Getting MIF'ed: Accounting for Market Effects in Residential New Construction Programs

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ABSTRACT

Often energy efficiency program elements are targeted at knowledge creation and delivery infrastructure development that can generate market effects beyond the program's direct impacts. However, the lack of clear baselines and methods to assess progress toward market transformation make it difficult to effectively claim indirect market influence savings from these activities. This paper presents the story of Arizona Public Services' (APS) examination of its residential new construction program's broader market influence, and its innovative evaluation efforts to quantify these broader savings from the program's influence over its fourteen-year history.

While not new evaluation methods, they have been used in an innovative way to enable a holistic look at the program over time. We used historical tracing of 14 years of regulatory documents to create timelines of the program presence and activities. We created an influence diagram of all market influences on specific building practices. Using those data, we performed two in-person Delphi studies with market experts to estimate both the percent of homes built in 2010 using specific building practices as well as the counterfactual from the experts that showed the percent of homes that would have been built with the practices in the absence of the utility program. The Delphi outputs were used to develop inputs for an engineering simulation model to calculate energy savings per home. After combining the engineering results with market information (i.e., homes built), the final output is the Market Influence Factor (MIF), the new net-to-gross ratio, of 1.39.

Introduction

Energy efficiency (EE) programs and their related savings have become more central to a utility's operations in recent years. This increased importance primarily reflects regulatory priorities, as commissions have set increasingly stringent EE savings goals, decoupled revenues and production, established related penalty and reward structures, and increased uncertainty about optimal power plant additions. Consequently, comprehensive evaluations of utility EE programs have increased in importance for utility management.

Arizona Public Service (APS) operates in an environment that is emblematic of this type of situation. In the energy efficiency realm, the utility faces a multitude of challenges: an Energy Efficiency Standard (EES) requiring a 22% savings goal by 2020, a future decoupling proceeding, and a tiered incentive based on the EE percent of MWhs saved vs. the MWh goal established in the EES. At the same time, in an avoided cost white paper that was submitted to ACC staff, APS in collaboration with other utilities and interested parties in the state proposed that Arizona utilities receive credit for market effects from the utility's EE programs[1]. These facts have encouraged APS EE management to take a harder look at how their programs have generated savings more broadly across their markets. In

[1]The ACC is considering the white paper proposal at this point.

turn, the utility's evaluation contractor was directed to assess APS' broader influence in its energy efficiency markets.

The original white paper hypothesized three different components that were part of any long term effects: market development, market maintenance and market transformation. Together called the Market Influence Factors (MIF), these concepts were the guiding principles in the research effort undertaken to assess possible energy savings from long term utility intervention in the market.

APS has a long history of funding energy efficiency programs, although its approach has changed over time. In the early nineties, like many other utilities, APS ran resource acquisition programs. In the mid-nineties, however, the Arizona Corporation Commission voted to deregulate the power market, and APS discontinued the existing EE programs, replacing them with a few market transformation programs with relatively limited funding. Then, in the mid 2000's, APS discontinued its market transformation programs and again implemented a portfolio of resource-acquisition based EE programs.

This story begins in 2010, when APS asked its evaluation team to take a harder look at how all of APS' EE programs may have affected their broader markets, including the residential new construction (RNC) market. The evaluation team chose the RNC program to be one of the first programs the team tackled in their market effects research because APS had a long history – at least fourteen years – of intervening in the market and taking actions to increase energy efficient building practices. It appeared that if market effects could be found at all, this program would show the strongest evidence.

APS now has an RNC program that, like most utility RNC programs, takes advantage of the national ENERGY STAR® brand name, and promotes the EPA ENERGY STAR label to prospective homebuyers. In addition, *beginning in the mid-1990's*, APS' program included the following key program elements:

- Shape and subsidize training to apply building science principles
- Provide energy efficiency education for prospective homebuyers
- Emphasize the whole building approach to improving energy-efficiency
- Include field testing of homes to ensure performance

APS' program focus beginning in 1997 on applying building science principles in training **and** field testing of homes is a particularly important characteristic of this program and a critical driver behind how the evaluators chose to evaluate the program. APS program management was convinced that contractors and subcontractors in the APS residential new construction market were applying key building science construction practices - taught over the years to participating contractors and their subcontractors - in non-participating homes as well as participating homes. The evaluation team tested this theory by focusing on thirteen specific building practices as opposed to an alternative approach of identifying "ENERGY STAR-like" homes that were built outside the program. The practices chosen reflected where the training had focused over time and ranged from installation of insulation to efficient framing.

