

Advanced Diagnostics & Service for Rooftop Air Conditioners



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The Problem

Maintenance for conventional rooftop packaged air conditioners is generally a reactive practice where problems are addressed only when a failure results in occupant discomfort. Thus, many system inefficiencies tend to go unnoticed as long as equipment continues to provide a minimum level of comfort. Many things contribute to this pattern, including the uncertainty of whether or not preventative maintenance is financially worthwhile, and the lack of tools and information to guide tuning of a system for optimal performance. Accordingly, there is potential for significant energy savings within an existing stock of HVAC equipment, if only systems were tuned to operate most effectively.

The Solution

AirCare Plus® is a third-party energy efficiency program that provides contractors with the necessary training, tools, and incentives to conduct quality in-field assessment of efficiency for commercial rooftop air conditioners. Service provided through the program is different from that of typical maintenance contractors especially in that evaluation of equipment performance is conducted using the Service Assistant™ developed by Field Diagnostics. This field tool is a hand held data acquisition device that measures pressure, temperature, and humidity at ten key points in an air conditioner and automates thermodynamic diagnosis of the vapor compression cycle. The tool presents real time performance data, evaluates whether or not a system is operating near optimal efficiency, and directs technicians to consider specific problems. The Service Assistant guides technicians to resolve inefficiencies related to the vapor-compression cycle, but the service also addresses several other aspects of air conditioner operation that impact energy use. The basic performance enhancing changes generally made by an AirCare Plus® technician include:

- Refrigerant charge adjustment
- Supply air flow adjustment
- Evaporator or condenser coil cleaning
- Refrigerant valve cap replacement
- Economizer repair
- Economizer set point adjustment
- Economizer sensor replacement
- Programmable thermostat replacement
- Thermostat scheduling and set point adjustment

After conducting adjustments, the Service Assistant measures improvement to system performance, and communicates



The Service Assistant is a hand held field tool for HVAC technicians that automates diagnostics and thermodynamic optimization of conventional air conditioners

results to a central database through which the measured improvements are recorded and verified. In the end, a summary of changes and estimate of energy and cost savings is delivered to the customer to provide information about the value of the services.

Generally this type of service is provided to commercial customers at no cost. In the Pacific Gas & Electric service territory contractor's efforts are paid for through utility rebates administered by third parties such as Peci's AirCare Plus®, funded by California utility ratepayers under the auspices of the California Public Utilities Commission.

Field Demonstration at University of California, Davis

During the 2010 cooling season, WCEC conducted a field demonstration and monitored evaluation of the AirCare Plus® service for rooftop packaged air conditioners. The goal was to quantify performance improvements observed in a group of equipment serviced at UC Davis. Technicians used the AirCare Plus® Program Tools to conduct performance analyses on 98 RTUs and serviced those that were found to have degraded efficiency, improper settings, or non-

functional components. Of these systems, 20 units were instrumented for a pre and post-service monitored field evaluation in order to observe impacts on air flow, cooling capacity, and energy efficiency.

