A Business-Venture Approach to Premium O&M Service for Commercial Packaged HVAC Systems

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ABSTRACT

Many commercial buildings are served by "packaged" units that combine heating, ventilating, and air-conditioning (HVAC). These systems, also known as “rooftop units” (RTUs), are often oversized, and can deliver cooling and heating necessary for comfort even with significant energy efficiency degradation. As a result, these systems typically receive little or no attention until they fail altogether.

Current maintenance contracts for smaller commercial buildings focus on routine maintenance, such as filter replacement, while the functional efficiency of systems is ignored. However, new diagnostic tools and protocols have recently become available that are much less expensive to deploy. Coupled with technician training and effective marketing, these advances could make energy-efficiency optimization of RTUs a cost-effective proposition for HVAC service providers.

The Northwest Energy Efficiency Alliance (Alliance) is undertaking a pilot project to test the presence of three market conditions necessary to support a regional market transformation effort:

1. A significant opportunity to improve the efficiency of packaged units
2. HVAC service providers with an interest in "up-selling" additional services to existing maintenance service contract customers
3. New diagnostic tools that reduce service costs and provide customers with both energy and non-energy benefits

Key elements of the pilot project include review and development of diagnostic tools, technical training, sales training, and marketing assistance. The program will seek to establish a viable market for RTU efficiency optimization as a new component of existing maintenance services.

The pilot project was launched in January 2002 with final results expected by October 2002. This paper presents preliminary findings.

Introduction

Historically, small commercial buildings[1] have been an extremely difficult sector to reach with utility-based energy efficiency programs. The most successful programs have

[1] Small refers primarily to buildings served by unitary air-conditioning systems of 15 tons and less. This covers the majority of strip malls, fast-food restaurants, and small office buildings, regardless of floorspace.

focused on direct install lighting retrofits. Very few, if any, have successfully delivered efficiency improvements to the heating, ventilating and air conditioning (HVAC) systems, despite the fact that research shows some potential for energy savings. (Lunneberg, 1999; Proctor, 1999)

Although about half of these packaged rooftop units (RTUs) are covered by some kind of service contract (Houghton 1997), such contracts provide minimum services such as filter changes, with little effort to minimize energy use. There have been several efforts recently that have resulted in the development of new tools to simplify the process of diagnosing energy efficiency problems in RTUs. These tools could be used to help define an enhanced maintenance service for existing RTUs.

The Alliance believes that a market transformation effort can be created based on an enhanced service. The service providers would be enlisted to market the enhanced service to their customers, based on such benefits as comfort, indoor air-quality, and fewer emergency replacements. The Alliance has launched a pilot effort to define an enhanced O&M service for existing RTUs, develop a marketing strategy, validate savings, and then test the market acceptance of this on the part of the service providers and their customers.

Preliminary Research

Prior to launching the pilot program, the Alliance investigated six programs to incorporate their experience and lessons learned into the pilot design. The programs were sponsored by the following entities:

- California Energy Commission
- San Diego Gas & Electric, San Diego (SDG&E), CA
- Eugene Water and Electric Board (EWEB), Eugene, Oregon
- Avista, Spokane, Washington
- Puget Sound Energy (PSE), Seattle, Washington
- Clark Public Utilities (CPU), Vancouver, Washington

One of the most significant findings of the program review is that the majority of RTUs display some form of inefficiency, ranging from an improper refrigerant charge to a non-functioning economizer. The contractor for the CPU program reported that only two of 54 units tested were operating properly (Rose 2002). The majority of the units have a potential for substantial energy savings through efficient tuning. However, the programs also demonstrated challenges. The following barriers emerged:

- A successful program must build on existing relationships between service providers and their customers.
- Field training for providers is essential to ensure quality control and boost the level of service.
- In addition to technical field training, providers can benefit from sales and marketing training.
- The small building owners are a tough sell, and the program must give the providers the tools to present a credible product, and demonstrate the value of their services.

