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Transforming Routine Air Conditioner Maintenance Practices to Improve Equipment Efficiency and Performance

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Transforming Routine Air Conditioner Maintenance Practices to Improve Equipment Efficiency and Performance

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ABSTRACT

Air conditioners and heat pumps perform far below their designed efficiency and capacity largely because routine HVAC service practices do not address two parameters critical to equipment performance: low airflow and incorrect refrigerant charge. This pilot project, funded by the California Board for Energy Efficiency, sought to correct inadequate air conditioner service and installation procedures and to transform the market so that contractors and homeowners would want to use the improved technique. Researchers evaluated the use and acceptance of a computer expert system designed to ensure that technicians properly test airflow and refrigerant charge. They also assessed the potential of consumer education, classroom and on-site technician training, and mass marketing to transform the market. More than 50 technicians, employed by 10 contractors, were trained in the use and promotion of the computerized system. Through surveys and focus groups, researchers identified factors that would motivate consumers, HVAC contractors, and technicians to accept the approach; barriers to market acceptance; and the most promising points of intervention. Researchers found that use of the computer expert system, in combination with training, education, and contractor support, can transform the air conditioner service market. However, contractors will not adopt the approach unless they are convinced that the method will affirm the customer's trust in the technician. Scheduling consumer education and marketing campaigns to coincide with seasonal equipment maintenance procedures is critical to success. If the intervention does not take place very early in the season, the opportunity is missed for another year.

Introduction

In 1998, Proctor Engineering Group (PEG) proposed a third party pilot program to Pacific Gas and Electric Company (PG&E) and the California Board for Energy Efficiency (CBEE) to investigate the potential to transform consumer equipment service practices in the residential air conditioner market. A key feature of the project was a computer expert system (CES) for central air conditioning that was designed to ensure that airflow across the inside coil and refrigerant charge are properly tested and to promote customer education on the critical essence of a good check-up.

Both airflow and refrigerant charge have substantial impact on equipment efficiency and capacity but the two factors are not adequately addressed during "normal practice" air conditioner installation or tune-up procedures. The adverse effect of this is that the average performance of residential air conditioners is at least 17% below design performance. This is equivalent to a 12 SEER air conditioner operating at 10 SEER.

The problems are significant and widespread. National studies compiled by Vermont Energy Investment Corporation (Neme, Proctor & Nadel 1999) have found efficiency is adversely affected if

the refrigerant charge is incorrect by more than 5%, and this problem exists in more than 60% of residential air conditioners studied. Low air flow, defined as less than 350 cfm per ton, is a problem for more than 70% of residential air conditioners studied. Correcting these conditions can produce between 12% and 31% in energy savings.

In one of the earliest reports in this area, a 1987 field study of residential air conditioners indicated that with standard installation and maintenance, the average air conditioner efficiency had degraded significantly. It estimated a lost efficiency in the order of 30% to 40%. (Neal 1988).

As a result of the Neal report, PEG developed an Appliance Doctor program designed to recover the lost efficiency through training, quality assurance, customer education, and system development. From 1989 to 1992, four separate studies were conducted on more than 1300 air conditioning customers in California (Jacobson, Proctor & Polak 1992; Kinert et al. 1992; Proctor et al. 1990; Proctor 1991). Those studies have helped quantify the magnitude and extent of space conditioning problems in California.

These four studies also began to address the barriers to changing the current installation and service practice. In these studies it was concluded that an effective change depended upon an economic incentive, a system to perform the tasks efficiently and properly, training, feedback on performance, and a method of holding everyone to the system. These studies investigated: training on efficient step by step procedures, review of results, feedback, and inspections; as well as economic incentives. One of the primary problems associated with the system tested in these studies was the requirement of a human expert review of every unit's numeric results. This was too time consuming and expensive to be practical. Considering this problem, PEG developed a computer expert system which nearly eliminated the need for the human expert and reduced the turn-around time on technician feedback to a matter of seconds.

The pervasiveness of charge and airflow problems creates substantial opportunity for market transformation within the air conditioning service and maintenance market. The saturation of central air conditioners has been increasing in all regions of the country. In 1993 over 44% of the occupied housing units had central air conditioning (ARI 1996). Approximately 25% of those air conditioners are serviced every year. Yet typical service does not include checking refrigerant charge and airflow according to the manufactures' specified methods.

