FALL 2012

EDITOR: KAREN NOTSUND

The Energy Efficiency Gap: What is the Best Policy?

Energy efficiency is often billed as a "win-win" proposition because it can both save money and reduce pollution associated with energy use. Many argue that there is insufficient investment in energy efficiency due to two market failures: externalities (e.g., pollution) associated with fossil-fuel energy use and investment inefficiencies. Investment inefficiencies arise when consumers and firms under-invest in energy efficiency due, for example, to imperfect information.

The argument for government intervention to encourage energy efficiency is to correct these two market failures. From a policy perspective, it is crucial to distinguish between these two types of market failures so that the most appropriate energy efficiency policy can be adopted.

In their new paper "Is There an Energy Efficiency Gap?" (EI @ Haas Working Paper #228), **Hunt Allcott** (New York University) and **Michael Greenstone** (Massachusetts Institute of Technology) distinguish between these two market failures and clarify the separate policy implications. If externalities associated with fossil-fuel energy use were the only market failure, it is widely agreed that the optimal policy would be to tax the pollution directly or through an equivalent cap-and-trade program such that the cost of the pollution is incorporated into the price of the energy. On the other hand, if investment inefficiencies exist, then the optimal policy is to address the inefficiency directly, for example, by providing information to imperfectly informed consumers. Allcott and Greenstone argue that investment inefficiencies create an Energy Efficiency Gap, which they define as the difference between the cost-minimizing level of energy efficiency and the level actually realized. The central economic question they examine is whether there are investment inefficiencies that a policy can correct – in other words, is there an Energy Efficiency Gap?

Allcott and Greenstone focus on household energy use and personal transportation instead of commercial and industrial energy use because the former are areas where inefficiencies of imperfect information might be more severe. They examine choices by consumers and firms to adopt or not adopt energy efficient technologies and attempt to infer whether there is an Energy Efficiency Gap. The four categories of evidence that

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Cash for Coolers: A Good Policy?

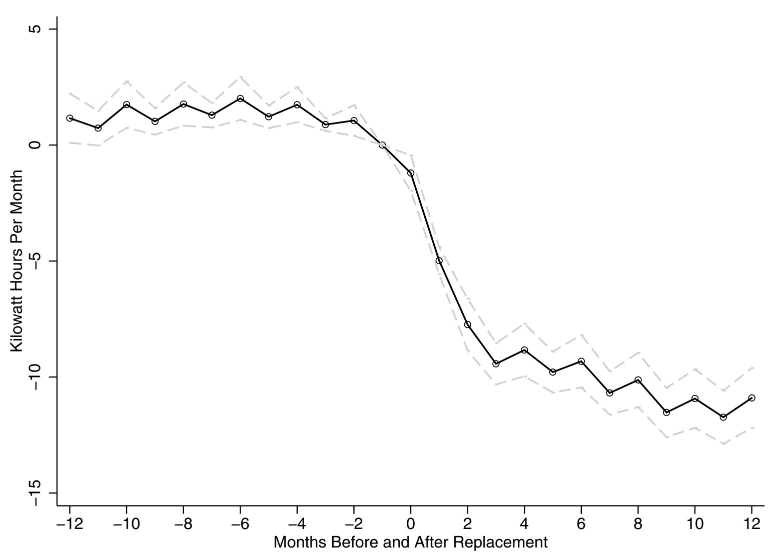
Energy efficiency policies receive an enormous amount of attention and resources. Electric utilities in the United States, for example, spent $22 billion dollars on energy-efficiency programs between 1994 and 2010, leading to a reported total savings of more than 1 million gigawatt hours of electricity. Supporters view these policies as a "win-win," helping participants reduce energy expenditures while also reducing greenhouse gas emissions.

Skeptics, however, question the magnitude of the savings and argue that there are important economic costs to energy-efficiency programs that tend to be overlooked. These claims are difficult to evaluate, however, because there is a surprisingly small amount of verifiable evidence on the amount of electricity saved.

