SEER is Overrated: Capturing Savings from Residential HVAC Market Effects

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ABSTRACT

Utility residential HVAC programs in cooling-dominant climates have long recognized the potential for large savings through promoting energy efficient contractor practices and for offering rebates on efficient equipment. Beginning in the mid 1990's, Arizona Public Service (APS) undertook a concerted effort to capture that savings potential. This effort began with a market transformation program and later transitioned to the more traditional incentive-based equipment program combined with proper sizing, refrigerant charge and airflow correction (RCA), duct/plenum sealing in conjunction with an install, and whole system duct test and repair (DTR). With Arizona's increasingly stringent energy savings goals, APS decided to measure the market effects from its long involvement in the local HVAC industry. The work presented here quantifies these "market effect" savings through inclusion of a market influence factor (MIF), additive to free-ridership (FR) and spill-over (SO) within the standard net-to-gross (NTG) equation.

This paper presents the steps, from conception to completion, in deriving these market-effect related savings. First, the project team historically traced program milestones and identified market influences. The resulting timelines and influence diagrams were then presented to a panel of local HVAC experts, who estimated the frequency of HVAC efficiency practices occurring inside and outside the APS program, as well as in the absence of the program. Expert panel results were applied to program savings estimates to calculate NTG ratios for each practice, inclusive of market effects. Resulting net-to-gross ratios for DTR and quality installation of new equipment (sizing and RCA) practices are estimated at 103% and 107%, confirming that total market effect savings were positive.

Introduction and Program Background

APS faces increasingly stringent energy efficiency goals over the next decade and is consequently striving to maximize program kilowatt-hour (kWh) savings and receive credit from the Arizona Corporation Commission (ACC) for said savings. APS implemented a ResHVAC market transformation program beginning in 1997, and the company's staff believes it has, over the course of the subsequent fourteen-year period, had considerable impact on its ResHVAC market that is not fully captured in reported program savings to date. APS' program specifically targeted the equipment recommendation, sizing, installation and duct sealing practices of the residential ResHVAC home contractors. The research presented in this paper was designed to identify APS' impact on these aspects of the ResHVAC market in its territory and to quantify any related savings not historically captured in program savings calculations. The research included the following eight key activities:

1. Benchmarking of ResHVAC market effects research nationwide,
2. Designing a logic-model market effects metric matrix,
3. Developing a ResHVAC market effects calculation straw man,
4. Documenting key ResHVAC market influences,
5. Historical tracing of ResHVAC market and APS program development,
6. Conducting an expert panel Delphi session and aggregating the results,
7. Findings triangulation, and
8. Savings quantification through engineering modeling.

This market effects research effort found considerable electricity savings attributable to APS' influence on their ResHVAC market in the Phoenix metro area from 1997 through 2010. Inclusive of free-ridership and broader market effects, net-to-gross ratios[1] (NTGR) for individual program measures are 103% for duct leakage testing and repair and 107% for quality installation.

Market Effects Benchmarking

The team initially reviewed publicly available market effects research in mid-2010 to determine approaches most commonly used in such research and typical levels of identified market effects. The team identified only one market study focusing on installation practices and measured impacts conducted in New Jersey in 2006. Even in the case of this study, however, the impact was quantified in terms of market penetration, and not the related savings. Other identified studies focused on equipment installation, but did not address the related impacts. The Team's relevant findings are briefly summarized in Table 1.

The identified New Jersey study assessed the market impact of the Qualified Installation (QI) program primarily by using the self-report method, which involves conducting in-depth interviews with key market actors and participants. The study identified a 9% increase in the use of the QI practices across the market from the baseline 2001 level (SBC 2006). The study did not, however, quantify the related savings, nor did it break out the market impact attributable to the utility program, either direct (program reported) or indirect.

Table 1. Summary of Residential HVAC Market Effects Studies Measured Impacts

Program	Market Effects
NJ 2006	9% increase in market penetration of QI practices from 2001 baseline level. Includes program effects.

Logic-Model Based Market Effects Data Matrix

Energy efficiency (EE) program logic models provide a framework to identify potential indirect program market influences and point to data that demonstrate their presence and magnitude. The team identified several key components of the ResHVAC program logic model, including APS program objectives. The team researched and quantified these factors, listed

[1] The methodology employed calculates a total net-to-gross ratio inclusive of market effects and free-ridership, as opposed to calculating each factor individually.

below, as part of the historic tracing process. Ultimately, these topics became the foundation of discussion points for the Delphi panel of local HVAC experts.

