Finding and Counting Market Effects: A New Construction Program Example

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ABSTRACT

This paper describes an effort to assess and quantify the market effects of California's investor-owned utility programs targeting the residential new construction sector. The research began with a scoping study to specify a program theory and recommend an approach for data collection and analysis, followed by a qualitative assessment to see if there was evidence that market effects had actually occurred, and then quantitative estimation of the net energy savings associated with those market effects.

The qualitative phase assessed whether each outcome posited in the program theory had in fact occurred, and, if so, whether the outcome could be linked to IOU program activities. The quantitative phase started with gross savings estimates derived from on-site audits of newly constructed non-program homes in California. To quantify net market effects, the study team asked a Delphi panel of energy efficiency consultants and a separate panel of RNC experts to assign attribution scores to IOU programs and non-IOU factors, and to identify which elements of the IOU programs, if any, were most responsible for savings.

The study found that energy savings associated with the observed market effects in non-participant homes are large and quantifiable, and that training is the IOU program element most responsible for the market effects. This study illuminates how the IOUs' activities made a difference beyond natural market changes including other non-IOU activities targeting the residential new construction sector, which could provide guidance to program administrators on how to refine the programs to maximize market effects in the future.

Introduction

The investor-owned utilities (IOUs) in the State of California—Pacific Gas and Electric (PG&E or PGE), San Diego Gas & Electric (SDG&E or SDGE), Southern California Edison (SCE), and Southern California Gas (SCG)—have been operating energy-efficiency programs for many years, with the most recent iteration of these programs having been implemented in the 2006-2008 time period. These included a variety of programs targeting the residential new construction (RNC) sector. This study was conducted for the California Public Utilities Commission's (CPUC) as part of the 2006-08 evaluation of the IOUs' programs.

The study, as well as the CPUC's Market Effects Evaluation Protocol, follow the definition of market effects offered by Eto, Prahl, and Schlegel: "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, & Schegel 1996; CPUC 2006). The objectives of the overall market effects study were: to understand the market effects of California's 2006-2008 utility energy efficiency programs on construction practices for new single-family homes; to quantify the energy savings caused by these market effects

occurring in the years 2006-2008, with special attention to non-participant spillover; and to assess the effects of pre-2006 IOU programs on the adoption of more efficient technologies and practices in the 2005 Title 24 code.

After a scoping study to specify a market and program theory and recommend an approach for data collection and analysis, the study was performed in two phases. Phase I—because of uncertainty as to whether any market effects would be identified—addressed only the first objective of the overall market effects study: to understand the market effects of California IOUs' energy efficiency programs on construction practices for new single-family homes. Phase I established that there was sufficient qualitative evidence of market effects that may reasonably be attributed to the IOUs' programs targeting the RNC sector to justify continuing with Phase II.

Phase II was designed to quantify the energy savings caused by the market effects, and relied on on-site assessment of newly constructed non-IOU-program homes in California, followed by a Delphi study. Delphi panelists, consisting of Title 24 consultants[1] and experts on the RNC market in California, were asked to assign attribution scores to IOU programs and other factors, and to identify which elements of the IOU programs were most responsible for savings.

Scoping Study

The study began with the development of a program theory and logic model, based on in-depth interviews with eleven managers of the IOUs' programs targeting the RNC sector, in-depth interviews with 14 experts on the California RNC industry,[2] review of previous directly related market effects studies of the IOUs' programs, and review of evaluations of RNC programs outside California (KEMA et al. 2009a). The theory posited that there were three ways the IOUs' 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 advocating for the adoption of more stringent building codes for energy efficiency, and the CPUC commissioned a separate impact evaluation of these programs (Cadmus et al. 2010). The market effects study examined net impacts achieved in the first two ways only (i.e., by increasing above-code practices in non-participating homes, and by increasing code compliance in non-participating homes).

