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Assessment of HVAC Installations in New Homes in Nevada Power Company's Service Territory

Prepared for:
Electric Power Research Institute
Nevada Power Company
Nevada State Energy Office

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REPORT SUMMARY

Assessment of HVAC Installations in New Homes in Nevada Power Company's Service Territory

In residential air conditioning systems, duct leakage, low duct insulation levels, and insufficient air flow across the indoor coil can result in significantly reduced efficiency. This project investigates opportunities for enhancing the performance of air conditioning systems and recommends a package of moderate cost improvements leading to lower energy usage and demand and greater occupant comfort.

INTEREST CATEGORIES

Building systems and analysis tools
HVAC
Home automation and energy

KEYWORDS

Air conditioning
Heat transfer
Air infiltration
Ducts
Ventilation
Peak loads

BACKGROUND In 1991, more than 950 billion kWh of electricity were used in the residential sector, 25% of which involved space heating and cooling. Estimated energy losses of 25—30% occur as a result of improper installation practices and deficiencies in air conditioning systems and ancillary devices. These estimated annual losses exceed 30 billion kWh, valued at more than $2.5 billion, with peak electricity demands due to duct leakage rising as high as 2 kW in hot, humid climates and 1 kW in less extreme climates. A better understanding of the issues, possible remedies, cost ramifications of improvements, and the potential energy and peak demand savings is important to electric utilities in their demand-side planning process. This project was cosponsored by EPRI, the Nevada Power Company, and the Nevada State Energy Office.

OBJECTIVES To assess the present state of air conditioning systems in new residential construction in the Las Vegas area; to suggest improvements that would lead to cost-effective energy savings and a reduction in peak demand.

APPROACH Investigators first field tested air conditioning units, duct systems, and building shells of a sample of newly built houses in Nevada Power Company's service territory. They next identified typical problems with current heating, ventilation, and air conditioning (HVAC) installation practices. Finally, they performed an engineering and cost analysis to determine the energy savings and peak demand reductions achievable from an HVAC efficiency program targeted at residential customers in Nevada Power's service territory.

RESULTS New residential construction in Nevada Power's service territory showed evidence of considerable deficiencies with respect to air conditioning systems, not unlike other parts of the United States. Research has demonstrated that cost-effective improvements can enhance energy savings and reduce peak demand, while ensuring occupant comfort and satisfaction. This report provides a framework for utilities to follow in creating an efficient HVAC program along with energy savings and cost estimates associated with each remedial measure. Overall, the study showed that:

- Duct leakage and low duct insulation levels cause an average loss of 37% in overall cooling efficiency. Reasonable improvements can reduce this by approximately half, at an estimated cost of $235 per house.

- Air conditioners often have insufficient air flow across the indoor coils and are frequently undercharged due to improper installation procedures, resulting in approximately 12% efficiency penalties. If manufacturer suggested installation practices are followed and testing is performed to ensure proper installation, the problem can be remedied for approximately $68 per house.

- A program that ensures tight, well-insulated duct systems along with properly installed air conditioners can reduce cooling usage by approximately 47% and peak demand by 1.2 kW. In addition, these modifications can reduce the specified size of installed systems, potentially leading to an additional 0.4 kW demand savings. The cost to implement these improvements and achieve these savings is estimated to be $650 per unit.

EPRI PERSPECTIVE Typically, air conditioning systems in residential new construction have some deficiencies that negatively impact energy and peak demand. Utilities can improve the efficiency of these air conditioning systems by developing an effective HVAC program that will address deficiencies in current practices. While the program described in this report was specifically designed for Nevada Power, it can be used as a model and customized by other utilities. Related EPRI work describes the New Construction HVAC Program Implementation Plan for Nevada Power Company (TR-105310).

PROJECT
WO3841-03
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TR-105309
Research Project 3841-03

Final Report, October 1995

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ABSTRACT

In 1994, Proctor Engineering Group investigated opportunities for improving air conditioning system performance in new residential construction. This investigation, sponsored by Nevada Power Company, the Electric Power Research Institute, and the Nevada State Energy Office, involved field testing air conditioning units, duct systems, and building shells in 30 houses; assessing achievable improvements to the systems; and analyzing the potential energy savings and peak demand reductions from such improvements. The investigation found substantial deficiencies in air conditioning systems. Duct leakage and existing duct insulation levels cause an average capacity loss of 37%. Air conditioners often had insufficient air flow across the indoor coil and were frequently overcharged, leading to a 12% average efficiency loss. A package of moderate cost improvements was recommended that would lower energy usage and demand with improved occupant comfort and satisfaction.

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EXECUTIVE SUMMARY

Nevada Power Company (NPC), the Electric Power Research Institute, and the Nevada State Energy Office, contracted with Proctor Engineering Group to investigate opportunities in Nevada Power's service territory for improving air conditioning system performance in new residential construction. This investigation has involved field testing the air conditioning units, duct systems, and building shells of a sample of newly built houses; assessing achievable improvements to the systems; and analyzing the potential energy savings and peak demand reductions from such improvements. The investigation found that newly constructed homes in NPC's service territory have substantial deficiencies in their air conditioning systems, similar to those found in studies from other parts of the country (Appendix A contains brief descriptions of related studies). Improvements can be made to provide lower energy usage and reduced demand while improving occupant comfort and satisfaction. These improvements can be accomplished at moderate cost.

The key findings of this study include:

- Duct leakage and existing duct insulation levels cause an average loss of 37% in overall cooling efficiency. Reasonable improvements can eliminate over half of these losses (save 26% ± 5% of the cooling energy[1]) for about $235;
- Air conditioners often have insufficient air flow across the indoor coil and are frequently overcharged, leading to a 12% ± 3% average efficiency loss. Proper installation (following the manufacturers installation instructions) and testing would remedy these problems at a cost of about $68;
- A program which ensures tight, well-insulated ducts and properly installed efficient air conditioners could reduce cooling usage by approximately 47% and diversified peak demand by 1.2 kW. The additional cost is estimated to be $650 per unit;
- With properly installed systems featuring well insulated tight ducts the air conditioners should be resized to take advantage of the lower load. This would "lock in" the peak reduction and further reduce the peak demand by 0.4 kW.

NPC has a variety of potentially worthwhile options to pursue for improving cooling efficiency and reducing peak demand. Proper program design, training, and quality assurance are critical issues for actually achieving these improvements. These topics are the focus of a follow-up report under this project.

[1] See Appendix D for a discussion of sample variability and overall uncertainty.

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BACKGROUND

The Las Vegas area is currently the fastest growing market for new residential units in the nation with an annual growth rate of over 5% in 1993. (SOURCE: Chicago Title & Trust). Nevada Power Company (NPC), the Electric Power Research Institute (EPRI) and Nevada State Energy Office (NSEO) contracted with Proctor Engineering Group (PEG) to assess the energy savings and peak demand reductions achievable from a Heating, Ventilating and Air Conditioning (HVAC) efficiency program targeted to new residential construction in Nevada Power's service territory. This assessment involved the following:

- detailed field testing of a sample of 30 newly built homes in the Las Vegas area to identify problems with current practice HVAC system installations;
- a determination of achievable improvements to current practice and the costs of those improvements;
- an engineering analysis of field data to estimate the impacts of potential improvements on energy usage and peak demand, and;
- an implementation plan for changing current practice.

This report describes the activities and results from the first three items.

PRIOR RESEARCH

PEG's prior experience, and the findings of other research projects around the country (see Appendix A), has found that typical air conditioning system installations have numerous problems which adversely impact efficiency, demand, and comfort. The primary problems identified include:

- excessive duct leakage in unconditioned spaces leading to substantial loss of conditioned air, heated return air, and increased house infiltration;
- insufficient air flow across the indoor coil;
- incorrect refrigerant charge;
- excessive system oversizing.

In prior studies, these problems were found to be common, not unusual, circumstances. Duct leakage has become a significant concern in the recent past. Studies from California, Florida, and the Pacific Northwest have consistently found large efficiency losses due to typical levels of duct leakage.