- Technical protocols are complex, and no program to date has worked out a comprehensive tool or service that address all problems.

This pilot project seeks to address these market barriers and challenges through developing protocols for the technical service and marketing materials for service providers to use with building owners. Although many service providers work on RTUs and claim a high level of expertise very few have the technical knowledge to finely tune all of the different types that exist.

Pilot Project Overview

The Alliance is undertaking a pilot project to test the feasibility of a self-sustaining business venture to improve the energy efficiency of packaged RTUs. The pilot project will build on the lessons of previous programs. It will attempt to not only achieve short-term energy savings, but also catalyze a market transformation that will change the expectations and delivery of maintenance. This should achieve persistent energy savings with lower costs to customers and higher revenue to service providers.

The Alliance pilot project will subsidize the initial cost to launch the business venture, including the production of marketing materials to convey the benefits of energy optimization services. Once the resources are developed, the full-scale program has the potential to become self-supporting in the market.

The pilot project will include the following segments, which are described more fully in the following sections:

- Tools & Protocols
- Energy Savings Methodology
- Marketing Strategy
- Field Tests

Tools & Protocols

The Alliance conducted a comprehensive investigation of existing tools and protocols for efficient RTU maintenance. The Alliance will recommend a tool or combination of tools to be used in the pilot project, develop a customized protocol for service providers, and will develop and deliver training materials. A ten-building field test will focus on developing an effective economizer protocol to guide the identification and repair of economizer problems.

This new maintenance service is intended to complement the existing regular maintenance, not replace it. In the investigation and development of maintenance protocols and diagnostic tools, there are four key areas that present the greatest savings opportunities:

- Refrigerant charge
- Airflow
- Coil Cleaning
- Economizers

Tools Reviewed

Current information on diagnostic tools and economizer protocols were reviewed. This effort involved a literature search and interviews with tool developers. Listed below are the tools that were reviewed:

- CheckMe!
- ACRx Handtool
- Performance Assessment Tool
- True Flow™ flow meters

Two tools available commercially diagnose efficiency problems for the refrigeration system: CheckMe! and ACRx. The Energy Conservatory's TrueFlow™ flow plates are a measurement tool used to directly measure air flow in air conditioning units. The fourth tool, which is not commercialized, PG&E's Performance Assessment Tool (PAT), uses data loggers to assess air-side performance. The following paragraphs highlight the information gathered on each tool.

CheckMe! The CheckMe! software tool was developed by Proctor Engineering Group for residential air conditioners, and entered the small commercial market about five years ago. CheckMe! assesses the performance of the refrigeration system in a single testing visit that takes 10-20 minutes, not including 15 minute warm-up time for the unit or repairs. CheckMe! uses the superheat and subcooling method to check refrigerant charge, and adds a quality control feature that checks the data for validity. If the data does not pass the validity checks, the provider must redo the measurements.

ACRx handtool. The ACRx Handtool assesses the performance of the refrigeration system in a single testing visit that takes less than 20 minutes (beyond the 15-minute RTU warm-up period). The tool has been developed through research at Purdue University and by Field Diagnostic Services, Inc., and has recently been acquired and distributed by Honeywell. The tool consists of the manifold where the measurement interface and diagnostic software resides, the sensors array, and the Palm pilot user interface. The ACRx Handtool connects to a Palm computer that displays data and diagnostic messages. Measurements are saved on the Palm computer and uploaded to the internet for data collection from multiple users.

Performance assessment tool. In 1998, PG&E funded the development of the Performance Assessment Tool for RTUs. As the only tool that utilizes data loggers for diagnostic analysis, this tool assesses economizer operation, outside air fraction, compressor cycling, efficiency benchmarking, nighttime setback, and an estimation of refrigerant charge (using the temperature drop across the evaporator). In a field test, data was collected at one-minute intervals for 3-5 days, and then the PAT software facilitated data analysis. While the energy savings were significant, the tool proved to be too time consuming to be cost effective.