The program theory showed how key program elements were designed to increase the adoption of energy-efficient design, equipment, and practices in the single-family building market. These program elements included: incentives for meeting efficiency criteria; Program Plan Check;[3] research and development on new technologies and practices; training of builders and other market actors in new technologies and practices; training (by PG&E only) for building code officials on how to inspect homes for purposes of code enforcement; requirements for Home Energy Rating System (HERS) ratings to verify proper installation of the specified equipment that allow a home to achieve program-specified efficiency levels; and advertising and outreach to increase consumer awareness of efficiency and associated benefits.

In addition to identifying expected outcomes of the IOUs' program efforts, the theory delineated indicators that could be measured in order to establish whether expected outcomes had occurred, and recommended alternative hypotheses to test in order to assess whether observed

[1] Title 24 Consultants provide calculations and documentation that a home is compliant with Title 24 (the California Energy Efficiency Standards for Residential and Nonresidential Buildings) and provide recommendations to improve the energy efficiency of homes.

[2] Identified as experts by the CPUC and their advisors, the evaluation team, and by initial interviewees

[3] Program Plan Check is a process in which IOU staff reviews participating builders' plans and Title 24 compliance documentation to ensure accurate modeling. If significant modeling errors are discovered, Program Plan Check staff utilize CEC-approved Title 24 compliance software to correctly model the home. The revised model and revised compliance margins are then provided to the builder and energy consultant. This feedback mechanism is intended both to ensure that applications meet program requirements and to educate energy consultants on proper modeling techniques.

market changes can reasonably be attributed to market forces or actors outside the IOUs' programs. These included: programs offered by other organizations, naturally occurring changes in building measures and practices, the economic downturn and its effect on the housing market, changes in energy prices, and awareness of climate change. Finally, the scoping study laid out a plan for data collection and analysis to assess the market effects of the IOUs' programs targeting the RNC sector.

Phase I: Qualitative Attribution Analysis

Phase I covered the market and attribution analysis of the IOUs' programs targeting the RNC sector (KEMA et al., 2009b). The aim was to establish whether or not there was substantial evidence of increases in the efficiency of the California RNC market—beyond the direct effects of the IOUs programs—that may reasonably be attributed to those programs. In addition, Phase I was designed to assess the historical context of RNC design and construction practices in California.

The Phase I attribution analysis was based on 976 computer-assisted telephone interviewing (CATI) interviews with non-participating new home buyers, 32 CATI interviews with builders of non-participating homes, 9 CATI interviews with heating, ventilation, and air-conditioning (HVAC) contractors, 45 CATI interviews with Title 24 consultants, 17 telephone interviews (non-CATI) with window distributors, 6 telephone interviews with HVAC distributors, 16 telephone interviews with lighting fixture and control distributors, 5 telephone interviews with insulation distributors, and 8 in-depth interviews with managers of other voluntary RNC programs.

This research indicated that the 2006-2008 IOU programs had discernible effects on improved code compliance of non-program homes, especially through training of builders leading to greater knowledge of how to comply, training of Title 24 consultants leading to improved design, and influencing builders to use HERS raters for Quality Insulation Installation in non-program homes. Phase I also identified probable effects of the 2006-2008 IOU programs on increased above-code practices, primarily through Title 24 consultants' more efficient designs which, in turn, came partially through IOU program training, and through builders' increased knowledge about above-code practices—again partly through IOU program training. Phase I also established that the 2006-2008 IOU programs had probable effects—both direct and indirect—on market readiness for the January 2011 code upgrade, with the indirect effects coming primarily from contributions to improved code compliance and increased above-code practices, primarily through builder and Title 24 consultant training, and through promoting the use of HERS raters.

Thus, Phase I identified sufficient qualitative evidence of market effects that may reasonably be attributed to the IOUs' programs targeting the RNC sector to justify continuing with Phase II.