Market Transformation

An industry achieves market transformation by intervening in the market to stimulate a change. The transformation is considered successful when the effects of the intervention remain in place after the stimulus is removed. Cooperative efforts involving all market players—contractors and customers—can be a cost-effective way to reduce barriers to market acceptance of new practices or procedures.

In the energy efficiency sector, market transformation is used to remove barriers to cost effective, energy efficiency measures that are currently not in demand or routinely implemented in the marketplace. Once the benefits of the energy efficiency measures are seen, the measures will remain in place based on their own merit.

Market barriers to adoption of energy efficient practices include a lack of information, a lack of trained technicians, and a lack of uniform demand for the service, to name a few.

Transformation of the Air Conditioning Service Market

There is an opportunity to introduce manufacturers' specified refrigerant charge and airflow tests to the air conditioning system service market, and to create a demand for use of those procedures. This change can be sustainable if the technician and contractor can overcome the following barriers: lack of practice in the technique (technician resistance); uncertainty about how the customer will respond to the change in service (will the customer notice, will this reduce call-backs, will this increase customer loyalty); as well as a contractor assumption that the procedure will take more time, increase costs, and reduce demand.

Homeowners are unaware that efficiency can be improved and they have no way of determining whether their air conditioners are operating efficiently. They can only tell if the equipment cools the home. Once customers realize the increased equipment performance and efficiency benefits to be gained from a proper tune-up, they need reliable mechanisms to differentiate between effective and inferior service and to locate contractors that will perform the needed work effectively. Such a change will be sustainable if the mechanism creates customer trust in the contractor.

Utilities, manufacturers, and government agencies could help promote effective tune-ups through the support of reliable mechanisms.

The Pilot Program

This pilot program was designed to transform the interaction at the point of an air conditioner tune-up, which is usually conducted in the spring. Using marketing, training, and incentives, the program brings the contractors, technicians, and customers past their initial barriers (such as costs and outcome uncertainties) to market acceptance. Implementing an air conditioner tune-up that meets the manufacturers' standards produces positive benefits to the contractors and satisfaction of the customers' need for a properly performing air conditioner.

A pilot project to promote market acceptance of a proper AC check-up was conducted from May through September 1998 in Fresno and Clovis, California. These adjoining cities represent one of Northern California's largest cooling markets, with nearly 90,000 households that have significant air conditioner use.

The primary target for the pilot test was customers who were anticipated to have an air conditioner tune-up in the spring of 1998. This represented about 20,000 customers in the Fresno and Clovis areas. The secondary target included those customers who were not planning on an air conditioner check-up but who might request service in response to the program. This is the remaining 70,000 AC customers.

Program Goals and Objectives

The goal of the program was to test a market intervention in the contractor/customer interchange during the annual air conditioner tune-up process.

The ultimate goal is to cause market transformation by 1) demonstrating to the contractors that they can make a greater profit by providing superior service and; 2) demonstrating to the customer that they can be confident their air conditioner is performing properly.

The project objectives were to:

- Demonstrate the ease of use and effectiveness of the program.
- Permanently transform the services provided by contractors.
- Motivate contractors to conform with manufacturers' installation and service recommendations.
- Increase consumer demand for effective service work.

The program was designed to transform the market by:

- Providing an intermediary (third party) to enable the desired change in the standard air conditioner installation and service practice;
- Supplying the market transformation tool (software and support) to both the contractor and the consumer
- Educating consumers so that they want the improved level of service and expect it from their contractors;
- Supplying a means for the consumer to determine if they are receiving quality service;
- Providing a means for contractors to use the tool to differentiate themselves from the competition;
- Increasing participating contractors' market share through increased consumer knowledge

Pilot Program Components

The program had four components: (1) the CES software program; (2) contractor and technician recruitment and training; (3) program marketing to residential air conditioning customers; and (4) toll free telephone support.

1. The CES System

The CES is a computer expert system that enhances the air conditioner tune-up process. It is used by the service technician during the service visit. It can also be used independently by the customer, as a means of evaluating the quality of service received. The program can be obtained on floppy disc, or accessed by toll free telephone service.

