Customer Energy Efficiency Program
Measurement and Evaluation Program

PACIFIC GAS & ELECTRIC COMPANY'S 1998 Commercial Refrigeration Simulation Tool Baseline Study

STUDY ID: 420MS-H

June 30, 1999

Measurement and Evaluation
Customer Energy Efficiency Policy & Evaluation Section
Pacific Gas and Electric Company
San Francisco, California

Disclaimer of Warranties and Limitation of Liabilities

As part of its Customer Energy Efficiency Programs, Pacific Gas and Electric Company (PG&E) has engaged consultants to conduct a series of studies designed to increase the certainty of and confidence in the energy savings delivered by the programs. This report describes one of those studies. It represents the findings and views of the consultant employed to conduct the study and not of PG&E itself.

Furthermore, the results of the study may be applicable only to the unique geographic, meteorological, cultural, and social circumstances existing within PG&E's service area during the time frame of the study. PG&E and its employees expressly disclaim any responsibility or liability for any use of the report or any information, method, process, results or similar item contained in the report for any circumstances other than the unique circumstances existing in PG&E's service area and any other circumstances described within the parameters of the study.

All inquiries should be directed to:

Lisa K. Lieu
Revenue Requirements
Pacific Gas and Electric Company
P. O. Box 770000, Mail Code B9A
San Francisco, CA 94177

Copyright © 1999 Pacific Gas and Electric Company. All rights reserved.

Reproduction or distribution of the whole, or any part of the contents of, this document without written permission of PG&E is prohibited. The document was prepared by PG&E for the exclusive use of its employees and its contractors. Neither PG&E nor any of its employees makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any data, information, method, product or process disclosed in this document, or represents that its use will not infringe any privately-owned rights, including but not limited to, patents, trademarks or copyrights.

Equipoise Consulting, Inc.

Energy Analysis

Project Management

Training

Final Report for

Pacific Gas & Electric's 1998 Commercial Refrigeration Simulation Tool Baseline Study

Submitted by:

Equipoise Consulting Incorporated

June 30, 1999

Equipoise Consulting Incorporated is committed to environmentally friendly practices in the workplace. We use recycled paper in all our proposals and reports. We print double sided and use electronic faxes when possible to decrease paper use. All our office paper is recycled. Our ‘virtual’ office setup means that work between colleagues is performed by telecommuting, thereby minimizing transportation requirements.

Acknowledgments

The evaluation team would like to thank the designers, manufacturers, and end user decision-makers that were willing to participate in data collection efforts during their busy working days. It is irrefutable that this evaluation would not have been possible without their help.

In addition, the evaluation team would like to thank Doug Scott of VaCom for his assistance in building the sample lists and his contribution to the program background, Jeff Hirsch of JJHirsch and Associates for his review of the tool development status, and Don Felts and Peter Turnbull of PG&E for assisting in documenting the program goals and history, and the evaluation project manager, Valerie Richardson, for her support and confidence during the project.

TABLE OF CONTENTS

TABLE OF EXHIBITS

Page

Section 1.
Executive Summary

1.1 Commercial Refrigeration Simulation Tools Program Description

The Commercial Refrigeration Simulation Tools Program (CRST) is designed to develop an interactive computer simulation software tool for use by supermarket refrigeration system designers. As currently planned, the tool will allow designers to construct a DOE2 model of a planned supermarket and evaluate the effects of changes in refrigeration system design on both refrigeration system energy use and whole supermarket energy consumption. The 1998 and 1999 CRST Program is targeted solely at supermarkets that use central refrigeration systems.

1.2 Evaluation Study Description

The study was designed to leverage on previous studies (Study of Market Effects on the Supermarket Industry and PG&E Supermarket Refrigeration Baselining Design Practices Study) and combine that data with selective additional primary data collection to meet the following Study objectives:

1. construct a detailed market characterization,
2. attempt to establish baselines and define market barriers, and
3. establish methodology for measuring market effects at some future time.

The biggest factor limiting the ability to meet these objectives is the extremely limited number of market actors in this market. The market is dominated by 4-5 refrigeration manufacturers and 15-20 large supermarket chains nationwide. Many of these had been interviewed within the last eighteen months during the prior two evaluations.

1.3 Major Findings

1.3.1 Market Characterization Summary

The key parameters characterizing the California supermarket refrigeration market are:

- The market is composed of a very limited number of market actors, many of those being intermediaries. Four to five large chains and four manufacturers dominate the market.
- Large supermarket chains tend to have established relationships with specific equipment suppliers. They also tend to do their refrigeration design in conjunction with those companies, and already feel they are installing refrigeration systems that

are cost effectively energy efficient. Independent supermarkets contract refrigeration design efforts to companies specializing in servicing that market.

- Maintenance and repair services are usually supplied by independent companies.
- The California supermarket refrigeration market is estimated to represent 39 trillion Btu of primary energy annually across approximately 3,700 stores.
- The market event resulting in the installation of a new refrigeration system is the construction of a new store. It is estimated that 360 new stores are built in California annually.

1.3.2 Baseline

The evaluation surveyed thirteen of the largest supermarkets, manufacturers, and consultants in California. Although the analysis can only be qualitative because of the small sample, a majority of the targeted market was interviewed. As such, the results can be considered indicative of the market as a whole.

The following is a summary of the baseline conclusions for the California supermarket refrigeration market.

- In the supermarket refrigeration market, marketability (i.e., product presentation, display appearance, display location) and product integrity are the driving forces. The equipment in the stores is used as a tool to meet these primary needs.
- The large supermarket market actors involved in the design of and decision-making regarding refrigeration systems are a knowledgeable group of market actors who believe in cost-effective energy efficiency (simple payback of less than three years). They are willing to investigate options and invest money if savings can be achieved. This target market involves a very small number of market actors, but a large market share.
- Small supermarket market actors appear more interested in minimizing first costs and are less proactive about energy efficiency.
- The market actors are satisfied with the current level of energy efficiency information they obtain and feel they get all that is available from the manufacturer.
- Their goal to supply cost-effective energy efficiency is consistent with their actions. That is they systematically install energy efficiency measures that fit their payback criteria when they are convinced that they will result in real savings.
- While most designers say they need a tool that is quick and simple, designers and decision-makers with the larger chains indicated an interest in assessing a more sophisticated tool. They felt that the potential operating cost savings from systems developed with such a design tool were large enough to make the effort worthwhile.
- The credibility gap is large. Design professionals and decision-makers understand the store-to-store variability and will need to be convinced that savings are real. Real building demonstration projects will almost surely be required. Acceptance of the veracity of any final tool will take a long time and will be hard earned.

1.4 Major Recommendations

1.4.1 Study Methods Recommendations

- Use a longitudinal approach.
  - Periodically, maybe every three years, field the same set of evaluation questions used for this study to the same group of market actors. The market metric questions may allow the evaluations to identify a trend over time, despite the small sample sizes.
  - Similarly, follow the market actors who obtain the tool, to determine the systems and technologies installed due to the savings shown by the tool.
- Proactively counter sample attrition through:
  - personal phone calls from senior PG&E staff or other influential market actors requesting participation in the study,
  - distribution of this report upon its completion to all participants, with a cover letter thanking them and mentioning future needs to repeat the study, and
  - supplying demonstration software to designers with good support information in order to interest them in the project.
- Develop replacement questions for the metrics that failed to achieve meaningful responses.

1.4.2 Program Design Recommendations

- Carefully market the tool to selected influential market actors. Interviews indicated that the large chains are most receptive to the concept. They have the resources to evaluate the tool and, if convinced of its ability to correctly predict system/store performance, to implement changes in a large number of stores. Anecdotal comments during interviews indicate that when large market actors make changes in overall approach, smaller market actors usually follow. The small number of market actors and the free flow of information within the industry enhance this effect.
- Track all the people who receive the program – get contact names, addresses, phone numbers, and e-mail addresses. Only with this information can future evaluations successfully track the penetration of the tool.
- Conduct demonstration projects on actual buildings to show the ability of the tool to reflect the actual level of energy usage. Emphasize how the tool predicts interaction with the HVAC system and allows optimization of HVAC as well as refrigeration
- Create the ability to easily enter financial data into the tool to allow more complete cost/benefit analysis within one tool. Interviewees emphasized the criticality of cost benefit analysis as part of system evaluation.

Section 2. Introduction

This section summarizes the CRST Program and documents the background and purpose of the study covered by this report.

2.1 Commercial Refrigeration Simulation Tools Program Description

The Commercial Refrigeration Simulation Tools (CRST) Program consists of the development of an interactive computer simulation software tool for use by supermarket refrigeration system designers. As currently planned, the tool will allow designers to construct a DOE 2 model of a planned supermarket and evaluate the effects of changes in refrigeration system design on both refrigeration system energy use and whole supermarket energy consumption. The 1998 and 1999 CRST Program is targeted solely at supermarkets that use central refrigeration systems.

The tool is in the conceptual design/prototype stage. A contractor has created a module for DOE2.1E that is specific to refrigeration in supermarkets and incorporates an extensive library of type/model-specific performance data. At this stage, the tool is said to properly predict the energy consumption of the refrigeration system, but as yet it has not been calibrated to real building performance data. In addition, the interaction of the refrigeration module with the remainder of the DOE 2 modules still needs to be correctly programmed.

2.2 Evaluation Study Description

In 1996, 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.

PG&E commissioned two evaluations of the commercial refrigeration market during 1998. The Study of Market Effects on the Supermarket Industry was performed as part of an evaluation of the supermarket industry on behalf of the CADMAC Market Effects

Subcommittee (PG&E was the Project Manager for this study). The final report for this evaluation was released July 15, 1998. In addition, the PG&E Supermarket Refrigeration Baselining Design Practices Study was conducted in September 1998, on behalf of the PG&E Commercial Simulation Tool design staff. This study focused primarily on establishing a baseline on commercial refrigeration design practices. This study was a requirement in the reporting milestones established by the CBEE.

Using these two studies as a starting point, the following market characterization and baseline study was designed.

2.2.1 Objectives

The study was designed to leverage on the data existing in the Study of Market Effects on the Supermarket Industry and PG&E Supermarket Refrigeration Baselining Design Practices Study reports and combine that data with selective additional primary data collection to meet the Study objectives. The objectives of the Study were:

(1) construct more detailed market characterization surveys that will support the task of conducting a structured analysis (i.e., identify and define roles of key actors in the refrigeration design market segment),

(2) attempt to establish baselines and define market barriers, and

(3) establish methodology for measuring market effects at some future time.

2.2.2 Results

The study results are presented separately for the market characterization, the baseline and the proposals for future evaluation plans.

The market characterization was developed based on the market characterization elements defined in the CBEE Policy Rules. The study attempts to describe and clearly define the market, document the technologies involved, identify the market actors and their interactions, and summarize the market character, size, and number of market events relevant to the market.

The baseline element uses market actor responses to develop and measure metrics that indicate the current level of the market barriers studied. Because of the extremely small market size, these metrics are inherently qualitative.

Finally, recommendations for future study approaches are made.

2.2.3 Timing

The 1998 CRST Program evaluation commenced January 13, 1999, completed the planning stages in February 1999, conducted data collection from March through early May 1999, and completed the reporting phase in June 1999 to meet a PG&E June 30, 1999 filing date.

2.2.4 Governing Rules

The evaluation planning and execution is intended to follow the California Board for Energy Efficiency (CBEE) Policy Rules. These rules were used, in combination with the realities of the market being evaluated and prudent budget restrictions, to develop a cost-effective evaluation plan.

2.3 Report Layout

This report is divided into seven sections plus the supporting appendices. These are:

Section 1. Executive Summary –supplies a synopsis of the report findings.

Section 2. Introduction – summarizes the report, introduces the program, and presents a synopsis of the evaluation.

Section 3. Methodology – presents the data sources and the approach used to analyze the data and derive the results.

Section 4. Evaluation Results – presents the study findings and discusses alternatives for future evaluations.

Section 5. Recommendations – discusses recommendations emanating from the evaluation.

Appendix A. Analysis Plan by Market Barrier – presents a detailed explanation of the qualitative analysis plan by market barrier.

Appendix B. Final Decision-Maker Interview Instrument with Responses – supplies the final field data collection instrument for the decision-maker interviews with the cumulative responses.

Appendix C. Final System Designer Interview Instrument with Responses – supplies the final field data collection instrument for the refrigeration system designer interviews with the cumulative responses.

Appendix D. Final Project Team Interview Instrument with Responses – supplies the final field data collection instrument for the interviews of the project team members with the cumulative responses.

Appendix E. Detailed Computations

Section 3. Methodology

This section documents the data sources and analysis approach used in the study.

3.1 Data Sources

From the beginning, it was clear that much of the work for this baseline study would be extracting key information from data in two existing commercial refrigeration baseline assessments and combining it with selected data collection. This section identifies both the existing data and the additional data collected to complete the supermarket refrigeration market characterization and baseline assessment.

3.1.1 Existing Data

The two previous studies available to support this market characterization and baseline study were:

- Study of Market Effects on the Supermarket Industry was an evaluation of the supermarket industry on behalf of the CADMAC Market Effects Subcommittee. The final report for this evaluation was released July 15, 1998. This evaluation covered the entire commercial supermarket sector. It supplied much of the information for the market characterization and a qualitative assessment of some of the barriers existing in the market.
- PG&E Supermarket Refrigeration Baselining Design Practices Study was conducted in September 1998, on behalf of the PG&E Commercial Simulation Tool design staff. This study focused primarily on establishing a baseline on commercial refrigeration design practices. This study was a requirement in the reporting milestones established by the CBEE.

These two studies were obtained and reviewed by the evaluation team.

3.1.2 Collected Data

Additional data collected to support this evaluation came from the following sources:

- U.S. Census Bureau
- Food Marketing Institute
- 1998 ACEEE Proceedings, Energy Efficiency in a Competitive Environment, *Cool Energy Savings Opportunities in Commercial Refrigeration,* Westphalen, D. Broderick, J, and Zogg, R.
- In-person interviews of two PG&E program staff and two program contractors
- Telephone surveys from thirteen designers and decision-makers in the supermarket industry

The target market for the CSRT program is the large supermarket chains and those designers who work with a large number of supermarkets. On the demand side, the supermarket industry has recently been consolidating through mergers of the larger chains. On the supply side, three or four large refrigeration equipment manufacturers dominate the industry. As such, the number of market actors within the market is relatively small nationwide. When this is combined with the fact that two previous market assessments had targeted many of the market actors within the prior eighteen months (thus reducing probable response rates), the list of available market actors willing to be interviewed is even smaller.

Based on the market characterization, the decision was made to obtain information from the market from both the designer and decision-maker point of view. The market characterization suggested that while the designer may be recommending energy efficient designs, the decision-makers were potentially deciding not to install them based on other criteria. The evaluation team wanted to explore this hypothesis. Therefore, interview guides were created for each targeted group.

The evaluation team first interviewed the program implementers in order to determine how they viewed potential barriers in the marketplace and to obtain possible contact information for interviews. Contact information was an issue for the evaluation since a relatively small number of market actors exist and many had already been contacted by two evaluations within the past eighteen months. The original sample lists were obtained from the Study of Market Effects on the Supermarket Industry and PG&E Supermarket Refrigeration Baselining Design Practices Study to determine who had been contacted in the past. While previous contact did not eliminate candidates from contact lists, it allowed the interview staff to acknowledge that the person had been previously contacted during the interview introduction.

One of the first interviews with a program implementer was instrumental in determining the sample frame and obtaining contact names and phone numbers for the market actors who sell product within California. Based on that interview, it was determined that there are basically three large supermarket chains in California (those with >100 stores) and one planning to move into the California market, three medium-sized supermarket chains in California (those with 20-100 stores), and three main suppliers for the smaller independents. Two of the largest manufacturers of refrigeration systems also design systems for smaller customers in California. These two manufacturers and a large California-based energy service company completed the sample frame. A census of these market actors was attempted by the evaluation team, with the results shown in Exhibit 3.1. Two market actors moved from the original sample of "designers" to "decision-makers" based on conversations at the beginning of the interview (one large supermarket and one independent supplier).

All interviews were done by evaluation engineering staff. This approach was believed to be essential in order to establish credibility with these technical contacts and to extract the maximum amount of information from the interview.

Exhibit 3.1
Sample Design and Completed Sample Points

Market Actor	Sample Design		Completed	
	Designer	Decision-Maker	Designer	Decision-Maker
Large Supermarket Chain	3	6	1	6
Medium Supermarket Chain	0	3	0	1
Independent Supplier	2	1	1	1
Manufacturer/ESCO	3	0	3	0
Total	8	10	5	8

3.2 Analysis Approach

Prior to determining how to obtain and analyze additional information for the evaluation of the refrigeration simulation tool, the market actors and interactions between them had to be understood. The evaluation team used the previous Study of Market Effects on the Supermarket Industry and PG&E Supermarket Refrigeration Baselining Design Practices Study reports to create a market characterization. The understanding of how the market worked led to the determination that both the decision-makers and refrigeration system designers could have potential influence on the use of the refrigeration simulation tool. The potential market barriers as outlined in the Scoping Study[1] were evaluated for each of the market actors (decision-makers and system designers).

3.2.1 Market Barriers Addressed

The program design essentially hypothesizes that the barriers to the installation of energy efficient refrigeration systems are really composed of two elements. The first element is the barriers that keep designers from designing energy efficient refrigeration systems in supermarkets. The second element is the set of barriers that, despite the availability of efficient system designs, inhibit decision-makers from deciding to install energy efficient systems. Since the goal is energy savings through installation of energy efficient systems, it was concluded that the evaluation needed to look at both elements. Exhibit 3.2 provides a summary of the barriers analyzed during the evaluation.

Following this exhibit, the rationale for the inclusion or exclusion of each barrier is discussed from both the design and implementation points of view.

[1] A Scoping Study on Energy-Efficient Market Transformation by California Utility DSM Programs. Eto, J.; Prahl, R.; Schlegel, J. July 1996.

Exhibit 3.2
Summary of Barriers to be Investigated

Barrier	System Designers	Decision-Makers
Information and Search Costs	**Yes**	**Yes**
Performance Uncertainty	**Yes**	**Yes**
Asymmetric Information & Opportunism	**Yes**	No
Hassle or Transaction Costs	**Yes**	No
Hidden Costs	No	**Yes**
Access to Financing	No	No
Bounded Rationality	**Yes**	**Yes**
Organizational Practices or Custom	**Yes**	**Yes**
Misplaced or Split Incentives	No	**Yes**
Product or Service Unavailability	**Yes**	No
Externalies	No	No
Nonexternality Mispricing	No	No
Inseparability of Product Features	No	No
Irreversibility	No	**Yes**

Information or Search Costs

Assess for System Designers? **Yes** Much information comes from equipment manufacturers with probable vested interest in their product being used. To design a system using equipment from various manufacturers, and predict how efficiently it will run, is difficult to do. It is known from previous reports that efficiency information on specific pieces of equipment is fairly easy to obtain. However, it may be more difficult to obtain such information on a complete system.