Phase II: Quantifying Savings from Market Effects

The quantitative phase involved two tasks: estimating compliance rates and gross savings, and estimating net energy savings (KEMA et al. 2010b). Compliance rates are the proportions of homes that are built above code, below code, and just meeting code.[4] The compliance margin is the percentage more or less energy a home uses compared to the energy it is permitted to use under the California State Building Code (i.e. Title 24):[5]

$$\%\,Compliance\ Margin_{i,RNC} = \frac{Standard\ Design_{i,RNC} - Proposed\ Design_{i,RNC}}{Standard\ Design_{i,RNC}}$$

where

$Standard\ Design_{i,RNC}$ = Total energy use (space heating, space cooling and water heating) for a home with Prescriptive Package D features (standard design) from the RNC Interface (*RNC*)

$Proposed\ Design_{i,RNC}$ = Total energy use (space heating, space cooling and water heating) for home *i* with proposed construction plan features (proposed design) from the RNC Interface (*RNC*)

Estimating Compliance Rates and Gross Energy Savings

The first task, based on 194 on-site audits of newly constructed non-program homes in California conducted for another study (KEMA et al. 2010a), was to develop a hypothetical baseline of RNC efficiency in California by estimating code compliance and gross energy savings for non-program homes[6] built from 2006-2008. The evaluation team calculated the gross savings for two categories of non-program homes: 1) homes built above code (compliance margins above +4%) compared to homes just meeting code (compliance margins from -5% to +4%); and 2) homes just meeting code (i.e., code-compliant homes) compared to below-code homes (compliance margins below -4%). These two gross savings estimates correspond to two of the three ways program theory had posited that the IOUs' programs targeting the RNC sector could affect the efficiency of California homes built outside those programs: 1) by increasing above-code practices in non-participating homes, and 2) by increasing code compliance in non-participating homes.

Statewide, the average compliance margin was 7.4% above code, meaning that the average new home built from 2006 to 2008 used 7.4% less energy than it was permitted to use under Title 24. Fifty-eight percent of homes were above code, 29% of homes were code compliant and 13% were below code. While the overall compliance margin was above code, a sizeable proportion of homes, 13%, were below code and thus did not meet Title 24 requirements.

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[4] Code-compliant homes are defined as those with compliance margins above -5% and below +4%.

[5] Title 24 compliance software also generates a virtual measure of energy use that is calculated by weighting energy used on peak more heavily than energy used off peak. This is referred to as Time Dependent Valuation energy, or TDV. Because our objective was to assess compliance based on actual energy used compared to the amount permitted by the code, our calculations are all done based on standard electricity and fossil fuel energy units.

[6] That is, homes not incentivized by SCG's Advanced Home Program, SDGE's Advanced Home Program, SCE's California New Homes Program, PG&E's Residential New Construction Program or PG&E's Duct & Cover Program.

Table 1 shows that the average above-code home would result in 17% savings in electricity usage and 11% savings in natural gas usage over the average code-compliant home. This amounts to 39,225 MWh of electricity annually and 711 MDth[7] of natural gas annually.

Table 1: Annual Gross Energy Savings of Above-Code Non-Program Homes Compared to Code-Compliant Non-Program Homes, 2006-2008

Savings on Electricity Usage	%	17%
	MWh	39,225
Savings on Natural Gas Usage	%	11%
	MDth	711

Table 2 presents data on the electricity and natural gas savings due to homes just meeting code compared to below-code homes. The average code-compliant home would result in 27% savings in electricity usage and 5% savings in natural gas usage over the average below-code home. Overall, code-compliant homes would save 5,471 MWh of electricity annually and 78 MDth of natural gas annually compared to below-code homes.

Table 2: Annual Energy Savings of Code-Compliant Non-Program Homes Compared to Below-Code Non-Program Homes, 2006-2008

Savings on Electricity Usage	%	27%
	MWh	5,471
Savings on Natural Gas Usage	%	5%
	MDth	78

Estimating Net Savings

To convert the gross savings estimates into net savings estimates, the evaluation team employed two Delphi panels, consisting of 24 Title 24 consultants and seven building industry experts.[8] The Delphi technique is often characterized as a group communication process or forecasting method that relies upon panels of experts to develop an estimate or group judgment on a topic or issue. It is an iterative process that involves at least two rounds of questions or interviews with the panels. The Delphi technique is based on the principle that structured responses from experts will be more accurate than unstructured responses from individuals (Hsu and Sandford 2007; Linstone and Turoff 1975; Ludwig 1997).

