



**Comments on the Proposed Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units, 79 FR 34830 (June 18, 2014)**

**Submitted by The E2e Project:**

**Lucas Davis, University of California Berkeley, Berkeley, CA 94720**

**Michael Greenstone, University of Chicago, Chicago, IL 60637**

**Christopher Knittel, Massachusetts Institute of Technology, Cambridge, MA 02138**

**Catherine Wolfram, University of California Berkeley, Berkeley, CA 94720**

**Comments on Energy Efficiency in the Clean Power Plan**

In the proposed plan the denominator for the rate-based standard includes an adjustment for generation avoided due to demand-side efficiency improvements. Although energy-efficiency programs may, at first, seem like a ‘win-win’ proposition, a growing body of evidence has shown that savings from energy-efficiency programs are frequently overestimated, often by a wide margin. This is potentially a serious problem because it means that this adjustment could significantly weaken the stringency of the standard.

The following example illustrates the problem we have in mind. The emissions ratio is calculated according to this formula:

$$2030 \text{ state goal} = \frac{\overbrace{\text{emissions (lb.CO2)}}^{\text{coal + oil/gas + NGCC + other}}}{\underbrace{(\text{coal + oil/gas + NGCC + other})_{\text{baseline}} + (\text{RE + Nuc})_{\text{goal}} + (\text{EE})_{\text{goal}}}_{\text{generation (MWh)}}}$$

Consider a state that generates electricity with 100 MWh of coal at an emissions rate of 2,000 lbs/MWh and 100 MWh of natural gas at a rate of 1,000 lbs/MWh. The state has a goal of 1,200 lbs/MWh. Without taking any compliance steps, the state’s ratio would be:

$$\text{Emissions ratio} = \frac{2,000\text{lbs/MWh} \times 100 \text{ MWh} + 1,000 \text{ lbs/MWh} \times 100 \text{ MWh}}{100 \text{ MWh} + 100 \text{ MWh}} = 1,500 \text{ lbs/MWh}$$

Now assume that this state invested in some energy efficiency measures to meet the goal. Engineering estimates calculate these measures avoided 50 MWh of in-state electricity generation that year. Then the state will think it has met the goal, as the ratio becomes:

$$\text{Emissions ratio} = \frac{2,000\text{lbs/MWh} \times 75 \text{ MWh} + 1,000 \text{ lbs/MWh} \times 75 \text{ MWh}}{75 \text{ MWh} + 75 \text{ MWh} + 50 \text{ MWh}} = 1,125 \text{ lbs/MWh}$$

We are assuming that the energy efficiency measures lead to equal sized reductions in both coal and natural gas generation. Suppose, however, that the engineering estimates overestimated the energy efficiency savings, and that the avoided generation was only 30 MWh of savings. Then the state would not have met its goal in reality, but would have appeared to because of flaws in measuring the efficiency savings. The true emissions ratio would be significantly higher:

$$\text{Emissions ratio} = \frac{2,000\text{lbs/MWh} \times 85 \text{ MWh} + 1,000 \text{ lbs/MWh} \times 85 \text{ MWh}}{85 \text{ MWh} + 85 \text{ MWh} + 30 \text{ MWh}} = 1,275 \text{ lbs/MWh}$$

This “loophole” is quantitatively important because the proposed plan relies heavily on energy efficiency to generate the targeted 30% reduction below 2005 levels in emissions from the power sector, with energy efficiency accounting for approximately 20% of the targeted emissions reduction by 2030. Depending on how states choose to comply, national annual spending on utility energy efficiency programs could triple.<sup>1</sup>

### **Why Energy-Efficiency Savings Tend to Be Overestimated**

Economic studies have found that there are many reasons why actual energy savings often end up smaller than predicted. In this section we describe several issues that have been discussed in an emerging literature on this topic. We briefly summarize the main issues here and then Appendix 1 describes several recent studies in detail.

First, many participants in energy-efficiency programs are “free riders,” getting paid to do what they would have done otherwise. Many energy-efficiency programs work by subsidizing households and firms to adopt energy-efficient technologies. Often program evaluations make very optimistic assumptions about participation, often assuming that none of the participants would have adopted the energy-efficient technologies in the absence of the program. However, when economists have examined this question rigorously they have often found a high fraction of participants are free riders.<sup>2</sup>

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<sup>1</sup> ICF International. “EPA’s 111(d) Clean Power Plan Could Increase Energy Efficiency Impacts, Net Benefits, and Total Value.” White Paper and Webinar: October 28, 2014.