Assess for Decision-Makers? **Yes** Since the basis for any decision to proceed with installation of any energy efficient variation will necessarily include information on system energy use and, hence, money saved, comprehensive estimates of system savings are necessary. If the designer cannot estimate it using a design tool, then the information is probably not available.

Performance Uncertainties

Assess for System Designers? **Yes** Since no satisfactory system design tool currently exists, any new tool entering the market will have to prove its ability to correctly predict savings. This means that, for the present, there will be uncertainties in the market as to the validity of the current predictions of benefits.

Assess for Decision-Makers? Yes Values obtained from the simulation may be questioned by a decision-maker who does not have the expertise to determine whether the model has been implemented correctly. Also, the differences between a model and reality may be questioned. Additionally, there are always questions regarding the performance of the refrigeration system, especially when putting together equipment from multiple manufacturers.

Asymmetric Information and Opportunism

Assess for System Designers? Yes A few large manufacturers dominate the refrigeration equipment market. It is the evaluation team's understanding that consumers generally have long-term relationships with specific manufacturers and may trust claims made by them. Thus, it would appear that asymmetric information is not a barrier in this market. However, since it has the potential to be a significant inhibition to the design process, it was assessed

Assess for Decision-Makers? No Asymmetric information and opportunism barrier, by its name, primarily focuses on the control of information to give one side an advantage. Since most of the information comes to bear in the design process, this was considered a potential barrier for design but not for implementation. Any nuances are subsumed into other barriers (e.g., performance uncertainty).

Hassle or Transaction Costs

Assess for System Designers? Yes Current designers of refrigeration systems use in-house spreadsheets or work with the manufacturer and their proprietary design programs. The development of a computer program that can compare systems would be an expensive venture. Thus, this was viewed as a barrier to the design of energy efficient systems.

Assess for Decision-Makers? No Given that there are so few suppliers, it is reasonable to assume that buyers would have no trouble identifying and attracting the attention of suppliers. Suppliers would be more than willing to facilitate the installation of the needed hardware since it is in their self-interest.

Hidden Costs

Assess for System Designers? No Hidden costs are not seen as a potential barrier for using system design tools since there are few hidden costs in the operation of a piece of software. Potentially, if the specific equipment being modeled is not in the database, there could be unexpected time and labor in finding that information. However, it is hard to believe that these costs could be significant enough to inhibit use of a design tool.

Assess for Decision-Makers? Yes This is closely related to performance uncertainties and is viewed as a potential barrier for system implementation. Reliability is a major issue. As refrigeration equipment becomes more efficient, it tends to become more complex. As such, energy efficiency measures represent an unknown in terms of reliability; potential reliability problems represent potential (hidden) equipment repair and product loss costs.

Access to Financing

Assess for System Designers? No Paying for a tool (if there is to be a cost to the customer) was not expected to be an issue inhibiting the use of the design tool.

Assess for Decision-Makers? No Previous studies indicate that access to financing is not a significant barrier to the installation of energy efficient components in this market. It is rational to assume that this also holds true for energy efficient systems. Supermarkets generally finance expansion and remodeling through their capital budgeting process. Thus, this is one item in a stream of items paid for out of capital.

Bounded Rationality

Assess for System Designers? Yes Based on the earlier reports, rules of thumb have long played a central role in refrigeration system design. While new and better tools may be available, designers often rely on older empirical rules of thumb because they have been found to be reliable and safe (i.e., they result in systems that do not cause problems). This approach may well be in conflict with stated desires by designers to produce energy efficient designs.

Assess for Decision-Makers? Yes The decision-makers have historically put marketing concerns ahead of anything else. This is possibly in conflict with the stated goals for profitability or market expansion. This action may have a secondary inhibiting effect on the use of a design tool.

Organizational Practices or Custom

Assess for System Designers? Yes This was seen as a barrier, but one that may not be able to be breached at any cost. Energy efficiency may always take a back seat to product presentation in supermarkets. Additionally, the added cost of a less-efficient refrigeration system may be far lower than the cost of litigation due to spoiled food. Whether and how a system design tool could change this needs to be assessed.

Assess for Decision-Makers? Yes Same reasons as above.

Misplaced or Split Incentives

Assess for System Designers? No There does not appear to be any significant misplaced or split incentive barrier to design tool use.

Assess for Decision-Makers? Yes Supermarkets are a low margin business, meaning that minimizing operating costs should be a high priority. Yet, in the previous reports, keeping the initial store construction cost down was continually quoted as one of the primary reasons that energy efficient products were not installed. There appears to be no incentive on the part of the construction arm to keep operating costs down (i.e., misplaced incentives).

Product or Service Unavailability

Assess for System Designers? **Yes** Energy efficient products seem to be widely available and widely promoted by supermarket refrigeration manufacturers. However, there are no system design tools available on the market. This is seen as a potential barrier for efficient system design.

Assess for Decision-Makers? **No** Efficient systems are not available primarily because there is no way for designers to determine whether or not combinations of components would provide better performance. So the product unavailability here is the unavailability of the design tool. As indicated above, this was assessed.

Externalities

Assess for System Designers? **No** There is no evidence from the previous studies that this barrier plays any role in this market.

Assess for Decision-Makers? **No** There is no evidence from the previous studies that this barrier plays any role in this market.

Nonexternality Mispricing

Assess for System Designers? **No** There is no evidence from the previous studies that this barrier plays any role in this market.

Assess for Decision-Makers? **No** There is no evidence from the previous studies that this barrier plays any role in this market.

Inseparability of Product Features

Assess for System Designers? **No** Inseparability of products features is not a barrier for the design tool since the fundamental hypothesis is that there are no design tools capable of performing the system design task.

Assess for Decision-Makers? **No** Inseparability of products features is not a barrier for system implementation because the principle behind development of a whole system design is that designers cannot develop an optimally efficient system without the ability to simulate it correctly. Thus the issue is not inability to separate features, but rather the ability to accurately predict design impacts.

Irreversibility

Assess for System Designers? **No** The concept behind doing computer simulations is that one can iterate and change the design until the desired product is achieved. Thus, for the system design tool, designs are easily reversible. If the software is found to be undesirable or doesn't work the way the designer wants, it is easily replaced. Thus, irreversibility is not a barrier for the designer.

Assess for Decision-Makers? **Yes** The concern that the energy efficient system will not work as planned, or that it will not meet the refrigeration load and will then need to be replaced at large expense, is a very real fear in the market. This was considered to be a barrier and was assessed.

3.2.2 Analysis Method

The analysis began with a literature review and market characterization. These sources provided the evaluation team with an understanding of the market, enabling the determination of potential market barriers. Structured interview guides were created with the intention of collecting metrics for each market barrier and identifying the roles of the key market actors. The analysis plan for the interview guides is presented in Appendix A. This plan outlines specifically how each question was to be used and analyzed by barrier and interview type.

The analysis approach involved asking a series of questions that pertained to each barrier. At least one question per barrier was intended to act as a "metric" for future assessment of whether the barrier has changed. The current response to the metric was combined with responses to other questions to develop a qualitative assessment of the current state of the market barriers. The small number of data points meant that qualitative analysis was the only feasible approach.

With such a small sample, attrition was a large concern. The survey was kept as short as possible to minimize dropouts; thus, only one quantitative "metric" question on the seven barriers was asked per group. Despite that, the average length was 24 minutes. Because the evaluation was interviewing busy designers and executive decision-makers, obtaining much of their time was extremely difficult. Several interviewees indicated a need to finish the interview because of other business. This will continue to be a major concern for future evaluations.

Simple statistics (average, standard deviation, standard error) were calculated for each market barrier metric. Although the two samples were only five and eight data points each, where both groups were asked about a barrier, a t-test was used to determine if differences between the two groups were significant. Because the samples were so small, it is not surprising that none of the metrics indicated significant differences between the decision-maker and designer groups. Therefore, all averages and confidence levels were calculated for the entire sample of thirteen points.

Section 4. Study Findings

4.1 Market Characterization

4.1.1 Definition of Market

The definition of market characterization used in this study is drawn from the California Board for Energy Efficiency (CBEE) Policy Guidelines dated February 4, 1998; specifically, the subsection titled Guidelines for Market Assessment. This subsection of the CBEE Policy Guidelines covers a mixture of elements that should be considered by the utility when planning a program (e.g., cost-effectiveness tests) and elements that define or characterize the market. Specifically, elements have been extracted that pertain to an *ex post* market characterization of an existing program. Thus, the market characterization should include the following elements:

1. A clear definition of the market or markets to be discussed, and a description of the scope and natural boundaries implicit in this definition.
2. A description of the structure of the market, including the following features:
    a. A summary of the specific technologies, services, or products being exchanged.
    b. A summary of the major market participants and the nature of the transactions and other interactions between them, including buyers, sellers and intermediaries.
    c. 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.
    d. A description of the geographic boundaries of the market.
    e. A description of circumstances and settings under which transactions tend to occur, including sales practices and market events that tend to result in transactions within the market (e.g., a decision to remodel precipitating the purchase of a new lighting system).
    f. Approximate 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.
    g. An analysis of efficient market share, or the percentage of measures or services sold, that meet appropriate energy-efficiency criteria.

3. A thorough description of the market barriers impeding the adoption of cost-effective energy-efficiency measures and services within the market, if any.

The remainder of this section is divided into subsections addressing the primary characteristics contained in this definition.

4.1.2 Geographic Boundaries

The geographic boundary of the market being studied is the borders of the State of California. The State of California became the market at the beginning of 1998 when the CBEE assumed sponsorship of the DSM programs previously designed and implemented by PG&E. Prior to January 1, 1998, the CRST Program was primarily targeted to benefit the customers within the PG&E service territory.

However, even though the official geographic boundaries for the CRST Program is the borders of the State of California, the target audience is, by necessity, national manufacturers and large regional and national chain stores. In addition, as will be discussed later, the supermarket refrigeration equipment market is dominated by a handful of large national refrigeration companies. Therefore, in order to have an effect in California, the CRST Program must target the large regional and national chains, along with the major refrigeration suppliers that supply their refrigeration equipment.

Thus, while California businesses benefit from the CRST Program, it also affects supermarkets outside California.

4.1.3 Market Segment Description

The commercial supermarket refrigeration market is being studied in this evaluation. This target market includes all grocery stores large enough to use a centralized refrigeration system. This generally includes stores above 40,000 square feet and can include independents stores up to the large chains such as Safeway, Wal-Mart, and K-Mart. The definition of a supermarket used by the Food Marketing Institute, an industry trade association, is a grocery store with more than $2 million in annual sales.[2] While that definition probably covers the organizations studied here, it was not a selection criteria for selecting the market actors for interviews. While future program plans include expansion to refrigerated warehouses, this evaluation does not include that segment.

The CRST Program really attempts to address two elements of this market segment through the use of the simulation tool. First, it attempts to accurately simulate the overall refrigeration system efficiency and second, it attempts to quantify the effects of changes in the refrigeration system efficiency on whole-building energy consumption. Thus, the market segment relevant to the CRST program is the supermarket whole-building efficiency as affected by changes in the refrigeration system efficiency.

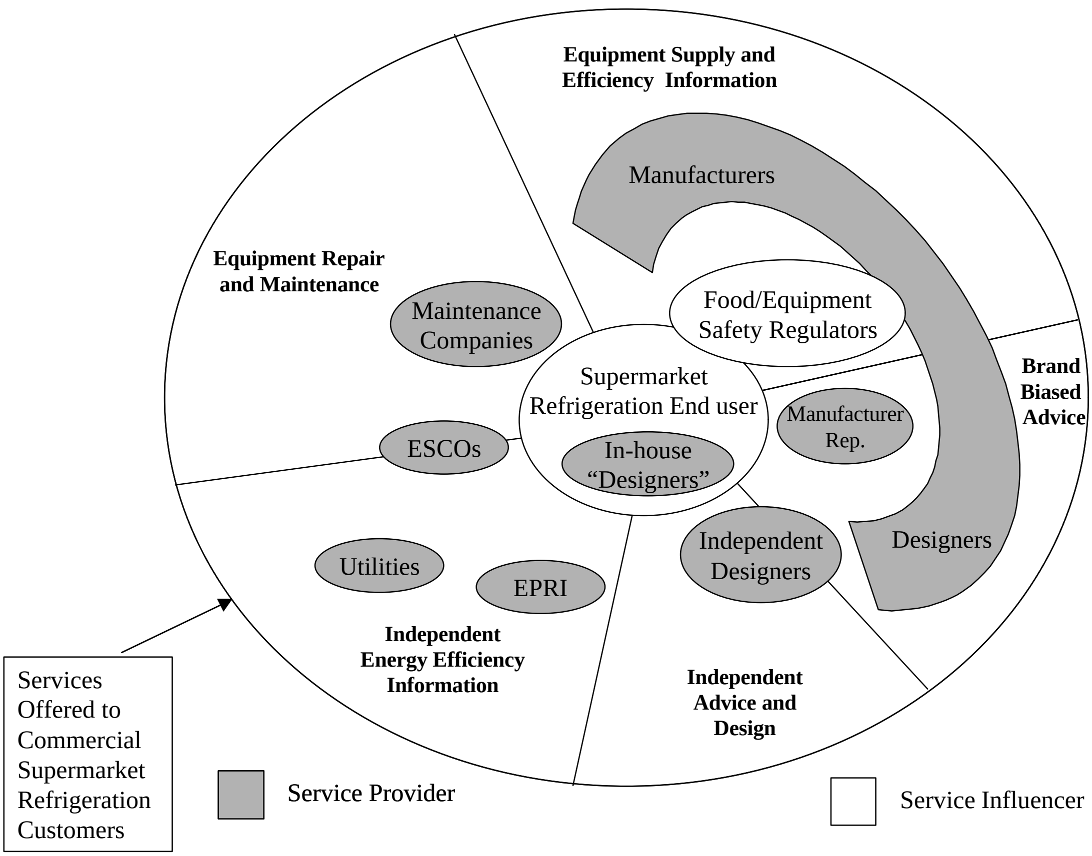
[2] From the Study of Market Effects on the Supermarket Industry.

For the purposes of this market characterization, the services provided within the supermarket refrigeration efficiency market have been divided into five primary services. These services are illustrated in Exhibit 4.1, along with the market actor offering the various services.

What may not be immediately obvious from this exhibit is the dominant role played in the industry by the manufacturers. Manufacturers supply much of the design for the industry and virtually all of the equipment efficiency information.

As illustrated by Exhibit 4.1, there are a limited number of service providers in the commercial supermarket refrigeration market. Not all end users have a need for, or access to, all of the services or service providers available in the industry. A short summary of each service sector, and the role played by each service provider, is presented below.

Exhibit 4.1
Supermarket Refrigeration Services and Service Providers



Equipment and Efficiency Information Supply – Equipment and information on that equipment, including efficiency information, is supplied by the equipment manufacturers. Unlike other industries, there does not appear to be independent testing or verification entities. This would seem to be because manufacturers supply reliable information and end users continually verify performance claims by monitoring equipment performance, energy use, and by actual end-use metering.

Brand-Biased Advice – Manufacturers and their designers and representatives supply advice and information to end users. However, this advice, by its source and purpose, is necessarily biased toward the interests of the manufacturer. Many end users form alliances with a single manufacturer and that manufacturer then supplies all their refrigeration equipment. In some cases, end users pass system design responsibility to the manufacturers, using their own staff for design review.

Independent Advice and Design – There are a set of market actors who supply independent design advice to end users. There are two types of independent designers. The first type specializes in highly sophisticated design analysis and design improvements. These companies usually supply the larger chains with sophisticated analysis or advanced designs on a project by project basis. The second are independent designers who specialize in designing supermarket refrigeration systems for small chains and independent grocers. They often have long-standing relationships with their clients. They depend heavily on the manufacturers for design assistance, acting mostly as design review. This way, issues and performance accountability can be passed back to the manufacturers.

Independent Energy Efficiency Information – There are generally two market actors who supply independent efficiency information to the supermarket industry, the utilities and the Electric Power Research Institute (EPRI). The utilities usually supply the supermarkets with free audits and advice as part of their large customer service programs. Similarly, EPRI is servicing the electric utilities, who view supermarkets, and their refrigeration energy use, as a major component of their business.

Equipment Repair and Maintenance – The supermarkets rely on an array of service and repair companies to maintain their equipment. These companies are generally independent (i.e., not direct affiliates of the equipment manufacturers) although large franchisees may have in-house equipment and repair capabilities. An emerging trend in the supermarket industry is Energy Service Companies (ESCOs) taking over complete responsibility for supermarket refrigeration systems. Under this arrangement, they pay the energy bill and supply maintenance, repair, and operation services for a fixed fee. They then optimize the operation of the refrigeration system and make their profit from the difference between the payment and operating costs. The emergence of this type of operation was mentioned by at least three end users during the interviews.

4.1.4 Technologies

Detailed discussion of the full range of individual equipment types is not feasible in this market characterization because of the large number of equipment types.

The supermarket refrigeration technology discussion is divided into three categories of equipment: the compressor/condenser system that is out of customer view, the refrigeration display cases, and the types of equipment in the supermarket with which the refrigeration system interacts. The equipment types and/or measures included in each of these categories are discussed below.

Compressor/Condenser System - The majority of the refrigeration systems in most commercial applications is "in the back room", out of site of the customer. As stated earlier, a supermarket is differentiated from smaller grocery stores by the existence of a centralized refrigeration system that supplies refrigerant to remote cases for cooling retail products. The refrigeration system is composed of a compressor (or group of compressors), a condenser or series of condensers, a receiver, an expansion valve, and a heat exchanger to cool the product. All but the expansion valve and the refrigeration heat exchanger are in the back of the supermarket (or on top of the store), out of site of the customers. The expansion valve and refrigeration heat exchanger are part of the display cases discussed below. All of these components are controlled by control systems, ranging from simple controls to Energy Management Systems (often referred to as EMS) that monitor the state of the system at various points and optimize overall performance.

The compressor system is usually composed of a series of compressors that are carefully staged to optimize refrigeration and energy efficiency. The type of compressor effects efficiency. The two primary types used for refrigeration are reciprocating and scroll or screw compressors. For each type of compressor there are design details that can significantly effect overall efficiency. Using multiple compressor sizes within a multiplexed system affects efficiency since you can run smaller compressors at full load. In addition, the choice of the efficiency of the electric motor to drive the compressor affects the overall system efficiency.

Condensers are usually either evaporative or ambient air cooled. The ambient air is blown across the condenser using electric fans. Usually the condenser will also incorporate evaporative cooling by running water over the outside of the condenser to increase the cooling effect through evaporation. Condensers are usually staged either by having several fans and/or several condensers that can be turned on as needed. The size and efficiency of the condenser and the control of the fans all affect the efficiency of the condenser system.

