

CASH FOR COOLERS:

EVALUATING A LARGE-SCALE APPLIANCE REPLACEMENT PROGRAM IN MEXICO



DID THIS INTERVENTION WORK? COULD ENERGY EFFICIENCY PROGRAMS LIKE CASH FOR COOLERS SERVE AS A SUBSTITUTE FOR CAPITAL-INTENSIVE INVESTMENTS?

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CONTEXT

Energy consumption is forecast to increase worldwide over the next decades, raising concerns about energy prices, geopolitics, and greenhouse gas emissions. Meeting this demand represents a challenge from both an economic and an environmental perspective.

This is one of the first studies of a large-scale energy efficiency program in a middle-income country. It evaluates a nation-wide appliance replacement program in Mexico: since 2009, “Cash for Coolers” (“C4C”) has given subsidies to 1.5 million households to help them replace their old refrigerators and air conditioners (AC) with newer models.

FAST FACTS

Location: Mexico

Working Paper: Nov 2013

Data analyzed: 2009 to 2011

Methodology: DID

Status: Complete

Results underscore the urgent need for careful modeling of household behavior in the evaluation of energy-efficiency programs.

MAIN LESSONS

- Refrigerator replacement reduced consumption by 7%, about ¼ of what was predicted.**
- Air conditioner replacement increased electricity consumption.** More energy-efficient ACs cost less to use, which lead households to use them more.
- The program was an expensive way to reduce externalities,** reducing electricity consumption at a program cost of \$0.30 per kilowatt hour and reducing carbon dioxide emissions at a program cost of \$500 per ton.

ORIGINAL CITATION

DAVIS, Lucas, Alan FUCHS, and Paul GERTLER, 2013. “Cash for Coolers”. E2e WP-004 forthcoming in American Economic Journal: Economic Policy



KEY RESULTS

COMPARISON TO EX-ANTE STUDIES

	Kilowatt Hours Saved per Year		
	Findings	Ex-Ante Studies	
		World Bank (2009)	Arroyo-Cabañas, et al. (2009)
Refrigerators	-134	-481	-315
Air Conditioners	92	-1200	N/A

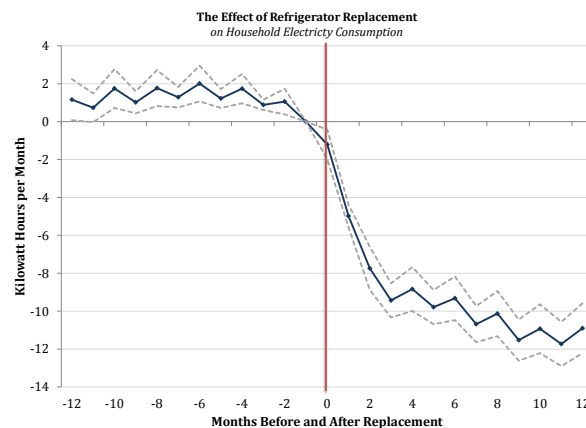
Estimates imply annual savings from refrigerator replacement of 134 kilowatt hours per year and that air-conditioning replacement increases electricity consumption by 92 kilowatt hours per year.

Households who replace their refrigerators indeed decrease their energy consumption, but by **an amount considerably smaller than that predicted** by ex-ante engineering analyses. Even larger decreases were predicted for air-conditioners, but **results find that households who replace their air conditioners actually end up increasing their energy consumption.**

BACKGROUND ON MEXICO

- ✓ Over 98% of households have electricity, supplied exclusively by the Mexican Federal Electricity Commission.
- ✓ The Mexican average per capita consumption is 1,900 kilowatt hours annually, low compared to 13,600 kwh for the US.
- ✓ The generation of energy is forecast to increase 3.2% per year, almost quadruple the rate forecast for the United States.

HOUSEHOLD CONSUMPTION WITH NEW C4C REFRIGERATORS



Source: Authors.

Note: Refrigerators used because they make up for 90% of replacements

One of the major drivers of this growth is the increase in residential appliance ownership, due to poverty reduction programs and growth. Meeting this demand will require investments in infrastructure. C4C is viewed by some policy-makers as a way to potentially reduce these capital expenditures.