Demonstration Results

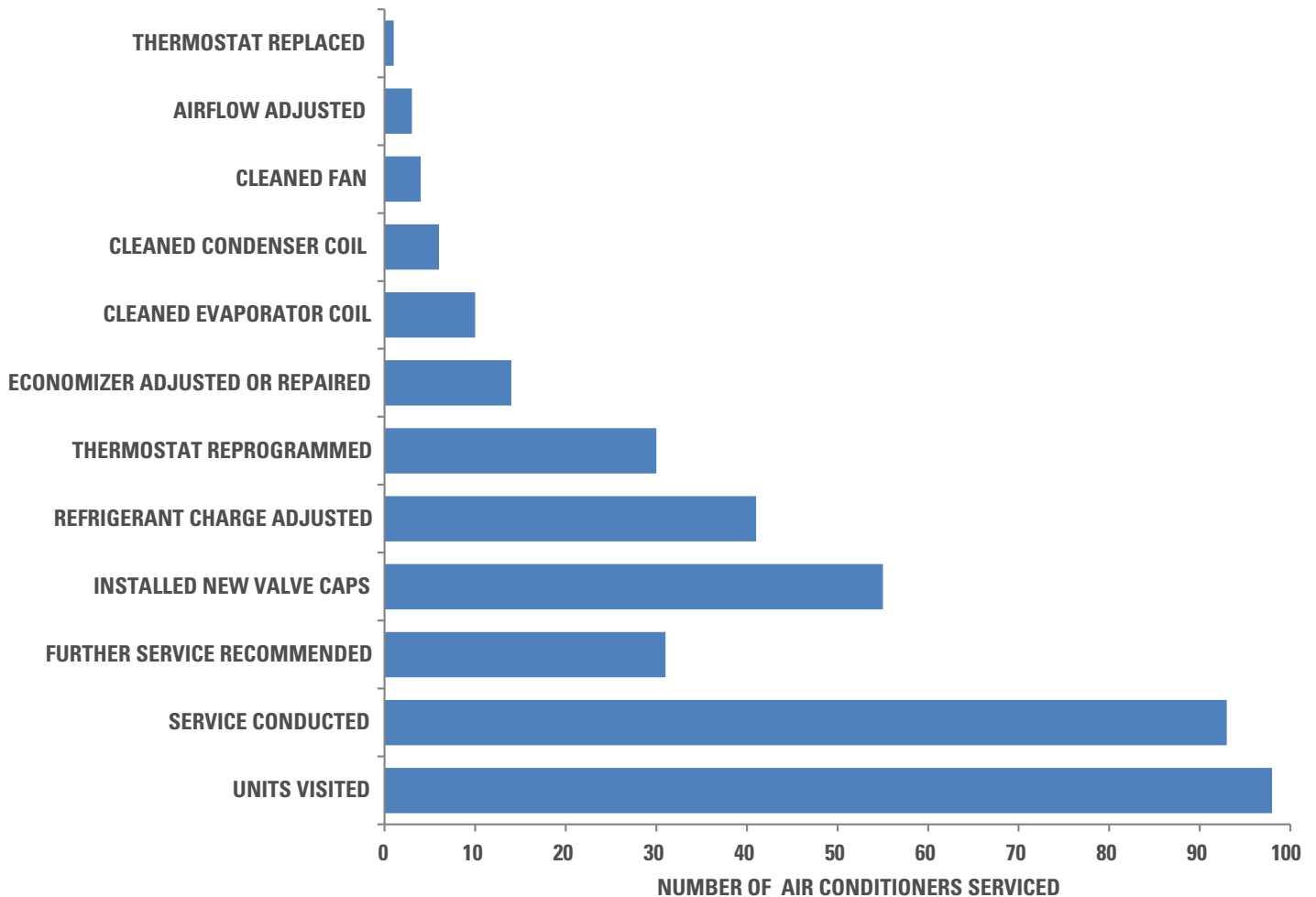
Figure 1 summarizes the types of repairs done by AirCare Plus® technicians on all units serviced at UC Davis. Of 98 units in the demonstration, 93 were found to need adjustments to improve energy performance. The most common services conducted were refrigerant charge adjustment, installation of new valve caps, thermostat reprogramming, and economizer repair or adjustment. Aside from the installation of valve caps designed to reduce refrigerant leakage, charge adjustment was the most common service – provided to more than 40% of the systems visited.