In addition to the selection of the equipment discussed above, system additions such as floating head pressure control and refrigerant sub-cooling can both significantly improve system efficiency.

The overall system efficiency is highly dependent upon the designer choosing the correct combinations of equipment and the presence/sophistication of the EMS. These choices are often driven by a combination of priorities including first costs, maintainability, availability of maintenance staff, etc.

Refrigerated Display Cases - The display cases play a major role in the efficiency of the refrigeration system. They are also the main point at which the system interacts with the other energy-consuming systems in the stores.

The display cases contain the expansion valve and the refrigeration heat exchanger since they are where the retail product is kept cool. The primary choices that affect the efficiency of the display cases are:

- Insulation levels of the cases, especially for frozen food cases.
- Whether the cases have doors.

- The use of cycling anti-sweat heaters to control fogging of display case windows/doors.

However, it should be recognized that the choice of the display case design is primarily driven by the merchandising requirements of the stores. The first requirement is maintaining safe food that does not spoil. After that, the mantra that ran through all data collection and reports was that product presentation was the prime criteria in selecting case design and appearance.

Interactions with Other Energy Consuming Equipment - All refrigeration cases interact with the store HVAC systems. If the cases contain lighting they also interact with the lighting systems. The choice of presentation case design can have a major effect on HVAC loads. If the cases do not have doors, cool air is continually dumped into the conditioned space. If the cases have doors with anti-sweat heaters, they are heating the conditioned space as well as the refrigerated space, while limiting the contribution of refrigerated air to the conditioned space.

It should be noted that most supermarkets heat the store year round because of the refrigeration contribution to the store heat load.

4.1.5 Market Structure

The market structure for the supermarket refrigeration market is relatively straightforward. It involves relatively few market actors at each market level. However, interactions between market actors vary by customer size. The following discussion is divided first into a description of market actors by their position in the supply stream (up-stream, mid-stream, and down-stream), and a second description of the interaction of various market actors by customer size.

4.1.6 Market Actors

Exhibit 4.2 presents an illustration of the market flow for large chains stores. It includes all market actors and identifies up-stream, mid-stream, and down-stream market actors.

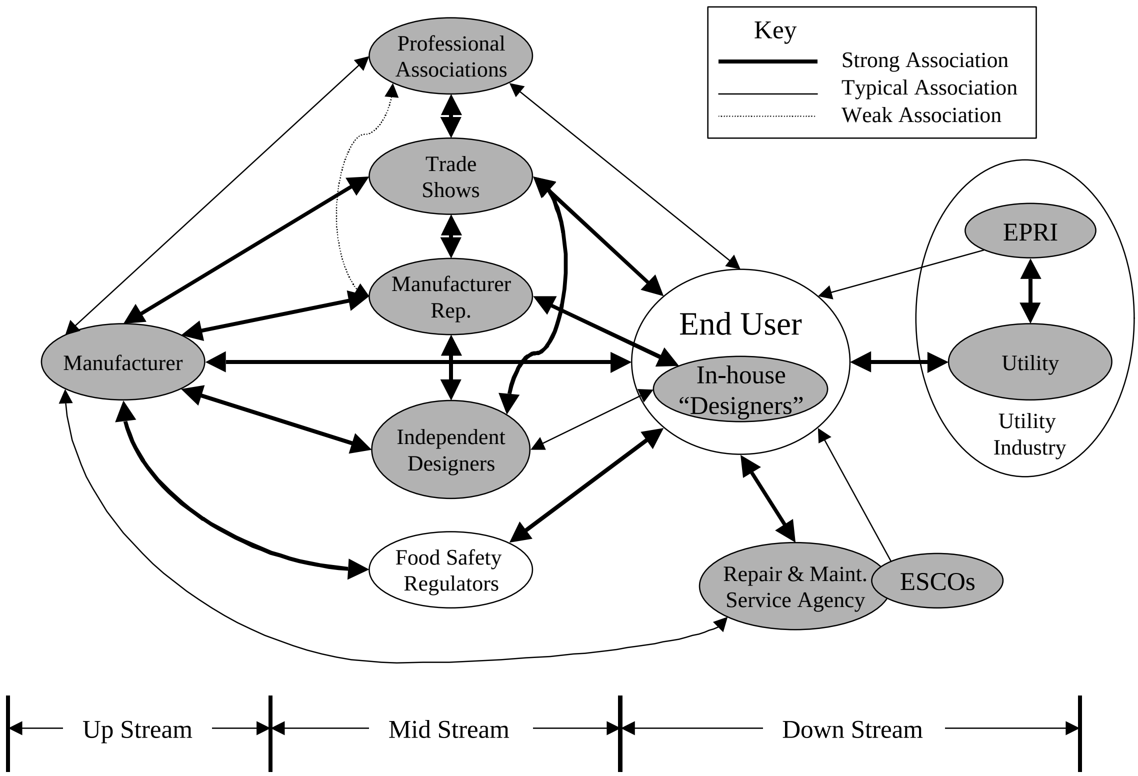
Up-stream Market Actors - The up-stream market actors in the supermarket refrigeration market include only equipment manufacturers and illustrate their dominant market position.

Equipment Manufacturers. One of the over-riding factors in the supermarket industry is the dominance of the market by a very small number of large national manufacturers[3]. Hussman, Tyler, and Hill-Phoenix are three of the largest manufacturers. These companies often set up exclusive arrangements with large chains and supply all of their refrigeration equipment. While much of the component efficiency information is readily available from the manufacturers, individual manufacturers seem to feel that they can put together more efficient systems than their competition using proprietary information and design criteria. Because of the sophistication of the designs, the stores usually work

[3] This is documented more extensively in the Study of Market Effects on the Supermarket Industry .

very closely with manufacturers or their representatives in the design of their refrigeration systems.

Exhibit 4.2
Flow Diagram of Market Interactions for Large End Users



Mid-stream Market Actors - The mid-stream market actors consist of the manufacturers' representatives, independent designers, food safety regulators, professional associations, and supermarket equipment tradeshows. For the purposes of this market structure/market actor discussion, mid-stream market actors have been broken into three groups: Information Transfer Agents, Design Assistance, and Regulators.

Information Transfer Agents. The trade shows supply information to the market, interacting with most levels of market actors. The trade shows play a major role in creating awareness of new technologies and also seem to act as a main venue in the exchange of information between market actors. The professional associations primarily benefit the designers, supplying a forum for education and exchange of information on design approaches.

Design Assistance. The manufacturers' representatives and the independent designers provide design assistance to the end users, in most cases to in-house designers or project managers. The manufacturers' representatives are essentially a marketing arm or tool of the manufacturer. The independent designer has two apparent market forms. The first is a highly specialized refrigeration company that supplies specialized design expertise or research capability. These people are used by the larger chains to analyze difficult designs or to model experimental approaches when the supermarkets want independent/unbiased estimates. The second type of independent designers are companies that specialize in designing refrigeration systems for small chains and independents who do not have their own design capability.

Regulators. The primary regulators of interest in the supermarket refrigeration market are agencies (such as the U.S. Food and Drug Administration) that regulate the conditions of the food sold by supermarkets. Because over 50% of supermarket revenue is represented by refrigerated products, avoiding spoilage and safety issues are of paramount importance to them. These regulators play an important role (though not a direct one) in the design and operation of the refrigeration systems.

Down-stream Market Actors - The down-stream market actors consist of (1) end users (supermarkets), (2) utilities and (3) repair and maintenance companies.

End Users. The end users are composed of a spectrum of supermarkets from independent stores to local chains to national and international conglomerates. Many of the intermediate and large chains have their own in-house design specialists. These specialists range in capability, from staff who specify equipment to the point that they issue bid specifications with exact equipment size and model, to staff who are equipment procurement managers and leave the design details to the suppliers. In one extreme case discovered during the evaluation surveys, an end user manufactured their own cases, thus having the maximum ability to design and specify what the company needed. As was mentioned earlier, smaller stores tend to rely on independent designers to act as go-betweens in the design of the refrigeration systems.

Utilities. Because supermarkets represent a large market for most utilities, they tend to get a high level of attention. Besides simply supplying electricity, the utilities often offer energy efficiency programs including audit and rebates.

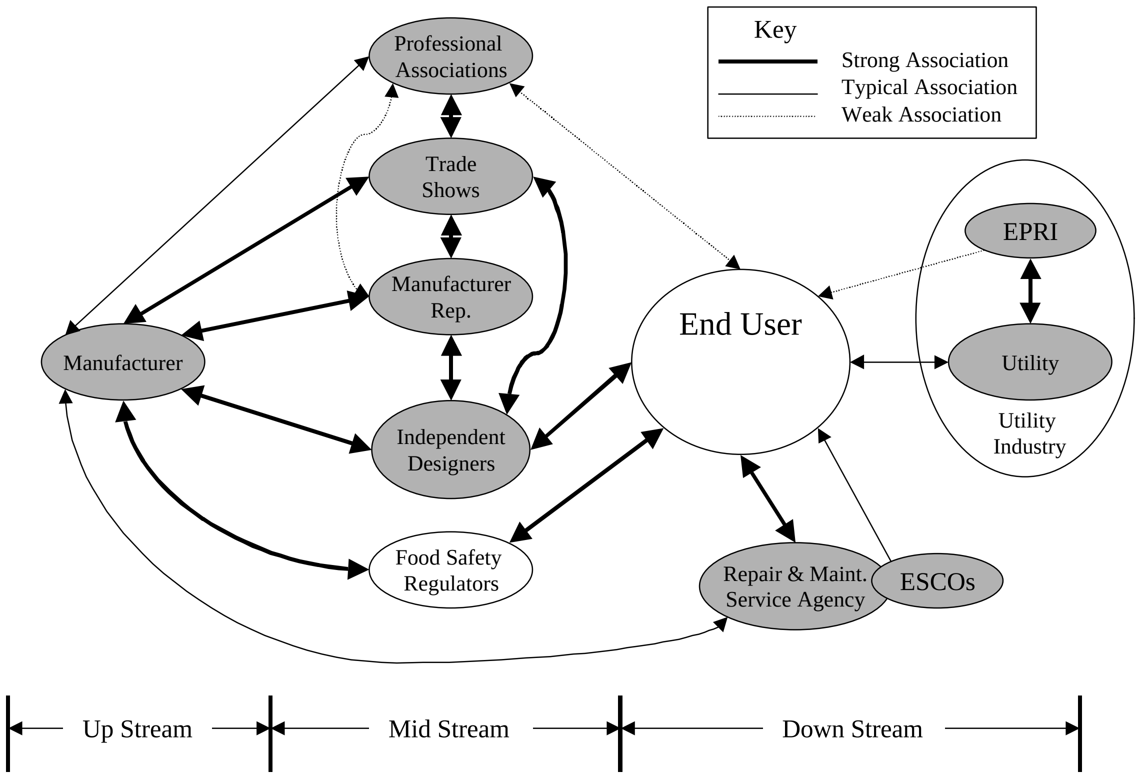
EPRI, which can also be viewed as part of the utility industry, seems to have carved out a unique role in supplying supermarket refrigeration information though its highly publicized supermarket refrigeration research.

Equipment Repair and Maintenance Agencies. Most supermarkets purchase repair and maintenance services from independent companies through service contracts. As mentioned earlier, an emerging trend in the supermarket industry is Energy Service Companies (ESCOs) taking over complete responsibility for the supermarket refrigeration systems operation and maintenance.

4.1.7 Market Actor Interaction

This section discusses the interactions of the market actors identified in Section 4.1.6. As discussed earlier, one of the primary data sources for this market characterization were interviews with supermarket refrigeration designers and decision-makers. As the data collection evolved, it became obvious that the interaction of the market actors was dependent upon the size of the supermarket chain. As a result, this discussion of how the markets interact is divided in two, depicting typical interactions for large supermarket chains and small independents. Exhibit 4.2 (presented above) and Exhibit 4.3 illustrate these cases. All market actors have been included in each diagram, despite the fact that they may have no interaction for that customer size. The dotted lines indicate weak or infrequent interaction/influence; the normal weight lines indicate moderate interaction or recognized open potential for influence; and the bold lines indicate primary modes of interaction or avenues of major influence for this customer size.

Exhibit 4.3
Flow Diagram of Market Interactions for Small End Users



To simplify overall discussion and attempt to remove the "clutter" caused by all of the weak and typical interactions, Exhibit 4.4 combines the strong associations for all sizes of market actors. It may be helpful to refer to this exhibit while reading this section.

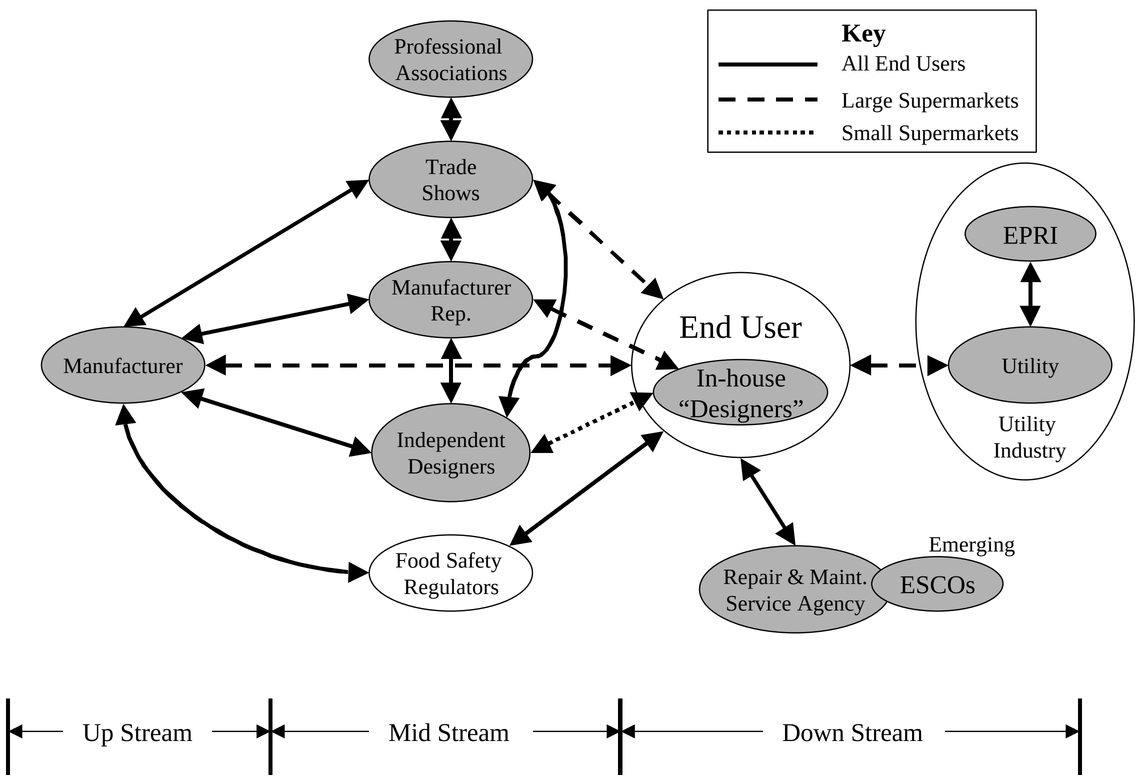
Interactions Common to All End Users - The interaction between up-stream and mid-stream market actors, are independent of the size of end user. Additionally, the supply of repair and maintenance services is common to all market actors. As a result, these will be discussed jointly.

Manufacturers to Mid-Stream Market Actors. Manufacturers' strong interaction with mid-stream market actors pretty much define their primary sales channels. They have strong linkages with their sales representative, independent designers, and to trade shows. By necessity, they have interaction (depicted as normal) with food service regulators and repair and maintenance service organizations. These relationships are important in order to maintain customer satisfaction and compliance with safety regulations, but are identified as typical because they are a business necessity and are not tied directly to sales. Similarly, manufacturer connections to trade associations are secondary avenues to sales and, as such, are shown as typical.

Trade Shows. Trade Shows act as a central sales point for marketing in the supermarket refrigeration arena. These shows are usually sponsored by one of the trade associations (e.g., Food Marketing Institute) and are widely attended by corporate supermarket designers, independent designers, supermarket decision-makers, equipment manufacturers, and equipment manufacturers' representatives. These shows seem to act as a hub to information. This may be because the importance of appearance in merchandising product makes actually seeing the equipment essential.

Food Safety Regulators. All supermarkets, independent of size, are required to meet regulatory requirements for maintaining food at safe temperatures. Because such a large part of the retail sales are refrigerated or frozen, food safety regulators/regulations play a primary role in the thinking of all customer sizes. The relationship between the manufacturers and the food safety regulators is shown as strong because it is seen as a strong criteria for customer purchase decisions and, therefore, one to which the manufacturer must pay close attention. Meeting regulations is of major importance to customers and is considered a necessary criteria for inclusion in the potential purchase list.

Exhibit 4.4
Combined Flow Diagram of Primary Market Interactions



Repair and Maintenance Agencies. All end users rely heavily on repair and maintenance organizations. The general mode of operation in the industry is to hire maintenance services locally because of the wide geographic distribution of the stores. Many admitted that the availability of skilled maintenance staff was a problem and often played a role in decisions about implementation of more sophisticated technology.

Repair and maintenance services must rely on manufacturers for spare parts and service information on their equipment.

The evolving penetration of ESCOs in the supermarket arena was identified for both large and small markets. This is shown as a typical association, but the depth of actual penetration, and the longevity of this trend, are unknown.

Large End Users - For the purposes of this discussion, large end users are defined as the large regional and national supermarket chains. Some classic examples are Albertson's, Safeway, and Wal-Mart.

The overall interaction for large end users is illustrated in Exhibit 4.2 and summarized with other size users in Exhibit 4.4. Large end users often have long-standing, strong purchasing associations with specific manufacturers. They usually have in-house designers that design or specify their equipment purchases. While they may work with the manufacturers' representative on prices, they tend to go directly to the manufacturer for design information. Because there are so few manufacturers, and because the manufacturers' representatives are tied to one manufacturer, it was often hard to distinguish between the manufacturers' representative and the manufacturer as information sources in interviews.

While it varies from chain to chain, the large chain supermarkets tend to have several "models" or "prototypes" on which they base all of their construction. The plans may be modified slightly to fit the site or the local maintenance capability, but in essence it will be one of their standard stores. The review of the standard designs is typically on a 12 to 18-month cycle.

Large supermarket chains will, on occasion, use independent designers for specific projects where they want in-depth analysis for which they either do not have the expertise or the staffing/time to complete.

The large supermarkets use trade shows and professional associations, along with their standing contacts with manufacturers and their representatives, to keep current on trends in the industry and to stay competitive. Energy efficiency information is often obtained through their relationships with utility efficiency programs. EPRI was identified as a source by several interviewees.