TrueFlow™ flow plates. One alternative to the Carrier method is to measure air flow with The Energy Conservatory's TrueFlow™ flow plate; a calibrated perforated plate. The flow plates must be inserted so that no air can bypass the plate and flow is then determined by

measuring the pressure drop across the plate. A digital pressure gauge is used to measure this pressure difference and the flow is found by applying the plate's discharge coefficient.

Economizer Protocols Reviewed

Economizers, which regulate the amount of fresh outside air incorporated into the system for cooling purposes, are required by local codes in many parts of the Pacific Northwest (Ecotope 2001). Repairing economizers presents the largest opportunity for RTU energy savings in the Northwest. The economizer protocols that were reviewed include:

- EWEB program economizer protocol
- PG&E's RTU Economizer Procedure
- Puget Sound Energy Packaged RTU Protocol
- Draft protocol for California Title 24 performance verification code additions
- PG&E's Commissioning Test Protocol Library general commissioning procedure for economizers
- PECI's Model Commissioning Plan and Guide Specifications

After reviewing the existing protocols, it was determined that a new protocol needs to be developed. The existing RTU protocols do not facilitate problem identification and repair by providers who are not well versed in economizer troubleshooting. Without an economizer protocol, the energy savings will be difficult to achieve. Developing an economizer protocol is challenging because there are a variety of economizer configurations in the field and providers are generally unfamiliar with fixing economizers. Economizer repair procedures may consist of a two-tier approach: repair economizers if possible, and retrofit if the repairs are expected to be too costly.

Criteria for Selection

In selecting a diagnostic tool and developing the recommended protocol, the Alliance will consider the following criteria:

- Time required to complete a diagnosis
- Cost effectiveness (cost of service versus value of benefits)
- Ease of implementation
- Non-energy benefits
- Quality control
- Previous success in the market

The feasibility of implementing tools and protocols depends on the service provider's technical knowledge and the market conditions. Technical knowledge can be enhanced with training, but the level of provider expertise should be kept in mind when selecting tools and protocols. Traditionally service providers work in a market that rewards the low bidder, with great importance placed on reducing service time and selling replacement parts and new equipment. This environment does not support high cost maintenance practices, complex technical protocols or time-intensive training for new tools. The advanced service that the

tools and protocols help provide must differentiate the provider from the low-bid market, yet not result in prohibitively high labor costs. Even if fixing a RTU problem saves a significant amount of energy, if implementation is not practical for the market, then the measure will not be selected.

Non-energy benefits are important in selecting the measures to include in the protocol since they may provide the incentive for the owner to choose this enhanced service, especially in a market where energy costs are low. The tools and protocols should help solve capacity and ventilation problems while increasing overall efficiency. In addition, the tools and protocols should facilitate higher-level maintenance that postpones major breakdowns, results in more reliable space conditioning, and improves comfort.

Quality control measures help ensure good workmanship and satisfied customers. In selecting tools and protocols, the method and cost of implementing quality control measures is important. Since this market has historically been dominated by the low bid, quality control has often been overlooked. Therefore, a quality control system must be built into this program.

Tools & Protocol Recommendation

After careful review and application of the selection criteria, a set of tools and protocols have been identified that will provide a higher-level maintenance service, beyond the current practice of checking basic operation and changing filters. They are described in more detail in the following sections.

Refrigerant Charge

The CheckMe! Tool for assessing refrigerant charge was selected because the tool has sound technical features, excellent quality control and reporting mechanisms, and engineering support for the service providers. The phone calls to the CheckMe! call center facilitate the correction of refrigerant charge and provide engineering support in understanding difficult diagnoses – features that none of the other tools offer. Calling in data from the jobsite and receiving instant feedback is important since providers could sell the repairs at the time the problem is found. In addition, the training that is required to become a certified CheckMe! provider increases the quality of service. The reporting in place for the refrigerant charge assessment could be used to document the as-found and post repair conditions for the entire RTU service. Also, these calls provide an efficient data collection system, eliminating extra paperwork.

