Customer Energy Efficiency Program
Measurement and Evaluation Program

1998 PG&E NATURAL COOLING BASELINE STUDY

PG&E Study ID number: 420 MS-i

June 30, 1999

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Final Report

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EXECUTIVE SUMMARY

In 1996, the California State Assembly Bill 1890 (AB1890) established a uniform funding mechanism for ratepayer funded energy efficiency programs and charged the California Public Utilities Commission (CPUC) with overseeing the mechanism. Subsequently, the CPUC established the California Board for Energy Efficiency (CBEE) to advise it on how best to provide public purpose energy efficiency programs in California.

In addition, CPUC Decision (D.) 95-12-063 calls for public spending to shift toward activities that will transform the energy market (Eto et al. 1996). Based on the utility performance award mechanisms approved in D. 97-12-103 and updated in Resolution E-3555, adopted July 23, 1998, for the 1998 energy efficiency programs, the CBEE has directed PG&E to use Public Goods Charge (PGC) funds to perform market baseline and transformation Studies on the 1998 energy efficiency programs. The present study represents an evaluation covered under that directive. There is currently no regulatory verification plan in place for these studies. PG&E and the CBEE will use the results of these reports, as appropriate, to augment and refine future programs.

BASELINE STUDY OBJECTIVES

The intent of this study is to accomplish the following three objectives:

1. Characterize the market for evaporative cooling technologies
2. Test for the existence and importance of expected market barriers
3. Develop a theoretical framework explaining how programs might create sustainable supply-side and demand-side market effects

The first objective provides an overall view of the market dynamics associated with evaporative cooling technologies. The second objective provides an understanding of the market conditions contributing to the gap between actual and expected levels of investment in evaporative cooling. This information should be useful as a benchmark for measuring the market effects of any future program interventions. The third objective provides a quantitative model for how the market changes over time. This model sheds light on useful strategies for producing desired market effects and can serve as an analysis tool for measuring those effects.

In working to meet these objectives, we focused on various types of indirect evaporative cooling technologies. Since indirect evaporative cooling has both residential and nonresidential applications, we examined both sectors. In doing so, we focused our attention on those geographical areas within the PG&E service territory that offer the greatest opportunities, namely the Central Valley and surrounding transitional climate zones (i.e., all of PG&E's service territory, excluding the coastal climate zone).

PROGRAM OVERVIEW

PG&E's 1998 natural cooling programs focused primarily on field testing and demonstration projects. The main goal was to evaluate the effectiveness and viability of natural cooling in the residential and small-commercial building design and energy retrofit processes. In addition, the programs attempted to develop control strategies for the technology that would eliminate odor, mold, and mildew problems; evaporative element deterioration; and common stigmas associated with the technology. Lastly, the programs aimed to develop testing protocols, calibration and commissioning standards, performance specifications, and a product database, as well as conduct product testing. PG&E's strategy was to work closely with natural cooling system manufacturers and professional organizations to gain technology approval and adoption.

The program for future years is still in the planning stage. Before determining the ultimate direction of the program, PG&E would like to characterize the market and address the barriers that exist with evaporative cooling technologies. This study will serve as a baseline for planning activities that help shape program design efforts and ultimately aid in market transformation.

EVALUATION METHODOLOGY

Our process for conducting this study consisted of three stages:

- An extensive review of published literature and secondary data sources

- Preliminary exploration of evaluation issues using qualitative data collection techniques
- Analysis based on systematic survey and interview efforts for key groups of market actors

The literature review served as the basis for developing a preliminary market characterization and identifying expected market barriers. A review of published literature on the diffusion of innovations served as the basis for developing a theoretical framework explaining market dynamics.

Further evaluation work focused on acquiring and analyzing additional secondary data sources, exploring evaluation issues using a combination of focus groups and Delphi interview techniques, conducting systematic telephone surveys with a fax component, and analyzing results. Exploratory data collection efforts focused on owners and technicians, while more structured data collection focused on technicians and suppliers.

FINDINGS AND CONCLUSIONS

Our research into the dynamics of the market and the barriers that inhibit adoption of indirect evaporative cooling technologies has produced a number of findings, which can be summarized as follows:

- The market share of indirect evaporative cooling is very small and correspondingly difficult to quantify.
- Technicians play a key role in cooling specification. Their endorsement is critical (though not necessarily sufficient) for indirect evaporative cooling technologies to gain greater market success.
- Credible channels for communicating with technicians include manufacturers, equipment vendors, trade journals, and word-of-mouth recommendations from other technicians.
- While building owners play a more passive role in cooling technology selection, their endorsement is also important since they control the purse strings.
- In general, concerns about equipment performance and reliability are important factors in technicians' recommendations.

- Market barriers relating to performance uncertainties appear to be the most important impediments to adoption of evaporative cooling.
- To minimize concerns about performance and callbacks, technicians report favoring products from well-established manufacturers with a long track records and a demonstrated willingness to stand behind their products.
- Expert panelists expect very little increase in market penetration without program intervention.

RECOMMENDATIONS

Our most basic recommendation for program design stems from the finding that current evaporative cooling technologies may still suffer from performance problems independent of market actors' perceptions. Any remaining performance issues should be thoroughly worked out (at least to the point that installing evaporative cooling presents no greater risk to the contractor or building owner than installing conventional systems) before attempting to promote widespread market adoption. Aggressive promotion of a poorly performing technology runs the risk of generating or reinforcing negative perceptions and thus undermining the long-term prospects for adoption.

As part of program design, it would be useful to supplement the analysis presented in this study with an assessment of the cost-effectiveness of the programs considered. In conducting this analysis, it may be useful to consider a range of cost-effectiveness estimates, using the results of both the most optimistic and the most pessimistic market penetration projections.

Once evaporative cooling technologies are ready for full-scale market adoption, findings from the market characterization, adoption process modeling, Delphi interviews, and choice models yield a number of recommendations for program design and implementation. Taken together, the findings can be summarized as follows:

- Do not focus only on increasing awareness of existing technologies.
- Rename new technologies to disassociate them from existing evaporative cooling.
- Form alliances with major manufacturers with long-standing name recognition and fully capitalized support infrastructure.

- Offer extended warrantees.
- Financial incentives may not be necessary to drive down purchase prices but may be useful in attracting attention and demonstrating the program's commitment to the technology.

Guide to the Remainder of This Document

The remainder of this report is organized into the following chapters:

1. **Introduction:** Discusses the baseline study objectives and provides an overview of the program in recent years
2. **Methodology:** Outlines the theoretical framework developed for forecasting potential program impacts; discusses the data collection effort and the subsequent qualitative and quantitative analyses.
3. **Market Characterization:** Summarizes the qualitative findings from the literature review and data collection effort. Documented results are consistent with the CBEE evaluation guidelines, supplemented with elements considered necessary from a diffusion of innovations perspective.
4. **Market Barriers:** Discusses existing market barriers inhibiting adoption of indirect evaporative cooling technologies. Barriers are discussed within the general framework outlined in *A Scoping Study on Energy-Efficiency Market Transformation by California Utility DSM Programs* (Scoping Study) (Eto et al. 1996).
5. **Delphi Analysis of Market Penetration:** Documents projections of future technology adoption and other results from the Delphi interviews with expert panelists.
6. **Choice Analysis of Market Penetration:** Documents market penetration estimates and underlying drivers, as evident from the choice analysis.
7. **Estimates of Adoption Rates:** Discusses estimated adoption rates from application of an adoption process model.
8. **Diffusion Model Results:** Integrates results from chapters 5 through 7 into the market penetration framework outlined in chapter 2.
9. **Conclusions and Recommendations:** Summarizes study findings, including major issues arising from the study, methodology

recommendations for future studies, and recommendations for program design and implementation.

10. **Appendix A: References:** Lists published sources consulted in preparing this report.
11. **Appendix B: Survey Instruments:** Includes survey instruments, interview guides, and supporting documents for the focus groups, Delphi interviews, manufacturer interviews, and technician surveys.
12. **Appendix C: Call Disposition:** Summarizes the disposition of call attempts for the manufacturer interviews and technician surveys.
13. **Appendix D: Focus Group Results:** Summarizes focus group discussions.
14. **Appendix E: Manufacturer Interview Results:** Summarizes interviews with cooling system manufacturers.
15. **Appendix F: Technician Survey Results:** Summarizes results from surveys of HVAC contractors.

1 INTRODUCTION

In 1996, the California State Assembly Bill 1890 (AB1890) established a uniform funding mechanism for ratepayer funded energy efficiency programs and charged the California Public Utilities Commission (CPUC) with overseeing the mechanism. Subsequently, the CPUC established the California Board for Energy Efficiency (CBEE) to advise it on how best to provide public purpose energy efficiency programs in California.

In addition, CPUC Decision (D.) 95-12-063 calls for public spending to shift toward activities that will transform the energy market (Eto et al. 1996). Based on the utility performance award mechanisms approved in D. 97-12-103 and updated in Resolution E-3555, adopted July 23, 1998, for the 1998 energy efficiency programs, the CBEE has directed PG&E to use Public Goods Charge (PGC) funds to perform market baseline and transformation studies on the 1998 energy efficiency programs. The present study represents an evaluation covered under that directive. There is currently no regulatory verification plan in place for these studies. PG&E and the CBEE will use the results of these reports as appropriate to augment and refine future programs.

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The intent of this study is to accomplish the following three objectives:

4. Characterize the market for evaporative cooling technologies
5. Test for the existence and importance of expected market barriers
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The first objective provides an overall view of the market dynamics associated with evaporative cooling technologies. The second objective provides an understanding of the market conditions contributing to the gap between actual and expected levels of investment in evaporative cooling. This information should be useful as a benchmark for measuring the market effects of any future program interventions. The third objective provides a quantitative model for how the market changes over time. This model sheds light on useful strategies for producing desired market effects and can serve as an analysis tool for measuring those effects.

In working to meet these objectives, we focused on various types of indirect evaporative cooling technologies. As described in more detail below, we have concluded that direct evaporative cooling does not offer significant opportunities for new applications beyond the market segments it already serves. Since indirect evaporative cooling has both residential and nonresidential applications, we examined both sectors. In doing so, we focused our attention on those geographical areas within the PG&E service territory that offer the greatest opportunities, namely the Central Valley and surrounding transitional climate zones (i.e., all of PG&E's service territory, excluding the coastal climate zone). However, it is worth noting that indirect evaporative cooling is adaptable to a broader range of climate conditions than direct evaporative cooling. Thus, plenty of viable opportunities for application exist even in cooler and more humid climates.

Our process for conducting this study consisted of three stages:

- An extensive review of published literature and secondary data sources
- Preliminary exploration of evaluation issues using qualitative data collection techniques
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The literature review served as the basis for developing a preliminary market characterization and identifying expected market barriers. A review of published literature on the diffusion of innovations served as the basis for developing a theoretical framework explaining market dynamics.

Further evaluation work focused on acquiring and analyzing additional secondary data sources, exploring evaluation issues using a combination of focus groups and Delphi interview techniques, conducting systematic telephone surveys with a fax component, and analyzing results. As discussed in more detail below, exploratory data collection efforts focused on owners and technicians, while more structured data collection focused on technicians and suppliers.

PROGRAM OVERVIEW

PG&E's 1998 natural cooling programs focused primarily on field testing and demonstration projects. The main goal was to evaluate the effectiveness and viability of natural cooling in the residential and small-commercial building design and energy retrofit processes. In addition, the programs attempted to develop control strategies for the technology that would eliminate odor, mold, and mildew problems; evaporative element deterioration; and common stigmas associated with the technology. Lastly, the programs aimed to develop testing protocols, calibration and commissioning standards, performance specifications, and a product database, as well as conduct product testing. PG&E's strategy for accomplishing this was to work closely with natural cooling system manufacturers and professional organizations to gain technology approval and adoption.

The program participants in 1998 included only a handful of participants representing commercial (U.C. Davis) and industrial applications appropriate for measuring market potential and characterization. The residential sector offered participants incentives for evaporative cooler installation. CoolTech Industries was paid $450 per installation, and, according to PG&E data, installed about 50 units in 1998.

The program for future years is still in the planning stage. Before determining the ultimate direction of the program, PG&E would like to characterize the market and address the barriers that exist with evaporative cooling technologies. This study will serve as a baseline for planning activities that help shape program design efforts and ultimately aid in market transformation.

2 METHODOLOGY

THEORETICAL FRAMEWORK

The theoretical framework used to guide this study draws heavily from the market transformation framework outlined in the Scoping Study. Doing so is appropriate since the Scoping Study incorporates years of research into market imperfections and strategies for intervening to correct them. We further enhanced the Scoping Study framework to incorporate concepts from innovation diffusion theory. This body of social science research provided the following benefits:

- Understanding of the *process* of transformation as well as the barriers to transformation
- More complete descriptions of the structure and functioning of information flows
- Better understanding of the role of the perceived product characteristics in determining whether and how rapidly an evaporative cooling technology might be adopted and markets transformed
- Better understanding of how the market transformation process is influenced by the characteristics of those doing the adopting
- Insight into how the nature and importance of the market barriers change with each stage of the market transformation process

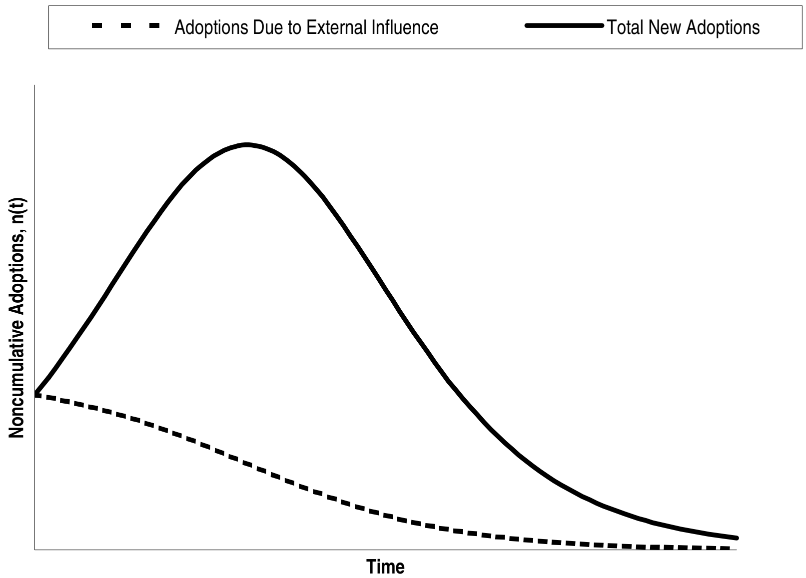
Our strategy for incorporating innovation diffusion into the evaluation exploited its basic strength, which is its ability to explain and forecast changes over time in the adoption rate for a particular innovation. According to Mahajan, et al. (1990), "the purpose of the diffusion model is to depict the successive increases in the number of adopters and predict the continued development of a diffusion process already in progress." We thus used diffusion models to establish relationships between the wealth of measurable and observable baseline information gathered (e.g., market barriers, customer awareness, product availability, attitudes and perceptions of the technology, marketing activities, historical market penetration rates, etc.) and the two parameters of most interest to proponents of energy efficiency: market penetration and time.

The basic Bass first-purchase diffusion model describes potential adopters of an innovation as falling into two groups: one that is influenced by mass media (including program promotional activities) and one that is influenced by word of mouth. The assumptions of the Bass model can be expressed mathematically as:

$$n(t) = \frac{dN(t)}{dt} = p[m - N(t)] + \frac{q}{m}N(t)[m - N(t)] \qquad (1)$$

In this equation, n(t) is the number of adopters at time t; N(t) is the cumulative number of adopters at time t; and m is the potential number of ultimate adopters; that is, the market potential. The first component of the equation, p[m-N(t)], represents adoptions due to buyers who are not influenced in the timing of their adoption by the number of people who already have bought the product. These people are likely to be motivated to adopt natural cooling by program messages or mass media. Thus Bass referred to p as the "coefficient of innovation." The second term, (q/m)N(t)[m-N(t)], represents adoptions due to buyers who are influenced by the number of previous buyers. These people will tend to adopt natural cooling technologies only after hearing positive endorsements from friends or colleagues. Thus Bass referred to q as the "coefficient of imitation." Using nomenclature from Everett Rogers (substituting "external influence" for "innovation" and "internal influence" for "imitation"), the functional form of the above equation is illustrated in the following figure.

Figure 1. Bass Model of Adoptions*



* Adopted from Mahajan, et al. (1990)

The diffusion model and associated qualitative concepts from the Scoping Study and diffusion of innovation research provided a road map for (a) collecting market baseline data that are most germane to future programs and promoted technologies; (b) identifying the most important market barriers; (c) tailoring program interventions for maximum market impact; and (d) designing and implementing market effects studies to track the diffusion of natural cooling technologies over time. To maximize the robustness of the results, we emphasized a triangulation approach to evaluation design that incorporates analysis techniques from multiple disciplines, all within a general diffusion of innovation framework.

DATA COLLECTION

The data collection for this study was designed to specifically address three key objectives:

- characterize the market
- confirm market barriers
- develop a theoretical framework

For this study, we relied on two types of data collection: exploratory and structured. We have defined exploratory research as focus groups and Delphi interviews. The purpose of this type of research was primarily to address the more qualitative issues and provide feedback that allowed for succinct structured surveys. Our data collection efforts began with focus groups and then initial Delphi interviews. The second form of data collection, the structured survey, was more precise in terms of content and based primarily on the results of the focus groups.

We initially developed a framework for classifying decision makers into three distinct groups. This hypothesis reflected the way the decision process may work, as well as which market actors fall into which category. These categories were:

- Owners (builders, building owners, building managers, and tenants)
- Technicians/designers (HVAC contractors, architects, engineers, and design/ build firms)
- Suppliers (manufacturers, dealers, and vendors)

Through our initial exploratory research, we learned that owners were not involved with the decision-making process as much we had originally anticipated. Technicians play a key role in cooling specification. Their endorsement is critical (though not necessarily sufficient) for indirect evaporative cooling technologies to gain greater market success. Building owners play a more passive role in cooling technology selection. Focus group participants (both owners and technicians) described owners playing one of two roles: (a) they hired a contractor, established general parameters (including performance and cost), and then left it to the contractor to recommend the specific technology; or (b) they solicited multiple bids (each of which would include a proposed technology specification) and then chose the one best suited to their general parameters. Thus, for evaporative cooling to be specified for a particular project, the technician must have the technical expertise and the confidence in the technology to make the recommendation. To accept the recommendation, the building owner must have either a high level of confidence in the contractor or a pre-existing level of familiarity with and confidence in evaporative cooling. Any building owner unwillingness to accept the technology, whether real or imagined, can act as a disincentive to the contractor to make the recommendation.

Focus Groups

The first form of data collection for this study was that of focus groups. We conducted our research in the Central Valley based on our initial characterization of the market. We conducted a total of four focus groups with the following samples:

- Owners—one residential group, one nonresidential group; the commercial group was held in Sacramento, and the residential group in Fresno.
- Technicians—two groups with builders, HVAC contractors, architects/engineers, and build/design firms; one group was held in Sacramento, and the other in Fresno.

One of the goals of the initial focus groups was to determine the need for additional focus groups—to make sure our initial assumptions about the marketplace, including key market actors, were correct. The first four groups made it clear that we had made accurate assumptions about the evaporative cooling market, so we were then able to turn our data collection efforts to the structured surveys. The focus group discussion guide focused on the following specific areas:

- **Decision-making process:** What are the roles of different market participants? What are the key equipment characteristics and performance criteria that drive the cooling equipment selection process? Why would one choose an evaporative cooling system over a compressor system? What circumstances would indicate whether an engineered system is more appropriate than a packaged unit? Why would one choose to add an evaporative cooler to a compressor system rather than purchase a new, larger compressor system?
- **Communication channels and information sources:** Which broadcast and interpersonal channels of communication are most relied on for information about cooling technologies? How much credibility do these sources have? How much information does one need to make an equipment specification decision?

- **Market barriers:** What are the specific barriers to the adoption and acceptance of natural cooling technology? Are they different for each of the market segments we are focusing on? What actions are they aware of that attempt to address and overcome these barriers? What are their opinions regarding real versus perceived barriers?

The focus group discussion guide can be found in Appendix B. The summary of findings for the focus groups can be found in Appendix D.

Delphi Interviews

Delphi interviews were conducted with industry experts to gather information about the following issues:

- Likely penetration rate of new evaporative cooling technologies in the region, in the absence of any market intervention by PG&E (base case)
- Likely penetration rates of these technologies given specific market interventions by PG&E (moderate and aggressive scenarios)
- Factors that might affect the penetration rate of these evaporative cooling technologies other than PG&E market interventions

A senior member of the team called potential panelists to invite participation, outlining the project purpose, the overall design, and the responsibilities involved. He also noted that compensation would be provided in the form of a $250 donation to the participant's favorite charity. Seven of the 10 nominees contacted readily agreed to participate in the study and included representatives from

- California utility program manager
- A design/build contractor with an important patent in this technology
- Mechanical engineers with particular expertise in evaporative cooling technologies; additional holder of relevant patents
- Chair of ASHRAE's design standards committee
- Additional ASHRAE committee member

- Author of journal articles on evaporative cooling

The initial materials were sent to panelists in mid-April and were returned by the end of the month. A senior member of the research team reviewed the responses and called each respondent to review their key assumptions, the metric they used, and any interpretive problems associated with the individual sets of estimates.

The team then compiled the initial results. In addition, we prepared and distributed a follow-up letter with a summary of assumptions offered by all panelists and instructions for the second round of estimates. In the letter, we asked each panelist to consider the estimates provided by other members of the group but stressed that we were not striving for a consensus among them.

Owner Surveys

We initially hypothesized that owners were not only key market actors and decision makers, but actual drivers (along with trade allies) of evaporative cooling technology. Accordingly, we devised a choice model that would rely heavily on data gathered through structured surveys. However, as previously mentioned, we determined that owners were generally not the key decision makers; rather, they hire technicians (i.e., contractors, designers, or engineers) to make their HVAC decisions for them. As such, barriers addressed to consumers, or building owners, were adequately addressed in the focus groups. Therefore, the choice model and adoption process model we had planned on constructing with this group were shifted to the technicians, who were discovered to be the key decision makers with respect to the type of technology installed. Data collected from the owner group was therefore based on exploratory research, as well as historical market actor characterization information, and covered the following market barriers:

- Information search costs (awareness of technology, perception of difficulty to gain information, interest in gaining information, perception of market interest in evaporative cooling technologies)
- Performance uncertainties (views on health, comfort, indoor air quality [IAQ], operating requirements, attribution of poor performance to direct evaporative cooling, and other evaporative cooling technologies)

- Hidden costs (views on product and service liability issues)
- Institutional barriers (views on California's building codes related to HVAC energy efficiency [Title 24] and the Office of Statewide Health Planning and Development [OSHPD] rules for evaporative cooling, and their effect on design/construction practice)
- Misplaced or split incentives (views on costs of evaporative cooling systems as owner versus speculative builder)

Technician Interviews

Conversations with Sacramento Municipal Utility District's (SMUD) evaporative cooling program manager indicated that the success of SMUD's program has been driven largely by the utility's trade allies. Given this input, we devoted significant attention to this segment of market actors. In fact, as we learned, the success of evaporative cooling technology overall seems to rely on trade allies. For this reason, we developed surveys that collected data to drive the choice and adoption process models. In total, we conducted 34 in-depth interviews with technicians who serve the California residential and commercial/industrial markets. And, while the focus groups included several architects and designers, HVAC contractors made up most of the sample for data collection. The interviews were designed to test the generality of trade ally findings from the focus groups.

In support of the analytical framework for the choice models, our survey included a phone-fax-phone section. Interviews of this nature lend themselves well to issues involving market share by allowing technicians to rate different scenarios in terms of their most preferred technology to their least preferred technology. Results of the technician surveys are summarized in Appendix F, and the survey instruments for technicians are presented in Appendix B.

Suppliers

Based on our initial review of literature, we expanded the notion of evaporative cooler manufacturers to include not only companies that produce evaporative coolers, but also those that manufacture components (e.g., padding, coils). Accordingly, we attempted to diversify our data collection efforts, relying on our initial Delphi interviews with industry experts for leads to this group of manufacturers. The sample was also drawn from industry associations, Internet industry lists, as well as our initial literature review.

The discussion guide focused on the design/performance criteria and product purchasers (e.g., contractors versus homeowners). In addition, through sales data collected during these surveys, we were able to identify where the largest market appears to be and learn what suppliers feel is the market potential, based on feedback from their customers. A complete summary of findings for manufacturers can be found in Appendix E.

ANALYSIS

The analysis for this project consisted of two components, a historical component and a forecasting component. The historical component focused on completing the market characterization and the analysis of market barriers (objectives 1 and 2). Methodologically, it involved reviewing primary and secondary data sources. While this portion of the analysis made use of quantitative data to some degree, the results are primarily qualitative in nature.

The forecasting component focused on objective 3, developing a theoretical framework explaining how programs might create sustainable supply-side and demand-side market effects. This component involved

- specifying a set of forecasting models to describe the market penetration process for evaporative cooling
- identifying key inputs for those models
- measuring initial input values
- developing preliminary forecasts of market penetration based on expected changes to input values
- describing a process future evaluators can use to update the forecasts using true time-series data

The forecasting component produced both quantitative and qualitative findings.

Market Potential (*m*)

For this project, we calculated market potential in three steps:

- Estimate the cumulative market population (P)

- Estimate the technical potential (T); that is, the fraction of the market population that is likely to adopt, based on technical considerations
- Estimate the economic potential (E); that is, the fraction of the market population that is likely to adopt, based on economic considerations

Our approach to developing estimates for each of these three quantities is discussed below.

Cumulative Market Population (P)

We define the cumulative market population as being the number of residential and nonresidential customers in the target market area (i.e., the Central Valley) that fall into the building types identified as being candidates for evaporative cooling.

Numeric estimates of the number of customers in each category were developed from PG&E's customer demographic data. PG&E's growth assumptions were adopted to estimate growth in the cumulative market population over time.

Technical Potential (T)

The primary potential for adopting evaporative cooling lies in situations in which purchase of a new cooling system is already under consideration. Such situations include existing buildings in hot or transitional climates that lack mechanical cooling, new construction, major renovation or "gut rehab" (to the extent that new HVAC is part of the renovation), and deferred maintenance or "replace-on-burnout," in which an existing nonfunctional cooling unit must be replaced. Our estimate of technical potential incorporates three parameters: the fraction of existing buildings without cooling, the rate of new construction, and the rate of cooling equipment replacement (including replacement from renovations and deferred maintenance). The technical potential in year j can be written as

$$T_j = P_j \bullet R + C_j \qquad (2)$$

Where P_j is the market population in year j, R is the rate of cooling equipment replacement, and C_j is the number of new buildings constructed in year j.

We adopted PG&E's estimates of expected new construction rates and replacement rates for existing cooling equipment.

Economic Potential (E)

We calculated the economic potential in year j as the product of the technical potential in year j and the economic market share, M. That is,

$$E_j = T_j \bullet M \tag{3}$$

We expanded on an approach outlined in Teotia and Raju (1986) for expressing economic market share as a function of relative utility, as shown in equation 4:

$$M = \frac{ae^{f(X)}}{1+ae^{f(X)}} \tag{4}$$

In this model, M is the economic market share, f(X) is a vector representing the relative advantage of the new technology (in this case, one of several types of indirect evaporative cooling) in relation to conventional technology (i.e., direct expansion) and is a linear function of X. X is a vector of variables that measure evaporative cooling's utility relative to direct expansion cooling, and the parameter *a* is positive.

This model has the form of a logistical function. Thus, as f(X) tends toward positive infinity (large relative advantage), market share goes to one (100% of technical potential). Conversely, as f(X) tends toward negative infinity (large economic disadvantage), market share goes to zero. If the new technology and conventional technology are on par economically (i.e., f(X)=0), then new technology market share is calculated as a/(1+a).

The primary challenge to estimating economic potential is to correctly specify f(X) in equation 4. The method we used generates empirical data on decision makers' perceptions of value by asking key stakeholders to rank cooling technology characteristics for different applications. These ranked items are "cooling scenarios," each made up of different combinations of cooling technology and auxiliary characteristics. By asking decision makers to rank the choices, we statistically determined the influence of each of the characteristics on the overall value of different cooling scenarios, and estimated the ultimate market share for different combinations of characteristics—or different cooling technologies—in different applications.

The HVAC contractors participating in our phone interviews were faxed nine cards drawn from a larger set of cards. Each card described a different cooling service scenario. The scenarios, or hypothetical cooling technology packages, differed in characteristics important to adoption of natural cooling technologies. The cards were designed to force the respondent to make trade-offs: to have more of one desirable characteristic, the respondent is forced to give up some other desirable characteristic.

Respondents were asked to rank the different scenarios in terms of most preferred to least preferred. The tradeoffs made among the different attributes when ranking the hypothetical scenarios allowed us to determine the actual importance placed on each attribute.

The tradeoffs were analyzed using a form of logistic regression analysis. The model coefficients reflect the relative importance respondents attach to the tradeoffs they made in choosing a cooling technology. The characteristics and their associated coefficients constitute f(X).

Once the logit model was estimated, we used the results to forecast the probability of a respondent choosing evaporative cooling technologies over direct expansion cooling (DX). Knowing the relative probability of choosing various competing technologies, we then calculated the share of the overall market that can be expected to adopt each technology by summing the choice probabilities over respondents. The product of the evaporative cooling market share (M) and the technical potential (T) gives the economic potential (E).

Cumulative Number of Adopters Over Time (N(t))

Estimates of the historical number of adopters of evaporative cooling have been developed in other studies PG&E has commissioned. We adopted these estimates without modification.

The usual application of a diffusion model is to estimate the model parameters p and q, given a historic time-series of cumulative adopters over time, and then use the estimated parameters in the equation to forecast future adoption, ultimate adoption levels, and the timing of the adoption peak. However, the evaporative cooling technologies of interest have been introduced too recently to permit estimation of p and q based solely on historical data.

To compensate for the lack of historical data, we have attempted to develop credible short-term estimates of future adoption. These will permit us to estimate p and q and thus develop longer term estimates of adoption. We developed estimates in two different ways, using Delphi interviews and using an adoption process model.

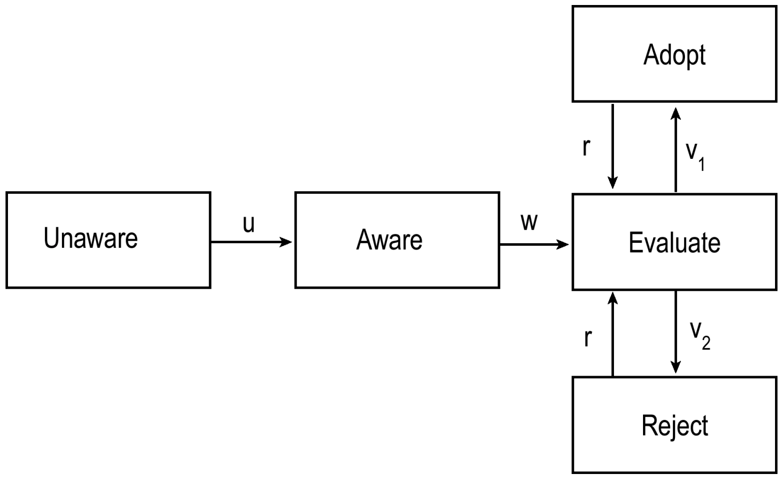
Delphi Survey Estimate

We used the Delphi technique to develop consensus estimates from a panel of experts through an iterative process. Among other things, the members of the panel were polled for independent estimates of the expected rate of adoption over the next seven years. They were also asked to specify their assumptions and the factors that would cause their estimates to rise or fall. A summary of the panel's initial responses were then communicated to the members and they were asked to provide new estimates that take into account the feedback received, as well as their initial thinking.

Adoption Process Model Estimate

Our second method for estimating the cumulative number of adopters over time made use of adoption process models. We used a five-state evaluate-adopt model, which is appropriate for one-time purchase decisions on expensive technologies. This approach models potential adopters' progression through the five states, from unaware to aware, to evaluate, and then to either adopt or reject, as illustrated in the following figure.

Figure 2. Five-State Evaluate-Adopt Model



In Figure 2, the quantities UNAWARE, AWARE, EVALUATE, ADOPT, and REJECT represent the number of potential adopters (or, alternatively, the fraction of the potential market) in each adoption state (unaware, aware, evaluate, adopt, and reject, respectively) at a given point in time. The quantities u, w, v_1, v_2, and r represent the probability of making the transition (or, alternatively, the rate of change) from one state to another within a given time frame (in this case, one year). The process for developing model inputs is described as part of the discussion of results.

Given an initial population distribution across the five adoption states and given values for the transition probabilities, the population distribution in any given year, t, can be determined by iteratively applying the following set of equations:

$$ADOPT_t = ADOPT_{t-1} + v_1 \bullet EVALUATE_{t-1} - r \bullet ADOPT_{t-1} \quad (5)$$

$$REJECT_t = REJECT_{t-1} + v_2 \bullet EVALUATE_{t-1} - r \bullet REJECT_{t-1} \quad (6)$$

$$EVALUATE_t = EVALUATE_{t-1} + w \bullet AWARE_{t-1} - (v_1 + v_2) \bullet EVALUATE_{t-1} + r \bullet (ADOPT_{t-1} + REJECT_{t-1}) \quad (7)$$

$$AWARE_t = AWARE_{t-1} + u \bullet UNAWARE_{t-1} - w \bullet AWARE_{t-1} \quad (8)$$

$$UNAWARE_t = UNAWARE_{t-1} - u \bullet UNAWARE_{t-1} \quad (9)$$

Coefficients of External and Internal Influence (p and q)

We determined that estimating p and q would be an unproductive exercise at this time. The findings that led to this conclusion are addressed in Chapter 8 (Diffusion Model Results), along with a discussion of possible avenues to pursue to derive informative results from diffusion curve estimation.

3 MARKET CHARACTERIZATION

Our market characterization process adheres to the CBEE evaluation guidelines on market assessment (Eto, et al, 1998). The guidelines identify four elements crucial to characterizing or assessing a market. These components include

- A clear definition of the market or markets to be discussed, and a description of the scope and natural boundaries implicit in this definition
- A description of the structure of the market
- An assessment of the relationship between the level of investment in energy efficiency within the market that would appear to be societally cost-effective and the level that currently exists
- A thorough description of the market barriers impeding the adoption of cost-effective energy efficiency measures and services within the market

We also investigated communication channels as part of our market characterization as they are an important component in the diffusion of innovation theory.

