Choosing the Right Tools:

How Different Markets and Programs Call for

Different Approaches to Estimating Net Savings

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ABSTRACT

Differences in markets and energy-efficiency programs can call for different approaches to estimating net savings. These differences include the extent to which the market addressed is comparable to markets in other (non-program) areas, the ability to identify program participants and non-participants, the diversity and complexity of end-uses or practices targeted by the program, the availability of sales and shipment data, who the decision makers and decision influencers are, the reliability and validity of survey responses, and market actors' knowledge of the broader market. Variations in conditions of the market and the characteristics of the program under study can lead to estimation approaches of various types, the main options of which are as follows: deemed or stipulated savings estimates arrived at by negotiation or decree; self-reported or survey-based estimates in which survey respondents directly or indirectly indicate program influence; cross-sectional approaches involving comparison of the program area with one or more non-program areas; structured expert judgment, most commonly Delphi panels; and historical tracing or a "weight-of-evidence" approach.

This paper discusses two evaluations to illustrate how differences in programs and markets can necessitate different approaches to estimating net savings. One of these is the California Residential New Construction Market Effects Evaluation, conducted for the California Public Utilities Commission (CPUC) under the direction of the California Institute for Energy and Environment. The other is a collaborative effort among program sponsors in seven states in the U.S. to develop a statistical model providing net-to-gross estimates for their CFL programs.

Introduction

This paper uses two examples to illustrate how differences in programs and markets can require different approaches to estimating net savings. One example is the California Residential New Construction Market Effects Evaluation, conducted for the California Public Utilities Commission (CPUC) under the direction of the California Institute for Energy and Environment (KEMA et al. 2009a, 2009b). This study, covering the 2006-2008 program years, began with development of program theory, which posited that there were three ways the California investor owned utilities' (IOUs') residential new construction (RNC) programs could affect the efficiency of California homes built outside those programs: 1) by increasing above-code practices in non-participating homes; 2) by increasing code compliance in non-participating homes; and 3) by helping to bring about changes in code. The IOUs have separate Codes and Standards programs attempting to influence the adoption of more stringent building codes for energy efficiency, and the CPUC commissioned a separate study addressing the effects of these efforts (KEMA et al. 2010a). Therefore the market effects study examines net impacts achieved in the first two ways only: 1) net impacts achieved through the IOU programs' influence on above-code practices in homes built outside the IOU programs; and 2) net impacts achieved through the IOU programs' influence on increased code compliance in homes built outside the IOU programs.

The second example is a collaborative effort by program administrators in multiple states[1] to assess the market effects of compact fluorescent lamp (CFL) programs. The study involved modeling of CFL sales in those areas, which had active programs, as well as CFL sales in areas without active programs.[2] The principal goals of the modeling effort were to identify and examine factors associated with 2008 CFL purchases generally and the effect of CFL programs on those purchases. The study produced a separate net-to-gross estimate (NTG) for each of the study sponsors.[3]

Comparing Evaluation Objectives

Both the California Residential Market Effects Study and the Multistate CFL Modeling Study seek to estimate the net energy savings stemming from market effects. Some definitions are in order:

