Efficient Techniques for Estimating Baseline and Market Shares Projections From Market Transformation Interventions

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ABSTRACT

Researchers are looking for effective techniques to estimate market shares and impacts for market transformation and DSM interventions. This project used ordered logit techniques to examine impacts from interventions designed to encourage greater use of natural cooling technologies in the residential and commercial sectors.

Ordered logit solves a number of problems faced by evaluators and program planners estimating of baseline market shares and impacts from MT interventions. The technique provides estimates and confidence intervals for market shares for alternative technologies under intervention scenarios – both baseline and into the future. It also proved robust and cost-effective technique because it requires relatively few surveys to provide estimates.

In this application, we estimated baseline market shares for standard AC, more efficient, and natural cooling air conditioning technologies in both the residential and commercial sectors. The model also projected changes in market shares over time from a set of market transformation interventions, including: buying down warranties, providing rebates, and extended field / demonstration experience. The project involved designing "cards" incorporating combinations of technologies of interest and their key features with levels of proposed interventions to be ranked by respondents. This information was analyzed to develop the market shares, which were analyzed to develop recommendations of the most effective MT interventions for increasing natural cooling. In addition, we explored barriers to the adoption of natural cooling technologies and provided program design recommendations. Graphs of key results and implications for evaluation and planning are presented in the paper.

Introduction

This paper presents an analytic method that allows researchers to estimate baseline market shares and changes attributable to program interventions. While the authors have used this approach on several projects, the example application presented in this paper was conducted for Pacific Gas and Electric Company, in a project designed to identify key market barriers and examine options that might help transform the evaporative cooling market within the service territory. It was also important to estimate baseline market shares and market share due to program intervention for natural cooling technologies.

Using a method called "ordered logit," Skumatz Economic Research Associates (SERA) developed quantitative models designed to predict market shares of alternative "standard" (i.e., "DX") vs. evaporative cooling technologies. These types of models allow us to estimate technology market shares under a variety of scenarios because the individuals rank a set of

¹ The application of this approach presented in this paper was conducted on a project managed by Mary O'Drain, Pacific Gas and Electric Company.

technology alternatives that are described in terms of a set of attributes that varied for each alternative (Boggs, Cardell, and Hausman, 1981). These alternatives allow parameters to be estimated, which in turn are used in estimating the value function, which can be directly translated into relative market shares. This approach is applied in telecommuncations and other research to problems in which researchers are trying to understand tradeoffs between alternatives that vary on a number of attributes. This method has the key advantage of generating results even in the case of relatively small sample sizes.

The rest of this paper describes efforts that were undertaken to:

- Estimate the baseline of natural cooling technology sales (current and over time) in the residential and commercial sectors
- Project market shares over time for residential and commercial natural cooling technologies under variations in market interventions that the program might undertake
- Provide recommendations about the most effective MT intervention strategies for increasing natural cooling. In addition, we explored barriers to the adoption of natural cooling technologies and provided program design recommendations.

Survey Development

The project covered cooling technologies in both the residential and commercial market sectors. Because the survey approach requires ranking of cards that describe technologies and possible intervention factors, we needed to develop a set of attributes to describe each system. These included:

- Technical attributes (e.g., size, efficiency)
- Factors that represent potential barriers
- Factors that might be used as market interventions.

Feedback from HVAC engineers, market actors, and secondary air conditioning market research, were used to help identify systems, as well as a series of factors, that affected the selection between air conditioning systems. The factors of primary concern in both the residential and commercial sector centered on the following key issues:

- Financial first cost, rebates, operating cost, and payback issues.
- Quality brand, warranty, reliability, performance/maintenance factors.
- Appropriateness size and appropriateness of technology to design and use of the building, location and installation concerns, performance/comfort, and weather considerations.

Based on these factors, we selected attributes that were designed to represent, or serve as proxies for, the appropriateness, financial, and quality-type considerations that were identified as important decision criteria affecting the selection of systems. The factors included the following.

