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The High Costs of Federal Energy Efficiency Standards for Residential Appliances

by Ronald J. Sutherland

Executive Summary

The U. S. Department of Energy administers a program that imposes minimum energy efficiency standards for residential appliances. Analysts at DOE's Lawrence Berkeley National Laboratory estimate that those standards will save consumers a net total of $150 billion through 2050 with a benefit/cost ratio of 2.75/1.

The LBNL calculations, however, rely on an underestimation of energy efficiency gains that would occur absent government mandates and use an unrealistically low consumer discount rate to calculate the value of future energy savings. A correction of those errors suggests that the DOE's energy efficiency standards will actually cost consumers a net $46.4 billion to $56.2 billion through 2050 in addition to the $200 million to $250 million required to run the program over that period. The program's costs are borne disproportionately by low- and middle-income households.

Because the appliance standards do not correct a market failure, increases in energy efficiency via government mandates—even if the standards were recalibrated—are unlikely to enhance the efficient use of energy resources or improve consumer well-being.

Ronald Sutherland is a consulting economist and adjunct professor of law at George Mason University and a senior scholar at the Center for the Advancement of Energy Markets.

Mandated energy efficiency standards increase the initial cost of new appliances and reduce product selection by eliminating technically less efficient appliances from the market.

Introduction

The origins of today's mandatory energy efficiency standards for residential appliances can be traced back to 1978 when Congress authorized the Department of Energy to set minimum energy efficiency standards for 13 household appliances.[1] The Reagan administration opposed the program, however, and delayed the promulgation of standards for several years. But the proliferation of varying state standards prompted appliance manufacturers to support uniform national standards,[2] which resulted in passage of the 1987 National Appliance Energy Conservation Act.[3] That law set the first national energy efficiency standards for refrigerators, freezers, furnaces, air conditioners, dishwashers, and other appliances, as well as deadlines for mandatory review of those standards.[4] The Energy Policy Act of 1992 expanded the initial coverage of standards to common types of incandescent and fluorescent reflector lamps and to some commercial and industrial technologies.[5]

Mandated energy efficiency appliance standards are designed to reduce the use of energy in affected appliances and thereby reduce energy costs to consumers over the lifetime of the appliance. Yet mandated energy efficiency standards increase the initial cost of new appliances and reduce product selection by eliminating technically less efficient appliances from the market. All of that increases the price to consumers. Net benefits are estimated by comparing the one-time increase in purchase price as compared to the present value of the future energy savings. In sum, energy efficiency trades off higher upfront costs for lower operating costs.

This study examines the costs and benefits of federal mandated energy efficiency standards for residential appliances and finds that net benefits are highly overstated by supporters of the program. The main problem is that supporters underestimate energy efficiency gains that would occur absent government mandates and use an unrealistically low consumer discount rate to calculate the present value of future energy savings. A cost-benefit analysis that corrects those errors indicates that such standards impose significant net costs on consumers.

This conclusion should not come as a surprise. Most economists agree that—absent market failure[6]—government intervention reduces market efficiency and proves counterproductive.[7] The literature supporting energy efficiency standards seldom refers to market failures, however. Instead, "market barriers" are invoked to provide an economic rationale for standards.[8]

A typical example is a paper by Eric Hirst and Marilyn Brown, energy analysts from Oak Ridge National Laboratory, which discusses several barriers that purportedly discourage market participants from making the most cost-effective energy choices.[9] Those market barriers include perceived risks, limited information, uncertain fuel prices, and limited access to capital.

In a previous paper, I reviewed the alleged market barriers and concluded that they are not market failures but instead merely benign characteristics of well-functioning markets.[10] Some of the identified market barriers contribute to a slow rate of adoption of new technologies, but slow diffusion is typical of most markets and, thus, not a market failure that warrants government intervention.

Asserted Benefits of Energy Efficiency Standards in the Residential Sector

Proponents of mandatory energy efficiency standards cite several benefit-cost studies that conclude that federal regulation of residential appliances saves consumers billions of dollars. Most of those studies are prepared by the same DOE national laboratories that develop analyses in support of such standards. Mainstream economists have not, to my knowledge, closely examined those estimates, even though economists have successfully refuted many similar claims about other government and utility-sponsored energy conservation programs.[11]

Benefit-cost analyses of energy efficiency appliance standards appear complex because large spreadsheets are required to reflect all the variables and their annual changes over subsequent decades. However, the basic methodology for calculating the present value of benefits is relatively simple.

Net benefits are calculated by estimating future energy consumption *without* the standards and subtracting from that figure estimated future energy consumption *with* the standards. These estimated energy savings are multiplied by a projected electricity price to obtain an estimate of dollar savings. The estimated future cost savings are then discounted to the present, because a dollar today is more valuable than a dollar tomorrow. The increased cost of the appliances affected by the energy efficiency mandates is then subtracted from the calculated energy savings to obtain net benefits.

The net benefits of standards will be high if the new appliance has a low incremental cost for increased energy efficiency; if the appliance substantially reduces energy use relative to the base case; if the price of energy increases in the future; and if consumers use a low discount rate. Similarly, net benefits will be low if consumers use a high discount rate; if the energy saving is smaller than estimated; if energy prices decline, or if the investment costs of standards are higher than expected. For instance, if significant technical improvements in appliances were to occur without standards, actual energy saved would be less than estimated, and net benefits would be over-estimated.