Nine Steps in the APS RNC Market Effects Research

The evaluation team ultimately developed an evaluation approach that took advantage of unique characteristics of APS' situation and market and most effectively and credibly quantified APS' RNC program's market effects. The market effects research approach comprised ten steps in total as detailed in the following:

- RNC market effects study benchmarking
- Research scoping: markets and practices
- RNC analytic approach
- Logic model-based market effects data matrix development
- Historical tracing
- Market influence diagram development
- Expert Delphi panel #1
- APS program management staff review
- Expert Delphi panel #2
- Engineering modeling of market findings

Each of the steps is briefly described in the following paragraphs and followed by a discussion of the final results.

RNC Market Effects Study Benchmarking

The Navigant team's initial step was to review publicly available RNC market effects research to identify typical research methods used and levels of market effects found. The team identified seven relevant studies, only two of which quantified indirect program savings (CPUC PH2 2010; NYSERDA 2006). The other studies typically focused on structural or attitude changes in the markets due to the programs, but did not quantify related indirect program kWh or kW savings.

The team's research determined that methodologies commonly used to quantify energy savings from market effects are two-fold in this market: self-report and expert panel/Delphi. Both RNC market effects studies that measured energy savings reported significant residential new construction market influence by the utility. Only one of the two studies, however, measured market effects relative to gross program savings (NYSERDA 2006).

Research Scoping: Market and Practices

In order to focus the market effects research, the evaluation team elected to focus on 2010 production home building in APS' metro Phoenix service territory since the Phoenix metro area represents the vast majority of new home construction activity in APS' service area. This enabled the team to effectively capture the majority of the program's market effects while minimizing the research budget.

In addition to developing a particular market focus, the evaluation team selected thirteen construction practices to focus on. They included:

- Windows (prevalence of four types)
- Framing: Attic: ceiling interface
- Framing: Capping chases
- Framing: Floors - conditioned to unconditioned space
- Framing: Backing knee walls
- Framing: Double walls
- Insulation: Full contact with air barrier
- Insulation in contact with sub-floor
- Insulation: Air sealing all penetrations
- HVAC: Proper sizing

- HVAC: Duct Leakage/sealing
- HVAC: Pressure balancing
- HVAC: Refrigerant charge and air flow

The evaluation team chose to focus on these practices for two reasons: (1) the selected practices are notable contributors to energy efficiency in new home construction, and (2) APS' program was expected to have either a notable *or* a minimal impact on builders' and subcontractors' adoption of those practices. Practices where APS' impact was expected to be minimal were used to confirm the research processes operated effectively.

The team's focus on a range construction practices, however, created an evaluation challenge: how to measure the change in so many practices over the fourteen year period and to estimate what the market would have looked like without APS' intervention.

RNC Analytic Approach

Early in the RNC MIF research, the team had extensive discussions regarding an appropriate analytic model for RNC market effects and how those effects related to program savings as well as free-ridership (FR) and spillover (SO). The discussion starting point was the concept detailed in the Avoided Cost White Paper which posited a MIF which was additive to both FR and SO, and which had three components: market development, market maintenance and market transformation. In order to quantify market effects, several different scenarios were defined including performance trends over time for participating homes, non-participating homes and a theoretical baseline condition representing estimated performance had the APS RNC program never intervened in the market. **Figure 1** below presents the team's initial conceptual depiction of performance trajectories over time for these different market components.