Airflow

On most occasions, the Carrier Method is adequate to detect low air flow problems (300-375 CFM/ton) across the evaporator coil and almost all cases of very low flow (<300 CFM/ton). Even if measuring airflow directly is not necessary for assessing low airflow, measuring airflow aids economizer diagnostics and is fundamental for accurate efficiency calculations. Therefore, it was decided that TrueFlow™ flow plates be used to measure air flow for the pilot. Flow plates directly measure outside air fraction during different

economizer mode damper positions to help set minimum outside air for good indoor air quality and energy efficiency.

Coil Cleaning

In current service provider practices, the coils are not generally cleaned, and it is often difficult to determine the amount of fouling from visual inspection. Therefore, before making refrigerant modifications, we recommend that the condenser coils be thoroughly cleaned. Evaporator coils tend to be more protected and therefore less apt to need cleaning. If filters have failed, the evaporator shows build up of dirt, or air flow is low, then evaporator coil cleaning is recommended.

Economizer Protocol Development

Developing a protocol that will help providers diagnose and repair economizers is challenging for several reasons: There are few detailed testing and repair instructions currently available, there are a variety of economizer configurations in the field, and providers are generally unfamiliar with fixing economizers. To help define the protocol, ten buildings will be used to provide the field verification. There are four areas that will be considered for the protocol.

- Damper and actuator mechanical operation
- Control settings
- Control operation (sensors, control board, integration using multi-stage thermostat)
- Percent outside air at minimum and maximum position

After reviewing five economizer protocols, we have identified three options for economizer testing listed below in order of increasing protocol complexity.

1. **Checklist:** Functional testing is guided loosely by a checklist. This option is dependent on the service provider's understanding of economizer functional testing methods.
2. **Limited functional test:** Select a subset of the full functional test procedures that focuses on the most cost-effective measures. This method may not include economizer integration or full sensor calibration.
3. **Full functional test:** Functionally test dampers and controls. This option most fully tests all economizer functions, including minimum outside air, economizer integration, sensor calibration and the changeover or differential setpoint.

Checklists are common for economizer testing, but are not expected to bring about a high rate of repair due to a lack of description to guide testing and repair. A full functional test would make economizer optimization possible, but the effort required for this measure does not fit within provider time constraints. The Alliance is moving forward with option two, the limited functional test, the most feasible testing procedure for this project. The 10-building test will identify measures that are feasible to test and repair for a typical RTU economizer.

Quality control ensures that test protocols are implemented correctly and that repairs result from the testing performed. Quality control for economizer repairs is difficult since repairs can be subjective and difficult for some units. Therefore, quality control may include unit inspection and of tracking key program information.

Controls and Distribution System Protocol Options.

Duct leakage and temperature controls are the remaining RTU problems that should be assessed through the new service. In the ten-building field test, the condition of the RTU cabinet and any easily accessible ducts will be assessed for leaks. Based on these findings, we will determine the costs and benefits of including a limited duct assessment in the protocol. Because the procedures are labor-intensive, we do not recommend duct pressure testing and repairs to internal ductwork.

The protocol will include checking HVAC occupancy and setback schedules. If no schedules are present, it will be important to discuss this with the owner to determine the cause and if schedules can be put into place. In the initial ten building field test, all programmable thermostats will be checked for accurate programming.

Energy Savings Methodology

The Alliance will develop a simple energy savings estimation methodology that can be applied across the Northwest region. The energy savings methodology will help providers to sell the service. It will also allow independent verification of energy savings and to meet utility commission standards for utility programs.