Lawrence Berkeley National Laboratory has been the DOE's primary contractor for engineering and economic analysis of appliance standards since 1982. An LBNL group of about 20 full-time analysts produces technical and economic analyses of alternative standards. The DOE, however, selects the levels that become law. The main residential appliances covered by those standards are detailed in Table 1.

On the basis of analyses from the LBNL, Meyers et al.[12] estimate that federal energy efficiency standards for household appliances listed in Table 1 will

- reduce U.S. carbon dioxide emissions by 8–9 percent in 2020 compared with levels expected without any standard,
- save a cumulative total of 25–30 quads

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Table 1
Residential Appliances and Equipment Affected by DOE Energy Efficiency Standards

Product/year	Original Standard	First Update	Second Update
Refrigerators	1990	1993	2001
Freezers	1990	1993	2001
Room AC	1990	2000	Future
Central AC1	1992	2006	Future
Clothes Washers	1988	1994	2004
Clothes Dryers	1988	1994	Future
Dishwashers	1988	1994	Future
Water Heater	1990	2004	Future
Gas Furnaces	1992	Future	Future

[1] Heat pumps are included.

Source: James McMahon, Peter Chan, and Stuart Chaitkin, "Impacts of U.S. Standards to Date," *Proceedings of the 2nd International Conference on Energy Efficiency in Household Appliances and Lighting*, Naples, Italy, September 27–29, 2000. Updated information from S. Meyers, J. E. McMahon, M. McNeil and X. Liu, "Impacts of US Federal Energy Efficiency Standards for Residential Appliances," *Energy* 28 (June 2003): 756.

of energy by the year 2015 and 60 quads of energy by 2030,

- save consumers nearly $80 billion by 2015, $130 billion by 2030, and $150 billion by 2050,[13] and
- provide a 2.75:1 benefit/cost ratio over the period 1987–2050.[14]

Moreover, they concluded that the cumulative cost of the DOE's program to establish and implement standards is in the range of $200 million–$250 million over the entire course of the program.

An examination of the assumptions underlying the LBNL cost-benefit calculation, however, reveals serious problems. Using more appropriate assumptions and a more rigorous definition of benefits produces a rather unfavorable cost-benefit finding. In brief:

The program will impose a net cost of at least $46.4 billion on consumers over the life of the program.

- Energy savings and corresponding emissions reductions are approximately one-third of those reported,
- The program will impose a net cost of at least $46.4 billion on consumers over the life of the program, and
- Economic costs will be borne primarily by the poor.

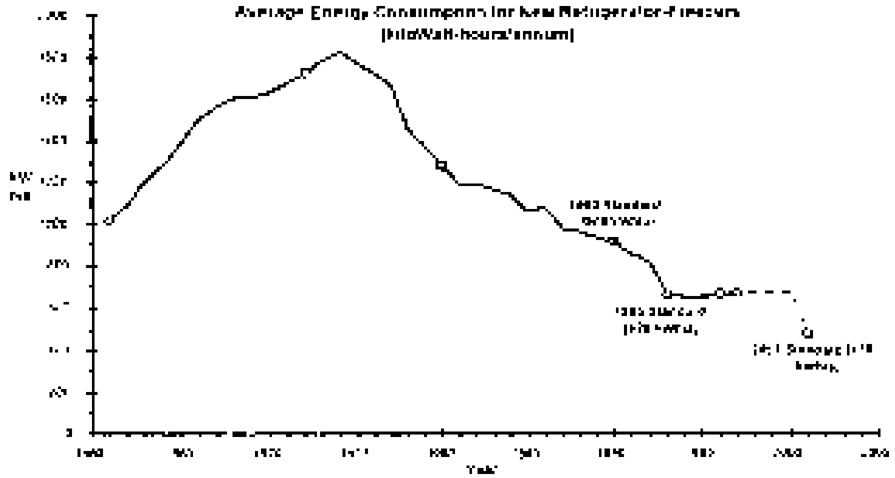
Energy Efficiency Trends for Residential Appliances

Estimating the impact of standards requires estimating the hypothetical alternative—the energy efficiency rating in new models in the absence of standards. Contrary to popular belief, the historical trends in average energy consumption for new appliances show significant increases in energy efficiency before the imposition of standards. Those trends cast doubt on one of the most fundamental aspects of the cost-benefit calculations used to justify the program.

Data from McMahon, Chan, and Chaitkin, for instance, show historical energy intensity in new refrigerators from 1960 through 2000.[15] The McMahon data indicate a clear trend toward increasing energy use from 1960 through 1974, followed by a declining trend thereafter.

Not coincidentally, the average energy con-

Figure 1
Average Energy Consumption for New Refrigerator-Freezers (in kilowatt-hours)



Source: James McMahon, Peter Chan, and Stuart Chaitkin, "Impacts of U.S. Standards to Date," *Proceedings of the 2nd International Conference on Energy Efficiency in Household Appliances and Lighting*, Naples, Italy, September 27–29, 2000, p. 2, http://eappc76.lbl.gov/tmacal/docs/45825_Mcmahon_Impacts.pdf.

sumption for new refrigerators is strongly correlated to trends in electricity prices. According to the Energy Information Administration, the price of residential electricity in constant dollars fell from 11.7 cents/kWh in 1960 to 7.4 cents/kWh in 1973, a decline of 36.7 percent.[16] It then rose from its 1973 trough to 10.03 cents/kWh in 1985 before leveling off.[17]

The increasing demand for energy to power refrigerators from 1960–1973 should therefore not surprise—it is an expected market response to declining energy prices. Likewise, the decline in energy costs to run refrigerators between 1973–1985 should not surprise—it is an expected market response to increasing energy prices. The decline in energy use per refrigerator (from about 1800 kWh/year in 1974 to about 800 kWh/year in 1990) cannot be attributed to federal energy efficiency standards because those standards did not come into effect until 1990. The long-term decline in energy use per new refrigerator is more likely explained by the increasing energy prices of the 1970s.