The tested CES is a proprietary Windows-based program that runs on any personal computer that has a 486 or higher CPU. The program uses information and input screens to guide the user through the service, repair, or maintenance visit. Data input to the program include customer information, contractor and service technician identification, and air conditioner operating parameters (including coil entering and exiting temperatures as well as appropriate refrigerant pressures and temperatures). Based on the data inputs, the system assesses air conditioner performance in accordance with the manufacturer's recommended airflow and charge specifications. The CES output includes an analysis of refrigerant charge and airflow, recommended efficiency measures that should be taken to optimize equipment performance, and additional customer education information.

2. Contractor Recruitment and Technician Training

One of the first tasks in the program was to recruit contractors. A concerted effort was made to include as many contractors as possible to achieve the greatest exposure and impact on the local air conditioning market. Recruitment activities included identifying contractors through Internet and yellow page searches; inviting participation through letters, phone calls, and personal visits to company

principals; and securing written agreements from contractors concerning licensing, insurance, program performance, etc. Six training sessions were conducted during May 1998. Training was held in a classroom setting.

The technicians were shown the proper techniques for testing refrigerant charge specific to manufacturers' recommendations for different refrigerant metering devices. The technicians were also shown the proper techniques for assessing airflow. The training covered program policies and procedures, use and purpose of the CES computer program, contractor and technician incentives, and how to interact with the customer to gain their support.

Each technician was given a written examination at the end of the training. Written feedback was mailed to each technician on any questions that were answered incorrectly.

PEG also provided ride-along and post-service inspections of the service technicians' work in order to supply feedback to the technicians on the quality of the work performed and the accuracy of the data they reported. The inspection process also allowed PEG to gather customer feedback about the effectiveness of the program, the contractors' performance, and program implementation.

3. Marketing to the Residential Air Conditioning Segment

Proctor Engineering Group employed a professional marketing firm to develop and implement the marketing campaign. Marketing activities included: direct mail advertising to 80,000 households; a second mailing (software and instructions) to 15,000 households with the highest assessed value homes; telephone follow-up to the software mailing; as well as feature and news stories in print, radio, and television media.

From May through September, media coverage was obtained in three of the four television affiliates in the Fresno area, both major newspapers, and in two of the four news radio stations.

4. Toll Free Telephone Support

Proctor Engineering Group established and maintained telephone support for both the customers and the trained technicians through two toll free numbers. The consumers' phone line was staffed during normal business hours with people who provided information about the program, made referrals, and ran the CES for consumers. The technicians' phone line was staffed with technical experts during business hours, and backed up by pager service during non-business hours.

The phone support enabled customers to learn more about the program, get a referral to a participating contractor, or have the data gathered by the service technician run through the software for confirmation of the technician's findings. The contractor and service technicians also used the telephone support for both technical assistance and obtaining CES run results while on site.

Market Players

The program targeted four primary players in the air conditioning service process: (1) contractors; (2) service technicians; (3) customers who regularly get their air conditioners serviced; and (4) customers who do not normally get their air conditioners serviced.

1. Contractors

The contractors are, first of all, interested in the economic viability of their businesses. Market share, revenue per transaction, and profit are their primary motivations. The service call or annual tune-up provides them with the opportunity to achieve an advantage over their competition. In general, service calls and annual tune-ups are not profit makers. However, the annual tune-up is a way for the contractor to maintain contact with their customer base and give their employees work during periods of low demand. The bulk of the contractors' profits comes from selling replacement parts and from selling a replacement air conditioner when the current unit fails. The system works as it is for the successful contractor. In the absence of a market disruption, they see no need to change it.

2. Service Technicians

It was obvious in the training that many technicians were sold on the program and thought it was of value. However, several stated that they thought the program was only viable during the spring tune-up season. Their feeling was that it would be hard to implement the program under the pressure of having several "no cool" calls waiting for their arrival.

Some technicians privately expressed concern about what would happen when the manufacturers' specified charge tests were used along with the appropriate airflow checking technique on systems that their company had installed or previously serviced. Many thought that their old systems would show problems. The most sufficient answer generated was that the software was a new tool never before used on residential systems in Fresno.