- System type: We used three basic systems for the residential choices and three for the commercial. The most common air conditioning choices (DX) were included, and required comparisons with at least one natural cooling technology of interest to the study. Key system-dependent features were presented to the technicians as part of the system description, including relative footprint, whether piping was required, SEER, humidity and temperature limitations (if any), and relative first costs. The systems were described by attributes only no names were attached to the different system types.
- Demonstrated field experience: Consumer confidence in systems is affected by how long the system has been operating widely and successfully in the field as suggested by evidence from interviews, literature, and the focus groups. Three "levels" were included for this attribute to capture its influence, and its effect on the expected market shares of newer, natural cooling technologies. Both commercial and residential respondents were faced with field experience levels described as 3 years or less with demonstration sites; 4-7 years with good performance; and 8 or more years with good performance.
- Rebates: Systems varied in first costs and operating costs. First costs were addressed directly in the descriptions by comparisons to the "standard available packaged system meeting Title 24" requirements. These differences were expressed as a percentage, above or below, this base cost. Rather than specifying operating costs as dollars or as relatives, we determined to allow technicians to mimic the decision-making that they would use in practice. We merely specified the initial first costs as above, and then identified the SEER ratings for the equipment. Based on their experience, local weather, and their normal assumptions on operating conditions, they would infer paybacks they felt would be realized, and judge whether or not those paybacks would represent more preferable (or acceptable) or less preferable systems in the commercial or residential application. Therefore, we used "rebates" as our policy lever and the way to affect paybacks for the systems. The same three levels were used for both the residential and commercial applications: 5%, 20%, and 35% rebates. These levels assured that the purchase prices of the natural cooling could be reflected as higher or lower than standard technologies.
- Warranty: Warranties are another indicator of quality. Technicians have made it very clear that a successful system is one that does not and has not required repeat visits to fix it or adjust it after installation. A manufacturer's confidence that this will not be necessary, and their willingness to contribute financially should it occur, can be reflected in warranties. Respondents were faced with three levels of warranty: parts and labor for 90 days; parts and labor for 2 years, and parts and labor for 5 years.

These three programmatic options were used because we believed they covered the main areas we believed would be of concern to decision-makers: price, performance, and reliability.

The design of the cards was based on a "latin square" to provide an independent and nonoverlapping design to allow us to minimize the number of cards each technician needed to rank – but still describe the coefficients for each factor. Thus, there was only a limited number of separate factors we could model, which was limited by the maximum number of cards we were willing to have respondents rank. After comparing the limitations of several different research designs, we selected a design that would require customers to rank nine cards, each including a different set of attributes as described above.² The ranking of these nine cards would allow us to estimate the influence of a maximum of four separate factors, each taking on three values. An example of one of the residential cards follows.

Table 1. Sample Residential Card						
Situation	Air conditioning installation in new construction, residential single family, medium size, located relatively near					
	your office.					
System	Split system, EER rating of 12, cooling capabilities that meet residential comfort needs, no piping required.					
features						
Maintenance	Known, established brand.					
and Maker	Manufacturer provides warranty on all parts and labor for 90 days.					
	Maintenance required twice a year, neglected maintenance results in insufficient cooling capacity, but no further					
	effects.					
	Equipment has been available and in the field for 9 years or more with good performance record.					
Economics	Purchase price comparable to standard available package meeting Title 24.					
	Relative operating costs associated with EER rating of 12.					
	5% rebate off purchase price available.					

Table 1. Sample Residential Card

Survey Administration and Data Analysis

To conduct the survey, each technician was provided with nine residential cards and nine commercial cards, and was asked to rank them from most to least preferred. The application for the residential sector was described as a new construction, single-family home of medium size, located near their office. The commercial application was described as new construction, small/light commercial retail, restaurant, or office-type building, located relatively near their office.