As part of the market characterization, we reviewed substantial documentation on evaporative cooling technologies, and we collected additional data through interviews with manufacturers and trade allies and focus groups with trade allies and customers. A complete bibliography can be found in Appendix A of this document. Based on analysis of these sources, previous experience, and the data we collected for this project, we developed the following characterization of the natural cooling market.

DEFINITION OF THE MARKET

Recent studies and corresponding literature conclude that the technical potential for evaporative cooling in California is substantial. The dry hot climate, specifically in the Central Valley area, along with growing construction rates, makes California an ideal market for a technology such as evaporative cooling. Current estimates are that direct evaporative cooling accounts for 5–10% of California's total cooling capacity[1] and about 7% of PG&E's cooling load.[2] Natural boundaries for this technology include climate zones with low cooling loads (i.e., coastal areas) as well as more humid climates. In addition, in extremely warm areas, installation of an indirect/direct evaporative cooling system would be necessary to match the low temperatures achieved with standard air conditioning.

Other drivers that could stimulate adoption of evaporative cooling include an electric rate increase that leads to interest in demand-shifting, which is more readily done in combination with evaporative cooling. Additionally, of implementation of the Kyoto protocols might prompt a shift away from traditional air conditioning. All of these factors—the technical potential, the climatic conditions and the economic and policy environment—suggest evaporative cooling, especially the indirect systems, may become important.

MARKET STRUCTURE

The market structure includes the following components:

- A summary of the specific technologies, services, or products being exchanged
- A summary of the major market participants and the nature of the transactions and other interactions between them, including buyers, sellers, and intermediaries
- A description of the distribution chain; i.e., the variety of paths that a product follows on its way from a manufacturer to an end user
- A description of the geographic boundaries of the market
- A description of the circumstances and settings under which transactions tend to occur, including the sales practices and the market events that are likely to result in transactions within the market
- A description of the communication channels that lead to information exchange among market participants

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[1] "Evaporative Cooling Mini Study," by Xenergy, Inc.

[2] "1994 Residential Energy Survey Report." PG&E, 1995.

- Estimates of the number of buyers, sellers, and intermediaries in the market, as well as an order-of-magnitude estimate of the total annual sales of relevant measures and services
- An analysis of efficient market share, or the percentage of the measures or services sold that meet appropriate energy efficiency criteria

Summary of Evaporative Cooling Technologies

For purposes of this study, natural cooling is defined as evaporative cooling technologies. There are three main types of evaporative cooling: direct evaporative cooling (DEC), indirect evaporative cooling (IEC), and indirect/direct evaporative cooling (IDEC). These technologies can be installed either as unitary or engineered units. Unitary or packaged units include units manufactured and sold as a complete, ready-to-install system, and split systems, which are made up of indoor and outdoor components connected by refrigerant piping installed by field technicians. Engineered or built-up units are custom-designed to meet site-specific requirements and are assembled from manufactured components.

Numerous sources concur that the market for direct evaporative cooling is mature and has, for the most part, reached market saturation. While engineered or built-up IEC and IDEC systems have been installed for over 30 years, unitary IEC and IDEC systems are fairly new in the marketplace and are prime for market penetration. Accordingly, this study looked at DEC only when it was necessary to compare characteristics of DEC to those of the IEC and/or IDEC market. In other words, the baseline study reflects the assumption that future program efforts will target IEC and IDEC but not DEC. The following section describes each technology in more detail and elaborates on the differences between unitary and engineered units.

Direct Evaporative Cooling (DEC)

Direct evaporative cooling has been used as an inexpensive and efficient way of cooling for many decades. Simply stated, DEC involves adding moisture by evaporation to outside air as it is blown, by an electric fan through pads usually composed of cellulose. The result is increased, and lower dry-bulb air temperature, such that the air is and feels cooler; hence the common name "swamp cooler." The increase in humidity makes this technology well suited for arid climates. These systems also tend to be less expensive than their more elaborate counterparts (i.e., compressor-based HVAC systems or DX, IEC, and IDEC systems).

The supply-air temperature of a DEC system is 75–80°F during peak summer heat. This range is considered to be out of the comfort range for many people. The high humidity as well may exceed acceptable levels and can be a problem for allergy sufferers. Thus, there are limited new construction installations of DEC in the residential and commercial sectors. Today DEC is found primarily in older existing homes in arid areas of California, in mobile homes, and in some industrial and warehouse applications where humidity concerns are minimal.

Indirect Evaporative Cooling (IEC)

Indirect evaporative cooling is similar to direct evaporative cooling *but* does not add moisture to the supply air stream. An IEC system cools the primary air stream (supply air) using a heat exchanger in contact with a cooler secondary air stream. A direct evaporation process cools the secondary air stream. The secondary air can be outside air or exhaust air from the building space. The secondary air, cooled by evaporation, passes through a heat exchanger to cool the supply air without adding moisture. While the electricity demand of an IEC is less than that of a standard compressor cooler, the technology cannot perform as well with respect to dehumidification for humidity level control. Commercial applications are more likely to use a stand-alone indirect evaporative cooler than are residential applications.[3] Also, IECs are an attractive "add-on" to the supply-air side of compressor coolers, because even with the increased demand on the supply-air fans, the net demand on the compressor is reduced by essentially "pre-cooling" the incoming air, thus resulting in energy savings.

In a broader definition, IECs are also an attractive add-on to the condenser-air side of air-cooled compressor coolers. In this application, condenser air is pre-cooled by an evaporative process. This cooler air reduces the energy demand of the compressor. Similarly, application of evaporatively cooled condensers

[3] Hunt, Marshal. (1998) “Residential Natural Cooling Project Report for 1998,” PG&E.

and water-cooled compressor coolers in place of air-cooled units can result in substantial energy savings.

Each of these applications takes advantage of the benefits of evaporative cooling. For this study, we simplified the survey questionnaire to only partially address and consider the application of evaporative condensers and similar concepts.

Evaporative Condenser Cooling

A compressor-based technology uses a refrigerant to remove heat from a building. This technology rejects heat to water by submerging copper tubing containing refrigerant gas into a sump rather than rejecting heat to the air. This process is a more efficient means for transferring heat. The heat transferred to the water in the sump is then rejected to the outdoor air through an evaporative process, that takes place in an evaporative pad that surrounds the compressor. This approach allows further downsizing of the compressor due to more efficient heat transfer, even during periods when outdoor temperatures exceed 100°F. Refrigeration Technologies, Inc. currently manufactures such a unit for the residential and small-commercial market (up to five tons).

Indirect/Direct Evaporative Cooling (IDEC)

This type of evaporative cooling is the most efficient and the most effective of the three, allowing supply air to cool to 65–70°F; a more acceptable comfort level. This is achieved through a two-stage cooling process. The first stage of the system lowers both the wet-bulb and dry-bulb temperature of the incoming air stream as it flows through the IEC, as discussed above. Then the air is cooled by the DEC, reducing the dry-bulb temperature while the wet-bulb temperature remains constant. In using this process, the IDEC is able to cool air below the wet-bulb temperature of the outside air. Previous studies in PG&E's territory found that the IDEC unit saved 60–80% or more of the energy consumed by a conventional air conditioner performing the same task.[4]

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[4] "Technical Issues Which Affect Widespread Acceptance of Evaporative Cooling in Commercial Buildings," prepared for PG&E, author and date unknown.

There are two major types of IDEC units: packaged or unitary units and engineered or built-up systems. The unitary technology is closely associated in the mind of the public and contractors with DEC. However, the IDEC technology is significantly different. This association is one of the major barriers to product adoption. Engineered IDEC systems are less likely to be associated with DEC by those familiar with cooling technology, due to their longer history and the fact that mechanical engineers are required to design these systems. Nonetheless, for less knowledgeable building owners, the image of DEC persists. Coupled with a limited number of engineers experienced in the design of these systems, multiple perceptual barriers interfere with the adoption of engineered IDEC systems.

Unitary units are mainly used in residential and small-commercial/industrial applications. The literature reviewed indicates two unitary units are commercially available, one from CoolTech Industries and one from Adobe Air, Inc. The CoolTech SmartCool unit is the result of a California Energy Commission (CEC) Energy Technologies Advancement Program (ETAP) investment from 1992–1995.[5] The Davis Energy Group implemented the ETAP project in a joint venture with a manufacturer and an HVAC contracting company. This type of partnership illustrates the market relationships required to bring unitary IDEC units to market. The product became commercially available in 1995/96 and is incented in the PG&E Natural Cooling program at the rate of $450 per installed unit. The incentive is paid directly to the manufacturer, CoolTech Industries.

While unitary IDCE systems are relatively new, engineered IDEC systems have been designed and built for well over 30 years. The nature of larger commercial system requirements has made it possible for mechanical engineers to design site-specific systems that were IDEC systems when called for by customer interest and application.

Circumstances for Transactions

This project examined the acquisition of evaporative cooling and other types of cooling systems in the context of four distinct market activities:

[5] Davis Energy Group, Inc. (1995) "Indirect-direct Evaporative Cooler (IDEC) Development Project Final Report." California Energy Commission. May 18, 1995.

- Building remodel or minor renovation
- New construction and major renovation
- Cooling system replacement
- Cooling system acquisition or expansion

We did not examine HVAC retrofit; that is, early replacement of working conventional systems with evaporative cooling systems. Current replacement rates of cooling systems are estimated to be 5% a year.[6] Retrofit to IDEC or IEC therefore is likely to account for a negligible fraction of all market-based evaporative cooling system installations. The four targeted market activities are described in more detail below.

Remodel or Minor Renovation

Remodel/renovation is understood to encompass replacement of existing equipment as part of extensive building renovation, rehabilitation, or addition. Common triggers of remodel/renovation activities include changes or expansions in building function, including changes in tenancy. They do not typically involve total system replacement unless the use requires it. Thus, current construction code requirements usually do not apply.

New Construction/Major Renovation

New construction encompasses both custom-built buildings (i.e., buildings constructed for owner occupancy according to owner specifications) and speculation-built buildings (buildings constructed for lease or sale). Major renovations involve complete system replacement and must be done in accordance with current construction codes.

Cooling System Replacement

Cooling system replacement encompasses replacement of existing equipment as part of maintenance and repair activities.

Cooling System Acquisition or Expansion

Cooling system expansion activities are a subset of replacement activities in which the existing cooling system is modified rather than replaced. Evaporative cooling systems are good candidates to enhance operation and

[6] Hunt, Marshal. (1998) "Residential Natural Cooling Project Report for 1998." PG&E.

efficiency of existing compressor coolers. For example, a building that already has a compressor unit can add an evaporative cooler to its existing unit at significantly lower cost than purchasing a new, larger compressor unit. By pre cooling the air, the evaporative cooler maximizes compressor efficiency and extends the capacity of the existing system.

New cooling system acquisition means adding a cooling system to an existing building that currently lacks mechanical cooling when no major structural construction occurs simultaneously. The available literature suggests that certain industrial buildings would be the most likely candidates to select evaporative cooling as part of new cooling system acquisition. Depending on the nature of what is produced or warehoused, warmer temperatures can be tolerated and humidity is not a concern—usually because of large air exchange rates. In these circumstances, the less expensive direct evaporative coolers are often chosen over compressor units. However, since using a direct system increases humidity levels, sensitivity to water and mildew needs to be addressed before opting for this system.

Major Market Participants

The literature review and focus group results indicate that market participants vary by both market sector and type of system. The market participants having the most significant roles in influencing the purchase and installation of evaporative cooling technology are the contractors and manufacturers. This is clearly true for the residential sector, while some commercial and industrial end users rely either on in-house staff or a designer/architect.

The simplest unit, DEC, can be bought in retail home improvement centers, and are usually simple enough for "do-it-yourselfers," contractors or small-commercial in-house engineers to install. New unitary IDEC units have begun to appear as well. Like the DEC systems, these unitary units do not require additional ductwork. In this application, market participants are the retailer, the building owner, and usually a contractor. The focus groups with owners and contractors confirmed that the ultimate decision maker for most unitary units is the contractor or owner. Other market participants include manufacturers and distributors. With unitary IDEC systems only recently commercialized, the types of market participants are the same as DEC, though retailers are not yet involved.

Engineered or built-up units or larger units installed in large commercial and industrial applications require much more input from a variety of market actors. Often, in new construction, design professionals (i.e., architects and mechanical engineers) are involved in the initial HVAC planning, with the mechanical engineer completing the system design. In addition, builders and contractors have significant input as the system is installed. Building owners fall into two categories, those who occupy the building they own and those who lease or rent their building to tenants. Manufacturers also play a different role with engineered systems in that several may be involved in a project, each providing different components. The mechanical engineer, the mechanical contractor, and the building designer all play a critical role in the selection of the technology. But ultimately, the building owner has final say. Though engineered IDEC systems have been installed for over 30 years they have never been widely adopted; thus, while the number of market participants involved in at least one IDEC application in their career is large, there have been not been large numbers of installations.

Contractors, engineers, and designers are critical to the choice of cooling system.. However, their primary role is to recommend a technology to the owner. The interviews and focus groups confirmed that when there are performance uncertainties (as there are for IEC and IDEC), building and design professionals are reluctant to recommend evaporative cooling equipment. The designers and contractors effectively follow the path of least resistance, recommending traditional technologies except in those cases where the owner expresses an interest in evaporative cooling or where (as in some industrial applications) evaporative cooling is the standard technology.

In 1995, a study conducted for PG&E found that fewer than 10 major evaporative equipment manufacturers sell into the California market; for half of these manufacturers, evaporative cooling is not the sole technology they carry.[7] Our research identified eight firms. We included 1 manufacturer in the Delphi and 5 of the 12 manufacturers we spoke with manufacture evaporative cooling equipment. Through the 5 we identified 2 additional manufacturers. One of these 8 only sells components.

[7] "Evaporative Cooling Mini Study"

The following matrices document the primary market participants involved in the specification and design of cooling technologies. Table 1 summarizes the decision makers involved in equipment replacement and acquisition/expansion decisions, by building type. Table 2 provides a similar matrix for decision makers involved in new construction, remodel, and renovation decisions.

Table 1. Replacement/Expansion Decision Makers by Building Type

Building Type	HVAC Contractor/	Maintenance Contractor	Owner
Residence, Multi-family	•	•	•
Residence, Single-family	•		•
Office, Owner-occupied	•	•	•
Office, Leased	•	•	•
Retail, Sole location	•	•	•
Retail, Multi-site	•	•	•
Institutional	•	•	•
Other	•	•	•

Table 2. New Construction/ Remodel Decision Makers by Building Type

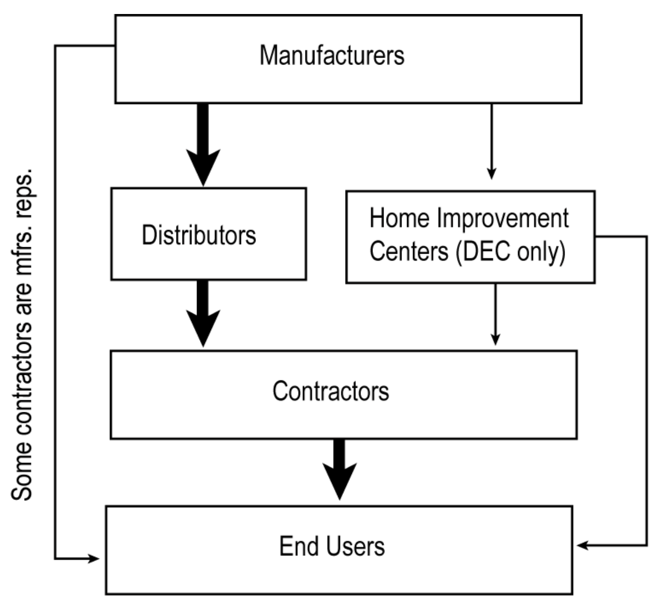
Building Type	Architect/ Engineer	Builder/ General Contractor	HVAC Contractor	Maintenance Contractor	Owner
Multi-family	•	•	•	•	•
Production, Single-family		•	•		•
Custom, Single-family	•	•	•		•
Office, Owner-occupied	•	•	•	•	•
Office, Leased	•	•	•	•	•
Retail, Sole location	•	•	•	•	•
Retail, Multi-site	•	•	•	•	•
Institutional	•	•	•	•	•
Other	•	•	•	•	•

Distribution Chain

Unitary Units

As discussed above, unitary units are simple enough for in-house engineers or even astute homeowners to install. Most unitary IDEC units are purchased through contractors who, in turn, receive their equipment directly from the manufacturer. In some cases, end users go directly to the manufacturer, since there are so few. For small DEC applications, end users can go to a home improvement center, such as Home Depot or Home Base, but IDEC unitary systems are not currently available at home improvement centers. Both residential and commercial applications seem better suited for installation by contractors, though homeowners or commercial building maintenance staff do some installations.

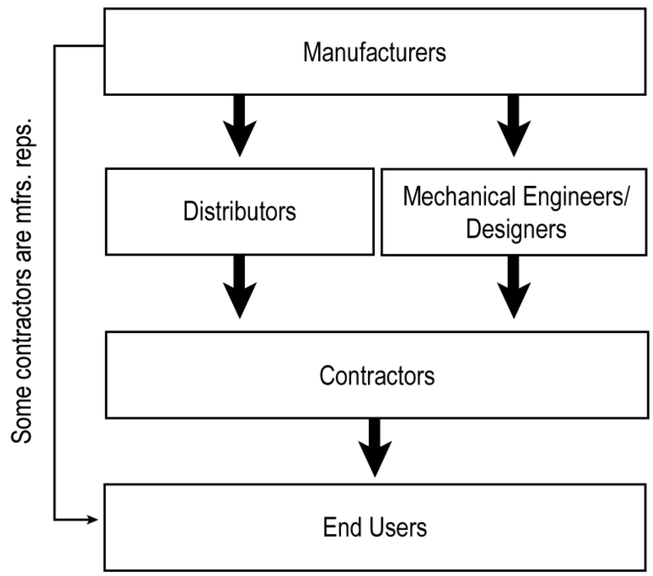
Figure 3. Unitary System Distribution Chain



Engineered Systems

Engineered systems require involvement from a variety of parties to design and install a system. The systems require engineering, which can be accomplished by a mechanical design-engineer firm or by a design-build mechanical contractor. Components for the system are purchased from manufacturers or distributors and the system requires installation by mechanical contractors and sheet metal fabricators.

Figure 4. Engineered System Distribution Chain



Geographic Boundaries of the Market

The geographic boundaries for evaporative cooling are marked primarily by climate zones. This technology is particularly sensitive to humid environments; it is best suited for more arid areas. For purposes of this study, the market boundaries are the Central Valley and transitional areas. The market under consideration at this time excludes the coastal region. The conclusions from this study are generally applicable to other hot, arid regions in California, such as the Mojave and Sonoran deserts and portions of the Los Angeles basin. It is not the intent of this presentation to set limits to the technology, as it is understood that detailed site specifics may support application even in cooler, more humid areas.

Number of Market Actors

Our current research plus our review of the literature provides the following information regarding the approximate number of market actors in the evaporative cooling market:

- **Manufacturers:** A 1995 review had identified about 10 major manufacturers providing evaporative cooling equipment to the market. We were able to identify 8 such firms in 1999. These firms are located throughout the United States and provide their products primarily to contractors and builders. Seven of the firms provide systems; these are

Adobe Manufacturing (MasterCool), Champion/Essex, Cool Tech Industries, Deschamps, Heatcraft, Phoenix Manufacturing, and United Metals. United Metals and Heatcraft only make commercial systems. One other manufacturer was found to be a significant player in the evaporative cooling market, providing evaporative condensers for compressor coolers, Howden Compressors. We found 2 evaporative cooler manufacturers who are no longer in business: Norsaire Systems and Aztec.

- **Contractors:** We estimate that there are 1034 HVAC contractors in the geographic target areas for natural cooling.[8] As most of the literature indicates, contractors are often the determining party when choosing what type of HVAC system to install. A subcategory is design/build HVAC contractors who design engineered IDEC systems. We found that about 50% of the contractors we spoke with were familiar with indirect evaporative cooling. Fewer were aware in the focus groups with technicians in Fresno (residential) and Sacramento (commercial).
- **Owners (building owners, managers and, occupants):** Owners of commercial buildings in a more humid area of the Central Valley (Sacramento) were not aware of any evaporative cooling technologies for their businesses. Residential homeowners in an area with substantial amounts of evaporative cooling (Fresno) were familiar with DEC technology (swamp coolers).
- **Retailers** (e.g., home improvement centers, hardware stores): Secondary research has also shown that many small-commercial and residential DEC applications do not require a contractor. These smaller units can be purchased at home improvement centers, such as Home Depot and Home Express. We did not gather any new information about whether the amount of information available to both retailers and consumers on IEC and IDEC equipment is adequate for consumers to make informed purchases. Currently, there are hundreds of home improvement centers throughout the study area, if IDEC units become available through this

[8] We obtained a list of 3533 contractors in PG&E's service territory. Of these, 2906 are in the target area. When we called these, we found about 25% duplicate firm entries, 73% with working phone numbers, and 45% did not do HVAC work. This provided an estimate of 1034 contractors actively doing HVAC work in the target area.

channel it will be important to ensure that the information available is adequate.

- **General contractors and home builders:** General contractors and home builders, especially in new construction applications, have input HVAC system selection; however, they rely on their mechanical subcontractor to make recommendations. The general contractor's primary role is to keep the project on budget and on time. We did not gather additional information on these market participants, finding the mechanical contractors to be the more significant decision makers.
- **Architects:** Architects are often part of the planning process for new construction applications. Their design specifications reflect specific HVAC requirements. They rely on the mechanical engineer or the design/build contractor to design the HVAC system. If they lack awareness of evaporative cooling options they may not contact a mechanical engineer who can design an evaporative cooling system. We did not gather additional information on these market participants as their role is less well defined. Instead we focused on the role of mechanical contractors and engineers.
- **Engineers:** Engineers are significant members of the team for engineered indirect systems. Studies we reviewed identified engineers in the Northern California area who are actively designing evaporative cooling systems.[9] These studies provide insight into the issues associated with IDEC and IEC technologies. We did not conduct additional interviews with engineers; however, some of these engineers were included as experts in the Delphi study.

Communication Channels

Our current research and a review of the literature provides the following information on the communication channels used most frequently by market participants to obtain information about new technologies.

[9] Pacific Gas & Electric. (1998) “Evaporative Cooling Mini-Study.” Executive Summary for report regarding Indirect-Direct Evaporative Cooling.

- **Manufacturers:** The manufacturers we spoke with rely on multiple sources of information for emerging cooling technologies. All rely on trade journals and four had internal research and development (R&D) departments. Other sources of information include other news and publications, trade association activities (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, [ASHRAE], Air-conditioning and Refrigeration Institute [ARI], and [IIAR]), field staff and customer feedback, and competitor activities.

  The factors that most affect manufacturer decisions about investments in new technologies include customer feedback, in house R&D, published R&D, and competitor activities. The types of information manufacturers need to decide whether to manufacture a new technology include: cost/benefit and return-on-investment analysis, confidence in reliability and maintenance, overall feasibility relative to in-house capabilities, value to the customers, market potential, and in-house R&D support for the product.

- **Contractors:** In our survey of contractors, 60% listed manufacturers as their first choice for information about new technologies, followed by trade journals (25%) and their distributor (20%). In terms of what contractors used the most for information, 100% of the contractors indicated they use distributors, 94% use trade journals, and 85% use manufacturers. In addition, 76% use popular magazines, 73% use trade shows, 65% use their colleagues, 59% use trade associations (though only 44% belong to trade associations), and 53% say they use their own R&D for information. Somewhat unexpectedly, we found contractors look to each other only some of the time or rarely, and it is usually just to talk about a technology or problem, rather than to learn something entirely new.

- **Owners (building owners, managers and occupants):** We asked owners about their sources of information for new technologies. The *Consumer's Guide* rated high for residential homeowners, but most relied more on testimonials and word-of-mouth referrals from contractors, friends, and retailers. Some noted they had begun to use the Internet as well. Commercial building owners indicated they rely on trade associations, trade publications, and utilities for information, but don't pay much attention unless they are in the market. They also noted that they rely on their contractors for accurate and up-to-date information. We also we asked them to discuss their sources of information for heating and cooling equipment. According to the comments in the focus groups, whether residential or commercial, owners rely on their own research—though they don't spend much time on it—and on contractors to give them information about products. Most use a bidding process but say they tend to use the same contractor on most projects. About half also report that they rely on friends and neighbors for reputable contacts and information.

- **Retailers:** We did not interview retailers. However, retailers need to know the technology exists, the benefits of the technology, how to install and maintain the technology, and whether the technology has appeal to their target market.
- **General contractors and home builders:** We did not interview general contractors and home builders. However, general contractors and home builders need to know the technology exists, the benefits of the technology, how to install and maintain the technology, and whether the technology has appeal to their target market.
- **Architects:** We did not interview architects. However, in a study conducted for the Northwest Energy Efficiency Alliance, focus groups with 27 architects showed conferences and publications were the preferred sources of information for architects to learn new tools and techniques. Other environments less frequently used include professional organizations, workshops, Web sites, and recognition awards.[10]
- **Engineers:** We did not interview engineers and do not have information on engineers' preferred sources of information.

Total Annual Sales of Indirect Evaporative Cooling Technologies

The manufacturers we spoke with were asked to provide an estimate of the number of IEC and IDEC units they had sold in California in the previous two years. Based on their responses, we estimate that about 400–600 units were

[10] Peters, J. S. & Marjorie McRae. (1999) "First Market Progress Evaluation Report Architecture + Energy Program." (Draft Report) Northwest Energy Efficiency Alliance.

sold in California in the past two years, or 200–300 per year. Given the number of manufacturers that focus on unitary or engineered systems, their estimates suggest about 40–80 unitary units are sold each year, and 150–200 engineered systems are sold each year in California.

The contractors we spoke with also provided an estimate of the number of IEC and IDEC units they had installed in the past year. These estimates, however, are not consistent with manufacturers. Fifty percent of the 34 contractors reported that their companies installed 170–240 IDEC and IEC units in 1998, for an average of 10–14 units per year. An extrapolation to the population of 1034 HVAC contractors in the target area would go as follows: If 50% of the HVAC contractors install 10–14 IDEC or IEC units per year, some 5170 to 7238 units would be installed in the target area annually. However, these 34 represent larger companies (average 15 employees/company), so we believe they probably represent about 10% of the installations in the target area. Given the reported 170–240 IDEC and IEC units installed in 1998, and assuming they represent 10% of the units installed, this would mean that 1700 to 2400 IDEC and IEC units are installed annually in the target area.

The contractor estimates, cut either way, do not jibe well with ARI shipment data for 1993 reported in a commercial HVAC study[11] in which the total shipments of air conditioning units (excluding heat pumps and combined air conditioner/furnace units) under five tons in the target area was 535 and the total shipment of over five ton units in the target area was 259. Therefore, we feel more comfortable with the low-end manufacturer estimates (40 unitary and 150 engineered.) .

Efficient Market Share

We were not able to obtain any saturation data for commercial evaporative cooling installations. We examined three sources of information for residential installations. The PG&E residential survey[12] indicates that 7% of PG&E's residential cooling load is attributable to evaporative cooling and approximately 73% of PG&E's residential customers have space cooling.

[11] Regional Economic Research, Inc. and ADM. (1993) “Commercial HVAC Study”. PG&E. 1993.

[12] “1994 Residential Energy Survey Report.” 1995. PG&E.

Therefore we estimate 5% of all PG&E's residential customers have evaporative cooling, mostly DEC. A study conducted by PG&E in 1998 estimated current penetration of DEC at 9% for all residential customers.[13]

Both PG&E estimates are lower than the statewide estimates developed in 1995 by Regional Economic Research, Inc. (RER).[14] The RER study estimated the current saturation of DEC units for California as displayed in the following table.

Table 3. Residential Saturation of Direct Evaporative Cooling Units, 1995

Housing type	Existing Construction	New Construction
Single-family	14.7%	2.0%
Multi-family	3.6%	2.0%
Mobile Home	35.9%	2.0%

The RER study estimated the current statewide saturation of IDEC systems in commercial buildings in 1995 to be 3% in existing buildings and 2% in new buildings. This estimate may include DEC as well, though the report indicated the focus for commercial buildings was on IDEC.

[13] Hunt, Marshal. (1998) "Residential Natural Cooling Project Report for 1998." PG&E.

[14] Regional Economic Research, Inc. (1995) “Evaporative Cooling Market Assessment Actions Identification.” California Energy Commission. February 21, 1995.

4 MARKET BARRIERS

THE EXISTING MARKET BARRIERS

Market barriers for evaporative cooling are presented below, along with brief descriptions of each barrier type. Market barriers are defined by the Scoping Study as "any characteristic of the market for an energy-related product, service, or practice that helps to explain the gap between the actual level of investment in or practice of energy efficiency and an increased level that would appear to be cost beneficial."

Many of the previous studies on evaporative cooling focused on market barriers as well as inherent advantages of conventional systems. Our analysis is based on a review of the previous studies; interviews with contractors and manufacturers, and focus groups with technicians, homeowners, and commercial building owners. We used the interviews and focus groups to test the veracity and importance of the claims made in previous studies.

Table 4. Market Barriers for Unitary Units

Barrier	Manufacturer	Distributor/ Retailer	Contractor/ Builder	Building Owner/ Occupier	Building Owner/ Tenant
Performance uncertainty	•	•	•	•	•
Institutional barriers	•	•	•		
Information/ search costs	•	•	•	•	•
Hidden costs			•	•	•
Transaction costs		•	•		
Organizational practices	•	•			
Spilt incentives					•
Lack of product		•	•	•	•

Table 5. Market Barriers for Engineered Systems

Barrier	Manufacturer	Architect/ Engineer	Contractor	Building Owner/ Occupier	Building Owner/ Developer/ Tenant
Performance uncertainty	•	•	•	•	•
Institutional barriers	•	•	•		
Information and search costs	•	•		•	•
Hidden costs			•	•	•
Transaction costs		•	•		
Organizational practices	•	•			
Split incentives					•
Structural barriers				•	•

Performance Uncertainties

Performance uncertainties include the difficulties building owners and technicians encounter in evaluating future costs and benefits of the technology. Different types of evaporative cooling pose different concerns regarding performance uncertainties. We found performance uncertainty to be a major concern. In some cases, personal experience with performance problems of IDEC and AC2 systems were noted, in other cases here-say drove the concern; in still other cases we found experience with DEC dominated the respondents' concerns about any evaporative cooling technology.

Indirect Evaporative Cooling

- There are losses in cooling capacity due to the inefficiencies in the heat exchanger, and added energy consumption from additional fans for the secondary air stream.
- In humid climates, dehumidification is usually required and can not be achieved with current indirect evaporative cooling technology.

Direct/Indirect Evaporative Cooling

- These coolers must be designed with maximum wet-bulb temperatures in mind. In some cases, there may be a need for mechanical refrigeration to satisfy cooling loads, if the temperatures are at moderate dry-bulb levels.

Across All Three Technologies

In general, market actors experience performance uncertainty regarding an array of issues such as operating and maintenance costs and additional staff required to operate the equipment. Some of these uncertainties stem from

- Potential for increased maintenance costs for cleaning the pads of built up water sediment and airborne particles, and corrosion due to the use of water in the systems
- Uncertainty about how much water is required using evaporative cooling
- Perception of poor or ineffective cooling capacity
- Perception of unhygienic conditions ("Legionnaires Disease") and potential problems for allergy sufferers
- Real and perceived uncomfortable humidity levels
- Minimal control ability for direct and indirect evaporative cooling
- Increased concern over poor air quality and "sick building syndrome" in commercial applications

Institutional Barriers

This barrier involves rules or policies implemented by government agencies that make it difficult for organizations to implement energy-efficient decisions. Evaporative cooling has encountered this barrier through both Title 24 and OSHPD constraints.

- There are significant Title 24 barriers, both real and perceived. On the one hand, there are no T-24 CEC Standards published for evaporative systems, so no comparative cookbook methodology. This leads most designers to an ill-conceived conclusion that evaporative systems have little T-24 (energy) benefit. On the other hand, T-24 does allow for "no-cooling equipment" (which is how most users would indicate evaporative cooling). With this T-24 approach, a default SEER of 10 is applied, which does little toward reducing the energy budget calculations, thus not enticing the user to even consider natural cooling. The commonly used Alternative Calculation Methods (ACM), which are approved by Title 24, do not adequately calculate the application of evaporative systems. It is possible to apply for an "exceptional" compliance; however this is seldom done. Fundamentally, natural cooling is not easily nor fully credited for compliance calculations under Title 24. The effect is to either prohibit evaporative cooling through ACM or to seriously delay review and approval of such technology such that firms are reluctant to use evaporative cooling.
- OSHPD prohibits the use of the technology in certain applications (i.e., hospitals). This, coupled with past public concerns regarding health related issues and evaporative cooling add to the public and professional perception that evaporative cooling is not a wise choice as a cooling technology.

Though these institutional barriers are known to exist, neither the contractors nor the manufacturers cited these as a concern. This lack of expressed concern may be due to the fact that they have never had to deal with the requirements and are therefore unaware of the negative effect these barriers have on a designer's consideration of natural cooling. The institutional barriers appear to be known to engineers yet indirectly affect manufacturers and contractors who do not experience a larger demand for IDEC and IEC systems due to the difficulty in meeting Title 24 requirements.

Information or Search Costs

This barrier includes those costs associated with identifying energy-efficient products or services and can include the value of time spent learning about such practices. For indirect evaporative cooling, most market participants lack the knowledge and design experience with the technology that could assist in expanding its use in current markets, as well as to climates other than arid ones. Most manufacturers, engineers, architects, contractors, and distributors lack technical knowledge about IDEC and IEC and have a perception of low market potential, reducing their willingness to devote time to learning to design such systems. Just over 50% of the contractors were aware of IDEC. Building owners tend to use DEC technology as their framework for evaluating any evaporative cooling technology. They lack the knowledge or even awareness of the potential for IDEC and IEC and are unwilling to expend the search costs to gain the knowledge.

Hidden Costs

Hidden costs include the potential for product and service liability. For example, an HVAC contractor could be concerned that installation of evaporative cooling may lead to customer callbacks to address a perceived performance issue, such as noise or odors. This may prompt the contractor to avoid specifying such a system, even if, in practice, the performance issue would not be a source of customer concern. Another hidden cost related to performance uncertainty, is building owner concerns about costs for water and maintenance that are unpredictable at the time of installation due to lack of experience with the technology.