2

FIELD INVESTIGATION

Trade practices and housing styles vary throughout the country and so do the relative frequency and severity of different air conditioner installation problems. In addition, other problems or savings opportunities may be as or more important in NPC's service territory than those listed in Appendix A. A field investigation of newly constructed houses in NPC's service territory was needed to characterize the local problems and opportunities.

Proctor Engineering Group examined 30 newly built houses in the Las Vegas area with a total of 40 air conditioning systems. Houses were unoccupied, but ready for occupancy (i.e., fully drywalled with operating central air conditioning systems). NPC provided contacts with local builders. The 30 houses came from 17 developments built by 10 general contractors, utilizing 11 HVAC contractors. They are believed to be representative of typical new construction in the area.

FIELD DATA COLLECTION PROTOCOL

PEG designed the field investigation to examine a wide variety of potential HVAC problem areas and to collect information needed to assess summer design cooling loads and overall building shell thermal integrity. The field procedures included many recently developed state-of-the-art diagnostic tests (particularly for assessing the duct systems). The field testing protocol is summarized in Table 2-1. Copies of the field data collection forms are attached as Appendices F, G, and H.

IMPLEMENTATION

Highly trained, efficient and organized field technicians were needed to perform the field work within the project's time and budget constraints. PEG contracted with Conservation Services Group (CSG) to perform the work. The lead technician had been previously trained by PEG and was experienced with PEG procedures. All technicians were carefully trained by PEG to ensure high quality data for the study.

The two person teams required an average of half a day per house. Scheduling began at the end of June, 1994 and all field work was completed promptly by mid-July.

Table 2-1
Summary of Field Test Procedures

Parameter	Tests	Description / Use
Duct Leakage	Duct Blaster™ - total leakage	pressurize ducts to 25 pa with registers sealed, measure fan flow, check pressures in other parts of duct system
	Duct Blaster™ - exterior leakage	repeat above test while blower door pressurizes house to 25 pa, eliminating pressure difference between ducts and house
	Half Nelson - return/supply leakage split	measure pressures in supply and return plenums with air handler on and registers sealed - results used to adjust duct blaster results into supply and return leakage rates
	Pressure Pan - leakage location indicator	measure pressures at individual registers with blower door pressurizing house to 50 pa
Air Handler Flow	Flow Hood	measure flow rate into return grille(s) and supply registers - return flow plus return leakage equals total air handler flow
	Operating Static Pressures	measure static pressures in supply and return plenums - used for adjusting duct blaster results to estimate supply and return leakage fractions when air handler operates, also useful for assessing duct design
AC Capacity	Enthalpy Change across AC coil	measure wet and dry bulb temperatures in supply and return plenums - when combined with air handler flow rate can calculate actual capacity (under test conditions, which can be adjusted to ARI standard)[2]
AC EER	Wattage Input	use house electric meter to measure actual electric input to AC, calculate EER at test conditions by dividing input into capacity
AC Charge	Superheat / Subcooling	measure subcooling, superheat, head pressure, hot gas discharge temp., outdoor unit delta T, and power draw - compare to manufacturer target values when possible. Assess charge from available evidence including air handler flow rate, capacity, input, measured EER
AC other	miscellaneous	collect nameplate information from indoor and outdoor units, assess potential outdoor unit air recirculation
Duct Conduction	Delivery Temperatures	measure delivery temperatures at near, middle, and far registers, compare to plenum temperatures and ambient conditions.
	Duct System Location	Estimate percentage of supply and return ducts in various locations (attic, garage, inside, etc.) - used to estimate ambient conditions around ducts for modeling conduction and leakage
Design Cooling Load	Building Dimensions, materials, R-values, shading/exposures,	calculate design cooling loads & proper AC size using enhanced ACCA Manual J[3]
Building Airtightness	Blower Door Test	Measure CFM_{50} of house, also measure pressures developed in key building zones such as attics

CSG's field manager and PEG staff reviewed all data. The data were entered into spreadsheets along with supplementary information from published manufacturer ratings. The raw data were further analyzed for quality and calculations were performed to derive the system parameters of interest.

[2] Air Conditioning & Refrigeration Institute (ARI) standard rating conditions of 80°F dry bulb and 67°F wet bulb indoors and 95°F dry bulb outdoors.

[3] The Manual J program used in this project used blower door measured leakage rate to estimate Air Changes per Hour (ACH) rather than based on visual observations of the building shell (standard ACCA practice).

FINDINGS - GENERAL CHARACTERISTICS

The typical house in the study was a slab-on-grade home with 3 bedrooms, about 1800 square feet of living space, a volume of 16,733 cubic feet, gas heat, double glazed windows, and R-30 attic insulation with a tile roof (5 of the homes in this study had a radiant barrier attached to the underside of the roof sheathing). Few south or west facing windows had any architectural shading. There were 13 one story and 17 two story houses. Nine of the ten houses with two AC systems had two stories and only one was in a one story house. All of the single AC houses had the air handler located in the attic or had a roof mounted package unit. The attic location exacerbates the impacts of return system leakage and increases conductive heat gains. Houses with two systems usually had the air handler for both systems in the attic or had a roof mounted package units, although a two houses had the air handler for the system serving the first floor in the garage. Houses with two systems usually had both return grilles located in one central location, commonly the upstairs hallway.

The houses were fairly tight, with an average air leakage of 2022 Cubic Feet per Minute at 50 Pascals pressure (CFM50) measured with a blower door. This level of air tightness lowers the cooling and heating load of the house and saves energy. However, when the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 62-1989 is applied to modeled ventilation nearly a third of the houses do not meet the minimum infiltration criteria. ASHRAE standard 62-1989 specifies that residential structures must have 0.35 natural Air Changes per Hour (ACH) or 15 CFM per person whichever is greater. The number of units that do not meet the ASHRAE standard (with the windows closed[4]) based on blower door measurements and the Lawrence Berkeley Laboratory (LBL) infiltration model[5], is shown in Table 2-2.

Table 2-2
Houses Failing to Meet ASHRAE Infiltration Standard

	Heating .35 ACH	Cooling .35 ACH	Heating 15 CFM/person[6]	Cooling 15 CFM/person
Houses Failing to Meet Standard	5	9	2	2
% Failing to Meet Standard	17%	30%	7%	7%

FINDINGS - DUCT SYSTEMS

The duct systems commonly consisted of a rigid metal return plenum, duct board supply plenum and connecting boxes with R-4 insulated 6" to 8" round flex duct branches to the individual rooms. Most of the systems tested were "bag" systems which are used by the majority of Las Vegas contractors. Bag systems are factory built to the specifications of the contractor. The individual duct runs are assembled at the factory

[4]The ASHRAE standard assumes that adequate ventilation can be accomplished by opening windows. Since the lowest ventilation rates will occur when the indoor to outdoor temperature difference is small, opening windows for ventilation may be a viable option.

[5] Calculated using Las Vegas specific wind speeds published in the 1993 ASHRAE Fundamentals and bin weather data published in the Air Conditioning Contractors of America (ACCA) Manual J Seventh Edition Table A4-1. Based on an indoor temperature of 70°F in winter and 75°F in summer.

[6] Occupancy estimated as number of bedrooms plus one.

including the main branch ducts and individual runs to each room. The installers simply put the system in place and make plenum connections. For the final system to be tight both the factory connections and the field connections must be tight. During the testing, the technicians noted that most of the duct systems had obvious and easily eliminated leakage at the plenums, boot connections and air handler. They also noted that existing factory built connections may be subject to future failure because they were made with duct tape. Therefore, the systems were tested when they were as tight as they will ever be. They can be expected to leak more over time due to tape failure and disturbances (i.e., disconnections and tears) caused by cable TV and alarm system installers.

Detailed duct leakage measurements were used to quantify the magnitude and impact of the existing leakage problems and the opportunities for improvement. Duct leakage can be measured in several different ways (Proctor et al, 1994). Total leakage and leakage to the exterior at a particular test pressure are both measurable, but normal operating leakage, split between supply and return, must be estimated to calculate the energy and peak effect of duct leakage.

The total duct leakage test establishes the total amount of leakage out of the ducts when all the registers are sealed and the ducts are pressurized to the test pressure (usually 25 or 50 pascals). Total duct leakage is a fast and accurate test method that is easily applied to new construction even before the drywall is installed. In this study, total duct leakage was tested using a Duct Blaster™ (a trademark of the Energy Conservatory). The average measured total leakage rate was 369 CFM50. The distribution of total duct leakage is shown in Figure 2-1.