Each panelist completed two rounds of detailed surveys. The second round provided a comparison with other panelists' responses and logic, and provided the panelists the opportunity to change their answers. The evaluation team analyzed the Title 24 consultant responses (both weighted and unweighted)[9] and used the building industry expert responses as a qualitative check on the responses of the Title 24 consultants.

Delphi panelists were presented with detailed data pertaining to code compliance, compliance margins, and estimates of annual gross energy savings in non-program homes at the state level and by the three climate regions (i.e., Coastal, Inland and Mountain & Desert). After reviewing the compliance and gross savings data, panelists were asked to: 1) estimate the proportion of the electricity and natural gas savings attributable to the IOU programs (i.e., market effects of the IOUs' programs targeting the RNC sector) and to other factors (e.g., non-IOU RNC programs, the economy/housing market, energy prices, climate change); 2) estimate the percentage of net savings

[7] MDth is an abbreviation for thousand decatherms
[8] Identified as experts in the California RNC market by the CPUC, their advisors, and the evaluation team
[9] Weights were based on the number of non-program homes rated by the Title 24 Consultants from 2006–2008.

in non-program homes attributable to different IOU program elements (e.g., training of builders, incentives, advertising, design assistance, etc.); 3) assess the extent to which the market effects are likely to persist in the absence or reduction of the IOU programs (i.e., the sustainability of the market effects); and 4) estimate the percentage of homes that would have been below-code in the absence of the IOUs' programs and other factors and to estimate the compliance margin of the below-code homes in the absence of each factor.

Based on the unweighted Title 24 consultant responses, the Delphi panel estimated that the 2006-2008 IOU programs targeting the RNC sector were responsible for 25%[10] (9,970 MWh) of the gross electricity savings and 26%[11] (187.8 MDth) of the gross natural gas savings due to above-code homes compared to code-compliant homes (**Figure 1**). In addition, the Delphi panel estimated that 21% (8,172 MWh) of the gross electricity savings and 20% (144.3 MDth) of the gross natural gas savings were due to the pre-2006 IOU programs. *Thus, the 2006-2008 and pre-2006 IOU programs taken together accounted for nearly half of the gross electricity and natural gas savings in above-code non-program homes.* Both panels identified the various elements of training (builders, subcontractors, Title 24 and code officials) as the most important elements of the IOUs' programs.