- More efficient installation practices and duct sealing methods
- Increased interest in APS training in targeted practices
- Subcontractors adopt leading edge practices
- Increased subcontractor knowledge of EE practices
- Increased home owner awareness of EE benefits and costs
- Increased subcontractor EE marketing
- Increased consumer demand and willingness to pay
- Market penetration of quality installation and duct sealing practices
- Reduced energy use and demand

Residential HVAC Analytic Construct

An early effort in the ResHVAC market influence research was developing an appropriate analytic model for ResHVAC market effects. The analytic construct was initially grounded in the concept detailed in a white paper submitted to the ACC (UNS & APS 2010) which posited a market influence factor (MIF) additive to both free-ridership (FR) and spillover (SO), and composed of three components: market development, market maintenance and market transformation. In practice, the market effect research methodology employed by the Team allowed for qualitative assessments of FR, SO, and the three MIF components, but not for a separate quantification of each. Rather, the methodology quantifies these factors in a single NTG ratio. The theoretical construct for ResHVAC market effects is depicted in **Error! Reference source not found.**. Each line represents typical HVAC consumption over time, as a percent of an established 1996 baseline, for program installs (blue), non-program installs (red), and installs in absence of APS influence (green). Direct program savings are represented as the difference between the red and blue lines, while non-participant spillover is the difference between the red and green lines. The sum of the differences represents overall market effects.

The MIF construct required that the Team and APS identify the concrete energy saving actions to be measured. While other industry studies focused primarily on installed equipment SEER and not on how the equipment was installed, the team determined that measurement must focus on the key energy efficient practices promoted by APS, displayed in **Error! Reference source not found.**. Quality installation (QI) and duct test and repair (DTR) are independently quantifiable, with QI composed of the four practices detailed in Table 2.