DETAILS OF THE PROGRAM

Cash for Coolers was implemented in part because ex-ante engineering analyses calculated a negative net cost for this type of program. Cash for Coolers subsidies were available for both refrigerators and air conditioners, but 90%+ of the replacements to date have been refrigerators. The participating retailer removes the old appliance, which must be at least 10 years old, when it installs the new energy-efficient model. Households are eligible to replace only one appliance of each type and the new appliances must meet size requirements. As of February 2012, about 15% of all eligible households (~25 million) had participated.

THE AMERICAN EXPERIENCE

Dozens of similar programs have been implemented recently in the US, albeit at a much smaller scale. Most US programs emphasize rebates for new energy-efficient appliances with no requirement that the old appliance be permanently destroyed. Electric utilities in the US 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.



COMPARING TO EX-ANTE PREDICTIONS

LESS THAN PREDICTED RESULTS

The ex-ante analyses predicted larger savings. The World Bank study predicted average savings of 481 kilowatt hours per year. The same study predicts that replacing ACs would save 1,200 kilowatt hours per year. This study implies more modest results.

One important explanation for the differences is that **the ex-ante analyses did not account for changes in appliance utilization.** Energy-efficient durable goods cost less to operate so households will use them more.

BIGGER AND BETTER

Appliance sizes have increased over time. Even modest increases in size substantially offset the potential efficiency gains of replacement. For example, each additional cubic foot of refrigerator capacity adds about 10 kilowatt hours of electricity consumption per year.

Appliance features have also increased: ice-makers, side-by-side doors and through-the-door ice and water. These features are **valued by households but they are also energy-intensive.**

SUB-OPTIMAL TARGETING

The program does not appear to have been particularly effective at targeting households with very old appliances. **A disproportionate fraction of old appliances were reported to just barely meet this requirement.**

Appliances were also supposed to be in working order to be eligible, but enforcement was performed by the participating retailer and neither the participant nor the retailer had much incentive to hold up a mutually beneficial purchase.

COST-EFFECTIVENESS

SAVINGS AND COST-EFFECTIVENESS

	Refrigerators	Air Conditioners
Savings		
Per household, annually	Saves \$13	Costs an additional \$9
Cost-Effectiveness*		
Cost per kilowatt hour**	\$0.25	N/A***
Cost per CO2 saved	> \$500 per ton	

Source: Authors

Notes: * A 5% annual discount rate was used. It was assumed that the program accelerated appliance replacement by 5 years.

TOTAL PROGRAM IMPACTS

	Total Reductions Annually	Value in Dollars
Electricity consumption	~100 GwH	\$10 million**
Carbon dioxide emissions*	60,000 T	\$1.2 million***

Source: Authors

* Multiplying the change in electricity consumption by the average carbon intensity of electricity generation. ** At average residential electricity prices. *** Using a conservative estimate for the social cost of carbon dioxide (\$20 per ton).

CAN THIS BE IMPROVED?

Some have argued that C4C would have been much more cost-effective if participants had been required to purchase more energy-efficient appliances. Program rules required participants to purchase appliances that exceeded the minimum energy-efficiency standards by 5%. These **standards date back to 2002, and there were dozens of available models that exceeded the standard by 20% or more.** The program could have required that the new appliances meet a much stricter standard.



FINAL THOUGHTS

Meeting the increase in energy demand over the next several decades will be an immense challenge. In theory, energy efficiency programs could represent a “win-win” by reducing energy expenditures while decreasing greenhouse gas emissions and other externalities. In countries where energy prices are subsidized, there is even a potential third “win” as governments reduce the amount spent on subsidies. Moreover, an appliance replacement subsidy like C4C would appear to have a great deal of potential to decrease energy consumption. Residential appliances have experienced dramatic gains in energy efficiency so replacing old appliances with newer, more energy-efficient models would seem to result in lower energy usage.