Small End User - For the purposes of this discussion, small end users are defined as small regional chains and independents. Almost by definition, these operations have more limited financial resources and are either just starting out, or are trying to stay in business long enough to expand.

The overall interaction for small end users is illustrated in Exhibit 4.3 and summarized with other size users in Exhibit 4.4. These interactions tend to be more limited simply because of the lack of resources.

Small supermarkets are much less likely to have in-house designers. If they do have a person designated as their refrigeration designer, he/she is likely to be wearing many different hats and would be better described as an equipment specifier or decision-maker. Smaller end users tend to use co-ops or design firms that specialize in supplying refrigeration system design to many supermarkets. These design firms act as an intermediary between the small end user and the manufacturer or the manufacturers' representative.

Small end users get their information from more limited sources than large end users. They are more likely to obtain their information from industry publications and professional associations, and probably do not have time to attend conventions/exhibitions.

The small user's contact with the utility is primarily to obtain what they need to operate their business. The utilities are less likely to target the smaller supermarkets for energy-efficiency efforts because their more limited resources make energy efficiency projects less likely.

Overview of Important Associations for All Users - Exhibit 4.4 presents a summary of Exhibit 4.2 and Exhibit 4.3 without the weak and typical associations. The key has been changed to identify the size of the end user.

The exhibit illustrates the overall supply chain for the supermarket refrigeration industry. It shows that:

- The manufacturers distribute information through their manufacturers' representatives and independent designers.
- The large supermarkets obtain design information directly from manufacturers, and indirectly through their representatives, using independent designers for special projects.
- Trade shows are a major avenue for information, especially for the larger end users.
- Small chains and independents obtain refrigeration design services from firms that specialize in supplying refrigeration design services to this market.
- Utilities play a large role in supply of energy efficiency information to large end users, and a much more limited role for small end users.
- All sizes of end users rely on independent repair and maintenance companies, with ESCOs potentially playing an increasing role.

4.1.8 Market Character

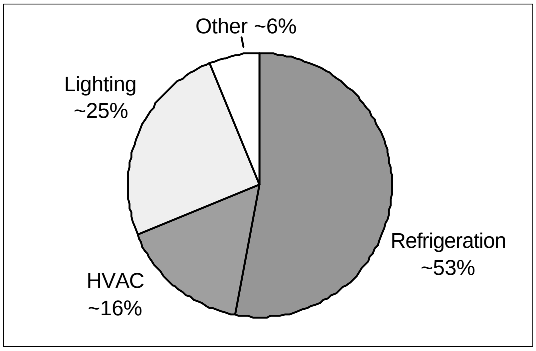
The general paradigm that emerged from the review of background literature and the interviews with market actors has the following key elements:

- The supermarket industry is a highly competitive, low margin business.
- Store-to-store variability makes documentation of energy savings difficult to impossible. While some of the stores attempt to measure design change savings, they acknowledge that they only obtain directional evidence.
- Initial cost, reliability, and serviceability are often identified as just as important if not more important than energy efficiency.
- The larger the chain, the higher energy efficiency seems to be in the priority ranking. However, even large chains acknowledge that reliability and serviceability are key factors in their decision-making.

4.1.9 Market Size

Exhibit 4.5 shows the breakdown of the energy use for a supermarket. As shown, the refrigeration system represents approximately 53% of this total while HVAC, with which the refrigeration system interacts, represents an estimated 16%.

Exhibit 4.5
Distribution of Supermarket Energy Use[4]



Nationwide supermarkets use 326 trillion Btu[5] of primary energy annually for refrigeration. The California supermarket industry is estimated to represent ~3,700 stores representing approximately 39 trillion Btu of refrigeration system energy consumption annually. (Exhibit 4.6) With over half of the revenue associated with refrigerated items, this indicates that refrigerated items represent more than $21 billion in annual revenue to California supermarkets.

Exhibit 4.6
1998 Estimates of Supermarket Market Size

	Units	**Nationwide****	**California***
Total Number of Grocery Stores**	(#)	126,000	15,120
Total Number of Supermarkets**	(#)	30,700	3,684
Total Annual Supermarket Sales**	($B)	346	42
Total Annual Supermarket Refrigeration Energy Use***	(T Btuh)	326	39

* Prorated estimate based on population
** 66th Annual Report of the Grocery Industry, April 1999, Page 10.
*** Westphalen, 1998, Figure 3

The energy savings potential for supermarket refrigeration has been estimated to be anywhere from 6%[6] to 10%[7]. Converting the primary Btu to kWh (10,867 Btu/kWh) gives a potential savings for California from 215 to 339 million kWh annually. (See Appendix E for the detailed calculation of the potential savings.)

[4] Study of Market Effects on the Supermarket Industry, Page 20, Exhibit 4-1.

[5] Westphalen 1998, Figure 3.

[6] Westphalen 1998, Table 6 figures.

[7] Designer Interviewee

4.1.10 Market Events

The primary market event of interest in the supermarket refrigeration equipment arena is the number of new supermarkets constructed annually. New stores are the primary way that new refrigeration systems enter the market. New supermarkets are constructed as replacements for aging stores and for expansion into new markets. Supermarket remodels generally only address the consumer space, leaving the equipment as originally configured. Equipment failure usually leads to immediate replacement with either the same equipment or a similar model that is immediately available. It is estimated that nationwide 3,000[8] new supermarkets are constructed annually. Prorated for California based on population, this represents about 360 new supermarkets per year in California.

4.2 Current Baseline Levels

As discussed in Section 3.2.2, the baseline market barrier levels is a qualitative assessment combining the reported current level of the metric combined with the responses to other market barrier questions. The baseline levels of the responses to the metric questions will be discussed first, then an overall qualitative assessment of each barrier will be presented.

The questions used to develop the metrics are listed by market barriers and data collection source in Exhibit 4.7. The questions presented are paraphrased from the actual instruments since they may have been phrased slightly differently depending on whether the designer or the decision-maker was being interviewed. Most are based on a straight-forward 1 to 10 scale and are presented as such. Bounded Rationality and Hidden Costs metrics were developed as the difference between the responses to the two questions listed in Exhibit 4.7 for each, respectively. Misplaced Incentives and Product or Service Unavailability did not elicit responses that could be easily charted. These barrier metrics are discussed more comprehensively by market barrier below.

[8] Average new establishments based on U.S. Census data from 1989-1995, SIC code 5410. Only those establishments with 20-500+ employees per establishment were used in the calculation.

Exhibit 4.7
Questions Used for Market Barrier Metrics

Barrier	Question	System Designers	Decision-Makers
Information and Search Costs	On a scale of 1 to 10, with 10 being very easy, how would you rate the level of difficulty in obtaining that [energy efficiency] information?	X	X
Performance Uncertainty	On a scale of 1 to 10, with 10 being very certain {confident}, how certain {confident} are you that the energy use estimates…reflect the use of the installed system?	X	X
Asymmetric Information & Opportunism	On a scale of 1 to 10, with 10 being totally confident, how confident are you in the energy use information you do receive?	X	
Hassle or Transaction Costs	On a scale of 1 to 10, with 10 meaning you stongly agree, please rate this statement: Optimizing the energy use of a refrigeration system that we design requires too many resources.	X	
Hidden Costs**	On a scale of 1 to 10, with 10 being very confident, how confident are you in the operating and maintenance costs of a typical refrigeration system? Of an energy efficient refrigeration system?		X
Bounded Rationality**	On a scale of 1 to 10, with 10 being very high priority, what priority is energy efficiency when you decide to install a refrigeration system? What percent of the systems installed would you consider to be optimized for energy efficiency?		X
Bounded Rationality**	On a scale of 1 to 10, with 10 being very high priority, what priority is energy efficiency when you design a refrigeration system? What percent of the systems you design would you consider to be optimized for energy efficiency?	X	
Organizational Practices or Custom	On a scale of 1 to 10, where 10 is highly encouraged, would you say that the overall signals that you are being given within your company encourage or discourage development {installation} of energy efficient refrigeration systems?	X	X
Misplaced or Split Incentives*	Are you responsible for the operation and maintenance of the refrigeration systems in the supermarkets where you decide to install them?		X
Product or Service Unavailability*	Do you have a computer simulation tool that can compare the energy use of different refrigeration systems? If yes, on what percent of your designs do you use this tool?	X	
Irreversibility	On a scale of 1 to 10, with 10 being very easy, how easy do you think it would be to change back from an installed energy efficient system to a typical standard system if you wanted to in the future?		X

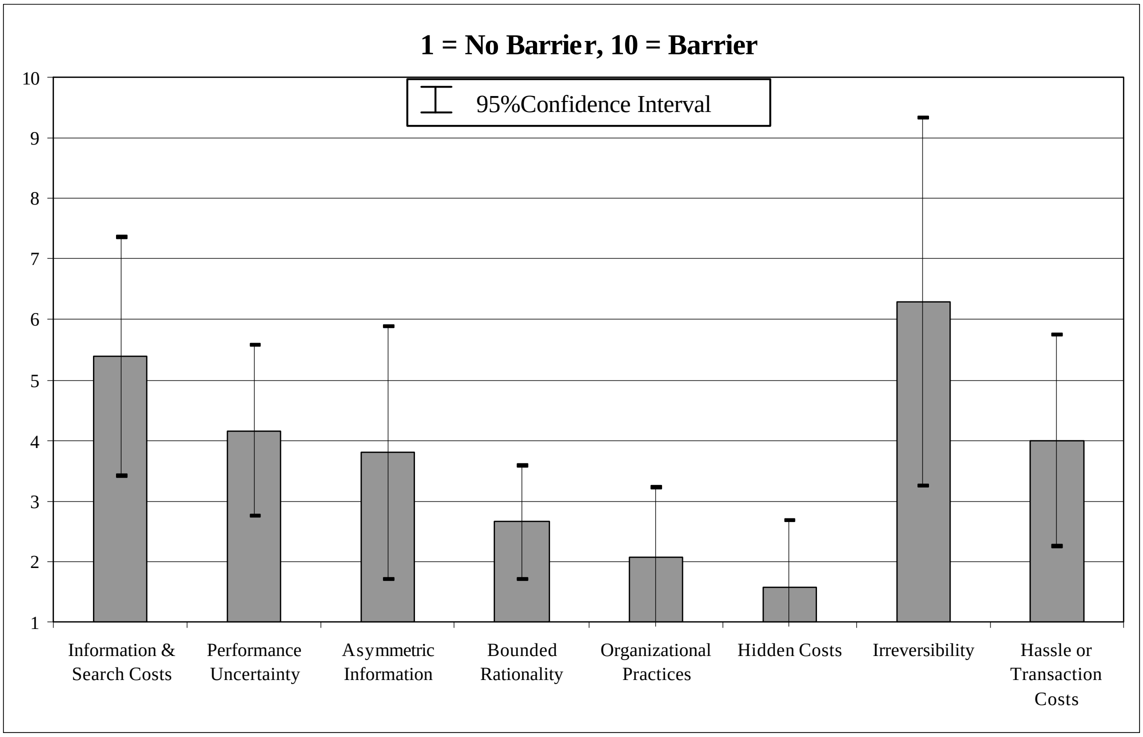
*These barriers were not given a 1 to 10 scale metric, discussed further in text.

** Assessed as the difference between the responses to the two questions listed

The current levels of market barrier metric as determined from the metric questions are shown in Exhibit 4.8. The range brackets indicate the 95% confidence interval base on the data collected. As can be seen, very little if anything can be said with statistical validity. It is probably safe to surmise from this information that irreversibility is a significant barrier in the market and that organizational practices are probably not significant barrier to cost-effective energy efficiency.

It should be remembered that the level of the market barrier as measured by the metric is primarily to act as a baseline for measuring future change in the response to these questions.

Exhibit 4.8
Market Barrier Levels



The overall assessment of the current state of the barrier in the market is presented below. This assessment combines the response to the quantitative metric question with other more qualitative questions about the barrier in order to develop an overall qualitative judgement of the influence of the barrier in the market.

4.2.1 Information & Search Costs

Decision-Makers - The decision-makers get information on energy efficiency from their own staff and vendors. Only one relies solely on a vendor for information and three use only their own staff. They use life cycle costs the majority of the time (63%) and all but one look at efficiency when determining the implementation of a refrigeration system. First cost was the driver only for the smaller size stores. Included in the life cycle costs were initial costs, energy efficiency, serviceability, and cost effectiveness. The group appeared satisfied with the information they receive.

Half of the decision-makers state they use metering to obtain the energy efficiency of a refrigeration system while the other half get that information from manufacturers or vendors.

System Designers - When the designers think of energy efficiency information on refrigeration systems, they think of the blueprints of the store. They would go to the manufacturer for new installations to get data on pieces of equipment and the as-built systems for the specific stores. Since the compressor use tends to be around 70% of the refrigeration energy usage, most think of the efficiency of the compressors when looking at the efficiency of the system. One stated that there really is nowhere to get system efficiency data, while the others related compressor type information.

Conclusion - The metric for this barrier indicates that, on average, the market actors do not perceive energy efficiency information to be either difficult or easy to obtain. The large bounds around the average indicate that there is wide variation in how the barrier is perceived. It was the second highest apparent barrier.

Overall, though, the market actors seem fairly satisfied with the level of data they receive and feel they have the option of getting more if desired. However, the type of data they are used to getting appears to be component-specific as indicated by half of the decision-makers who felt they could obtain the energy efficiency of a system only by metering.

4.2.2 Performance Uncertainty

Decision-Makers - Seventy-five percent of the decision-makers receive some sort of energy use estimate before their systems are installed. They get the information from the vendors installing the system and from their own experience with their stores in other locations. In general, they are confident that the energy usage estimates reflect the actual usage. They point out that the maintenance of the system plays a big part in the actual energy use. Those who felt a lack of confidence in a pre-installation energy estimate provided maintenance issues as an explanation. Additionally, both ends of the spectrum were supplied in that one decision-maker felt that each store is unique enough so that estimates cannot ever be accurate, while another felt they have a history on so many stores that they have a good idea of the usage.

System Designer - All the designers state that they have the ability to calculate the energy use of the system they design. They are fairly certain that their estimates reflect the actual usage of the installed system. All of the designers use a spreadsheet to obtain information on energy usage. They feel the spreadsheets provide them with data that is close enough for their work and very quick to use. Some of the weaknesses seen in using the spreadsheets were: 1) variables are easily manipulated and can throw off estimates, 2) maintenance of the system changes the usage within a year anyway, 3) spreadsheets do not reflect seasonal or daily variation, and 4) there are undocumented variable defaults within the spreadsheet.

Conclusion - The metric for this barrier indicates that decision-makers believe in the estimates provided and designers believe in the estimates they create. However, the decision-makers were more varied in their certainty of the energy use information they obtain than the designers were in what they create. The designers rated their confidence in their energy estimates to be a 7 or an 8 (7.8 ± 0.4), while the decision-maker answers ranged from a 2 to an 8 (6.1 ± 1.7). This seems to indicate that the decision-makers may be a bit more skeptical of the answers they receive than the designers. Both market actors mentioned that maintenance of the system played a big part in the energy use. Their ability to be certain about energy use dwindled as time progressed because of the ramifications of possible poor maintenance.

4.2.3 Bounded Rationality

Decision-Makers - The decision-makers ask for and receive energy efficient information. As shown under the performance uncertainty barrier, they tend to believe it, although there is a range in that certainty. They give efficiency a high priority, although the priority is tempered by other operating concerns (i.e., marketability of product). Additionally, they consider a high percentage of the refrigeration systems installed to be energy efficient. Therefore, they are acting consistently and bounded rationality does not appear to be a barrier.

System Designers - The system designers put energy efficiency as a high priority and all estimate the energy use of systems they design. While they believe the systems could potentially be a higher efficiency than designed, they feel the systems are optimized for a cost-effective level of energy efficiency. In this sense, the designers are acting consistently within the criteria they analyze and bounded rationality is not seen as a barrier for system designers.

Conclusion - Both the decision-makers and system designers appear to act consistently with their stated priorities and bounded rationality is not seen as a barrier.

4.2.4 Organizational Practices

Decision-Makers – The decision-makers state that a high percentage of the systems installed are energy efficient (79%). All but one of the decision-makers receive positive reinforcement for installing such systems. The one decision-maker who did not receive encouragement stated that he often worked with the independent grocery stores that tend to look at first cost above life cycle cost.

System Designers - In general, the designers appear to be encouraged to design efficient systems. While they realize they could design to a higher efficiency than what is actually installed, they take into account issues such as reliability and serviceability to create a total system that meets the needs of their client or company. The questions resulted in a range of responses. First cost was an overriding concern for those designers that work with small/independent stores. The small sample size precludes a definite statement regarding large versus small stores.

Conclusion - Organizational practices, especially in the large supermarket chains, encourage the design and installation of cost-effective, energy efficient refrigeration systems. Organizational practice barriers may exist for independent stores, but it is difficult to make a definite statement because of the small sample size.

4.2.5 Split Incentives

Decision-Makers - There appears to be the potential for split incentives, but the responses indicate that split incentives as a barrier is not a strong factor in this market. The decision-makers, while only being responsible for the operation and maintenance 25% of the time, state they generally do take maintenance and energy use into account when they decide to purchase and install a system. Also, the majority of responses indicate coordination of goals between purchasing and operating staff. This is consistent with the information that the organizations encourage energy efficiency in the company.

System Designers - This barrier was not felt to be an issue for the designers since the largest opportunity for split or misplaced incentives in this field is the discontinuity between the factors going into a decision on what to install and operation and maintenance costs of the piece of equipment that is installed. Designers are not part of this communication. No questions were directed toward designers eliciting information regarding split incentives.

Conclusions - While the potential exists, split incentives does not appear to be a major barrier to the installation of energy efficient refrigeration systems in supermarkets.

4.2.6 Hidden Costs

Decision-Makers - The decision-makers indicated little difference in their confidence in the operating and maintenance costs between a typical and energy efficient refrigeration system. The actual metric value is quite low (1.5). However, this is difficult to reconcile with the responses given when asked about the primary disadvantages or uncertainties of an energy efficient system[9]. In that case, decision-makers gave a wide variety of difficulties they could foresee such as: 1) not sure that a new technology would keep the food safe, 2) would it perform as specified and could it be maintained by the average refrigerator contractor, and 3) complexity. Since the decision-makers did express potential difficulties, it is probable that the metric question did not elicit the information as desired.

System Designers - This barrier was not felt to be an issue for the designers since they are not involved in the operating and maintenance of the systems they design. No questions were directed to designers eliciting information regarding hidden costs.

Conclusions - It is unclear to what extent hidden costs are a barrier. The metric shows that decision-makers do not appear to be worried about potential hidden costs associated with an energy efficient system. The qualitative responses do show that decision-makers see a potential for difficulties over and above those of a standard efficiency system. However, that level of difficulty could not be quantified. Hidden costs most likely do exist as a barrier, but are inextricably linked to performance uncertainty. The metric did not appear to measure this barrier effectively.