<sup>2</sup> Judson Boomhower and Lucas Davis. 2014 “A Credible Approach for Measuring Inframarginal Participation in Energy-Efficiency Programs,” *Journal of Public Economics*, 113, 67-79. Houde, Sébastien, and Joseph Aldy.

Second, energy-efficiency technologies cost less to operate, so firms and households may use them more. This “rebound effect” has been widely understood by economists for decades, but it continues to be downplayed or completely ignored in engineering studies. A small but growing collection of studies has been able to measure the “rebound effect” directly, often finding substantial increases in usage.<sup>3</sup> Although 100% rebound is rare, it is not uncommon for as much as 30% or 40% of the predicted gains from energy-efficiency to be offset. Moreover, several studies have found evidence of energy-efficiency policies leading participants to upgrade to larger, more feature-rich technologies, thereby further eroding potential savings.<sup>4</sup>

Third, there are institutional factors which create incentives to inflate *ex ante* estimates. Some programs explicitly require *ex ante* estimates to be of a certain size in order for participants to receive subsidies. Contractors and energy-efficiency auditors would like to see their clients have access to these subsidies, so may make conscious or unconscious choices in performing audits that bias the estimated savings upward. Similarly, the compensation received by investor-owned utilities for administering energy-efficiency programs usually depends, in part, on the magnitude of the estimated savings, which creates a potential incentive for overstatement. Although public utility commissions should, in theory, protect ratepayers from paying for illusory demand reductions, many don’t have the capacity or expertise to carefully review all energy-efficiency programs.

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October 2014. “Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments.” *E2e Working Paper* 14. Chandra, A., Gulati, S., Kandlikar, M., 2010. “Green Drivers or Free Riders? An Analysis of Tax Rebates for Hybrid Vehicles.” *Journal of Environmental Economics and Management*. 60 (2), 78–93. Hartman, R., 1988. “Self-Selection Bias in the Evolution of Voluntary Energy Conservation Programs.” *Review of Economics and Statistics*. 448–458. Ito, Koichiro, 2013. “Asymmetric incentives in subsidies: evidence from a large-scale electricity rebate program.” *American Economic Journal: Economic Policy*, forthcoming. Alberini, Anna; Gans, Will; and Towe, Charles, “Free Riding, Upsizing, and Energy Efficiency Incentives in Maryland Homes” (October 01, 2013). Fondazione Eni Enrico Mattei Working Papers. Paper 835. Hossein Haeri and M. Sami Khawaja, “The Trouble with Freeriders,” *Public Utilities Fortnightly*, March 2012.

<sup>3</sup> Meredith Fowlie, Michael Greenstone, and Catherine Wolfram. 2014. “Reducing Energy Consumption and Greenhouse Gas Emissions through Energy-Efficiency Retrofits: Evidence from Low-Income Households.” *E2e Working Paper* Forthcoming. Ken Gillingham, David Rapson, and Gernot Wagner. 2014. “*The Rebound Effect and Energy Efficiency Policy*,” *Working Paper*. Davis, Lucas. 2008. “Durable Goods and Residential Demand for Energy and Water: Evidence from a Field Trial.” *RAND Journal of Economics* 39 (2): 530-546. Azevedo, Ines L. 2014. “Consumer End-Use Energy Efficiency and Rebound Effects.” *Annual Review of Environment and Resources* forthcoming. Sorrell, Steve. 2007. “The Rebound Effect: An Assessment of the Evidence for Economy-wide Energy Savings from Improved Energy Efficiency.” *UK Energy Research Center Report*. Thomas, Brinda A., and Ines L. Azevedo. 2013. “Estimating Direct and Indirect Rebound Effects for U.S. Households With Input-Output Analysis. Part 2: Simulation.” *Ecological Economics* 86 (C): 188-198. Allcott, Hunt and Michael Greenstone. 2012. “Is There an Energy-efficiency Gap?” *Journal of Economic Perspectives*, 26(1), 3-28. Dubin, Jeffrey A., Allen K. Miedema, and Ram V. Chandran. 1986. “Price Effects of Energy-Efficient Technologies: A Study of Residential Demand for Heating and Cooling,” *RAND Journal of Economics*, 17(3), 310-325.

<sup>4</sup> Houde, Sébastien, and Joseph Aldy. October 2014. “Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments.” *E2e Working Paper* 14. Lucas Davis, Alan Fuchs and Paul Gertler, “Cash for Coolers: Evaluating a Large-Scale Appliance Replacement Program in Mexico”, *American Economic Journal: Economic Policy*, 2014, 6(4), 207-238.