A predictive energy savings methodology is under development for each part of the technical protocol. For charge and airflow, the pilot will use the energy savings methodology developed by Proctor Engineering for the CheckMe! system. For economizer and controls, we are developing an energy savings methodology based on look-up tables. The tables will be applicable to small office buildings, small retail buildings and restaurants. (Energy savings in grocery stores will focus only on charge and airflow, since economizers can be very problematic in grocery stores.) The following look-up tables have been developed to estimate economizer energy savings for various control setting changes, assuming the minimum outside air damper is functional (moves from minimum to maximum) and the minimum outside air damper position is set at one of the following:

- 10 degrees
- 20 degrees
- 50 degrees
- 100 degrees

All of the tables assume typical building operation per Bonneville Power Administration Guidelines. Tables are customized for climate conditions in each target market area, resulting in five tables for each minimum outside air setting. These tables can also be used to estimate the energy savings that result when a non-functional economizer is repaired to work correctly assuming typical building operation.

In addition, similar look-up tables are being developed to estimate scheduling energy savings. At this time, we plan to estimate energy savings only when the HVAC system was running 24 hours a day (i.e. systems operated and maintained constant heating/cooling setpoints 24 hours per day without any setback/setup implemented) and operation was changed to run on a typical operating schedule for that type of business, based on BPA Guidelines.

Marketing Strategy

The Alliance seeks to achieve permanent change in the marketplace rather than short-term energy savings. Therefore, the relationship with the service providers and the building owners is not focused on short-term rebates but seeks to change their long-term behavior. To determine how best to do this, the Alliance will conduct market research. This research will include service provider interviews, building owner interviews, and building owner focus groups. This research will be applied to the creation of targeted marketing materials for owners and providers to validate that the benefits of an RTU efficiency service are much greater than the costs. It is hoped that this knowledge will lead to a change in the marketplace.

Service Provider Interviews

The Alliance will conduct limited market research to define strategies to move HVAC service providers into offering the service to building owners. The Alliance conducted interviews with 24 service providers located in four target markets: South Tacoma, Washington; the Tri-Cities, Washington; Boise, Idaho; and Missoula, Montana. The same markets, with the addition of Billings, Montana, will be used for the field demonstration portion of this project. The interviews were designed to gauge provider interest in the pilot project and gather information on how the service providers conduct their business.

These interviews indicate that there is enough interest in the service to continue to develop the business proposition. Although not all service providers were willing to participate in a field test, there were industry leaders in each target market that were eager to test the marketability of such a program. The interviews provided several lessons for program design. These are summarized below, in order of descending importance.

- Need for incentives
- Need for owner education
- Build upon existing relationships
- Address seasonality of offering maintenance service
- Equipment manufacturers can have significant influence

Building Owner Interview and Survey

In addition to interviewing service providers, the Alliance conducted targeted market research with building owners. The goal of this research was to better understand the demographic characteristics and decision-making processes of small commercial customers

for each building type, and to collect information that will aid in the development of effective marketing strategies for the program.

The specific objectives of the building owner research fall into two broad categories. First, the research aimed to determine who is responsible for decisions regarding HVAC system repair, service and replacement, and what factors or considerations influence their decision-making. Second, the interviews sought to obtain a more detailed understanding of owner attitudes and awareness regarding HVAC system maintenance. The interviews tested overall interest in energy efficiency, the perceived importance of HVAC systems to their business, the nature of existing service relationships, attitudes toward HVAC maintenance, and willingness to invest in HVAC maintenance.

Building Owner Focus Groups

Using the findings from the interviews and surveys, preliminary marketing materials and concepts have been developed. These materials will be tested in a series of focus groups with small commercial decision makers to help refine the marketing messages and further develop communication tools. .

Marketing Plan & Concepts

The Alliance will use the results of the interviews and focus groups to develop a preliminary marketing plan and to guide development of marketing materials that will be applicable to all target markets with a particular emphasis on smaller providers. Materials will be primarily for providers to use with potential clients and could include brochures, web templates, art slicks, tool and service descriptions, case studies, and cost benefit information.