Are those trends evidence of the inefficiency of private markets? It depends on whether we define efficiency as requiring "the efficient use of energy" (a technological concept) or "the efficient use of energy resources" (an economic concept).[18]

The refrigerator offers an excellent case in point. Consumers value low operating costs (and thus energy efficiency), but they also tend to like large refrigerators and features such as

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Table 2
Energy Use by Selected Residential Appliances: 1980–2001

	kWh/year		kWh/cycle		
Year	Refrigerator	Room AC	Freezer	Clothes Washer	Dishwasher
1980	1275	1134	883	2.59	2.87
1981	1190	1161	837	2.57	2.70
1982	1191	1135	813	2.54	2.67
1983	1160	1088	813	2.58	2.72
1984	1139	1044	799	2.62	2.65
1985	1058	1002	787	2.71	2.66
1986	1074	1000	754	2.74	2.71
1987	874	938	685	2.68	2.69
1988	964	915	766	**2.67**	**2.67**
1989	934	900	611	2.68	2.67
1990	**916**	**862**	**600**	2.67	2.66
1991	857	925	600	2.71	2.56
1992	821	853	590	2.21	2.14
1993	**660**	851	**453**	2.22	2.07
1994	653	843	471	**2.24**	**2.06**
1995	649	838	465	2.21	2.02
1996	661	820	461	2.27	1.97
1997	669	826	469	2.17	1.98
1998	NA	NA	NA	2.22	2.00
1999	690	794	472	2.19	1.92
2000	704	**786**	NA	NA	NA
2001	566	769	438	NA	NA

Note: Bold indicates year of standard.
Source: American Home Appliance Manufacturers.

Most of the reduced energy use in new appliances is due to the normal functioning of markets, and especially from technical improvements induced by energy price changes.

automatic defrosting, both of which require more energy than would otherwise be the case. Consumers allocate their resources efficiently by purchasing energy efficient refrigerators when electricity prices are high and energy-intensive refrigerators with attractive features when electricity prices are low. The optimal trade-off between energy efficiency and other amenities is a matter of individual preference.[19] The singular focus on energy efficiency, instead of actual benefits to consumers, is one explanation for the faulty cost-benefit analysis of DOE programs.[20]

The Association of Home Appliance Manufacturers publishes annual historical data on the energy consumption of new appliances. Table 2 shows the trend in energy consumption per year of new refrigerators, freezers, room air conditioners, clothes washing machines, and dishwashers. The year in which federal standards are imposed or revised is indicated by denoting energy use in bold.

The data in Table 2 cast serious doubt about the energy savings allegedly secured via federal standards. Generally, energy use declined in new appliances well before standards came into effect. In the case of clothes washers it appears that more energy was used per cycle after the 1988 standards came into effect than before. This decline in energy use of new units was no doubt motivated by the energy price increases during the 1970s.

To better understand the factors affecting trends in energy efficiency, economists Richard Newell (then a graduate student at Harvard, now a fellow at Resources for the Future), Adam Jaffe of Brandeis, and Robert Stavins of Harvard examined the data on energy efficiency for new room air conditioners, central air conditioners, and gas water heaters.[21] The evidence presented by Newell et al. differs among the three appliances, but overall it indicates that changes in technology independent of regulatory standards had the largest effect on energy intensity, followed by energy price effects that induced technical improvements. Appliance standards had the least overall effect on energy use, but had the largest effect on gas water heaters.

The LBNL analyses of projected energy saving per appliance is the difference between projected energy use without new standards and projected energy use with standards imposed. LBNL base case projections are apparently modest but difficult to discern. For instance, Meyers et al. state: “We then made a subjective estimate as to how AAEU (or energy efficiency) might have evolved if no standard had been implemented.” The LBNL base case assumptions are not apparent from published research, but an LBNL report contains a graphic representation of base case projections for several appliances. The LBNL cases “without standards” typically reflect a modest increase in energy efficiency, but in some instances indicate that energy efficiency does not increase at all.[22]

The LBNL projections of energy savings with appliance standards are in marked contrast to those of Newell et al., who found that perhaps less than one-third of the energy savings in new appliances could be attributed to federal standards. In contrast, most of the reduced energy use in new appliances is due to the normal functioning of markets, and especially from technical improvements induced by energy price changes. In sum, LBNL researchers are overestimating energy saved under federal standards.

Discount Rates: The Ghost in the Machine

Estimates of consumer benefits are highly sensitive to the choice of consumer discount rate. Accordingly, discount rates are a continual subject of controversy, especially the discount rates used to value government investments. The discount rate that produces the correct value that consumers place on future energy savings is the discount rate that characterizes actual consumer behavior. That is, consumers trade off present consumption for future consumption according to some discount rate, and that discount rate should be used to value future energy savings.

LBNL analysts use discount rates of 3 percent and 7 percent to calculate the benefits of federal energy efficiency standards. To put those numbers into perspective, consider the question, "How much are households willing to pay for an investment that reduces future energy costs by $20 per year in perpetuity?"[23] A household willing to pay $286 for $20 per year in perpetuity would have a 7 percent discount rate. A household willing to pay only $100 for such an investment would have a 20 percent discount rate. Consumers that have a 3 percent rate would be willing to pay $667 to receive just $20 per year.