Lucas Davis (University of California, Berkeley), **Alan Fuchs** (United Nations Development Program), and **Paul Gertler** (University of California, Berkeley) provide the first large-scale empirical analysis of a national residential energy efficiency program. In their paper "Cash for Coolers" (EI @ Haas Working Paper #230), they examine an appliance replacement program in Mexico that has helped 1.5 million households upgrade their refrigerators and air conditioners since 2009. To participate in the program, the household's old appliance must be at least 10 years old and the household must agree to purchase an energy-efficient appliance of the same type. The program provides both direct cash payments and subsidized financing. The old appliances are destroyed after they are turned in, making the program similar to "Cash for Clunkers," the well-known U.S. vehicle replacement program.

The study is particularly interesting because many middle-income countries like Mexico are currently adopting energy-efficiency programs. Electricity consumption in Mexico is increasing rapidly, driven in part by growth in residential appliances. Hoping to stem these increases, the Mexican government turned to *Cash for Coolers* based on engineering analyses that estimated refrigerator and air-conditioner replacements would lead to substantial decreases in electricity consumption. In independent studies of available energy-related investments in Mexico, both the World Bank and McKinsey concluded that replacing residential refrigerators and air conditioners would be extremely cost-effective. In fact, both reports found a negative net cost for these investments. That is, they were found to be investments that would pay for themselves even without accounting for greenhouse gas emissions.

FIGURE 1: THE EFFECT OF REFRIGERATOR REPLACEMENT ON HOUSEHOLD ELECTRICITY CONSUMPTION



The goal of the Davis/Fuchs/Gertler study is to quantify the overall impact of *Cash for Coolers* on electricity consumption and greenhouse gas emissions. A key feature of their analysis is the use of household-level electric billing records for the population of residential electricity consumers in Mexico. The central dataset used in the analysis is a two-year panel dataset of household-level bimonthly electricity billing records from the universe of Mexican residential customers. These data allow the researchers to compare electricity consumption before and after the appliance replacements occur, using nearby households as a comparison group. Equally important for the analysis is a second dataset which describes *Cash for Coolers* participants. These data describe all participants in the program between March 2009 and June 2011, a total of 1,162,775 participants.

The researchers found that refrigerator replacement reduced electricity consumption by an average of 7%. Figure 1 describes graphically the effect of refrigerator replacement on household electricity consumption.

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Residential Electricity Rates: Who Subsidizes Whom?

The residential electricity rate structures within California's three largest utilities service territories – Pacific Gas & Electric, Southern California Edison and San Diego Gas & Electric – are incredibly confusing, not cost-based, and not found in any other state. California has the steepest increasing block schedule (higher rates for higher levels of electricity usage) in the country, substantial differences across regions within a utility's service area, and little or no fixed charges. There is interest in re-designing the rates so they are easier to understand and more aligned with their underlying costs. If California were to change its residential tariff, who would win and who would lose?

Many market participants and regulators in California have suggested changing residential tariffs to make them more like tariffs elsewhere in the U.S.: eliminating or greatly reducing the steepness of the increasing block pricing and instituting significant fixed charges. The argument in support of these changes is that there is a true fixed cost per customer that is independent of the amount of electricity consumed and that the prices on the highest electric price tiers are well above the incremental cost, even when accounting for environmental costs. Although the policy discussion has focused on aligning prices with costs, there has also been concern about the distributional impacts of these changes. Much of the concern is for low-income customers as a ratepayer class. Another focus has been the regional impact of these potential rate changes, i.e., coastal versus inland customers.

In the paper "Regional and Income Distribution Effects of Alternative Retail Electricity Tariffs," (EI @ Haas Working Paper #225), **Severin Borenstein** (University of California, Berkeley) analyzes the impact by region and income group of two different potential rate changes: 1) a move from increasing block pricing to a flat rate, and 2) adding a fixed monthly charge and offsetting the increase by lowering the prices on the higher tiers of the increasing block rates. Using detailed 2006 billing household data from the three utilities, he calculates what each household's bill would be under the alternative rate designs. By knowing the specific region each household is in, Borenstein can evaluate the regional impact of these rate structure changes. In previous research, Borenstein matched the billing data with U.S. census data to estimate the income distribution of the households within each of these utilities' service areas. This previous work allows him to estimate the impact of the rate changes on households at different income levels.