As standard protocol, AirCare Plus® replaces manual thermostats with programmable thermostats, though for the systems serviced at UC Davis, only two manual thermostats were found. A larger impact in this demonstration came from reprogramming existing

thermostats to better reflect regular occupancy hours. Of the systems with existing programmable thermostats, 29 units were reprogrammed with more appropriate settings. This resulted in an elimination of approximately 818 scheduled occupied hours each week or an average of 28 hours for each system adjusted. Additionally the fan settings for 12 units were shifted from continuous to intermittent (auto) mode, such that supply fan operation cycles only in concert with heating and cooling instead of operating for all scheduled occupancy hours. The energy impact of these thermostat adjustments are difficult to ascertain, but in some instances could reduce HVAC energy use by more than 25%.

Of the 98 units visited at UC Davis, 22 had economizers, yet only eight functioned upon inspection, and six of these were improperly programmed. With only simple adjustments, AirCare Plus® technicians were able to repair eight of the 14 non-functional economizers, and reprogrammed setpoints for the six that were not setup optimally. Upon completion, 16 of the 22 economizers functioned optimally. Depending on the building thermal load, occupancy hours, and cooling set points, economizers can save roughly 20% of annual cooling

FIGURE 1: HISTOGRAM OF MAINTENANCE CONDUCTED BY AIRCARE PLUS® AT UC DAVIS



energy consumption; thus it is estimated that economizer repair is the most impactful individual practice in this suite of measures.

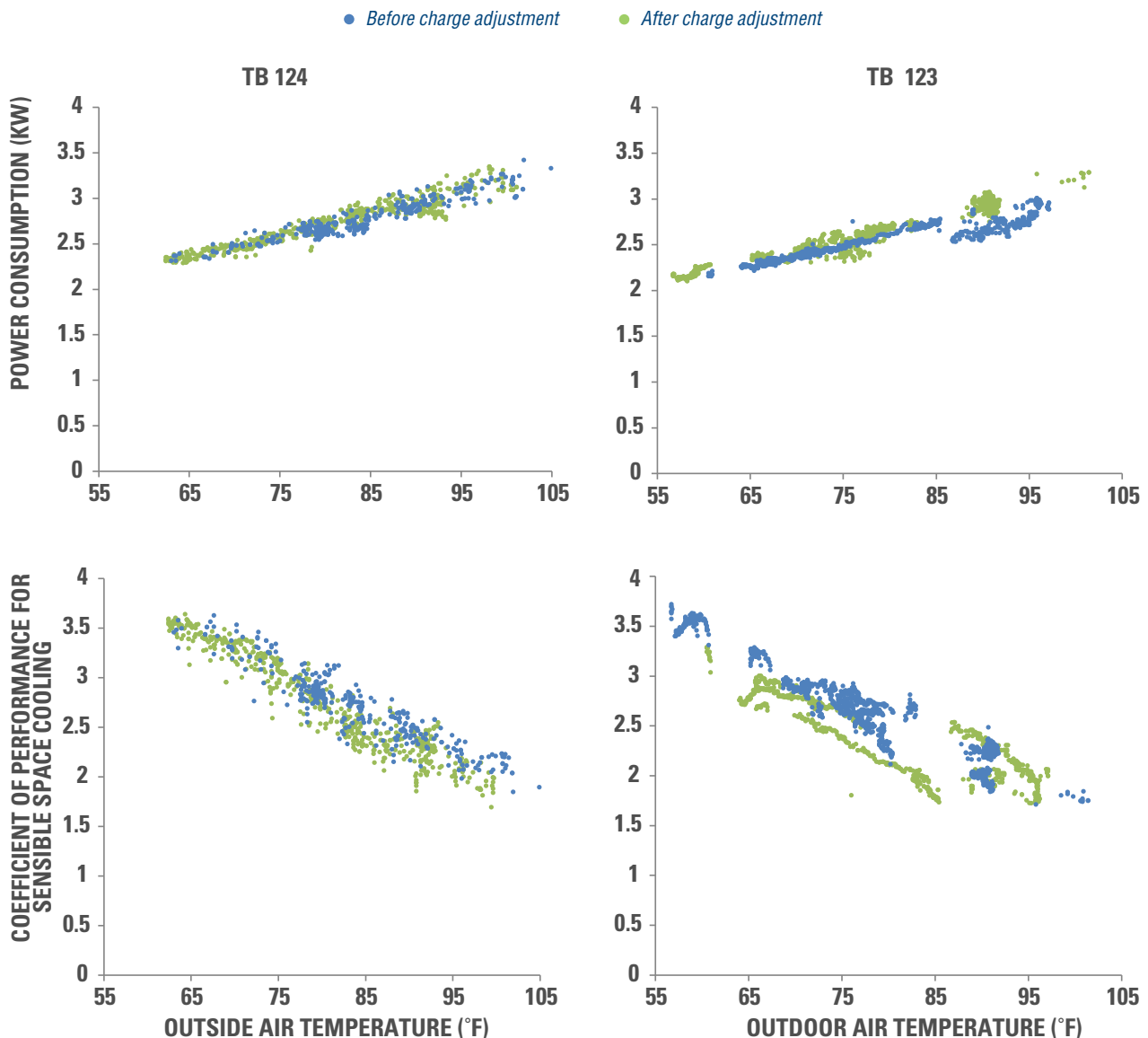
A pre and post-service monitored performance evaluation was conducted on several 3-4 ton rooftop units without economizers, and data was analyzed to capture steady state operating efficiency across a range of outside air temperatures. This analysis measures the impact of charge and airflow adjustments, but does not offer any indication of the energy savings available from thermostat set point changes, schedule re-programming, or economizer repairs. From this analysis it is clear that refrigerant charge adjustment noticeably improves efficiency, especially at higher outside air temperatures. The comparison of pre and post-service performance for two different systems is shown in Figure 2. The top two plots trend electric power draw as a function of outside air temperature, while the second two plots trend the coefficient of performance