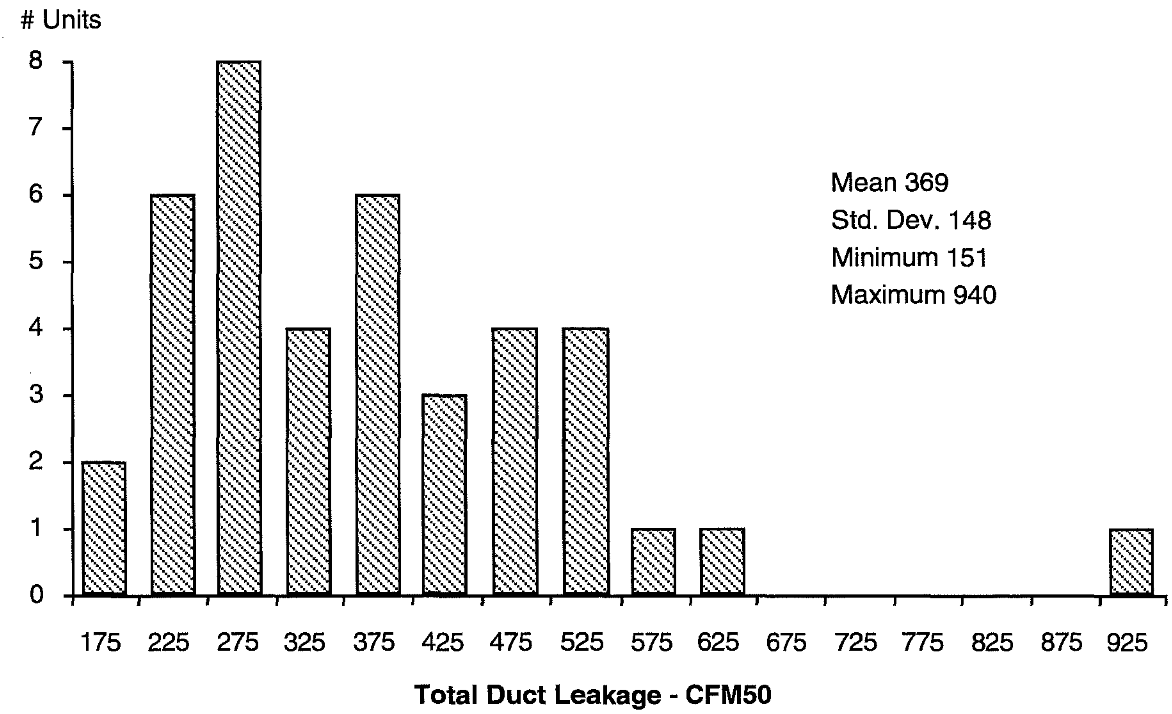

Figure 2-1
Total Duct Leakage

The unit with over 900 CFM50 of total duct leakage was the unit serving the bottom floor of a two system house. It had a ducted platform return in the garage with an extremely large return leak.

Duct leakage to (and from) the exterior is a better measure of duct leakage problems than the total leakage measurement, but involves more difficult and time-consuming tests. In this study, exterior duct leakage was measured using a blower door and a Duct Blaster™ pressurizing both the building and the ducts simultaneously. This reduces the duct leakage to inside to a minimum and thus measures the duct leakage to the exterior. The distribution of exterior duct leakage is shown in Figure 2-2.

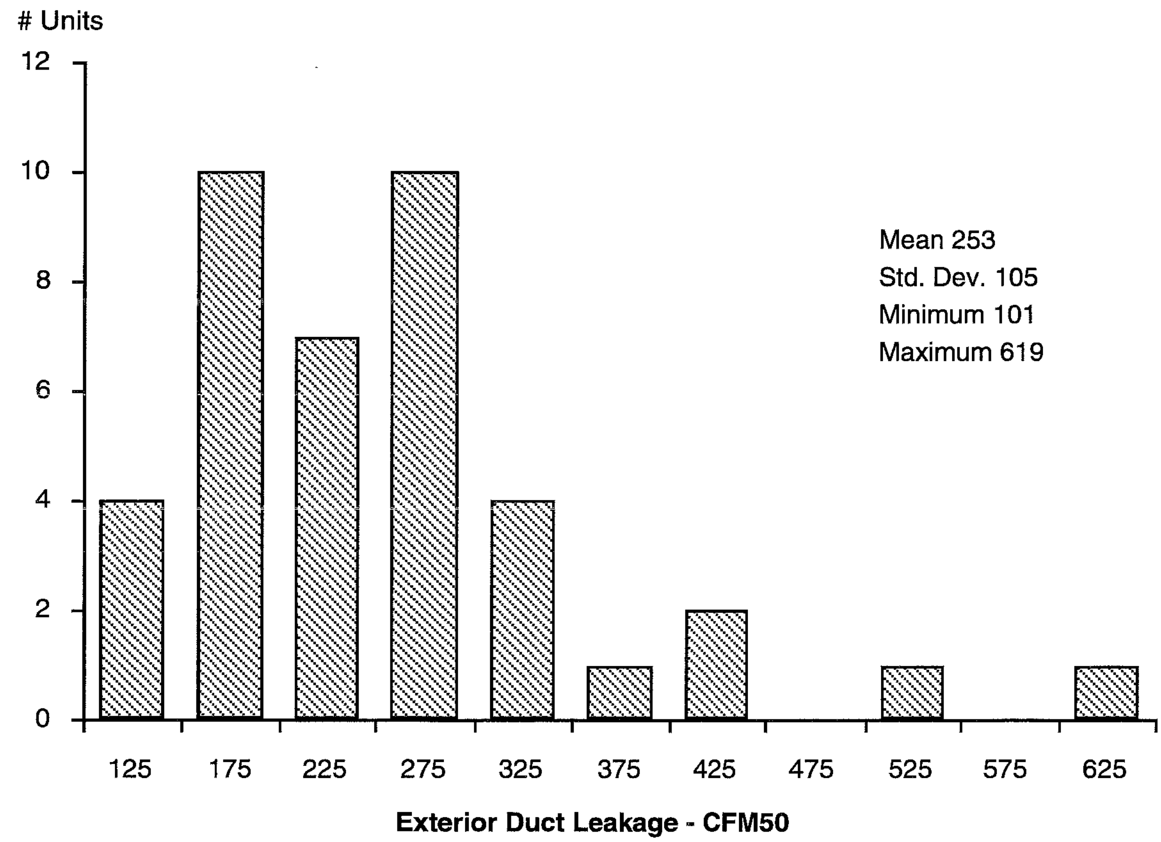

Figure 2-2
Duct Leakage to the Exterior

The average leakage is 253 CFM50, comprising about 17% of total building leakage on average[7], slightly tighter than the duct leakage rates found in studies of existing housing in California and Florida (SOURCE: Proctor, 1991; Tooley & Moyer, 1989).

The unit with the largest duct leakage to outside was the unit with the largest total duct leakage. The unit with the second highest leakage to outside was in a single air conditioner home and had a very large supply leak into the attic.

Both the duct leakage to outside test and the total duct leakage test are useful in informing us of the size of the holes in the duct system. The key quantities however are the leakage in the supply and return under operating conditions (as a percentage of the air flow through the indoor coil). In this study, exterior leakage was allocated to the supply and return based on the half Nelson test and the proportion of each side of the system that was in conditioned space. The operating leakage for each side was then estimated by adjusting the leakage rate to the average pressure in that side of the duct

[7] Calculated as the total exterior duct leakage for each house, including both systems in two system houses, divided by the house leakage as measured by a blower door test.

system[8]. Finally, the operating leakage estimates were divided by the flow through the coil. The operating duct leakage split between supply and return is summarized in Figure 2-3. The flow rates averaged 99 cfm for supply leakage and 103 cfm for return leakage, representing about 9 percent of the air handler flow in each case.