Transaction Costs

This barriers includes those indirect costs associated with actually obtaining the energy-efficient product or service and can include time, materials, and labor. For indirect evaporative cooling technologies, transaction costs appear to be a significant barrier, in that there are currently only a handful of manufacturers for unitary applications of this technology. Engineered systems require a high degree of technical knowledge and expertise that can be difficult to obtain. However, there are no difficulties in gaining this expertise at the current demand level.

Organizational Practices

This barrier involves rules, policies, and practices of the organization that reduce its willingness to consider new technologies or new methods. A barrier for indirect evaporative cooling is that some organizations specialize in evaporative cooling while others have little or no expertise in the area. Evaporative cooling is somewhat of a niche market for mechanical engineering firms and manufacturers and there is insufficient demand at this time to warrant others adding it to their firm capability. Not surprisingly, contractors report no such barrier in their practices; they are generally willing and consider themselves able to install any type of equipment they believe will perform.

Other organizational barriers also limit a firm's willingness to expand into evaporative cooling. Many firms rely on oversized HVAC systems to avoid future callbacks and servicing. Performance uncertainties about the cooling capability of IDEC and IEC systems limit interest in pursuing these technologies.

Finally, architects and owners tend to include engineers at the point of mechanical system design. Lack of consultation from engineers in the early design phase means that IDEC and IEC systems are less likely to be considered as an option, since they require features that must be considered in the basic building design process.

Misplaced or Split Incentives

This barrier addresses the relationships whereby the incentives of the market participants charged with purchasing the energy-efficient product or service are not the same as those who will ultimately benefit from the decision. For example, contractors or builders may be more concerned with project budget costs than a homebuyer, who may be more concerned with efficiency levels. For example:

- Pressure for developers, owners, and investors to complete improvements and construction the "fast and cheap" way; evaporative cooling equipment purchase costs are higher, though operating costs are lower.
- Lack of project funding for higher-cost equipment.
- Scheduling and budgetary limitations eliminate consideration of other more efficient designs.

Product or Service Unavailability

This barrier concerns the lack of supply of the energy-efficient product or service. Appropriately sized unitary IDEC and IEC equipment for small-commercial and residential evaporative cooling applications is not readily available. Only two companies manufacture such units and these became available only in the last few years.

Engineered IDEC and IEC systems, on the other hand, have been installed for over 30 years. The components for these systems must be purchased individually and built into the final system. We did not identify any concerns on the part of contractors regarding purchase of required components for IDEC and IEC systems.

Structural Barriers

This barrier refers to the potential that once an installation is in place, it cannot be easily changed to accommodate new designs. In some cases, where larger air volumes are required to maintain preferred temperatures, IDEC systems may require larger ducting than a standard DX system. The effect is to increase the cost of retrofitting existing DX systems to IDEC. This barrier only applies to engineered systems; it was not a concern to the contractors we spoke with. We were unable to determine if it would become a barrier if demand for IDEC and IEC systems increased.

Measuring Market Barriers

Table 6 displays the extent to which we found these barriers are present in the marketplace at this time. If these barriers were not present, we would expect to find market conditions as indicated in the second column "ideal market conditions." The findings from our research are noted in the third column, "existing market conditions." The ideal market conditions might also be viewed as the anticipated or possible market effects that would indicate program interventions had reduced or eliminated the expected market barriers.

Table 6. Market Conditions–Market Barrier Hypothesis

Barrier	Ideal Market Condition	Existing Market Condition
Performance uncertainties	Contacts perceive limited performance issues for evaporative cooling, seeing the issues as comparable to DX. The basis for making a choice between DX and evaporative cooling is clear.	Manufacturers, distributors, contractors, engineers, and owners perceive performance issues with IDEC, some driven by DEC experiences. Other issues are poor cooling, too high humidity, allergy problems, major maintenance problems.
Institutional barriers	Title 24 offers a prescriptive path for evaporative cooling; OSHPD regulations for hospitals distinguish between acceptable and not acceptable evaporative cooling technologies.	There is no prescriptive path for IDEC; OSHPD regulations persist. However, no contractor or manufacturer perceived these as problems given current level of demand, so this is primarily a concern for engineers.
Information/ search costs	Owners are aware of evaporative cooling options and request them for their buildings from architects, contractors, and engineers. Contractors and designers are aware of evaporative cooling options and have the knowledge and capability to design and install these systems; they readily recommend them to building owners.	Owners are aware of DEC technologies, but not indirect technologies. Very few owners request evaporative cooling. Just 50% of contractors are aware of IDEC/IEC, few recommend these systems. A limited number of engineers specialize in IDEC/IEC.
Hidden costs	Contacts are aware of the operation requirements for indirect evaporative cooling systems and consider these in their decisions.	Contractors express concern over maintenance and water costs for indirect systems.
Transaction costs	Information is readily available; contacts do not perceive evaporative cooling as more difficult to understand or learn about than DX.	Information on unitary indirect systems is not readily available, though 50% of contractors indicate awareness of the technology. Information on engineered systems is available but indirect systems are considered more complex than DX.
Organizational practices	A comparable number of HVAC design firms and contractors are capable in both DX and evaporative cooling systems.	Some 50% of contractor organizations claim capability with evaporative cooling, but installations are limited. Only one of the seven manufacturers not currently offering IDEC/IEC was interested in adding it to its capability.
Misplaced/split incentives	First cost differences between DX and evaporative cooling systems do not form a basis for owner versus speculative builder HVAC investment decisions.	First cost differences exist for IDEC/IEC.

Table 6 (cont.). Market Conditions–Market Barrier Hypothesis

Barrier	Ideal Market Condition	Existing Market Condition
Product/service unavailability	Unitary evaporative cooling systems are readily available in comparable sizes to DX; components for engineered systems are readily available.	Unitary systems are not readily available. Components for IDEC/IEC systems are readily available at current demand level.
Structural barriers	Alternative systems are present to address air flow requirements in existing ducting systems.	At the current level of demand, structural barriers are not a problem for unitary systems and are only occasionally a problem for engineered systems.

5 DELPHI ANALYSIS OF MARKET PENETRATION

As indicated earlier, we implemented several different approaches to estimate the rates of adoption for indirect evaporative cooling technologies and to understand the factors that might affect those rates. The Delphi technique is a structured method of obtaining information from industry experts.

In this application, we identified seven panelists, including technical experts, contractors, academic authorities, and utility program managers. We described three different scenarios embodying a range of possible promotional activities, and obtained from the experts their projections of market penetration for the relevant technologies over the next seven years — under each of those scenarios. We then provided each of the experts with feedback regarding the range of estimates and assumptions given by their peers on the panel and asked them to respond with any revisions or additional comments. The responses of the experts indicate the factors that must be considered in developing a program, setting forth program targets, and estimating the cost-effectiveness of such programs.

The next section describes more fully the research methods employed. The remaining sections summarize the results obtained and the conclusions drawn from this portion of the research.

METHODS

This section summarizes the sample of panelists and the recruiting effort; the design of the task posed and the relevant materials; and the procedures for implementing the research.

Sample and Recruitment

Our objectives in developing the Delphi panel were twofold. We sought (a) a diverse group of participants representing a variety of perspectives and participants, (b) who are recognized experts in the field. We selected the potential members of the panel on the basis of the literature review and recommendations by technical experts on our team and at PG&E. A senior member of the team called each of the potential panelists to invite his/her participation, outlining the project purpose, the overall design, and the responsibilities involved. He also noted that compensation would be provided in the form of a $250 donation to the participant's favorite charity. Seven of the 10 nominees contacted readily agreed to participate in the study. Of the remainder, 1 considered himself not qualified, 1 could not be reached, and the third could not commit the time. Members of the expert panel included the following:

- California utility program manager
- Representative from a design/build contractor with an important patent in this technology
- Two additional mechanical engineers with particular expertise in evaporative cooling technologies; additional holder of relevant patents
- Chair of ASHRAE's design standards committee
- Additional ASHRAE committee member
- Author of journal articles on evaporative cooling

Design and Relevant Materials

After initial contact and recruiting were completed, materials were faxed to panelists for their review and completion. These materials included a cover letter that thanked them for their participation, reviewed what was expected of them, and soliciting complete contact information. The materials also included detailed instructions and a form for recording and transmitting their initial market projections.

The research was designed to gather three key types of information from the expert panelists. These elements were the following:

- Likely penetration rate of new evaporative cooling technologies in the region, in the absence of any market intervention by PG&E (base case)

- Likely penetration rates of those technologies given specific market interventions by PG&E (moderate and aggressive scenarios)
- Factors that might affect the penetration rate of these evaporative cooling technologies other than PG&E market interventions

Additional details about the base case and the two intervention scenarios follow.

In the ***base case***, panelists were to assume that no publicly funded programs were conducted. (Thus, manufacturers and dealers might offer rebates, improve the technology, etc., just as with any other product. However, neither PG&E nor any utility group nor government agency would intervene in the market.)

In the ***moderate intervention scenario***, incentives would be offered to support the sale of packaged units in central California. In addition, through 10 publicly funded demonstration projects, the technology would be incorporated into a range of residential and commercial buildings for detailed monitoring and testing over a three-year period. The timing of the projects and the rebates (including the ramp-down over time) were laid out in detail. (See Appendix B.)

In the ***aggressive intervention scenario***, the incentives were continued longer and the number of publicly funded demonstration projects was increased to 15. Moreover, the intervention included publicly funded promotional activities, conducted at industry trade shows, and training of Central Valley HVAC contractors and mechanical engineers. The training addressed design, installation, and maintenance issues. The aggressive scenario also assumed changes in the state's Title 24 building codes or ASHRAE standards to better accommodate evaporative cooling and condensing technologies as a strategy for meeting energy efficiency objectives. Again, the timing of the demonstration projects, the promotional efforts, and the rebates (including ramp-down of those incentives) were laid out in detail. (See Appendix B.)

Based on the literature review, the focus group results, and the project objectives, we asked the panelists to ignore the penetration of direct evaporative cooling. Instead, they were asked to consider only indirect evaporative cooling, indirect-direct evaporative cooling, and evaporative condenser cooling. Moreover, recognizing the difference between the markets, we asked for separate projections for the residential market and the commercial market.[15] Panelists were asked to focus their estimates on annual penetration (percentage of all new cooling units each year of the types considered) in the Central Valley and foothill regions.

The research team compiled a summary of the initial estimates by each of the panelists as well as their comments and assumptions regarding the scenarios and the overall market. These summaries were then sent back to each of the panelists, along with a request that they review the materials and provide a second set of estimates, based on their initial responses and the review of the panel's responses. The instructions also indicated that, while we were interested in their considered opinions, we were not striving for homogeneity and that they were under no obligation to change their initial estimates.

RESULTS

We believe that the most appropriate way of summarizing the results is to treat the expert projections in terms of ranges and medians. In other words, we do not find it appropriate, given the small number of panelists involved and the purposive manner in which they were chosen, to calculate arithmetic means and variances, with all the precision they imply. Rather, in examining each of the scenario results, we focus on the range of estimates provided under each scenario and examine the trends and the dispersion shown. (It would be possible to emphasize either the diversity of responses among the panelists or their relative convergence. Although we note the importance of the diversity observed—which should give pause to any modeling of the future that relies on one or two selected experts—we believe the most useful approach here is to focus on the central tendencies. Accordingly, to reduce the effect of the most extreme views, we first eliminate the highest and lowest set of estimates

15 Panelists were further instructed to consider only indirect-direct and evaporative condensing cooling the residential market.

in each group.[16]) Finally, to simplify the analysis when *comparing* scenarios, we use the median responses for each. In the remainder of this section, we first summarize some of the major assumptions that became explicit either as the scenarios were developed or as discussions proceeded with the panelists.

Assumptions Made Explicit

An immediate and important product of the Delphi method is the requirement that the scenarios to be considered must be as explicit as possible. By achieving clarity, we reduce—insofar as possible—the variation in panelist responses due to idiosyncratic assumptions regarding the technology, the intervention, etc. We took considerable care to be explicit when constructing the initial material for distribution to the panelists, as may be seen in Appendix B.

Nonetheless, discussions with panelists as well as their written comments indicated that issues beyond the bounds of our metering are interpreted differently by individual panelists. For example, some respondents appear to hold quite different views on the current level of penetration of evaporative cooling technologies in the region under consideration. (The variation is consistent with difficulties encountered in this project in identifying reliable sources of market penetration data.) These differing views—which were not completely homogenized by the feedback provided— may account for much of the variation in panelists' responses.[17] Different estimates may also be traced to varying assumptions regarding the degree to which performance problems associated with these technologies should be considered solved for the purposes of the Delphi analysis. (Further discussion of the importance of performance uncertainties is discussed later in this section.) Additional assumptions that some panelists listed as affecting their estimates—and that may have had differential impacts—include changes/stability of initial costs and regulatory treatment of evaporative-enhanced equipment. Finally, one panelist expects that a combination of emission abatement rules and a growth

16 For consistency, the panelists projecting the highest and lowest penetrations at the end of the target period was eliminated from the results of each scenario, rather than the highest and lowest estimates in each individual year.

17 Lacking a widely acknowledged expert source of such information, we were unable to provide a definitive base to the panelists.

in attractiveness of demand-shifting will markedly increase the attractiveness of evaporative cooling technologies. Another sees increased energy costs and indoor air quality enforcement as relevant drivers. There is little reason to believe that the various panelists treated these issues consistently.

On the one hand, understanding participants' assumptions helps to clarify the reasons for differences among their estimates. On the other hand, these assumptions are equally important in helping us understand the critical factors that should be considered when estimating the future penetration of the technology. Thus, the use of the Delphi approach in this research provides a self-correcting method for increasing the accuracy of the analysis and improving our understanding of the market.

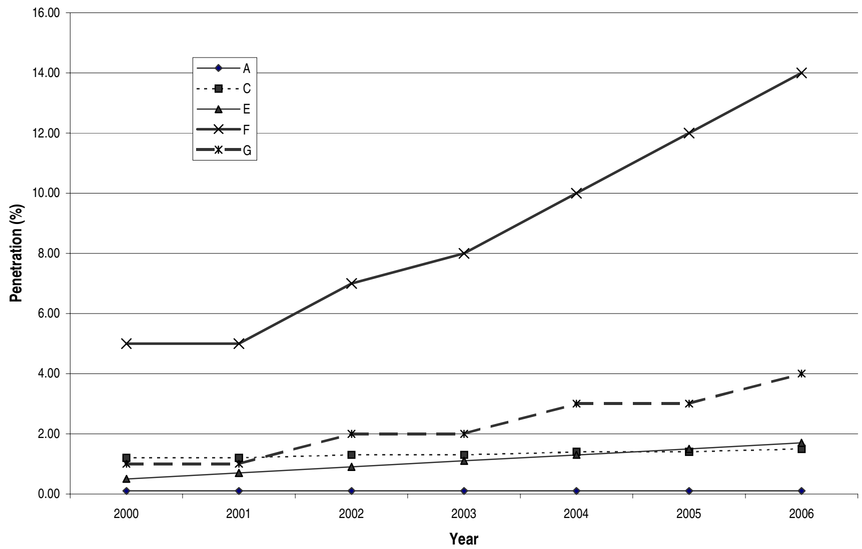
Responses to Scenarios

We first summarize the projections of the panelists for the residential sector, discussing, in turn, the base case, the moderate intervention scenario, and the aggressive intervention scenario. We then compare the results across the three scenarios. Next, we proceed in the same way for the commercial sector results.

Residential Sector

Overall, most experts do not believe that the "natural" market for evaporative cooling technologies will develop very far on its own. Figure 5, which depicts five of the seven panelists' responses, indicates that most panelists do not expect the ***base case*** penetration of evaporative cooling technologies to go beyond 4% over the next seven years. The range of estimates goes from less than 1% to 5% in calendar year 2000 to less than 1% to 14% in 2006. Although the dispersion is wide in terms of the relative estimates, it is small in absolute terms. Also, as might be expected, the dispersion is small for near-term estimates and increases for the outyears. It may also be noted that most panelists—with one notable exception — foresee a relatively modest slope to the growth curve for penetration.

Figure 5. Residential Base Case Scenario



The panelists believe that the promotional efforts described in the ***moderate intervention scenario*** will have a beneficial effect on the market. Figure 6 shows that panelists see intervention as increasing penetration systematically—to levels of 5% or better, according to three of the five responses charted. Again, the dispersion for most estimates is small in absolute terms, but does grow in the outyears. The projected range in calendar year 2006 is an order of magnitude—from 2% to 20%. One panelist (F in the figure) expects that penetration will grow rapidly after the first year of the intervention and then level off. Panelist A, however, believes that penetration will begin to take off only after four years of the intervention. In contrast, the other experts anticipate relatively slow growth throughout the time period considered.

Figure 6. Residential Moderate Intervention Scenario

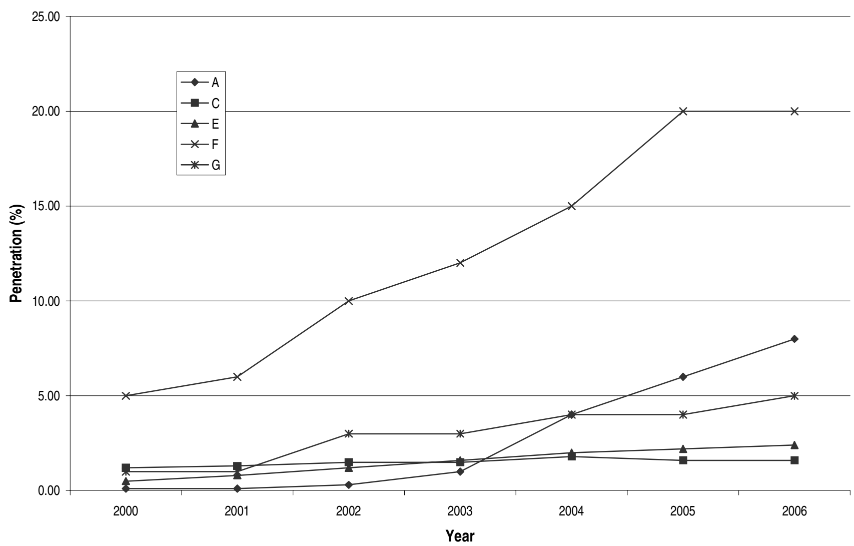


Figure 7 indicates panelists' opinions varied more regarding the ***aggressive intervention scenario*** than for the other scenarios. Although there is general agreement regarding the effects of the intervention during the first three to four years under consideration, that agreement appears to break down markedly in the outyears. One panelist (C in the figure) foresees the aggressive intervention having little more effect than the moderate intervention. A second (A) expects penetration to leap forward after several years of slow growth. A third (G) believes that ending the aggressive intervention will result in a decline in the penetration level achieved—although it will still be above that which would have occurred in the absence of the intervention. The estimates for 2006 are once again close to an order of magnitude different, ranging from 3.5% to 30%. Moreover, while two of the panelists foresee a penetration rate of at least 20%, two do not see penetration growing to even 10% and one other sees little effect of the intervention altogether.

Figure 7. Residential Aggressive Intervention Scenario

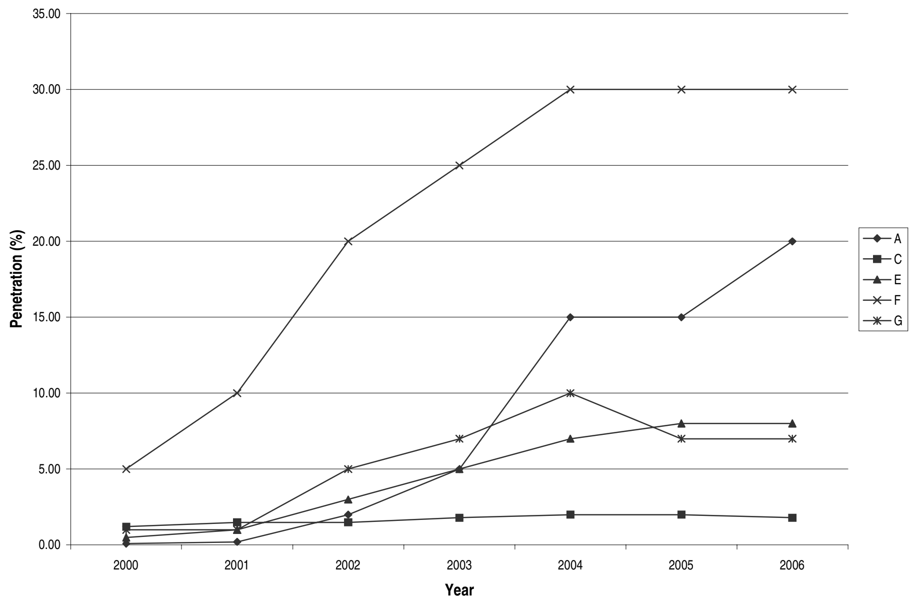


Figure 8 summarizes the results for the residential market by showing the median estimates for each of the three scenarios.[18] These data indicate that the median panelist sees very little increase in penetration under the base case scenario, from 1% in 2000 to less than 2% in 2006. The median panelist believes that the moderate intervention will spark slightly greater growth, with an increase of 3 share points required until 2004 and an additional gain of a share point (to 5% total penetration) by 2006. Finally, the median panelist expects that the aggressive intervention scenario will lead to increases in penetration over its course, peaking at 10% in 2004, but a decline after program phaseout, to 8% in 2006.

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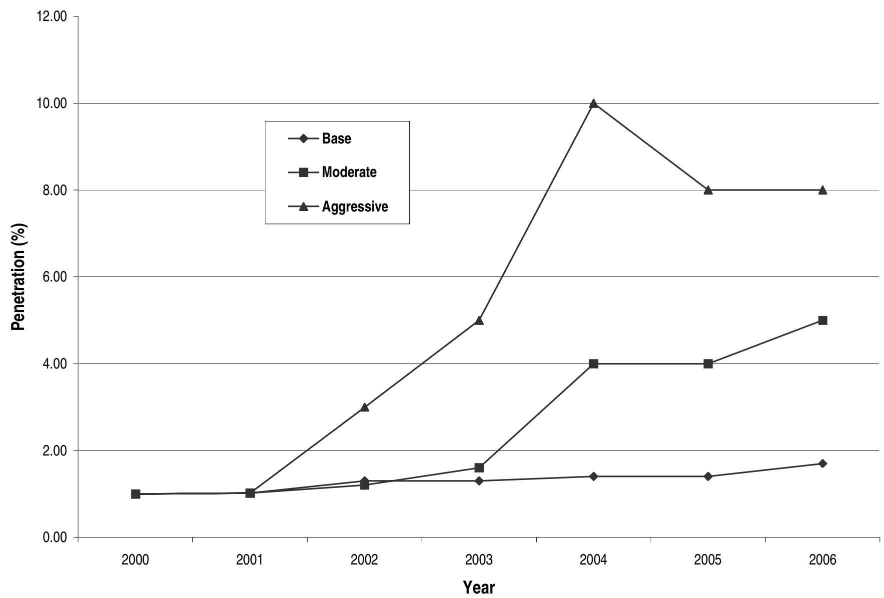
[18] The median panelist for each scenario was constructed by selecting the median value for each year in that scenario.

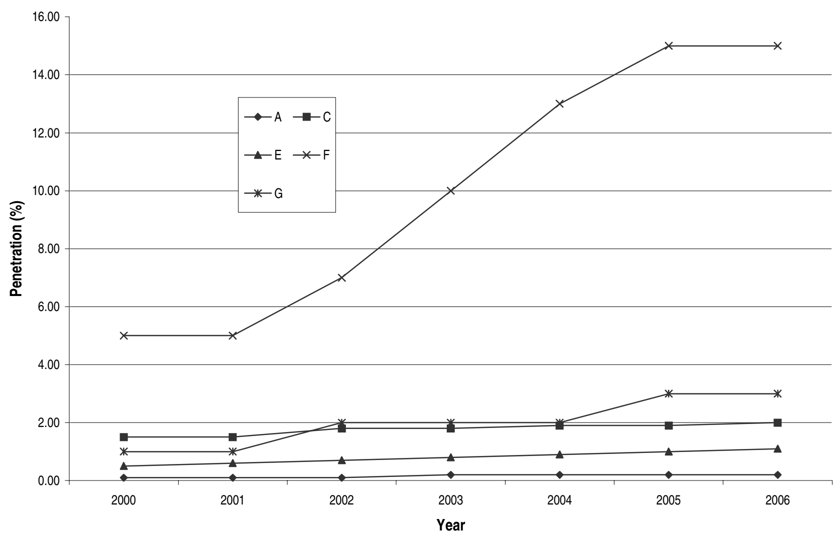
Figure 8. Median Projections, Residential Sector, by Scenario



Commercial Sector

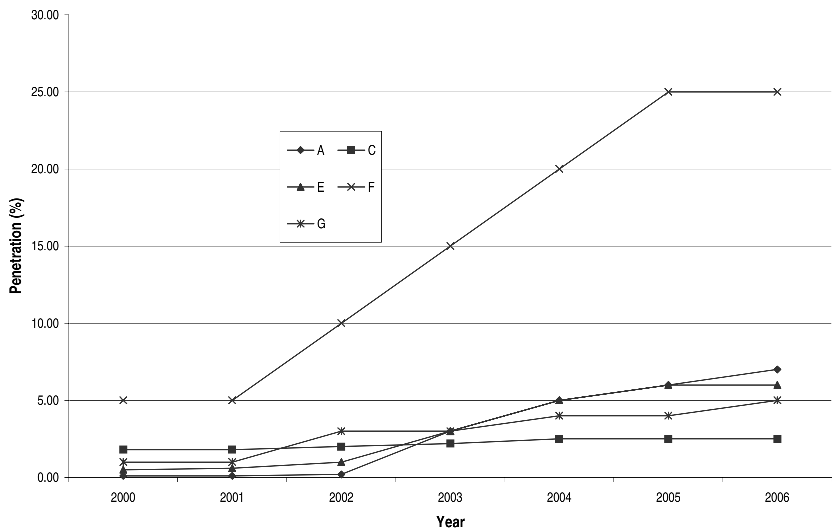
Most experts anticipate that the "natural" commercial sector market for evaporative cooling technologies will remain quite close to its current level. Figure 9 shows that only one (panelist F) foresees major growth under the ***base case***, and only one other (G) expects growth of at least one share point over the next seven years. The estimates range from less than 1% to 5% in calendar year 2000 to less than 1% to 15 % in 2006.

Figure 9. Commercial Base Case Scenario



Moreover, most panelists indicate that the promotional efforts described in the ***moderate intervention scenario*** will have only a small effect on the market. Figure 10 indicates that most panelists (with the exception of panelist C) see intervention as increasing penetration to a level of 5% or better. The projected range in calendar year 2006 is an order of magnitude—from 2.5% to 25%. Again, only panelist F expects that penetration will grow rapidly after the first year of the intervention (although it will finally tail off).

Figure 10. Commercial Moderate Intervention Scenario



As observed in the residential sector analysis, greater disagreement among the panelists emerges regarding ***the aggressive intervention scenario***, as may be seen in Figure 11. Again, there is general agreement regarding the effects of the intervention during the first three years under consideration. However, that agreement breaks down completely in the outyears. Panelist C believes the aggressive intervention will have little more effect than the moderate intervention. In contrast, panelist A expects penetration to leap forward after several years of slow growth and to remain constant at the end of the period under consideration. However, Panelist G believes that the ending of the aggressive intervention will result in a decline in the penetration level achieved—although it will still exceed baseline. The estimates for 2006 range from 3% to 35%. Moreover, while two of the panelists foresee a penetration rate of 25% or more, two do not see it growing to even 10%.

Figure 11. Commercial Aggressive Intervention Scenario

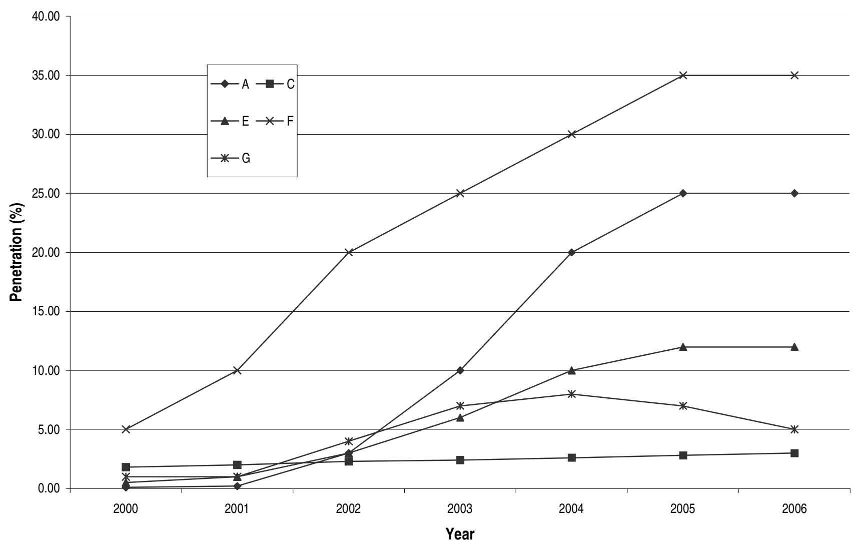
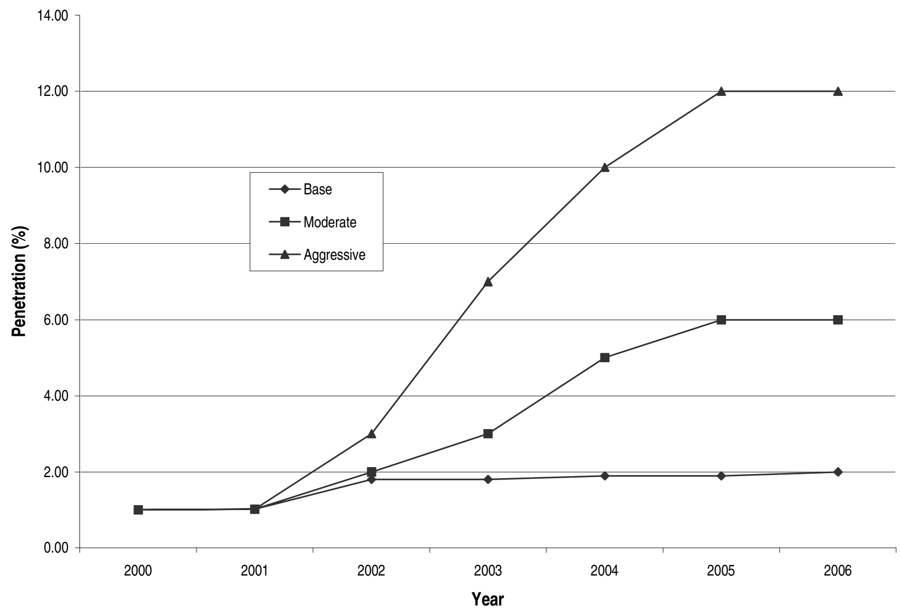


Figure 12 summarizes the results for the commercial market by showing the median estimates for each of the three scenarios. As was found in the residential sector, the median panelist sees very little increase in penetration under the base case scenario, from 1% in 2000 to just 2% in 2006. The median panelist believes that the moderate intervention will spark steady growth, but to no more than 6% penetration. Finally, the median panelist expects that the aggressive intervention scenario will lead to considerably faster growth in penetration over its course, but will peak at 12% and remain there when the intervention has concluded.

Figure 12. Median Projections, Commercial Sector, By Scenario



CONCLUSIONS

The Delphi analysis indicates that experts believe the promotional efforts described in the two intervention scenarios would increase the penetration of evaporative cooling technologies in the Central Valley and foothills regions beyond what can be expected in the "natural" market. Indeed, the Delphi participants expect very little increase in penetration—in either the residential or the commercial market—without such interventions. However, the median panelist sees the moderate intervention scenario as increasing penetration to no more than 5% in the residential sector or 6% in the commercial sector. Under the aggressive scenario, the median participant anticipates greater gains, but still a limited market share—to 8% in the residential sector and 12% in the commercial sector. One positive sign is that only one of the panelists expects a drop in market share once the interventions are removed. In other words, the majority of those consulted believe that the penetration levels attained under the program scenarios may persist (although the evidence is limited by the time period considered and the ability of experts to assess the status of many factors in the outyears).

Overall, these conclusions appear to be consistent with those derived from the other methods employed in this research. Efforts to increase contractors' awareness of evaporative cooling technologies and to reduce the first cost premium on the units sold do not seem likely to spark a huge growth in the penetration of this technology. Risk (tied to performance uncertainties) appears to be the critical barrier to the market success of these technologies, rather than awareness or financing issues. As one panelist wrote:

> "The biggest factor is equipment. Most of the engineers and contractors are very familiar with the technology and have specified and installed evaporative cooling on a number of jobs in the past. These past experiences have been poor, ranging from merely annoying to jobs that were so bad that lawsuits were filed. In general, the equipment is of poor quality, is not designed well, leaks, creates a need for much maintenance and virtually never performs as the manufacturer claims."[19]

It should be noted that the research team included "performance uncertainties" as an issue in the tradeoff exercise and subsequent modeling. And, as indicated in the next chapter, mechanisms for reducing or shifting risk—such as improved warranties—may be an effective intervention.

Methodologically, we believe the results show the value of applying the Delphi technique to the development of penetration estimates. Moreover, it would be relatively easy to create and collect data for additional scenarios for consideration under the Delphi technique; these interventions could focus on equipment improvements or extended warranties rather than promotion. At the same time, there is room for improvement. Most importantly, the method should go beyond a single iteration of estimates and feedback. Had the project schedule permitted, for example, further debriefing of the panelists could have provided additional insight to the reasons for the variation in estimates and trend lines. Moreover, the initial written feedback should be combined with a later direct sharing of estimates and assumptions; for example, a conference call among the panelists, moderated by a senior member of the research team.

19 Panelist G; letter of June 3, 1999, page 1.

6 CHOICE ANALYSIS OF MARKET PENETRATION

One important component in the baseline and market assessment of natural cooling is to estimate the effects that potential policy interventions may have on technology adoption. Our objective was to identify key market barriers and examine options that might help transform the evaporative cooling market. Using a method called "ordered logit," we developed quantitative models designed to predict market shares of alternative "standard" (i.e., DX) versus evaporative cooling technologies. The models allow us to estimate technology market shares under a variety of scenarios.