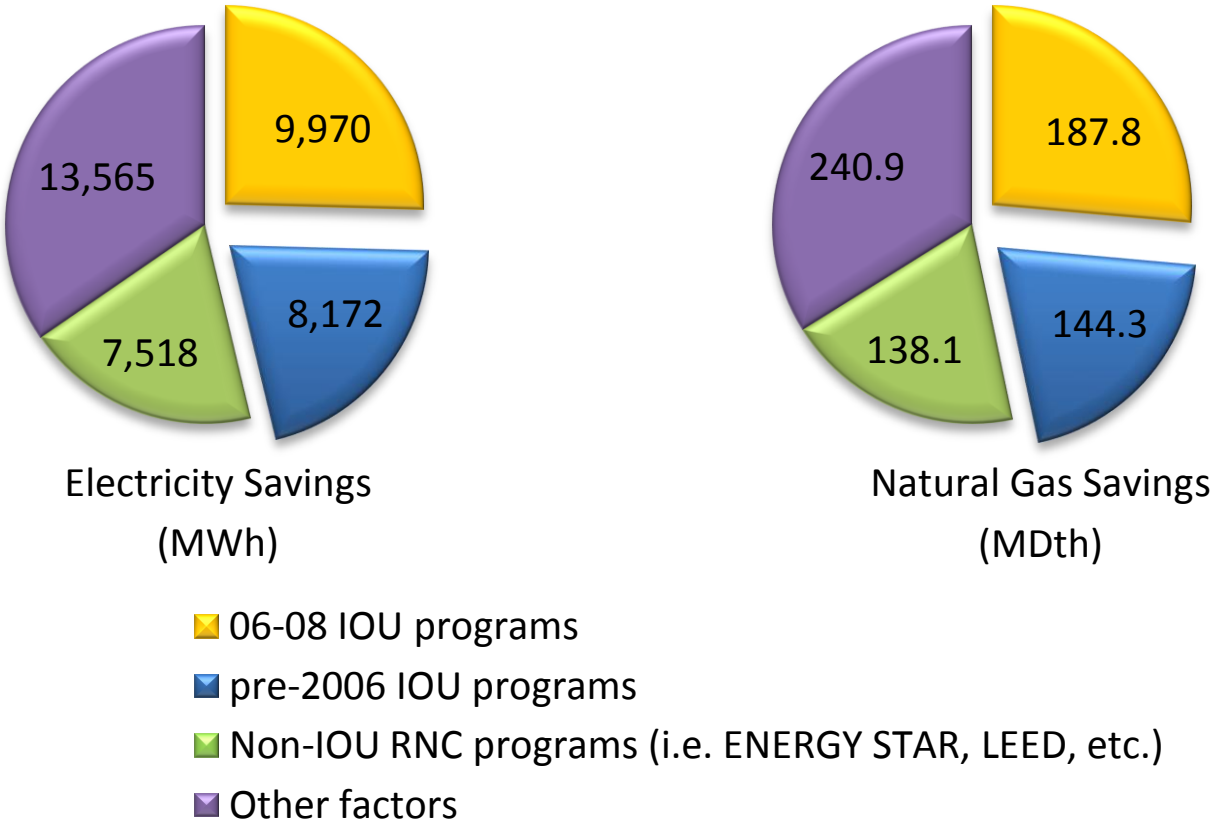

Figure 1: Net Savings of Above-Code Homes Compared to Code-Compliant Homes

[10] The 90% confidence interval ranges from 20% to 31% of gross electricity savings
[11] The 90% confidence interval ranging from 21% to 32% of gross natural gas savings

Based on the unweighted Title 24 consultant responses, the Delphi panel estimated that the 2006-2008 IOUs' programs were responsible for 23%[12] (1,282 MWh) of the gross electricity savings and 23%[13] (18.2 MDth) of the gross natural gas savings in code-compliant homes compared to below-code homes (**Figure 2**). In addition, the Delphi panel estimated that 23% (1,284 MWh) of the gross electricity savings and 24% (18.6 MDth) of the gross natural gas savings were due to the pre-2006 IOU programs. *Thus, the 2006-2008 and pre-2006 IOU programs taken together accounted for nearly half of gross electricity and natural gas savings from achieving code compliance in non-program homes.*[14] Both panels identified the various elements of training (builders, subcontractors, Title 24 and code officials) as the most important elements of the IOUs' programs.