4.2.7 Irreversibility

Decision-Makers - The responses were highly split for this barrier – half gave a metric of very difficult while the other half said it would be very easy. It is an issue for at least 50% of the market.

---

[9] Eto, et.al. (1996) state that "To some extent, they [hidden costs] can also be thought of as performance uncertainties".

System Designers - This barrier was not felt to be an issue for the designers since they are not generally involved in the installation of the systems they design. No questions were directed toward eliciting information regarding irreversibility.

Conclusions - This barrier is important for half of the market. The decision-makers appeared to look at this barrier quite differently. One group seemed to feel that they could revert from a high-efficiency to typical-efficiency system by simply bypassing a specific portion of the system or changing setpoints within the system. Another part of this first group felt they could pass the problem back to their suppliers and force them to fix the problem. The second group saw the cost of all the equipment and what it would take to remove and replace it within the system as a large barrier.

4.2.8 Asymmetric Information

Decision-Makers - This barrier was not felt to be an issue for decision-makers since it related to the relationship between the designer who used specific energy information and the supplier of that information. No questions were asked about asymmetric information.

System Designer - The designers do not often compare equipment (20% do a comparison on a regular basis)[10]. They tend to have good relationships with the suppliers of equipment, generally get the information on energy efficiency they want, and believe what is provided to them.

Conclusion - Asymmetric information does not appear to play a part in the market at this time. This is consistent with the Study of Market Effects on the Supermarket Industry report where energy efficiency information was reported to be readily available and to flow easily throughout the market.

4.2.9 Hassle or Transaction Costs

Decision-Makers - This barrier was not felt to be an issue for decision-makers since the hassle or transaction cost at issue is the hassle or cost of obtaining design information. This type of hassle cost is a designer issue, not a decision-maker issue. Alternatively, if one views it as the hassle of obtaining equipment, this is unlikely to be an issue in this industry because of the close relationships between the suppliers and the end users. No questions were asked about hassle or transaction costs.

System Designers - The designers use hardcopy information along with computer spreadsheets and other computer programs (i.e., compressor manufacturer programs) for each design they create. They appear to be satisfied with the tools they have to optimize the refrigeration systems since they don't tend to do energy comparisons on a regular basis (60% of the designers make comparisons less than 15% of the time). One designer does not have such a comparison tool and stated they have no need for such a

[10] This is consistent with the findings in the PG&E Supermarket Refrigeration Baselining Design Practices Study.

tool. Another designer felt it would take quite a bit of work to create such a tool and, for a single company, would not be worth the time needed to create it.

Conclusion - There are little to no hassle costs perceived by the designers. They do not make energy comparisons on a regular basis and feel satisfied with the level of information they have available to them when needed. The estimates that they do make provide them with "good enough" answers.

4.2.10 Product or Service Unavailability

Decision-Makers - The decision-makers do not use the program that compares energy use. No questions were asked about product unavailability.

System Designers – This barrier is closely linked with hassle or transaction costs in this evaluation since the product in question is a computer simulation tool, which is currently not available, and the hassle is viewed as the time and materials to create such a product. However, the lack of a tool to make energy comparisons is not an issue for most of the designers since only one designer stated that he makes comparisons on a regular basis. As stated under hassle or transaction costs, 60% of the designers feel they have a computer program that provides them with the ability to compare energy use of different refrigeration systems with answers that are good enough for their needs. These designers use the tool less than 15% of the time.

Conclusions - The comparisons made with the current tools are rudimentary, but satisfactory, for those designers who feel they have such a tool. Other designers feel there is no product available that does this. However, there also appears to be a low demand for such a product. Product unavailability does not appear to be an issue in the market. Most designers requiring information get the information they want from current tools and sources.

4.3 Open Opportunity

There were questions asked during the interviews to elicit opinions from the market actors and provide them with an open opportunity to discuss issues related to energy efficiency and refrigeration systems. This also afforded an opportunity for them to identify market barriers that had previously been discounted by the evaluation team.

Both the designers and decision-makers were queried about the most important factors in either designing or deciding upon a refrigeration system. Retail product integrity was among the most frequently mentioned factor for designers. It is of primary importance to keep the food at the proper temperature, or the refrigeration system has failed in its only purpose. The decision-makers added the ability to merchandise the product as an important criteria. Since the grocery business has such a small margin, if the cases in the refrigeration system hampers sales, they have failed to meet the needs of the company. The five most important factors (in order of most mentioned to least mentioned among all respondents) were: 1) efficiency, 2) first cost, 3) maintenance and serviceability, 4) reliability, and 5) product integrity.

The designers varied in their opinions about what it would take to get more energy efficient systems installed. A couple felt that systems installed in the market were as efficient as possible. One felt that educating the buyer about long-term benefits could increase the number of efficient systems installed, while another thought that more standardized features that are easier to maintain would help. The remaining designer felt that only higher energy prices would cause the installation of more energy efficient systems. When asked what factors tend to discourage the design of energy efficient systems, space was mentioned more than once. The desire to have systems on the roof can increase the structural costs of the overall building. Also, the fact that merchandisers have the final say in what type of cases to use was felt to hinder efficient design. Interestingly, one respondent stated that there was a dearth of engineers properly trained in supermarket refrigeration and the complexities inherent in such a system.

A few decision-makers felt that the priority to install efficient systems was as high as it ever would get and that the market was already installing the most efficient systems possible – i.e., the most cost-effective systems. This is backed up by others who stated that the cost/benefit analysis must show that the company can mitigate the potentially premium cost of higher efficiency and also believe the payback. (A simple payback of around three years is typical.) One decision-maker stated that anything that helps to reduce the total life cycle costs, such as rebates, would increase the number of efficient systems installed.

Seven of the decision-makers and two of the designers were questioned about the availability and potential use of a computer simulation program that can compare whole-building energy use with different refrigeration systems. Five of the decision-makers thought they might use (actually, direct someone else to use) such a tool if it were available. The ability to obtain believable cost/benefit information could help in the decision-making process. The designers felt such a tool would be very difficult to create and would have to prove its credibility.

4.4 Overall Conclusions

The evaluation surveys were conducted with thirteen of the largest supermarkets, manufacturers, and consultants in California. Although the analysis can only be qualitative, the majority of the targeted market for the PG&E supermarket simulation tool was interviewed. As such, the results can be considered indicative of the market as a whole.

It should be noted that a major difficulty in performing this evaluation was getting the interviewees to respond to the questions on an overall refrigeration system basis rather than on a component basis. Most of the people interviewed had lots of experience designing and assessing refrigeration systems in supermarkets. On a daily basis they think of the system in terms of the efficiency of its components, or even its most important component, the compressor. So when asked about efficient refrigeration systems, they automatically translated that into the component efficiency and responded on a component basis. On occasion, it was possible to understand that they had made the paradigm shift and redirect the question. Most of the time, though, it was necessary to assume that they understood the difference and were talking about energy efficient refrigeration systems.

To reach an overall conclusion, one must step back from a myopic view of energy efficiency and the specific technologies that are or are not implemented in supermarkets and look at the overall picture of the needs of the market. To be successful, the supermarket must sell their product. To sell their product, the stores must use all the sales tools available to them. Such tools include making the store attractive, making sure the customer feels that the items purchased are "safe", and anything that assures customer satisfaction in general. Although representing less than 1% of the store operating costs as a percentage of sales[11], refrigeration plays a major role in the safety of meat and produce. The stores must meet standards of proper temperatures within cases. If these temperatures are not maintained, the ramifications for the store could be huge. The extra energy used to keep the meat and produce at the required temperatures is overshadowed by the actual revenues brought into the store by these food products (33% of the profits come from meat and produce areas in the supermarket). A small increase in sales can bring in greater profit than a small decrease in the cost of the refrigeration. Additionally, a loss of product due to poor refrigeration is potentially an extreme burden. What is brought into focus is a market where marketability and product integrity are the driving forces, with the equipment in the stores used as the tools to meet these primary needs.

However, taking the whole picture into account, since the profit margin for supermarkets is small, any potential avenue for increasing sales or decreasing costs are explored. The supermarket market actors involved in the design of and decision-making regarding refrigeration systems are a knowledgeable group of market actors who believe in energy efficiency that is cost effective. The term cost effectiveness must be stressed. Simple payback of less than three years is often used to determine the cost/benefit ratio applied to technologies. There is a good understanding of the variability of energy savings and how maintenance can adversely effect efficiency. The market actors realize that it is difficult to see savings store to store because of the variability in the energy use. Even so, because of the focus on increasing the profit margin, the companies encourage cost-effective energy efficiency.

The market actors are satisfied with current level of energy efficiency information they obtain and feel they get all that is available from the manufacturer. They are happy with their ability to compute estimates of energy use and feel that the current tools provide estimates that are "good enough" to base decisions on. Their goals (to supply cost-effective energy efficiency) are consistent with their actions. Seventy-nine percent of the refrigeration systems currently installed are considered energy efficient by the decision-makers. However, there were reservations voiced regarding the possible downside of new, efficient technologies.

Any new product would have to prove to these market actors that it can accurately estimate potential savings, although there is tolerance for "good enough" answers, as

---

[11] Food Manufacturers Institute Operations Review – 1st Quarter 1998, Income Statement Analysis, Pg. 26

long as they are believable. To be accepted by the designers, the tool must prove that it can handle the complexities of refrigeration, HVAC, and site-specific interactions in the supermarkets.

While most designers stated that any tool they used would have to be quick and simple, designers and decision-makers with larger chains indicated an interest in assessing a more sophisticated tool. Most acknowledged they would probably have to use outside contractors to analyze results from a more complex tool because current staff did not have the time to do it. At the same time, they indicated they felt that the operating cost savings potential from systems developed with such a design tool were large enough to make the effort worthwhile.

4.5 Plan for Future Assessment of Market Effects

Because of the extremely limited number of market actors, evaluation of this market will continue to be a challenge. The only viable approach to assessing future market effects is to use a longitudinal approach, that is to collect data periodically over a long period of time.

Periodically (maybe every three years) field the same set of evaluation questions used for this study to the same group of market actors. The market metric questions may allow the evaluations to identify a trend over time, despite the small numbers. There are several issues that will need to be taken into account using this approach:

- As staff change jobs, it will be important to try to interview individuals in the same position, in order to obtain responses from the same level of market actor.
- Corporate mergers may cause positions to disappear or be condensed, thus causing sample attrition. This could potentially be counteracted by identifying similar positions in the new corporate entity. Care must be taken in such replacements. The majority of the market actors interviewed in this evaluation represented large market actors or firms that serviced a large number of independents. In order for responses to be considered comparable, similar firmographics is a necessity. There is much circumstantial evidence that the attitudes toward energy efficiency are highly dependent upon firm size. Companies with more capital resources seem more willing to encourage and invest in energy efficiency.
- Sample fatigue will certainly be an issue. Sample attrition will occur unless proactive steps are taken to counteract it. Suggestions include: (1) personal phone calls well in advance of the solicitation effort, possibly from senior PG&E staff, requesting participation in the study, (2) distribution of this report upon its completion to all participants, with a cover letter thanking them and mentioning future needs to repeat the study, and (3) supplying demonstration software to designers with good support information to assist in interesting them in the project.
- Replacement questions should be developed for the metrics that failed to achieve meaningful responses.

As the program enters the field, questioning study participants on awareness of the program and technologies encouraged by the CRST will allow tracking of CRST Program influence over time.

Section 5. Findings and Recommendations

This section summarizes the key findings of the evaluation and presents recommendations on evaluation methods and program design.

5.1 Study Findings

- The target market for the CRST Program is the large chain stores in (or just entering) California. These stores have centralized planning, a modularized approach to building stores, an interest in energy efficiency as a means of cost reduction, and the resources and willingness to assess the tool and implement cost-effective energy saving technologies.
- The target market for the CRST Program is literally a handful of market actors. However, the savings potential resulting from influencing this set of market actors is large.
- The target market has minimal barriers to energy efficiency. It currently implements energy efficiency measures that it considers cost effective. If the CRST Program can document that new energy efficiency measures have predictable paybacks of three years or less and do not degrade reliability, chances are good for acceptance.
- The credibility gap is large. Design professionals and decision-makers understand the store-to-store variability and will need to be convinced that savings are real. Real building demonstration projects will almost surely be required. Acceptance of the veracity of any final tool will take a long time and will be hard earned.

5.2 Study Methods Recommendations

- Use a longitudinal approach.
  - Periodically, maybe every three years, field the same set of evaluation questions used for this study to the <u>same group of market actors</u>. The market metric questions may allow the evaluations to identify a trend over time, despite the small numbers.
  - Similarly, follow the same market actors <u>who obtain the tool</u>, to determine the systems and technologies installed due to the savings shown by the tool.
- Proactively counter potential sample attrition through:
  - personal phone calls from senior PG&E staff requesting participation in the study,
  - distribution of this report upon its completion to all participants, with a cover letter thanking them and mentioning future needs to repeat the study, and

  - supplying demonstration software to designers with good support information to assist in interesting them in the project.

- Develop replacement questions for the metrics that failed to achieve meaningful responses.

5.3 Program Design Recommendations

- Carefully market the tool to selected influential market actors. Interviews indicated that the large chains are most receptive to the concept. They have the resources to evaluate the tool and, if convinced of its ability to correctly predict system/store performance, to implement changes in a large number of stores. Anecdotal comments during interviews indicate that when large market actors make changes in overall approach, smaller market actors usually follow. The small number of market actors and the free flow of information within the industry enhance this effect.
- Track all the people who receive the program – get contact names, addresses, phone numbers, and e-mail addresses. Only with this information can future evaluations successfully track the penetration of the tool.
- Conduct demonstration projects on actual buildings to show the ability of the tool to reflect the actual level of energy usage of an existing building. Emphasize how the tool predicts interaction with the HVAC system and allows optimization of HVAC as well as refrigeration
- Create the ability to easily enter financial data into the tool to allow more complete cost/benefit analysis within one tool. Interviewees emphasized the criticality of cost benefit analysis as part of system evaluation.

Appendix A
Analysis Plan by Market Barrier

Analysis Plan for the Decision-Maker Survey Instrument

Information and Search Costs:

The analysis of this barrier is based on the following questions:

1. What information do you base your decisions on when you look at implementing a refrigeration system? Where do you get that information? {A1}
2. If you wanted information specifically on the energy efficiency of a refrigeration system, how would you get it? {A3}
3. On a 1 to 10 scale, with 10 being very easy, how would you rate the level of difficulty in obtaining that information? {A2}

The planned analysis is as follows:

- Question 5 is a baseline question aimed at eliciting how the decision-makers obtain their information. It is meant to establish to lines of communication and determine what they use for their decision.
- Question 7 is the metric for this barrier.
- Question 6 is asked based on the assumption that there really is no place to get information on the energy efficiency of a system. The answers to this question will prove or disprove that assumption as well as provide insight into how the decision-maker may problem solve the problem and may bring up areas that we have not thought of.

Performance Uncertainty:

The analysis of this barrier is based on the following questions:

4. Do you generally have an estimate of the energy use of the refrigeration systems before they are installed? If yes, from whom do you receive it? {B1 and E2}
5. [If yes in Q8] On a 1 to 10 scale, with 10 being very confident, how confident are you that the energy use estimates reflect the actual use of the installed system? Why? {B2}
6. [If no on Q8] If you did have an estimate of the energy use, on a 1 to 10 scale, with 10 being very confident, how confident might you be that the energy use estimate reflected the actual use of the installed system? Why? {B3}

The planned analysis is as follows:

- Q8 is asked to determine if they actually receive an estimate of the energy use of the refrigeration systems and to determine the lines of communication. The question also is used in the analysis of the bounded rationality barrier since they may state that energy efficiency is a high priority, yet actually receive no information on which to base that priority.

- Q9 and Q10 are used as the metric no matter how the customer answers Q8. Each question is followed up with a "Why" in order to explain the value provided.

Bounded Rationality:

The analysis of this barrier is based on the following questions:

7. On a scale of 1 to 10, with 10 being very high priority, what priority is energy efficiency when you decide to install a refrigeration system? Why? {E1}
8. What percent of the systems installed would you consider to be optimized for energy efficiency? Why? {E3 and F1}

The planned analysis is as follows:

- Q11 sets the priority of the customer and is used to compare with the information received (Q8) and if there really are energy efficiency systems being installed (Q12).
- If there is discontinuity between the three bounded rationality questions, it is assumed that the barrier exists.
- The metric is determined by comparing the scalar in Q11 and the percentage in Q12. The "Why" in Q11 and Q12 help to determine the basis for the answers.

Organization Practices or Custom:

The analysis of this barrier is based on the following questions:

12. What percent of the systems installed would you consider to be optimized for energy efficiency? Why? {E3 and F1}
13. On a scale of 1 to 10, where 10 is highly encouraged, would you say that the overall signals that you are being given within your company encourage or discourage installation of energy efficient refrigeration systems? {F2} What are the factors that encourage/discourage you from installing energy efficient refrigeration systems? {Open Opportunity}

The planned analysis is as follows:

- Question 12 establishes current practice among the interviewed decision-makers. This would allow the current practice to be assessed in the future.
- Question 13 supplies a metric on the current signals being given within the company. Again, this metric could be reproduced in the future to see whether the market has changed. The follow on question will allow us to expand on the factors that drive the market.

Misplaced or Split Incentives:

The analysis of this barrier is based on the following questions:

14. What are the most important factors in deciding on a specific refrigeration system installation? {Open Opportunity and I2}
15. Are you responsible for the operation and maintenance of the refrigeration systems in the supermarkets where you decide to install them? If not, who is and what do you think are their highest priorities for the refrigeration system? {I1}

The planned analysis is as follows:

- Question 14 allows both an open opportunity to discuss the factors driving designs and elicits an opportunity state whether operating cost is amongst them.
- Question 15 will identify the percentage of designers that are responsible for O&M costs. This can be rechecked in the future to see if this number has changed significantly. Secondly, the question collects information on the decision-makers opinion of the priorities of the personnel responsible for O&M costs.

Hidden Costs:

The analysis of this barrier is based on the following questions:

16. What do you think might be the primary disadvantages or uncertainties in the operation of an energy efficient refrigeration system? {H1}
17. On a scale of 1 to 10 with 10 being very confident, how confident are you in the operating and maintenance costs of a typical refrigeration system? Of an energy efficient refrigeration system? {H2}

The planned analysis is as follows:

- Question 16 is designed to allow the interviewee to identify, or not identify, future cost uncertainty as a barrier in the field.
- Question 17 provides a subjective view of the confidence in the future operating costs of standard and high efficiency equipment. The difference between the two scores provides the metric for measurement of market effects.