Which is the "right" discount rate? The answer largely hinges on the potential yield for alternative investments and the risk of the investment in question.

The opportunity cost of capital is critical in determining the discount rate. In their textbook *Principles of Corporate Finance*, Richard Brealey and Stewart Myers explain:

> To calculate present value, we discount expected payoffs by the rate of return offered by equivalent investment alternatives in the capital market. This rate of return is often referred to as the **discount rate**, **hurdle rate**, or **opportunity cost of capital**. It is called the *opportunity cost* because it is the return forgone by investing in the project rather than investing in securities.[24]

Suppose, for instance, that a firm can borrow at 8 percent and earn a rate of return of 10 percent by investing in a project. The project has a positive net present value. Suppose further that investments in the stock market yield an expected rate of return of 13 percent with the same risk as that posed by the aforementioned project.[25] Even though the proposed project appears feasible, it is an inefficient investment. The opportunity cost of capital is 13 percent. If the best opportunity is to invest in common stocks with an expected nominal rate of return of 13 percent per year, then an alternative investment of similar risk must yield at least 13 percent to be attractive.

Similarly, consumers who invest in energy efficiency are forgoing financial investments with an expected rate of return of 13 percent. A possible opportunity cost of an energy efficient investment is the expected rate of return on common stocks, hence such consumers have a discount rate of at least 13 percent. Middle- and low-income households typically do not trade off common stock investments for energy-saving investments, but instead must forgo present consumption of basic necessities of life. This opportunity cost would suggest an even higher discount rate for these households.

The attractiveness of investments also depends on risk, liquidity, and irreversibility. All things being equal, investors rightly demand higher rates of return for riskier investments than for less risky investments. Both stock market investments and energy efficient investments are risky. However, energy investments are typically irreversible, whereas common stock purchases are almost immediately liquid. The irreversibility of energy efficiency investments is apparent; a consumer who purchases an energy efficient heat pump in response to high energy prices cannot readily sell the heat pump should energy prices decline. The irreversibility property of energy efficiency investments means that consumers should require higher discount rates to value such investments.[26]

Economists Kevin Hassett of the American Enterprise Institute and Gilbert Metcalf of Tufts University calculate that the irreversible nature of energy conservation investments justifies a discount rate four times higher than the norm.[27] Metcalf and Rosenthal (then a DOE economist) reach a similar conclusion in applying the model to commercial lighting and energy efficient refrigerators.[28]

The literature indicates that an appropriate discount rate for residential energy efficiency investments is at least 21–28 percent, if not higher. Consumers appear to agree, according to a review of the literature undertaken by economist Kenneth Train of the University of California at Berkeley.[29] And as Coleman Bazelon of the Congressional Budget Office and economist Kent Smetters of the Wharton School at the University of

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Pennsylvania note: "There is little rationale for the government to discount future costs and benefits of any particular project or program differently than the private market."[30]

Costs and Benefits Reconsidered

The LBNL analysis performed by Meyers et al. uses a discount rate of 7 percent and provides a benefit/cost estimate of 2.75/1.[31] Doing the math with Meyers et al. numbers suggests that total consumer benefits from federally mandated energy efficiency programs total $235.7 billion, incremental consumer costs total $85.7 billion, with a net present value to consumers of $150 billion.[32] The annual dollar value of energy saved, according to Meyers et al., is about $16.5 billion per year.

Recall that the present value of energy efficiency investments depends on both the assumed discount rate and assumptions about how much energy efficiency will increase in the absence of standards. Table 3 examines the present value of an $85.7 billion investment in energy efficiency with alternative discount rates and assumed future energy savings. Consumer preferred discount rates range from 7 percent per year up to 35 percent, reflecting the above discussion. Using the Newell result that two-thirds of the energy efficiency increases are market induced, standards should account for one-third of the energy efficiency increases. In the LBNL analysis, some increase in energy efficiency is market induced, but this amount is small and not clearly specified. In the following analysis, we assume, somewhat arbitrarily, that standards account for 50 percent of the claimed dollar savings. Hence, 50 percent of the energy efficiency assumed by LBNL occurs as a result of technical change caused by market forces, rather than from appliance standards.

The first row in Table 3 reproduces the LBNL result wherein a 7 percent discount rate produces $235.7 billion in present value to consumers for saving energy. This row is the LBNL estimate of net benefits equal to $150 billion ($235.7–$85.7), and where benefits/cost = 2.75/1. The second row in Table 3 shows that if energy saving is reduced by half (the Newell result), the present value of consumer benefits is likewise reduced by half. The table reveals that consumers with high discount rates place a lower value on energy efficiency investments. For instance, consumers with a 21 percent discount rate (cases 5 and 6) would value future energy cost saving at a net loss of $46.41 billion to $7.13 billion. Consumers would not make such an investment without government mandates. If consumers discount future energy cost savings by 14 percent in the Newell case or by 21 percent or more, energy efficiency appliance standards would make consumers worse off. The main implication of the results in Table 3 is that the use of higher but reasonable consumer discount rates and market-induced technology improvements reverses the LBNL results of positive net benefits due to federal appliance standards.

A review of Table 3 clearly shows that federal energy efficiency standards for residential appliances are nowhere near the "good deal" suggested by supporters. More reasonable assumptions regarding discount rates and energy efficiency trends in the marketplace absent federal standards demonstrate that the federal standards impose net costs on consumers.