Figure 1. Residential HVAC Market Effects Concept

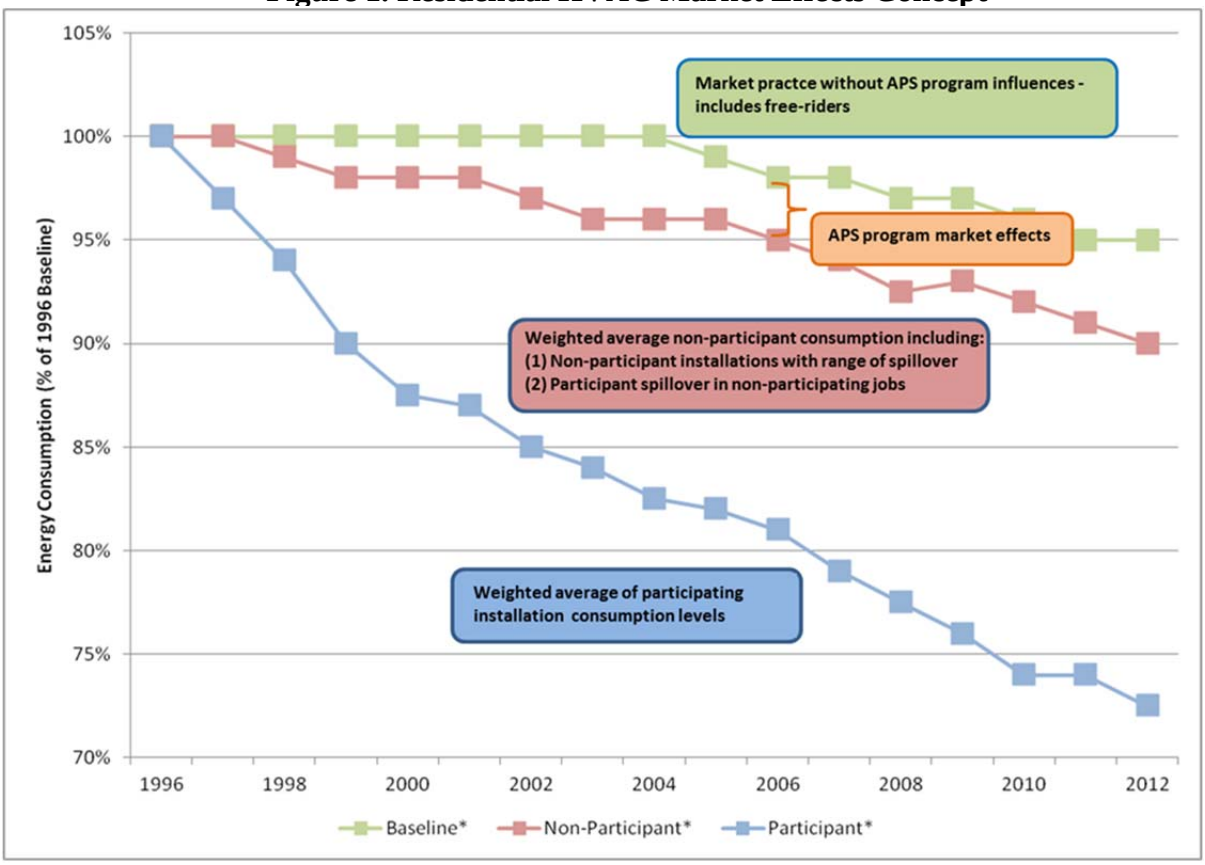


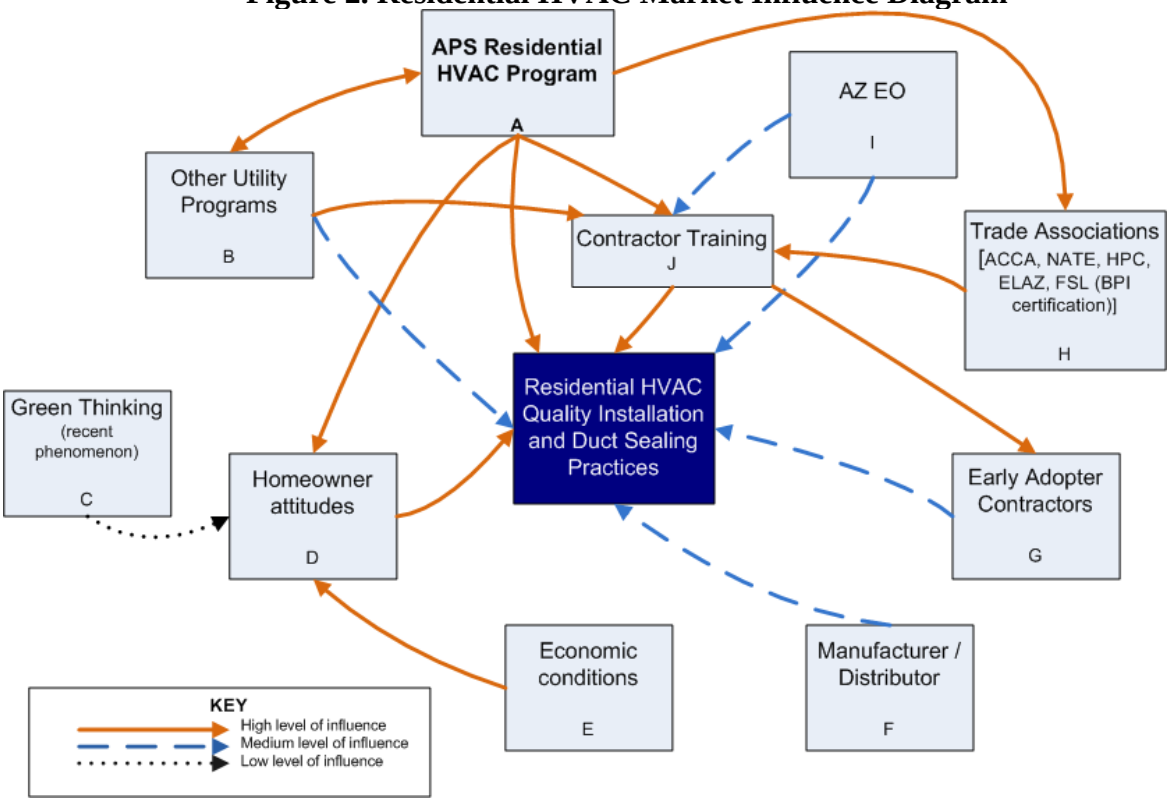
Table 2. Energy Efficient Practices and Related APS Program Measures

APS Residential HVAC Measure	Energy Efficient Practice
Duct Leakage Testing and Repair (DTR)	Duct sealing of entire distribution system
Quality Installation (QI)	Proper sizing
	Refrigerant charge correction
	Airflow correction
	Duct/Plenum sealing during install

Market Influence Diagram

A critical component of determining utility program market influence is the accurate identification of other influences in the market. This is a necessary step to properly attribute market impacts to the full range of market actors. The market influence diagram shown in Figure 2 is rooted in data collected from market participants asked to identify and rank the influence level of the many Arizona ResHVAC market actors. As shown, the APS program is viewed as having a high-level of influence on contractors, home owners, and trade associations - directly impacting the presence of energy efficient HVAC practices, This diagram was discussed in detail in another research step, the Delphi panels, to help ground the panelists in the range of actors influencing the ResHVAC market and to enable the panelists to more accurately assess APS' contribution to the evolution of practices in that market.