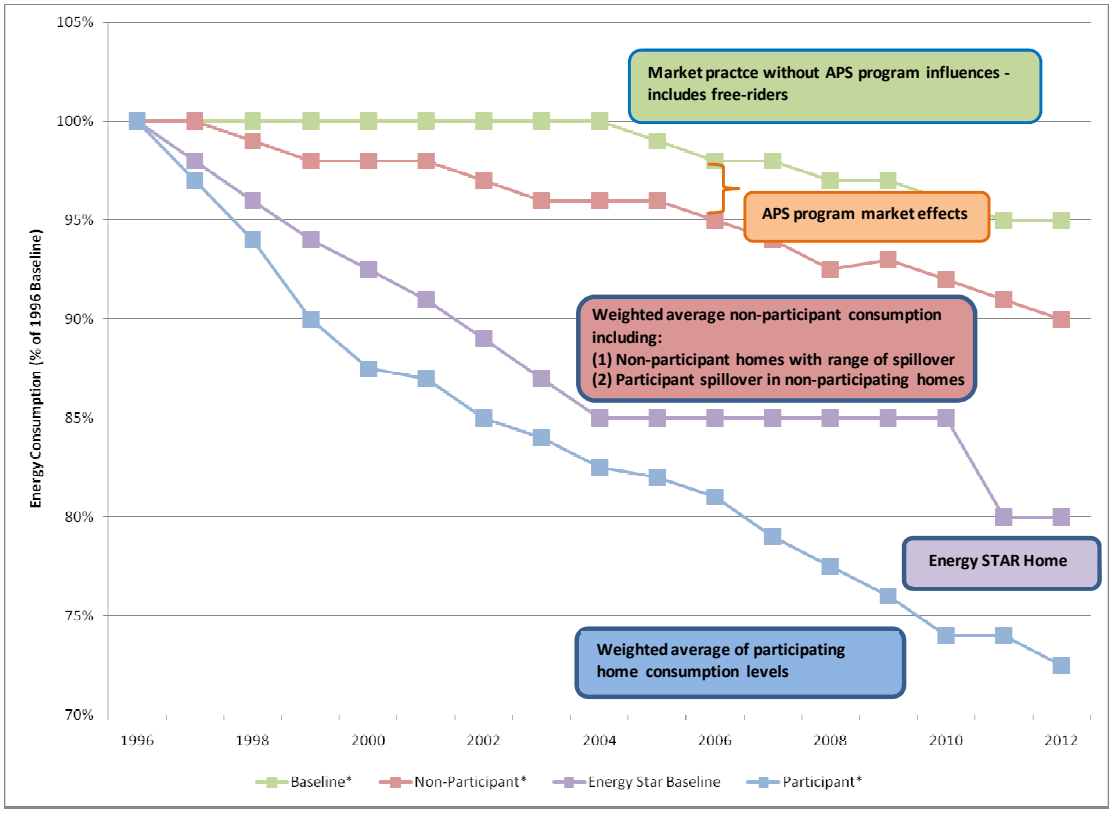

Figure 1. Market Effects Graphic Representation Relative to Program Savings

Logic Model-Based Market Effects Data Matrix Development

The evaluation team used the APS RNC program logic model to identify measures and metrics in the marketplace, whether convertible to kWh or not, that would signal the transformation of the RNC market. This framework helps identify potential indirect program market influences and data to demonstrate the effect's presence and magnitude. Key components of the RNC program logic model – and APS program objectives - include the following:

- Increased interest in APS training in targeted practices
- Increased builder and subcontractor EE building practices knowledge
- Builder and subcontractors adopt leading edge practices
- Increased above standard/code practices
- More efficient design
- Improved ENERGY STAR compliance
- Increased builder home EE marketing
- Increased home buyer awareness of EE benefits and costs
- Increased consumer demand and willingness to pay
- Increased market penetration of builder EE homes
- Comparable ENERGY STAR home penetration rates in other states
- Reduced energy use and demand

The Navigant team translated those model elements into a matrix of related metrics, conducted research on those metrics and quantified them where possible in the historic tracing step detailed below.

Historical Tracing

The evaluation team developed important background to determining APS' market influence through the historical tracing method. Historical tracing involves using secondary source and market actor recollections to trace the development of the market and key market practices. Secondary source data can also be used to suggest appropriate levels of savings attribution to the utility.