The ranking approach and ordered logit techniques were far more robust than originally anticipated. This was discovered because we initially expected to have several hundred survey completions to analyze, but the survey firm used for the project did not deliver the number of completes contracted for. Therefore, despite our best efforts to correct the problem (scheduling interviews for the survey firm, etc.), we found we had to conduct the analysis with fewer than 50 ranking responses. Therefore, one of the main points of this paper is that, even with the smaller sample, we were able to use the results to project the baseline market shares and the separate influences of each of our market interventions on sales in the residential and commercial markets. The fact that this method uses all the information from the rankings supported quantitative results from a fairly small sample size – a benefit of this approach that can make it very attractive to researchers looking to leverage scarce data collection dollars.

After completing the survey portion of the project, the data were analyzed and estimates of the parameters were derived using a non-linear estimation procedure, and the estimated coefficients were used to calculate market shares under a wide variety of scenarios. An important caveat related to the estimated results is that the choice modeling assumes that the technicians are familiar with the systems and the system characteristics or attributes. Therefore, the market shares are, in a sense, market shares assuming that advertising or other activities to

²Statistical and design limitations required us to develop choices that could be portrayed using a maximum of four factors with three levels each. Using an orthogonal "latin square" design, we could then limit the number of scenario alternative cards that respondents had to rank to nine each, which we believed would be a reasonable number to ask respondents to place in order of most preferred to least preferred. However, this design did not allow us to estimate the influence of interactions between terms or attributes. If we had wanted to examine all the interaction terms, respondents would have had to rank an unacceptably large number of cards.

educate decision-makers about the existence and basic characteristics of the various system types are accomplished.³

Results for the Estimation Work

The results of the model could be used to compute the base case estimated market shares for three systems for residential and three for commercial.

- Residential options consisted of: DX, which refers to a standard SEER 12 air conditioner, higher efficiency DX (called DX+ here) which refers to standard air conditioner, SEER 13.5, and AC2 systems, which refers to natural cooling or evaporative types.
- Commercial options consisted of: DX, which refers to standard air conditioning system, indirect direct air conditioner (IDAC, evaporative system), and indirect only (I/O evaporative).

Table 2 shows the incremental changes in projected residential and commercial evaporative cooling market shares associated with variations in potential program interventions. The results are also illustrated in Figures 1 and 2. Factors that would be expected to speed the adoption of this system include increases in energy prices. This would cause the technicians to re-evaluate the relative paybacks realized from these systems – changes that would tend to favor the higher efficiency AC2 systems. However, the results show that there is a significant potential to affect the ultimate market shares for the natural cooling technology and speed transformation of the market by a variety of instruments, including both warranty "buy-up" and rebates.

Scenario	Residential Increments / Projections	Commercial Increments / Projections	
Baseline / Normal Market shares start at:		Market shares start at:	
Progression	11% for AC2 (evaporative), 34% for DX (standard	53% for DX (standard A/C), 35% for indirect /	
	A/C SEER 12), and 55% for DX+ (standard A/C SEER	direct A/C (IDAC, evaporative), and 12% for	
	13.5). The normal progression – without any special	indirect only (I/O evaporative). The normal	
	program incentives – would have the AC2 market	progression – without any special program	
	share increase to 17% after 10 years, with two-thirds of	incentives - would have the I/O system market	
	this growth coming from DX+.	share increase to 18% after 8 years.	
Warranty effects	Double the AC2 warranty increases share from 11% to	Double warranty increases I/O from 12-18%	
	18% (2/3 from DX+)	("by" 8 years); Double warranty on IDAC also	
		increases total I/O and IDAC market shares to	
		57%.	
Rebate effects	10% off AC2 increases market share from 11% to 14%	10% on IDAC increases market share to 38%.	
	20% rebate increases AC2 market share to 19%	10% on I/O increases market share to 13%	
	30% rebate increases AC2 market share to 24%	("buy" 2-3 years)	
Conclusions from	Doubling warranties, 20% rebates, or various partial	Without the intervention, market share	
interventions combinations increases the market share for AC2 to		increases 0.7% per year; doubling warranty	
	levels that would be equivalent to 10 years of unaided	moves market share forward 8 years; 10%	
	growth.	rebates move progress forward 2-3 years.	