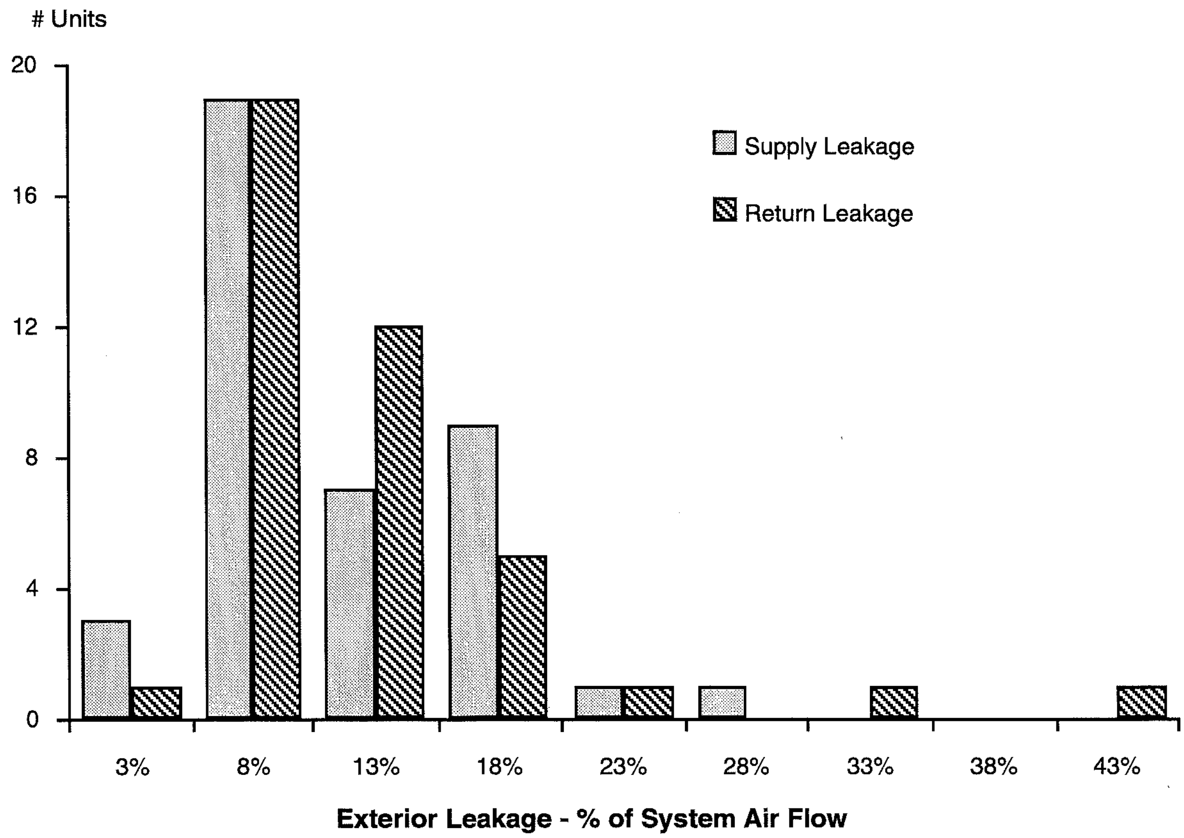

Figure 2-3
Supply and Return Leakage as a Percentage of Flow

The unit with the highest leakage relative to air flow is the unit that had the highest total duct leakage. The unit with the second highest leakage relative to air flow has very low air flow through the system with moderate leakage.

FINDINGS - AIR CONDITIONING SYSTEMS

The houses had a wide variety of air conditioning system makes and models. Air conditioners serving an entire house were usually four or five tons while those in the two system houses were usually three tons each. About thirty percent of the units were

[8] The flow exponent was assumed to be 0.65. The leakage at operating conditions therefore was calculated as Test Flow * (operating pressure/test pressure)^.65

package systems. A third had "upsized" indoor coils (most of those were rated a half ton larger than the outdoor unit). Rated EERs ranged from 8.8 to 9.9 and averaged 9.2. Rated SEER values ranged from 10 to 12. Three systems could not be properly tested -- one had no charge, the other two were in the same house and had their refrigerant lines crossed so that the indoor air handler of each unit operated with the outdoor unit of the other system! The remaining 37 systems were analyzed with a detailed testing protocol.

Air Handler Flow Rate

The proper operation of an air conditioning system depends upon providing the correct air flow rate across the indoor coil -- usually 400 cfm per ton of nominal capacity. Low air flow has been a common problem found in other studies of air conditioner performance (Proctor, 1991; Neal, 1990). In addition to potentially shortening equipment life, incorrect air flow renders most standard tests for proper refrigerant charge invalid. In a hot/dry climate such as Las Vegas, where sensible cooling is almost the exclusive goal of air conditioning, ACCA recommends higher air flows.

Air flow rate through the return grill was measured (all systems had a single return grill) using a flow hood. Return grill flow was added to the return leakage flow derived from Duct Blaster™ testing[9]. Figure 2-4 shows the distribution of measured flow rates compared to manufacturers' specifications. The average measured flow rate was 345 cfm per ton, fourteen percent below the target value of 400. Half of the units were below 350 cfm/ton (often used as a level requiring corrective action), and thirty percent were below 300 cfm/ton.

[9] Supply register flows were also measured as a cross-check, although their lower flow rates make the measurements inherently less accurate.

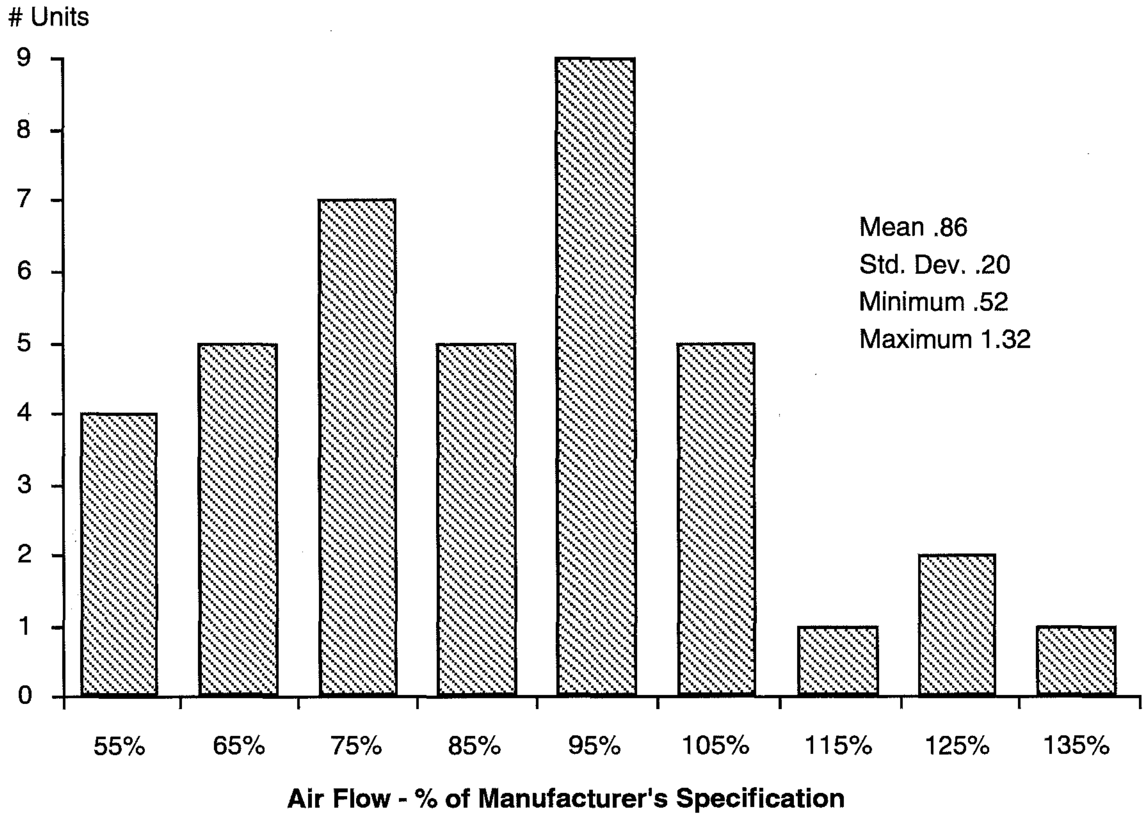

Figure 2-4
Air Handler Flow

Causes of the low air flow were investigated. ACCA Manual D specifies one supply outlet for every 4,000 Btu/hr heat gain and that the cooling capacity of the equipment should not exceed 30,000 Btu/hr per filter grill. Forty two percent of units had an <u>average</u> heat gain of over 4,000 Btu/hr per supply register. Only five of the forty units were less than 30,000 Btu/hr, but none had more than one filter grill.