For these reasons, actual energy savings often end up being considerably smaller than *ex ante* estimates. Furthermore, economists have pointed out that the *costs* of energy-efficiency programs often end up being *higher* than reported.<sup>5</sup> In addition to direct program costs like subsidies, these programs impose substantial indirect costs, including design, advertising, and administration. These indirect costs tend to be ignored or understated in energy-efficiency evaluations, causing the overall cost-effectiveness of these programs to be overstated.

### **Closing the Loophole**

As we demonstrated above, the adjustment for generation avoided due to energy-efficiency programs risks significantly weakening the stringency of the standard. We see several potential approaches for mitigating this concern.

To mitigate this concern, the EPA should establish detailed protocols and guidance for evaluation, monitoring, and verification of efficiency programs. Moreover, in quantifying the savings from these interventions, the EPA should favor field-based savings estimates over engineering estimates and should encourage evaluators to take advantage of state-of-the-art approaches to program evaluation.

In particular, the EPA should credit states for energy-efficiency savings based on the rigor of the methodology used to measure the savings. Randomized controlled trials (RCTs) are the most rigorous design, followed by quasi-experimental methods, non-experimental methods, and engineering studies. Execution and internal validity must be considered, as well, to determine which studies would most accurately represent real-world savings.

The EPA should discount estimated savings from non-RCT based evaluations, according to which methodology was used. Under this approach, savings estimates from high-quality, well-executed RCTs would be credited at 100%. But savings estimates based on engineering estimates, or using field data and less rigorous evaluation techniques would be credited at some fraction (i.e., less than 100%) of the predicted savings.

The exact “discount” should be based on the ratio of actual savings to predicted savings in previous studies. For example, if an engineering study predicted 450 kWh savings per year per household from replacing old refrigerators with energy-efficient models, but then a high-quality RCT found that this same program actually generated savings of only 135 kWh, then future engineering-based estimates for refrigerator programs should be credited at  $135/450=30\%$ .

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<sup>5</sup> Joskow, Paul L., and Donald B. Marron. 1992. “What Does a Negawatt Really Cost? Evidence from Utility Conservation Programs.” *Energy Journal* 13 (4): 41–74. Meredith Fowlie, Michael Greenstone, and Catherine Wolfram. 2014. “Reducing Energy Consumption and Greenhouse Gas Emissions through Energy-Efficiency Retrofits: Evidence from Low-Income Households.” E2e Working Paper Forthcoming.

Of course if a state doesn't like the discount that is offered, it can perform a high-quality RCT, and then be credited with the documented amount of savings. And, the EPA can update these discounts over time as more evidence is produced. Over time, the number and quality of studies will increase and the system of crediting will become more and more accurate.

## **About Us**



*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 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.*

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## **Appendix 1: Detailed Discussion of Several Recent Energy-Efficiency Studies**

A recent experiment evaluating the federal Weatherization Assistance Program in Michigan provides one example in which recent research results suggest that engineering estimates overstate actual savings.<sup>6</sup> The program provides free energy efficiency audits and retrofits to households with incomes at or below 200% of the poverty line, spending a maximum of \$6,500 per household. The National Energy Audit Tool (NEAT) identified cost-effective energy efficiency measures for the household, and it was estimated that the average household receiving this weatherization assistance would see heating costs drop by 20-25%. The study had 30,000 household participants, a randomly selected subset of which were encouraged to participate in the program through house visits, robot calls, personal calls, and in-person follow up appointments.

Results from the study find that the energy savings from these retrofits are lower than expected. Part of this could be that the initial savings estimates were too optimistic, perhaps because the engineering model was miscalibrated or incorrectly specified. The authors find that a small part of this, however, is that the retrofits induced a behavioral change among some households: the “rebound effect.” After receiving the upgrade, some households turned up their thermostat, increasing their electricity usage. This only accounted for a small component of the difference between predicted and actual savings, but it highlights an important caveat to relying on bottom-up engineering estimates: they do not account for the human element. To understand what real energy savings are, we need to understand how people will use these investments.

Savings from energy-efficient appliances are also lower than expected. A consulting group contracted to evaluate the “Cash for Appliances” program that provided rebates for EnergyStar appliance purchases claimed a large impact and savings of 116 kWh / y, 257 kWh / y, and 57 kWh / y for refrigerators, clothes washers, and dishwashers, respectively. Aldy and Houde (2014) evaluate the same program, however, and find that the effect of rebates on electricity consumption tended to be fairly small, if there even was an effect.<sup>7</sup> This study did not directly observe electricity consumption, but calculated energy savings through rebates. The rebates created energy savings by encouraging some consumers to replace old appliances earlier (though other consumers may have chosen to wait until the program started) and by encouraging consumers to substitute towards efficient EnergyStar products. The study found close to no effect on electricity consumption (<1 kWh / year of

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<sup>6</sup> Meredith Fowle, Michael Greenstone, and Catherine Wolfram. 2014. “Reducing Energy Consumption and Greenhouse Gas Emissions through Energy-Efficiency Retrofits: Evidence from Low-Income Households.” *E2e Working Paper Forthcoming*.

