/kWh for appliance standards and utility DSM respectively.

The price of the energy that is saved by these programs can be used as a measure of benefits to which one can compare the cost-effectiveness estimates. While this price varies over time, as a benchmark the average price of electricity in 2000 was \$6.3 billion/quad of primary energy (or 7.4 cents/kWh of end-use consumption). As these energy savings are greater than the cost estimates cited above, this suggests that, as a group, efficiency standards are likely to have had positive net benefits (before environmental benefits are included). The cost-effectiveness of DSM is similar, but includes only utility costs. The average price we use for comparison is only a rough measure of benefits, however, and a more accurate measure would account for differences between this price and the *marginal* cost of the energy conserved.

The environmental benefits resulting from energy efficiency programs—from lower emissions of carbon dioxide (CO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), sulfur dioxide (SO<sub>2</sub>), and particulate matter (PM-10)—add value to these programs on top of the value of the energy they save. Based on national average emissions rates and available estimates of the dollar value of reducing air pollutants, we find that the environmental benefits of reduced energy consumption may add approximately 10 percent to the value of the energy savings rel-

ative to basing that value on the price of energy alone. That is, for every dollar energy efficiency programs save in reduced energy costs, they save about another 10 cents in reduced environmental harm. The majority (7 percent) of these benefits come from CO<sub>2</sub> reductions, with fewer benefits from NO<sub>x</sub> (2 percent), and SO<sub>2</sub> and PM-10 (0.5 percent each). Including environmental benefits therefore strengthens the case for energy efficiency programs but does not dramatically change their value based simply on energy savings. Viewed as a means for addressing climate change, however, energy efficiency policies appear likely to be a relatively inexpensive option, as the energy savings alone can cover the cost.

The continued use of energy efficiency policies over more than two decades and the prospect of expanded and new policies on the horizon suggest that this approach to achieving energy and carbon reductions will have a lasting presence. This is particularly true if conservation programs have positive net benefits in their own right and therefore yield emissions reductions at zero or negative net cost. But even if these estimates are overly optimistic, energy efficiency programs can be an important part of a low-cost, moderate climate policy, given that the effect of existing efficiency programs is of similar magnitude to what rough estimates suggest might come from a moderate carbon tax. ■

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### Further Readings

This article is based on the authors' much longer, more comprehensive assessment of the literature on energy-efficiency programs, which was supported by the National Commission on Energy Policy. See *Retrospective Examination of Demand-Side Energy Efficiency Policies*, [www.rff.org/Documents/RFF-DP-04-19rev.pdf](http://www.rff.org/Documents/RFF-DP-04-19rev.pdf).

Newell, Richard G. 2000. Balancing Policies for Energy Efficiency and Climate Change. *Resources*, Summer 2000 (140): 14–17. [www.rff.org/Documents/RFF-Resources-140-balancpol.pdf](http://www.rff.org/Documents/RFF-Resources-140-balancpol.pdf).

## Summary of Estimates of Energy Savings from Largest Conservation Programs in 2000

| Program Name          | Date | Energy Savings (quads) | Costs (billion \$2002) | Cost-Effectiveness (billion \$2002 per quad <sup>d</sup> ) | Carbon Emissions Savings (MMtCE) |
|-----------------------|------|------------------------|------------------------|--|----------------------------------|
| Appliance standards   | 2000 | 1.20                   | \$2.51 <sup>a</sup>    | \$3.28 <sup>a</sup>  | 17.75                            |
| Utility DSM           | 2000 | 0.62                   | \$1.78 <sup>b</sup>    | \$2.89 <sup>b</sup><br>(high \$19.64)                      | 10.02                            |
| Energy Star           | 2001 | less than 0.93         | \$0.05 <sup>c</sup>    | —  | less than 13.80                  |
| 1605b registry        | 2000 | less than 0.41         | \$0.0004 <sup>c</sup>  | —  | less than 6.08                   |
| DOE Climate Challenge | 2000 | less than 0.81         | —                      | —  | less than 12.04                  |

<sup>a</sup> Indicates that total costs and cost-effectiveness estimates are for residential appliance standards only while the energy savings and carbon emissions savings estimates are for commercial and residential standards combined. <sup>b</sup> Indicates only utility costs are included. <sup>c</sup> Indicates that only direct government administrative costs are included. <sup>d</sup> Billion dollars per quad of primary energy can be roughly converted to cents/kWh of end use consumption by multiplying by 1.166, which assumes all of the savings come from electricity using the average mix of generating facilities.