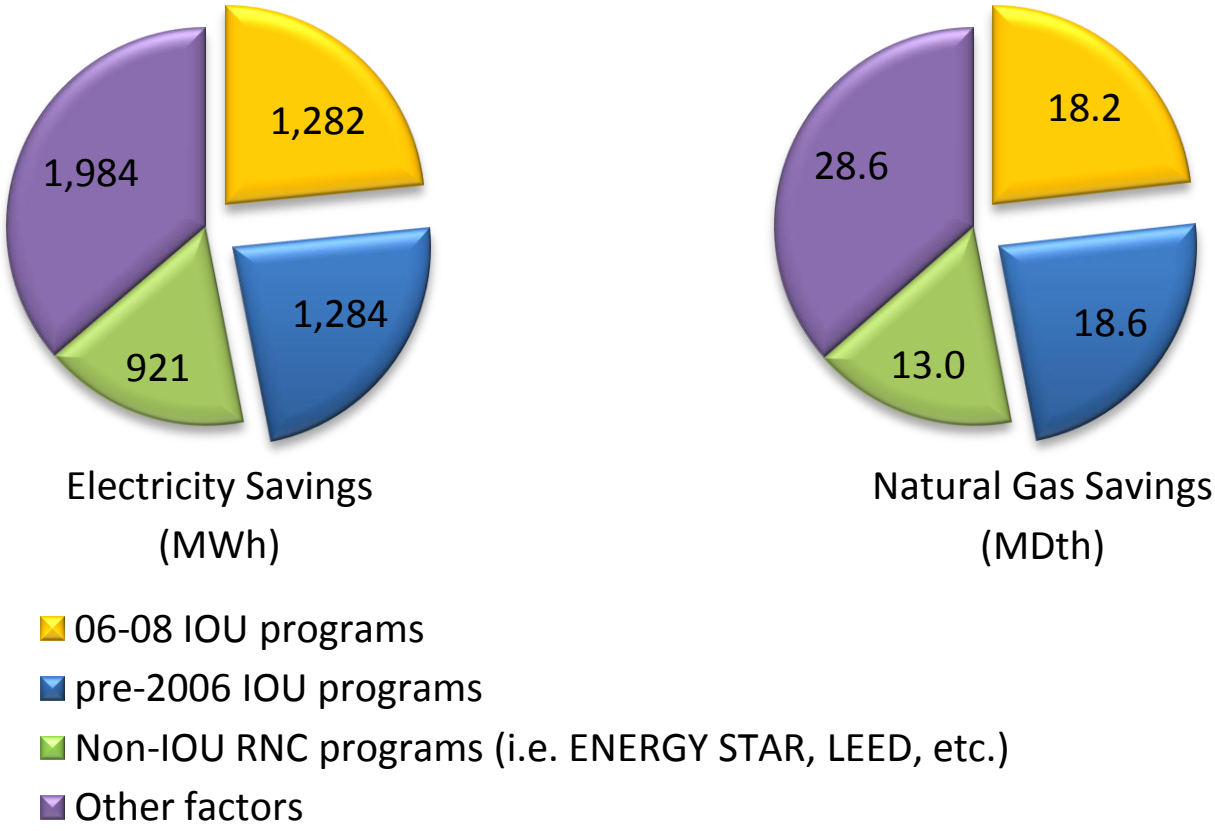

Figure 2: Net Savings of Code-Compliant Homes Compared to Below-Code Homes

In addition to net energy savings, Delphi panelists were asked to estimate the percentage of homes that would have been below-code in the absence of the IOUs' programs targeting the RNC sector and other factors (but assuming all other factors remain unchanged from what actually occurred), and the compliance margin of the below-code homes in the absence of each factor. The two panels, Title 24 consultants and industry experts, had fairly divergent views on the effect on compliance rates (i.e., the percentage of homes that would meet code requirements) if IOUs' programs were eliminated. However, the fact that the estimate provided by energy experts—meant to serve as a qualitative check on the unweighted Title 24 consultant results—was the higher of the two suggests that relying on the lower, more conservative Title 24 consultant estimate is reasonable.

[12] The 90% confidence interval ranging from 18% to 29% of gross electricity savings
[13] The 90% confidence interval ranging from 17% to 29% of gross natural gas savings
[14] Before 2006, IOUs could claim commitments for homes that were not necessarily completed, so many of the homes claimed as commitments in 2005 were likely completed in 2006

The two groups had similar estimates of the effects on compliance *margins* if the IOU programs or other factors did not exist or did not occur (**Table 3**). For example, Title 24 consultants estimated, on average, that the percentage of below-code homes would increase from 22% of homes to 27% of homes, and that the average below-code home would be 17% below code instead of 12% below code if the 2006-08 IOUs' programs did not exist. The building industry panel estimated, on average, that the percentage of below-code homes would increase from 22% of homes to 43% of homes if the 2006-08 IOUs' programs did not exist, and that the average below-code home would be 18% below code instead of 12% below code. These results indicate that the IOUs' programs and non-IOU program factors would have had approximately the same impact if they were absent. This provides a consistency check with the net savings results, which suggested that the IOUs' programs and non-IOU program factors were each responsible for about one-half of the observed impact.