The evaluation team benefited in the step from three factors that may be unique to APS:

1. APS had filed and retained a complete set of semi-annual regulatory filings regarding their EE program performance and spending, including detailed performance metrics beginning in 1997. The reports provided significant useful data for most six month periods since 1997, including:
   - Expenditures
   - Number of participating builders
   - Number of training sessions held and attendees
   - Training session types
   - Advertising campaigns and marketing literature
   - Partnerships and joint working relationships
   - These data served as valuable references to recreate what occurred over time.
2. Current APS' RNC program management was in place at the time the market transformation program was first designed and implemented. They provided critical background, perspective and contacts as well as research materials that were essential in conducting the research and telling APS' story.
3. Two industry-leading studies detailing the targeted practices at different points in time provided selected baseline information throughout the program period. One key study (Proctor 1996) focused on the HVAC installations in RNC, including all of the practices that the evaluation team assessed. This study specifically assessed HVAC equipment sizing, refrigerant charge, air flow, and duct leakage, as well as the effect of these measures on as-installed performance of HVAC systems. This study in particular provided a critical touch point for the team's market effects research. Additionally, a 2005 U.S. EPA study assessing 1999 and 2001 performance and practices in non-participating program homes (U.S. EPA 2005) reviewed duct leakage, sizing, windows, and HVAC equipment SEER values, providing an additional data point demonstrating the impact of the APS program at that point in time.

Key findings from the historical tracing effort were summarized in several timelines and provided to the expert panel for discussion during the Delphi. One example, shown in **Figure 2** below, details the range of residential new construction programs in the Metro Phoenix market over this time period. Other timelines summarized APS' activity in the market and the evolution of key construction practices over the 1996 to 2010 timeframe.

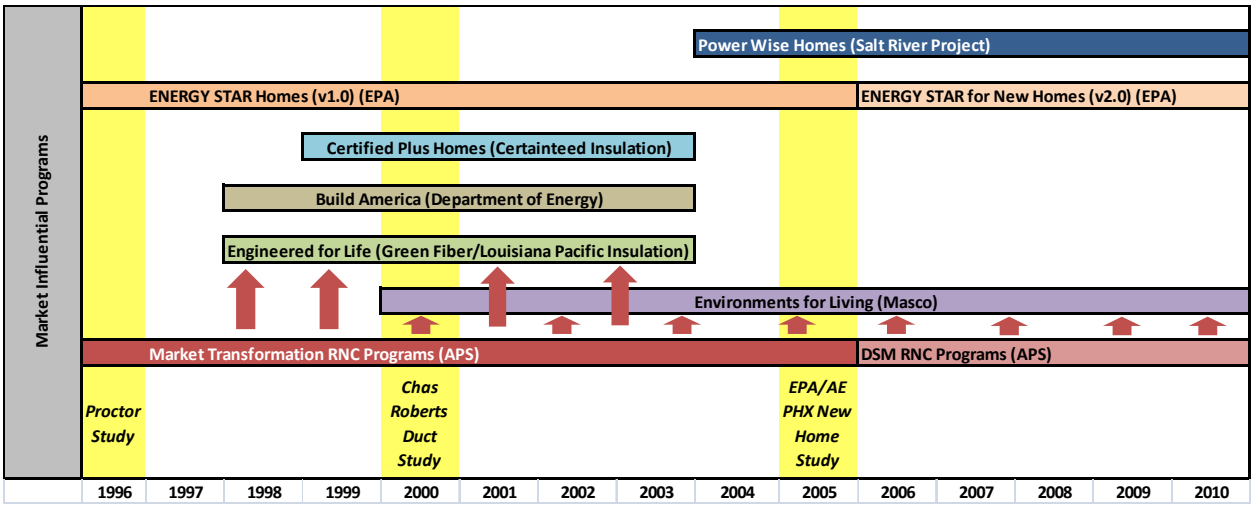

Figure 2. RNC Key Programs and Studies in the Metro Phoenix Market over Time

Market Influence Diagram Development

A critical component of utility program market influence determination is the accurate identification of other influences in the market and appropriate attribution of the various market impacts to the full range of actors in the market. The evaluation team identified and ranked the influence level of the many Arizona RNC market actors below in **Figure 3**. The market influence diagram was a key focus of much discussion during the first expert panel Delphi session to assure that participants had fully thought through the full range of market influences over this period.