Table 2.	Changes in	Projected	A/C Market	Shares from	Potential Program	n Interventions

Findings related to the market share are as follows:

³Therefore, these represent the likely or potential market shares after advertising. The adoption modeling portion of this study addressees issues of how long it might take to "get the word out" under a variety of assumptions about education efforts.

- The evaporative systems represented a fairly small market share under the base assumptions
- The standard A/C systems showed high market shares, reflecting familiarity with the systems, confidence in their performance, the requirements and tradeoffs associated with Title 24, and the fact that standard systems have been actively "in the field" longer than the evaporative system(s).
- Field experience / natural progression: According to the projections, the natural market shares for the evaporative system(s) would increase (as field experience increases), and in the process, decrease the market share for standard systems.

Figure 1. Residential Air Conditioning Market Share Predicted by Ordered Logit Model



Residential Air Conditioning Market Shares

- The AC2 system was also portrayed as a more expensive first-cost system. While the DX system was used as the "base", the DX+ was given a higher price, and the AC2 as the highest first cost system. Relative efficiencies also varied, in the opposite direction. AC2 systems were also described as having some piping and direct drain requirements, unlike the other two systems. Therefore, we also reflected in our descriptions the higher maintenance requirements and the potential for damage to the home from these systems if the system leaked.
- "Buying up" the Warranty: Warranties with longer coverage periods increase market share. Whether implemented by the manufacturer, or whether additional years of coverage are provided as a policy tool by the utilities or board, we found that increasing the warranty can have a very strong potential influence on the market share. Based on the rankings provided by the technicians, we find that the warranty may be a strong

instrument for increasing market share of natural cooling technologies, and that widespread adoption can be shorted via this strategy. The relative quality of these warranty improvements may be diluted, however, if the warranty intervention sparks warranty competition with standard models.

• Rebates: The results showed that providing rebates represents a potentially strong influence. Detailed forecasts and scenario analyses showed changes in market share with variations in rebates, and determined the models that would increase and decrease.

Figure 2. Commercial Air Conditioning Market Shares Predicted by Ordered Logit Model



Commercial Air Conditioning Market Shares

Overall, the results showed that baseline market shares could be increased significantly through the market interventions. The potential program options modeled show the potential to speed up adoption of the technologies by eight to ten years through the use of variations in the values of the intervention methods modeled. The results for the commercial technologies were similar to the residential results, with interventions capable of advancing the market shares predicted by the model by anywhere from three to eight years. Thus, using descriptions of the product and intervention attributes, the utility might be expected to move forward adoption of the technologies and as a result, transform the market.

Beyond the "Ordered Logit" Work - Interviewing on Possible Barriers

Decisions related to cooling technologies might not only be based on attributes or independent assessments of characteristics, but also might include barriers related to the perceptions and fears that consumers might have regarding "evaporative cooling" (Diamond, Remus, and Vincent 1996).⁴ The choice modeling was chosen specifically as an analytic tool because it asked about choices without identifying (by name) the technology involved. Instead, the cards specifically asked for preferences based on an analysis of independent attributes.

However, given the negative cachet that can be associated with the term "evaporative cooling", we also wanted to specifically test whether the results and rankings would change if the technology were named. This extra step was due to concern that there might be factors beyond just actual physical attributes of the system that might affect system selections. More specifically, it was incorporated to determine if there is a bias against natural cooling technologies because of health fears, bad reputations, or other factors, regardless of actual system characteristics. Therefore, we added a question to the choice survey that would address this issue. Rather than asking for a full re-ranking (which was taking too much time), we asked whether the rankings provided would change if the system they ranked highest turned out to be an evaporative cooling system. The following summarizes their comments for residential and commercial systems.⁵