Table 3: Code Compliance in the Absence of IOU Programs and Other Factors—Statewide

	Title 24 Consultants, Unwt (n = 24)			Title 24 Consultants, Wt (n = 24)			Experts (n = 6)
	Mean	90% Confidence Interval for the Mean		Mean	90% Confidence Interval for the Mean		Mean
		Lower	Upper		Lower	Upper Bound	
If the 2006-2008 IOU Residential New Construction programs did not exist							
Proportion of below-code homes	27%	25%	30%	28%	25%	31%	43%
Average percentage below code	17%	15%	19%	20%	18%	22%	18%
If non-IOU Residential New Construction programs did not exit[*]							
Proportion of below-code homes	25%	23%	28%	24%	23%	25%	27%†
Average percentage below code	16%	14%	18%	18%	16%	20%	16%†
If other factors did not occur[‡]							
Proportion of below-code homes	25%	22%	28%	22%	21%	23%	25%†
Average percentage below code	15%	13%	16%	12%	12%	13%	14%†

[*] Programs such as ENERGY STAR homes, LEED for homes, programs sponsored by municipal utilities such as SMUD and LADWP, Environments for Living, ComfortWise, and the Solar Initiative.

† Only four Building Industry Experts were able to provide responses for non-IOU and other factors.

[‡] Factors such as the downturn in the housing market, changes in energy prices, global warming and naturally occurring advances in the residential new construction industry.

Recommendations

The recommendations stemming from this study—supported by the full report but not necessarily addressed in this short paper—fall into four categories: recommendations for the IOUs' programs targeting the RNC sector, recommendations for future evaluations, recommendations for changes to California's Market Effects Evaluation Protocol, and recommendations for treatment of non-participant spillover.

Recommendations for the IOUs' programs targeting the RNC sector

The findings from this evaluation led to the recommendation that, first, the IOUs should continue (and as feasible, expand) the successful training of builders and other market actors. Second, while there were probably good reasons for distinguishing the IOU programs from the national ENERGY STAR Homes Program, IOU program managers should consider realigning with ENERGY STAR, as there is already considerable equity built up in the brand.

Third, before pent-up demand for new housing surges as the economy recovers, the IOUs should consider ramping up advertising and promotion of the IOU programs, so that when potential buyers go to look for new homes, they ask for efficiency and ENERGY STAR certification. Many builders will build more efficient homes if they perceive efficiency as a customer need; otherwise, demand for housing in general might allow any level of efficiency to sell—as was apparently the case in the most recent boom, which ended at beginning of the 2006-2008 period. Participation in the IOU programs could perhaps be increased with renewed effort on channeling consumer demand for efficiency, thus leveraging the outside forces such as gasoline prices, housing market cycles, and global warming that are already driving demand for efficiency.

Fourth, insofar as market transformation is truly a program goal, the IOUs should design the programs to achieve market transformation. The IOU programs' focus on the supply side reflects an orientation toward resource acquisition, with an apparent expectation that market transformation will automatically follow—"build it and they will buy." While this study makes it clear that there are some market effects resulting from the IOU programs, the program elements stimulating them—such as training for market actors—are not systematically aimed at transforming the market; such efforts might include advertising, outreach, and other ways of stimulating home buyer demand.

Recommendations for Future Evaluations

Again, insofar as market transformation is a program goal, market effects research should occur on a regular basis; otherwise, program planners cannot know if the goal is being achieved. Before this study, there had been no market effects research on IOU programs targeting the RNC market since 2000, giving little opportunity to provide feedback to program planners.

Related to the need for regular market effects evaluations, the protocols call for the collection of baseline and longitudinal indicators. This market effects research benefited from the collection of the RNC Baseline as part of the 2006-08 California RNC Program Impact Evaluation and previous baseline studies that allowed for the comparison of building practices and code compliance over time. Baseline studies should continue in the future every two or three years to allow continued examination of efficiency trends over time.