Manual D also suggests that the typical static pressure difference from before the fan to after the coil is 0.40 inches of water column (100 pascals). The measured values for the systems examined averaged 0.41 inches of water column (102 pascals).

The relationship between the static pressure and air flow is somewhat complex (due to interaction between the air handler fan curve and the actual duct system). To reduce the effect of confounding interactions the relationship between average static pressure and measured flow was evaluated builder by builder. The results are shown in Figure 2-5.

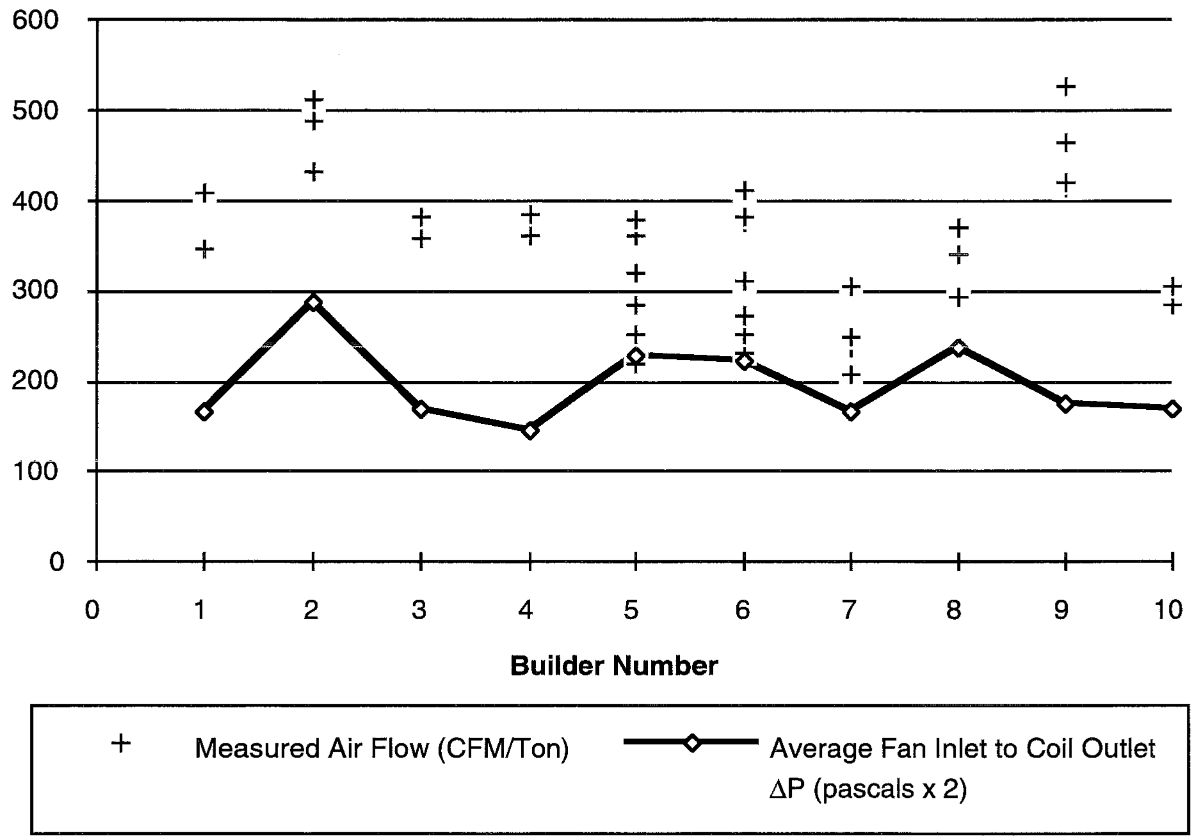

Figure 2-5
Air Flow vs. Static Pressure by Contractor

Builders 2 and 9 have the highest air flows. Builder number 2 uses oversized air handlers. The two units with the highest air flow for this builder had air handlers rated one ton larger than the outdoor unit. Builder number 9 had high air flow with relatively low external static pressure. This is the only builder who uses rigid duct work rather than flex duct.

Checking Refrigerant Charge

Manufacturers of residential air conditioning systems recommend various methodologies for determining proper system charge. The most common method for air conditioners with fixed metering devices (cap tube and orifice) is evaporator superheat. For systems with Thermostatic Expansion Valves (TXV) the subcooling method is suggested. Only one system in this study had a TXV.

Evaporator superheat is the difference in temperature between the saturated refrigerant vapor in the evaporator and the refrigerant vapor in the suction line exiting the evaporator. The basic operation of a refrigerant system makes evaporator superheat a reliable method of checking refrigerant system charge under many conditions. In order for this method to be accurate several items must be determined prior to its use:

- Air flow through the indoor coil must be within +/- 50 CFM of the manufacturers suggested flow (400 CFM per ton).
- Refrigerant system evacuation must be complete (all non-condensables must be removed from the system).
- The indoor and outdoor temperatures must be within the range specified by the manufacturer as being acceptable for checking charge though the superheat method.

There are several problems in using the superheat methodology (one is specific to hot dry climates such as Las Vegas):

- Contractors do not measure air flow through the indoor coil. Contractors assume the air flow through the indoor coil is correct.
- Installation technicians often do not properly evacuate the refrigerant system when it is installed (the vast majority do not even carry the micron gauge needed to ensure proper evacuation).
- The superheat methodology was developed for conditions that exist in the more humid and cooler parts of the United States. It will not work in hot dry climates that experience low indoor wet bulb temperatures in combination with high outdoor dry bulb temperatures.

The last problem is severe, as can be illustrated by the superheat charging chart shown in Figure 2-6. The superheat charging method consists of running the air conditioner long enough to reach steady state, then testing the superheat, indoor wet bulb temperature and outdoor dry bulb temperature.

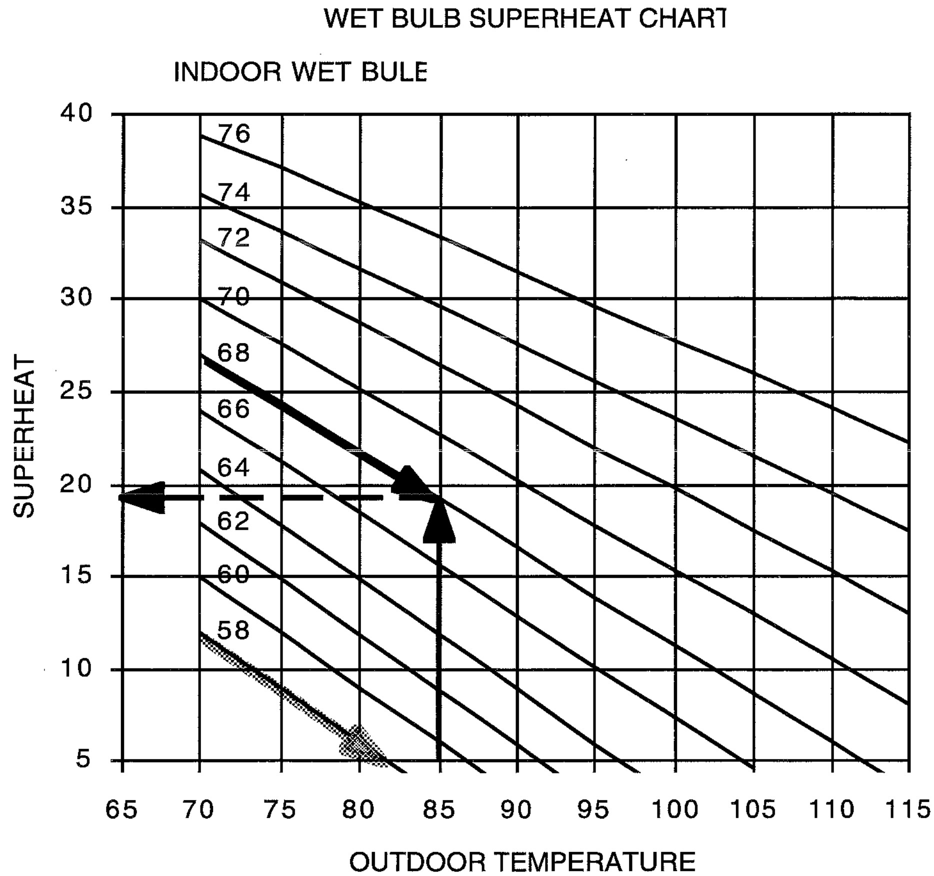

Figure 2-6
Superheat Charging Chart

For a given indoor wet bulb temperature and a given outdoor temperature the target superheat can be read off the chart. For example if the indoor wet bulb temperature is 68°F and the outdoor temperature is 85°F the target superheat can be determined by following the diagonal line marked 68°F to the vertical line marked 85°F. Moving straight to the left from that intersection point the target superheat can be read as 19°F.