The ordered logit approach is a qualitative choice model that uses information derived from the rankings of a set of options by survey respondents. The individuals rank a set of technology alternatives that are described in terms of attributes that vary for each alternative. The information from this ranking is then translated into a likelihood function, and then parameters are estimated that maximize the likelihood function. The parameters are used in estimating the value function, which can be directly translated into relative market shares. This approach is widely applied to problems in which researchers are trying to understand tradeoffs between alternatives that vary on a number of attributes. This method has several advantages: it does not require respondents to make a "purchase/don't purchase" decision, and it can generate results even in the case of relatively small sample sizes.

Developing the Choice Survey

Separate models and market share estimates were needed for the residential and commercial sectors. Setting up the survey and the modeling work required identifying

- the set of air conditioning systems to be compared or ranked; and

- a set of attributes to use to describe the systems, including attributes that represent important technical features, attributes that might represent barriers, and attributes that might be used as policy or market interventions to affect market share.

Based on information from the focus groups, HVAC engineers, market actors, and background research on the air conditioning market, we identified systems as well as a series of factors that affect the selection of air conditioning systems. The factors of primary concern in both the residential and commercial sectors centered on several key issues:

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

The number of factors we could model was limited by the maximum number of cards we were willing to have respondents rank (to avoid respondent fatigue and ensure their cooperation). After comparing the limitations of several research designs, we selected a design that would require participants to rank nine cards, each representing a different set of attributes. The ranking of these nine cards would allow us to estimate the influence of a maximum of four factors, each taking on three values. The selected attributes were designed to represent, or serve as proxies for, the appropriateness, financial, and quality-type considerations that were identified as important criteria affecting the selection of systems. The factors included

- System type
- Demonstrated field experience
- Warranty
- Rebates

System Type

We used three basic systems for the residential choices and three for the commercial choices. We included the most common air conditioning choices

(DX) and required comparisons with at least one natural cooling technology of interest to the study. For the residential options, these included

- DX: standard direct expansion system (SEER 12)
- DX+: a higher efficiency direct expansion system (SEER 13.5)
- AC2: an evaporative condensing system

For the commercial rankings, the system options included

- DX: a standard direct expansion system (SEER 12)
- IDEC: an indirect/direct evaporative cooling system (SEER 30)
- IEC: an indirect evaporative cooling system (SEER 25)

Key system-dependent features were presented to the technicians as part of the system description, including relative footprint, piping requirements, SEER, humidity and temperature limitations (if any), and relative first costs. No names were attached to the different system types—the systems were described by attributes only.

Demonstrated Field Experience

Evidence from interviews, literature, and the focus groups strongly suggests that confidence in a system is affected by how long the system has been operating widely and successfully in the field. To try to capture the influence of this attribute, and its effect on the expected market shares of newer evaporative cooling technologies, we included three "levels" for this attribute. Respondents were faced with field experience levels described as

- Three years or less with demonstration sites
- Four to seven years with good performance
- Eight or more years with good performance

The same levels were used for both the residential and commercial rankings.

Warranty

Warranties are another indicator of quality. Technicians have made it very clear that a successful system is one that does not and historically has not required repeat visits for repairs or adjustments after installation.

Manufacturers' 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
- parts and labor for 5 years

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 relative amounts, we allowed technicians to mimic the decision-making they use in practice (based on anecdotal evidence from conversations with HVAC contractors and engineers). 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, technicians were left to infer the paybacks they felt would be realized, and judge whether or not those paybacks would represent more preferable 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:

- Rebate of 5% off purchase price
- Rebate of 20% off purchase price
- Rebate of 35% off purchase price

These levels assured that the purchase prices of the natural cooling could be reflected as higher or lower than standard technologies.

Each technician was provided with nine residential cards and nine commercial cards and was asked to rank the systems described from most to least preferred. The application for the residential sector was described as a new construction project, single-family home of medium size, located near their office. The commercial application was described as a new construction project, small/light commercial retail, restaurant, or office-type building, located relatively near their office. Given that the respondents were expected to be located across the PG&E territory (in the Central Valley), we anticipated we would get responses that would be fairly typical of the distribution across this region.

Finally, we were concerned that factors beyond the physical attributes of the systems might affect system selections. Therefore, although we initially did not name the systems presented on the cards, we asked one more question of respondents *after* the rankings were complete: We asked whether their rankings would have changed if they were told that their high-ranking system was an evaporative or natural cooling technology. This was incorporated to try to determine whether, regardless of actual characteristics, there is a bias against natural cooling technologies because of health fears, bad reputation, or other factors.

The results of these analyses are described below.

MARKET SHARE ESTIMATION

Estimates of the parameters were derived using the SAS® "NLP" procedure, and the estimated coefficients were used to calculate market shares under a wide variety of scenarios.

One very important caveat related to the estimated results is that the choice modeling assumes that the systems are all known to the technicians, as are their characteristics or attributes. Therefore, the market share estimates assume prior advertising or other activities to educate decision-makers about the existence and basic characteristics of the various system types.

Residential Results

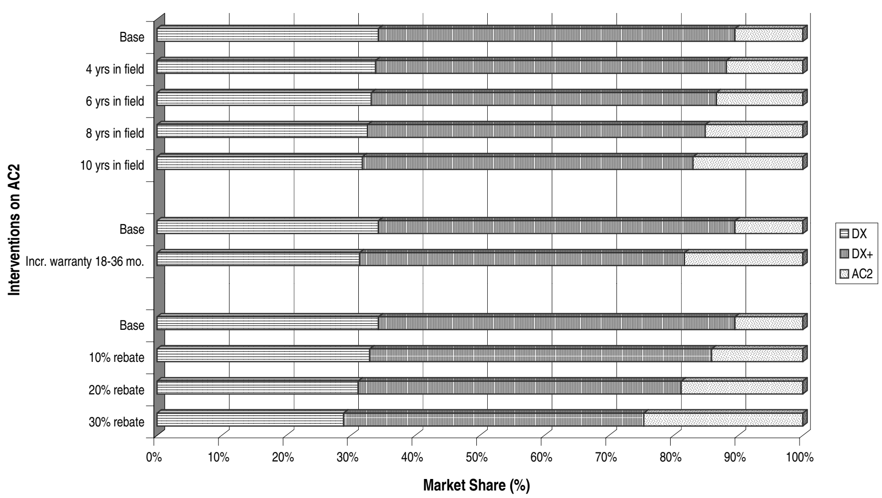
Residential model coefficients are shown in Table 7 and analysis results are shown in Figure 13.

Table 7. Residential Model Coefficients

Variable	Coefficient	Standard Error	T-Statistic
DX	0.609	0.139	4.388
DX+	1.083	0.127	8.502
AC2	-0.020	0.174	-0.112
Warranty	0.036	0.006	6.550
Field experience	0.070	0.026	2.710
Rebate	-3.430	0.758	-4.523

All coefficients except the AC2 constant term are significantly different from zero at the 95% confidence level.

Figure 13. Residential Air Conditioning Market Shares



Using the results of the ordered logit model, we calculate base case estimated market shares for the DX, high-efficiency DX (called DX+ here), and AC2 systems as 34.3%, 55.2%, and 10.5%, respectively. The AC2 systems represent a fairly small market share under the base assumptions. The large share for the high-efficiency DX systems reflects participants' familiarity with the systems, confidence in their performance, the requirements and tradeoffs associated with Title 24, and the fact that both DX-type systems have been "in the field" much longer than the AC2 system (we assumed only 2 years of field experience for the AC2, and ten or more years for the DX systems).

The AC2 system is also portrayed as a more expensive system to buy and install. While the DX system is used as the "base," the DX+ is described as 10% more costly than the standard system, and the AC2 as 20% higher purchase price. Relative efficiencies were described as SEER 12, 13.5, and 15, respectively. AC2 systems were also described as having some piping and direct drain requirements, unlike the other two systems. Therefore, the descriptions reflected the higher maintenance requirements and the potential for damage to the building if the system leaked.

Field Experience / Natural Progression

The top portion of Figure 13 shows the progression in the market as time goes on and the AC2 system gains more field exposure. Over a period of ten years, the market share for this system would be expected to increase by 6.5 percentage points, with two-thirds of this shift coming from the high-efficiency DX system market share.

"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 the CBEE, we find that increasing a warranty can potentially exert a very strong influence on the market share. Doubling the assumed length of the standard warranty from 18 months to 36 months for the AC2 technology only (without changing the warranties for the other technologies) increases the estimated market share from 10.5% to over 18%. Again, a high portion of this comes from the high efficiency DX system (five percentage points), and the market share for the standard DX system is reduced by three percentage points. The results indicate that the time to widespread adoption can be significantly shorted by use of this type of warranty strategy.

For several reasons, it may not be appropriate to assume that the anticipated increase (more than seven percentage points) will be fully realized: (1) the coefficient has an error band around it, and the sample size for the study was relatively small; and (2) it may be that, to avoid losing market share, market actors might increase the warranties on other models to comparable levels. However, 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. The relative quality of these warranty improvements may be diluted, however, if the warranty intervention sparks warranty competition with standard models.

Rebates

Providing a rebate of 10% off the purchase price for the AC2 system leads to a projected market share increase from 10.5% to 14%, or 3.5 percentage points; a 20% rebate increases the AC2 market share to almost 19%, and a 30% rebate is reflected in a market share of over 24%. Again, this is a potentially strong influence. Given that the purchase price differential was indicated as 20%, in two of the scenarios the purchase price is at or below that of standard technologies, which had a significantly lower SEER (15 for AC2 versus 12 for standard DX). The bulk of the market share transfers from the DX+ system, but the transfer is proportional to the initial market shares of DX and DX+.

The results show that, without interventions, we could expect the market share for the AC2 system to increase perhaps two-thirds of a percentage point per year. One could hypothesize a number of factors that might speed the adoption of this system. For example, increases in energy prices might cause technicians to reevaluate 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 warranty "buy-up" and rebates. These options show the potential to reach and achieve market shares that otherwise might not be realized in the marketplace for eight years.

Commercial Results

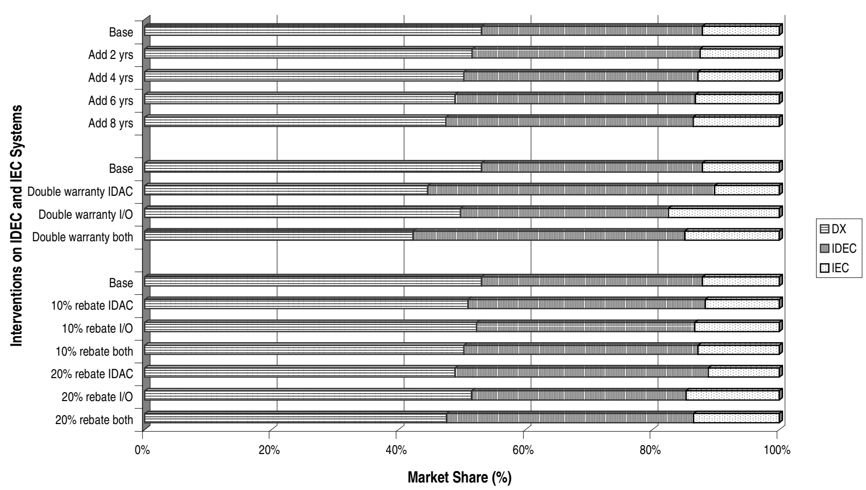
Commercial model coefficients are shown in Table 8 and analysis results are shown in Figure 14.

Table 8. Commercial Model Coefficients

Variable	Coefficient	Standard Error	T-Statistic
DX	1.012	0.209	4.843
IDEC	1.196	0.178	6.706
IEC	0.159	0.205	0.777
Warranty	0.024	0.004	5.393
Field Experience	0.027	0.020	1.387
Rebate	-1.904	0.565	-3.371

All terms except the IEC term (t=0.777) and the field experience term (t=1.387) have coefficients that are significantly different from zero at the 95% confidence level.

Figure 14. Commercial Air Conditioning Market Shares



The results of the ordered logit model can be used to generate market shares for the three systems included among the choices for small/light commercial applications. The estimated market shares for these three systems based on the model are 53% for DX, 34.8% for indirect/direct evaporative cooling systems (IDEC), and 12.1% for indirect only (IEC) systems. Note that there are also other practical systems available and utilized in the commercial sector—chilled water cooling systems, among others. However, in order to limit the number of cards to nine, respondents were asked to make selections among the DX system and the two evaporative cooling systems options.

Among these three systems, the market share for the two evaporative cooling systems combined are estimated to as the same as for the commercial DX system. The estimated IEC market share is only about one-third that of the IDEC system and 20% to 25% of the commercial DX system market share. As described by their attributes in the cards, both the natural cooling systems have higher SEER ratings than the DX system options. In addition, both have slightly lower first costs. However, both require some piping and drains and have higher maintenance schedules. The lowest estimated market share is for the IEC system, which cannot maintain the same, more stringent, cooling and humidity tolerances as the other two systems. On the highest demand days, the humidity under the IEC system may be as high as 70%, and temperatures may exceed the standard comfort zone. The DX system was assumed to have more than 30 years of field experience; in comparison, the IDEC and IEC systems have had only 5–10 years of field experience.

Field Experience / Natural Progression

The top portion of the graph shows the progression of market shares as time goes on and the two natural cooling systems gather more field experience. With eight additional years of field experience, the market share estimates for the natural cooling systems increase by a total of 5.5 percentage points. Each system shows a 12% increase, so a higher percentage point increase is seen by the relatively more commonly selected IDEC system. The commercial systems are less responsive to extra time in the field than the residential natural cooling system under study, perhaps because they start out with longer experience in the field.

"Buying Up" the Warranty

Again, longer warranties increase the acceptance of the systems, and this could be accomplished through actions by the manufacturer (to increase market share) or by the utilities or the CBEE to assist in transforming the market. Whichever tool is used to increase the warranty coverage from a base of 18 months (with parts and labor) to 36 months has the following results. Doubling the warranty on the IDEC system only, increases its market share fairly dramatically—from 35% to over 45% (resulting in a drop of two percentage points from the IEC system, and the remainder from the DX system). Doubling the warranty on the IEC system increases its market share by an even higher percentage (from 12% to 17.5%, with again two percentage points drawn from the other evaporative cooling technology and the remainder from the DX). If the warranties on both evaporative cooling technologies are doubled from 18 months to 36, we find their share increases from a total of 47% of the market (for the three technologies) to over 57% of the combined share. The IDEC increases from 35% to almost 43%, and the IEC increases from 12% share to just under 15%. Again, warranty increases are a very strong influence, and may be more potent than additional time in the field. Again, the actual market shares may not be quite as relevant as the relative increases shown by various strategies and interventions. However, based on the rankings provided by the technicians, we find that the warranty looks as though it can be a strong instrument for increasing market share of natural cooling technologies.

Rebates

Another potential tool to influence market share is to provide additional financial incentives to purchase natural cooling technologies. Providing a rebate of 10% off the purchase price for the IDEC system only, leads to a projected market share increase of 2.6 percentage points, to 37.4% (a 7% increase), with a slightly higher proportion of this increase coming from the DX system than the IEC system. Doubling the rebate led to double the effect. When the rebate was instead applied to the IEC system only, its market share increased from 12.1% to 13.3% (a 10% increase in its market share). Each of the other systems decreased by a little more than 1% (given their larger starting shares). Again, double rebates doubled the impacts. Providing 10% rebates on both natural cooling systems increased their market shares—6% for each system (0.7 percentage points for the IEC system and 2.1 percentage points for the IDEC).

The estimated market share results show that, without interventions, we could expect the sum of the market shares for the two natural cooling systems to increase a little less than 0.7% per year. Certainly, increasing energy rates would be expected to increase market shares, because these systems have higher SEER ratings, which would affect the payback calculations for the 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 using the two instruments we analyzed: buying up the warranty, and providing rebates on purchases of natural cooling systems.

Based purely on the results of attribute descriptions, these interventions show the potential to achieve market shares that might take more than eight years unassisted in the marketplace, significantly aiding in transforming the market.

Influences Beyond "Attributes"

One important concern related to the adoption of "natural" cooling technologies was the fact that decisions about the technologies might not be based on attributes or independent assessments of characteristics alone, but that perceptions and fears related to terms like "evaporative cooling" might be barriers to their adoption. The choice modeling was chosen specifically as an analytic tool because it asked about choices without identifying the technology involved. Rather, it specifically asked for preferences based on an analysis of independent attributes. However, we also wanted to specifically test the influence of factors related to perceptions about "evaporative cooling" names, so we added a question to the choice survey that would address this issue.

The results for both the residential and commercial sectors 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. It implies that evaporative systems have significant market perception problems that could significantly affect market share interventions.[20]

Comfort issues. Fully half (8) of the respondents who noted they might change their response provided reasons that centered around concerns that the systems may leave the space too humid or too warm on high-demand days, or concerns that their area was too humid for the system to work well.

[20] As an aside, the issue of program/technology names came up in a focus group discussion. One technician suggested the term "natural cooling" and the others thought that was great.

Since this was an attribute that was clearly stated in the attributes description for the IEC 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. The fact that technicians lowered their ranking of evaporative cooling systems independent of the scenario attributes indicates a clear discrepancy between the scenario attributes for evaporative cooling and the attributes technicians associate with the technologies.

Maintenance issues. Another four respondents had specific concerns about maintenance, including the length of time to get parts; local water acidity issues and the effect of acidity on maintenance; and concerns that the maintenance requirements in terms of filter changes and callbacks are too expensive.

Other issues. Other respondents voiced concerns about warranties (also accounted for in the attributes modeling) and that the systems have a lifetime of only ten years; several noted that the systems were not as efficient as expected or promised.

The only differences cited specifically for residential versus 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.

Clearly, evaporative and natural systems have marketplace issues that are somewhat independent of their purported operating characteristics. 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. There seems to be a disconnect between strict descriptions of attributes and the term "evaporative cooler."

The results indicate that the potential market shares for new natural cooling technologies may be negatively affected by perceptions and experience with previous systems. If new systems can perform reliably with characteristics as identified by the manufacturers, then outreach and education may be needed to get HVAC contractors to a point where the systems can be selected based on operational characteristics and attributes. Issues related to credibility and outreach are discussed briefly in the section below and in the market adoption modeling section of the report.

CONCLUSIONS AND IMPLICATIONS

The estimated results from the choice modeling work show that, in addition to price preferences, various methods of increasing the credibility of technologies in the marketplace are important drivers in increasing relative market shares. Based on previous interviews and our underlying understanding of the HVAC contractor marketplace, it is clear that reducing the potential for callbacks is critical to contractors. Extended warranties can be influential. Getting word out about successful field experience and operating characteristics of new technologies can also be important.

HVAC contractor interviews conducted for other projects has made it fairly clear that information about field experience with these technologies needs to be disseminated in credible ways for it to be accepted in the market. For example, reports for research organizations or ads by manufacturers are less influential; trade journal articles written by field practitioners in similar building/business types are more influential and credible. In addition, utilities seem to have some credibility among a number of HVAC contractors. In interviews, some have specifically pointed out the value of "free" training they have received from utilities on various technologies. This may provide another opportunity to increase the visibility and credibility of newer technologies.

It is also clear that rebates can be effective in turning serious attention to newer technologies. This has transformed the residential washing machine market, cutting years off the natural market share progression of horizontal axis machines. Interviews with HVAC contractors make it clear they consider rebates in their decisions about technologies—with the strong caveat that reliability/performance is a crucial element as well. Finally, education and outreach from third parties like utilities have also been effective in getting customers to ask about efficient equipment, according to HVAC contractors, and this may be another avenue for utilities to consider in trying to affect the market for natural cooling systems.

However, there are clearly reservations about selecting and installing evaporative systems. Concerns about maintenance, capabilities, and other issues will need to be addressed relative to the newer natural cooling technologies before we are likely to see the projected market shares. Clearly, the term "evaporative cooler" is to be avoided, but the differences in attributes for the new systems will probably have to be made very clear to assure a level playing field for these technologies; that is, before they can be expected to be selected on the basis of their own attributes.

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; they are key decision makers in the specification of cooling systems in both the residential and commercial marketplaces. 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.

7 ESTIMATES OF ADOPTION RATES

Applying the adoption process model described in Chapter 2, our first task was to develop plausible inputs for equations 5 through 9, repeated here for ease of reference.

$$ADOPT_t = ADOPT_{t-1} + v_1 \bullet EVALUATE_{t-1} - r \bullet ADOPT_{t-1} \quad (5)$$

$$REJECT_t = REJECT_{t-1} + v_2 \bullet EVALUATE_{t-1} - r \bullet REJECT_{t-1} \quad (6)$$

$$EVALUATE_t = EVALUATE_{t-1} + w \bullet AWARE_{t-1} - (v_1 + v_2) \bullet EVALUATE_{t-1} + r \bullet (ADOPT_{t-1} + REJECT_{t-1}) \quad (7)$$

$$AWARE_t = AWARE_{t-1} + u \bullet UNAWARE_{t-1} - w \bullet AWARE_{t-1} \quad (8)$$

$$UNAWARE_t = UNAWARE_{t-1} - u \bullet UNAWARE_{t-1} \quad (9)$$

INITIAL POPULATION DISTRIBUTION

In designing the technician survey, we included specific questions regarding HVAC contractors' awareness of IEC, IDEC, and evaporative condensers. Responses were technology-specific. Those respondents who reported familiarity with one or more of these technologies were asked whether they specified or installed any of them. Again, responses were technology-specific. Finally, respondents who were familiar with a technology of interest but did not specify or install any were asked whether they

- Have heard of the technologies but never looked into them
- Are currently looking into them
- Have looked into and rejected them
- Have looked into and intend to specify or install them

Tallying responses to these questions produced the following distributions:

Table 9. Self-Reported Adoption States

Technology	UNAWARE	AWARE	ADOPT	Other States
IEC	44.1%	14.7%	41.2%	0%
IDEC	50.0%	11.8%	38.2%	0%
Evaporative condensing	55.2%	13.8%	31.0%	0%
Any one of three	35.3%	5.9%	58.8%	0%

The most remarkable finding from these results is that the percentages of self-reported adopters are already much higher than the market share model's estimates, even for the aggressive promotion scenarios. They are also orders of magnitude higher than the current market share for these technologies.

Even allowing for the fact that the results are based on a small sample, the differences are noteworthy. The reported adoption rates confirm a picture of the market that has also emerged from focus groups and Delphi interviews. As a group, HVAC contractors are relatively well informed about the existing cooling technologies on the market, including evaporative cooling technologies. Many contractors specify indirect evaporative technologies once in a while but few do so with any regularity.

For existing technologies, at least, the adoption rates will not be increased by merely improving information dissemination, but only after a number of serious performance issues have been addressed. But it is precisely the flow of information and the transfer of awareness that the adoption process model and the related Bass diffusion model are designed to show. Thus, we concluded that estimating adoption process models would not be an informative exercise for the technologies currently on the market.

For modeling purposes, we considered the scenario in which a new generation of evaporative cooling technologies comes out that is quite different from what contractors envision when they say they currently specify or install IEC, IDEC, or evaporative condensing. For this scenario, we assumed that the new generation would have product and market characteristics reasonably similar to those used in the market share models, thus allowing us to use those results in developing adoption process model inputs. For the scenario proposed, everyone would initially be unaware of the new technologies, making the initial value of UNAWARE equal to 100% of the population, and initial values of the remaining states zero.

TRANSITION PROBABILITIES

Transition probabilities were largely based on a series of technician survey questions relating to past experience adopting a new technology. Respondents were first asked to think of a specific recent innovation in HVAC technology or equipment, regardless whether they currently offer or promote it to their customers. With a specific example in mind, respondents were then asked a series of questions, including

- When they first heard about the technology
- When they first started actively researching it
- How long they spent researching it
- Whether they had ever reviewed their initial adoption or rejection decision

Unaware-aware (u). Since this parameter reflects hypothetical levels of information dissemination from future program activities and other market events, we tested values ranging from 0.1 to 0.5; that is, we considered scenarios in which communication initiatives reached between 10% and 50% of the pool of unaware HVAC contractors in any given year.

Aware-evaluate (w). To determine a plausible value for this parameter, we reviewed respondent reports of elapsed time from when they first became aware of a new technology to when they started researching it. We found that 70% of valid responses were one year or less, equivalent to a transition probability at 0.7.

Evaluate-adopt/reject (v_1+v_2=v). Before determining separate transition probabilities for adoption and rejection, we first estimated a joint probability of transitioning from the evaluation stage to either the adoption or rejection stage. To do so, we compared responses to three questions:

- When respondents first started researching a new technology
- How long they spent researching it
- When they decided to adopt or reject it

Many respondents reported making this transition in little or no time. Everyone reported making it in a year or less. Thus, we set the transition probability v equal to one.

Evaluate-adopt (v_1). We determined v_1 by noting that the adoption process model predicts that the distribution of potential adopters will eventually converge to a steady-state distribution of adopters, rejecters, and evaluators. The ultimate share represented by adopters is determined by v_1. We then made note of the choice model results, which showed that, depending on the specific technology and market intervention, ultimate market share could range from 10% to 50%. We thus tested values for v_1 ranging from 0.1 to 0.5.

Evaluate-reject (v_2). Given values for v and v_1, we then calculated v_2 as the complement of the adopters, (i.e., $1 – v_1$).

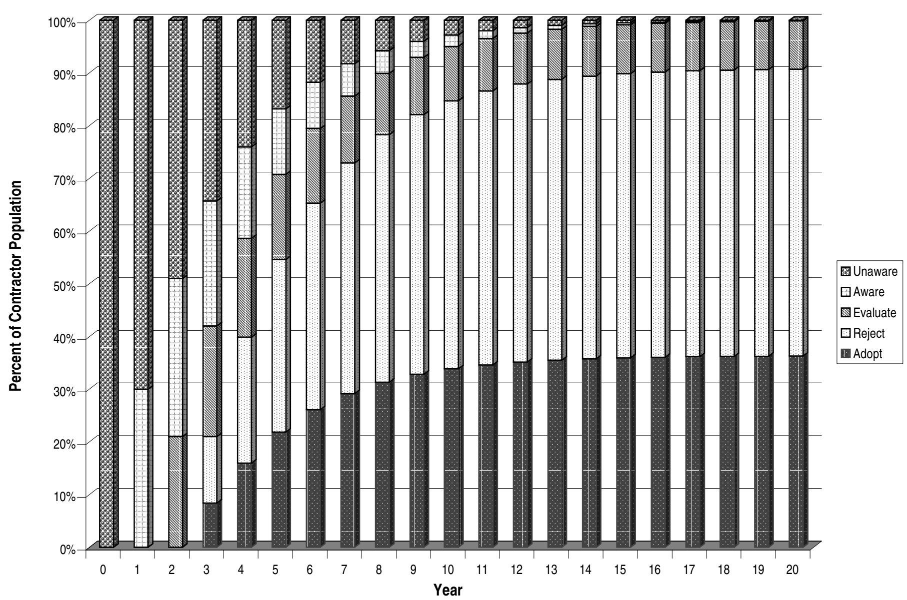
Adopt/reject-evaluate (r). Finally, we set a parameter for reevaluation. To do so, we noted that the steady-state fraction of the population in the evaluation stage is determined by the ratio $r / (r + v)$. Survey results showed that 50% of respondents reevaluated their adoption decision at some point (not necessarily every year) so we took 0.5 as the upper bound for the ratio. We further noted that, in the previously described line of questioning about evaporative cooling, shown in Table 9, no one reported being in the process of evaluating a technology. This observation led us to conclude that the annual rate of reevaluation is likely much less than 50%. We tested values for r between 0.1 and 0.2 as being the most plausible, given the available evidence.

MODEL RESULTS

We focused our analysis of model results on pinpointing factors that drive the rate of adoption. The choice models described above produce estimates of ultimate market share, which the adoption process models incorporate. The adoption process models do not provide an independent estimate of market share.

To test the effect of varying different parameters on the rate of adoption, we took as our measure the projected time lapse until adoption reached 50% of its ultimate level. It can be shown that the parameters v1, v2, and r, which determine the ultimate distribution of adopters, rejecters, and evaluators, do not affect the rate of adoption. Thus we focused our inquiry on the parameters u and w. Figure 15 shows projected adoption rates, with u set to the midpoint of what we consider to be the plausible range (0.3) and w set to our best estimate (0.7). To aid in making comparisons, we fixed v_1, v_2, and r for this and the following figures at 0.4, 0.6, and 0.1, respectively. We set v_1 near the high end of plausible values indicated by the choice models to better illustrate the effects of varying u and w on the rate of adoption. Given these parameters, the model projects convergence to a steady-state population made up of 9.1% evaluators, 36.4% adopters, and 54.5% rejecters. The model predicts half of ultimate adopters (18.2% of the total) will do so by year five.

Figure 15. Adoption Process, u = 0.3, w = 0.7



Effect of Varying u

To test the effect of varying u (i.e., modifying the assumed rate of transition from unawareness to awareness), we developed adoption projections with u set to what we considered the upper and lower bounds of plausibility, holding other transition probabilities constant. Figure 16 shows results for u = 0.1 and Figure 17 shows results for u = 0.5.

Figure 16. Adoption Process for Lower Bound u = 0.1

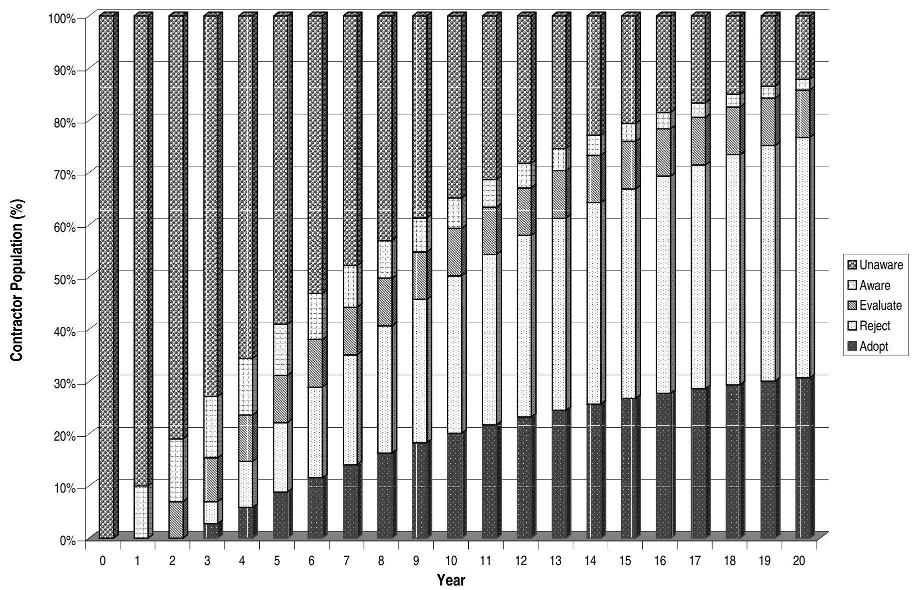
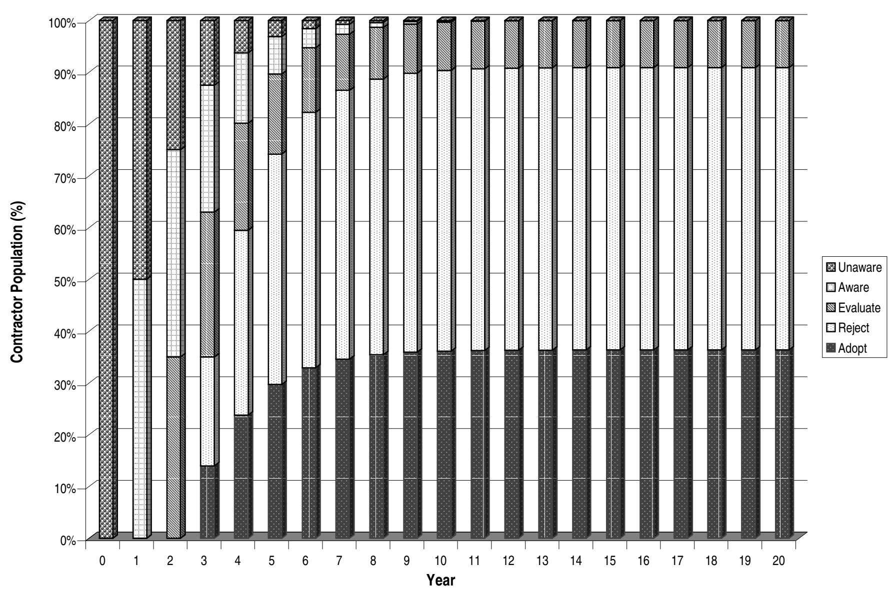


Figure 17. Adoption Process for Upper Bound u = 0.5



Input parameters for figures 14 and 15 were both set to produce ultimate adoption levels of 36.4%. However, the adoption process in Figure 16 does not surpass the midpoint (18.2%) until year nine, whereas the process in Figure 17 surpasses the midpoint in year four. The effect of u on adoption rates is summarized in Table 10.

Table 10. Effect of u on Adoption Rate

Unaware-Aware Transition (u)	Year of Adoption Midpoint (18.2%)
0.1	9
0.3	5
0.5	4

One conclusion clearly evident from Table 10 is that the effect of changing u is not linear. A 20 percentage point increase from 0.1 to 0.3 produces a large acceleration in adoption, whereas a 20 percentage point increase from 0.3 to 0.5 produces a small acceleration.

Effect of Varying w

To test the effect of varying w (i.e., modifying the assumed rate of transition from awareness to evaluation), we developed adoption projections with w set to what we considered the upper and lower bounds of plausibility, holding other transition probabilities constant (u was held fixed at 0.3, consistent with the Base model shown in Figure 15). Figure 18 shows results for w = 0.4 and Figure 19 shows results for w = 1.0.