As IOU-sponsored training programs were consistently identified as being critical to the observed market effects, the CPUC should consider coordinating the evaluation of education and training programs to include elements of market effects evaluations to better understand what building techniques and technologies are being applied to non-program homes.

The evaluation team had some difficulty identifying and recruiting building industry experts for the Delphi panel. For future program cycles, the CPUC could identify and recruit building industry experts who could serve on a similar Delphi panel at the conclusion of the program cycle.

Panelists would be asked to follow the programs during the program cycle, paying particular attention to non-participant spillover.

Recommendations for Changes to the Market Effects Evaluation Protocol

The evaluation team suggests modifying the Market Effects Evaluation for estimating the net impacts of new construction programs. In the California residential new construction market, distinctive and continually changing state building codes, multiple and varied climates, and the prevalence of local market actors preclude a cross-sectional modeling approach for analyzing causation. New construction in California simply is not comparable enough to new construction in any other area—or even a combination of areas—to allow valid comparisons. In addition, the diversity and complexity of the end-uses and practices involved in new construction make a modeling approach problematic. This is in contrast to other types of markets that are relatively similar across areas, with relatively uniform technologies, in which quasi-experimental designs taking into account differences over time and across areas are more feasible. Hence, the Market Effects Evaluation Protocol could be modified to encourage a Delphi or expert panel approach, in which gross savings and penetration of technologies and practices are estimated and presented to panel members, who are then asked to attribute savings to energy efficiency programs and other factors. It is essential that there be at least two rounds of Delphi surveys, with the first round results summarized and presented in the second round survey so panel members can understand and learn from each other in developing the final attribution estimates.

Recommendations for Treatment of Non-Participant Spillover

A goal of this study was to "support the CPUC's strategic planning efforts by clarifying whether energy savings from non-participant spillover can be quantified with sufficient reliability to be treated as a resource and, potentially, afforded shareholder incentive treatment" (CPUC 2007).

To answer the broader question: "Yes, we could identify and quantify with reasonable reliability market effects in this market." However, an important factor bearing on the reliability of the non-participant spillover savings estimate is determining the extent to which the savings were counted in other utility program evaluations, in particular, the Codes and Standards Program evaluation, in order to avoid double-counting of savings. The evaluation team found that all of the energy savings from non-participant spillover had been counted in the Codes and Standards evaluation.

The Codes and Standards Program evaluation captured all spillover savings in non-program (baseline) homes (i.e., improved compliance with code and facilitating the construction of above-code homes) from 2006-2008 utility programs, because such savings contribute to compliance with Title 24 (Cadmus et al. 2010). The RNC market effects (ME) study measured savings in homes exceeding the 2005 code relative to homes just meeting the code, and in homes just meeting the 2005 code relative to homes not meeting the code. The Codes and Standards (C & S) Program evaluation measured savings in all homes using the 2001 code as baseline. Therefore, all gross savings in the RNC ME study are a strict subset of and should have been counted in the C & S Program evaluation's gross standard savings (see Appendix F of KEMA et al. 2010b for more details).

It is important to point out that while it is likely that there is overlap in savings with the C & S Programs, the market effects research helps program administrators understand how and why the savings were achieved and where they should consider concentrating their efforts in future program cycles. While the gross savings overlap, the RNC ME study was important because it provides an example of how market effects could be measured and how the scoping study, logic model and the results of a market effects pilot evaluation could identify the mechanisms behind program effects. The purpose of this and the other market effects studies was to test the reliability of quantifying market effects. The finding that the spillover savings overlap with savings counted in the Codes and

Standards evaluation provides valuable corroboration of the scope and size of the impact of the IOUs' programs on non-participants. Also, unlike the C &S evaluation, the RNC ME study identifies the *mechanisms* by which non-participant spillover is achieved and the relative importance of these mechanisms.

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