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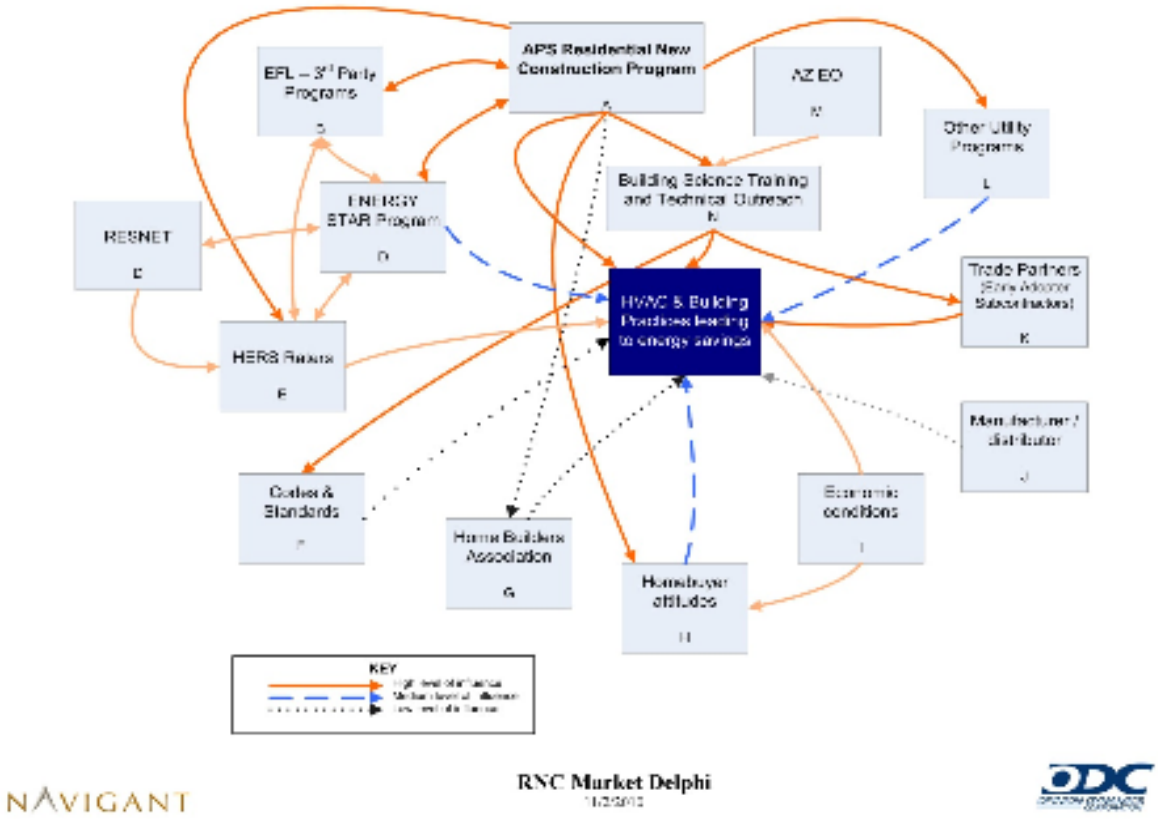

Figure 3. APS Draft Market Influence Diagram

Expert Panel Delphi Session #1

The metro Phoenix RNC market was highly concentrated—that is, dominated by relatively few builders, HVAC contractors and insulation contractors over this period. Specifically, the top three builders account for about 65% of new production homes, while three insulation contractors account for 80% of new home construction and one HVAC contractor accounts for 70% of new home installations. These market characteristics are important to the team's evaluation approach as they allowed us to engage with relatively few people and still cover a large swath of the market.