Irreversibility:

The analysis of this barrier is based on the following questions:

18. On a scale of 1 to 10, with 10 being very easy, how easy do you think it would be to change back from an installed energy efficient system to a typical standard system if you wanted to in the future? {J1}

The planned analysis is as follows:

- The primary purpose of question 18 is to identify the degree to which this barrier may play a role in this market. The barrier interacts so heavily with hidden costs and performance uncertainty that we believe there is little chance of identifying it as a separate barrier.

Analysis Plan for the Designer Survey Instrument

Information and Search Costs:

The analysis of this barrier is based on the following questions:

6. How do you get information on refrigeration <u>systems</u> (compressors, cases, and refrigerants)? {A1}
7. On a 1 to 10 scale, with 10 being very easy, how would you rate the level of difficulty in obtaining that information? {A2}
8. If you were to look for information specifically on the <u>energy efficiency</u> of a refrigeration system, how would you go about it? {A3}

The planned analysis is as follows:

- Question 6 is a baseline question aimed at eliciting how the designers obtain their information. It is meant to establish the lines of communication.
- Question 7 is the metric for this barrier.
- Question 8 is asked based on the assumption that there really is no place to get information on the energy efficiency of a system. The answers to this question will prove or disprove that assumption as well as provide insight into how the designer may problem solve the problem and may bring up areas that we have not thought of.

Performance Uncertainty:

The analysis of this barrier is based on the following questions:

9. Do you (or anyone else) currently calculate the energy use of the refrigeration systems you design? {B1 and E2}
10. [If yes in Q9] On a 1 to 10 scale, with 10 being very certain, how certain are you that the energy use estimates that you come up with reflect the use of the installed system? {B2}
11. [If yes in Q9] What do you use to estimate energy use? What are the strengths and weakness of using this method? {B3}

The planned analysis is as follows:

- Question 9 is asked to screen out those who don't look at the energy use. If they do not calculate the energy use (or rely on someone else to do it), there can be no barrier to their certainty (or not) of the simulation tool. This question is also part of the bounded rationality barrier. If the person states a high priority for energy efficiency (Q19), but does not calculate the energy use, then bounded rationality probably is present.

- Question 10 is the metric for this barrier. The metric measures the performance uncertainty of the values obtained from a design tool, not the installed system.
- Question 11 is meant to provide an opportunity for the designer to discuss how they actually go about determining the energy use of the systems they design. Additionally, the strengths and weaknesses of the methods used provides information on areas where they may be uncertain about the performance of the approaches.

Asymmetric Information:

The analysis of this barrier is based on the following questions:

12. When you are designing a refrigeration system, how often do you compare similar equipment from different manufacturers for incorporation in the system? Why? {C1 and G1}
13. What type of relationship do you have with the supplier of your refrigeration equipment? {C2}
14. Do you feel that they provide you with all the energy use information you want? {C3}
15. On a scale of 1 to 10, with 10 being totally confident, how confident are you in the energy use information you do receive? Why do you give it that number? {C4}

The planned analysis is as follows:

- Question 12 is asked to see if they ever really compare equipment as they design a system. This is the premise of the simulation tool, that they will now have the ability to swap out equipment and do comparisons. The "Why" follows up on their response – i.e., if they say never, we determine why they don't. This question also relates to the product or service unavailability barrier. The answer may be that they don't do this comparison because there is no way to do it, responses here will help to determine the absence or presence of this barrier.
- Question 13 helps us to understand the interactions between the designer and manufacturer. If there is a long term relationship, the designer may deal with the information provided to them in a different way than from someone they just met.
- Question 14 furthers the reasoning from Q13 – regardless of the type of relationship, does the designer get all the information they want from the manufacturer?
- Question 15 is the metric for the barrier and follows closely on the previous two questions.

Hassle or Transaction Costs:

The analysis of this barrier is based on the following questions:

16. What tools do you use to help you design a refrigeration system (hardcopy information, computer spreadsheets, computer software)? In what percent of the designs are each of these tools used? {D1}
17. On a scale of 1 to 10, with 10 meaning you strongly agree, please rate this statement: Optimizing the energy use of a refrigeration system that we design requires too many resources. {D2}
18. Do you have a computer simulation tool that can compare the energy use of different refrigeration systems? If yes, what is it and who runs it? If no, do you know of any such tool that is available? {G2} What do you think it would take to create one? {D3}

The planned analysis is as follows:

- Question 16 establishes the current use patterns for tools. The percentages used in designs would be used in future evaluations to establish whether computer simulations tools are becoming easier to use and are being used more often as a result.
- Question 17 establishes a metric for future assessment of changes in this barrier.
- Question 18 attempts to establish the level of effort that would be required to create a simulation tool under the current conditions. This question supports question 17.

Bounded Rationality:

The analysis of this barrier is based on the following questions:

19. On a scale of 1 to 10, with 10 being your highest priority and 1 being your lowest priority, what priority is energy efficiency when you design a refrigeration system? What priority is energy efficiency in the decision to install? {E1}

9. Do you (or anyone else) currently calculate the energy use of the refrigeration systems you design? {B1 and E2}

20. What percent of the systems you design would you consider to be optimized for energy efficiency? Why? {E3}{F1}

The planned analysis is as follows:

- Question 19 establishes their stated goals in terms of energy efficiency.
- Question 9 and 20 establishes their actual actions, that is, whether they are acting consistent with their goals.

The degree of divergence between the response to Q19 and questions 9 and 20 indicates the degree to which bounded rationality plays a role in the design process. For the actual metric we will convert the percentage in Q20 to a 1 to 10 scale, then take the difference between the response to Q19 and Q20 as an indicator of divergence.

Organization Practices and Customs:

The analysis of this barrier is based on the following questions:

20. What percent of the systems you design would you consider to be optimized for energy efficiency? Why? {E3}{F1}
21. What are the most important factors in designing a refrigeration system? {Open Opportunity}
22. To whose specifications do you design your system? {F2} Who decides whether the design will be installed. What in general is the basis for the decision?
23. On a scale of 1 to 10, where 10 is highly encouraged, would you say that the overall signals that you are being given within your company encourage or discourage development of energy efficient refrigeration systems? {F3} What factors that encourage/discourage you from designing more energy efficient refrigeration systems? {Open Opportunity}
24. What do you think would it take to significantly increase the number of energy efficient systems installed? {Open Opportunity}

The planned analysis is as follows:

- Question 20 forms the baseline for current level of energy efficient design under the existing practices and customs.
- Question 22 establishes the lines of authority for final installation of designs.
- Question 23 supplies the metric for measuring the current level of the practices and customs market barrier.

Product or Service Availability:

The analysis of this barrier is based on the following questions:

12 When you are designing a refrigeration system, how often do you compare similar equipment from different manufacturers for incorporation in the system? Why? {C1 and G1}

18. Do you have a computer simulation tool that can compare the energy use of different refrigeration systems? If yes, on what percent of your designs do you use this tool. What is it and who runs it? If no, do you know of any such tool that is available? {G2} What do you think it would take to create one? {D3}

The planned analysis is as follows:

- Question 12 establishes the desire/need for a simulation tool. If there is no demand, then it does not matter whether a tool is available or not.
- Question 18 will supply the metric for future measurement of market change. It will be expressed in terms of the percentage of respondents who have a tool and the percentage of respondents that use the tool

Appendix B
Final Decision-Maker Interview Instrument with Responses

Commercial Refrigeration Simulation Tools Program

Decision-Maker Instrument

Company Profile

1. Are you involved with the decision on refrigeration system implementation for your company?

All stated Yes

2. What is your title and responsibilities?

Q2
Director of facilities Responsible for design, engineering, construction and maintenance of all their buildings
Responsible for the operation and maintenance of all their stores in US and Canada - Involved in retrofits as well
Operations manager, all refrigeration, AC, energy management.
Director. Responsible for decisions on electrical, mechanical, and other types of equipment for our stores.
Senior Engineering Supervisor. Responsible for Energy Management, both demand and supply side.
Manager of Mechanical Engineering, West. Manage the design and installation of our refrigeration systems. Most of the design is contracted out.
Director of Equipment Procurement – purchase all equipment in 1,500 stores in US and Canada Both for retrofit and new stores
Director of Store Planning. Responsibilities are running store planning department, equipment purchasing, consulting on store planning matters.

3. Compared to other companies such as yours, would you consider yourself to be small, medium, or large in terms of revenue?

Response	Frequency of Response	
	N	%
Small	0	0.0
Medium	2	25.
Large	6	75.
Total	8	100

4. Would you consider you company a national chain, local chain, or an independent?

Response	Frequency of Response	
	N	%
National Chain	6	75.
Regional Chain	1	12.5
Wholesaler	1	12.5
Total	8	100

Potential Barriers

5. What information do you base your decisions on when you look at implementing a refrigeration system? Where do you get that information? {A1}

Q5
Philosophy is – is it simple, reliable and energy efficient Field experience from their staff
Required load (from electrical engineer), efficiency (from the refrigeration engineer)
Cost effectiveness, up front costs plus maintainability, Return On Investment (ROI) Where: Make vendors supply it all, make them totally responsible, if it doesn't do what they claim, either they fix it so it does or they are history.
Life cycle costs. This includes first costs, maintenance and operating costs, energy use. Also reliability, serviceability. Get the information from vendors, trade shows and our own research.
Initial cost, energy efficiency, serviceability. Empirical data (costs) we build a hundred stores a year, maintenance we get from maintenance department, energy efficiency we get from studies and from manufacturers.
First cost, maintenance and energy use, reliability, availability service. Get it from personal experience (we have many stores), manufactures, our maintenance department
Refrigeration engineer plays a major role and also my boss who is also an engineer. He looks at total life cycle cost (includes first cost, energy costs, maintenance costs, reliability) Vendors, industry studies, PG&E test center (FSTC), EPRI are all places he gets information
Cost, in 90% of the cases cost is the ultimate driver. Second is getting the job done. We have very little room for cutting edge technologies with our clients. Many want used equipment. Rely on the refrigeration companies to design the system. Have all the factory criteria in our AutoCAD.

6. If you wanted information specifically on the energy efficiency of a refrigeration system, how would you get it? {A3}

Q6
Little different from other groceries, they manufacture themselves, information form the metering of the store.
From the engineers who are doing the retrofit
Use watt transducers, collect the information ourselves.
Vendor or manufacturer, do some of our own research also.
Develop that internally, empirical data from sub-metering of stores.
Run our own data, we look at projected efficiency, bin analysis, then possibly do some metering (use EMS systems), watch cycling and head pressures.
Some independent testing, some EPRI testing, PG&E studies, manufacturer data (although don't always believe what information gotten from them since he feels they can skew the data to better show off their product)
From the manufacturers.

7. On a 1 to 10 scale, with 10 being very easy, how would you rate the level of difficulty in obtaining that information? {A2}

Response	Frequency of Response	
	N	%
1	1	12.5
2	1	12.5
3	0	0.0
4	0	0.0
5	3	37.5
6	0	0.0
7	2	25.
8	1	12.5
9	0	0.0
10	0	0.0
Total	8	100

8. Do you generally have an estimate of the energy use of the refrigeration systems before they are installed ? If yes, from whom do you receive it? {B1 and E2}

Response	Frequency of Response	
	N	%
Yes	5	62.5
No	3	37.5
Total	8	100

Q8
No
No for new - yes for retrofit - get info from ESCO or equipment supplier - engineer gets advice and relies on ESCOs
Yes - from vendors
Yes. We get the information from manufacturers, then we do some of our own calculations also.
No, but the systems are so similar from store to store that we have a good idea of the energy use of planned systems.
Yes, we develop them when we design the overall system. Crank some of the numbers ourselves and go to manufacturers for some. Go to Vacom if we want an elaborate study. Refrigerant analysis we can do ourselves.
Not on an individual basis – refrigeration engineer provides overall energy for a typical system.
Yes, from the manufacturers

9. [If yes in Q8] On a 1 to 10 scale, with 10 being very confident, how confident are you that the energy use estimates reflect the actual use of the installed system? Why? {B2}

Response	Frequency of Response	
	N	%
1	0	0.0
2	1	20.
3	0	0.0
4	0	0.0
5	1	20.
6	0	0.0
7	1	20.
8	2	40.
9	0	0.0
10	0	0.0
Total	5	100

Q9A
Too many things that go into it and don't do M&V because of cost of it - degradation of performance of equipment
From our experience. Depends on conditions, depends on the power supplied, people walking through the doors, track that also.
We get good information from the manufacturers.
9 Vacom, 7 for ours, manufactures 6 (only because they are usually selling something).
The manufacturers give us the information in good faith, but how it is used and maintained makes a big difference

10. [If no on Q8] If you did have an estimate of the energy use, on a 1 to 10 scale, with 10 being very confident, how confident might you be that the energy use estimate reflected the actual use of the installed system? Why? {B3}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	1	50.
6	0	0.0
7	0	0.0
8	1	50.
9	0	0.0
10	0	0.0
Total	2	100

Q10A
Couldn't comment – just putting in submetering on refrigeration and will know then When he gets the information will be very confident, but don't have it yet
We have history on a thousand stores so we have a very good idea what to expect.
every store is unique due to installation, climate, etc

11. On a scale of 1 to 10, with 10 being very high priority, what priority is energy efficiency when you decide to install a refrigeration system? Why? {E1}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	0	0.0
7	2	28.6
8	1	14.3
9	2	28.6
10	2	28.6
Total	7	100.1

Q11A
It's the third priority
Is up there 7 or 8 - reliability and defined use are higher priority
Saves us a lot of money
Energy costs are our second highest expense next to labor.
Depends on where we are building it. Overall platform is fairly efficient. Cannot modify for every store for every circumstance. If energy costs are 1 cent per kWh then we may not install certain items because the payback isn't there. At 11 cents per kWh we will make a lot more effort. We try to be good citizens but we have to look at ROI also.
9 or 10 One of the largest on-going expenses for the store
10 for me personally, but the restrictions from our clients sometimes limit that.

12. What percent of the systems installed would you consider energy efficient? Why? {E3 and F1}

Q12
Of the 120 stores – half are considered energy efficient
Total fleet - 60% is state-of-the-art - have EMS controlling refrig. Algorithms, rack systems, been doing it for a number of years
99%, we focus because it saves money. It also helps us get better utility rates.
70%
100%. All of our systems are so very similar. We have been using parallel systems & floating head pressure controls for 10 years. We use the same design every where based on ROI. Our ROI criteria is 2.5 years simple.
80%. Have to meet merchandisers needs sometimes.
70% A relative scale since there can be more efficient systems installed, but they are more complex as well and as a result more difficult to maintain.
100% of the new systems are pretty efficient. They don't necessarily all have all of the bells and whistles but they are pretty good. Others are used systems and I do not consider these efficient.

13. On a scale of 1 to 10, where 10 is highly encouraged, would you say that the overall signals that you are being given within your company encourage or discourage installation of energy efficient refrigeration systems? {F2} What are the factors that encourage/discourage you from installing energy efficient refrigeration systems? {Open Opportunity}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	1	12.5
6	0	0.0
7	0	0.0
8	1	12.5
9	1	12.5
10	5	62.5
Total	8	100

Q13A
9.5-10 - like to save money with energy efficiency - if meet investment criteria - simple payback of <3 yrs.
Company stock rises and my profit sharing goes up.
We get signals to keep store expenses down.
The signal is that when I propose an energy efficient device that pays back, I never get turned down.
We are allowed to tailor our systems to get the most efficiency, get it as efficient as possible.
Sr. management wants to be the low cost operator in the industry – energy costs play a big part of that goal A discouraging part is that complex systems are harder to maintain – many have outside contractors for maintenance and they don't always know how to keep the system running at it's optimum efficiency
Our clients have an overly developed consciousness about cost. The indicators are the use of used equipment. There is a glut of used equipment on the market.

14. What are the most important factors in deciding on a specific refrigeration system installation? {Open Opportunity and I2}

Q14
Applicability to task (merchandising) - compatibility with existing, reliability of system & efficiency
Cost effectiveness, up front costs plus maintainability, Return On Investment (ROI)
Energy efficiency , maintainability, first cost
Does it merchandise the produce well, we sell product so it needs to present well.
First cost, maintenance and energy use, reliability, availability service. Get it from personal experience (we have many stores), manufactures, our maintenance department
Total life cycle cost
Cost, efficiency. But some clients do have brand loyalty.
Reliability

15. Are you responsible for the operation and maintenance of the refrigeration systems in the supermarkets where you decide to install them? If not, who is and what do you think are their highest priorities for the refrigeration system? {I1}

Response	Frequency of Response	
	N	%
Yes	2	25.
No	6	75.
Total	8	100

Q15
Yes
Yes
Just through warranty. But efficiency is also high priority for operations. I know because they sit in the office right next door and if the operating costs are too high I hear about it.
No. The store operator. Their priorities are probably maintainability, associated operating expenses, energy use.
No, but if they have problems then they come back to us, we have very direct feedback.
No, maintenance takes over after 60 days. We have for the first 60 days to commission it. Highest priority is cost control.
No – the divisions have a manager who is responsible for maintenance and energy use (same person for both) – Reliability is #1 and energy usage is #2 for these folks – however there is a dichotomy there since the site managers can decrease maintenance costs to improve their own bottom line
No, that is up to independents. Nobody wants to pay for it.

16. What do you think might be the primary disadvantages or uncertainties in the operation of an energy efficient refrigeration system? {H1}

Q16
Don't feel that there are any - but complexity is a disadvantage if had to say something
New technology has concerns with capacity to accomplish task (food safety) above all have to be sure food remains safe and customers get a high quality product – merchandisers have first say in what cases look like and are used
Marking sure you have the true savings numbers. How much can you save.
Be sure that it is proven reliable technology.
Does it really perform as advertised and can the average maintenance technician maintain it.
Some of the new technologies are unproven. One manufacturer had valve problems and that gave us problems for two years. Complexity leads to bypassing of system so that it runs inefficiently. Parts supply can be a problem for newer products.
Quality of local service organizations and their ability to properly maintain the systems – some divisions are now using an outside company for a set monthly cost of operation and maintenance. Example – meat case isn't keeping temperature, previously a contractor was in and out as quickly as possible to keep costs down, now the outside company fixes the meat case, checks out all the other cases, optimizes and tunes the system all in one visit – not an issue any more how long the contractor is in the store since it is all one (known) cost
Maintenance. Often EMS has been disconnected and made inoperable by technicians who don't know how to maintain it. Many of the independents stores don't have the controls or discipline to maintain the systems the way that they need to be maintained to deliver the savings.