However, for an indoor dry bulb temperature of 75°F the indoor wet bulb in Las Vegas is often below 58°F. (In our tests the indoor wet bulb averaged 59°F with a dry bulb of 85°F). If the 58°F (the lowest diagonal line) on Figure 2-6 is followed to the lower limit of the graph it is apparent that the outside temperature cannot exceed 82°F to check charge in this manner. An outdoor temperature of less than 82°F during daylight hours in the cooling season is rare in Las Vegas (the average outdoor temperature during our testing was 99°F).

There are at least two approaches to the problem of ensuring correct charge in hot/dry climates. The first is to ensure that the installation technicians have the proper equipment (and training to use it) to properly evacuate and weigh in the correct amount of charge. This would have to include random quality assurance checks and action to obtain compliance. The second approach is to work with manufacturers and researchers to devise a charge test that is easily applied in hot/dry climates.

An advantage to the second option is that the optimal charge could be determined for these hot/dry climates (the optimal charge for a hot dry climate is not necessarily the same as the optimal charge for the purpose of an SEER rating based on 82°F outdoors). Research at Texas A&M University has shown for higher temperatures that air conditioner capacity is greater and efficiency is higher for systems containing less than the manufacturers specified charge (SOURCE: Farzad & O'Neal, 1988, 1989). This is illustrated in Figure 2-7.

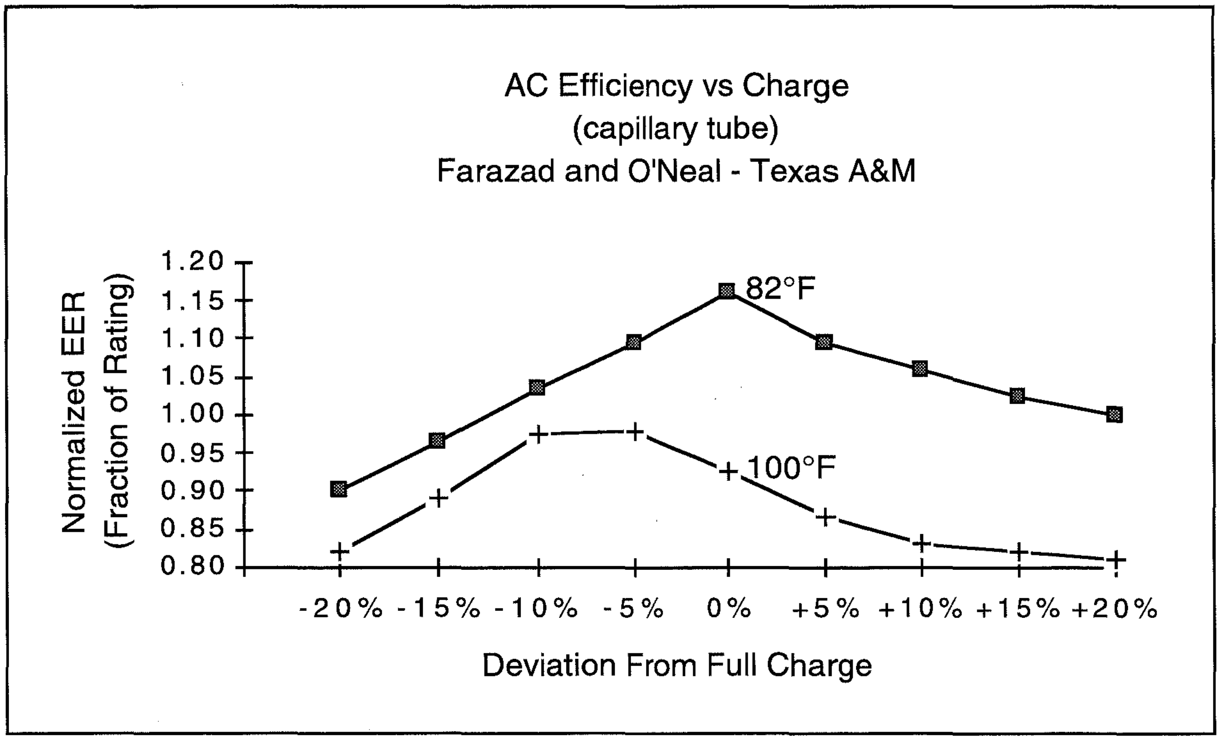

Figure 2-7
EER vs. Charge and Outdoor Temperature (capillary tube system)

Refrigerant Charge

Incorrect refrigerant charge is a common problem with air conditioning systems. It is a common expectation that newly installed systems would be properly charged. Unfortunately, new systems appear to suffer from incorrect charge as often as older systems (SOURCE: Hamerlund et al, 1990).

In addition to the problems associated with the hot/dry climate of Las Vegas, technicians rely on rules of thumb and guesswork. Technicians consider weighing in the charge too time consuming (although evacuating the system and weighing in the refrigerant can actually be accomplished in approximately 20 minutes when done properly). PEG has been active in developing step-by-step approaches for assessing air conditioner performance based on a combination of measurable system parameters. The general approach is:

- Field technicians measure a number of key temperatures, system pressures, air handler flow rate, and power draw. Nameplate information and manufacturer ratings are also noted.
- Parameters such as subcooling, head pressure, and superheat are compared to manufacturers ratings and/or charts. If the charts are available, air flow is correct, and the test conditions are within the chart, then proper charge can be determined. Commonly, this approach fails to provide results or the results are inconclusive (as was the case for 28 of the 37 systems tested in this project).
- When the above information is combined with measurements of power draw, actual capacity and EER, air flow across the indoor coil, and temperature difference across the outdoor coil, a more informed conclusion can be reached because overcharge and undercharge are often identifiable by characteristic patterns in these measurements.

This approach is usually effective at determining whether a unit is properly charged. The results of applying these procedures[10] to the units in this study are summarized in Table 2-3. If some of the key system parameters conflicted with the general conclusion on charge, the results are qualified as "possibly".

Table 2-3
Air Conditioner Refrigerant Charge

Charge Indication	# units	% of units
Correct Possibly Correct	5 3	21%
Undercharged Possibly Undercharged	3 8	29%
Overcharged Possibly Overcharged	10 9	50%

Only 21% of the units inspected appeared to be properly charged. Overcharging was most common with up to half of the units overcharged, and the remainder apparently undercharged. These results are quite similar to the published research from new construction in California (ibid.).

Air Conditioner Sizing

The Air Conditioning Contractors of America (ACCA) Manual J is a standard reference for estimating the design load for residential air conditioning systems. The enhanced Manual J calculations performed on the houses in this study found cooling loads at design conditions ranging from 15,000 to 52,000 Btu/hr with an average of 32,948

[10] Pumping down the system and weighing the charge is also a viable tool. In this study, the systems were not pumped down due to warranty considerations.

Btu/hr. About half of the design load came from heat gains through windows and glass doors. The remainder of the gains were nearly evenly dispersed between infiltration, attic conduction, wall conduction, duct conduction, and internal gains.