(COP) for sensible space cooling as a function of outside air temperature.

The impact of charge adjustment varies between instances, but seems to improve efficiency by roughly 5% on average, as presented in Figure 2. Although there is some scatter and incongruity in the results, a general trend in improvement is clear. A temperature-binned analysis shows a maximum improvement to COP of almost 20% in the 90-95 °F temperature range, but also indicates decrease in performance within some temperature ranges for certain units at lower temperature operation. Unfortunately, observations prior to service did not experience operating hours at very high temperatures, so a comparison of pre and post-service performance is not possible above 95 °F for this study.

Overall, advanced diagnostic and service programs such as AirCare Plus® can be a viable method to achieve

FIGURE 2: COMPARISON OF POWER DRAW AND EFFICIENCY FOR TWO ROOFTOP UNITS BEFORE AND AFTER CHARGE ADJUSTMENT



energy savings from existing equipment with minimal investment. The total annual savings from service on 98 small rooftop packaged units at UC Davis is estimated by AirCare Plus® at 175,000 kWh, and the total peak demand reduction is estimated to be 23 kW. For UC Davis at 8.5¢/kWh, this translates to more than \$15,000 saved annually. The keys to success of such a program rely in part on the advanced field diagnostic tools that are used, and in part on the fact that several simple efficiency strategies are packaged into a single service protocol. As opposed to conventional equipment maintenance contracts which operate mainly to ensure equipment operation at low cost, this type of service focuses expressly on delivering energy savings. In the PG&E region, the grouping of service measures conducted on systems in this study is provided free of charge, and contractors efforts are funded by utility energy efficiency programs. As a commercial facility owner it is sensible to engage in such a program, as it can produce significant savings with little or no investment. In addition to providing the simple service adjustments presented here, AirCare Plus® also identifies equipment that needs further service – highlighting those systems that should be the focus of conventional service programs and HVAC maintenance or further efficiency enhancements.



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About PIER

This project was conducted by the California Energy Commission's Public Interest Energy Research (PIER) Program. PIER supports public interest energy research and development that helps improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

Jerry Brown, Governor

California Energy Commission

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