TABLE 1: STANDARD 2006 IBP TARIFF, ALTERNATIVE FLAT RATE, AND ALTERNATIVE IBP + FIXED CHARGE

		Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Percent of baseline		0%-100%	100%-130%	130%-200%	200%-300%	over 300%
	Fixed Charge					
Southern California Edison						
IBP	$0.00	$0.1162	$0.1361	$0.2201	$0.3049	$0.3049
Flat Rate	$0.00	$0.1731	$0.1731	$0.1731	$0.1731	$0.1731
IBP + FC	$5.00	$0.1162	$0.1361	$0.2023	$0.2802	$0.2802
Pacific Gas & Electric						
IBP	$0.00	$0.1143	$0.1299	$0.2178	$0.2987	$0.3394
Flat Rate	$0.00	$0.1643	$0.1643	$0.1643	$0.1643	$0.1643
IBP + FC	$5.00	$0.1143	$0.1299	$0.1963	$0.2134	$0.2285
San Diego Gas & Electric						
IBP	$0.00	$0.1287	$0.1488	$0.2312	$0.2401	$0.2571
Flat Rate	$0.00	$0.1690	$0.1690	$0.1690	$0.1690	$0.1690
IBP + FC	$5.00	$0.1287	$0.1488	$0.2055	$0.2134	$0.2285

Table 1 presents the rates for all three utilities under the standard increasing block price (IBP) tariff that was in effect in 2006, the alternative flat rate tariff and the alternative IBP with a $5 per month fixed charge. The alternative tariffs were constructed to raise the same amount of revenue for each utility as they received under the standard tariff. Each of the utilities includes a baseline quantity of electricity in their tariffs. The baseline quantities vary by region within a utility's service territory. In 2006, PG&E had 10 climate regions, SCE had 6, and SDG&E had 4. For a given utility, the baselines in each climate region are set in order to reflect approximately the same proportion of average household consumption within the climate region. So, for instance, SCE's hottest inland climate regions have much higher baselines in the summer months than do the coastal regions, but in each region the baseline quantity is intended to be approximately 55% of the average residential consumption.

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RESIDENTIAL ELECTRICITY RATES: WHO SUBSIDIZES WHOM?

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As a result, while consumers within a utility's service territory face the same prices on each tier, they face different price schedules. Figure 1 presents the summer price schedules for the two most populous baseline regions in PG&E's service territory. Region T is on the coast and quite temperate, while region X is further inland and experiences wider temperature swings. Each utility calculates both a winter and a summer baseline quantity per region.