3. Customers That Regularly Get Their Air Conditioners Serviced

Those customers that participated did so, for the most part, as a direct result of being informed of the program by the service technician. The telephone follow up indicated that most customers who have annual service had already had it done by the time of the second mailing.

4. Customers That Do Not Regularly Get Their Air Conditioners Serviced

Customers that do not get annual tune-ups were generally not influenced by the media campaign. However, service technicians were often successful with this group of customers. Once the service technician was at their house on a repair call, it was easy for them to persuade the customer to participate in the program.

Market Transformation Results

Two methods were used to evaluate market transformation effects: focus groups and surveys.

Focus Groups

Four focus group sessions were conducted. Two were conducted before the program was introduced and two were conducted at the end of the program. The focus groups were divided into consumers (the consumer group) and contractors/technicians (the contractor group).

Surveys

Proctor Engineering Group conducted a telephone survey during June 1998. The survey attempted to contact the 53 identified AC contractors in the Fresno and Clovis area. Twenty-nine of the contractors (55%) were reached. Twenty-five contractors (47%) could not be reached after repeated attempts. Of the 29 contractors contacted, 20 agreed to participate in the survey.

The survey found that these contractors reported a total of 17,700 checkups a year and (when their estimates were combined) represented 118% of the residential market. Thirty percent of their residential business is tune-ups.

A follow-up telephone survey, of the 55 contractors who had been approached in the spring to participate in the program, was conducted from September 11-22. Of the 55 contractors, seven were either under the ownership of another contractor or had gone bankrupt. Eighteen of the remaining 48 contractors (38%) were successfully contacted by phone.

Observed Changes in Market Effects

There were a number market effects hypothesized for this program. These observations are based primarily on the post-program focus groups supplemented by the survey results.

Primary Hypothesis -- The program will result in improved diagnosis and repair of charge and air flow. Primary among the market effects is a hypothesized change in how tune-ups are done with the software as opposed to the "common method". There is good evidence to support that this project changed how participating technicians checked and tuned the air conditioner. It was evident in the technician focus group that participating technicians changed their behavior. The following are some examples from technicians:

"I was surprised to find charge wrong on units I have serviced over the years. I even have found 8 ounces overcharge on brand new units."

"I did it for education. I loved it. I don't see anyone really checking charge right, most technicians only do a touch method."

"Most of those units are overcharged new --- 8 out of 10 are overcharged."

"If you do it every time you have covered the bases. It has opened a whole new thing for me."

"You learn how to be more precise."

These changes were also observed on the ride-along inspections of technicians work. These changes are beginning to be institutionalized. It was observed that the technicians had new test equipment to properly check charge and air flow.

Sustainability. The primary question is whether these changes will be long term. There is some evidence that they have long term potential. Some examples from technicians and contractors:

Service Manager: "We are going to take this on no matter who is promoting it. It is our responsibility to do the job correctly."

Technician: "I don't want to say it is fun exactly, but it is the right way to do it. I am going to

do it on every one.”

Technician: “In all actuality it will make you money - call the numbers in and you will make a sale (selling the actual repairs to the unit).”

Technician: “I am really trying to get all the technicians to do it.”

Technician: “CheckMe!™ is accurate and we don’t have any call backs.”

Technician: “If you do the CheckMe!™; the on the spot second opinion makes it so you pretty much have the sale on the repairs.”

Service Manager: “It’s a great tool that will help us. It is something that should be done by everyone, no matter what.”

In addition, one major contractor made institutional changes that to sustain the switch to proper diagnostic procedures. That contractor added the measurements to their service sheet.

While the focus group responses and contractor actions show both attitudes and motivations that could lead to long term adoption of an improved tune-up, they certainly do not prove that such a transformation has taken place. It is Proctor Engineering Group’s opinion that without at least one full year of implementation there will not be enough local experience to sustain the change.

Contractor: “It needs to be a year or more.”

Contractor: “It should be a three or four year program”

Hypothesis -- Reduced Market Barrier - “it takes too long”. One major barrier to adoption of the improved system is that technicians and contractors perceive that a proper diagnosis will take too long. The sustainability at the contractor level is dependent on how many technicians and contractors get over their initial fears. It was clear that the time perception barrier can be overcome. At the final focus group, the technicians and contractors were at different stages of adopting the proper diagnostic process. The responses showed a cross-section of the technician population at various stages of transformation. The technicians with the least experience with the system still thought it added significant time to the job. The technicians with more experience were both faster and had found how to sell the additional repair time suggested by the diagnosis. On the other hand, the service manager with 36 uses has not yet integrated it into his system.