Energy Efficiency Standards: Taxing the Poor?

According to a review of the economic literature by Kenneth Train, low-income households require much higher discount rates than high-income households to make similar investments. The net losses to consumers from appliance standards are therefore much greater for low-income consumers than for high-income consumers. This conclusion follows from studies of discount rates that consistently conclude that consumer discount rates are inversely related to household

Table 3
The Present Value of an $87.5 Billion Investment in Energy Efficiency with Alternative Assumptions

Case	Discount Rate	Autonomous Energy Efficiency	PV of Investment (in bill. $)	Net PV of Investment (in bill. $)
1	7%	0%	$235.70	$150.00
2	7%	50%	$117.85	$32.15
3	14%	0%	$117.85	$32.15
4	14%	50%	$58.93	-$26.77
5	21%	0%	$78.57	-$7.13
6	21%	50%	$39.29	-$46.41
7	28%	0%	$58.93	-$26.77
8	28%	50%	$29.46	-$56.24
9	35%	0%	$47.14	-$41.44
10	35%	50%	$23.57	-$62.13

Notes: These calculations use the equation I = R/r (see endnote 27), where an investment of $85.7 billion for EE produces a present value of energy saving of $235.7 billion. Where r = .07, annual energy saving is $16.5 billion. The base case is the LBNL result where the B/C ratio is 2.75/1, B – C = $150 billion, and r = .07.

income. Summaries of those studies are presented in Tables 4–7.

The evidence indicates clearly that low-income consumers have very high discount rates and therefore require a very high rate of return to make the same investment that higher income households make with lower discount rates. Because the Train survey article of 1985 refers to previous studies, the income classes in the above tables are low by current income levels. However, the results have not been challenged, and the estimated discount rates should reflect relative income levels today.

Although Tables 4–7 are merely a sample, the results are consistent with all 14 studies that Train reviewed.[33]

Another study, this one by economists Hartman and Doane, calculated the discount rates for household energy conservation choices by household characteristic. Their main finding was that the lowest three income

Appliance efficiency standards appear to affect market choices by removing the low-end and less energy-efficient units from the market.

Table 4
Consumer Discount Rates and Income: Space Heating System

Household Income	Discount Rate
$1,000	56%
$5,000	46%
$10,000	38%
$25,000	25%
$40,000	19%
$60,000	14%

Source: J. Berkovec, J. Hausman, and J. Rust, "Heating System and Appliance Choice," Report Number MIT-EL 830004WP, MIT Energy Laboratory (1983), cited in Kenneth Train, "Discount Rates in Consumers' Energy-Related Decisions: A Review of the Literature," *Energy* 10, no. 12 (1985): 1251.

Table 5
Consumer Discount Rates and Household Income: Air Conditioners

Household Income	Discount Rate
$6,000	89%
$10,000	39%
$15,000	27%
$25,000	17%
$35,000	8.9%
$50,000	5.1%

Source: J. Hausman, ”Individual Discount Rates and the Purchase and Utilization of Energy-Using Durables,” *The Bell Journal of Economics* 10 (Spring 1979): 33-54, cited in Kenneth Train, ”Discount Rates in Consumers’ Energy-Related Decisions: A Review of the Literature,” *Energy* 10, no. 12 (1985): 1251.

Table 6
Consumer Discount Rates and Income

Household Income	Discount Rate
$10,000	59%
$20,000	35%
$25,000	31%
$30,000	29%
$50,000	24%

Source: S. Beggs, N. Cardell and Hausman, *Journal of Econometrics* 17, no. 1 (1981). Cited in Kenneth Train, “Discount Rates in Consumers’ Energy-Related Decisions: A Review of the Literature,” *Energy* 10, no. 12 (1985): 1251.

Table 7
Discount Rates and Household Income: Space Heating Systems

Household Income	Discount Rate
$4,000	51%
$8,000	25%
$12,000	17%
$16,000	13%
$20,000	10%
$25,000	8%
$35,000	5.8%
$50,000	4.1%

Source: A. Goett and D. McFadden, “Residential End-Use Energy Planning System (REEPS),” Report EA-2512, Electric Power Research Institute, Palo Alto, CA. Cited in Kenneth Train, “Discount Rates in Consumers’ Energy-Related Decisions: A Review of the Literature,” *Energy* 10, no. 12 (1985): 1251.

classes applied discount rates of 87.8 percent, 79 percent, and 52.8 percent respectively for those investments.[34] Discount rates were also found to be higher for the elderly than for others and higher for renters than home owners. Hartman and Doane conclude, "Use of the market rate of interest *simply will not do*."[35]

The inverse relationship between discount rates and household income is defensible from a consumer's point of view. A consumer's discount rate, remember, is determined by his opportunity cost, which is what the consumer must forgo to make the investment. High-income consumers may forgo an investment in common stocks to invest in energy efficiency, and the long-run rate of return on common stocks over the last century was about 13 percent per year. Although appliances have unattractive investment properties, high-income households that forgo investments that yield 13 percent would require a rate of return for energy efficiency investments of at least 13 percent, plus an irreversibility penalty. As explained above, the irreversibility property of such investments suggests a required rate of return of at least 20 to 30 percent.