The 97.5% design conditions for Las Vegas are 106°F dry bulb -- 65°F wet bulb outdoors (about 27 grains of moisture per pound of air) and 75°F dry bulb indoors. With the extremely low outdoor humidity it is no surprise that the latent load will be near zero. The capacity of the installed equipment at design conditions was estimated from manufacturers' data for a dry coil corrected to 105°F outside and 75°F inside. The average design capacity of the equipment installed per house is 43,686 Btu/hr. This capacity represents an average 33% oversizing when compared to the calculated design loads. This percentage of oversizing is less than PEG has found in previous work and is inconsistent with the submetered air conditioner data from Nevada Power. For this reason the effect of two levels of oversizing were tested in the final calculations.

SUMMARY OF FIELD FINDINGS

The new homes in this sample were relatively air tight with up to 30% that may not meet ASHRAE ventilation standards in the summer with the windows closed. The measured supply duct leakage averaged 9% of the air handler flow. Return leakage was approximately of the same size (9.3%). Significant problems were also found with the air conditioners which exhibited low flow and were incorrectly charged over half the time. These findings are consistent with similar investigations (See Appendix A). Table 2-4 summarizes the key results from the field investigation.

Table 2-4
Summary of Field Findings

	Shell	Ducts		Air Conditioner				
	Leakage	Operating Leakage (% of flow)		Rated Capacity	EER	Air Flow	Charge	
	CFM50	Supply	Return			cfm/ton		
Unit Mean		9%	9%	41278	9.2	345	Correct	21%
House Mean	2022			55037			Under	29%
Std Deviation	485	5%	7%	9766	0.3	81	Over	50%
Median	1925	7%	7%	40000	9.0	346		
Minimum	1000	2%	2%	21600	8.8	207		
Maximum	2850	24%	39%	59000	9.9	527		

3

ACHIEVABLE IMPROVEMENTS AND THEIR COSTS

Once the nature and extent of the problems were defined in the field investigation, PEG staff investigated the realistically achievable improvements that could be made to the duct and air conditioning systems and the associated costs. Improvements examined include: sealing the ducts, using better insulated ducts, properly installing and testing the air conditioner, and increasing the peak EER of the air conditioner by two points.

- PEG staff accompanied duct installers for several installations to assess work methods and estimate the additional time and materials needed to properly seal the systems with mastic and ties. The incremental cost is estimated at $95 per system, $50 for materials and $45 for 1 hour of extra labor. Based on prior experience with systems in California, Florida, and North Carolina, PEG estimates that total duct leakage of 75 CFM25 per system is realistically achievable on every new unit[11]. This opportunity is effectively lost if the ducts are not sealed when the house is being built. On a retrofit basis the cost would exceed $200 and the final leakage would exceed that achievable upon construction.
- The prime manufacturer of the "bag" duct systems for Las Vegas estimated the extra cost for doubling the insulation level to R-8 at about $140 per house ($490 per system compared to the current average of $350).
- PEG estimates that properly installing and testing an air conditioner (including proper evacuation, proper charge, checking capacity and EER) requires an extra 1.5 hours per system at an incremental cost of about $68. There is also a material savings from using less refrigerant[12].
- Using a properly sized air conditioner (about one ton reduction after system improvements) will save $100 per air conditioner.
- The incremental cost of an air conditioner with a two point higher peak EER[13] is estimated at $350 per system based on price quotes from 5 manufacturers.

[11] Researchers and practitioners have a variety of opinions on the proper specification. Some argue for a more stringent standard based on the potential gains from a well sealed distribution system. Some argue for a less stringent standard based on the level of success they have had while using contractors with little training and little or no follow up. Seventy five CFM at 25 pascals is a standard that is achievable with the contractors PEG observed in Las Vegas, if adequate training and follow up is supplied. A more stringent standard could be met with significant sealing of the air handler. Twenty five pascals was chosen as the test pressure because it is closer to the average pressure across the duct leaks than 50 pascals. Seventy five CFM at 25 pascals is approximately equal to 118 CFM at 50 pascals.

[12] For approximately $25 contractors could install TXV metering devices in place of fixed metering devices. TXV's are less sensitive to incorrect charge. Local contractors however are concerned over TXV failures. Until their concerns are adequately investigated specifying TXV's would probably not be productive. They are more likely to agree that the correct amount of charge should be in the system.

[13] Peak EER and SEER are not equivalent. Peak load reductions are not assured by increasing SEER. (SOURCE: Proctor, et al, 1994)

The benefits of these potential improvements were assessed through detailed modeling of air conditioner and duct performance.

4

MODELING IMPACTS ON USAGE & PEAK DEMAND

The field investigation found opportunities for potentially significant improvements in system efficiency. Assessing the impacts of the identified problems and their solutions on energy usage and peak demand requires an analysis which models the air conditioner, duct system, and building shell and incorporates the interactions between them. For example, when a leaky return draws air from the attic it raises the temperature at the inlet to the indoor coil resulting in an increase in air conditioner capacity and watt draw. PEG has adapted the Palmiter Duct Model (SOURCE: Palmiter and Bond, 1991) and created an AC model for dry climate performance. These models are combined into a comprehensive model that incorporates many of the complex interactions in the systems studied. The model calculates system efficiencies, losses, loads, energy usage, and demand at a series of outdoor temperature bins based on a typical weather year (TMY) in Las Vegas.

A realistic analysis of peak demand impact also requires characterizing the effect of occupant behavior patterns on actual cooling demand. PEG has developed a model which utilizes submetered air conditioner data to characterize the interactions between occupant behavior patterns/cooling load and effective capacity. This peak model (Model P) significantly improves upon most existing peak models which usually model peak from one general residential AC demand curve.

AIR CONDITIONER PERFORMANCE MODELING

Air conditioner performance can be characterized at given conditions by system capacity and EER. These two quantities can be used to calculate the power draw and, along with air handler flow rate, the temperature drop across the indoor coil. System capacity is modeled as a function of outdoor temperature, return plenum temperature, air handler flow rate, and charge. The model assumes a nearly dry coil given local climate. EER is modeled as a function of outdoor temperature, return plenum temperature and charge. The air conditioner model return plenum temperature is calculated from the duct system model.

For both capacity and EER, each factor effecting performance is represented as a multiplicative adjustment to the rated value. The adjustment factors are based on available published data and studies by PEG. This model is discussed in Appendices B and C.

DUCT EFFICIENCY MODELING

The impacts of duct leakage and conduction on effective system efficiency and building loads is complex. Duct leakage can cause four types of efficiency losses:

- the supply air that leaks to the exterior is a direct efficiency loss;
- the return air coming from outside and spaces warmer than outside (e.g. the attic) adds to building loads;
- the supply and return flows increase the air leakage rate of the building shell depending upon the relative size of the flows and the building's natural infiltration rate;
- when the air handler is off, the duct leaks still add to the building shell leakage rate.

Each of these effects is accounted for in the duct efficiency model. The model inputs include the supply and return leak fractions (as a percentage of the air handler flow rate[14]), the temperature of the air surrounding the return ducts, and the natural air leakage rate of the building shell (based on the blower door test and a limited implementation of the LBL infiltration model).

Conductive heat gain into the ducts is modeled as a function of duct area, R-values, the temperature of the air around the ducts (which depends on outdoor temperature and duct location), and the temperature of the air in the ducts (which depends on the air conditioner capacity, duct air flow, and duct leakage rate). Duct conduction losses are dependent on the duty cycle of the air conditioner and as such are dependent on the relationship between the load, capacity, and duct size.

The leakage and conduction models interact in terms of calculating return plenum and average supply duct temperatures and in avoiding any "double-counting" (e.g., the efficiency loss due to conductive gains into the portion of supply air which leaks out of the ducts is not included).

ENERGY USAGE MODELING

All of the duct-related losses are expressed in terms of percentage efficiency losses to the air conditioning system. The effective capacity of the air conditioner is calculated as the system capacity at given conditions adjusted for duct efficiency losses. The building shell load is calculated as a piece wise linear response to outdoor temperature. The effective capacity and the building shell load are used to calculate the duty cycle, which is used to calculate the hourly energy usage (adjusted for cycling losses). These calculations are performed at each of several different outdoor temperature bins and the results are combined by weighting by the number of hours at that temperature each year in Las Vegas to arrive at an annual energy usage rate. The energy usage model assumes that all units are controlled by a constant thermostat setting (75°F). Occupant interactions other than constant temperature setting are modeled for the peak demand model.