Technician #1 (60 uses with the system)

“It was a lot easier than it sounded.”

“The only additional time I see is just the telephone call.”

“In all actuality it will make you money - call the numbers in and you will make a sale (selling the actual repairs to the unit).”

Technician #2 (52 addresses)

“It was a simple procedure.”

“If you do the CheckMe!™; the on the spot second opinion makes it so you pretty much have the sale on the repairs.”

Technician #3 (36 addresses) (Service Manager)

“If you have no problems CheckMe!™ takes 20 minutes - realistically 30 minutes.”

Hypothesis -- Reduced Market Barrier - “there is no benefit”. It was hypothesized that experience with the program would show the contractors that there was benefit (revenue potential, cost reduction, and hassle reduction) in adopting the process.

The sustainability is dependent on the contractors' perception of a benefit to using the system. The contractors with the most CheckMe!™ runs have expressed new appreciation for the process and found tangible benefits. Comments from the final focus group confirm this:

Contractor: “It bailed us out on a couple of jobs where we were battling with equipment (and the customer). CheckMe!™ backed me up 100%. Having an independent party do that is great.”

Contractor: “CheckMe!™ has generated more revenue for me.”

Contractor: “With the system our younger technicians can get right in there and do a good job. That is a real advantage.”

Contractor: “We haven’t had any callbacks on CheckMe!™ jobs.”

Contractor: “It is the right way to do any service.”

Service Manager: “You can show pass or fail; it will give you credibility.”

Service Manager: “On the job today it reaffirmed that we are a legitimate contractor”

Hypothesis -- Target and Timing -- Customers who get annual tune-ups. It was hypothesized that the primary target for the project should be customers who get annual checkups. Timing is extremely important in this market interaction. Contractors do their initial checkups (also called preventative maintenance or PM) early in the year. This avoids the rush period when it is hot and repairs are the only focus. Early in the year, contractors who want to distinguish themselves are willing to try a new process with their regular customers. In that time, the time and effort (“information costs”) of finding out how this will really work are reasonable. In the early period, they also have the opportunity to institute new organizational practices, spend time on training, and observe the results. This project missed that opportunity. In spite of that a number of the contractors are still interested in pursuing this project further.

Service Manager: “We could have done a lot more if it were done earlier.”

Contractor: “It would have been real nice during the spring, but they brought it in during the repair season. It is a service, it needs to be in the service season.”

Contractor: “March, April, May should be when the program is running.”

Contractor: “It needs to happen year round.”

Hypothesis -- Reduced Market Barrier -- “media campaign will increase overall demand”. A secondary target was customers who do not usually have their air conditioners serviced every year. It was hypothesized that a media blitz would induce individuals to have their air conditioners checked.

There are indications in the focus group that the media blitz was noticed and raised questions for some consumers, for example:

Technician: I did one today where the customer got the literature and I was going out to do a heater call. He says: You know, I got this thing. What is that?...He was all excited about it. So he got the information but never decided to act upon it.

When the Focus Group Moderator asked: "Did any of your regular customers ask you about the Check Me service?" five respondents answered affirmatively.

The participant data base showed some responses that indicated that the contractor was chosen because they were a CheckMe!TM contractor. Nevertheless the increase in checkups due to the media campaign appears to be minimal. The focus group contractors saw no particular advantage to referrals as bringing them new business.

"I don't see much value in the referrals that they would give us or ever will give us. I place pretty much zero value in that."

"I did not do one referral and I kind of know why. I don't run the office but they couldn't get hold of the referrals. So they just gave up."

There is no known evidence that the total number of checkups in Fresno increased significantly over this summer.

Hypothesis -- "customers will use the toll free number to obtain information on how their AC is running". The toll free phone access to a human interface with the computer program was originally envisioned as a backup. It was considered secondary to use on the customer's or the technician's PC at the site. This method ended up being the primary method of use and it drew an appreciative response.