- M*arket effect*: a change in the structure of a market or the behavior of participants in a market that is reflective of an increase in the adoption of energy-efficient products, services, or practices and is causally related to market intervention(s) (Eto, Prahl, and Schlegel 1996).
- *Market transformation*: a reduction in market barriers resulting from a market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced, or changed. (Eto, Prahl, and Schlegel 1996).
- *Net savings:* The total change in load that is attributable to an energy efficiency program. This change in load may include, implicitly or explicitly, the effects of free drivers, free riders, energy efficiency standards, changes in the level of energy service, and other causes of changes in energy consumption or demand (Horowitz 2009).
- *Net-to-Gross Ratio (NTG):* A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program load impacts. The factor itself may be made up of a variety of factors that create differences between gross and net savings, commonly including free riders and spillover. Other adjustments may include a correction factor to account for errors within the project tracking data, breakage, and other factors that may be estimated which relate the gross savings to the net effect of the program. Can be applied separately to either energy or demand savings (Horowitz 2009).
- *Free rider:* A program participant who would have implemented the program measure or practice in the absence of the program. Free riders can be 1) total, in which the participant's activity would have completely replicated the program measure; 2) partial, in which the participant's activity would have partially replicated the program measure; or 3) deferred, in which the participant's activity would have completely replicated the program measure, but at a future time than the program's timeframe (Horowitz 2009).
- *Spillover:* Reductions in energy consumption and/or demand caused by the presence of an energy efficiency program, beyond the program-related gross savings of the participants and without financial or technical assistance from the program. There can be participant and/or nonparticipant spillover. Participant spillover is the additional energy savings that occur when a program participant independently installs energy efficiency measures or applies energy saving practices after having participated in the efficiency program as a result of the program's influence. Non-participant spillover refers to energy savings that occur when a program nonparticipant installs energy efficiency measures or

[1] Study sponsors included the California Public Utilities Commission, the Connecticut Energy Conservation Management Board, Xcel Energy (Colorado), program administrators in Massachusetts (Cape Light Compact, National Grid, NSTAR, Unitil, and Western Massachusetts Electric), Consumers Energy (Michigan), New York State Energy Research and Development Authority, and the Wisconsin Department of Public Service.

[2] Georgia, Kansas, Pennsylvania, Maryland, Ohio, Indiana, the District of Columbia, Houston.

[3] An example of a publicly available report is NMR 2010

applies energy savings practices as a result as a result of a program's influence (Horowitz 2009).

The two examples discussed in this paper are both market effect studies, in that they attempt to tie market interventions (programs) to increases in energy-efficiency practices. While market transformation may well result from these interventions, these two studies focus on market effects but not on market transformation; it is possible to have market effects without market transformation if the market changes are not sustainable.

Also, both studies estimate net energy savings stemming from market effects. They do so through estimating and applying net-to-gross ratios; therefore both studies start with gross savings estimates. The California Residential New Construction Market Effects Study relies on gross savings estimates developed for another study (KEMA et al. 2010b), which involved on-site audits of newly constructed non-program homes in California, trued up to electric and natural gas bills. Then, to match the two ways program theory posited that the IOU RNC programs could lead to net energy savings, the study team developed gross savings estimates for 1) non-program homes built to be more efficient than required by code, compared to homes that just meet code; and 2) homes that just meet code compared to homes that are built below the energy requirements of the code.

In the Multi-State CFL modeling study, the various study sponsors used savings parameters from other sources—including hours of use of CFLs, the wattage difference between the CFL and the bulb it replaced, the percentage of purchased CFLs that were actually installed, the average lifetime of CFLs, and coincidence factors—to develop gross savings estimates. They then applied the NTG estimate from the Multi-State Modeling Study (a separate estimate for each sponsor) to the gross savings estimates to develop net savings estimates.

A key concept underlying the net savings and NTG estimates is the baseline—that is, what would have happened in the absence of the program. Of course, literally speaking, we cannot really know what would have happened, not having a time machine allowing us to repeat the same time period with and without the program. But all net savings estimates either explicitly or implicitly rely on a baseline. The difference between what has happened and what would have happened—or the baseline—is the net savings. Both of these studies, then, involve baseline estimates.

A difference between the two studies is how they treat participants and non-participants. The California Residential New Construction Program Market Effects Study examines non-participant spillover only, because another study (KEMA et al. 2010b) had dealt with free-ridership and participant spillover. The Multi-State CFL Modeling Study, in contrast, examines net effects at the market level, without differentiating among free-ridership, participant spillover, and non-participant spillover; the study develops a single NTG (for each sponsor) that encompasses all three.