Figure 18. Adoption Process for Lower Bound w = 0.4

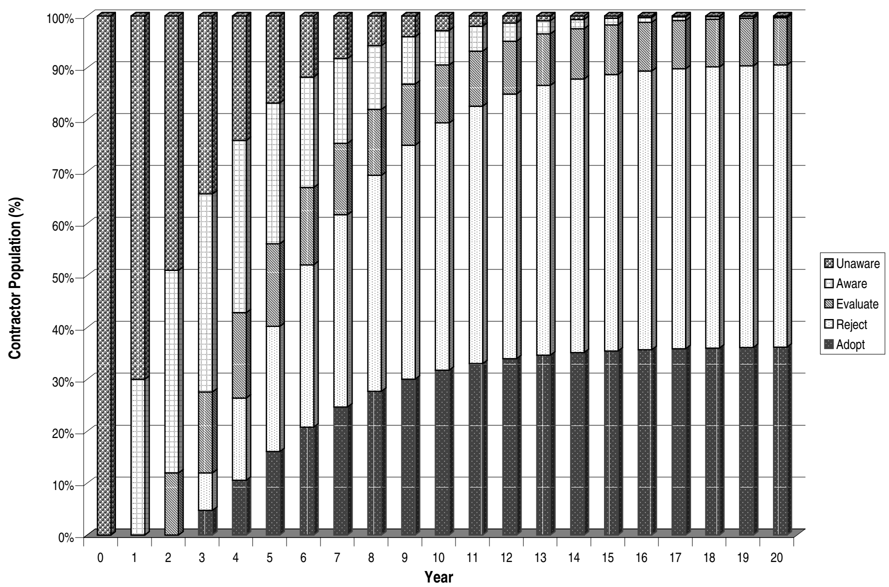
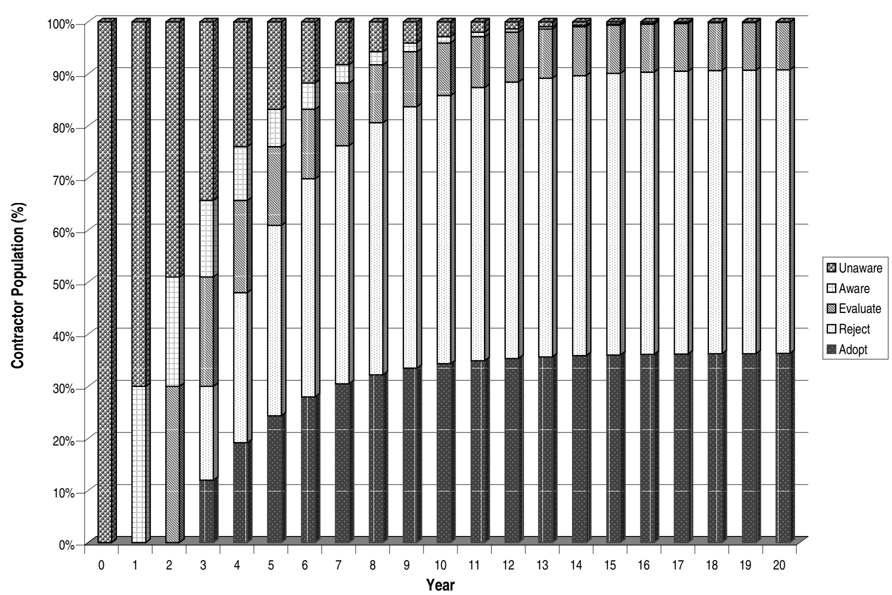


Figure 19. Adoption Process for Upper Bound w = 1.0



The adoption process in Figure 18 does not surpass the midpoint (18.2%) until year six, whereas the process in Figure 19 surpasses the midpoint in year four. The effect of w on adoption rates is summarized in Table 11.

Table 11. Effect of w on Adoption Rate

Aware-Evaluate Transition (w)	Year of Adoption Midpoint (18.2%)
0.4	6
0.7	5
1.0	4

In contrast to the results from varying u, Table 11 shows only marginal acceleration in the overall adoption rate from fairly large variations in w. The difference can be attributed to the adoption rate's nonlinear response to variations in the transition parameters. The plausible range for w is fairly high, centered around 0.7, whereas the range tested for u is much lower, centered around 0.3. Of course, one must keep in mind that the range for w is based on empirical, albeit imprecise, data, whereas the range for u reflects speculation about a hypothetical program. Nevertheless, the results support the general conclusion that when introducing a new natural cooling technology program, communication elements should focus on developing basic awareness as the most effective way to accelerate adoption. As long as the promoted technology offers some promise of benefits to HVAC contractors and their clients, they will tend to move quickly through the evaluation and decision states on their own.

CONCLUSIONS

Two general conclusions can be drawn from the adoption process model analysis. First, as a group, HVAC contractors are relatively well informed about the existing cooling technologies on the market, including evaporative cooling technologies. Many contractors specify indirect evaporative technologies once in a while but few do so with any regularity. For these existing technologies, the adoption rates will not likely be increased by merely improving information dissemination. Rather a number of serious performance issues must be addressed that currently discourage contractors from specifying or recommending indirect cooling technologies with any regularity.

Second, information dissemination will be very important for any initiative that promotes new technologies (or improvements to existing technologies) with which most contractors are unfamiliar. Under this scenario, establishing initial awareness will be most critical to rapid overall adoption rates. Available evidence suggests that HVAC contractors quickly evaluate new technologies they become aware of and even more quickly decide whether they and their clients are likely to benefit from the technologies.

8 DIFFUSION MODEL RESULTS

MARKET POTENTIAL

As described previously in Chapter 2 (Methodology), we estimated the market potential as a function of three quantities:

- Cumulative market population (P):
- Technical potential (T)
- Economic potential (E)

Cumulative Market Population (P)

For the commercial sector, we developed estimates for the cumulative market population (P) from PG&E's *Commercial Building Survey Report* (1997), which summarizes commercial end-use survey data collected in 1993. To maintain consistency with research design assumptions for this project, we included only commercial premises with packaged electric cooling. We also excluded premises in the coastal climate zone. To derive cumulative market population estimates for the year 2000, we applied an annual growth rate of 3.6% per year, which is consistent with documented growth from 1982 to 1993. Table 12 documents the number of commercial premises, by climate zone, from the *Commercial Building Survey Report*; the fraction of those buildings with packaged electric cooling; and estimates of cumulative market population in 2000, after applying the packaged electric cooling fraction and the annual growth factor.

Table 12. Commercial Cumulative Market Population

Climate Zone	Total Number Premises (1993)	Premises with Packaged Electric Cooling (%)	Cumulative Market Population (2000)
Desert/mountain	52,600	88%	58,891
Valley	60,800	75%	58,016
Hill	100,000	75%	95,421
Total	213,300	78%	212,328

For the residential sector, we developed estimates for the cumulative market population (P) from PG&E's *Residential Natural Cooling Project Report* (Hunt and Elberling 1998). Data sources for the population statistics cited in that report are not known. To maintain consistency with research design assumptions for this project, we included only residential premises with mechanical cooling. Again, we excluded residences in the coastal climate zone.

From the *Residential Natural Cooling Project Report,* we adopted estimates of the number of PG&E residential customers, by climate zone, in 1998; the growth rate in the residential sector; the fraction of new homes with mechanical cooling; and the fraction of existing homes with central or window DX air conditioning or direct evaporative cooling (52%). Table 13 documents the number of residences, by climate zone; the growth rate; the fraction of new homes with mechanical cooling; and estimates of cumulative market population in 2000, after applying the mechanical cooling fraction and the annual growth factors.

Table 13. Residential Cumulative Market Population

Climate Zone	Number of Customers (1998)	Customer Growth Rate	New Homes with A/C (%)	Cumulative Market Population (2000)
Desert/mountain	650,000	1.2%	100%	346,161
Valley	1,255,917	1.5%	95%	671,822
Hill	1,652,013	1.2%	50%	869,386
Total	3,567,930	1.3%	75%	1,891,648

Technical Potential (T)

As described in Chapter 2, we calculated the technical potential as the fraction of existing building stock expected to replace its cooling system in any given year plus the volume of new construction; that is

$$T_j = P_j \bullet R + C_j \tag{2}$$

Where P_j is the market population in year j, R is the rate of cooling equipment replacement, and C_j is the number of new buildings constructed in year j.

For both residential and commercial applications, we took the replacement rate for old systems to be 5% per year (20 year life), consistent with assumptions from the *Residential Natural Cooling Project Report 1998*. Applying the estimates of technical potential to the cumulative market population, we arrived at "technical market penetration;" that is, the market penetration expected to occur if the entire technical potential were realized. Commercial results are shown in Table 14; residential results are shown in Table 15.

Table 14. Commercial Technical Market Penetration

Year	Commercial Market Population	New Construction	Technical Market Penetration
2000	212,328	7,431	18,048
2001	219,760	7,692	18,680
2002	227,451	7,961	19,333
2003	235,412	8,239	20,010
2004	243,651	8,528	20,710
2005	252,179	8,826	21,435
2006	261,005	9,135	22,185

Table 15. Residential Technical Market Penetration

Year	Residential Market Population	New Construction	Technical Market Penetration
2000	1,887,369	18,944	113,312
2001	1,906,313	19,161	114,477
2002	1,925,474	19,382	115,655
2003	1,944,856	19,605	116,847
2004	1,964,460	19,831	118,054
2005	1,9874,291	20,059	119,274
2006	2,004,350	20,291	120,508

Economic Potential (E)

As described in Chapter 2, we estimated economic potential as the fraction of the market expected to adopt, based on economic choice factors. Economic potential estimates for various scenarios were developed using choice models, the results of which are described in Chapter 6.

Selected choice model results are summarized in Table 16, below. Results are documented for the three technologies examined: in the residential sector, AC2 (an evaporative condensing unit); in the commercial sector IEC and IDEC. For each technology, market share estimates are shown for two scenarios: the first assuming the technology has been in the field at least eight years; the second assuming that warranties for evaporative cooling are longer than for competing technologies. Both sets of assumptions address performance uncertainties, given the additional assumptions that any true performance issues have been resolved and awareness of the technologies' performance characteristics among HVAC contractors is 100%.

Table 16. Economic Market Potential (Selected Results)

Technology	8 Years in Field	Extended Warranty
Residential: AC2	15.1%	18.3%
Commercial: IEC	13.6%	14.9%
Commercial: IDEC	38.9%	42.8%

Applying the estimates of economic potential to the technical market penetration estimates, we arrived at "economic market penetration;" that is, the market penetration expected to occur if the entire economic potential were realized. Table 17 summarizes the estimates for the commercial sector (IEC and IDEC combined); Table 18 summarizes economic market penetration estimates for the residential sector (AC2 only).

Table 17. Commercial Economic Market Penetration

Year	Technical Market Penetration	Economic Market Penetration	
		8 Years in Field	Extended Warranty
2000	18,048	9,475	10,414
2001	18,680	9,807	10,778
2002	19,333	10,150	11,155
2003	20,010	10,505	11,546
2004	20,710	10,873	11,950
2005	21,435	11,253	12,368
2006	22,185	11,647	12,801

Table 18. Residential Economic Market Penetration

Year	Technical Market Penetration	Economic Market Penetration	
		8 Years in Field	Extended Warranty
2000	113,312	17,110	20,736
2001	114,477	17,286	20,949
2002	115,655	17,464	21,165
2003	116,847	17,644	21,383
2004	118,054	17,826	21,604
2005	119,274	18,010	21,827
2006	120,508	18,197	22,053

Coefficients of External and Internal Influence

Two factors led us to the conclusion that estimating diffusion curve parameters (the coefficients of external and internal influence, p and q, respectively) would be an unproductive exercise. First, model inputs were subject to large degrees of measurement uncertainty and possible bias. Both the choice model and adoption process model results were compromised by the small size of the technician sample. Adoption process model results were further compromised by their derivation from a single-purchase form of the model, which is generally appropriate for purchases of durable goods but not well suited for repeated recommendation or specification of durable goods.

By itself, uncertainty in the input values would not have dissuaded us from estimating diffusion curve parameters. We recognized at the outset of the project that model inputs would be vulnerable to measurement uncertainty simply because we were trying to develop estimates of changes over time from measurements made at a single point in time. Despite the potential for measurement uncertainty and bias, we considered it worthwhile to illustrate how the inputs could ultimately be used to forecast evaporative cooling adoption.

The second factor that dissuaded us from estimating diffusion curve parameters was the realization that the modeling approach described here appears overly simplistic. It assumes awareness to be the limiting factor in the adoption rate and it assumes that the word-of-mouth communication regarding the technology is uniformly positive. These assumptions are implicit in both the adoption process model and the diffusion curve specification (equation 1). In practice, it appears that performance uncertainties are the dominant barriers to adopting evaporative cooling technologies, and these barriers impede adoption by generating negative word-of-mouth communication.

A more refined approach should explicitly consider the effect of both positive and negative communication. One source for guidance in this area is Mahajan, Muller, and Kerin (1984), which describes a version of the adoption process model that incorporates positive and negative word-of-mouth communication. A second source, Kalish and Lilien (1986), describes a method for incorporating positive and negative market feedback into the Bass diffusion curve.

9 CONCLUSIONS AND RECOMMENDATIONS

As previously indicated, this study adopted a number of limitations in scope relating to technology, geography, and market segment. Our primary technology restriction was to focus on indirect evaporative cooling technologies in general (excluding direct evaporative cooling and other cooling techniques such as roof spraying and desiccant cooling) and, when greater specificity was called for, on the following three technologies:

- Indirect evaporative cooling
- Indirect/direct evaporative cooling
- Evaporative condensing

Direct evaporative cooling was excluded because available evidence indicated the market for this technology is mature; that is, the technology does not present a notable market transformation opportunity. Other technologies were excluded to avoid diluting research resources and to focus on the technologies that appear to offer the greatest promise for market transformation.

Existing applications of the three technologies listed above are primarily designed for residential and small commercial applications in which a packaged or split system would be appropriate. Thus our attention gravitated toward these unitary systems. However, our emphasis on unitary systems is not meant to imply that the technologies are not applicable to engineered or built-up systems.

Geographically, we focused our data collection on the PG&E service territory, excluding the coastal areas. The area of focus covered virtually all the interior regions of northern California, including the Central Valley, the Sierras, and the inland portions of the coastal range. Our focus on the interior regions was driven by the determination that evaporative cooling technologies are most widely applicable in hotter, drier climates. Nevertheless, depending on individual building characteristics, suitable applications almost certainly exist even in coastal climates.

We directed our quantitative data collection efforts to technicians; that is, HVAC contractors. This direction emerged from the focus group discussions with technicians and with building owners (both residential and commercial), which indicated that building owners rely heavily on their contractors for advice regarding specific technology choices. Building owners certainly set the general project parameters and control the purse strings, but we concluded that the technicians exert the primary influence on the ultimate selection decision. Of course, quantitative data collection was complemented by qualitative data collection, in the form of focus groups, Delphi interviews, and manufacturer interviews, to provide a comprehensive picture of the market.

Finally, the choice models and Delphi interviews required detailed specification of market circumstances to develop market penetration estimates. Maintaining a tractable data collection process required an additional restriction in scope. For these two analytic efforts, we considered only evaporative cooling installation as part of new construction projects. We focused on new construction because these projects pose fewer structural limitations on equipment selection and because the selection process can be more deliberate. Focus group discussions of replace-on-burnout situations indicated that equipment tends to break down when it is in use (i.e., in hot weather). Replacement with a working unit was seen as fairly urgent, with little time for consideration of innovative cooling technologies.

Major Issues Arising from the Study

Our research into the dynamics of the market and the barriers that inhibit adoption of indirect evaporative cooling technologies has produced a number of findings, which can be summarized as follows:

- Indirect evaporative cooling market share is very small and correspondingly difficult to quantify.
- Technicians play a key role in cooling equipment specification. Their endorsement is critical (though not necessarily sufficient) for indirect evaporative cooling technologies to gain greater market success.

- Credible channels for communicating with technicians include manufacturers, equipment vendors, trade journals, and word-of-mouth communication from other technicians.
- While building owners play a more passive role in cooling technology selection, their endorsement is also important, since they control the purse strings.
- In general, concerns about equipment performance and reliability are important factors in technicians' recommendations.
- Market barriers relating to performance uncertainties appear to be the most important impediments to adoption of evaporative cooling.
- To minimize concerns about performance and callbacks, technicians report favoring products from well-established manufacturers with a long track record and a demonstrated willingness to stand behind their products.
- Expert panelists expect very little increase in market penetration without program intervention.

In general, indirect evaporative cooling makes up such a small fraction of the overall market that quantification of its actual market share is problematic. Direct evaporative cooling comprises a measurable, though still small, fraction of the overall residential market. However, existing HVAC market share data sources do not provide data of sufficient detail to measure indirect evaporative cooling as a distinct category.

Technicians play a key role in cooling specification. Their endorsement is critical (though not necessarily sufficient) for indirect evaporative cooling technologies to gain greater market success. Building owners play a more passive role in cooling technology selection. They set general parameters and budgets and have final veto authority, but their selection decision is bounded by the recommendations they get from their contractors. Their own research tends to focus on the selection of a contractor rather than an independent assessment of the technology choices offered or available.

Market barriers relating to performance uncertainties appear to be the most important impediments to adoption. These barriers are partly attributable to negative associations with direct evaporative cooling and partly attributable to true shortcomings in equipment performance, at least in the past.

The term "evaporative cooling" clearly has negative connotations for a large segment of the market, judging from focus group discussions and choice model results. In response to choice model questions, approximately half the technicians reported their ranking of a particular cooling system would go down if they learned that it was an evaporative system. They cited a number of concerns with evaporative cooling relating to comfort and maintenance issues, among others. Clearly, the performance characteristics respondents associate with the term evaporative cooling are worse than those we attributed to evaporative cooling in our modeling. Our model attributes were developed to reflect actual equipment attributes, leading us to the conclusion that the perception of evaporative cooling is worse than the reality. Nevertheless, anecdotal evidence from Delphi panelists and PG&E's previous case studies suggest the concerns are not entirely unfounded.

Delphi panelists generally agree some type of market intervention would be necessary to stimulate a noticeable increase in market penetration. However, program interventions designed only to raise levels of general awareness are expected to have minimal effect. Those interventions designed to reduce performance uncertainties are considered to have the best prospects of success. The median panelist sees the moderate intervention scenario as increasing penetration to no more than 5% (in the residential sector) or 6% (in the commercial sector). Under the aggressive scenario, the median participant anticipates greater gains, but still a limited market share—to 8% in the residential sector and 12% in the commercial sector. One positive sign is the fact that only one of the panelists expects a drop in market share once the interventions are removed. In other words, the majority of those consulted believe that the penetration levels attained will persist after the program ends.

Methodology Recommendations for Future Studies

The present study offers a methodologically sound approach for analyzing markets for both descriptive and prescriptive purposes. The combination of a thorough literature review with primary data collection from a variety of market actors provides a comprehensive picture of current and historical market conditions. The modeling techniques employed can provide a realistic assessment of likely future market conditions and a means for testing hypothesized effects of various market intervention strategies.

Nevertheless, this study suffers from a number of limitations that bear mentioning. Most fundamentally, the study is limited by its design as a "snap-shot" at a single point in time. This limitation was recognized from the outset. The project was conceived to establish a framework for measuring markets over time and forecasting market trends. Inferred and extrapolated time-series data were used to illustrate the application of the proposed methods. However, they were not expected to provide rigorous documentation of actual and future market conditions. The reader should continually bear in mind that the modeling techniques, to produce robust results, require repeated data collection over several time intervals.

The study is also limited in that we had to commit to a set of model specifications and supporting data collection design before we were able to fully explore the market dynamics. Further research identified ways in which the adoption process and diffusion model specifications relied on unsupportable assumptions. The five-state evaluate-adopt model was chosen for the adoption process specification because it is generally appropriate for one-time purchases of expensive technologies, such as HVAC equipment. While this specification would be appropriate for modeling building owners' adoption processes, preliminary results led us to shift our attention to HVAC contractors because they appear to be the critical decision makers. For this group, the model specification may not be best suited to modeling the adoption process because contractors are faced with an adoption decision every time they specify equipment for a project.

The diffusion model specification described here also relies on unsupported assumptions. It assumes awareness to be the limiting factor in the adoption rate and it assumes that the word-of-mouth communication regarding the technology is uniformly positive. A more refined approach should explicitly consider the effect of both positive and negative communication. One source for guidance in this area is Mahajan, Muller, and Kerin (1984), which describes a version of the adoption process model that incorporates positive and negative word-of-mouth communication. A second source, Kalish and Lilien

(1986), describes a method for incorporating positive and negative market feedback into the Bass diffusion curve.

Recommendations for Program Design and Implementation

Our most basic recommendation for program design stems from the finding that current evaporative cooling technologies may still suffer from performance problems, independent of market actors' perceptions. Any remaining performance issues should be thoroughly worked out (at least to the point that installing evaporative cooling presents no greater risk to the contractor or building owner than installing conventional systems) before attempting to promote widespread market adoption. Aggressive promotion of a poorly performing technology runs the risk of generating or reinforcing negative perceptions and thus undermining the long-term prospects for adoption. The following quote, taken from Kalish and Lilien (1986), illustrates this point succinctly:

> We rushed to the market with a new product because it was clearly a superior technical device. We wanted to grab market share quickly. But reliability was awful. Our share peaked at fourteen percent and is now down below eight percent, while we should have had thirty or thirty-five percent of the market. A six month delay in introduction to iron out the bugs would have done it. (Computer peripherals executive, quoted in Peters and Waterman, 1982, p. 179)

Program designers should focus on fully field-testing any equipment the program endorses. Before promoting a technology market-wide, the program should be completely confident that advertised performance characteristics are consistent with the actual field performance characteristics; that instructions for installing, operating, and maintaining equipment are crystal clear and achievable in the field; that the equipment will perform reliably once it is installed; and that high-quality, responsive support services are available in those (hopefully) rare instances when they are needed. In short, the program should be confident that the market's experiences with the equipment will be uniformly positive.

As part of program design, it would be useful to supplement the analysis presented in this study with an assessment of the cost-effectiveness of the programs considered. This would entail estimating the costs of the interventions described and comparing them with the net benefits of the increased penetration under alternative market intervention scenarios. In conducting this analysis, it may be useful to consider a range of cost-effectiveness estimates, using the results of both the most optimistic and the most pessimistic market penetration projections.

Once evaporative cooling technologies are ready for full-scale market adoption, a number of recommendations for program design and implementation can be distilled from the findings from the market characterization, adoption process modeling, Delphi interviews, and choice models. Taken together the findings can be summarized as follows:

- Do not focus only on increasing awareness of existing technologies.
- Rename new technologies to disassociate them from existing evaporative cooling.
- Form alliances with major manufacturers with long-standing name recognition and fully capitalized support infrastructure.
- Offer extended warrantees.
- Financial incentives may not be necessary to drive down purchase prices but may be useful in attracting attention and demonstrating the program's commitment to the technology.

Program interventions focusing only on increasing awareness appear to be of limited value. For existing technologies at least, those are not the primary barriers. This conclusion is borne out by comments from Delphi panelists, and from the adoption process models. The latter show high rates of self-reported awareness of existing indirect evaporative technologies among technicians, despite the fact that they specify or recommend these technologies only rarely.

Renaming new technologies to disassociate them from existing evaporative cooling (particularly DEC) may be warranted. This finding basically confirms the direction PG&E has already taken in calling its program "natural cooling" rather than "evaporative cooling." (The term natural cooling is also more inclusive.)

We believe forming alliances with major manufacturers will be an important component of any market transformation strategy. Involvement of a major manufacturer with a fully capitalized support infrastructure may help during the performance testing phase by sharing some of the burden for testing. During this phase, manufacturers' direct involvement should also help reconcile performance claims with in-field results. During the promotional phase, involvement of a manufacturer with long-standing name recognition and a solid reputation will help overcome any remaining concerns HVAC contractors might have about recommending evaporative cooling. Contractors report attaching significant importance to the manufacturer's reputation when considering a technology with which they lack direct experience.

In addition to manufacturer name recognition, the program can overcome contractors' concerns about equipment performance by offering extended warrantees. This finding is clearly supported by the choice model results and is consistent with previous program experience with related technologies.

The Wisconsin experience with high-efficiency furnaces is an illustrative example of the potential benefits of extended warrantees.[21]

> High-efficiency gas furnaces were available in the Wisconsin market in the early 1980s but sales were uncommon due to high cost, concerns about reliability and differences in installation practices compared to standard efficiency furnaces. Cooling the flue gases to extract more heat meant that potentially corrosive gases would condense on the heat exchanger, causing premature failure of a critical and safety related component. The sales and service industry was concerned about call backs, liability and warranty issues and was reluctant to sell high-efficiency equipment even to customers who wanted to reduce energy bills.

Part of the analysis that went into furnace program design determined that the manufacturers offered only minimal warranties. Thus, the risk was almost entirely on the installers. "As part of the requirements for inclusion in the [rebate] programs, utilities required manufacturers to provide adequate

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[21] Hewitt, D. (1999), "Case Study in sustainability. Residential gas furnaces in Wisconsin, 1982-1996." Northeast Energy Efficiency Partnerships, Inc. Lexington, MA.

warranties, especially on the vulnerable heat exchangers. Utilities also provided training and quality control inspections to ensure that contractors installed the new equipment properly." The Wisconsin program was wildly successful in that penetration reached the 90% level by the end of the program. Market penetration remains in the high 60s and 70s around the state (almost a decade later), which compares favorably with penetrations that have yet to cross the 50% point in Michigan (which has a very similar climate).

Beyond measures to address performance uncertainties, we also examined the potential role of financial incentives. On this issue, the results are more ambiguous. On the one hand, choice model results indicated that financial incentives could clearly be effective at increasing market penetration, at least for the price differentials we modeled for standard and efficient equipment. On the other hand, Delphi panelists did not attribute large market effects to financial incentives. On this subject, they were quite clear in emphasizing that, if financial incentives are offered, they should go to the building owner rather than the manufacturer. These findings, along with previous market effects research, leads us to conclude that financial incentives may not be necessary to drive down purchase prices but may be useful in attracting attention and demonstrating the program's commitment to the technology.

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APPENDIX B: SURVEY INSTRUMENTS

Focus Group Discussion Guide

Building Owners/Managers

I. Introduction (15 minutes)

- Overview of study context – cooling technologies
- Our client – PG&E
- Ground rules – open honest discussion, importance of hearing everyone's opinion, video/audio taping for research purposes only and so that I don't have to worry about taking notes now, colleague in back room taking notes. One person at a time, confidentiality, who I am.

II. Market Structure (60 minutes)

A. Thinking about HVAC equipment, cooling in particular, what sorts of events happen that trigger installation or replacement or even an addition to your systems? When would you decide to replace your system rather than expand or add on to their existing system? MAKE LIST

B. What is YOUR role in these situations? In other words, how involved, and in what ways, are you in the decision to install/expand/replace equipment? Who else is involved? Who has the final decision to purchase and install something like this? What sorts of protocols or processes are you required to conduct before the final decision is made? What I mean by that is some building managers are required by the owner to obtain three bids from different contractors – do any of you have to do anything like this? Who do you rely on to give you information, within your own company (i.e., maintenance staff)?

C. EXERCISE 1: What factors do you consider when selecting equipment? RANK ORDER OF IMPORTANCE. Okay, now, which one of these factors do you consider to be "most important"? Why?

D. If you heard of a new HVAC technology, what sorts of concerns would you have right off the bat? What kind of information would you need in order to determine whether you would try the new technology? Who would you look to and depend on for this information? Would you be more inclined to try the new technology, or would you wait for others to try it?

E. Where do you get the information you need to make those decisions? Who do you talk to? What kinds of publications or other sources do you look for? Why those?

F. Do you ever have to do research on technology options? How much time do you allocate for that research? Is there ever a circumstance where you have to spend more time researching other options than initially anticipated? When are you able to cut off your inquiries soon than anticipated? How do you know when to do so?

G. What kinds of information do you need that you have trouble finding? How could this information be made more accessible or more readily available to you when you need it? CHART (3 COLUMNS – TYPES OF INFORMATION, CURRENT SOURCES, OTHER OPTIONS AND COMMENTS ABOUT EACH)

III. Market Barriers (15 minutes)

A. Has anyone heard of "evaporative cooling"? What do you know about it? Do any of your buildings have an evaporative cooler, or have you considered installing an evaporative cooler in any of your buildings? PROBE

B. For those of you who manage properties, Do you ever use energy efficiency as a means for 'selling' the space? Do your tenants show interest in or ask for evaporative coolers when they are considering leasing space?

C. For those of you who own the space you occupy, have you looked into evaporative cooling technology for your buildings?

D. What concerns, and/or perceptions of evaporative cooling do you have? What is your overall opinion of this type of technology?

IV. Closing

- Thanks for coming. Appreciate feedback Use information to help design better programs.
- Any last comments?
- Incentives at the front.

Focus Group Discussion Guide

Residential Homeowners

I. Introduction (12 minutes)

- Overview of study context – cooling technologies
- Our client – PG&E
- Ground rules – open, honest discussion, importance of hearing everyone's opinion, video/audio taping to back analysis if necessary, colleagues in back room taking notes. One person at a time speaking, confidentiality and who I am.
- What part of the town/area they live in. How long ago they bought their home, what specifically attracted them to that home.

II. Market Structure (60 minutes)

A. Thinking about your air conditioners, what sorts of events would trigger you to decide that you need to replace or add on to your current system? Would there ever be an occasion where you would decide to expand or add on to your system? When would you decide to replace their system rather than expand or add? MAKE LIST

B. PICK SOMEONE "How did you decide which air conditioner you would install in your house? PICK SOMEONE ELSE "How about you?" Well, when you bought your home or your air conditioning system, how much input did you have into the kind of AC that was installed? In other words, how involved, and in what ways, were you involved in the decision to install your equipment? Who else was involved? (PROBE: builders, contractors, HVAC/appliance dealers) Did you end up accepting the recommendation offered or did you require a specific type of unit you had heard about elsewhere?

C. What factors do you consider when selecting air conditioning equipment? LIST. Okay, now, which one of these factors do you consider to be "most important"? Why?

D. Where would you go to find information to make these decisions? Who would you talk to? What kinds of publications or other sources would you look for? Why those? Did you actually do any of that when making your most recent purchase? How easy was it/would it be to get this information?

E. With respect to air conditioning, would you rely solely on your contractor or builder to provide you with information, or would you conduct any research on your own? Why is that? (In other words, what factors, if any, lead folks to do their own research? Is it just a question of trusting their contractor, or is there more? How would go about this research? How much time would you spend researching such a thing? How would you decide that you had enough?

III. Market Barriers (20 minutes)

A. Introduce "evaporative cooling" and ask them what they know about it – try to gauge their initial level of knowledge; does anyone have an evaporative cooler in their home? Or in a previous home? Do they know someone who has one? Has anyone ever had one and replaced it with a traditional compressor air conditioner? Or, has anyone had a traditional air conditioner and replaced it with an evaporative cooler? Were they presented with an option to install an evaporative cooler when their home was being built? Where have they learned about it?

B. As far as you can tell, what would be some of the benefits of this type of technology, if any? What would be some of the negative aspect of something like this?

C. What are the comfort issues with this technology – how does it compare to DX systems? Do they cool as well or do you think they would cool as well?

D. Looking at our list, how does evaporative cooling compare to other technologies with respect to our top five most important criteria? (LIST ON FLIP CHART)

IV. Closing

- Thanks for coming. Appreciate feedback Use information to help design better programs.
- Any last comments?
- Incentives at the front.

Focus Group Discussion Guide

Technicians

I. Introduction (20 minutes)

- Overview of study context – cooling technologies
- Our client – PG&E
- Ground rules – open honest discussion, importance of hearing everyone's opinion, video/audio taping for research purposes only and so that I don't have to worry about taking notes now, colleague in back room taking notes. One person at a time, confidentiality, who I am.

- What kind of HVAC systems and technologies do you typically recommend and install in your customer's buildings/homes?

II. Market Structure (60 minutes)

A. LIST: Thinking about HVAC equipment, cooling in particular, what sorts of events would trigger the installation, replacement or modification of a cooling system? For example, building a new building – obvious new construction. What else? When would one decide to replace their system rather than expand or add on to their existing system?

B. REFER TO LIST: What is YOUR role in these situations? In other words, how involved, and in what ways, are you in the decision to install/expand/replace equipment? Who else is involved? (probe: builders, end-user, engineers) How about others in your own company? Okay, what is the level of involvement from the (building owners/property managers) (home buyer/owner)?

C. Now I'd like to talk about the different factors that you consider when selecting equipment? What sorts of things do you take into consideration when choosing which system you will install? LIST

D. EXERCISE 1: SELECTION LIST AND RANKING Okay, now, which one of these factors do you consider to be "most important"? Why?

E. Where do you get the information you need to make those decisions? Who do you talk to? What kinds of publications or other sources do you look for? Why those?

F. If a new cooling technology came out, what kinds of concerns would you initially have? From who would you seek 'expert' opinion from about this technology? Who would you trust to provide reliable information? Do you consider yourself someone who would jump in try the new technology out, or would you wait and see if it was accepted by other customers? How would you go about finding out more information on the new technology?

G. Do you ever have to do research on technology options? How much time do you allocate for that research? Is there ever a circumstance where you have to spend more time researching other options than initially anticipated? When are you able to cut off your inquiries? How do you know when to do so?

H. What kinds of information do you need that you have trouble finding? How could this information be made more accessible or more readily available to you when you need it? CHART (3 COLUMNS – TYPES OF INFORMATION, CURRENT SOURCES, OTHER OPTIONS AND COMMENTS ABOUT EACH)

III. Market Barriers (15 minutes)

A. Has anyone heard of evaporative cooling? What is it? How does it work? Aren't there different kinds of applications for it? What do you think of evaporative coolers? Are they better than traditional air conditioners? How so/why not?

B. IF HEARD OF: have any of them specified it, installed it, monitored results?

C. Have you ever had one of your customers ask you about it? Do you offer this technology as an alternative to standard or DX systems?

D. What about liability issues? Is there anything about the evaporative cooling technology that would cause you to question its reliability – resulting in your having to return to repair or replace the cooler? Do you find that manufacturers are making good equipment? Do they stand behind it and provide good warranties? Are there any issues with the equipment that would deter you from recommending the technology to a customer that might otherwise be interested?

IV. Closing

- Thanks for coming. Appreciate feedback Use information to help design better programs.
- Any last comments?
- Incentives at the front.

PG&E Natural Cooling Study

Technician Survey
Recruiting

Interviewer: ______________________ Time Start: ______________________
Date: ____________________________ Telephone Number: ________________
Respondent: ______________________ Company:_________________________

A. INTRODUCTION

A1. Hi. I'm calling to speak to someone who does the design and estimation work for air conditioning? Would that be you?

- ❐ Yes (**GO TO A2)**
- ❐ No, not right person **(ASK 1a)**
- ❐ Refused **(THANK AND TERMINATE)**

A1a. May I please speak to the person who handles this?