Field Tests

Following completion of the ten-building technical study and the development of marketing materials, the Alliance will test the technical protocol and preliminary marketing plan in at least 50 buildings. The buildings will be distributed across four market areas in order to get experience with each of the regional service provider markets. The target market will be single zone, constant volume package RTUs with five to fifteen tons of cooling capacity. Ideally, the RTUs will have external ductwork. The field test will have two phases: a technical phase to test and refine the technical protocol (approximately 20 buildings), and a market phase to test the marketing strategy (approximately 30 more buildings).

Service Provider Selection and Technical Training

The Alliance will select four HVAC service providers, one in each of the four market areas, to test the technical protocol and marketing plan. Service providers will be selected on the basis of technical experience, entrepreneurial energy, interest in the service, and ability to commit to the program requirements. Selected service providers will then be trained in the technical protocols.

Technical Field Tests

The Alliance will assist the service providers in finding customers interested in participating in the technical demonstration projects. This effort will be coordinated with local utilities and the team members of an existing Alliance program called the Commercial Buildings Initiative.

The Alliance will then work with the service providers to implement the technical aspect of the projects on twenty buildings, five in each market area. Each building will involve at least one Alliance staff engineer and at least one service provider. Project-specific energy savings will be estimated using the energy savings methodology developed for the pilot project. Results from 5 to 10 buildings will be used in developing case studies and marketing materials for the full-scale program.

Marketing Field Tests

The Alliance will then work with the same service providers to implement a larger market test with at least thirty more buildings, in the four-state market areas. Additional service providers will be trained as needed. Providers will be provided with guidelines for recruiting buildings to assure good geographical and building type distribution. In these buildings, service providers will educate the owner and perform the service on the RTU. The cost of the service will be paid for by the owner, but the Alliance will seek local utility incentives as defined in the Market Strategy. The focus will be on small buildings and rural markets. The Alliance will assure quality control by having an Alliance staff engineer visit a sample of the buildings. The Alliance will also check with participating providers to assess their progress in marketing the service. The marketing strategy may need to be changed based on results of these check-ins.

Project Status

As of April 2002, several elements of this project have been completed. The review of tools has led the Alliance to choose the CheckMe! assessment tool. The CheckMe! tool's method for assessing and recommending adjustments to refrigerant charge and airflow is a good fit for this Small Commercial HVAC program. The tool has sound technical features, excellent quality control and reporting mechanisms, and engineering support for the service providers. It is also easy to use and the protocol has been streamlined to reduce provider time. The CheckMe! call center provides engineering support and "plain English" help in understanding difficult diagnoses — a feature that none of the other tools offer. Calling in data from the jobsite and receiving instant feedback from a real person will save providers time and money since they do not have to leave the rooftop. In addition, the operator at the call center immediately enters the field data to the centralized CheckMe! collection system, thus eliminating extra paperwork.

Although the CheckMe! method has an adequate proxy for assessing low airflow, measuring airflow directly aids in the economizer diagnosis and it allows more accurate efficiency calculations. Therefore, the Alliance has decided to use TrueFlow flow plates to measure airflow.

The interviews with service providers and decision makers have been completed. The results indicate that service providers are very interested in opportunities to develop niches for themselves in the competitive market, but that they are skeptical that building owners will see the value of these additional services without significant education. Although most decision makers thought their service provider was already providing this level of service, they expressed willingness to participate if the service were recommended by their provider.

Technical training is scheduled to begin in May 2002 with the phase one buildings immediately following. Pilot results should be available by October 2002.

References

Ecotope. 2001. Enhanced Maintenance for Small Package Rooftop HVAC Systems. Seattle, Wash.

Houghton, David. 1997. Operating and Maintaining Rooftop Air-Conditioning Units. E SOURCE Tech Update TU-97-2. January 1997. Boulder, CO.

Lunneberg, Tom. 1999. When Good Economizers Go Bad: Keeping this airside energy saver on the upside. Boulder: Colorado. E Source Report ER-99-14, September 1999. Boulder, CO.

Rose, Ken (Area Heating). 2002. Personal communication. February 6.