Options for Estimating Net Savings

As background for discussing the key program and market differences that demand different approaches for estimating net savings, it is first helpful to review the available choices. In general, they can be categorized as follows:

- *Deemed or Stipulated Savings:* a particular NTG is assumed (1, 0.8, 0.7, etc.) that is applied to all programs or all programs of specific types. This is generally negotiated between utilities and regulators or assigned by regulators (Skumatz, Khawaja, and Colby, 2009).
- *Self-Reported or Survey-Based Estimates:* This approach relies on local market actors' own descriptions of the influence of the program on purchase (end users) or promotional (suppliers) decisions to characterize the extent of the program's effect. These data are gathered through surveys of program participants and nonparticipants to estimate adoptions within the program *less* free ridership *plus* participant spillover *plus* non-participant spillover (Rosenberg and Hoefgen, 2009). A variant of this approach is *revealed preference* estimation, typically through discrete choice analysis, in which local market actors indirectly indicate the net effects of a program without being asked in so many words (see, for example, KEMA et al. 2010c).

- *Cross-Sectional Estimates:* This approach uses comparisons of market share of the targeted technologies or other indicators of adoption among groups of market actors not addressed by the program as a baseline for estimating the net effects of the program on adoptions in the program area. The baseline can be a simple, geographic comparison area, or a modeled comparison area made to resemble the program area in all respects except the presence of the program (Rosenberg and Hoefgen, 2009).
- *Structured expert judgment:* Structured expert judgment studies assemble panels of individuals with close working knowledge of the technology, infrastructure systems, markets, and political environments addressed by a given energy efficiency measure to estimate baseline market share and, in some cases, forecast market share with and without the program in place. Structured expert judgment processes employ a variety of specific techniques to ensure that the participating experts specify and take into account key known facts about the program, the technologies supported, and the development of other influence factors over time. The Delphi process is the most widely known method of this family of methods (Rosenberg and Hoefgen, 2009).
- *Historical Tracing:* Also called the case study method, this involves the careful reconstruction of events leading to the outcome of interest—for example, the launch of a product or the passage of legislation—to develop a 'weight of evidence' conclusion regarding the specific influence or role of the program in question on the outcome. Historical tracing relies on logical devices typically found in historical studies, journalism, and legal argument (Rosenberg and Hoefgen, 2009).[4,5] These include:
    - Compiling, comparing, and weighing the merits of narratives of the same set of events provided by individuals with different points of view and interests in the outcome
    - Compiling detailed chronological narratives of the events in question to validate hypotheses regarding patterns of influence
    - Positing a number of alternative causal hypotheses and examining their consistency with the narrative fact pattern
    - Assessing the consistency of the observed fact pattern with linkages predicted by the program logic model
    - Using information from a wide range of sources, such as public and private documents, personal interviews, and surveys

As might be expected, these approaches are not mutually exclusive. Deemed savings estimates often come from other sources, such as studies conducted in other areas or studies conducted in other years, and these studies typically involve the other approaches. Delphi panels often base their judgment on information from other sources. Historical tracing can be informed by almost any relevant information.

Key Program and Market Differences

This section outlines the differences between programs and markets that can affect the selection of appropriate methods for estimating net impacts. While the discussion is based on a comparison of the California Residential New Construction Market Effects Study and the Multi-State CFL Modeling Study, the criteria outlined here are likely to apply to other markets and programs as well—although it is possible that other programs could differ in ways that would necessitate additional decision criteria for selecting net savings estimation methods.

[4] For an example in the energy efficiency evaluation field, see Shel Feldman Management Consulting, Research Into Action, and Xenergy 2001.
[5] For an example outside of evaluation, in the realm of historical studies, see Skocpol 1979.

Degree of Comparability to Markets in Other Areas

The residential new construction market in California operates within a market having unique state building codes and various unique climates—from deserts with high cooling needs to coastal areas with very limited cooling and heating needs—affecting how homes are built. In addition, the market actors making key decisions about the efficiency of homes are local, including builders, but also including an entire class of market actors that is unique to California: Title 24 Consultants, who advise builders and provide certificates of compliance with the energy efficiency portion of the building code for newly constructed homes, as required by state law. These features make the California new construction market very difficult to compare with the residential new construction markets in other states, and preclude a cross-sectional approach for assessing net savings.