<sup>7</sup> Houde, Sébastien, and Joseph Aldy. October 2014. “Belt and Suspenders and More: The Incremental Impact of Energy Efficiency Subsidies in the Presence of Existing Policy Instruments.” *E2e Working Paper 14*.

savings for refrigerator replacement, and statistical zero effects on clothes washers and dishwashers), except for fairly small effects in states with the greatest energy savings. Contributing to the small effect, however, was the behavioral element: the authors found evidence that some consumers used the rebates to upgrade to larger, less-energy efficient models, erasing some of the intended energy savings.

Similarly, Davis, Fuchs and Gertler (2014) conducted a study on Mexico's biggest appliance rebate program, "Cash for Coolers," and found that energy savings were far lower than expected and sometimes nonexistent.<sup>8</sup> Replacing 10+ year old refrigerators with energy-efficient models reduced energy consumption by 8%, saving 134 kWh per year on average – while a World Bank study on a nearly identical intervention predicted savings of 481 kWh per year.<sup>9</sup> The World Bank study predicted that replacing 10+ year old air conditioners (ACs) with newer, energy efficient models would save 1,200 kWh per year, but the Davis, et al. study found that electricity consumption actually *increased* after AC replacement, by an average of 92 kWh per year. A McKinsey study also estimated that replacing refrigerators and ACs would be extremely cost-effective and have a negative net cost of carbon abatement, paying for themselves before even considering externalities such as emissions.<sup>10</sup>

A significant part of this difference is because the World Bank study relied on engineering and not field estimates and did not account for behavioral changes caused by the program. Here, too, consumers upgraded to larger models with more energy-intensive features, decreasing the energy savings. Since more energy efficient ACs cost less to use, households used them more often. Additionally, in making these predictions, the World Bank assumed the program would effectively target very old appliances, but most of the appliances that were replaced were close to the 10-year cutoff.

Table 1 below compares the observed savings from field experiments with predicted savings from ex ante analyses. In all of the cases, realized savings are far lower than the predicted savings.

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<sup>8</sup> Davis, Lucas, Alan Fuchs, and Paul Gertler. 2014. "Cash for Coolers: Evaluating a Large-Scale Appliance Replacement Program in Mexico" *American Economic Journal: Economic Policy*, 6(4), 207-238.

<sup>9</sup> Johnson, Todd M., Claudio Alatorre, Zayra Romo, and Feng Lui. 2009. "Low-Carbon Development for Mexico," World Bank, Conference Edition.

<sup>10</sup> McKinsey and Company. 2009. "Low Carbon Growth – A Potential Path for Mexico," Presentation by Francisco Barnes Jr. at Carbon Markets Workshop, August 20, 2009.

**Table 1: Comparing observed savings from field studies with predicted savings**

	<b>Type of Evaluation</b>	<b>Impact Evaluation Savings</b>	<b>Engineering Estimates</b>	<b>Ratio (Observed / Predicted Savings)</b>
<b>Refrigerator Replacement ("Cash for Coolers")<sup>9</sup></b>	Field: Difference-in-Differences	134 kWh	481 kWh	0.28
<b>Air Conditioner Replacement ("Cash for Coolers")<sup>9</sup></b>	Field: Difference-in-Differences	-92 kWh	1,200 kWh	-.077
<b>Refrigerator Replacement ("Cash for Appliances")<sup>9</sup></b>	Field: Difference-in-Differences	< 1 kWh / y	116 kWh / y	< 0.009
<b>Clothes Washer Replacement ("Cash for Appliances")<sup>8</sup></b>	Field: Difference-in-Differences	~ 0 kWh / y (statistically insignificant)	257 kWh / y	0
<b>Dishwasher Replacement ("Cash for Appliances")<sup>8</sup></b>	Field: Difference-in-Differences	~ 0 kWh / y (statistically insignificant)	57 kWh / y	0
<b>Weatherization<sup>7</sup></b>	Field: RCT			
<b>Weatherization<sup>7</sup></b>	Field: Quasi-Experimental			