"You say: 'If you like, I can call these numbers in for you right now and you can find out in sixty seconds or less if your air conditioner is in top shape.' And they are eager to know. They say 'Oh 60 seconds,' you know, they're bringing you the phone! They want to know right now before you leave if everything is running in top shape."

"I like to go back where the customer was. I'd say, well you call, it's your house, it's your phone, call in, it's your unit. They would call. They were instantly involved in the call. They paid more attention right away."

The data support that the toll free call is a viable method of operation.

Hypothesis -- "enthusiastic technicians will sell the improved service to their customers". It was hypothesized that technicians would be an important avenue of selling the improved service. Almost without exception, the CheckMe!TM runs that were done were sold to the customer by an enthusiastic technician. Technicians found it very effective in getting the equipment to perform properly for two reasons: first, they could diagnose problems that had previously slipped by them, and second, they found that the necessary repairs were easier to sell if the computerized diagnostic was used.

Hypothesis -- "offering the software for free will increase participation". Offering the software for free and the phoned in reports for free was expected to increase participation in the program. The data do not support that hypothesis. In fact the free offer confused customers who thought that the entire checkup would be free. It was a mistake to tout free in the literature.

Hypothesis -- "flooding the market place with software will result in use by individual homeowners on their PCs". This hypothesis, known colloquially as the "AOL Model", was one of the

marketing methods in the project. Very few individuals used the software on their home PCs. The data do not support this hypothesis.

Hypothesis -- “building trust between the technician and the customer is key to market implementation”. Trust is the cornerstone of a positive interaction between the contractor and the consumer. For contractors who used the system the most, performance uncertainties associated with trust were reduced or eliminated. Customers responded favorably to the new service. Simultaneously the consumer was more comfortable with the interchange because the contractor was using this high tech independent third party method of getting the air conditioner tuned properly. While many customers did not understand the technical side of the checkup, they liked the additional information and openness of the technician in providing the information. The benefits of a proper tune-up were no longer hidden. The process reduced the barrier of asymmetric information. Focus group comments:

Technician: The customer loved having a third party second opinion immediately available to them.

Technician: First time customers love it.

Contractor: Regular customers asked me about the CheckMe!TM service.

Technician: People liked it because it was a computer and people believe computers.

Technician: I would much rather be dealing with my own customers because we have a relationship that is developed. We know them, they know us. Because they have called us back, they already have trust in us and faith in us, and I think it is a great tool that we could use to improve.

Key Findings and Observations

The program demonstrated some workable solutions to current residential AC problems. At the same time, it revealed ineffective methods and tactics that should be modified in future programs.

- The computer program, in combination with training, education, and contractor support can result in a sustainable transformation of the air conditioner service market.
- The keystone to the interaction between the service technician and the consumer is trust. Any project targeted at this interaction must build the consumer’s trust in the technician. Otherwise, it will be rejected by the contractor.
- The program successfully reintroduced the manufacturers' specified refrigerant and airflow tests to the service technicians and got them to use these diagnostic procedures.
- Program timing is critical in gaining both contractor and consumer buy-in for the program. The program must be launched in time to intervene in the seasonal tune-up cycle (February to April).
- The “America On-line model” of sending the software to all households was not successful in stimulating customer participation.
- The toll free telephone support was widely accepted by both service technicians and customers.
- While many customers did not understand the technical side of the checkup, they liked the additional information and openness of the technician in providing the information. The benefits of a proper tune-up were no longer hidden.
- A significant number of high volume residential HVAC contractors are interested in the program.

These contractors see benefits of reduced call-backs, improved technician performance, reduced training failures, help with difficult customers, higher sales, and reinforcement of their legitimacy.

- The service technician was the key to selling the improved checkup. They were the most effective sales method.
- Targeting by higher assessed home value was highly successful in finding customers who regularly have air conditioner checkups.
- The success of the program depends on the commitment of local contractors to communicate the availability of the program to their customers. Increasing the supply (i.e. the number of participating contractors) of the product is the most effective way to achieve the program goals, increase profitability for the participating contractors, and improve residential AC service.

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SYNOPSIS

HVAC service does not properly address airflow and refrigerant charge. The use and acceptance of a computer expert system to transform this practice is described.