In contrast, the CFLs sold in different parts of the United States are very similar, or even identical in most cases. There are differences among small retailers in different areas, but the manufacturers are the same across areas, and national retailers such as Wal-Mart and Home Depot—which account for a very large proportion of CFL sales on a national level—operate in most areas. There are differences among programs—and some areas have no programs at all—but this fact facilitates identification of program effects through comparison across areas. The difficulty with straight, state-to-state comparisons is that there may be no non-program state that is sufficiently similar to a program state in all respects except the presence or absence of a program to allow drawing any conclusions about program effects. For example, all six New England states[6] have CFL programs, and differences between New England and the rest of the country make comparisons outside the area problematic. For several years Michigan served as a non-program comparison area for Wisconsin, which has had CFL programs for many years (e.g., see Winch & Talerico 2008), but now Michigan also has programs, so it is no longer a pure comparison area. Hence if a cross-sectional approach is to be used for CFLs, it cannot be a straightforward single-comparison-area approach.

Ability to Identify Participants and Non-Participants

Identifying participants in the California Residential New Construction Program is relatively straightforward, since the IOUs keep records of program homes for which incentives are paid. Through new meter hookup requests it is also relatively easy to identify all newly constructed homes, and by subtracting participating homes it is relatively easy to identify non-participants.

For the past several years in the U.S., many if not most CFL programs promoted CFLs through upstream incentives, by paying manufacturers to reduce the prices of CFLs on retailers' shelves. While this approach vastly increased the number of CFLs moved through programs, it also made participants anonymous; there was no longer any record of who had purchased program-supported CFLs. That meant that program sponsors could not identify participants. In addition, program participants, because they were simply buying a product in a store without filling out any rebate forms, were unlikely even to be aware that they were participants. This has made questions asking for self-reported free-ridership and spillover extremely problematic.

Diversity and Complexity of End-Uses or Practices Targeted by the Program

The efficiency of a new home stems not only from the materials used in construction, but also from building and installation practices, which makes it very difficult for a non-expert—i.e., a homebuyer—to provide meaningful answers about the efficiency of their home. CFLs, in contrast, are relatively simple products with a fairly narrow range, and consumers can be expected to be able to identify them and to tell if they are installed or not.

[6] Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont

Availability and Quality of Sales and Shipment Data

Sales and shipment data for equipment used in residential new construction are only tangentially helpful for estimating whole-house savings; the house is a system, and highly efficient windows, for example, by themselves do not make a home more efficient than a home with standard efficiency windows. In addition, equipment sales data are often not available, and if so often do not differentiate new construction from other applications. Hence depending on equipment sales and shipment data in residential new construction is not a promising way to estimate net savings.

Using sales and shipment data for estimating net savings for CFL programs, however, is quite promising—and in fact there are some such data available. Unfortunately, the pieces that are missing from those data make them very misleading and unreliable—for example, certain retail channels but not others are well represented, and some regions are better represented than others. (cf. Cadmus Group et al. 2008). Hence analysis of sales data to estimate net sales is not a strong option, at least until those data are more complete. Were better sales or shipment data available, they could contribute greatly to a different approach to estimating net savings. For example, the U.S. Department of Energy provides state-by-state market share data for ENERGY STAR® appliances, which—along with other state-level variables such as presence/absence of appliance programs, electric rates, demographics, and others—allowed estimation of NTG and net energy savings for the Massachusetts appliance program (Wilson-Wright, Feldman, and Hoefgen 2004).

Who the Decision Makers and Decision Influencers Are

Decisions that affect efficiency in residential new construction are typically made by builders. Even in the case of a custom home, the home buyer may not know much about the home's efficiency and what made it that way; in any case, a large majority of new homes in California are spec-built, not custom-built. Because every new home built in California is required to have a certificate of compliance with the energy portion of the building code, and because Title 24 consultants provide those certificates as well as consulting on how to achieve compliance, Title 24 consultants are a key group of influencers. Thus potential sources for information about a home's efficiency and a program's influence on it include builders and Title 24 consultants.