The evaluation team used the Delphi method to arrive at the key primary data used in the calculation of the MIF. The Delphi method has been used in evaluation for several decades (Codes 2010; Energy Center of Wisconsin 2006; Mosenthal 2000; Ruegg 2003.) It is a systematic, interactive method which relies on a panel of independent experts. The carefully selected experts answer questionnaires in two or more rounds. After each round, a facilitator provides an anonymous summary of the experts' answers from the previous round as well as the reasons they provided for their judgments. Participants are encouraged to revise their earlier answers in light of the replies of other members of the group. It is believed that during this process the range of the answers will decrease and the group will converge towards the "correct" answer. Finally, the facilitator stops the process after a pre-defined stop criterion (e.g. number of rounds, achievement of consensus, and stability of results) and the mean or median scores of the final rounds determine the results.

The APS evaluation team modified this approach slightly as the facilitator provided an anonymous summary, but not the reasons for the values obtained. Instead, the panel members were encouraged to discuss why they thought that some of the values seen were present. No specific members were targeted or asked directly what they had answered. As such, anonymity was maintained.

The Navigant evaluation team convened a panel of eight long-time market actors and observers to provide expert input to the APS market influence analysis. The experts had 15-40 years in the residential new construction industry, and all had a long history with involvement in the APS RNC program. Six worked directly in APS' service territory while two currently reside outside of Phoenix, but were familiar with the residential new construction market in Phoenix. The experts represent all aspects of building new homes: builders, contractors (e.g., HVAC, framing, and insulation), home energy raters, and training of contractors. The panel convened for a three-hour meeting.

The expert panel's primary purpose was to provide an unbiased assessment of two key analytic elements: first, if there had been no APS involvement in the market (no programs, training, etc.), how would specific builder practices be different; and second, what percentages of participating and non-participating builders used each energy efficient practice in new production home construction? The combination of those inputs provided a solid initial basis to estimate APS' market influence and related energy savings.

APS Program Management Staff Review

The results from the expert panel Delphi session were subsequently discussed with the three APS program staff members who had been responsible for designing and fielding the program since 1997. The staff talked through the practices that their program emphasized, what they had seen in program and non-program houses, their discussions with builders and why there is more or less spillover in some practices (usually cost and implementation-ease driven) and other influences that were present in the market, such as ENERGY STAR® Homes, Environments for Living and the leading ResHVAC contractor, an early convert who drove certain practices on his own. As a result of these conversations, the internal team concluded that, while many of the expert panel's conclusions were quite reasonable, conclusions for several practices were not consistent either with the others or with the known ease and economics of their implementation.

Expert Delphi Panel #2

The evaluation team then convened a separate Delphi panel comprising fourteen APS metro Phoenix HERS raters to obtain input on those few construction practices for which the original panel's results were counterintuitive. Neither the expert panel's nor the APS Program team's conclusions were presented to the second expert panel so that the group could come to an unbiased opinion. The evaluation team presented the practice assessment background to the HERS rater panel, and then allowed them to make their own assessments about practice penetration under the three scenarios. The team presented the results of the first round of results for the three practices under the same three scenarios as for the initial Expert Panel, and then offered the panelists the opportunity to discuss and review their feedback. About one-half of the panelists adjusted their initial feedback based on the group's discussions.

Engineering Modeling of Market Findings

Once the Delphi panels had estimated changes in practices due to the program, the evaluation team derived both direct program savings and indirect savings from building energy models representing Participant, Non-Participant, and the hypothetical "Baseline" homes. The Navigant team constructed participant models from building characteristics sourced directly from APS program tracking data and calibrated to participant billing data and Phoenix weather data from 2009. The final expert panel results in Table 1 are used to determine appropriate "adjustment factors" for estimating model inputs for both Non-Participant and "Baseline" homes**. Table 1** displays the model input parameters affected by each building practice discussed by the expert panel.