17. On a scale of 1 to 10 with 10 being very confident, how confident are you in the operating and maintenance costs of a typical refrigeration system? Of an energy efficient refrigeration system? {H2}

Response	Typical		Efficient	
	Frequency of Response			
	N	%	N	%
1	0	0.0	0	0.0
2	0	0.0	0	0.0
3	0	0.0	0	0.0
4	0	0.0	0	0.0
5	1	12.5	2	25.
6	1	12.5	1	12.5
7	1	12.5	1	12.5
8	0	0.0	0	0.0
9	3	37.5	2	25.
10	1	12.5	1	12.5
Don't	1	12.5	1	12.5
Total	8	100	8	100

Q17B
Seen no difference in energy efficient or other
Very confident. We get feedback from operations group.
9 to both, but we don't really have two types of systems. Our stores are better than stores that we purchase when we calculate the cost per square foot.
6 for both Maintenance suffers because the store manager shines by keeping costs down.
Simple system – 9 or 10 Complex system – 5 or 6
Don't know, we don't do that part of it. It is controlled by the independent stores.

18. On a scale of 1 to 10, with 10 being very easy, how easy do you think it would be to change back from an installed energy efficient system to a typical standard system if you wanted to in the future? {J1}

Response	Frequency of Response	
	N	%
1	3	37.5
2	1	12.5
3	0	0.0
4	0	0.0
5	0	0.0
6	0	0.0
7	0	0.0
8	1	12.5
9	0	0.0
10	3	37.5
Total	8	100

Q18A
Would not be easy - would not even attempt it
Negative 1 really
Pretty easy, a couple of phone calls.
System is so integrated, each piece depends on the other, so going backward would be difficult.
Once they are in it is difficult to go back.
Would be very easy.
Most systems can simply be bypassed. Some systems many not be so easy, but most would

19. What kinds of changes do you think would be necessary in the market to make energy efficiency a high priority when your company installs refrigeration systems? {Open Opportunity}

Q19
Already installing the most efficient system can buy – so no changes.
Cost/benefit analysis needs to be done and must be able to mitigate the cost if cost is over premium
More advertising to show what it does for the customers, so they ask for it. If they knew that it would save them money, they will ask for it.
Still needs to have acceptable paybacks, that means that equipment costs have to go down and/ or energy costs have to go up.
It already is, can't be done, currently very high priority.
Boils down to reliability (pretty much overcome), payback has to improve or become more believable. On of the best approaches I have seen is a pilot program we are doing with an outside contractor. They maintain the equipment and get paid by keeping its energy use low. Thus the two are linked.
Love rebates/incentives – anything that helps to bring down the total life cycle cost Increase in energy prices
Cost of energy to go up. In my opinion a lot of the savings will evolve from deregulation. Some refrigeration energy management company (e.g., Edison Source) are offering packages of maintenance and energy for one price. A number of the stores are going that way.

20. Do you have a computer simulation tool that can compare the whole building energy use of different refrigeration systems? If yes, on what percent of your designs do you use this tool. What is it and who runs it? If no, do you know of any such tool that is available? {G2} What do you think it would take to create one? {D3}

Q20
No - nothing that appears to fit the supermarket well - DOE-2 doesn't fit (i.e., they heat buildings even when 80 outside, cases leak refrigeration) - if cost/benefit works, would use such a tool
Would look at it if it was available. If he believed it would result in cost savings he could easily get his vendors to use it. He would be very interested. He doesn't know of any such took on the market. Didn't know what it would take to create one.
No, we don't currently have one. Vacom does though, we have gone to Vacom for those kinds of estimates. We are interested in them. Would be interested in having one on computer. If it took too much time to set up we would probably have to farm it out to a consultant, but we would still do it
No, I think that some are available but don't use them. We use empirical data.
No, Doug Scott at Vacom has done those kinds of things for us. They are expensive. We use then to prove our design standards. We are currently upgrading all of our programs, but we are using the simplest (to operate) programs available. Has to be simple and usable by an engineer. Manufacturers are currently simplifying the programs for our specific use. This isn't to say that engineers are simple, they just think different than programmers and need to get product out quickly. Cannot spend a lot of time doing detailed estimates. When asked about whether they would use a whole building software: Would have to have Vacom set up a building then they could use it to fine tune the refrigeration. Outside projects are hard to justify. Have trouble selling the project internally if it is very expensive.
No – although he know SCE has a tool that they use that is fairly sophisticated Our refrigeration engineer has the decision to use such a tool or not, not me – although he feels they probably would use such a tool. It is his belief that they would be willing to put up front costs into customizing a viable tool to fit the needs of their chain if it then allowed them to compare equipment effectively and would lead to minimizing operating costs.
No. I am sure they do, but I don't know. We wouldn't be likely to use them. We want to pass responsibility back to the vendor.

Appendix C
Final System Designer Interview Instrument with Responses

Commercial Refrigeration Simulation Tools Program

System Designer Interview Instrument

Company Profile

1. Are you involved with the design of refrigeration systems for supermarkets (your company)?

All stated Yes

2. What is your title and role in designing refrigeration systems?

Q2
Director of Construction Engineering Role is to listen to customers and design refrigeration for remodel, new, upgrade stores
Chief Engineer - Do the design and quote the price, surveys for remodels, new installations
Senior refrigeration specialist; design, specify and purchase equipment
Senior Engineer – develop the specs and design criteria for new and remodels for stores in US and Canada
Energy Service Manager. Primarily responsible for the controls

3. How many people are involved in the refrigeration design process?

Q3
On the design side – sales engineer, project engineer, and designer (AutoCad) person who puts it to paper
One
3
He develops spec – only person in the company – Outside contractor does designs by store
8-10 for refrigeration in this branch, I don't know worldwide, a lot.

4. Compared to other companies such as yours, would you consider yourself to be small, medium, or large in terms of revenue?

Response	Frequency of Response	
	N	%
Small	0	0.0
Medium	2	40.
Large	3	60.
Total	5	100

5. [If consultant] Who are your clients (National chain, local chain, independent)?

Q5
All of the above
Local and national chains and independents
Own store (80%) and small independent stores (20%)

Potential Barriers

6. How do you get information on refrigeration systems (compressors, cases, and refrigerants)? {A1}

Q6
If an existing system, has team get the information If new, gets information from manufacturer Internet is useful
Go to the store for existing stores Call the manufacturer for the information
From the manufacturers
Once store is designed, refrigeration design shows system information from contractor
From the customer, they provide us with store layout and all specifications.

7. If you were to look for information specifically on the energy efficiency of a refrigeration system, how would you go about it? {A3}

Q7
Is nothing published that could tell you other than maybe a single condensing unit system
Calculate it myself – use own algorithms
Would go to the manufacturers. For technical information we go to the factories, for costs we go to the sales representatives.
Partly from the contractor form they fill out which is an EXCEL spreadsheet with compressor use (compressor use is 70% of the refrigeration use) – Refrigeration use is 40% of store energy use
We do our own calculations, based on compressor mfg. Information and the cases we manufacturer

8. On a 1 to 10 scale, with 10 being very easy, how would you rate the level of difficulty in obtaining that information? {A2}

Response	Frequency of Response	
	N	%
1	0	0.0
2	1	20.
3	0	0.0
4	1	20.
5	0	0.0
6	0	0.0
7	0	0.0
8	1	20.
9	1	20.
10	1	20.
Total	5	100

9. Do you (or anyone else) currently calculate the energy use of the refrigeration systems you design? {B1 and E2} If not, why not?

Q9
We do
Yes can but don't do it, not usually asked unless doing an energy comparison which happens only 1 out of every 10 jobs
Yes
Our company has energy consumption form that contractor fills out
Yes, spreadsheet system and our own knowledge.

10. [If yes in Q8] On a 1 to 10 scale, with 10 being very certain, how certain are you that the energy use estimates that you come up with reflect the use of the installed system? {B2}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	0	0.0
7	1	20.
8	4	80.
9	0	0.0
10	0	0.0
Total	5	100

11. [If yes in Q8] What do you use to estimate energy use? What are the strengths and weakness of using this method? {B3}

Q11
We have an old program developed 8 years ago, Lotus format that looks at annual weather data and compressor calculations (hourly), load factor per hour used as well Strengths – quick and in the ballpark Weakness – load factor never documented and don't know the load variation over season and hourly 90% of what they do construction wise, they don't have to do this on
Own algorithms in Excel patterned on our company's energy usage Strengths – most of the parameters are plugged in Weaknesses – 80-90% sure, but within a year, can through out the estimates anyway since the maintenance during that year plays a big part of how it works People don't service the equipment within the first year and it degrades
Go through a long spreadsheet calculation. It uses runtimes and defrost cycles, etc. Based on historical data. Weakness – only an estimate, close enough for our work, we are only comparing systems so we are not worried about the absolute answer as much as the relative performance as equipment is added and removed. Strengths – quick and accurate, Brought the software with me from a different company. Not a trade secret.
Excel spreadsheet - strengths is that it is simple, quick, based on EPRI data and in line with testing - Weaknesses – variables an be easily manipulated in the field and throw off the system so don't really see expected usage
Spreadsheet. Strength: we can get a close estimate of the actual use. Weakness – not at all user friendly.

12. When you are designing a refrigeration system, how often do you compare similar equipment from different manufacturers for incorporation in the system? Why? {C1 and G1}

Q12
Makes that comparison one initial time and then know their direction and set the standards and use it until feel the need to reevaluate
Only on a pricing basis – if going in with a big system, never. Use their own compressor systems which is why they don't.
Every time, that is what we do.
Not very often - don't have time to do permutations - they stay on top of all manufacturers, though
Not very often, usually specified by client, they will only use one type and that is what they specify.

13. What type of relationship do you have with the supplier of your refrigeration equipment? {C2}

Q13
They build refrigeration systems themselves, build compressor racks, buy and have access to people compressor systems that they don't build Condensers – good, people want their business Cases – compete with manufacturers who sell cases, so not always very good, distribute one manufacturer's cases – sold
Make their own cases, too. Condensers buy out. Pretty good relationships – deal with most of those who refuse to sell to the end user
A close working relationship.
National contract with a refrigeration company - in place since 1993 and renewed more than once - good relations
Use two manufacturers of compressors, we have a close relationship with them.

14. Do you feel that they provide you with all the energy use information you want? {C3}

Q14
Nope
Sure
Yes
Yes - get all they want and have time to deal with - can't always provide more detailed information about all the stuff in the store
Yes, it is in their published data or windows based programs that they supply. They help gives electrical use pretty close.

15. On a scale of 1 to 10, with 10 being totally confident, how confident are you in the energy use information you do receive? Why do you give it that number? {C4}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	1	20.
4	0	0.0
5	0	0.0
6	0	0.0
7	0	0.0
8	3	60.
9	1	20.
10	0	0.0
Total	5	100

Q15A
Some are simple to calculate and can check where they are, others (in terms of BTU loads) question if they really know what they are testing
They are motors and fans which are easy stuff to calculate
We have an ongoing relationship
They created it
Pretty close

16. What tools do you use to help you design a refrigeration system (hardcopy information, computer spreadsheets, computer software)? In what percent of the designs are each of these tools used? {D1}

Q16
Hardcopy – 100% Vender software programs – 100% Spreadsheets – 100% Combination of what they use depending on the use
Hardcopy and computer spreadsheet used 100% of the time
We use a spreadsheet system, we use it on every system that we design
Excel spreadsheet for all but smaller retrofits - manufacturers program for compressor sizing and catalogs for cases/condensers are used 100% of the time
We have specific designs, that are patented designs. We modify them to meet client needs. It all comes back to what the customers want. The design is done with a proprietary tool.

17. On a scale of 1 to 10, with 10 meaning you strongly agree, please rate this statement: optimizing the energy use of a refrigeration system that we design requires too many resources. {D2}

Response	Frequency of Response	
	N	%
1	0	0.0
2	1	20.
3	2	40.
4	0	0.0
5	1	20.
6	0	0.0
7	1	20.
8	0	0.0
9	0	0.0
10	0	0.0
Total	5	100

Q17A
Designer with good idea of locale, customers willingness to pay or not for energy efficiency, 96-98% there for a person with experience (19 years) Depends on level of process – they equip engineers so can
It just takes a lot of time to look up all of the inputs

18. Do you have a computer simulation tool that can compare the energy use of different refrigeration systems? If yes, on what percent of your designs do you use this tool. What is it and who runs it? If no, do you know of any such tool that is available? {G2} What do you think it would take to create one? {D3}

Q18
Access to one that can pay a fee to use Lotus spreadsheet which is rudimentary (can use air cooled and evaporative cooled system here) Use all the tools, but don't need to make an energy comparison – 5% of the time or less used
Yes – only where retrofitting, replacing existing compressor racks 15-20% of what they do is remodel – usually adding load to store
Have? – No Available? – No, one is probably available, but we don't have a use for it. To Create? – Don't know.
Not the whole system, other than Doug Scott, don't know of anything - it would take lots of work, but not worth it for a single company - may for a conglomerate
Yes, 5%, I run it (spreadsheet)

19. On a scale of 1 to 10, with 10 being your highest priority and 1 being your lowest priority, what priority is energy efficiency when you design a refrigeration system? What priority is energy efficiency in the decision to install? {E1}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	0	0.0
7	0	0.0
8	2	40.
9	2	40.
10	1	20.
Total	5	100

Q19A
Qualify by customer – some people not willing to pay for it then a 5 – when willing to pay for it is a 10 Customers are driven to bottom line pricing, some want both, but hard to give them, try to sell them up to something better and give them options to upgrade – some customers it's a 10 and others is a 5 – difficult question
2 for install – they are bottom dollar almost always, assume that their sold energy efficient equipment – they have specs which require parallel racks and efficient motors, etc.
for both design and install
9 for both since big on return on investment and see it with energy efficient technologies - look at life cycle cost - use simple payback of 3 years as cut off - things have to work on their own, not as a system
to make ours more attractive to the customer.

20. What percent of the systems you design would you consider to be optimized for energy efficiency? Why? {E3}{F1}

Q20
75% - they are allowed to do this on 75% of the jobs on a customer preference stand point, other 25% are efficient, but not optimal, probably
Only portion would be systems that are parallel, big systems are totally optimized which is about 50% of their work.
50%, a lot of time we have to keep it simple because of where it is being installed and what maintenance/parts are available.
Zero percent optimized but payback not worth it - they have the best efficiency for the payback - in that sense they are 100% optimized
50%

21. What are the most important factors in designing a refrigeration system? {Open Opportunity}

Q21
Product integrity (if super efficient, but can't keep the shelf life of the meat, not helped them), energy, low maintenance, serviceability, low cost
Product integrity (the ability to hold temperature)
Depends on the job:, simplicity, ease of operation, reliability, efficiency.
Product integrity (maintaining food) and system efficiency and cost of system
1. Cost, 2. Reliability, 3. Energy efficiency, 4. Serviceability.

22. To whose specifications do you design your system? {F2}Who decides whether the design will be installed? What in general is the basis for the decision?

Q22
Customer if they have it, or interject their good ideas to supplement, if none, design to their specs. Customer – decides on combination of cost, recognizing a good design, salesmanship, track record with a customer (repeat business)
The manufacturers, the customers if they have spec. Customer – cost is basis for decision
We design it to our specifications. Typically the decision has already been made to build by the time the requirement to design comes to us.
Specs to their own specs - set by him – looking at new design then him and/or other people in the company decide - if same types of stuff, he alone decides
Our customers specifications, their own engineering departments decide, cost is the basis.

23. On a scale of 1 to 10, where 10 is highly encouraged, would you say that the overall signals that you are being given within your company encourage or discourage development of energy efficient refrigeration systems? {F3} What are the factors that encourage/discourage you from designing more energy efficient refrigeration systems? {Open Opportunity}

Response	Frequency of Response	
	N	%
1	0	0.0
2	0	0.0
3	0	0.0
4	0	0.0
5	0	0.0
6	1	20.
7	0	0.0
8	0	0.0
9	2	40.
10	2	40.
Total	5	100

Q23A
They are a design/build contractor and they don't have an R&D lab and they improve the efficiency by what is done on a live project – as opposed to someone who has a lab to build it up and test it.
Encourage – a complete customer spec discourage – cost
Discourage: usually the need to keep it simple, have to keep it simple.
Responses of other industry folks that say are good systems - maintenance group and energy group all discuss things
R&D department continually asking for more efficient components

24. What do you think would it take to significantly increase the number of energy efficient systems installed? {Open Opportunity}

Q24
Because some customers are driven by price, it is an educational process to educate the buyer that is more involved than just low dollar price to buy a system, longer terms benefit to buying a more efficient system.
Don't know that it could be – certain number of stores being built and the big chains already have specs while the little ones only want low cost
More standardized features that are easier for installers to maintain.
Already there but more solid data on actual savings of specific technologies needed
Dramatic increase in energy costs, like in the 1980s.

25. Can you identify any other factors that may inhibit the design of energy efficient refrigeration systems for supermarkets. {Open Opportunity}

Q25
Industry as a whole – few people coming out of schools as engineers who can step into a supermarket refrigeration company and know what is what, difficulty finding engineering help and support – with the dissolving of CalPoly program, lack of engineers in the industry, void in application portion of the industry Only one or two colleges with specific engineering refrigeration degree – tough to recruit and find people.
Space to put the system (parallel) some of their customers don't want anything in the back at all, want it up on the roof – water costs play a part for evaporative condensers
No
Only have so much space to use, merchandising people have final say - better efficiency if have doors, but won't put it on - more weight on roof takes more $$ for support
Old line thinking

26. Do you have a computer simulation tool that can compare the whole building energy use of different refrigeration systems? If yes, on what percent of your designs do you use this tool. What is it and who runs it? If no, do you know of any such tool that is available? {G2} What do you think it would take to create one? {D3}

Q26
DOE2 doesn't take into account supermarket stuff such as refrigeration cases on the floor and heat stores when 70 outside - until a group of supermarket engineers get together it won't be right – may not have the time to use the tool, but could contract out to look at different designs - think could see 10% of total store savings with proper tool
No. Vacom Technologies has the ability to do it. No one company is likely to develop it. Lack of anyone wanting to share information. Proprietary information is very closely held in this industry. Would have to be developed by a third party. For it to be accepted, it would have to be used by the supermarkets, The EPRI tool still isn't uses. We aren't likely to use it. Most manufactures aren't likely to give up the information use. Most of the interactions are fairly well known and well published. Manufactures will do their own tool and are unlikely to use any other tool unless the customers require it.

Appendix D
Project Team Interview with Responses

Commercial Refrigeration Simulation Tools Program

Project Simulation Tool Consultant Interview

Program Background

1. What are the objectives of the Commercial Refrigeration Simulation Tools Program?

   To provide a tool to the large chain supermarkets to make decisions – provide accurate financial assessment and reliable bottom line savings they can trust

2. When did the program start?

   About 1.5 years ago

3. How long have you been working on the program? Always in your current capacity?

   Sub to Jeff Hirsch all along – provides industry specific information/needs – build database of equipment, developed and tested calculations

4. Was any research was done to establish baseline practices prior to starting the program?

   Some minor stuff, no major study – their role is to stay in touch with the major chains

   To define the need?

   Not really. They know what they do now and how the stores are operating a year later – feels that the industry is going backwards and energy efficiency is being taken out of specifications. The trend he sees is that more decisions are made by financial folks who need hard numbers to justify their decisions. If the don't have hard numbers, then energy efficiency measures are cut out in favor of lower first costs.