- ❐ Yes → **WAIT FOR RESPONDENT AND SKIP TO A2**
- ❐ Not available **(Ask A1b)**

A1b. When would be the best time to back to speak with him/her?

_________________________________**(RECORD TIME AND ASK A1c)**

A1c. And, whom should I ask for when I call back?

_________________________________**(RECORD TIME AND TERMINATE)**

A2. My name is ________________. I'm calling because PG&E is looking into developing new air conditioning programs and I am interviewing contractors about the kinds of air conditioning equipment they specify. I realize that your time is extremely valuable, and would like to thank you for your input by offering you $30. Are you able to help me with this important research?

- ❒ Yes (**GO TO A3)**
- ❒ Refused **(THANK AND TERMINATE)**

NOTE TO INTERVIEWER: If respondent requests to verify the validity of the survey, read: "if you would like to verify the validity of our study, you may contact the PG&E Project Manager, Mary O'Drain at 415/973-2317." Then, send an email with respondent's name and their company to jenniferm@pcsyes.com so that we may let PG&E know.

A3. Great. Now, this study focuses on new construction, so I just need to confirm, did you complete at least 10% of your total sales last year in new construction?

- ❒ Yes (**GO TO A4)**
- ❒ No **(READ: This study focuses specifically on the new construction market, so we're really trying to focus on companies that primarily serve that sector. Thank you very much anyway" [TERMINATE]**

A4. Great. In order to complete our discussion, I need to either fax or email you some information for you to look over. May I please have your fax number?

Fax number/email address: ________________________**(SKIP TO A5)**

Don't have a fax or email→ Okay, I will mail the materials to you today. Let me just confirm your address: ____**(SKIP TO A5)**

A5. Now, I just need to schedule a time to call you back so we can go through the materials. Overall, the interview will take about 20 minutes, so when would be the best time to call you **(IF FAXING, TRY TO SCHEDULE FOR LATER THAT AFTERNOON OR NEXT DAY)**?

(RECORD DATE AND TIME)____________________________________(SKIP TO END)

- ❒ Refused **(RESPONDENT MY REFUSE AFTER THEY FIND OUT HOW LONG IT WILL TAKE → THANK AND TERMINATE)**

END

(READ) Great. I will get those materials out to you today, and call you back ______**(repeat day) at (time)**__ to discuss them. Once we complete the interview, I will send you a check for $30 as a token of our thanks for your input. Have a nice day.

FAX MEMO

1320 Solano Ave., Ste. 203
Albany, CA 94706
510.526.3123
PCS@PCSyes.com

To:	sample	**`Fax**	
From:	Lisa Morrison	**Date**:	06/18/99
Re:	Air Conditioning Study	**Pages:**	8
CC:			

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Dear Mr. Sample:

Thank you for agreeing to participate in this important study. The remaining pages of this fax include summaries of hypothetical air conditioning systems. There are three "cards" or "systems" on a page, with 9 systems being residential systems, and 9 systems total being about light commercial systems.

We will be ranking the residential systems separate from the commercial systems. The residential systems have card numbers that begin with "R" and commercial systems a "C". There are no "right" or "wrong" answers – we are merely trying to gain feedback on preferred system features that will allow PG&E to design better programs to suit your needs. So, please follow the simple instructions below, and we will phone you back to discuss your rankings. Also, if you have any questions at all about this study, please feel free to call me directly.

1. Review the systems and their features described on the "cards".

2. Then rank the RESIDENTIAL cards, from the one you would rank as the best and most preferred system for the installation situation, followed by the second best, until you find the least desirable system. You can record your rankings on the following table.

3. After you finish, please rank the COMMERCIAL cards in a similar way, and record the order (most preferred to least preferred) in the table on the next page.

We will call you today, **Friday** at **2:30pm** to discuss your rankings. I'll also ask you some additional questions about air conditioning systems, and then send you a check for $30 to thank you for your participation.

Rankings of Residential and Commercial

<u>Use this table to write in your rankings.</u>

Order	**Residential Card Number**	**Commercial Card Number**
Best, most preferred		
Second Best		
Third		
Fourth		
Fifth		
Sixth		
Seventh		
Eighth		
Least Preferred		

CARD NUMBER - R0201: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 12, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 3 years, with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 20% rebate off purchase price available

- -

CARD NUMBER - R0020: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 12, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 5% rebate off purchase price available

- -

CARD NUMBER - R0112: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 12, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 35% rebate off purchase price available

CARD NUMBER - R1222: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 13.5, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price no more than 10% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 13.5
- √ 35% rebate off purchase price available

- -

CARD NUMBER - R1100: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 13.5, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 3 years with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price no more than 10% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 13.5
- √ 5% rebate off purchase price available

- -

CARD NUMBER - R1011: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 13.5, cooling capabilities that meet residential comfort needs, no piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price no more than 10% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 13.5
- √ 5% rebate off purchase price available

CARD NUMBER - R2002: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 15, cooling capabilities that meet residential comfort needs, direct drain and some piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required four times per year, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 3 years or less with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price no more than 20% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 15
- √ 35% rebate off purchase price available

- -

CARD NUMBER - R2210: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 15, cooling capabilities that meet residential comfort needs, direct drain and some piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required four times per year, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price no more than 20% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 15
- √ 5% rebate off purchase price available

- -

CARD NUMBER - R2121: ***SITUATION*****: Air Conditioning Installation in New Construction, Residential Single Family, Medium Size, Located relatively near your office**

System Features:

- √ Split System, EER rating of 15, cooling capabilities that meet residential comfort needs, direct drain and some piping required

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required four times per year, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price no more than 10% more than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 15
- √ 20% rebate off purchase price available

CARD NUMBER - C0201: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 12, standard footprint, no piping required
- √ 45-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 3 years, with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 20% rebate off purchase price available

- -

CARD NUMBER - C0020: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 12, standard footprint, no piping required
- √ 45-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 5% rebate off purchase price available

- -

CARD NUMBER - C0112: **S*****ITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 12, standard footprint, no piping required
- √ 45-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required twice per year, neglected maintenance results in insufficient cooling capacity, but no further effects
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price comparable to standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 12
- √ 35% rebate off purchase price available

CARD NUMBER - C1222: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 30, footprint 10-20% more than standard, some piping required
- √ 45%-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required four times/year, neglected maintenance results in insufficient cooling capacity & some potential for water damage to building & cooling equipment
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 30
- √ 35% rebate off purchase price available

- -

CARD NUMBER - C1100: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 30, footprint 10-20% more than standard, some piping required
- √ 45%-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required four times/year, neglected maintenance results in insufficient cooling capacity & some potential for water damage to building & cooling equipment
- √ Equipment has been available and in the field for 3 years with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 30
- √ 5% rebate off purchase price available

- -

CARD NUMBER - C1011: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 30, footprint 10-20% more than standard, some piping required
- √ 45%-55% humidity achievable. Cooling capabilities that meet acceptable comfort standards (close temperature tolerance range) for all seasons

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required four times/year, neglected maintenance results in insufficient cooling capacity & some potential for water damage to building & cooling equipment
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 30
- √ 5% rebate off purchase price available

CARD NUMBER - C2002: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 25, footprint 10-20% more than standard, some piping required
- √ Internal humidity may be higher than standard (40%-70%) and temperature may exceed standard on hot days.

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 90 days
- √ Maintenance required monthly, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 3 years or less with multiple demonstration sites in your area with good performance

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 25
- √ 35% rebate off purchase price available

\- -

CARD NUMBER - C2210: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 25, footprint 10-20% more than standard, some piping required
- √ Internal humidity may be higher than standard (40%-70%) and temperature may exceed standard on hot days.

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 5 years
- √ Maintenance required monthly, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 4-7 years with good performance record

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 25
- √ 5% rebate off purchase price available

\- -

CARD NUMBER - C2121: ***SITUATION*****: Air Conditioning Installation in New Construction, Small/light commercial retail, restaurant, or office-type building, Located relatively near your office**

System Features:

- √ Packaged System, EER rating of 25, footprint 10-20% more than standard, some piping required
- √ Internal humidity may be higher than standard (40%-70%) and temperature may exceed standard on hot days.

Maintenance & Maker:

- √ Known, established brand
- √ Manufacturer provides warranty on all parts and labor for 2 years
- √ Maintenance required monthly, neglected maintenance results in insufficient cooling capacity, and some potential for water damage to building and cooling equipment
- √ Equipment has been available and in the field for 8 years or more with good performance record

Economics:

- √ Purchase price 10% less than low priced standard available packaged system meeting Title 24
- √ Relative operating costs associated with an EER Rating of 25
- √ 20% rebate off purchase price available

PG&E Natural Cooling Study

Technician Telephone Survey

Interviewer: ______________________ Time Start: ______________________

Date: ___________________________ Telephone Number: ________________

A. INTRODUCTION

Hello, may I please speak with **(CUSTOMER NAME)**? **[IF NAMED RESPONDENT IS NOT AVAILABLE ARRANGE A CALLBACK APPOINTMENT, RECORD AS INITIAL CALLBACK – DO NOT INTERVIEW ANYONE ELSE.]**

My name is ________________and I'm following up on the air conditioning study that **JENNIFER / LISA** spoke to you about yesterday **(OR X DAYS AGO).**

A1. **JENNIFER / LISA** should have sent you some materials about air conditioning systems. Did you receive them?

❒ Yes **(SKIP TO A2)**
❒ No **(ASK A1a)**

A1a. I'm sorry you didn't receive it. Let me just verify your **(MAILING ADDRESS / FAX NUMBER/EMAIL ADDRESS)** so we can forward another set to you.

VERIFY NUMBERS FROM RECORDS. INDICATE CORRECTIONS BELOW.

NAME:__________________________COMPANY______________________________
ADDRESS:_______________________CITY:______________ ZIP:_______________
FAX NUMBER: ___________________ EMAIL_________________________________

We will be sending you a new set of materials today. Please be sure to review these materials as soon as they arrive. It would also be helpful to keep them by the phone, since you will need to refer to them when we call back to complete the interview. I'd also like to schedule another time for a callback to discuss the materials. Would a call **[IF REFAXING OR EMAILING]** in an hour or so work for you? **[IF REMAILING]** tomorrow work for you? **[SCHEDULE FOR THEIR CONVENIENCE]**

SCHEDULE DATE:_______________________SCHEDULE TIME: ________________

Great. Thank you very much. **RECORD AS REMAIL/REFAX.**

A2. Have you had a chance to review the materials?

- ❒ Yes **(SKIP TO A3)**
- ❒ No → **(ASK A2a)**

A2a. The interview will take much less of your time if you are familiar with the material before we talk. So, would it be possible to call you back in an hour after you've had a chance to review the material?

RECORD AS CALLBACK – NOT YET REVIEWED
RESCHEDULE DAY/TIME: _______ **[try to reschedule a ½ hour - which will keep it in their mind]**

A3. Do you have the materials available so we can do the interview now?

- ❒ Yes **(SKIP to B1)**
- ❒ No **(ASK A3a)**

A3a. We really do need you to have the materials in front of you to do the interview. Can you get them now? **[IF CAN'T GET THEM NOW]** When would be a good time to call back and go over the materials with you?

RECORD AS CALLBACK – HAS REVIEWED
RESCHEDULE DAY/TIME: _______ **[TRY TO RESCHEDULE IN THE NEXT FEW HOURS]**

B. ADOPTION PROCESS

Okay, first I'd like you to think about the most recent innovation in HVAC technologies or equipment that you've heard of – whether or not it's one that you are currently offering or promoting to your customers. Can you remember one? ________________**(LET THEM THINK AND OFFER SOMETHING → SKIP TO B1)**

IF THEY CAN NOT THINK OF ANYTHING – THEN READ WITH THE FOLLOWING) For example, a geothermal heat pump or a pulse furnace.

B1. Which of the following best describes the degree to which ______**[technology]**___was available in the marketplace when you first became aware of it? **(READ)**

- ❒ Research and development stage (R&D)
- ❒ Initial field testing
- ❒ Project or prototype demonstrations
- ❒ Available through manufacturers, or manufacturer's reps
- ❒ Widely adopted technology
- ❒ Other: ____________________________

B2 When you first considered ______**(technology)**___ did you decide to include it with the other types of equipment you specify or install, did you reject it, or did you decide to wait and see?

- ❒ Adopted
- ❒ Rejected
- ❒ Decided to wait and see **(SKIP TO B6)**

B3. When did you first hear about it? ____

B4. When did you first start to actively research whether it would be good for your company to specify/recommend or install it? ____

B5. How long did you spend researching ____**[technology]**___ before you determined whether you would specify/recommend or install it? ____

B6. And about how long ago was it that you made your decision? ______________________

____

B7. Since you made your initial decision, have you ever reviewed it?

- ❒ Yes
- ❒ No
- ❒ Don't know

B8. **IF YES:** What led you to review the decision? ______________________________

____

B9. Based on your past experience reviewing **[technology]**, how inclined would you be to consider any new technologies that come out in the future? **(READ)**

- ❒ More inclined
- ❒ Less inclined
- ❒ About the same

C. Emerging Technology Information Flow

C1. To what degree would your decision whether to start recommending a new type of cooling equipment be determined by a concern about callbacks? Would you say that you would be…**(READ)**

- ❐ Extremely concerned
- ❐ Very concerned
- ❐ Somewhat concerned
- ❐ Slightly concerned
- ❐ Not at all concerned

C1a. Why do you say that?______________________________

C2. Typically, how often are you called back within the first year, to service a piece of equipment you installed? ______________________________

C3. Where is the first place you would go for information on this new line?____________________

(READ) Now I am going to read you a list of possible sources of information that you might use to keep current about emerging cooling technologies. For each one, please tell me if you use it.

C5. What specific sources do you rely on to keep current about emerging cooling technologies? **(READ, CHECK ALL THAT APPLY)**

	Yes	**No**
Colleagues/Contractors	❐	❐ **(SKIP C6)**
Trade journals	❐	❐
Internet	❐	❐
Distributors/Vendors	❐	❐
Manufacturers	❐	❐
Own R&D	❐	❐
Popular magazine ads	❐	❐
Newspapers	❐	❐
Trade Associations	❐	❐
Trade Shows	❐	❐
Local Utility	❐	❐
Other: ____________	❐	❐

C6. How often do you rely on colleagues and other contractors to keep current about emerging cooling technologies? **(READ)**

- ❒ All the time
- ❒ Most of the time
- ❒ Some of the time
- ❒ Rarely
- ❒ Never

C7. Do you currently belong to any trade associations?

- ❒ Yes → **(ASK C7a)**
- ❒ No **(SKIP TO SECTION D)**

C7a. Which trade associations do you belong to? **(DON'T READ. CHECK ALL MENTIONS)**

- ❒ AGC California
- ❒ American Academy of Environmental Engineers
- ❒ American Institute of Architects
- ❒ American Society of Civil Engineers
- ❒ ASHRAE
- ❒ Associated General Contractors. Of CA
- ❒ Association of Engineering Construction Employers
- ❒ Association of Plumbing & Mechanical Contractors
- ❒ Building Owner/Manager Association (BOMA)
- ❒ Builders' Exchange of Stockton, Inc.
- ❒ Building Industry Assn. of Ca.
- ❒ Ca. Assn. of Sheet Metal & A/C Contractors
- ❒ California Bldg. & Construction Trades Council
- ❒ California Building Industry Association
- ❒ California Society Prof. Engineers
- ❒ Electrical Contractors Assn., Inc.
- ❒ Insulation Contractors Assn.
- ❒ Mechanical Contractors Association
- ❒ National Electrical Contractors Assoc.
- ❒ Natl. Assn. of the Remodeling Industry
- ❒ Natl. Electrical Contractors Assn.
- ❒ Plumbing, Heating, & Cooling Contractors
- ❒ Sacramento Builders' Exchange, Inc.
- ❒ SMACNA
- ❒ Structural Engineers Association of CA
- ❒ Valley Builders Exchange
- ❒ Western Electrical Contractors Association
- ❒ Other: ____________________________

C8. Do you ever attend other training sessions, perhaps sponsored by trade associations, local utility or manufacturer?

- ❒ Yes
- ❒ No

D. Selection Criteria

Great. Let's look at the material we faxed you now, do you have it in front of you? **(WAIT FOR THEM TO CONFIRM AND CONTINUE)**

D1. Please turn to the instruction / answer sheet marked SMALL/LIGHT COMMERCIAL in the material that we sent you. Where you indicated the rankings of the cards, please read the number of the card you ranked as …**(RECORD IN TABLE)**:

Rank	**Record Card Number**
Best	
Second	
Third	
Fourth	
Fifth	
Sixth	
Seventh	
Eighth	
Ninth/last	

D2. Please turn to the instruction / answer sheet marked RESIDENTIAL in the material that we sent you. Where you indicated the rankings of the cards, please read the number of the card you ranked as …**(RECORD IN TABLE)**

Rank	**Record Card Number**
Best	
Second	
Third	
Fourth	
Fifth	
Sixth	
Seventh	
Eighth	
Ninth/last	

D3. Looking at your rankings for small commercial systems, would your rankings change if you knew that the system you ranked highest turned out to be an evaporative cooling system?

- ❒ Yes → **(ASK D3a)**
- ❒ No

D3a. How So? ____

____

____

D4. Now looking at your rankings for residential systems, would your rankings change if you knew that the system you ranked highest turned out to be an evaporative cooling system?

- ❒ Yes → **(ASK D4a)**
- ❒ No

D4a. How So? ____

____

____

E. Evaporative Cooling Equipment

Now I just I have a few questions on a specific type of equipment.

E1. Are you familiar with…**(READ)**

	Yes	**No (IF b, c, and d ARE "NO", SKIP TO SECTION F)**
(a) Direct evaporative coolers	❒	❒
(b) Indirect evaporative coolers	❒	❒
(c) Indirect/direct evaporative coolers	❒	❒
(d) Evaporative condensers	❒	❒

[READ] In the next few questions I will use the term indirect to refer to all cooling equipment that uses evaporative cooling process, except direct evaporative cooling.

E2. Which of the following types of evaporative cooling systems do you specify/recommend or install? **(READ, CHECK ALL THAT APPLY) (IF b, c, d, e, are 'yes' go to E4)**

	Yes	**No**
(a) Direct evaporative coolers	❒	❒
(b) Indirect evaporative coolers	❒	❒
(c) Indirect/direct evaporative coolers	❒	❒
(d) Evaporative condensers	❒	❒
(e) Other equipment that uses evaporative cooling process: __________	❒	❒

E3. From these statements, which of the following best describes you?

(e) I've heard of indirect evaporative cooling technologies, but I've never looked into them. **(SKIP TO SECTION F)**

(f) I'm currently looking into including indirect evaporative cooling technologies in the products I specify/recommend. **(SKIP TO E11)**

(g) I've looked into indirect cooling technologies, but decided not to specify or recommend them to my customers **(ASK 3a)**

(h) I've looked into indirect evaporative cooling technologies and intend to specify and recommend them to my customers. **(ASK 3a)**

E3a. Why?____

____**(SKIP TO E11)**

E4. About what percent of your total annual installations are *direct* evaporative coolers?____________

E4a. And what percent are *indirect or indirect/direct* evaporative coolers? ___________

E5. About how many evaporative coolers *other than direct* have you sold in the past year? __________

(If they don't know, PROBE: Would you say is was…)

_______ Less than 10
_______ 11-25
_______ 26 – 50
_______ 51 – 100
_______ More than 100

E6. Do you expect your installations of indirect evaporative coolers (everything but direct evaporative cooling) to increase, decrease or remain the same over the next two years? How about over the next seven years?

	Increase	Decrease	Remain the same
Two years:	❒	❒	❒
Seven Years:	❒	❒	❒

E6a. Why do you say that?____
____

E7. Have you encountered any kind of technological/performance *problems* with indirect evaporative coolers?

❒ Yes → **(ASK E7a)**
❒ No → **(SKIP TO E8)**
❒ Don't know/unsure→ **(SKIP TO E8)**

E7a. What type of problem(s)? ____
E7b. How have you addressed these issues?_____________________________________

E8. Have you ever had any trouble obtaining information about indirect evaporative coolers or evaporative cooler components?

- ❒ Yes **(ASK E8a)**
- ❒ No

E8a. What was the problem? ______________________________

E8b. How did you overcome this? ______________________________

E9. Have you ever had any trouble obtaining indirect evaporative coolers or evaporative cooler components for a project?

- ❒ Yes **(ASK E9a)**
- ❒ No **(SKIP TO E10)**

E9a. What was the problem? ______________________________

E9b. How did you overcome this?______________________________

E10. Can you tell me about what percent of the time you have found it impossible to replace a compressor unit with an evaporative cooler because of structural limitations? ____%

E11. As you see it, what are the benefits of evaporative cooling technology? ______________________________

____

E12. What are the drawbacks?______________________________

____

E13. In your opinion, what kinds of events or activities would encourage market growth for indirect evaporative coolers **[PROBE: MORE MARKETING, BETTER PRODUCTS, INCREASED AWARENESS FROM CUSTOMERS, REBATES]**? ______________________________

____

F. Company Profile

Lastly, I'd like to gather a little information about your company.

F1. Including yourself, how many staff members at your company are involved in designing, specifying, replacing, or installing air conditioning systems? _____

F2. How many years have you personally been practicing in the field? _______

F3. What specific types of cooling equipment do you install/specify? **(READ. CHECK ALL THAT APPLY):**

❒ (DX) Refrigeration Compressor
❒ Whole House fans
❒ Chilled water
❒ Heat pumps
❒ Other: ___________________

F4. Can you estimate how many total air conditioning jobs your firm did last year that are residential? And, how about small commercial? And, large commercial or industrial?

_______ Residential _______ Small Commercial ___ Large Commercial/Industrial

F5. What are the top three brands of cooling equipment you typically recommend or specify? **(DON'T READ, CHECK ALL MENTIONS)**

		Note order mentioned (1st ,2nd ,3rd)
❒	AAON	_______
❒	Addison	_______
❒	Allied-Signal	_______
❒	Amana	_______
❒	American Standard	_______
❒	Bryant Corp.	_______
❒	Carrier Corp.	_______
❒	Climate Master	_______
❒	Coleman-Evcon	_______
❒	Copeland Corp.	_______
❒	Dunham Bush	_______
❒	Governair	_______
❒	Heatcraft	_______
❒	Hussmann Corp	_______
❒	Johnson Controls	_______
❒	Liebert	_______
❒	Lennox Ind.	_______
❒	Mammoth	_______
❒	Parker Hannifin	_______
❒	Powered Aire	_______
❒	Rheem/Ruud Air Conditioning	_______
❒	Standard Refrigeration	_______
❒	Trane Corp.	_______

❐ York International ______

❐ Other:____

F6. Roughly what percent of your business is with repeat customers versus one-time buyers?

Repeat customers ______
One time buyers ______

END

(READ) That is all the information I am looking for today. I want to thank you very much for helping me on this important study. You can just recycle or throw away the materials we sent to you. Now, I just need to confirm your address so that I may send you your $30 check.

CONFIRM ADDRESS: ____________________________________

(READ) Great. You should receive it within one week. If you do not receive it, you can call Bruce Mast at 510/526-3123.

Thank you again for your input.

RECORD TIME END:______________

FAX MEMO

PCS
1320 Solano Ave., Ste. 203
Albany, CA 94706
510.526.3123
bmast@PCSyes.com

To:	SAMPLE	**Fax:**	916/732-0902
From:	Bruce Mast	**Date:**	06/29/99
Re:	Evaporative Cooling	**Pages:**	4

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☒ **Please Reply** ☐ **Please Recycle**

Mr. SAMPLE:

It was a pleasure to talk with you today about Pacific Gas & Electric's current research into market opportunities for emerging technologies involving evaporative cooling processes.

As we discussed on the phone, if you agree to participate, you will be part of a panel of industry experts who will be helping us estimate the likely market penetration of emerging evaporative cooling technologies, given different promotion scenarios.

This letter and accompanying materials describe in more detail the extent of the commitment we are requesting of you. As I indicated on the phone, if you are willing to participate in this study, Pacific Consulting Services will donate $250 in your name to the charity of your choice. Upon request, we will also send you a bound copy of the project final report, to be completed in late June.

Dr. Shel Feldman will coordinate panel activities and synthesize results. Enclosed, you will find a response form to use to indicate your willingness to participate, and a description of this research (including a time table). Upon receipt of the response form, we will fax you a more complete description of the assumptions to use in estimating market penetration and a form for recording your estimates.

Please do not hesitate to call if you have any further questions.

Sincerely,

Bruce Mast

Bruce Mast
Project Manager

FAX MEMO

1320 Solano Ave., Ste. 203
Albany, CA 94706
510.526.3123
bmast@PCSyes.com

To:	SAMPLE	**Fax:**	510/234-3629
From:	Bruce Mast	**Date**:	06/29/99
Re:	Evaporative Cooling	**Pages:**	6

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Mr. SAMPLE:

Thank you for agreeing to participate in this important research on evaporative cooling technology. Enclosed with this letter are tabulation instructions for completing the forecasting tables and forms for recording your projections. If you have any questions regarding this study, please call Dr. Shel Feldman at 608/836-7474, or you may reach him via email at **sfeldma2@itis.com**.

Sincerely,

Bruce Mast

Project Manager

Encl.

Research Description

Background

Pacific Gas & Electric Company (PG&E) is interested in assessing the potential benefits of promoting evaporative cooling technologies. This interest is spurred, in part, by recent legislation to deregulate the electric utility industry in California. As part of that legislation, all California utility customers are assessed a public benefits charge (PBC) on their utility bill. Part of the PBC money is earmarked for improving the efficiency of California's energy use. The utilities have been given responsibility for designing programs to accomplish this goal, to be funded through the PBC.

Before committing to full-scale promotion of evaporative cooling technologies, PG&E is conducting an initial market assessment to determine the prospects of success. PG&E has hired Pacific Consulting Services, in collaboration with Shel Feldman Management Consulting, to conduct the research. An important component of our analysis is to estimate the ultimate market saturation of evaporative cooling technologies that might reasonably be achieved by such a program.

Technologies of Interest

Indirect evaporative cooling. Evaporative coolers that use a vaporizer air flow with water to internally cool a heat exchanger upon which outside air is blown. The outside air is cooled by the exchanger without coming in contact with the water source. Indirect evaporative cooling units are currently manufactured by Spec-Air.

Indirect-direct evaporative cooling. Two-stage evaporative coolers that use an indirect cooling stage on the upstream side of a direct evaporative cooling stage. Residential package units are currently manufactured by Adobe Air, Inc. and CoolTech.

Evaporative condenser cooling. The standard direct-exchange air conditioning technology is modified by sending the refrigerant vapor from the compressor discharge through a condensing coil that is continuously wetted on the outside by a recirculating water system. Air is simultaneously directed over the coil, causing a small portion of the water to evaporate. The evaporation removes the heat from the coil, thus condensing the refrigerant vapor. Refrigeration Technologies, Inc. currently manufactures such a unit for the residential sector. Development of a similar unit for the commercial sector is under consideration.

Process

One of our goals is to develop reasonable estimates of the likely market penetration of emerging evaporative cooling technologies over the next seven years, given different promotion scenarios. We will use an iterative process to achieve this goal.

1. Recruit a panel of experts in cooling technologies, marketing, and market analysis.

2. Poll panelists for independent estimates of important quantitative data and the assumptions underlying those estimates.

3. Summarize the assumptions and compile all estimates and will communicate these results back to panel members.
4. Poll panelists for new estimates that take into account the thinking of their peers as well as their own initial thinking.
5. Compile the revised estimates and again communicate results back to panelist members.
6. Schedule and convene a conference call to review results and identify differences in assumptions as well as points on which panelists "agree to disagree."
7. Poll panelists for independent final estimates.

Promotional Scenarios

For the technologies described above, panelists will be asked to estimate the likely market saturation over time in both the residential and commercial new construction projects. Market saturation estimates will consider three scenarios:

Base Condition: No market intervention from publicly funded programs.

Intervention 1: Financial incentives to manufacturers for packaged units sold in Central California; ten publicly-funded demonstration projects, incorporating the technology into a range of residential and commercial building types, with detailed monitoring and testing over a three year period.

Year	Intervention
2000	Five demonstration projects (3 residential, 2 commercial) in year 1 of monitoring and testing
2001	Five demonstration projects (3 residential, 2 commercial) in year 2 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 1 of monitoring and testing;
2002	Five demonstration projects (3 residential, 2 commercial) in year 3 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 2 of monitoring and testing; Manufacturer incentive of $200/residential unit, $250/commercial unit
2003	Five demonstration projects (2 residential, 3 commercial) in year 3 of monitoring and testing; Manufacturer incentive of $200/residential unit, $250/commercial unit
2004	Manufacturer incentive of $200/residential unit, $250/commercial unit
2005	Manufacturer incentive of $100/residential unit, $125/commercial unit
2006	Manufacturer incentive of $100/residential unit, $125/commercial unit

Intervention 2: Financial incentives to manufacturers for units sold in Central California; fifteen publicly-funded demonstration projects, incorporating the technology into a range of residential and commercial building types, with detailed monitoring and testing over a three year period; publicly-funded promotional activities conducted at industry trade shows; training program involving Central Valley HVAC contractors and mechanical engineers, focusing on design, installation, and maintenance

issues; changes in California's Title 24 building codes or ASHRAE standards to better accommodate evaporative cooling and condensing as a strategy for meeting energy efficiency objectives.

Year	Intervention
2000	Ten demonstration projects (5 residential, 5 commercial) in year 1 of monitoring and testing
2001	Ten demonstration projects (5 residential, 5 commercial) in year 2 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 1 of monitoring and testing; Product displays at 2 trade shows; Training program for 50 HVAC contractors and engineers
2002	Ten demonstration projects (5 residential, 5 commercial) in year 3 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 2 of monitoring and testing; Manufacturer incentive of $300/residential unit, $500/commercial unit; Product displays at 2 trade shows; Training program for 100 HVAC contractors and engineers
2003	Five demonstration projects (5 residential, 5 commercial) in year 3 of monitoring and testing; Manufacturer incentive of $300/residential unit, $500/commercial unit; Product displays at 2 trade shows; Training program for 100 HVAC contractors and engineers
2004	Manufacturer incentive of $300/residential unit, $500/commercial unit; Training program for 50 HVAC contractors and engineers
2005	Manufacturer incentive of $150/residential unit, $250/commercial unit; Changes in equipment design standards and building codes
2006	Manufacturer incentive of $150/residential unit, $250/commercial unit

FAX MEMO

PCS
1320 Solano Ave., Ste. 203
Albany, CA 94706
510.526.3123
bmast@PCSyes.com

To:	SAMPLE	**Fax:**	608/836-3503
From:	Bruce Mast	**Date**:	06/29/99
Re:	Evaporative Cooling	**Pages:**	9

☐ **Urgent** ☐ **For Review** ☐ **Please Comment** ☐ **Please Reply** ☐ **Please Recycle**

Mr. SAMPLE:

Thank you again for your assistance in the first round of our Delphi group process for estimating the penetration of natural cooling technologies under different future scenarios.

We apologize for the delay in getting back to you: we experienced some difficulties in getting and clarifying all the responses, but we are now on track for finishing this project quickly.

At this time, we would like you to do the following:

- Review the summary of responses we received, including the assumptions that were provided to us

- Provide your best estimates of the total new construction markets for residential and for commercial buildings that may use cooling technologies.

- Provide your best estimates for the penetration of indirect evaporative cooling, indirect-direct evaporative cooling, and evaporative condenser cooling for each of the calendar years 2000-2006.

  We hope you will consider the estimates and assumptions of other experts as well as your own; however, we are most interested in what you believe is likely and we are not interested in trying to homogenize the results. (Ultimately, we will be reporting the range of estimates, not a simple arithmetic mean.) If you find other estimates off the mark, you are under no obligation to consider them further.

- Add your own assumptions or your comments on the appropriateness of other assumptions listed.

To assist you, we have included the following attachments:

- a one-page summary of expert projections for the residential sector
- a one-page summary of expert projections for the commercial sector
- a four-page review of tabulation instructions
- a one-page tabulation form

Please note that the tabulation instructions have not changed materially from the first round. We are just resending them for the convenience of those who may have misplaced them.

Please fax your responses to Shel Feldman, at (608) 836-3503 by COB, Thursday, June 3. If that fax line is busy or doesn't pick up, you can fax your responses to Bruce Mast, at (510) 526-2727 and he will pass them on.

We will compile the results by next Monday and then arrange for one last exercise.

Tabulation Instructions

In compiling your forecasts, please use the forecast parameters and assumptions described below, unless you believe they are inaccurate or incomplete. Please express results as a percentage of new HVAC installations in the target markets in each given year. When filling out the tables, you may need to make additional assumptions regarding any number of factors, including but not limited to

- Economic conditions
- Regulatory requirements or environmental regulations
- Technology improvements
- Manufacturer promotional efforts
- Barriers to technology adoption
- Customer awareness
- Customer acceptance
- Availability of products
- Initial costs

As indicated on the tabulation form, please note any additional assumptions you have made or any of those shown here that you reject as inaccurate or unreasonable.

Forecast Parameters and Assumptions

Forecast period of interest: calendar year 2000 to 2006

Target markets: Residential and commercial new construction

Region: Central Valley and foothill regions of California (roughly all of California north of a line from San Luis Obispo through Bakersfield, excluding coastal areas)

Residential technologies of interest: indirect/direct evaporative cooling and evaporative condensing cooling (see description below)

Commercial technology of interest: indirect evaporative cooling, indirect/direct evaporative cooling, and evaporative condensing cooling (see description below)

Publicly funded promotional activities: See descriptions of three scenarios below

Panelist B offers the following additional assumptions:

- Economic conditions track population growth at 1.6% per year

- Regulatory requirements are loosened to permit alternate methods of providing safe operation of plastic indirect evaporative cooling heat exchangers

- Technology improvements, manufacturers' promotional efforts, and barriers to technology are unchanged, except that the California Energy Short Form is expanded to account for evaporative-enhanced equipment
- Customer awareness increases with intervention
- Customer acceptance increases with intervention
- Availability of product is unchanged
- Except for an inflation factor, initial cost does not change
- New commercial and residential construction all includes cooling
- There is no appreciable change in the market penetration (in this area) for stand-alone cooling units
- Gas will be available as a heat source for residential evaporative condenser cooling customers
- Increased energy costs and IAQ enforcement will drive the indirect technology
- Residential market penetration follows two years behind commercial penetration of evaporative condensers
- Electric demand reduction by OSA indirect pretreatment and evaporative condensers will be a major driving force

Technologies of Interest

Indirect evaporative cooling. Evaporative coolers that use a vaporizer air flow with water to internally cool a heat exchanger upon which outside air is blown. The outside air is cooled by the exchanger without coming in contact with the water source. Indirect evaporative cooling units suitable for commercial applications are currently manufactured by Spec-Air.