The key decision makers for CFLs are consumers; they typically decide whether to buy a CFL and whether to install it. Retailers and manufacturers are key influencers, as they make CFLs available to consumers and have the capability of providing sales and shipment data.

Reliability and Validity of Survey Responses

As mentioned, who the decision makers and decision influencers are affects the focus of inquiry about net savings. A further consideration affecting groups targeted and data collection techniques is the reliability of survey responses.

For residential new construction, builders are the primary decision makers and Title 24 consultants are key influencers. However, efficiency is not the primary concern for builders, unlike Title 24 consultants; builders tend to be more concerned about a home's appearance and "sexy" features that will help it sell. Moreover, builders are unlikely to admit not building to code.

In telephone surveys, consumers cannot accurately report the number of CFLs installed or purchased, according to comparisons of telephone survey responses with data recorded by professional auditors in the same homes (for example, see NMR Group 2010). Related to "Availability of and Quality of Sales and Shipment data" discussed above, retailers and manufacturers likely have reliable data, but are not always willing to provide them. Moreover, because they benefit from program sponsors' incentives, they may be prone to "game" the system and over-attribute program influence during interviews.

Market Actors' Knowledge of the Broader Market

Estimating the net savings occurring through market effects inherently requires identifying indirect changes occurring because of the influence of a program, not just those occurring directly as a result of the program intervention. As mentioned earlier, the ability to identify participants and non-participants is a necessary condition for self-reporting of net effects; it is not, however, sufficient. In the California new construction market, builders—much less home buyers—may not be in a position to know how the IOU programs have influenced availability and pricing of efficient materials, knowledge among subcontractors, etc. In the case of CFL programs, end-users, as discussed earlier, typically do not know they are participants and may not even know that there is a CFL program.

Methodologies Selected

Based on the above considerations, the following sections discuss the decisions reached about methodologies selected for net savings analysis in the two example evaluations.

California Residential New Construction Programs

To reiterate, the residential new construction market in California and the IOUs' Residential New Construction programs have the following characteristics that affect how net savings estimation can be approached:

- *Degree of comparability to markets in other areas:* Distinctive state building codes, multiple and varied climates, and the prevalence of local market actors preclude a cross-sectional approach; new construction in California simply is not comparable enough to construction in any other area—or even a combination of areas—to allow valid comparisons.
- *Ability to identify participants and non-participants:* Homes whose builders have received incentives for participating in IOU programs, as well as homes whose builders have not received such incentives, can easily be identified. This is a condition necessary for self-reporting of net effects, and also for calculation of non-participant spillover separate from participant spillover and free ridership.
- *Diversity and complexity of end-uses and practices:* Because the efficiency of a new home and how it got that way is not straightforward and obvious, homeowners cannot answer most questions about efficiency practices, and they usually are not the decision makers anyway. Homeowners, therefore, are not the right group to target for information about net savings.
- *Availability and quality of shipment and sales data:* Sales and shipment data for equipment and materials used in new construction are not always available, and in any case do not allow specification of the efficiency of a home as a whole.
- *Who the decision makers and decision influencers are:* Builders are the primary decision makers for residential new construction, and Title 24 consultants are key influencers.
- *Reliability and validity of survey responses:* Builders focus on efficiency as one of many considerations—usually not the most important one—and may tend to exaggerate the efficiency of the homes they build. Title 24 consultants, though, focus exclusively on energy efficiency, and since they do not build and sell the homes are not as invested in the claimed efficiency.
- *Market actors' knowledge of the broader market.* Builders and home buyers may not be in a position to know how the IOU programs have influenced availability and pricing of efficient materials, knowledge among subcontractors, etc. Title 24 consultants, with their exclusive focus on efficiency, have more of a global perspective.