In a previous paper, I suggested that the high discount rates characteristic of low-income households was the result of the risk and illiquidity associated with energy efficiency investments and the inability to diversify away risk.[36] An even more obvious explanation begins by noting that the opportunity cost for a low-income household to invest in energy efficient appliances is not a financial investment. Low-income households have low and even zero savings; their opportunity cost consists of the basic necessities of life: food, clothing, and shelter. Low-income households must give up these necessities to invest common stocks or in energy savings mandated by government. The high opportunity cost of forgoing necessities should require a very high discount rate.

Government mandates remove appliances that poor people would prefer to purchase from the market. They require the poor to make unattractive investments that are not in their self-interest. Appliance standards accordingly impose an economic burden that weighs particularly heavily on low- and middle-income people.

Appliance efficiency standards appear to affect market choices primarily by removing the low-end and less energy-efficient units from the market. For instance, Meyers et al. state that for new units sold in 1987–1999, actual energy efficiency exceeded the minimum required by the standard, sometimes by a significant amount.[37]

A reasonable conclusion is that high-income consumers tend to buy high-end appliances that have high energy efficiency ratings. Low-income consumers tend to buy low-end appliances that have lower energy efficiency ratings. Revealed household discount rates reported in the literature support this view. Newell demonstrates, moreover, that most of the increases in appliance energy efficiency are driven by consumer preferences and autonomous technological advances, not government mandates.

Hence, it appears that comparatively wealthy consumers purchase about the same appliances that they would have purchased in the absence of energy efficiency standards. Comparatively poorer consumers, however, find that their preferred choices are removed from the market because of federal energy efficiency standards.

Given that energy efficiency standards disproportionately affect lower-income households with very high discount rates, the program's net benefits should probably be calculated using at least a 35 percent discount rate—the rate used in cases 9 and 10 in Table 3. Moreover, the net costs almost certainly fall largely on lower-income households that are forced through the program to reallocate budgets away from the necessities of life and toward investment in energy efficiency—something they would not do if given a choice.

These costs to consumers do not include the costs to taxpayers of supporting the appliance standards program, which LBNL estimates to total from $200 million to $250 million. Distinguishing between costs to house-

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Do regulators know better than individual consumers how household income should best be spent?

holds and costs to taxpayers is important because the households adversely affected by standards are primarily lower and middle income, whereas federal taxes are paid disproportionately by higher-income households. As we should expect, the program expenses of $200 million or so paid by high-income households are almost trivial compared with the approximately $50 billion burden on low-income households.

Conclusion

This study finds that government-sponsored analyses of benefits from federal energy efficiency standards on residential appliances suffer from two problems. First, the analyses overestimate energy savings from those standards by underestimating energy efficiency in a world without said standards. Second, they apply unrealistically low discount rates on future energy savings.

The former issue is clear-cut. The analysis by Newell et al. establishes that the energy savings estimated from federal efficiency standards are grossly inflated.

The second issue is a bit murkier. Debates about discount rates for savings derived from government programs have long raged within policy circles. While there is generally little dispute that consumers often apply higher discount rates on future savings than do government regulators, there is some dispute about whether consumers *ought* to do so.

Do regulators know better than individual consumers how household income should best be spent? Evidence suggests that consumers are acting more rationally than some analysts think when they refuse to invest in energy efficient appliances that promise positive returns. Since individual circumstances differ, uniform government mandates will prove inherently inefficient at allocating resources.

LBNL analysts estimate the net present value of energy efficiency standards for residential appliances at $150 billion, with a benefit/cost ratio of 2.75/1. This study estimates that, on balance, these energy efficiency standards will cost consumers at least $46.4 billion, with a benefit/cost ratio much less than 1.

The estimate of $46.4 billion for the net costs of appliance standards is a rough approximation. Although such standards impose large net costs on consumers, I did not calculate the environmental benefits of reduced energy use. Such a calculation would reduce the net costs of energy efficiency standards.[38] On the other hand, the literature indicates that low-income households have very high discount rates for energy efficiency investments and the data suggest that it is their purchases that are primarily affected by such standards. I did not calculate the net costs of appliance standards using the extremely high discount rates found in empirical studies. Doing so would increase the net costs of energy efficiency standards even more than reported here.

A serious consequence of appliance standards is their disproportionate burden on the poor. The appliances low-income families would prefer to purchase are removed from the market, leaving more expensive and less desirable choices. When poor people must forgo the basic necessities to make long-term investments in energy cost savings, we should be cautious about proclaiming irrational behavior and imposing regulatory costs on that segment of society.

Notes

1. National Energy Policy Conservation Act of 1978, 42 USC 8251-8261. Energy efficiency standards require that each regulated appliance use a minimum specified amount of energy per unit of output.

2. State standards by California, Florida, and other states are cited in Howard Geller, “National Appliance Efficiency Standards: Cost Effective Federal Regulations,” American Council for an Energy Efficient Economy Report no. A951, Washington, DC, November 1995.

3. Geller, p.1.

4. National Appliance Energy Conservation Act of 1987, P.L. 100-12, March 17, 1987. The effected technologies are those listed in Table 1 herein

plus oil furnaces, ranges and ovens, pool heaters, and direct heating equipment.

5. Energy Policy Act of 1992, P.L. 102-486, October, 1992.

6. Market failure is characterized by economic activity that either imposes significant external costs on nonparticipants or disposes significant benefits on nonparticipants. In such cases, resources will be allocated inefficiently. In the former case, more of a good or service will be provided than is optimal. In the latter case, less of a good or service will be provided than is optimal. Market failures may also be said to exist when natural monopolies arise in various market sectors. For a summary of the theory of market failure and its actual role in the economy, see *The Theory of Market Failure: A Critical Examination*, ed. Tyler Cowen (Fairfax, VA: George Mason University Press, 1988).