Indirect-direct evaporative cooling. Two-stage evaporative coolers that use an indirect cooling stage on the upstream side of a direct evaporative cooling stage. The indirect stage uses a vaporizer air flow with water to internally cool a heat exchanger upon which outside air is blown. By pre-cooling the supply air with the indirect stage, the air leaving the second direct stage is cooler and dryer than conventional direct evaporative coolers. The indirect-direct technology can deliver air to a home or small commercial facility at or below the outdoor wet bulb temperature. CoolTech and Adobe Air, Inc. currently manufacture packaged units suitable for residential and small commercial applications.

Evaporative condenser cooling. A compressor-based technology that uses a refrigerant to remove heat from a house. This technology rejects heat to water by submerging copper tubing containing refrigerant gas in a sump rather than rejecting heat to the air. This process is a more efficient means for transferring heat.

The heat transferred to the water in the sump is then rejected to the outdoor air through an evaporative process, which takes place in an evaporative pad which surrounds the compressor. This approach allows further down sizing of the compressor due to more efficient heat transfer, even during periods when outdoor temperatures exceed 100 degrees F. Refrigeration Technologies, Inc. currently manufactures such a unit for the residential and small commercial sectors (up to five tons).

Promotional Scenarios

For the technologies described above, please base your market saturation estimates on the following scenarios.

Base Condition: No market intervention from publicly funded programs.

Intervention 1 (moderate): Financial incentives for packaged units sold in Central California; ten publicly-funded demonstration projects, incorporating the technology into a range of residential and commercial building types, with detailed monitoring and testing over a three year period.

Year	Intervention
2000	Five demonstration projects (3 residential, 2 commercial) in year 1 of monitoring and testing
2001	Five demonstration projects (3 residential, 2 commercial) in year 2 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 1 of monitoring and testing;
2002	Five demonstration projects (3 residential, 2 commercial) in year 3 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 2 of monitoring and testing; Incentive of 50% of additional first cost
2003	Five demonstration projects (2 residential, 3 commercial) in year 3 of monitoring and testing; Incentive of 50% of additional first cost
2004	Incentive of 50% of additional first cost
2005	Incentive of 25% of additional first cost
2006	Incentive of 25% of additional first cost

Intervention 2 (aggressive): Financial incentives for units sold in Central California; fifteen publicly-funded demonstration projects, incorporating the technology into a range of residential and commercial building types, with detailed monitoring and testing over a three year period; publicly-funded promotional activities conducted at industry trade shows; training program involving Central Valley HVAC contractors and mechanical engineers, focusing on design, installation, and maintenance issues; changes in California's Title 24 building codes or ASHRAE standards to better accommodate evaporative cooling and condensing as a strategy for meeting energy efficiency objectives.

Year	Intervention
2000	Ten demonstration projects (5 residential, 5 commercial) in year 1 of monitoring and testing
2001	Ten demonstration projects (5 residential, 5 commercial) in year 2 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 1 of monitoring and testing; Product displays at 2 trade shows; Training program for 50 HVAC contractors and engineers
2002	Ten demonstration projects (5 residential, 5 commercial) in year 3 of monitoring and testing; Five demonstration projects (2 residential, 3 commercial) in year 2 of monitoring and testing; Incentive of 100% of additional first cost; Product displays at 2 trade shows; Training program for 100 HVAC contractors and engineers
2003	Five demonstration projects (2 residential, 3 commercial) in year 3 of monitoring and testing; Incentive of 100% of additional first cost; Product displays at 2 trade shows; Training program for 100 HVAC contractors and engineers
2004	Incentive of 100% of additional first cost; Training program for 50 HVAC contractors and engineers
2005	Incentive of 50% of additional first cost; Changes in equipment design standards and building codes
2006	Incentive of 50% of additional first cost

Market Penetration Tables

Tables completed by:____

Table 1: Estimated residential annual new construction units

Year	Projected Penetration (%)		
	Base Condition	*Intervention 1*	*Intervention 2*
CY2000			
CY2001			
CY2002			
CY2003			
CY2004			
CY2005			
CY2006			

Additional Assumptions (if any):____

Table 2: Estimated commercial annual new construction units

Year	Projected Penetration (%)		
	Base Condition	*Intervention 1*	*Intervention 2*
CY2000			
CY2001			
CY2002			
CY2003			
CY2004			
CY2005			
CY2006			

Additional Assumptions (if any):____

Convenient times for a follow-up call (if necessary): ____________________________

Please fax this form to Dr. Shel Feldman at 608/836-3503. (If unable to connect, please fax to Bruce Mast at 510/526-2727.) Thank you!

Residential Sector

Scenario **Year**

Base	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.10	0.10	0.10	0.10	0.10	0.10	Assumes evap. condensing is highly reliable and maintenance issues are addressed
Expert B	1.00	1.02	1.03	1.05	1.07	1.08	1.10	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C	1.50	1.50	1.50	1.50	1.50	1.50	1.50	
Expert D	20.00	20.00	25.00	25.00	30.00	30.00	30.00	Appropriate water treatment provided
Expert E	0.50	0.70	0.90	1.10	1.30	1.50	1.70	IDAC/MC2 start at 40 in new construction; AC2 starts at 160.
Expert F	5.00	5.00	7.00	8.00	10.00	12.00	14.00	

Intervention 1	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.10	0.30	1.00	4.00	6.00	8.00	
Expert B	1.00	1.02	1.03	1.07	1.08	1.10	1.20	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C	1.50	1.50	1.70	1.80	1.80	1.90	2.00	
Expert D	20.00	25.00	30.00	35.00	40.00	50.00	50.00	Appropriate water treatment provided. Indirect cooling only is assumed to be limited to ventilation air precooling.
Expert E	0.50	0.80	1.20	1.60	2.00	2.20	2.40	
Expert F	5.00	6.00	10.00	12.00	15.00	20.00	20.00	

Intervention 2	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.20	2.00	5.00	15.00	15.00	20.00	
Expert B	1.00	1.02	1.05	1.08	1.10	1.30	1.50	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C	1.50	1.60	1.90	2.40	2.90	3.20	3.50	
Expert D	20.00	30.00	50.00	60.00	70.00	80.00	80.00	
Expert E	0.50	1.00	3.00	5.00	7.00	8.00	8.00	
Expert F	5.00	10.00	20.00	25.00	30.00	30.00	30.00	

General Notes: It is understood by all experts that the incentives described for the interventions do flow to the building owners involved.

Except for Expert B, the numbers shown describe the market share for the indicated year's new cooling installations that use any of the technologies described (indirect evaporative cooling, indirect-direct evaporative cooling, or evaporative condenser cooling).

Expert E estimates the total residential market at 40,000 units per year.

Expert F estimates the total U.S. cooling equipment market at $10 billion per year. Of that, he estimates the current market for evaporative cooling technologies at $150 million (+/- $20 million), with about 45%-50% of that in the residential sector.

Expert B writes: "Indirect-direct cooling has product in the packaged cooling residential market (2-5 tons) and I estimate that market to be about $15 million/year. Evaporative condenser cooling has product in the split system residential market and I estimate that market to be about $15 million per year." He bases this on 20,000 new residences/year, $500/ton and an average of 3 tons per residence. As with expert F, the estimate is for the equipment and does not include installation.

Demonstration project results are compared to "standard" technology installed in the same time frame in comparable facilities.

Commercial Sector

Scenario **Year**

Base Case	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.10	0.10	0.20	0.20	0.20	0.20	Spec-Air & Acer
Expert B	1.00	1.02	1.03	1.05	1.07	1.08	1.10	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C				`				These responses relate to increase over 1999 base, which expert does not estimate. Expert also notes that "some … incentives are already provided by utilities…."
Expert D	10.00	15.00	20.00	20.00	20.00	20.00	20.00	
Expert E	0.50	0.60	0.70	0.80	0.90	1.00	1.10	Indirect starts at 25; AC2 starts at 25; package-unit evaporative condensers with AC2 only
Expert F	5.00	5.00	7.00	10.00	13.00	15.00	15.00	

Intervention 1	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.10	0.20	3.00	5.00	6.00	7.00	
Expert B	1.00	1.02	1.05	1.08	1.10	1.20	1.30	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C	0.00	0.10	0.20	0.30	0.30	0.10	0.10	These responses relate to increase over 1999 base, which expert does not estimate. Expert also notes that "some … incentives are already provided by utilities…."
Expert D	10.00	20.00	30.00	40.00	50.00	50.00	50.00	Appropriate water treatment provided. Also, indirect cooling only is assumed to be limited to ventilation air precooling.
Expert E	0.50	0.60	1.00	3.00	5.00	6.00	6.00	
Expert F	5.00	5.00	10.00	15.00	20.00	25.00	25.00	

Intervention 2	2000	2001	2002	2003	2004	2005	2006	Notes/Assumptions
Expert A	0.10	0.20	3.00	10.00	20.00	25.00	25.00	
Expert B	1.00	1.02	1.08	1.10	1.30	1.50	1.70	These responses are growth factors (I.e., multiply the 1999 base percentage by these numbers to find the correct percentage for the given year.)
Expert C	0.00	0.20	0.50	0.50	0.50	0.30	0.30	These responses relate to increase over 1999 base, which expert does not estimate. Expert also notes that "some … incentives are already provided by utilities…."
Expert D	10.00	25.00	50.00	60.00	70.00	70.00	70.00	
Expert E	0.50	1.00	3.00	6.00	10.00	12.00	12.00	
Expert F	5.00	10.00	20.00	25.00	30.00	35.00	35.00	

General Notes: It is understood by all experts that the incentives described for the interventions flow to the building owners involved.

Except for Experts B and C, the numbers shown describe the market share for the indicated year's new cooling installations that use any of the technologies described (indirect evaporative cooling, indirect-direct evaporative cooling, or evaporative condenser cooling).

Expert E estimates the total commercial market at 10,000 units per year.

Expert F estimates the total U.S. cooling equipment market at $10 billion per year. Of that, he estimates the current market for evaporative cooling technologies at $150 million (+/- $20 million), with about 50%-55% of that in the commercial sector.

Expert B writes: "Indirect evaporative cooling is principally an outside air pretreatment device for comercial packaged units (5-50 tons). … only one manufacturer produces an appreciable number of these units … and I estimte their market to be about $1 million per year."

Maintenance is an issue in some areas.

Demonstration project results are compared to "standard" technology installed in the same time frame in comparable facilities.

PG&E Natural Cooling Study
Manufacturer Survey

Company Name:________________________________ **Contact:**________________

Phone:____ **Fax:**________________

Appointment Date:______________________________ **Appointment Time:** ______

Call Back Information/Notes:____

____

____

Introduction

Hello, my name is ____________ and I'm calling on behalf of PG&E. I would like to speak to someone in your marketing and sales department please.

(Once on line, continue)

Hi, my name is ________ and I am in the process of conducting research for PG&E with cooling manufacturers in order to examine the various types of cooling equipment that are in the market place, as well as the potential for new cooling technologies. This study will allow PG&E to better understand the cooling market and thereby design better programs for its customers.

As part of this study, I was hoping to ask you some questions regarding the products you manufacture as well as your overall opinion about the direction of cooling technology. Would you have about 20 minutes to help me out on this?

❐ No → schedule a call back
❐ Yes → Continue

Great. I just want to let you know, all of your responses are completely confidential and your responses will be reported only as part of the aggregate results.

SCREENER: Do you make cooling equipment for space conditioning for humans?

❐ Yes → continue
❐ No → **THANK AND TERMINATE**

Company Profile

First I'd like to learn a little about your company.

1. In terms of number of units, do you make equipment primarily for residential applications, or commercial?

   ❒ Residential
   ❒ Commercial
   ❒ Both
   ❒ Neither → **THANK AND TERMINATE**

2. How long has your company been in business? _____ Years

3. How many manufacturing plants do you have in the U.S.? _____

4. How many of your plants are in California _____

   4a. How many are located specifically in the Central Valley area? _____

   4b. Do you expect this to change in the next year or two?

   ❒ Yes **(ASK 4c)**
   ❒ No → **(SKIP TO 5)**
   ❒ Not sure/don't know **(SKIP TO 5)**

   4c. How will this change in the next year or two?

   ❒ Adding another/more plants
   ❒ Closing plants
   ❒ Unsure/don't know

5. How many employees does your company have in the United States? _____

6. Whom do you consider to be your three biggest competitors? ______________________________

____

Marketing and Promotion

7. Approximately what percentage of your business is cooling equipment?

   __________%

8. What kinds of promotional activities have you initiated or participated in to ensure your customers are aware of the latest cooling technologies?______________________________

9. Would you say you actively promote cooling technologies, or do you just have them in case someone asks for them?

❒ Actively promote → **(ASK 9a)**
❒ Make, but only if a customer specifically requests them
❒ Don't know/unsure

9a. Can you give me an example of how you actively promote cooling technologies?______

____

10. Do you offer any kinds of training to your customers?

❒ Yes → **[ASK 10a]**
❒ No
❒ Don't know/unsure

10a. What kinds of training do you offer?

❒ Trade shows
❒ Demonstration sites
❒ Technology seminars
❒ Breakfast meetings
❒ Manufacturer plant tours
❒ Pamphlets/brochures
❒ Other: ___________________

11. Do you offer warranties on the cooling equipment that you manufacture?

❒ Yes **[ASK 11a]**
❒ No **[SKIP TO 12]**
❒ Not sure/don't know **[SKIP TO 12]**

11a. What does your "typical" warranty include? **[PROBE: parts only, parts and labor, maintenance, length of warranties]**____

Customer Interaction

12. What specific kinds of cooling equipment do <u>you</u> manufacture? **(CHECK ALL THAT APPLY)**

❒ DX packaged equipment ❒ Evaporative coolers ❒ House fans

❒ Compressor-cycle based Refrigeration ❒ Absorption-cycle based refrigeration

❒ Chilled water (fan coils) ❒ Chillers ❒ Heat pumps ❒ Other: ____________

13. Do you tend to focus on complete cooling systems or components?

❒ Complete systems only **(SKIP TO 14)**
❒ Components only **(SKIP TO 14)**
❒ Both → (**ASK 13a)**

13a. About what percent of your cooling equipment business is in complete systems?
______________%

14. To which type of customer do you sell HVAC equipment?

❒ Distributors
❒ Contractors
❒ Retailers
❒ End-users
❒ Other: ________________

15. **(ASK ONLY IF <u>MORE</u> THAN ONE TYPE OF CUSTOMER)** Specifically, what percent of your business is conducted through:

Retailers__________
Contractors________
Distributors________
End-user _________
Other: ___________

16. What percent of these customers are located in Northern California **(FOR EACH GROUP)**:
Retailers__________%
Contractors________%
Distributors________%
End-user _________%
Other: ___________%

Cooling Technologies

17. Do you make evaporative coolers? **(EVEN IF ALREADY MENTIONED ABOVE, <u>CONFIRM</u>):**

- ❒ Yes → **(SKIP TO 18)**
- ❒ No → **(ASK 17a)**

17a. Do you have any plans in the future to manufacture evaporative coolers?

❒ Yes → What has made you decide to do this?________________________
❒ No → **SKIP TO 21**

18. What types of <u>evaporative coolers/evaporative cooler components</u> do you make?

- ❒ IDEC **[ASK 18a]**
- ❒ Evaporative Condensers
- ❒ Direct evaporative coolers
- ❒ Sprayed coils
- ❒ Closed-loop heat exchangers
- ❒ Other: ___________

18a. Whom do you ship these components to? ____

18b. Have you encountered any kind of technological/performance problems with this specific technology?

- ❒ Yes
- ❒ No
- ❒ Don't know/unsure

18c. How have you addressed these issues?____

____

19. Do you manufacture only d*irect* evaporative coolers or other evaporative cooling based equipment?

- ❒ Direct **(ASK 19a)**
- ❒ Indirect **(SKIP TO 20)**
- ❒ Both **(SKIP TO 20)**

19a. Do you have any plans in the near future to manufacture indirect evaporative cooling based equipment?

❒ Yes
❒ No → Why not?____**(SKIP TO 21)**

20. Have you encountered any changes in evaporative cooling based equipment technology over the past two years?

- ❒ Yes →**(ASK 20a)**
- ❒ No → **(SKIP TO 21)**
- ❒ Don't know/unsure

20a. Who do you think has influenced this change in the technology?

- ❒ Utilities
- ❒ End-Users
- ❒ Reps
- ❒ Contractors/Builders
- ❒ Government construction codes
- ❒ Professional organizations such as ASHRAE

20b. How have they influenced this change?__________________________________

____

Trade-Off Criteria

21. What do you consider to be the major competing cooling technologies to evaporative cooling based equipment? ____

____

22. Now, I'd like to briefly ask you to compare evaporative cooling based equipment on specific features, versus **[COMPETING TECHNOLOGIES].** In your opinion, how do evaporative cooling based equipment (indirect or indirect/direct systems) compare to **[PREVIOUSLY MENTIONED COMPETING TECHNOLOGIES]** in the following areas:

22a. Alternate Technology:____

Evap. Cooler is…	Much Better	Better	Same	Worse	Much Worse	**Why, or how so?**
Cost						
Reliability						
Performance						
Comfort						
Operating/Maint. Requirements						
Health Concerns (i.e, Legionnaires Disease, mold, allergies, etc.)						
Product Availability						

21b. Alternate technology: ____________________

Evap. Cooler is…	Much Better	Better	Same	Worse	Much Worse	**Why, or how so?**
Cost						
Reliability						
Performance						
Comfort						
Operating/Maint. Requirements						
Health Concerns (i.e, Legionnaires Disease, mold, etc.)						
Product Availability						

23. In what <u>other</u> ways is evaporative cooling based equipment much better or better than competing technologies? ____________________

____

24. In what <u>other</u> ways is evaporative cooling based equipment worse or much worse than competing technologies? ____________________

____

Sales Volume

25. Approximately what percentage of your entire cooling sales is indirect evaporative cooling or evaporative condensing? _____%

25a. Do you expect this percentage to increase, decrease or remain the same over the next two years? How about over the next ten years?

	Increase	Decrease	Remain the same
Two years:	❒	❒	❒
Ten Years:	❒	❒	❒

25b. To what would you attribute this change? ____________________

26. About how many evaporative coolers have you sold within the past two years in California? **(IF NECESSARY, PROMPT → Would you say it was less than 50? Between 50 and 100? More than 100?)**____________________

27. What kinds of events or activities would encourage market growth for evaporative coolers? __________

28. What kinds of events or activities would impede it? __________

29. What is the likelihood of these events occurring? __________

Emerging Technology Information Flow

30. Now I'd like to ask you about your relationships with different kinds of customers. What percent of your business is with repeat customers versus one-time buyers, with respect to…?

	Repeat customer's	One-time buyers
Distributors	❒	❒
Retailers	❒	❒
Contractors	❒	❒
End-Users	❒	❒

31. If a new cooling technology were introduced, what information would you need that would make you willing to invest in manufacturing it? __________

32. Have you ever participated in demonstration activities for a new technology?

❒ Yes → 32a. What did you do/What was it for? __________

❒ No

33. Would you be willing to participate in demonstration projects in the future for new technologies?

❒ Yes
❒ Maybe
❒ No

34. What would motivate you the most to begin manufacturing a new type of equipment?

- ❒ Customer feedback
- ❒ President of company initiating change
- ❒ Own research and development efforts, within company
- ❒ Changes in ASHRAE standards
- ❒ Trade journals, research
- ❒ Published R&D results from technology studies
- ❒ Competitor activities

35. What specific sources do you rely on to keep current about the emerging cooling technologies?

- ❒ Contractors
- ❒ Trade journals
- ❒ Internet
- ❒ News/ Publications
- ❒ Distributors/Vendors
- ❒ Internal R&D
- ❒ Trade Associations → 35a. Which ones: ________________________________
- ❒ Other: ____________________

36. Do you find that these sources provide you with enough information to make decisions regarding the type of cooling products you manufacture?

- ❒ Yes
- ❒ No → **(ASK 36a)**
- ❒ Don't Know/Unsure → **(ASK 36a)**

36a. What other kinds of information sources do you feel you need to make decisions? _
____

37. That is all the information I am looking for now. Do you have any final comments regarding cooling equipment and technology?

____
____
____

Thank you very much for your time.

APPENDIX C: CALL DISPOSITION

The sample disposition for the technician survey was compiled from several sources, beginning with statewide contractor search results provided by PG&E and their contractor. These contacts were included based on their type of license. The purpose of this was to avoid multiple contacts to the same contractors for different program data collection and evaluation efforts. Once we whittled the sample down, cleaning out invalid contacts (i.e., plumbing only companies), we ended up with a total of 571 names in our sample. The following table illustrates the results of our data collection efforts with this sample. Note that we generally attempt to contact any one respondent up to three times, so those numbers representative of "left messages" and "answering machine," were situations in which we called back repeatedly in an effort to collect data.

Table C.1. Technician Call Disposition

Disposition	N
Recruited (didn't complete)	32
Completed	34
Refused	14
Non-working/bad/wrong #s	62
No AC work	57
No new construction	53
Left messages	100
Answering machines	219
Total names	571

With results from our literature review, including Internet searches and contact with experts, we compiled a list of 47 cooling equipment manufacturers, including six who specifically manufacture evaporative cooling equipment. As shown in the following table, among these manufacturers, we were able to complete twelve interviews, three with evaporative cooling manufacturers specifically.

Table C.2. Manufacturer Call Disposition

Outcome	N
Completed	12
Refused	4
Non-working/bad/No listed numbers	9
Out of business	2
Left messages	15
Does not manufacture AC components	5
Total names	47

APPENDIX D: FOCUS GROUP RESULTS

BACKGROUND

The first form of data collection for this study was that of focus groups. Focus groups are an inexpensive method to gain detailed insights into market dynamics, identify perceived and actual market barriers, and better understand customer valuation of cooling system attributes. Initially, we planned on conducting the focus groups in a two-phase process: conduct initial exploratory focus groups, digest the information, and then determine the need for additional groups. However, upon completion of these initial groups, we quickly discovered that further focus groups were not necessary. The four focus groups were conducted with the following samples:

- **Residential homeowners (Fresno)**. This group had nine participants who had either recently bought their home, recently bought their air conditioner, or were in the market for a new home or air conditioner.
- **Commercial building owner/building managers (Sacramento)**. This group was made up of seven participants, representing building owners, managers, and building maintenance staff.
- **Technicians, including contractors, architects, engineers (Sacramento and Fresno)**. The two technician groups had nine participants each and were primarily made up of HVAC contractors; however, the Fresno group served the residential sector, while the Sacramento group mainly served the small-commercial market.

The results of these focus groups guided our survey design by confirming our predetermined market barriers and estimations regarding evaporative cooling technology.

The focus group discussion guides focused on the following areas:

- **Decision-making process:** What are the roles and relative importance of different market participants in the cooling equipment selection process? What are the key equipment characteristics and performance criteria that drive the selection process? Why would one choose an evaporative cooling system over a compressor system? What circumstances would indicate whether an engineered system is more appropriate versus a packaged unit? Why would one choose to add an evaporative cooler to their compressor system, rather than purchase a new larger compressor system?
- **Communication channels and information sources:** Which broadcast and interpersonal channels of communication are most relied on for information about cooling technologies? How much credibility do those sources have? How much information does one need to make an equipment specification decision?
- **Market barriers:** What are the specific barriers to the adoption and acceptance of natural cooling technology? Are they different for each of the market segments we are focusing on? What actions are they aware of that attempt to address and overcome these barriers? What are their opinions regarding real barriers versus perceived barriers?

Based on our initial market assessment, we concluded that the most opportunities for natural cooling will be found in the Central Valley, and therefore, conducted the focus groups in Fresno and Sacramento (which ensured the data are representative of the entire valley). The main goal of these focus groups was to determine whether initial assumptions about who the key market actors are, especially in terms of ultimate decision-makers, are correct. We have included the initial topic guide for the focus groups in Appendix B of this document.

MARKET STRUCTURE

Participants were first asked to think about HVAC equipment, cooling in particular, and then to describe the kinds of events that might have to happen to trigger installation or replacement, or even an addition, to those types of systems. They were also asked to talk about the role they played in each of the circumstances. The following summarizes each group's responses.

Residential. Residential participants reported that they would consider replacing their air conditioning units if

- "The size of the unit is too small, and the house is not getting cool enough"
- They had a high PG&E bill
- It would add value to the home for resale
- It would address any health and safety issues

The participants in this group said that they conducted their own research about the type of equipment they wanted installed, as well as listened to the advice of "a trusted contractor." And, even when they had a contractor they "trusted," all but two said they did additional research (either through outside resources such as the Internet, or by obtaining multiple bids from other contractors). However, most agreed that, "in the end, we usually go with the recommendation of our first contractor."

Building owners/managers. Nonresidential building owners and managers said they would replace or upgrade cooling equipment primarily to "retrofit" because of aging existing equipment. A couple have recently or are in the process of installing new HVAC equipment. One installed a $400,000 system because "financially it made sense—with utility rebates and incentives." Several described replacing their equipment only when it broke down (emergency situation). In these cases, more often than not they simply replaced what they had with the same type of equipment. All said that they maintained their systems regularly, and once it got old (if it did not break), they replaced it—usually every 10 years. Building managers said that they took their obligation to their tenants into consideration when deciding to replace or repair their HVAC equipment (i.e., listened to feedback from tenants) whereas building owners would primarily only replace systems when they broke. In one instance, the property manager said that since they paid their tenants' electric bill, it was in their best interest to ensure they have the most efficient systems in their buildings—as it costs them money.

When installing new equipment, all agreed that the building owners were the ultimate decision makers when it comes to purchasing HVAC systems. In emergency situations (i.e., the air conditioning goes out on the hottest day of summer), property managers have authority to purchase equipment. For the most part, however, the role of the property manager is to conduct thorough research. Typically, this involves obtaining multiple bids from contractors and perhaps even design engineers to determine which type of system should be installed. Most said they obtain multiple bids only for comparison, but they also said that they usually have one contractor whom they end up using "most of the time." For owners, their role as decision maker is to make sure they hire a qualified contractor to recommend the best system for their building.

Residential technicians. Contractors agreed that they get involved most often when there is an "emergency situation" and an air conditioner is malfunctioning. Sometimes new, more efficient systems are installed to "keep up with the Jones." Another significant part of their business is maintenance. Once they install a new system, they rely on repeat business in the form of maintenance. Participants in this group felt that their primary role in the replacement process was to recommend or prescribe equipment based on the needs of the customer. There were several opinions in this group about the sophistication of their customers, especially when it came to equipment selection. Some had customers who would conduct their own research and then tell them specifically what they wanted installed. If the equipment that the customer requests is a feasible option, obviously the contractor will sell and install it. However, some contractors complained that customers sometimes want equipment that is not appropriate for their home. In these situations, the contractors in this group were adamant that they "would refuse to complete the job," as they would then lose money by having to come back to fix the problem. They did agree that this was somewhat unusual, and in most cases their customers "go with their recommendation" for installation.

Commercial technicians. Participants in this group identified "typical" scenarios for which a new system would be installed. For example:

- Building use changed; needs new system
- Renovations (change part of building use)
- Breakdown: something is not comfortable; reactive charge
- Industrial sector pretty much the same.
- Change in use; look at factors such as process, occupancy
- Look at developer- versus owner-occupied

As most of the participants in the group were contractors (with only one engineer/designer), they saw their role primarily as making recommendations to the owner as to which system to install. Sometimes they would contribute toward the design of systems, but mainly in terms of sizing the system. These contractors were very familiar with the bidding system, and felt that much of their job was being competitive in the bidding war (i.e., they know customers get multiple bids). In fact, the "bidding system" was a source of contention among most everyone in the group. All said that "the low man gets the job," indicating that the main concern of customers is cost.

These participants also said that it was expected that each bid would have different recommendations and quite possibly even different technologies that they recommended. When queried as to why this would happen, most attributed it to "supplier affiliations," so if they had a relationship with a specific supplier, they would more often recommend that supplier's product over another (which, as a result, may also dictate the *type* of technology installed). These affiliations are established mainly because of '"track record" and "trust" that the supplier and their product have proven over time. This was true for both commercial and residential contracts. It is interesting to compare this part of the discussion with that of the consumer group. Consumers think that contractors *only* recommend certain brands because they "get something out of it—like an incentive."

There were also a few who agreed that the "intelligence" or awareness of the building owner/manager had to be taken into account during the bidding process. Some owners will rely quite heavily on the contractor's recommendation, while other owners have "done their homework" and are very clear about which type of system they want installed.

The one designer in the group was involved primarily when it came to major projects, where an entirely new system needed to be put in. He said that even in his role, there were owners who were insistent on the kind of system they wanted, even when presented with the "trade-offs." *All agreed that the building owner had the final decision when it came to purchase and installation.*

Contractor Issues

A good portion of the discussion with residential homeowners focused on how involved they felt in the process of equipment selection as well as how much they rely on contractors for providing them enough information as well as accurate information. One woman actually owned her own contractor referral business, so she was probably more sophisticated than most about how to find a trustworthy contractor. Another woman said that she and her neighbors have a "pool" of contacts that they share (i.e., plumbers, contractors, etc.) and that she relies solely on these referrals to find "qualified" service people.

The most interesting discovery on this topic was that homeowners think contractors only offer specific brands of equipment because "they get a kick-back for being loyal to certain suppliers." All but one was skeptical of contractors and felt they were simply out to make money. This directly contrasts what contractors said about why they are "loyal" to certain suppliers—because they are reliable and of "higher quality."

Selection Criteria and Ranking

The next topic area of the focus groups was to ask participants to identify specific factors they consider when selecting cooling equipment, and then to rank them in order of importance.

Residential homeowners. When asked about the criteria for selecting equipment, participants echoed mostly the same factors that would trigger them to replace their existing units (i.e., house not cool enough, proper sizing issues, high electric bills, resale value to home, health and safety issues). Comfort (i.e., the house being cool enough) was considered the most important factor, as it determined whether an air conditioner is actually "working."

Building owners/managers. It was interesting to note that there was little difference between building owners and managers in terms of equipment selection criteria. However, there was quite a bit of discussion surrounding whether the building was going to be sold within five years, or kept for twenty years. Not surprisingly, everyone felt that if the building was just going to be "fixed up and then sold within five years," first cost of the equipment was the main criteria for equipment selection, "who wants to invest a lot of money in something you're only going to sell?" However, if the building was going to be kept for a longer period, other elements, such as simple payback, energy

efficiency, and performance were much more important in equipment selection.
Getting this group to rank their criteria was extremely difficult. They were not willing to trade off different factors for each other. In addition, they felt differently about each aspect if they were only going to own their building for five years versus twenty years. In addition, everyone participated in this discussion as though they were the building owners. In other words, they spoke of both the criteria and ranking as a "hypothetical" situation, rather than applying it to their own situations—no matter how many times they were encouraged to do so.

Ultimately, everyone agreed that they try to get the lowest bid for the project, but there are other factors that sometimes outweigh first cost. For example, some said they place priority on "the track record of the vendor," indicating that the reputation and a known brand is often more important than simply a low first cost. The building owners in this group had had their buildings for some time and also had no immediate intention of selling them. As such, they said factors such as "reliability of the equipment," and "track record of the company (vendor)," were much more important than initial cost of the equipment.

Proper installation of the equipment was mentioned as an important factor, especially for the maintenance participant. His job was to make sure the equipment ran properly and that his building had the least amount of down time. Warranties, whether they be contractor or manufacturer, were also mentioned as an "important factor" when selecting equipment, as a couple seemed to have had problems in the past with their equipment. There were also a couple who said that the brand or name of the product was very important. Installing a trusted brand meant to them that they would not have to worry as much about malfunctions. In addition, they were concerned about compatibility issues of mixing brands and whether the brand they bought this year would be around for replacement parts in two years.

Once the group was finally able and agreeable to ranking each criteria, they put "cost of equipment," as their #1 criteria. Then, "long term value, energy savings and payback" were all grouped into #2. "Performance," and "down time," were next, followed by "ease of installation," "EMS controls," "service agreements (maintenance)," "aesthetics," and overall "building improvements" were last.

Residential technicians. The following list is the criteria for equipment selection for residential technicians:

- Manufacturers' "backup" ("Do they stand behind their own products?")
- Warranty (manufacturers')
- Performance of equipment ("Am I going to have to come back and fix it later?")
- Competitive cost ("I can't afford to be competitive with really expensive equipment")
- Availability of equipment ("If I can't get it, I'll use something else")
- Brand ("I only use one or two brands—like Trane, because I know they are reliable")
- Size (for commercial purposes) ("The equipment has to fit in the allotted space")
- Standardization (compatibility between existing and replacement equipment)
- Efficiency
- Quality ("This is similar to brand choice and reliability")
- Customer satisfaction ("I listen to what my customer says—if they are happy, I'm happy")

Participants were then asked to rank in order of importance each criterion. Like the previous two groups, this proved to be a difficult task. Finally, the group was able to determine that "cost of the equipment" was the overriding factor in equipment selection (especially since they were representatives of small companies). This group also spent a good amount of time discussing their loyalty to specific brands, and likened this to "quality" of the product. "Quality" was ranked high as well. The remaining factors "were all important," and as such could not be "ranked." As one contractor stated, "the above list is so inter-related that it is difficult to rank according to importance." All contractors agreed that in new construction, "cost" was the number one factor in determining what piece of equipment will be installed.

While no one in this group mentioned "sound" or "aesthetics" in their list of "criteria," when asked directly whether they were important factors in a residential application, all agreed that they were indeed important, especially "when it becomes a problem." Further probing allowed them to describe situations such as multi-family, apartment buildings, or detached homes that are right next to each other. "If someone is trying to relax on their deck and all they can hear is the humming of air conditioning systems all around them, it gets annoying."

In attempting to separate "what customers want," versus "what contractor's think their customers want," participants were asked what *their customers* thought the most important factor in HVAC equipment selection was. Not surprisingly, they said that cost, performance, quality (reliability) were the most important factors driving customers. They also said that customers pay attention to utility rebates (although interestingly, they did not mention this as "important" in their selection). According to contractors, the "brand" of the equipment was less important to customers.