Figure 2. Residential HVAC Market Influence Diagram



Historical Tracing

In order to develop an understanding of APS' ResHVAC market development, the Team compiled background information relevant to ResHVAC market evolution and APS' market influence through the historical tracing method. Historical tracing involves using secondary source data 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.

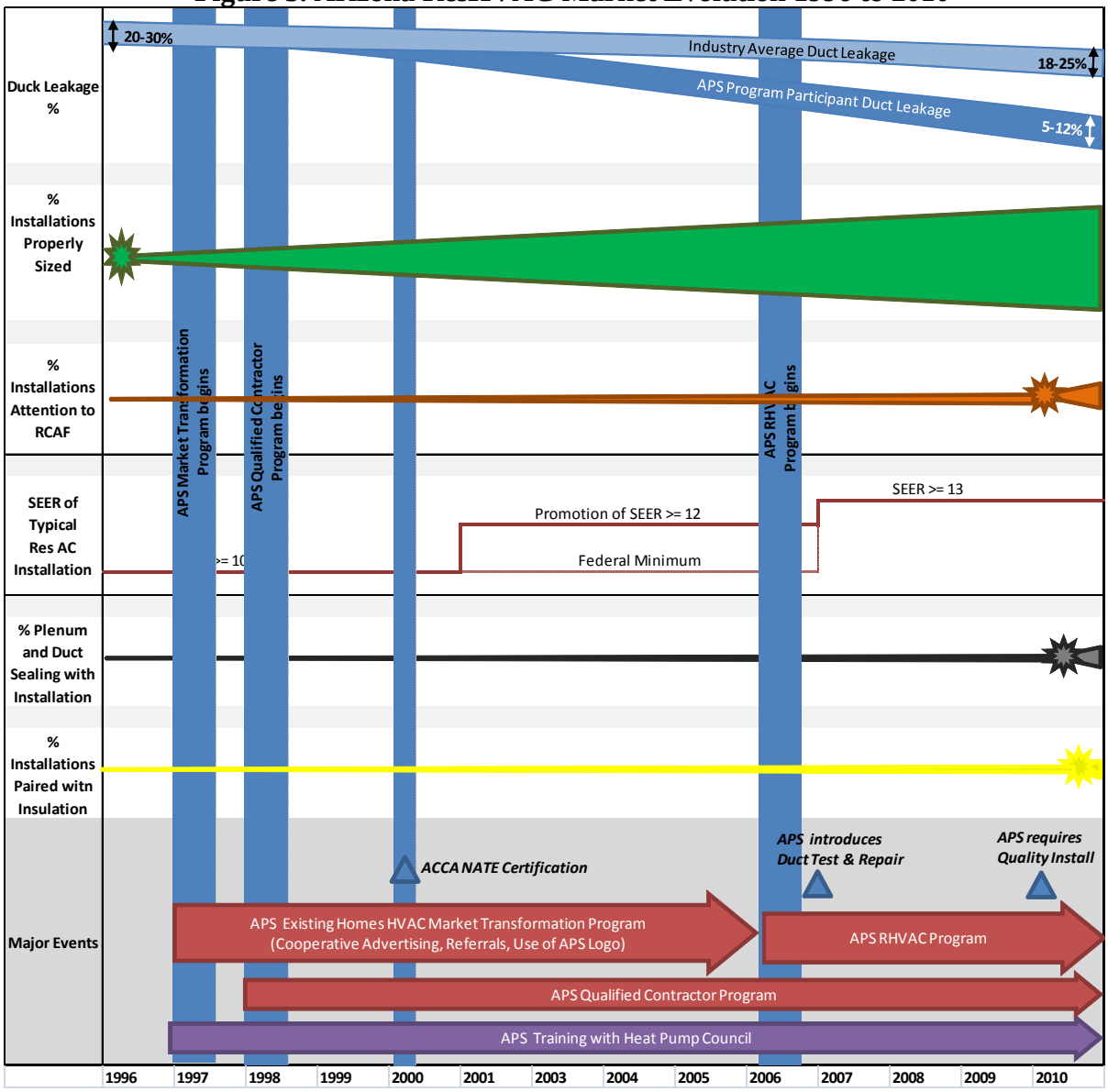
Key findings from the historical tracing effort were summarized in several timelines and provided to the expert panel discussed in the next section of this paper. One key timeline (Figure 3) presents the high-level market evolution of equipment SEER levels, QI practices, duct leakage, and the addition of insulation to the HVAC installation job[2]. Specifically, this timeline aligns APS activities with direct changes in these practices. Tracing of key APS interventions from 1997 to the present also focused on the following:

- Training, specifically number of participants and training type
- Number of qualified contractors
- APS program spending

[2] Figure 3 was designed to depict conceptually, not quantify, the evolution of the targeted HVAC practices. In a separate exercise within the historic tracing effort, the team quantified performance characteristics where possible, including duct leakage identified in field studies and SEER values based on program marketing materials.

- APS advertising, including type; promotional literature
- APS partnerships with thought leaders and industry

Figure 3. Arizona ResHVAC Market Evolution 1996 to 2010



Expert Panel Delphi Session

The Team convened a panel of eight long-time market actors and observers to provide expert input to the APS market influence analysis. The panel provided estimates in two areas: market size and the prevalence of the practices promoted by the APS program. In regard to practices on the job, the team asked the panel to estimate the percentage of jobs using energy efficient practices by qualified and non-qualified contractors within and outside of the APS program. The expert panel was then asked to estimate the likely prevalence of energy efficient installation practices in the absence of any APS involvement (the counterfactual). The

combination of these inputs provided a solid initial basis to estimate APS' market influence and related energy savings.

The expert panel Delphi session had several important features designed to elicit the most informed opinions possible from the panel participants:

- The Team's draft Market Influence Diagram (See Figure 2) was reviewed by the participants and modified to reflect their opinions, thus helping them bring to mind all the various influences in the existing home HVAC market.
- Timelines were introduced detailing key studies measuring HVAC installation practices as well as the history of other ResHVAC market developments (Figure 3).
- Finally, the Team provided details from Semi-Annual Reports submitted by APS to the Arizona Corporation Commission (APS 1997–2010) in timeline form (as described in the historic tracing step above) to the panel regarding program activities beginning in 1997.

The panel discussed and modified the timelines and then walked through two rounds of estimating the extent of each practice with and without APS involvement. Results were posted after the first round and different views were discussed before the second round of expert opinions were collected.

Findings Triangulation

The expert panel findings, although a firm starting point, could not be left to stand alone for a number of reasons. Some panelists responded only to selected scenarios as they did not feel knowledgeable enough to respond to all. Others were quite knowledgeable about some practices and not others. Consequently, the Team leveraged additional information sources and combined results to formulate the most likely set of findings.

The Team discussed the results from the expert panel session with APS program staff involved in the design and implementation of the program since 1997. The staff discussed four additional matters that bear on the ResHVAC market evolution and can be used to test the validity of the panels' conclusions. The four discussion areas included: a) practices the program emphasized, b) observations from recent field research assessing both qualified contractor and non-qualified contractor installations, c) reasons for more or less spillover in some practices (usually cost and ease driven); and d) other influences present in the market[3]. The internal team concluded that the expert panel's conclusions were consistent with these additional factors and therefore quite reasonable.

Table 3 displays the triangulated results of the Delphi panel. Duct test and repair numbers represent the number of jobs by each contractor/job type that performs appropriate duct sealing. The percentages for the remaining practices detailed in Table 3 represent the fraction of jobs done by each group that employ energy saving techniques.

[3] Such as the leading ResHVAC contractor, an early convert who drove certain practices on his own.

Table 3. Triangulated Market Research Results

	Duct Test and Repair	Quality Installation (% of Jobs)			
	(# of Jobs)	Sizing	Refrigerant Charge	Airflow	Duct Sealing
Qualified Contractor (In-Program)	2,009	64%	66%	68%	78%
Qualified Contractor (Outside-Program)	46	29%	54%	43%	55%
Non-Qualified Contractor	20	6%	21%	22%	26%
Baseline (Without APS)	14	5%	14%	17%	21%

The percentages for QI practices listed in Table 3 were then translated to actual numbers of jobs as shown in Table 4[4]. From this basis, the Team estimated market effects by subtracting the baseline number of jobs from those jobs occurring outside the program (i.e. Qualified Contractors (Outside-Program) and Non-Qualified Contractors. As can be seen in Table 4, APS' greatest market impact was in refrigerant charging. Negative market effects represent higher levels of free-ridership than of program spillover.