7. This point is developed in Daniel Spulber, *Regulation and Markets* (Cambridge, MA: MIT Press, 1989).

8. One of the few studies that did attempt to identify bona fide market failures in energy markets was Anthony Fisher and Michael Rothkopf, "Market Failure and Energy Policy: A Rationale for Selective Conservation," *Energy Policy*, August 1989, pp. 397–405. Their alleged market failures were actually market barriers or nonexistent "failures." For instance, they alleged that oil importers have no incentive to restrict imports and thus contribute to a market failure regarding national security, but they do not establish that oil imports have any negative impact on national security at all. See Douglas Bohi and Michael Toman, *The Economics of Energy Security* (Norwell, MA: Kluwer Academic Publishers, 1996). Fisher and Rothkopf concede nonetheless that the preferred remedy for the problems they identify lies elsewhere than in federally mandated appliance efficiency standards (Table 1, p. 405).

9. Eric Hirst and Marilyn Brown, "Closing the Energy Efficiency Gap: Barriers to the Efficient Use of Energy," *Resources, Conservation and Recycling* 3 (1990): 267–81.

10. Ronald J. Sutherland, "Market Barriers to Energy-Efficient Investments," *Energy Journal* 12, no. 3 (1991): 15–34.

11. See, for instance, Paul Joskow and Donald Marron, "What Does a Neqawatt Really Cost? Evidence from Utility Conservation Programs," *The Energy Journal* 13, no. 4, 1992, pp. 41–90, and Franz Wirl, *The Economics of Conservation Programs* (Norwell, MA: Kluwer Academic Publishers, 1997).

12. S. Meyers, J. E. McMahon, M. McNeil and X. Liu, "Impacts of US Federal Energy Efficiency Standards for Residential Appliances," *Energy* 28 (June 2003): 755–67. See also S. Meyers, J. E. McMahon, M. McNeil and X. Liu, "Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances," Lawrence Berkeley National Laboratory, LBNL-4950, June 2002.

13. It's worth noting that the aggregated benefits reported by Meyers et al. in Table 1 obscure the fact that not all consumers are made economically better off under the program. For instance, the Bush administration's proposed revision of the energy efficiency standards for room air conditioners would increase the cost of new room air conditioners by $144–$213 per unit on average. According to the DOE's own analysis, 19 percent of consumers who purchase clothes washers will never save enough money on their electricity bills to justify the investment because they won't use the units enough to recoup the additional capital costs. In sum, energy efficiency standards force some to bear higher costs than necessary in order to deliver savings to others who presumably wouldn't have acted in their own self interest absent government regulation. See Glenn Schleede, "Will Congress or the New Administration Protect Consumers from DOE, Clothes Washer Manufacturers and Self-Appointed Efficiency Advocates?" *Energy Markets and Policy Analysis*, Reston, VA, February 21, 2001; and Jerry Taylor, "Cool Off!" National Review Online, August 27, 2002. For another example pertaining to gas-fired residential furnaces, see The Gas Technology Institute, "The Impacts of Residential Appliance Efficiency Standards on the Gas Industry and Gas Consumers," White Paper, GTI-03/0013, May 2003.

14. LBNL analysts also rightly claim that energy efficiency standards reduce energy use during peak periods (when electricity is dramatically under priced) and hence have a secondary economic benefit that they do not quantify. Yet energy efficiency standards represent a command-and-control strategy that partially offsets the consequences of another regulatory failure—average cost pricing. Energy resources would be allocated more efficiently by prices closer to marginal costs, which provide consumers the opportunity to reduce peak loads by the most efficient means available. So at best, energy efficiency standards represent a "second-best" strategy for dealing with the problem of average cost pricing.

15. James McMahon, Peter Chan, and Stuart Chaitkin, "Impacts of U.S. Standards to Date," LBNL-45825, p. 2, *Proceedings of the 2nd International Conference on Energy Efficiency in Household Appliances and Lighting*, Naples, Italy, September 27–29, 2000, p. 2.

16. Energy Information Administration, *Annual Energy Review 2000*, DOE/EIA-0384(2000), August 2001, p. 247.

17. Ibid., p. 247.

18. Ronald J. Sutherland, “Energy Efficiency or the Efficient Use of Energy Resources” *Energy Sources* 16 (1994): 257–68.

19. Adam Jaffe and Robert Stavins, “The Energy Efficiency Gap: What Does It Mean?” *Energy Policy* 22, no. 10 (1994): 804–10.

20. Indeed, a lack of consideration for consumer preferences outside of strict engineering considerations is a common failing of engineers, regulators, and some economists. See Virginia Postrel, *The Substance of Style: How the Rise of Aesthetic Values Is Remaking Commerce, Culture, and Consciousness* (New York: HarperCollins, 2003).

21. Richard Newell, Adam Jaffe, and Robert Stavins, “The Induced Innovation Hypothesis and Energy-Saving Technological Change,” Resources for the Future, Discussion Paper, October 1998, and *Quarterly Journal of Economics* 114, no.3, pp. 941–75.