FIGURE 1: MONTHLY PRICE SCHEDULE FOR HOUSEHOLDS IN TWO PG&E CLIMATE REGIONS

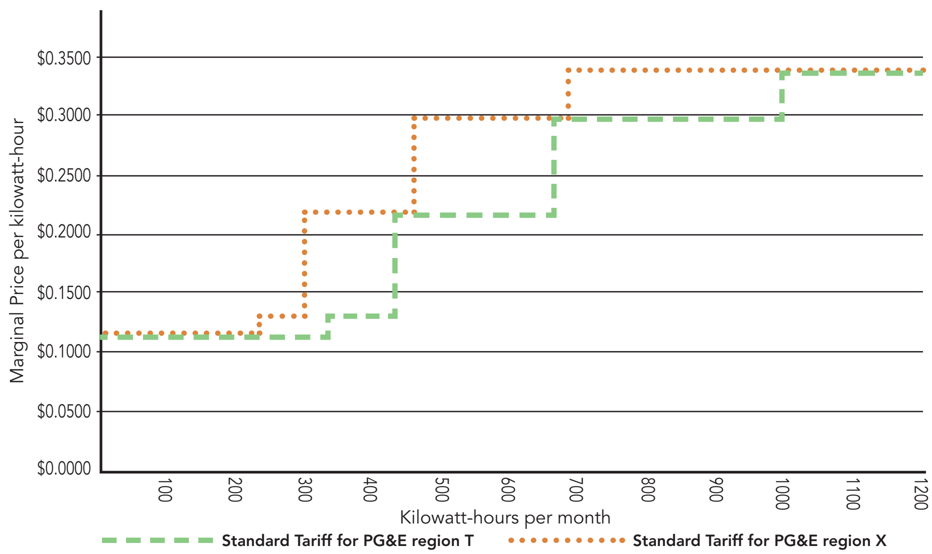

TABLE 2: CONSUMPTION ON TIERS OF IBP TARIFF BY INCOME GROUP

Income Bracket	Share of Total Residential Usage	Share of Total Residential Households	Avg Daily Use	% of usage on tier1	%of usage on tier2	%of usage on tier 3
Southern California Edison						
$0-$20k	3.2%	5.4%	11.7	77.8%	8.5%	8.7%
$20k-$40k	9.8%	11.7%	16.6	64.3%	10.7%	13.8%
$40-$60k	16.1%	16.8%	19.0	57.8%	11.1%	15.0%
$60k-100k	25.2%	23.5%	19.9	58.0%	11.1%	17.0%
over $100k	24.9%	17,4%	28.3	41.8	10.4%	18.3%
Pacific Gas & Electric						
$0-$20k	3.8%	6.0%	12.4	75.3%	8.6%	9.5%
$20k-$40k	11.4%	12.6%	17.4	64.0%	10.4%	13.7%
$40-$60k	16.0%	16.3%	18.9	60.4%	10.8%	15.0%
$60k-100k	24.2%	23.4%	19.9	58.0%	11.0%	15.8%
over $100k	25.7%	20.9%	23.7	50.4%	11.0%	17.4%
San Diego Gas & Electric						
$0-$20k	3.1%	6.8%	7.8	88.1%	5.5%	4.5%
$20k-$40k	10.8%	15.5%	11.8	74.8%	9.2%	9.8%
$40-$60k	16.2%	17.9%	15.3	64.3%	10.6%	13.7%
$60k-100k	26.5%	23.6%	19.1	55.7%	11.2%	16.2%
over $100k	30.4%	18.5%	28.0	40.5%	10.3%	18.3%

The effect of targeting baseline quantities to local consumption levels is that the share of consumption on each of the tiers does not vary a great deal across climate regions. As a result, changing the tariff from the standard IBP to a flat rate would not change the average bill by region very much. There would, of course, be quite a bit of variation within each climate region – lower-use consumers would pay more and higher-use consumers would pay less – but overall increasing-block pricing does not penalize customers living in hotter climate regions.

Switching from the standard IBP tariff to an IBP with a $5 per month fixed charge and lower rates on the tiers 3, 4 and 5 would cause hotter regions to see very small declines in bills. The small decline results from the fact that the fixed charge harms all customers equally, but the decline in prices on the upper tiers disproportionately benefits customers in higher-use regions.

In contrast to the regional impacts, the impact of these potential tariff changes on low-income consumers is significant. Table 2 shows the bill changes under the alternative tariffs by income group. Excluding households enrolled in CARE, a low-income utility program that offers deep discounts to qualifying households, Borenstein finds that customers in the lowest income group would see an increase in their bills if there were a switch to a flat tariff or the addition of a fixed fee. This result is consistent with his previous work which found that on average lower income households consume less electricity so a higher proportion of their consumption is on the lower tiers.

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THE ENERGY EFFICIENCY GAP: WHAT IS THE BEST POLICY?

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they analyze are: engineering estimates of returns to potential investments, empirical estimates of returns to observed investments, the cost effectiveness of energy conservation programs run by electric utilities, and estimated demand patterns for energy-using durables. Allcott and Greenstone find that these analyses generally suffer from three types of problems. First, there are important factors that are difficult to observe or measure, such as the time and effort required to weatherize a home. Second, the net present value of energy cost savings is often questionable. Third, there are often substantial differences across consumers in their use and unobserved costs such that identifying the average returns for adopters may not be informative for other communities. Their conclusion, based on the available evidence and studies, is that the size of an Energy Efficiency Gap is situation-specific, mixed and often inconclusive.

Policymakers, however, are often called upon to make policy in the absence of strong evidence of a market failure. Formulating policy becomes challenging if the first-best solutions are not possible – when information disclosure is not fully effective or when a tax is not politically feasible. Allcott and Greenstone examine the effects of energy efficiency policies considered as second-best alternatives. Second-best approaches often used in the U.S. to correct investment inefficiencies include policies that subsidize or mandate energy efficiency. The U.S. has long required energy-use information disclosure: for more than 30 years, retailers have been required to display fuel economy ratings for new vehicles and energy cost information for home appliances. However, consumers may not notice, understand or pay attention to this information. If information disclosure or other solutions to investment inefficiencies are not fully effective, how useful are energy efficiency subsidies and standards as a second-best approach?