Table 4. Jobs Impacted by APS' Existing Home HVAC Programs

	Duct Test and Repair	Quality Installation			
		Sizing	Refrigerant Charge	Airflow	Duct Sealing
Qualified Contractor (In-Program) (P_{in})	2,009	7,917	8,150	8,298	9,527
Qualified Contractor (Outside-Program) (P_{out})	46	775	1,465	1,160	1,470
Non-Qualified Contractor (NP)	20	1,653	5,967	6,051	7,368
Baseline (Without APS) (B)	14	2,064	6,192	7,439	8,987
Outside Free-ridership (OF)	0	0	0	0	0
Net Jobs due to APS Influence (P_{out}+NP-B-OF)	52	364	1,240	-227	-149

Engineering Modeling of Market Findings

The overall NTGR is calculated for DTR and QI using the following equation.

$$NTGR = \frac{(P_{in} + P_{out} + NP - B - OF)}{P_{in}}$$

[4] The number of jobs for QI practices is based on an assumed 43,000 installs, with in-program contractors accounting for 29%, outside-program contractors accounting for 6%, and non-program contractors accounting for 65% of all installs. For example, the number of jobs conducted by in-program contractors with proper sizing is calculated using the following equation: 43,000 * 28.6% * 64.4% = 7,917.

Where:

P_{in} = Savings from jobs performed by qualified contractors within the program
P_{out} = Savings from jobs performed by qualified contractors outside of the program
NP = Savings from jobs performed by non-qualified contractors outside the program
B = Savings from jobs performed by contractors in absence of APS efforts
OF = Savings due to outside free-ridership

Savings are calculated by multiplying the number of jobs by the estimated energy savings occurring from each practice. In the case of QI, the savings are aggregated for sizing, RCA, and duct/plenum sealing in conjunction with an install[5]. The final savings calculations by contractor grouping and overall NTGR by practice area are displayed in Table 5.

Table 5. NTGR Derivation for Existing Home HVAC Program by Practice

	Duct Test and Repair	**Quality Installation**
kWh Savings per Job	994	909
Number of Jobs	2,009	12,292
Gross Program kWh Savings (P_{in})	1,997,804	11,174,514
Qualified Contractor kWh Savings (Outside-Program) (P_{out})	45,949	1,821,242
Non-Qualified Contractor kWh Savings (NP)	19,978	8,189,368
Baseline kWh Savings (Without APS) (B)	-13,985	-9,251,603
Outside Free-ridership kWh Savings (OF)	0	0
Net kWh Savings	2,049,747	11,933,521
NTGR = Net Savings/P_{in}	103%	107%

The NTGR for DTR and QI are estimated at 103% and 107%, up from an estimated 92% and 90%[6] in 2009, respectively. This increase represents savings that are attributable to APS, but are not currently captured in reported numbers. The team estimates approximately 52 MWh and 760 MWh in additional, market effects-related savings[7] for DTR and QI, respectively. These savings primarily reflect the APS ResHVAC program's estimated impact on baseline practices across the marketplace; that is, on how both program qualified and non-qualified contractors would have installed ResHVAC equipment in 2011 if APS had not had a program over those 15 years.

Conclusions

This study identifies energy savings attributable to APS' ResHVAC program not captured in previous regulatory reports. The described methodology quantified market effects for individual ResHVAC measures through Net-To-Gross Ratios inclusive of free-ridership, spillover/market influence. The primary methodologies the Team employed were the Delphi panel combined with engineering modeling of the panel's conclusions. The research yielded

[5] This does not include isolated duct sealing jobs included in the DTR measure.

[6] Net-to-gross ratios from 2009 determined from evaluation work conducted by Summit Blue Consulting.

[7] Market effects-related savings account for jobs conducted outside of the program, net of free-ridership and relative to the counter-factual practices baseline.

individual measure NTGRs of 103% and 107% for DTR and QI respectively, representing an approximate increase of 11 percentage points and 17 percentage points in net savings relative to past years.

References

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