Taking these considerations into account, the team opted for structured expert judging—specifically a Delphi panel of Title 24 consultants, supplemented by a separate panel of experts who are knowledgeable about the California residential new construction market. Starting with estimates from another study of gross savings of above-code non-program homes compared to homes that just meet code, and non-program homes that just meet code compared to homes built below code (KEMA et al. 2010b), the study asked panel members to assign attribution scores to IOU programs and other factors, such as climate change, energy prices, the downturn in the housing market, and non-IOU programs promoting efficiency in residential new construction. After one round of responses, the panel members will receive a summary of other members' responses compared to their own, and will have an opportunity to change their attribution scores. The evaluation team will then combine the scores to develop an overall NTG, and apply it to the gross savings estimates to arrive at a net savings estimate. Because the study examines non-participants only, the net savings estimate will be for non-participant spillover only, and will not account for participant spillover or free ridership.

CFL Programs

CFL programs in the U.S. have the following characteristics that affect the selection of an approach for estimating net savings:

- *Degree of comparability to markets in other areas:* Unlike the California residential new construction market in California, CFL markets in the U.S. are fairly similar, although with the proliferation of CFL programs it is difficult if not impossible to find a single valid non-program comparison area.
- *Ability to identify participants and non-participants:* Because incentives are provided to upstream market actors rather than end-users, program sponsors cannot identify participants, nor can participants necessarily identify themselves as participants. Hence self-reported free ridership and spillover estimation have to be ruled out.
- *Diversity and complexity of end-uses or practices targeted by the program:* CFLs, from the perspective of how they are used and how they save energy, are fairly simple.
- *Availability and quality of shipment and sales data:* There are state- and national-level CFL sales and shipment data available, but unfortunately these data have crucial holes. If better sales data were available they would have to be strongly considered for use in estimating net savings.
- *Who the decision makers and decision influencers are:* Consumers are the primary decision makers for purchase and use of CFLs, and the decisions are made a household level. Retailers and manufacturers are key decision influencers.
- *Reliability and validity of survey responses:* While they are the key decision makers, consumers cannot reliably report how many CFLs they are using or have purchased. Retailers and manufacturers would have more knowledge, but may be motivated to exaggerate program influence because of their dependence on incentives.
- *Market actors' knowledge of the broader market.* Consumers who purchase CFLs cannot be expected to be aware of the influence of CFL programs on product pricing and availability, and hence cannot be expected to estimate the effect of those programs on the market.

These considerations, along with a willingness by program sponsors in multiple states to join a collaborative effort, led the team to select a cross-sectional approach—specifically multi-state statistical modeling. This approach obviated the need for a perfect comparison area, because it entailed a modeled comparison area, or baseline. It also allowed for statistical control of household-level variation, and took advantage of pooled resources to provide large sample sizes. Because of problems with self-reporting through telephone surveys, the model used on-site assessments of CFL use and purchases for estimation.

The study included both areas with CFL programs and areas without CFL programs—16 areas in all[7]—involving 9,325 telephone interviews and 1,444 onsite audits of homes. The dependent variable was CFL purchases in 2008, and the independent variables included presence/absence and strength of the CFL program in a given area, demographics, the years a household had used CFLs, and saturation of CFLs out of all sockets at the beginning of 2008; many other independent variables were included before the final model was developed. The model predicted sales with and without a CFL program (the latter being the baseline) in a given area. The team then computed a NTG as with-program sales minus no-program sales all over program-supported sales. Program sponsors then applied the NTG to gross savings estimates derived from other sources.

Conclusion

Accurate net savings estimates help ensure wise expenditures of program resources, tie rewards to actual savings, and guide programs toward maximizing savings—the reason for having programs to begin with. Without accurate net savings estimates, high free ridership on one hand and out-of-program savings on the other will go undetected, leading to overestimation or underestimation of savings, and hence misallocation of resources. Yet few things in energy efficiency evaluation are as difficult to come up with as defensible net savings estimates. A good place to start is to examine the options available for net savings estimation methods, and to compare the requirements of these methods with the conditions of the market and the characteristics of the program under study. As illustrated here with two disparate sets of markets and programs, this exercise can lead to widely varying approaches.

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[7] California, Colorado, Connecticut, District of Columbia, Georgia, Houston, Indiana, Kansas, Maryland, Massachusetts, Michigan, New York City, New York State, Ohio, Pennsylvania, and Wisconsin

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