22. Meyers et al., “Realized and Prospective Impacts of U.S. Energy Efficiency Standards for Residential Appliances.”

23. The net benefit calculations of an energy efficiency investment are illustrated with a simple model of a perpetual cash flow. An investment occurs when the present discounted value exceeds its investment cost. If the initial investment cost is I, the discount rate is r, and annual perpetual revenue (reduced energy cost) is R, the equation is $I = R/r$. The benefit of an investment is its present value, estimated as R/r. Net benefit is equal to the present value of the benefit minus the investment cost. This equation is a simplification, however, because it assumes that the reduction in energy cost is a constant per year that accrues forever. An application of this equation is provided in Ronald J. Sutherland, “No Cost Efforts to Reduce Carbon Emissions in the US: An Economic Perspective,” *The Energy Journal* 21, no.3 (2000): 89–112. A mathematical derivation of the equation is provided by mathematical economics textbooks, such as Alpha Chiang, *Fundamental Methods of Mathematical Economics*, 2nd Edition (New York: McGraw Hill, 1974), p. 459.

24. Richard Brealey and Stewart Myers, *Principles of Corporate Finance*, 7th Edition (New York: McGraw-Hill, 2003), p. 15. Emphasis in original.

25. Brealey and Myers note (p. 155) that the average annual rate of return on common stocks (S&P 500) from 1926–2000 was 13 percent per year and 9.7 percent per year in constant dollars.

26. Avinash Dixit, “Investments and Hysteresis,” *Journal of Economic Perspective* 6, no.1 (Winter 1992): 107–32; Saman Majd and Robert S. Pindyck, “Time to Build, Option Value, and Investment Decisions,” *Journal of Financial Economics* 18 (1987): 7–27; and Robert McDonald and Daniel Siegel, “The Value of Waiting to Invest,” *Quarterly Journal of Economics* 101 (1986): 707–28.

27. Kevin Hassett and Gilbert Metcalf, “Energy Conservation Investment: Do Consumers Discount the Future Correctly?” *Energy Policy* 21, no. 6 (June 1993): 710–16. For a criticism of Hassett and Metcalf’s findings, see Alan Sanstad, Carl Blumstein, and Steven Soft, “How High Are Option Values in Energy-Efficiency Investments?” *Energy Policy* 23, no. 9 (1995): 739–43. For a rejoinder to Sanstad, Blumstein, and Soft, see Kevin Hassett and Gilbert Metcalf, “Can Irreversibility Explain the Slow Diffusion of Energy-Saving Technologies?” *Energy Policy* 24, no. 1 (1996): 7–8.

28. Gilbert Metcalf and Donald Rosenthal, “The ‘New’ View of Investment Decisions and Public Policy Analysis: An Application of Green Lights and Cold Refrigerators,” *Journal of Policy Analysis and Management* 14, no. 4 (1995): 517–31.

29. Kenneth Train, ”Discount Rates in Consumers’ Energy-Related Decisions: A Review of the Literature,” *Energy* 10, no. 12 (1985): 1251. Result from J. Berkovic, J. Hausman, and J. Rust, “Heating Systems and Appliance Choice,” Report Number MIT-EL 83-004WP, MIT Energy Laboratory (1983).

30. Coleman Bazelon and Kent Smetters, “Discounting Inside the Washington D.C. Beltway,” *Journal of Economic Perspectives* 13, no. 4 (Fall 1999): 226.

31. The 2.75 estimate is from Meyers et al., “Impacts of US Federal Efficiency Standards,” p. 755; however, Koomey et al., p. i, present a benefit-cost estimate of 3:5/1. Note that Meyers et. al. use a 3 percent discount rate for the 1987–2000 period.

32. The simple present value model of a perpetual cash flow uses the investment cost I, the discount rate r, and annual perpetual revenue (reduced energy cost) R, and the equation is $I = R/r$. Note that I is the cost and R/r is the benefit. LBNL provides a benefit/cost ratio of 2.75 to 1, hence $R/r/I = 2.75$ to 1. With net benefits = $150 billion, we solve for gross benefits (R/r) of $235.7 billion and cost (I) of $85.7 billion. The annual dollar flow from energy saving is $16.5 billion, where $235 billion = $16.5/.07 These numbers are close, but not identi-

cal to LBNL numbers, because LBNL used a 3 percent discount rate for part of the period. An application of this equation is provided in Ronald J. Sutherland, "'No' Cost Efforts to Reduce Carbon Emissions in the U. S.: An Economic Perspective," pp. 89–112. A mathematical derivation of the equation is provided by mathematical economics textbooks, such as Alpha C. Chiang, *Fundamental Methods of Mathematical Economics*, 2nd Edition, p. 459.

33. Kenneth Train, "Discount Rates in Consumers' Energy-Related Decisions: A Review of the Literature," *Energy* 10, no. 12 (December 1985): 1251.

34. Raymond S. Hartman and Michael J. Doane, "Household Discount Rates Revisited," *The Energy Journal* 7, no. 1 (January 1986): 139–48.

35. Ibid, p. 148. Emphasis in original.

36. Ronald J. Sutherland, "Market Barriers to Energy Efficient Investments," pp. 15–34. For a critique, see Steven Stoft, "Appliance Standards and the Welfare of Poor Families," *The Energy Journal* 14, no. 4 (1993): 123–28.

37. See Meyers et al., "Impacts of US Federal Efficiency Standards," Figure 2, and p. 760.

38. Calculating the environmental costs of energy consumption, however, is impossible to do with any precision given the vast degree of uncertainty regarding the underlying science. Accordingly, estimates in the peer-reviewed literature about the environmental costs of energy consumption vary greatly. See Thomas Sundqvist and Patrik Soderholm, "Valuing the Economic Impacts of Electricity Generation: A Critical Survey," *Journal of Energy Literature* 8, no. 2 (December 2002): 19.

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