Commercial technicians. Participants were asked to provide a "laundry" list of the different criteria they assess when deciding which type of technology to install. Then, they were asked to "rank" them based on "level of importance," which proved to be hard for this group. The following list present this groups selection criteria:

- Geographical location ("recommendations might be different if the customer was in L.A.")
- Type of fuel (does the customer use gas or electricity)
- Affiliations with supplier/manufacturer (as discussed above)
- Efficiency of equipment ("some building owners are more concerned with efficiency than others")
- Building lay-out ("there are types of equipment that just won't fit in certain duct systems—then there is no way you can install them")

- Use of building (what does the tenant do with the space—an office space would require different cooling criteria than a warehouse)
- Capability of the contractor ("if the contractor only is aware of x,y,z, then they are only going to recommend x,y,z")
- Owner capability to maintain ("they either have to be willing pay for an outside maintenance person, or have in-house maintenance staff who know the technology and what type of maintenance it entails")
- Owner "sophistication" (there was one participant in particular who developed "client profiles" so that he could focus on clients who understand HVAC systems, "don't have to worry about 50 cents"—this is very different than residential contractors)
- Liability (liability issues surrounded mostly around "being aware and on top of situations *before* mistakes happen." For example, one said that they constantly review building and HVAC plans to ensure that the recommended system was appropriate for the actual building.) Another referred to the role of the designer, "If designer says put flap A in slot B and I do it and it doesn't work, then it's not my fault."
- Codes (especially in renovation work where one has to comply with Title 24 and zoning issues)
- Rebates (All liked utility and manufacturers rebates)
- Equipment location (roof, ground, inside, outside)—"where the equipment is located dictates what type of system can be installed"
- Financing
- Equipment availability (several complained of "parts of equipment" not being available)
- Budget ("even if we want to install a certain kind of system, the budget won't let us")
- Owner reputation ("do they pay their bills on time, are they easy to work for")

Since this group found it "impossible to rank one over another," they opted to group different criteria. So, all criteria having to do with money was #1 (budget, financing, rebates), as well as "use of building." They then put "design of building," "location of equipment," "affiliations with manufacturer," and "capability of contractor," as #2 importance. Everything else they ranked least important, or #3 (regulations, geography/weather, equipment availability). These rankings were very difficult for this group to do, as they did not think one could really trade off any of the criteria—"they are all extremely important." In addition, they were very focused on "circumstances" and said "it depends on the situation" for nearly every aspect of the discussion.

INFORMATION SOURCES

Next, participants were asked what sorts of information sources they look to in order to make decisions regarding new cooling technologies and equipment. Specifically, they were queried as who they look to, what kinds of information they look for, what publications, if any, they read to keep current about cooling technologies, and whether they conduct their own research on emerging technologies. The following summarized their responses.

Residential homeowners. *Consumer's Guide* was the first source mentioned for obtaining information on cooling technology. This group, however, seemed to "rely" more on testimonials and word-of-mouth information. There were a few that recently installed new air conditioning units who said that they asked their contractor for referrals and then actually checked them. Other sources include Home Depot/Home Base, and PG&E bill inserts. One participant recalled a "reminder" in his electric bill to clean his air conditioning in the Spring—he said he relies on this as a "reminder" of when to take care of equipment maintenance. All agreed that the best way to get the information that they need is through the Internet, however they also said that there is not enough information and information is not easily attainable (although, "the Internet certainly makes finding information easier than before").

Building owners/managers. Most said that they rely on trade associations and trade publications for information regarding technology. However, they also said that they really do not pay too much attention to the information unless they are specifically in the market for HVAC equipment. Specific associations mentioned were ASHRAE as well as the local utility (SMUD and PG&E). Participants also said that they rely a lot on their contractors to provide them with accurate and up-to-date information. One property manager said she looks to outside HVAC consultants to provide her with objective information, rather than from a contractor from whom she is receiving a bid from.

When asked what concerns they would have about a new cooling technology most were most worried about the reliability issues. Like the technicians, no one wanted to "be the guinea pig," especially property managers who had to answer to not only their owners, but also their tenants. In addition, some said they would be concerned about whether or not the new technology was environmentally friendly, especially with respect to emissions. The participant who was a maintenance supervisor said he would be concerned about whether he and his staff were able to maintain the system—and if not, how they would receive training. Owners said they would be worried about the added cost of maintenance—they would have to hire specialized maintenance staff who were familiar with the new technology.

Other concerns were "name recognition" although discussion about brand can be tied with reliability issues ('Is it a manufacturer we know or some guy who makes it in his garage?"). The owners in the group said they would need to hear "success stories" from other building owners before they installed in their buildings—and everyone echoed the fact that testimonials are the best way to convince them of the reliability of a product.

Participants said that for the most part they did not spend a lot of time researching new technologies. In emergency situations, they "call the contractor to come and install or fix the equipment right away—no time for research." However, in planned installations, some conducted little research and did so primarily on the Internet or through reading trade magazines. For the most part, research was only conducted out of "personal interest" rather than a personal sense of obligation, and the time spent researching was nominal. The one area where participants seemed to spend a little more time was in the financial aspect of a new system. This is particularly true for property managers who have to use this analysis when submitting the proposed installation to the ultimate decision makers (the owners). Lastly, all said they had "no trouble finding information when they needed it," and knew where they needed to go to find it.

Residential technicians. The primary resource for information among contractors is their suppliers, especially for product information. This particular group also reported that they use the Internet to conduct research on both products as well as cooling technologies. Several contractors reported that their supplier even has catalogs and information that can be downloaded off of the Internet, which they felt was a great way to receive information. Other sources of information included trade journals, trade shows, and personal contacts (i.e., other contractors) (most knew at least one other person in the group). In addition, no one reported that they had any trouble locating needed information, and they all knew where to go to find information (in most cases, their supplier was the first point of contact).

This group was not necessarily interested in new cooling technologies, mostly because of likely increased cost of materials. However, if they were to either adopt or recommend a new technology, they would first have to "see it working in the marketplace for at least five years." Several cited specific examples of a "new technology" that failed (e.g., a "leak filler" in the plumbing industry that actually clogged entire pipes). No one really wants to be the "guinea pig" especially as small business owners because there is too much to lose. They also commented that their customers "trusted tradition," as did they. They would be much more likely to go with what is "tried and true." There was also some discussion about liability—more so in this group than with commercial technicians. These participants were even less willing to take risks because they would ultimately be liable if anything about the equipment went awry, whereas commercial technicians could at least share responsibility with builders or design engineers. In addition, the ultimate cost of having to continuously repair non-working equipment could really destroy a smaller firm.

There were several aspects that these contractors said they would have to consider prior to recommending the equipment, once a technology had "proven itself in the market." For example, they would need to make sure that there was ample replacement equipment on hand in the event they needed to replace a customers existing equipment. Likewise, they would need to make sure that they were adequately trained on how to install and maintain the new technology.

Ultimately, this group agreed that changes in the market would force them to learn and recommend new technologies, "If our customers ask for it, and we don't know about it or how to install it, we lose the business." Also, since much of the work involved repair projects, if they are not up to speed on the technologies in the marketplace, they will lose work even in repair/retrofit situations. Participants "blamed" this trend on the new construction builders who were putting in newer more "high tech" equipment that perhaps in the future they would be asked to repair or maintain.

Commercial technicians. Most of the participants in this group reported that they learned the most about cooling technologies "through our suppliers," and described specific training presentations that they frequently attended. They felt that part of the job of their suppliers was to make sure they, as contracts, understood the technologies they were installing. Participants also named several trade publications that they subscribed to, as well as simply talking to each other ("Every contractor has a group of friends he deals with. If he has a problem he's not bashful about asking"). Moreover, when asked which source of information they trust to provide them with accurate information, nearly all echoed their "established relationships with manufacturers and vendors." On occasion, they may call "an 800 number at the factory for a quick answer on equipment," but for overall technology information, they rely and trust the manufacturers. It is interesting to note that larger contractor firms felt more allegiance to their manufactures than the smaller "mom and pop" type contractors. The one participant who typically worked on one or two projects at a time felt that his manufacturer rep did not pay any attention to him because he "wasn't a big seller," as compared to the larger contracting companies.

For the most part, this group indicated that they knew exactly how to find information when they needed it. And, in fact sometimes felt that they had too much information, which was hard to sort through. For new equipment, vendors were the best source of information. With respect to mass mailings, the only time a contractor would pay attention to them was if they happened to address a specific problem they were currently dealing with.

If a brand new cooling technology came out, all agreed that the primary way they would endorse such a product was to first see it working. When asked directly if they would ever be the first ones to try it, they all laughed, "something like that could kill our businesses." Some felt that the "vendor or seller would have to convince me it was a good product, but even then, it would have to be around for several years." Other concerns surrounded who the manufacturer of the new technology was ("who are they affiliated with—is it just a guy with a pet rock?"). Others said they might be interested as long as the manufacturer was willing to take on some of the risk, "What are you, the manufacturer, going to do to help me since I'm the guinea pig?" Performance of the new product was also mentioned as important—not only in terms of what it does, but how it functions, whether special additional equipment is necessary, and whether the owners will need to learn how to maintain it. A few also said they would be concerned about whether the new technology was compatible with the existing equipment, or would they have to replace the entire system.

Most indicated that while they used the Internet to research new technology options, they relied on the vendors to keep them abreast. Any research outside of that was simply to be aware of what is going on in the industry. And, other than trade shows, most spent minimal time in the evenings researching such things.

MARKET BARRIERS

The last topic area for the focus groups was that of market barriers. Specifically, they were asked about their awareness of evaporative cooling technology, what they know about it in general, and whether any of them has an evaporative cooler installed in their home (or installs them as part of their business). The following summaries discuss the responses from each group, respectively.

Residential homeowners. By far this topic was the most interesting part of the focus group with this group, as virtually everyone in the group had had prior experience with evaporative coolers ("swamp coolers"), and as noted early on, several still had them. There was one particular participant who considered himself a "handyman," and had been around swamp coolers since he was eight years old. This participant has two swamp coolers in his house, and is a huge advocate of them. He was also the only one aware that there was "newer and better" technology coming out (indirect) that addressed some of the problems with evaporative cooling. There were three people in the group who would never buy an evaporative cooler, or a home with one in it. Also, the one participant who was in the market for a custom home said specifically that, "he wouldn't rule out a home just because it had a swamp cooler," but that he would probably prefer a regular DX. The following presents further discussion about evaporative coolers and their experience, although based on direct systems only.

When asked whether they like swamp coolers, opinions were somewhat diverse. All but three participants either like them, or in a couple of cases, "wouldn't have anything else." And, contrary to contractor feedback, there were two members in this group who said that often, "the swamp coolers freeze us out."

The "downsides" of evaporative cooling included that they were "messy," the older ones are "ugly" and there were some concerns about allergies from the high humidity. Some also felt that problems with installation caused them to be less effective (i.e., placing the cooler on the hottest side of the house). The term "swamp cooler" was also mentioned as having a "stigma" attached to it, and that the name should be changed in order for the public to consider it. One participant suggested that they be called "natural coolers."

When queried about the benefits of evaporative coolers, most felt that the benefits outweighed the negatives. Such benefits included lower electric bills, better efficiency, environmentally friendly, and provided an indoor environment that was "very comfortable," and even comparable to the regular air conditioning systems.

Building owners/managers. Nearly everyone in this group was aware of evaporative coolers however no one had one in their building. All participants "preferred refrigeration," to "swamp coolers," and would not want them installed in their buildings. The maintenance worker was the most knowledgeable about the various evaporative cooling technologies, and could offer the most input with respect to the benefits and downsides of evaporative cooling. He felt that evaporative cooling worked best in warehouse situations, where there were not a lot of people. He also said that they were "great for the environment," but that they were "a nightmare for indoor air quality," due to the microbes that fester and grow and eventually get into the air stream. Humidity levels of evaporative cooling units were also mentioned, and this participant felt that, because of the low humidity levels in the area, this technology could be viable. For the most part, though, participants were negative on evaporative cooling technology and "would never install it in their buildings."

Residential technicians. Everyone in this group was both aware of evaporative cooling equipment and had installed evaporative coolers (or "swamp coolers"). However, throughout the discussion, there was no real distinction between different types of systems (i.e., direct, indirect, direct/indirect). Also, the prevailing opinion of evaporative cooling was that it was "no one [customers] wanted it in their homes," primarily because the technology did not cool well enough. No one in the group had ever replaced a DX system with an evaporative cooler, but all had replaced evaporative coolers with DX systems. There were several contractors who believed that evaporative coolers were, "just too expensive to maintain," and, "at first it appears that evaporative cooling is cheaper but in the long run it is not very efficient." There were also about half who felt most of the problems with evaporative cooling were in the installation, causing for larger problems than necessary.

Commercial technicians. Not surprisingly, all of these commercial contractors had also heard of evaporative cooling technologies. They described indirect evaporative cooling technology—in terms of how it works—in fairly accurate detail. They were aware of the geographical situations that lend themselves to such a technology (i.e., dry arid climate) and that "high humidity keeps them from working well." One of the concerns of the technology was that it did not cool enough, and comfort issues was more often than not why contractors are hired in the first place. Several thought that evaporative coolers were "not good for indoor air quality—especially for allergies, with all the molds and mildews brought on with the added humidity." And, since outdoor air is brought directly in, "allergens pass right on through." One contractor even mentioned Legionnaire's disease as a downside of the technology. Many felt that this technology was not appropriate for commercial buildings and was far better suited in residential applications and warehouses.

Further discussion of evaporative cooling then focused on the benefits of the technology. Here, there were a few who brought up "type of building" as important when deciding to use evaporative cooling. One contractor had installed it in an SPCA facility and said, "it's perfect for that type of business." For the most part, though, most said they only installed evaporative cooling when their customers specifically asked for it. Other circumstances where these contractors said they would recommend evaporative cooling were in situations where there was a lot of moving air, and in establishments such as an auto shop, exercise room or warehouse, where actually one may not want cold air. However, several said that "99.9% of the time, evaporative coolers do not provide cold enough air for humans." In order for the technology to be more acceptable, contractors felt that it needed to cool better and address the humidity issue. Interestingly, *all* felt that "this [Sacramento] was the wrong place to market evaporative cooling" (because of climate conditions—not dry and hot enough).

APPENDIX E: MANUFACTURER INTERVIEW RESULTS

COMPANY PROFILE

- We interviewed 12 manufacturers of cooling equipment. Over half (7/12) produce equipment for both residential and commercial applications. Only one company made equipment solely for residential applications.
- 9/12 of the participating companies are well-established and have been in business a significant time (60–100+ years). The remaining 3 companies had been in business 15 years or less.
- All but one company have manufacturing plants in the U.S. 9/12 of the companies we interviewed have 5 or fewer plants in the U.S. Only one company had a plant in California and this plant is located in the Central Valley area. This company does anticipate a change in this plant in the next two years, but the respondent was unsure what kind of change will occur.
- When asked about the number of employees they had in their U.S. operations, half of the companies stated that they had fewer than 1000, 4 stated 1000-5000, and one indicated over 20,000 employees.
- Carrier (5), York (5) and Trane (6) received the largest number of mentions when participants were asked to name their three largest competitors. 14 other companies each received single mentions.
- Over half (7/12) of the companies stated that 80–100% of their business is related to cooling equipment. Another two companies indicated that 50–75% of their business is cooling equipment-related.
- Most of the companies we interviewed manufacture multiple types of cooling equipment. Evaporative coolers (5), DX packaged equipment (4), chillers (3), and heat pumps (3) were mentioned most often. Two of the respondents were component manufacturers, indicating that while they produce other products, compressors are the only products they

manufacture for cooling systems. Half of the respondents (6/12) stated that they focus only on complete systems. Of the four companies that manufacture both components and complete systems, two indicated that at least 2/3 of their business was in complete systems.

MARKETING AND PROMOTION

- When asked what kinds of promotional activities they participated in to ensure customer awareness of new cooling technologies, trades shows/industry events received the largest number of mentions (6), followed by mass media advertising (3), trade advertising (3), and websites (3). Meetings with OEM's and sales reps, and articles in trade journals also received multiple mentions (2 each). Only one company indicated that they conduct no promotional activities for this purpose.

  Some of the companies seemed to follow a strategy of marketing primarily to either the end-user or to other industry players (distributors, retailers, contractors, etc.). This seems to be consistent with the types of customers they primarily sell to (Q14).

- Nearly all those interviewed (11/12) stated that they actively promote cooling technologies. Five companies mentioned using advertising and press releases for this promotion, and two mentioned employing field trials and trade shows. A variety of other promotions were mentioned including: technical seminars, retail marketing support, educational efforts during the bid process, and contacting engineers and other decision makers.

- Nearly all surveyed (11/12) mentioned that they do offer training to customers. The one remaining respondent is a component manufacturer and indicated that training is not necessary because they interact with highly trained engineers at OEM's.

  Most respondents indicated that their companies are involved in multiple types of training efforts and several respondents indicated having their own training facilities. Some companies mentioned training geared toward contractors/homeowners while others oriented their training more toward distributors or retailers. The types of training most often mentioned included: trade shows (6), technology seminars (6), manufacturing plant tours (6), service and/or product training (6), pamphlets/brochures (5) and demonstration sites (4).

- All companies interviewed stated that they offer warranties on the cooling equipment they manufacture. The warranty period varied from 90 days to 5 years, depending on the individual product, manufacturer, and what specifically was covered by the warranty. Three of the respondents stated that they operate on a "standard" 18/12 warranty, meaning that the warranty period was 18 months from ship date or 12 months from installation. Several companies had separate and different warranty periods for parts and labor, or for a specific component, such as the compressor. Five companies mentioned offering warranties primarily on "parts only", while another four companies described their warranties as including "parts and labor." Several of the companies mentioned that extended warranties (for longer coverage, and/or to include labor) were available at an additional cost.

CUSTOMER INTERACTION

- More than half (7/12) of those questioned sell cooling equipment to different types of customers. Of manufacturers selling to multiple customer-types, each sells predominantly to one type, accounting for 66–99% of their business. The largest number of manufacturers sell to contractors (7), followed by distributors (4), retailers (4), and end-users (3). Other manufacturers and sales reps were also each mentioned once. No observations could be made about those companies selling cooling equipment to only one customer type.

  4/5 of those selling evaporative cooling equipment sell to multiple types of customers. This same number also sells to contractors. Only 1 out of five respondents in this group sells to retailers.

- Few participants could provide information on the percentage of their customers located in Northern California. One indicated 100%, one estimated 95%, and two other respondents stated the percentage to be below 10%.

COOLING TECHNOLOGIES

- Of the seven companies who do not currently produce evaporative coolers, only one indicated any possible interest in manufacturing the technology in the future.
- The five companies interviewed who do currently manufacture evaporative coolers stated that they make IDEC (2), evaporative condensers (2), direct evaporative coolers (2), and "their own invention" (1). Two of this group

manufacture only indirect evaporative cooling based equipment, while the other three produce both direct and indirect systems.

- Four of the five evaporative cooling equipment manufacturers indicated that they have encountered changes in technology over the past two years. Contractors/builders (3) were described as the primary influencers of this change, followed by end-users (2), reps (1) and government construction codes (1). Evaporative systems being environmental friendly and maintenance issues were mentioned by two respondents as possible reasons for these changes.
- Of the two companies who produce IDEC products, one indicated encountering some technological/performance problems, which they fixed and continue to address by reinvesting profits from the sales of the product.

TRADE-OFF CRITERIA

- When asked to name major competing technologies to evaporative-cooling based equipment, the majority (10/12) of respondents mentioned some form(s) of standard air conditioning system. There were also single mentions for high-efficiency water-cooled systems and absorption-cycle compression system.
- The table below represents the responses received when respondents were asked to compare evaporative cooling based equipment to this form of standard air conditioning on specific features.

Table E.1. Evaporative Cooling Compared to Standard Air Conditioning

	Better	Same	Worse	DK/NA
Cost	4		4	1
Reliability	2	3	3	1
Performance	3			6
Comfort	3	2	2	2
Operating/maintenance requirements	2	1	5	1
Health concerns	2	2	3	2
Product availability	2		3	4

- Not surprisingly, the evaporative cooling manufacturers had more favorable comments about evaporative cooling systems overall than did the other manufacturers. The only exception was one evaporative cooler producer which produces evaporative cooling systems as only a small percentage of their overall cooling sales, and believes that evaporative cooling will virtually disappear during the next two years.
- Responses were mixed across the board. The most noticeable comparison relates to operating/maintenance requirements, where 5/8 responding described evaporative cooling as worse than other cooling technologies. The reasons cited most often related to water quality requirements and higher maintenance due to water in the system.
- Most respondents were unable to comment on performance issues, and of those answering (3), all were manufacturers of evaporative cooling based systems.
- When asked how evaporative cooling systems were better than competing technologies in general, more efficient under certain circumstances was mentioned most often (3), along with mentions of low environmental impact, low cost replacement parts, easier repair, the availability of free cooling on cool days, feels cooler at a given SEER level, and low operating costs.
- When asked how evaporative cooling systems were worse than competing technologies in general, the most common response was that systems were highly climate sensitive—under high wet bulb situations (or water scarcity) the systems did not perform well. Other comments included: limited product availability, large physical size of systems, shorter equipment life, the technology was difficult to apply and had more constraints, lack of familiarity, and that the payback was difficult to calculate.

SALES VOLUME

- When asked what percentage of their entire cooling sales is indirect evaporative cooling or condensing, 4/12 indicated 70–100%. The remaining companies indicated 2% or less.

  Most companies (9/12) expect this percentage to remain the same or increase in the next two years, due in part to rising utility costs, greater awareness of and more familiarity with the technology, and product improvements. Slightly fewer (7/12) would project the same thing for the next ten years, with a larger number of respondents uncertain of what the long term future will bring. The one respondent who expected his company's evaporative cooling sales to decline over the next two years, (sales less than 2% of company's total cooling sales) stated that he sees evaporative cooling systems as "fading out" and being non-existent within the next two years.

- Two evaporative cooler manufacturers estimated the number of evaporative coolers they have sold in California during the past two years at 85 to 100.

- When asked about events or activities that would encourage market growth for evaporative coolers, the only theme that emerged with any consistency was the need for increased education, awareness and promotional activities for the technology, both with the public, as well as consultants, engineers and other decision makers. Comments also included: greater education on applications, design and planning for the technology, more cost effective systems, greater availability of evaporative coolers, and teaming efforts between utilities and manufacturers. Respondents indicated that some of these events were beginning to occur, but more was needed to encourage real market growth.

  There was no consensus regarding factors that would impede market growth for evaporative coolers. Comments included: the institution of flat utility rate structures so that incentives to move toward energy efficiency were eliminated, the lack of information on evaporative coolers, reduced product availability, the production of poor quality or inefficient systems, and the implementation more stringent air quality regulations so that perceptions of health concerns might need to be overcome. Respondents indicated that none of these were likely to happen in the foreseeable future.

EMERGING TECHNOLOGY INFORMATION FLOW

- Virtually all of the companies interviewed conduct most of their business (80–100%), with repeat customers, regardless of customer type.

- Most (9/12) manufacturers interviewed have participated in demonstration activities for new technology. These activities ranged from trade shows/demonstrations of thermal ice storage systems and computer simulation demos of compressors, to in-home product placements of new cooling systems. The same respondents indicated that they would be willing to participate in demonstration projects of new technologies in the future.

- Companies interviewed mentioned that they would need a wide variety of information to assess whether to manufacture a new technology. Cost/benefit analyses and ROI were mentioned most often (3), along with reliability/maintenance issues (3), overall feasibility/in-house capabilities (3), customer feedback/value to customers (2), market potential/longevity/market size/saturation/players (2), and level of support from in-house R&D department (2). The success of the technology, how proven it is, and reactions from the marketplace were also mentioned as factors.
- Customer feedback (5), in-house R&D efforts (4), outside published R&D results (3), and competitor activities (3) were most often mentioned as factors that would most encourage the production of a new type of equipment. Several respondents indicated that decisions to manufacture new products are complex processes, involving financial analyses, feasibility and market studies, assessment of in-house capabilities, technology trends, etc. Only one respondent indicated that his company is not interested in manufacturing new types of equipment.
- Respondents indicated that they rely on a wide variety of sources to stay current with emerging cooling technologies. Most respondents mentioned multiple sources including, but not limited to: trade journals (10), internal R&D (4), other news/publications (4), trade associations (ASHRAE, IIAR, ARI) (4), and rep and customer feedback (2). Most respondents (9/12) stated that their current sources of information were sufficient for decision making.

APPENDIX F: TECHNICIAN SURVEY RESULTS

BACKGROUND

As part of the overall data collection efforts for this study, a group of HVAC contractors were surveyed in order to address those barriers believed to be in the marketplace, as well as assist in the overall market characterization. In addition, adoption process and choice modeling questions were posed to this group of market actors, after it was determined in the initial focus groups that they were the primary decision makers.

Due to the somewhat involved nature of the survey (i.e., initial recruiting survey, faxing materials for review and ranking, and follow-up survey), and given the nature of the contracting business in general, survey completion with this group posed some challenges. Thus, our completion total of 34 was less than we had hoped. The following presents the results of those interviews.

EMERGING TECHNOLOGY INFORMATION FLOW

Respondents were asked to what degree their decision whether to start recommending a new type of cooling equipment would be determined by their concern about callbacks. Not surprisingly, 28 respondents, or 82%, were "extremely concerned" to "very concerned" about callbacks. "Callbacks cost money…" was the most sited reason for their concern, in addition to maintaining good reputations and making customer satisfaction a high priority. The remaining 6 respondents were only "somewhat concerned" to "not at all concerned," claiming that "if the equipment is installed correctly, there is nothing to worry about." These responses imply that they avoid concerns about callbacks by sticking with equipment they know they can install correctly and will perform well. Table F-1 shows the distribution of contractor responses.

Table F.1. Level of Concern for Callbacks

Level of Concern	N	%
Extremely concerned	13	38%
Very concerned	15	44%
Somewhat concerned	3	9%
Slightly concerned	2	6%
Not at all concerned	1	3%

Contractors were then asked to estimate the number of callbacks within a year they had, due to faulty equipment or installations, and, as Table F.2 illustrates, more than half the respondents, (20, or 59%) reported that they had less then 1% callbacks in one year. An additional 9 reported that they were called back about 5% of the time within one year. And only 4 said they were called back about 10% of the time. One respondent expressed the opinion that callbacks were somewhat normal, and contractors should expect them from time to time, as they are essentially dealing with something mechanical, and problems are often out of their hands.

Survey respondents were then asked where they go first for information on a new line of cooling equipment and most said they rely on their manufacturer or manufacturer's representative (20, or 60%). An additional 6 reported they look to trade journals or other literature for emerging equipment information. Likewise, 5 said they talk to the distributors and dealers first for the most up-to-date information. The Internet (2) and technical information lines (1) were also mentioned.

Respondents were then given a list of possible resources they may use to keep current on emerging cooling technologies. The following table shows the sources contractors rely on the most.

Table F.2. Contractors' Source of Information

Source	Use		Don't Use	
	N	%	N	%
Colleagues/contractors	22	65%	12	35%
Trade journals	32	94%	2	6%
Internet	9	26%	25	73%
Distributors/vendors	34	100%	0	0
Manufacturers	29	85%	5	15%
Own R&D	18	53%	16	47%
Popular magazine ads	13	38%	21	62%
Newspapers	5	15%	29	85%
Trade associations	20	59%	14	41%
Trade shows	25	74%	9	26%
Local utility	9	26%	25	74%

In addition, those who said they looked to other contractors or colleagues for information were then asked how often they rely of them, and only four said "all the time or "most of the time." For the most part, contractors only look to each other some of the time or rarely, and it's usually only to talk about a technology or problem, rather than learning something entirely new. This is not surprising given the competitive nature of their business.

Contractors were split nearly half on whether they belonged to any trade associations, with 15, or 44%, belonging to at least one association. Several of these contractors belonged to ASHRAE (3), two belonged to the Mechanical Contractors Association and Electric & Gas Industry Association (EGIA), respectively. Moreover, all 15 of these respondents reported that they attend other training sessions offered by such associations as manufacturers and utilities.

Evaporative Cooling Equipment

Contractors were then asked to indicate their awareness of evaporative cooling technology, including direct, indirect, indirect/direct and evaporative condensers. Overall, nearly everyone surveyed was aware of direct evaporative cooling technology (29 of 34), and 19 were aware of indirect evaporative cooling. Seventeen respondents reported being aware of indirect/direct technology and 13 were aware of evaporative condensing technology. Of the 34 respondents, only 12 were not aware of any indirect technology, and were therefore not asked the remaining evaporative cooling sections.

Twenty-two respondents who reported being familiar with indirect or indirect/direct evaporative cooling technology, were then asked whether they recommended them for installation or not. Again, the majority said they recommended or installed direct evaporative coolers (18 of 22), while 14 reported they recommended or installed indirect cooling technology. Additionally, 13 said they recommended or installed indirect/direct technology, while 13 reported they installed or recommended evaporative coolers. In an attempt to measure specifically the level of awareness of indirect evaporative cooling technologies, respondents who did not recommend or install indirect technology were asked to respond to a series of statements that assessed the level of their awareness. Of the 3 respondents who answered this question (the remaining skipped on to the next section), 2 respondents reported that they had "heard of indirect evaporative cooling technologies, but I've never looked into them." The third respondent said that they had "looked into indirect evaporative cooling technologies and intend to specify and recommend them to their customers."

Of the 18 respondents who reported installing evaporative coolers, 5 said that direct evaporative coolers represented less than 5% of their total annual installations, while an additional 4 said they represented 6–10%. One contractor said evaporative coolers made up 25% of their installations, while another contractor reported 80% annual installations of evaporative coolers. One respondent reported they conduct 100% of their sales in evaporative coolers (they were an evaporative cooler contractor). With respect to actual units sold, half of the respondents said they had sold less than 10 units within the past year (8 of 16). An additional 2 said they sold 15 units within the last year, and the remaining could not recall specifically how many they had sold.

Twenty respondents were then asked whether they thought their installations of indirect evaporative coolers (including indirect and indirect/direct) would increase, decrease, or remain the same over the next two years, and then over the next seven years. Respondents felt the market would either increase, or remain the same over both two years, and seven years. Specifically, 8 of 20 felt the market would increase over the next two years, and 11 thought it would increase over the next seven years. Only 3 respondents thought their installations would decrease, both within 2 years and 7 years. Nine of the 20 said their installations would probably remain the same over the next two years, and 6 of 20 said they would remain the same over the next 7 years. Those who thought their sales would increase, either over the next two or seven years, attributed it to the "increased interest in energy efficiency" as well as lower utility bills that evaporative coolers allow. Those who felt it would decrease felt that because of the "humidity levels" and "allergy problems" currently in the Central Valley, which evaporative coolers exacerbate.

Those who installed evaporative coolers reported that, for the most part, they have not encountered any sort of technological problems with the technology (14 of 20). However, those who did, reported leakage problems and rusting equipment. They said the way they overcome these issues is to replace the evaporative cooler with a DX system. One respondent said that his customer had an evaporative cooler located on the warmest side of the building so that when the sun came up, it would heat the system up so much so that it was nearly impossible to get cool air in. He fixed this problem by lining the system with special tape to insulate the water and thus cooling the air.

Nearly all reported that they had not had any trouble obtaining information about evaporative coolers, and likewise with obtaining actual evaporative cooling components. Those who said they had difficulty finding information (3 of 20) blamed this on the vendor not being knowledgeable, or the inability to pass through cumbersome voice mail systems. And, the 2 respondents who reported problems with obtaining equipment said it was due to the product just "being out of stock." Neither were concerned about the delay, and said that they often have to wait for DX equipment as well.

Overall benefits of indirect evaporative cooling technologies include the lower costs of operating the system, high efficiency, and lower first cost. Drawbacks reported included humidity concerns, health concerns (especially for those with allergies), lack of cool enough air, mold, and the lack of exact temperature control.

Lastly, this group was asked what sort of market events or activities would encourage market growth for indirect evaporative coolers. Respondents thought that increased marketing, better products and even utility rebates on equipment would encourage growth. In addition, lower first cost of the better technologies would "definitely help."

COMPANY PROFILE

The survey concluded with general information about the respondents business and expertise. Respondents tended to be from smaller companies, with 29 reporting there were five or fewer contractors who specify and install equipment. While our sample was seemingly small, respondents seemed to have many years of experience, with the majority having between 16 and 35 years in the contracting business. Only 8 respondents had less than 15 years, and no one had less than 10 years of experience. Four respondents said they had personally been practicing in the field for more than 36 years.

All but 4 respondents said that they specified or installed DX, or refrigeration compressors and heat pumps in their line of work. In addition, 15 also installed whole-house fans, and 15 also installed chilled water units. Other technologies installed include gas-fired furnaces, evaporative coolers, and water boilers.

Eleven respondents completed 50 or less residential installations last year, whereas 5 completed between 51 and 100 installations. Six reported that they installed more than 100 residential installations, while 3 said they completed between 101 and 300 residential installations. There were 7 respondents who said they completed more than 400 residential projects last year. Eighteen respondents, however, said they completed less than 20 small-commercial projects last year, whereas 8 respondents installed 21 to 50 small-commercial applications. Three respondents installed equipment in 51 to 100 small-commercial buildings and 5 respondents said they completed more than 100-small commercial projects last year. Most did not complete any large-commercial or industrial installations last year, however 13 did report that they did less than 20 installations of large commercial/industrial projects. Two respondents reported that they completed between 21 and 50 large-commercial/industrial projects last year.

Contractors were then asked to name the top three brands of equipment they recommend or install most often. The reason we asked this question is that in focus groups it became quite evident that contractors are very brand loyal. Several said, "if Trane makes it, we trust it." If a specific manufacturer does not make evaporative coolers, yet is the brand of choice among a contractor, they may be a "missed opportunity" on that factor alone. The top brands, not surprisingly, were Carrier, Bryant, Trane, York, and Rheem/Ruud. Others mentioned Paine equipment, as well as evaporative cooler brands, such as Comfort Master and Smart Cool.

Lastly, contractors were asked what percent of their business was with repeat customers versus one-time buyers, and most said the majority of their business was with repeat customers (except in new building situations), with 21 of 34 reporting as such. This result supports the finding that contractors are a useful channel for communicating with building owners and developers.