5. What is your role in the program goals?

   VaCom has done ~300-400 surveys over the past 3-4 years where stores are not seeing savings but the energy efficient measure is there – feels they need commissioning after being built. See Q3 for what they have done.

Program Status

6. Please summarize what was accomplished since the program started.

   Beta stage that will function at the decision making level is completed. Maintained some industry involvement– major chains (Safeway and American Stores) know of the tool. However, doesn't feel that the tool will be used by the major chains by themselves – not easy or quick enough to do this. Those people in the chains who understand and could use it have so many other responsibilities that they don't have time now.

7. What is the current status of the tool libraries?

   85% of condensers/compressors/display cases present of current and old (10 years worth) – 100% of what they know about are present in the libraries

8. What is the target market for the design tool?

   Supermarket chains – he feels that it is likely that they will adopt the use of the tool for specification but will not do the simulation tool themselves. They will demand that suppliers that want to sell them equipment supply simulation results. Thus the tool will probably be packaged as a service and taken to chains and/or manufacturers by consultants or contractors. As he sees it these consultants, or possibly the larger manufactures, will develop the expertise to run simulations to meet the requirements of the large chains. Since the chains usually have 2 or 3 prototypical designs that they build, these prototypes would be used as the basis for comparison of alternatives. Since the chains may have large numbers of stores of the same design, they will be able to supply the typical overall consumption. This will at least allow overall calibration of the prototype models.

   Refrigeration manufacturers and some designers on the East Coast may use the tool.

   They need to work hard to get to the big stores to use it since it will be a big effects if can get them to change their specs (150 stores constructed per year). The tool facilities unbundling of products – the current consolidations is tending to cause the chain to go with one manufacturer and buy all products from one company. That unbundling would allow chains to bid individual pieces of equipment, thus resulting in lower first costs. This would be very attractive to chains.

Potential Barriers to Use of Design Tool

9. What keeps designers from using design tools to design energy efficient refrigeration systems?

	Comments
☒ Information & Search Costs	- Information from EPRI, FMI conferences, contractors and manufacturers, but no tool there either
	- Nobody will pay for the manpower to operate the tool since it has no perceived value - No income associated with the position
	- Knowledge level in the commercial refrigeration side is poor – not many refrigeration engineers out there who are capable of this type of calculation.

☒ Performance Uncertainty	-High level of skepticism about energy savings, past evaluations couldn't prove savings or showed no savings
❑ Asymmetric Information	- Doesn't seem to be an issue
☒ Hassle or Transaction Cost	- No tool available. No one supermarket is willing to pay for the manpower to develop a tool or even put in the building data.
❑ Hidden Costs	NA
❑ Access to Financing	
☒ Bounded Rationality	Exists, but he feels that it can be overcome if you work hard enough and consistently supply sound information.
☒ Organization Practices/Customs	Use rules of thumb.
❑ Misplaced or Split Incentives	NA
☒ Product/Service Unavailability	No current tools available
❑ Externalities or Non Externality Pricing	NA
❑ Inseparability of Product Features	NA
☒ Irreversibility	Tool actually facilitates reversibility by allowing comparison of options in advance. Also facilitates unbundling of equipment features

Potential Barriers to Implementation of Efficient Designs

10. What keeps decision-makers from implementing energy efficient refrigeration systems?

	Comments
☒ Information & Search Costs	- Information does not exist for accurate energy savings. It is difficult if not impossible to get.
☒ Performance Uncertainty	-High level of skepticism about energy savings, past evaluations couldn't prove savings and also showed no savings
❑ Asymmetric Information	No
❑ Hassle or Transaction Cost	No
☒ Hidden Costs	Decision makers are very skeptical about what the savings will be from energy efficient systems.

☐ Access to Financing	Chains generally finance the building of the stores, and the decisions on whether or not to use energy efficient systems are made based on other basis, such as first cost and performance uncertainty, rather than on whether they can get the money.
☒ Bounded Rationality	Exists, but he feels that it can be overcome if you work hard enough and consistently supply sound information.
☒ Organization Practices/Customs	- Big deal, often 3 different people and budgets that don't interact and bonuses tied to own budget
☒ Misplaced or Split Incentives	There may be as many as three different cost centers, none connected (construction, maintenance, and operations). Each taking actions that counter each other.
☐ Product/Service Unavailability	Not an issue, all of the equipment types are available, but no one can document the savings from the various combinations.
☐ Externalities or Non Externality Pricing	No
☐ Inseparability of Product Features	No
☒ Irreversibility	Can be an issue if something goes bad after an installation. This encourages caution. However, they don't generally fix problems that they can live with in current store, just change the design for the next store.

11. What are the key features of the tool that you believe will make it a success with designers?

    The tool has the resolution to answer their specific questions – can go down to the measure level with information

    Accurate energy use, mass flow model is new & deals with HVAC and case interactions

12. What are the features which will help to get the energy efficient systems installed?

    Providing credible financial value – NPV or similar – the tool handles TOU rates and energy and demand savings

13. Contact lists? For Designers? For Decision makers?

    Provided at end of interview

14. Comments

The trend with having a construction division is now going away or at least has stopped with the consolidation of companies.

Consolidation is BIG – feels that there will be 4 companies when it is all done.

The tool can show as much savings for HVAC as refrigeration, and potentially more control status savings.

Three main companies serve the little guys (independents). The independents buy food and whole stores from them

Big chain supermarkets drive the manufacturers to get what they want – supermarket often specifies all (down to the valve type) and the manufacturers give them whatever they want.

Manufacturers design refrigeration systems for the smaller guys.

Commercial Refrigeration Simulation Tools Program

Program Manager Interview

Program Background

1. What are the objectives of the Commercial Refrigeration Simulation Tools Program?

   All in planning documentation. I will give you a copy.

2. When did the program start?

   Planning started three years ago. Formal program started in 1998.

3. How long have you been working on the program? Always in your current capacity?

I instigated the program three years ago and have been the technical lead ever since. Worked with Jeff Hirsh and Doug Scott of Vacom. Jeff is doing the DOE2 work and Vacom has built the database of equipment available in the market. The program really has an incredible library of performance information on equipment.

4. Was any research was done prior to starting the program to establish a baseline?

No, only the experience of the team.

   To define the need?

   Based on the body of experience of the team.

5. What is your role in the program goals?

   Technical Lead, project manager. The project was co-sponsored by SCE where Ramin Faramarzi is the lead.

Program Status

6. Please summarize what was accomplished since the program started.

   Since 1998 , contracted with JJ Hirsch, he subcontracted Gates and Vacom. Gates doing refrigeration side, JJH doing building portion, Vacom creating library of equipment. The project will require an ongoing contract to keep library up to date. The user of the simulation can create their own quadratics using equipment specific parameters and then store the information in the library.

7. What is the current status of the project? Of the tool?

Bata 1 version released as of 12/31/98. This version is only the simulation code with no user-friendly interface. We had a roundtable during the last week of Dec 98. There is a memo available on the meeting. You can get it from Jeff Hirsch. Work is currently stopped until the '99 program is approved.

8. What is the target market for the design tool?

Supermarket energy manager for both existing and new stores. Small group of designers only (the supermarket designer), equipment manufacturers, and consultants.

9. How do they plan to market it?

   I think it will be part of a design assistance effort to the supermarket sector, but there is no official marketing plan

Potential Barriers to Use of Design Tool

10. What keeps designers from designing energy efficient refrigeration systems?

		Comments
☑ Information & Search Costs	Yes	EPRI has a simulation tool, but it is not used very often (and is more superficial) – additionally manufacturers have their own proprietary tools for their own components only
☑ Performance Uncertainty	Yes	Fear of Failure – no way to evaluate the impact on their store – anecdotal that it may work in Houston, but not necessarily in Walnut Creek.
❑ Asymmetric Information	No	
❑ Hassle or Transaction Cost	No	
☑ Hidden Costs	Yes	Food Safety, maintenance costs
❑ Access to Financing	No	
☑ Bounded Rationality	Yes	For the less progressive, yes – tend to design based on anecdotal evidence and rules of thumb
☑ Organization Practices/Customs	Yes	It worked in other stores so will do it again. Lowest first cost.
❑ Misplaced or Split Incentives	No	
☑ Product/Service Unavailability	Yes	No consistent way of documenting energy savings.
❑ Externalities or Non Externality Pricing	No	

❑ Inseparability of Product Features	No	Not a major issue. May be for refrigerated cases
☑ Irreversibility	Possibly	Tied to fear of failure on the part of the designers

Potential Barriers to Implementation of Efficient Designs

11. What keeps decision-makers from implementing energy efficient refrigeration systems?

		Comments
☑ Information & Search Costs	Yes	See Design discussion above. Design information hard to get. EPRI , utilities are good sources.
☑ Performance Uncertainty	Yes	Don't trust the information from designers.
❑ Asymmetric Information	No	
☑ Hassle or Transaction Cost	Yes	Construction schedule often plays into decisions.
❑ Hidden Costs	No	Not a big factor
❑ Access to Financing	No	
❑ Bounded Rationality	No	
☑ Organization Practices/Customs	Yes	Merchandizing is his main concern.
❑ Misplaced or Split Incentives	No	Because energy efficiency not a big enough part of operating costs to influence choice of system.
☑ Product/Service Unavailability	Yes	Because they don't have a credible tool to demonstrate potential savings.
❑ Externalities or Non Externality Pricing	No	
❑ Inseparability of Product Features	No	
☑ Irreversibility	Yes	Tied into all of the above, fear of failure

12. What are the key features of the tool that you believe will make it a success with designers?

    Integration of the whole building. Sophisticated model and wide library of available data.

13. What are the features which will help to get the energy efficient systems installed?

    The ability to do "what if" scenarios, parametric runs. Bringing in equipment performance information. The use of specific equipment performance data and a good visual interface will improve consistency.

14. Where do you plan to take the program in the next phases?

    The '99 program will develop a visual interface. It will pay for beta testing of the product. We currently plan to do closely controlled beta testing and pay companies to give us feedback.

15. Contact lists? For Designers? For Decision makers?

    Just send me an email list of the information you want and I will give you what I have.

Other Comments:

- *Anecdotal experience seems to be the normal basis for design in the refrigeration industry.*
- *EPRI has a supermarket refrigeration tool available. They readily acknowledge that it is not as detailed as the one we are developing. There are also other component oriented tools available.*
- *It takes a top down directive in the organization to make energy efficiency a priority.*
- *When asked what it would take to change the market so that energy efficiency was a priority in general: social pressures, a pressure that makes "green" important; and an increase in energy costs*
- *The market is really nationwide because most supermarket chains are national.*
- *The supermarket refrigeration and HVAC load is said to be equivalent to the commercial sector HVAC load, and it (the commercial sector HVAC load) gets a lot of attention.*

Commercial Refrigeration Simulation Tools Program

Program Manager Interview

Program Background

1. What are the objectives of the Commercial Refrigeration Simulation Tools Program?

   Impact the design community to design more efficient supermarket refrigeration systems.

2. When did the program start?

   The conceptual work started in the second half of 1997, funding began in 1997.

3. How long have you been working on the program? Always in your current capacity?

The whole time. Don Felts and I conceived the program together. The EPRI project influenced the decision to go ahead on the project.

4. Was any research was done prior to starting the program to establish a baseline?

The design practitioner is the right target. We did a baseline study study and in late 1997 we did focus groups.

   To define the need?

   The focus groups were used to confirm the need for the product. Don Felts and Peter Turnbull did the definition of the need.

5. What is your role in the program goals?

   Oversight and guidance of the project. Sort of Program Director.

Program Status

6. Please summarize what was accomplished since the program started.

   Confirmed the need for the tool, developed a prototype tool, have done some training of the beta testers.

7. What is the current status of the project?

   We will restart the program with Keith Foresman's arrival (Keith Foresman will take over the day-to-day management of the project from April 15, 1999, since Don Felts has left the company)

   Of the tool?

   Refinement of the tool is needed

8. What is the target market for the design tool?

Supermarket refrigeration designer

9. How do they plan to market it?

The project involves an advisory group. We will use the advisory group to guide the outreach effort. (PW will try to get us a copy of the project plan).

Potential Barriers to Use of Design Tool

10. What keeps designers from designing energy efficient refrigeration systems?

	Comments
☒ Information & Search Costs	Designers currently have no way to knowing which refrigeration system is more efficient.
☒ Performance Uncertainty	Too large a problem to figure out. Takes a long time to figure out.
❑ Asymmetric Information	No
☒ Hassle or Transaction Cost	Would possibly be but they cant get past the information & search cost barrier.
❑ Hidden Costs	
❑ Access to Financing	
❑ Bounded Rationality	Probably not, they have to know what the savings are to make a irrational decision. Right now they don't know.
☒ Organization Practices/Customs	Marketing of food products always takes first priority. Use rules of thumb a lot.
❑ Misplaced or Split Incentives	
☒ Product/Service Unavailability	Currently no product that can simulate, so the product is unavailable. Some other tools are available but he didn't think they were as ambitious as this tool.
❑ Externalities or Non Externality Pricing	
❑ Inseparability of Product Features	
❑ Irreversibility	

Potential Barriers to Implementation of Efficient Designs

11. What keeps decision-makers from implementing energy efficient refrigeration systems?

	Comments
☒ Information & Search Costs	Not enough information to allow selection of an efficient system. Can get components

	that save energy but not at the system level.
☒ Performance Uncertainty	
☐ Asymmetric Information	No
☐ Hassle or Transaction Cost	
☒ Hidden Costs	
☐ Access to Financing	Don't know.
☐ Bounded Rationality	
☐ Organization Practices/Customs	Rules of thumb, what worked in the past, and reliability are all key.
☒ Misplaced or Split Incentives	Probably exists in some of the organizations.
☒ Product/Service Unavailability	Not enough information to find the right equipment.
☐ Externalities or Non Externality Pricing	
☐ Inseparability of Product Features	
☐ Irreversibility	

12. What are the key features of the tool that you believe will make it a success with designers?

    Giving them the ability to predict energy consumption credibly. Some indication that they want it.

13. What are the features which will help to get the energy efficient systems installed?

    The ability to compare systems.

    In response to a question about how the tool will be made credible in the eyes of the customer: Tool will need to be verified. Don't know yet how they are going to convince the customer that the tool is credible

14. Where do you plan to take the program in the next phases?

    Will probably require development of user interface, but that is up to Keith.

15. Contact lists? For Designers? For Decision-makers?

    Most of the information needs to come from Doug Scott

Commercial Refrigeration Simulation Tools Program

Project Simulation Designer Interview

Program Background

1. What are the objectives of the Commercial Refrigeration Simulation Tools Program?

   Produce software that was comprehensive, reliable, able to be used in decision making. Include a wide variety of common practices.

2. How long have you been working on the program? Always in your current capacity?

   PG&E approached him regarding work on a tool. He presented information on what a tool could do. He has always been in the current capacity of developing the tool through technical services contract. Has been creating algorithms for the refrigeration tool.

3. What is your role in the program goals?

   Creation of the tool. So far it has only been the creation of the calculation engine. PG&E was not interested in creation of the interface last year.

Program Status

4. Please summarize what was accomplished since the program started.

   Beta version of the tool.

5. What is the current status of the tool?

   The beta version has been put out and they are waiting for further funding The current tool does not interact with the HVAC system.

6. What is the target market for the design tool?

   Manufacturers (those who push one thing or another) – consultants for specification review or design – chains may use once made easier – utilities (regulated and unregulated sides) may use to provide energy services to customers – ESCO's

Tool Properties

7. What are the strengths and weaknesses of the current simulation tool?

   Strengths – breadth of fundamental capabilities that are there, can build any configuration you want, flexibility.

   Weakness – complexity of the tool (goes hand in hand with flexibility)

8. What are outputs from the tool?

Annual, monthly predicted costs and fuel usage

Hourly (or sub-hour) energy use, from whole building down to refrigerant flows, and anything in between

Although DOE2 has the ability to handle inputs to create financial information (such as life cycle cost) the tool does not provide default information and so the user must input their own information (which he says is not trivial to obtain). The libraries do not include first cost or maintenance costs, so the life cycle costs cannot be computed without input from the user.

9. How long do you think it will take to input a standard supermarket using the current libraries?

   In the beta version, you need a design and a list of equipment first – if familiar with both design and DOE2, should take about 4 hours to input the data and a day or two more to tune it so that it reflects the performance of the actual building. If the project creates an interface as Jeff envisions, could be much less time to input (maybe around 10-15 minutes), although it will still needs the same time to tune the model.

10. How do you see the tool being operated? (i.e., by whom)

    See Question 6

11. Is the programming complete?

    No – he is working on the tool for other clients as well as PG&E. The portion contracted for last year by PG&E is completed, however, the tool needs ongoing work (e.g., the air cooled condenser module needs work). Getting the right options into the tool for refrigeration is needed.

    The focus was on creating the refrigeration module last year, but they still need to put in the interactions– need to merge the refrigeration version of DOE2 with the HVAC version – he is now working on this with other funding and will use PG&E funding to complete this.

    This year wants to get a completed public version with interface done.

Appendix E
Detailed Potential Savings Calculations

Determing Potential Savings for California Refrigeration

39	trillion Btu refrigeration in California		
2.4	6%	Low end potential savings	
3.9	10%	High end potential savings	
	10,867	Btu/kWh	Conversion efficiency from Westphalen, p. 3.347
	1,000,000,000,000	1 trillion	

217,917,870	Low end savings kWh
358,884,697	High end savings kWh

Taking Quantum Percent of new store installations into account (using exhibit 4-5) - assuming already doing these practices at percents shown

70%	Floating Heat Pressure
90%	PSC Motors - Assuming PSC motors provide similar efficiency as ECM motors for purposes of this estimate only
35%	Antisweat Heaters

Westphalen Potential Savings*		Estimated Savings using QC installed values	Estimated Savings using penetration estimates
ECM Evap Motor Fans (used same as PSC motors)	26	2.6	2.5
Hot Gas Defrost	3	3	2.1
Liquid-Suction HX	4	4	2.8
Antisweat Heat Control	5	3.3	2.3
Evap Condenser	6	6	4.2
Floating Head Pressure	5	1.5	1.1
Heat Reclaim	4	4	2.8
Mechanical Subcooling	3	3	2.1
Total	56	27.4	19.8
Total Refrigeration in Supermarkets	326	326	326
Potential Savings	17%	8%	6%

70% Penetration for all but PSC
95% Penetration for PSC

*Westphalen Potential Savings assume 100% penetration of a technology - this is not feasible
Therefore, use a penetration of 70% for all measures except PSC (ECM) motors to provide an estimate
For PSC motors, use 95% penetration since already being used 90% of the time.
PSC = Permanently Split Capacitor Motors
ECM = Electonically Commutated Motors