Table 1: Building Practices Linked to Model Input Parameters

	Building Practice	Model Input Parameters
Windows	Single Pane	• Shading Coefficient • Glass Conductance • Visible Transmittance • Outside Emissivity • Frame U-Value • Frame Conductance
	Metal Non-Low E Duel Pane	
	Metal Dual Pane Low E	
	Vinyl Dual Pane Low E	
Framing	Attic/Ceiling Interface	• Ceiling Insulation R-Value
	Capping Chases	• Ceiling Insulation R-Value • Infiltration (ACH)
	Floors (conditioned to unconditioned space)	• Floor Insulation R-Value
	Backing Knee Walls	• Ceiling Insulation R-Value • Infiltration (ACH)
	Double Walls	• Wall Insulation R-Value
Insulation	Full Contact w/Air Barrier	• Wall Insulation R-Value
	Insulation in contact w/subfloor	• Floor Insulation R-Value
	Air Sealing all Penetrations	• Ceiling Floor, & Wall Insulation R-Value • Infiltration (ACH)
HVAC	Proper Sizing	• Oversize Factor/Sizing Ratio
	Duct Leakage/Sealing	• Duct Leakage Ratio (%)
	Pressure Balancing	• Duct Leakage Ratio (%) • Infiltration (ACH)
	Proper RC&AF	• HVAC Efficiency (SEER)

The team then applied the adjustment factors from the Delphi results to each participant building characteristic to determine the model input parameters for the Non-Participant and Baseline models.

The energy consumption and demand for Participant, Non-participant, and Baseline homes were aligned with APS Program Tracking data and adjusted for size of home, HVAC type, number of stories, and HERS score. The following were calculated for each program home:

- Gross Program Savings – the difference between a Participant and Non-participant home
- Market Effects Savings – the difference between a Non-participant and Baseline home

As shown in **Table 2** below, the calculation produced 4,880 MWh in total gross savings across the ENERGY STAR® and ENERGY STAR® PLUS homes. The average market effects savings per home is estimated at 566 kWh, calculated by dividing the total Market Effects Savings for program homes by the number of homes in the program. This value is applicable to the 1,679 program homes as well as the 1,722 non-program homes constructed in metro Phoenix in 2010, for a total 1,927 MWh in market effects energy savings. Dividing the market effects savings by the gross program savings yields an MIF of 39%, or a NTGR of 1.39.

Table 2: Market Effects Savings Derivation

Category	Measure	Total
Gross Energy Savings (kWh)	Gross Energy Savings (kWh)	4,879,597
	Number of Program Homes	1,679
	Gross Energy Savings per Home (kWh/home)	2,906
Market Effects (kWh)	Market Effects Savings (kWh)	951,140
	Market Effects Savings per Home (kWh/home)	566
	Number of Non-Program Homes	1,722
	Market Effects Savings for Non-Program Homes (kWh)	975,499
	Total Market Effect Savings (kWh)	1,926,639
	Market Influence Factor	39%

Compared to the APS value, Summit Blue (NYSERDA 2006) reported 44% spillover for NYSERDA's RNC program and a net to gross ratio (NTGR) of 1.17. Another recently completed study of California's RNC market effects study similarly reported significant impact of utility programs on new construction code compliance (CPUC PH2 2010)**,** but due to complete overlap with savings from the codes and compliance program, did not identify any incremental savings.

Conclusions

APS and its evaluation contractor worked over the last nine months to measure the broader market effects of its RNC program and were well rewarded for their efforts. The team overcame the challenges of limited baseline data and no valid no-program comparison area and implemented a research methodology that yielded broadly consistent results. The team learned a lot about the challenges of translating building practices into whole house energy consumption. The engineering modeling team was challenged to think through the range of impacts of each practice on the key drivers

of energy consumption. And perhaps most exciting, the methodologies yielded results that were intuitively satisfying to participants: they showed market effects from APS' market interventions where anticipated and in the different orders of magnitude expected, with no effects where none were hypothesized.

We recommend this evaluation approach where the historical data is readily available, as it was a key component in walking the Delphi participants through time and helping them understand the myriad of influences on the market and how APS intervened over time. The long term personal relationships of the APS staff with many of the key market actors played a crucial role in assuring that our Delphi included the experts in the field. This type of champion within the utility is critical to persuading busy professionals to attend a Delphi meeting.

Acknowledgements

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