- The term "evaporative cooling" has significant perception problems, and caused half of the respondents to want to change their rankings: Residential and commercial sector results were very similar on this issue. Approximately half the respondents noted that their choices would likely change if they learned the system they ranked highest based purely on attributes turned out to be an evaporative system. This finding has important consequences for the market share results. Clearly, "evaporative systems" have significant market perception problems, and these might need to be addressed before the interventions can have the intended or estimated effect.
- Comfort concerns are one of the big issues with evaporative coolers: Respondents showed a significant concern related to whether humidity would affect system operation. Fully half of the respondents noted they might change their response if the systems may leave the space too humid or too warm on high demand days, or concern that their area was too humid for the system to work well. Since this was an attribute that was clearly stated in the attributes description for the I/O system (and we asked them to rank for their area), this should have been accounted for in the choice modeling at least to some degree.
- Evaporative coolers are believed to cause maintenance problems: Maintenance was also a concern by a large group of respondents concerns included the length of time to get parts, local water acidity issues and the effect on maintenance, and the expense related to filter changes and maintenance callbacks.⁶
- Lifetime, warranty and efficiency concerns with evaporative cooling: Others noted that the systems only have a 10 year lifetime, were concerned about the warranties⁷ or suggested that the systems were less efficient than advertised.

⁴ We were specifically interested in perceptions of health issues ("legionnaire's disease"), and other concerns.

⁵ The only differences cited specifically for residential vs. commercial applications included one respondent who felt that swamp coolers would be fairly unacceptable in residential applications because people need or want to be comfortable. In addition, the general issue of "reliability" was mentioned a little more frequently in association with comments on residential applications. ⁶ Note that the attributes modeling did note the higher maintenance requirements for these systems – we described it as needing

⁶ Note that the attributes modeling did note the higher maintenance requirements for these systems – we described it as needing monthly maintenance, compared to twice-yearly maintenance for DX systems.

⁷ We accounted for warranty as an attribute in the modeling as it was one of the factors specified on each card. Market shares were projected based on variations in the settings for this factor.

The results indicate that evaporative and natural systems have marketplace issues that are above and beyond their rated operating characteristics.⁸

Conclusions and Implications

The results show that ordered logit is a robust technique for estimating market shares – both base shares and changes due to potential market transformation or DSM interventions. We were able to develop estimated market shares for a number of values of possible interventions from just 50 interviews asking respondents to rank nine carefully-designed cards. Estimating the impacts of 4 interventions can be completed with 16 cards. The technique maximizes the use of the information provided by respondents.

The estimation work on the sample project showed that the interventions that were modeled had the potential to advance the market for natural cooling technologies by anywhere from three to eight or ten years (depending on the interventions and levels implemented) – a significant acceleration. The information from the models can be used to design the most cost-effective set of interventions to achieve market progress. Based on the results of the choice modeling, we find that factors related to price, reliability, and field experience are important (and consistent) influences in the selection of appropriate cooling technologies by HVAC contractors – key decision-makers in the specification of cooling systems in both the residential and commercial marketplace. The results provide indications of the relative shifts in market shares that might be expected based on interventions available to the utility or other actors. However, as mentioned, the results are dependent on the assumption that all the technologies (and their important attributes) are *known* by the contractors.

As an add-on to the ordered logit work, we found it was possible to explore the effects of other factors (in this case, negative cachet associated with the term "evaporative cooling") on the rankings, and potentially the resulting market shares.

The ordered logit technique proved to be a robust, flexible, and fairly straightforward method for assessing program alternatives and the market shares to be expected from market interventions.

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⁸ Interestingly, half the respondents noted that they would modify their choice if they learned it was an evaporative system – but more than half of the reasons given were factors that were included in the attributes descriptions or the choice modeling. We believe the name "evaporative cooler" is the basis for the problem, because the technical system features (without a name) were described in the survey and led to the previously described market share projections.