In analyzing previous studies, Allcott and Greenstone find that when consumers are sufficiently alike, subsidizing or mandating them to invest more can be the optimal policy. Energy efficiency policies are more likely to be a net benefit to society if they target consumers subject to the largest investment inefficiencies. Some existing policies do appear well-targeted. For example, households that use more energy than other comparable households are more likely to have low-cost energy conservation opportunities of which they are unaware and many U.S. utilities now target energy conservation information to these relatively heavy users. Aside from the diverse levels of investment inefficiencies among consumers and firms, there are other factors that affect demand for energy and for energy efficiency investments.

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TABLE 1: SIGNIFICANT US ENERGY EFFICIENCY POLICIES

NAME	YEARS	MAGNITUDE
Corporate Average Fuel Economy Standards	1978-	$10 billion annual incremental cost from tightened 2012 rule (NHTSA 2010)
Federal Hybrid Vehicle Tax Credit	2006-2010	$426 million total annual credit (Sallee 2010)
Gas guzzler tax	1980-	$200 million annual revenues (Sallee 2010)
Federal appliance energy efficiency standards	1990-	$2.9 billion annual incremental cost (Gillingham, Newell, and Palmer 2006)
Residential and commercial building codes	1978-	
Electricity Demand-Side Management programs	1978-	$3.6 billion annual cost (US EIA 2010)
Weatherization Assistance Program (WAP)	1976-	$250 million annual cost (US DOE 2011a)
2009 Economic Stimulus	2009-2011	$17 billion total (U.S. DOE 2011b)
Additional WAP funding		$5 billion
Recovery Through Retrofit		$454 million
State Energy Program		$3.1 billion
Energy Efficiency and Conservation Block Grants		$3.2 billion
Home Energy Efficiency Tax Credits		$5.8 billion total credit in 2009 (U.S. IRS 2011)
Residential and Commercial Building Initiative		$346 million
Energy Efficient Appliance Rebate Program		$300 million
Autos Cash for Clunkers		$5 billion

Years is years in effect, not year implemented.

CASH FOR COOLERS: A GOOD POLICY?

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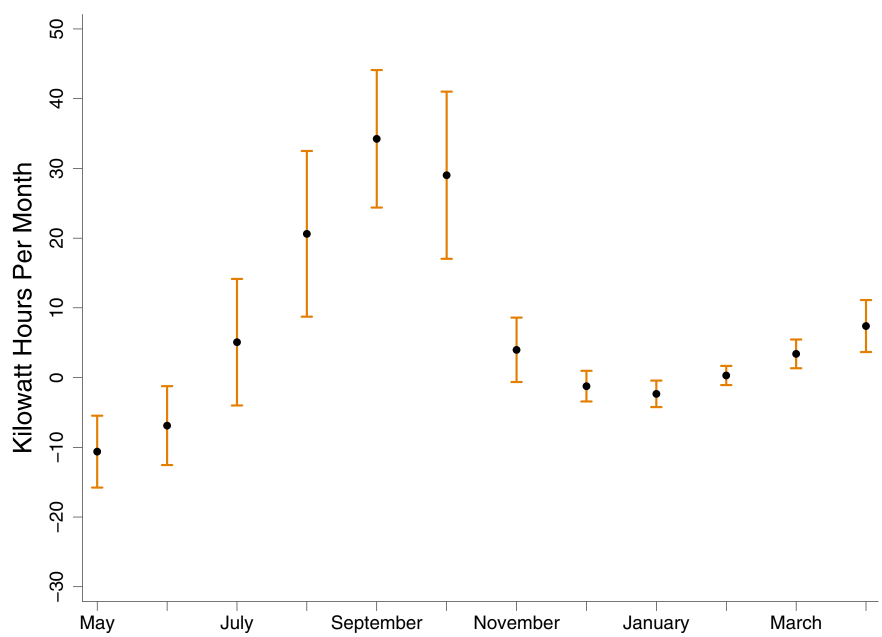
The reduction found by Davis/Fuchs/Gertler is about a quarter of the reduction predicted by the World Bank. The researchers also found that air conditioning replacement actually *increased* electricity consumption. The effect of air-conditioner replacement on electricity consumption varies across months, with near zero changes during the winter months and 20+ kilowatt hour increases per month in the summer. (See Figure 2.) Overall, the program appears to be an expensive way to reduce electricity consumption, reducing electricity consumption at a program cost of about $.30 per kilowatt hour, and reducing greenhouse gas emissions at a program cost of about $500 per ton.