It is hard to not be disappointed by the savings from C4C. Households who replace their refrigerators with energy-efficient models indeed decrease their energy consumption, but by an amount considerably smaller than that predicted by ex-ante engineering analyses. Even larger decreases were predicted for air-conditioners, but households who replaced their air conditioners actually ended up increasing their energy consumption. **Overall, the study finds that the program is an expensive way to reduce energy use, with a program cost of about \$0.30 per kilowatt hour, and reducing carbon dioxide emissions at a program cost of about \$500 per ton.**

These results underscore the urgent **need for careful analyses of household behavior** in the evaluation of energy-efficiency programs. Households receive benefits from using appliances, so they can and should increase their use in response to increases in energy efficiency. This “rebound” is a good thing – it means that households are better off. It does, however, complicate the design of a policy.

There are also several additional lessons to be drawn. **Over time cars, appliances, and houses have become more energy efficient, but also bigger and better.** These size and quality increases are another form of the demand for increased usage, and it makes sense to take them into account when designing a policy. **There is also a tendency for energy-efficiency programs to lose effectiveness over time.** While initially a program tends to attract participants with the most to gain, as time goes on the pool will be made up increasingly by participants who just barely meet the eligibility requirements. Finally, despite attempts by administrators to build enforcement mechanisms into program design, **it is difficult to strictly enforce eligibility requirements.** While one can envision third-party enforcement mechanisms, this adds costs to the program

ABOUT US: E2E PROJECT'S MISSION AND STRATEGY

Supported by a generous grant from The Alfred P. Sloan Foundation, the E2e Project is a joint initiative of the Energy Institute at the University of California at Berkeley's Haas School of Business, the Energy Policy Institute at Chicago at the University of Chicago, and the Center for Energy and Environmental Policy Research at the Massachusetts Institute of Technology. E2e unites top researchers in economics, engineering and other fields and uses transparent and state-of-the-art analytical techniques. Our mission is to solve one of the most perplexing energy puzzles of our time—the efficiency gap. Infusing the creation of knowledge with a commitment to non-partisan outreach, E2e aims to create a cheaper and greener future. (<http://e2e.haas.berkeley.edu/>)



METHODOLOGICAL APPENDIX

The effect of refrigerator and AC replacement on household electricity consumption was estimated using difference-in-differences as basic approach. Impacts are measured by comparing electricity consumption before and after appliance replacement. The table below has the summary of the methodology. For a deeper explanation, please refer to the original paper.

EMPIRICAL STRATEGY

Methodology	Comparison Groups	Other Factors Taken into Consideration
<ul style="list-style-type: none"> •Differences-in-Differences •Several specifications and comparison groups. The preferred specification was presented in this brief. •Clustered standard-errors at the county level 	<ul style="list-style-type: none"> •Four different comparison groups were chosen: <ul style="list-style-type: none"> •(1) Equal-sized random sample of non-participating households. • (2) Sample with participating households only, who have not yet replaced the appliances • (3) Matched sample based purely on location (the closest non-participating unit). •(4) BEST: Matched sample based location and pretreatment consumption (the closest and most similar non-participating unit) 	<ul style="list-style-type: none"> •Household by month-of-year fixed effects (controls for time-invariant household characteristic and for household-specific seasonal variation) •Month-of-sample fixed effects (controls for differences in weather and population-wide trends). •Month-of-sample by county fixed effects (controls for county-specific variation in year-to-year weather and differential population-wide trends across counties).

DATA USED

- ✓ Household-level electric billing records for the universe of 25+ million Mexican residential customers.
- ✓ Two-year panel dataset of household level bimonthly electricity consumption from May 2009 through April 2011.
- ✓ After cleaning, 957,080 treatment households.

RELATED READING

- ✓ ARROYO-CABAÑAS, F.G; J.E. AGUILLÓN-MARTÍNEZ, J.J. AMBRÍZ-GARCÍA, and G. CANIZAL. 2009. "Electric Energy Saving Potential by Substitution of Domestic Refrigerators in Mexico". Energy Policy, 37, 4737-4742.
- ✓ JOHNSON, T. M., C. ALATORRE, Z. ROMO, and F. LUI. 2009. "Low-Carbon Development for Mexico," World Bank, Conference Edition.
- ✓ MCKINSEY AND COMPANY. 2009b. "Low Carbon Growth – A Potential Path for Mexico," Presentation by Francisco Barnes Jr. at Carbon Markets Workshop, August 20, 2009.