One important explanation for the differences between the Davis/Fuchs/Gertler results and the engineering estimates is changes in appliance utilization. Although changes in utilization are likely to be modest or even non-existent for refrigerators, it makes sense that there would be considerable "rebound" effect for air conditioning. Since energy-efficient air conditioners cost less to operate, households will tend to use them more – this is often referred to as the "rebound" effect. In addition, over time appliances have also become bigger and better.

These size and quality increases are another form of demand for increased electricity consumption. It could also be that some of the old appliances were not working at the time of replacement. Appliances were supposed to be in working order to be eligible for the program, but enforcement was likely less than 100%. If the old air conditioning units were not working, or not working well prior to replacement, then the household's electricity consumption might have jumped once a new, fully functioning air conditioning unit was installed.

FIGURE 2: THE EFFECT OF AIR CONDITIONER REPLACEMENT BY MONTH OF YEAR



These results underscore the urgent need for careful modeling of household behavior. A central feature in their household production framework, and a key theme throughout the study, is the importance of accounting for changes in utilization. Households benefit from using these new appliances, and they can and should use them more when upgrading to more energy-efficient appliances. The "rebound" effect is a good thing – it means the households are better off. It is important however, for this to be taken into account when designing energy-efficiency policies.

Over the next several decades, much of the total growth in global energy demand is expected to come from middle-income countries like Mexico. Meeting this increased demand for energy will be a substantial challenge, so understanding the potential role of energy efficiency is extremely important. Many people believe that in these countries there is an abundant supply of low-cost, high-return investments in energy efficiency, but it is crucial that these policy decisions be made based on accurate and verifiable measures of actual savings.

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THE ENERGY EFFICIENCY GAP: WHAT IS THE BEST POLICY?

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Geographical differences, for example, can also alter the cost-benefit calculation for a given policy. Ideally, standards could vary geographically to take account of this, targeting consumers that may have the most to gain, such as building codes in states with extreme weather requiring more insulation than building codes in mild climates.

Since the energy crises of the 1970s, many have made the "win-win" argument for energy efficiency policy: subsidies and standards can both address investment inefficiencies in the purchase of energy-using durable goods and reduce pollution from energy use. Table 1 presents the most significant of these policies, along with some measure of their annual costs. However, Allcott and Greenstone find that it is difficult to assess definitively the magnitude of the Energy Efficiency Gap due to imprecise observational studies and the possibility of unobserved costs and benefits of energy efficiency. The available evidence suggests that while investment inefficiencies do appear in various settings, the actual magnitude of the Energy Efficiency Gap is small relative to the assessments from engineering analyses. Furthermore, it appears likely that there is substantial diversity in investment inefficiencies across the population. Thus, targeted energy efficiency policies have the potential to generate larger gains than general subsidies or mandates. Given this diversity, policy analysts need to do more than assess how much a policy affects energy efficiency; they must also identify what types of consumers are induced to be more energy efficient. EI@HASS

RESIDENTIAL ELECTRICITY RATES: WHO SUBSIDIZES WHOM?

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In all three utilities' areas, the impact of adding a fixed charge would also be a significant increase for the second-lowest income group, those with an annual income between $20,000 and $40,000, though smaller than for those in the poorest group. Customers in the third and fourth income groups (annual incomes from $40,000 to $100,000) would see smaller negative changes on average, while the average customer in the highest income group (over $100,000) would see a substantial decrease in their bill. Since the CARE customers are not included in this analysis, there are relatively few households in the lowest income group, which means that more of the transfers to the high-income groups would come from the second-lowest income group than from the lowest.

In response to the initial question of who would benefit from implementation of either a flat tariff or a tariff with a fixed fee and lower tiered rates, Borenstein shows that neither alternative tariff would disadvantage one region over another but that both would make low-income consumers worse off. EI@HASS

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