[14] Because duct leakage rates are specified as a percentage of the air handler flow rate, an increase in system air flow leads to an increase in duct leakage. This approach assumes that air handler flows are increased through means which increase static pressures in the ducts (e.g. increasing fan speed), not decrease static pressure (e.g. by increasing the size of the ducts).

PEAK DEMAND MODELING (MODEL P)

The diversified demand of air conditioning systems during system peak involves more than simply modeling performance and efficiency during peak conditions. Occupant behavior patterns can have a large influence on actual demand during peak. Some households (Group A) have no air conditioning use during peak. These homes may be unoccupied at that time or the occupants have the air conditioner switched off. Other households may have the air conditioner running continuously (Group D). This is the case because often occupants have adjusted the thermostat down. Another group of households (Group B) have their air conditioners cycling on and off based on thermostatic control. Some households may effectively have a constant thermostat setting in the period of interest but the effective capacity of their air conditioning system is less than the load. These households (Group C) have air conditioners running continuously, but some achievable reduction in load or increase in effective capacity would result in them cycling. The proportion of households in each of these categories must be estimated to arrive at reasonable estimates of diversified peak demand.

PEG received two samples of existing load research data from Nevada Power in order to estimate the proportion of households in each of the above customer groups during system peak times (4-5 PM on hot weekdays is the residential and system peak for Nevada Power). Both load data samples are from customers participating in a load management program which cycles their air conditioners on and off during peak times on particular days. These customers may or may not represent the new construction market in terms of demographics, behavior patterns, building shell characteristics, or air conditioning equipment. Sample #1 consisted of data from July 12 to August 20, 1992 for 40 primary air conditioners (the second unit in two air conditioner households was not metered). Sample #2 was selected with particular effort to represent typical customers in terms of usage levels and demographics. This sample was from a metering project of 78 primary and secondary air conditioners begun in the summer of 1994 and data from three uncontrolled hot days were available for the analysis.

In order to increase confidence in the results, an additional set of data was obtained from the EPRI Center for Electric End-Use Data. Sample #3 consisted of 136 air conditioners located near 18 different weather stations in hot climates. Submetered data on new homes in the Las Vegas area were not available.

PEG analyzed the available load data from all three samples and classified each customer-peak hour into one of the four groups. Mean connected loads were also calculated by group in order to assess inter-group differences. The average duty cycle of Group B customers on peak hours was also analyzed. The percentages of customers in each class for each sample are shown in Figure 4-1.

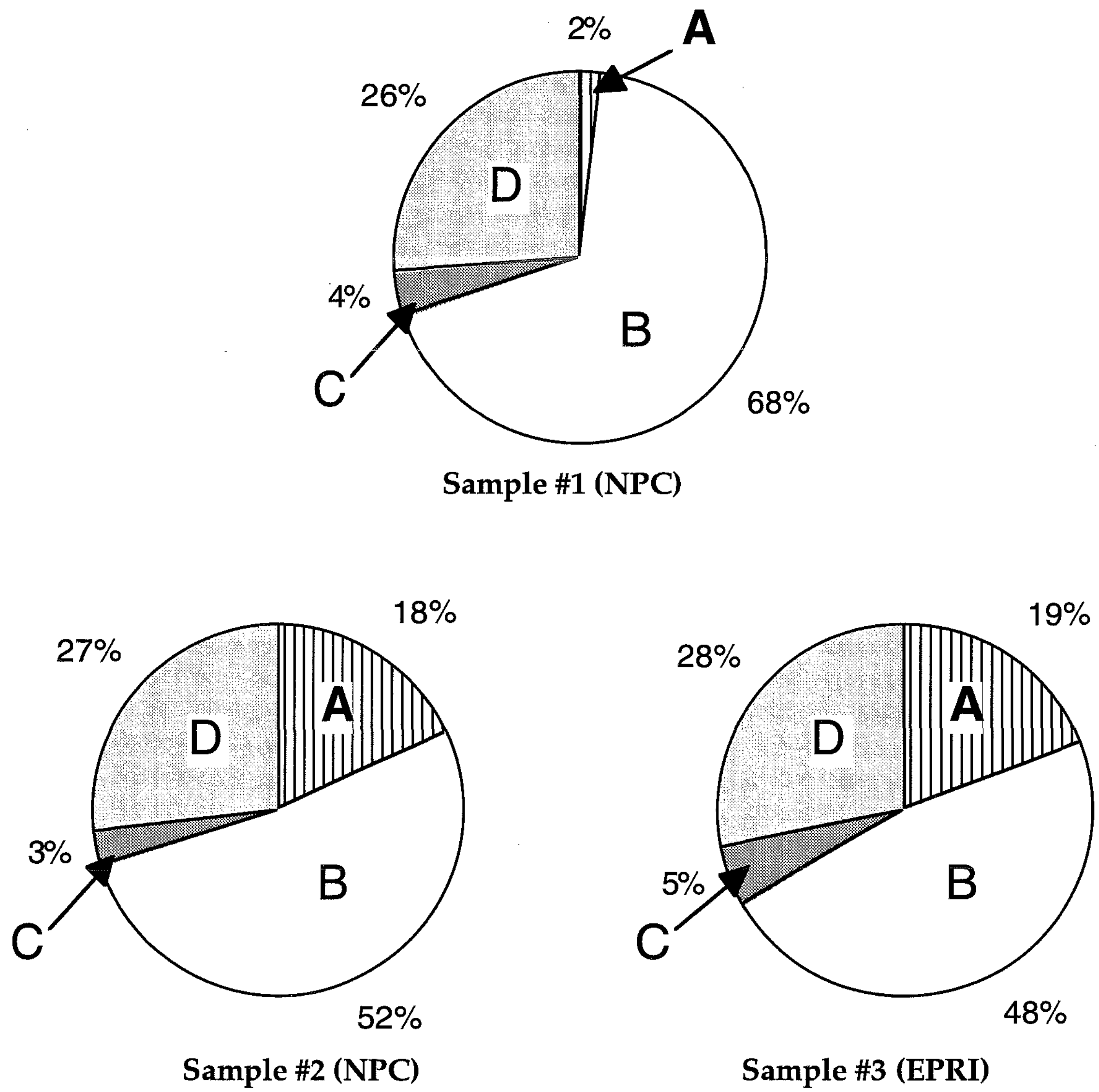

Figure 4-1
Model P Classes from Submetered Samples

Since demographic and other variables indicate that Sample #1 is not representative of NPC's new residential customers, the data from Sample #2 were used to classify the mix of customers assumed to occupy new construction in Las Vegas.

The actual cooling loads for the new houses inspected in this program are not known. However, when the effective capacity equals the actual load, the duty cycle of the equipment will be 100%. For homes that are in Class B/C in the NPC #2 data, the underlying duty cycle at 112°F is 67.9%. The sensitivity of the results to actual loads in these new homes was assessed by modeling a cooling load that produced an underlying average duty cycle of 67.9% (lower cooling load) and a cooling load that produced an underlying duty cycle of 77.9% (higher cooling load).

The data used in the model is summarized in Table 4-1.

Table 4-1
Model P Classes Used in Comprehensive Model

	Group A System Off	Group B/C Cycling or could cycle	Group D Continuous
Connected Load (kW)	5.09	4.69	4.48
Underlying Duty Cycle (lower cooling load)	0%	67.9%	100%
Underlying Duty Cycle (higher cooling load)	0%	77.9%	100%
Percent of Customers	18.1%	55.1%	26.8%

The data in the table are used to adjust the system modeling results by Model P class. The diversified demand is calculated as the weighted sum of the demands of the four groups. Group A households have no demand at peak. Group D households' demand equals their modeled connected load (adjusted by the relative loads of a D household to an average household). Group B and C households are in a constant thermostat setting mode and their duty cycle changes as different scenarios are modeled. This is discussed in Appendix B.

SUMMARY OF MODEL INPUTS

The cooling model requires information on numerous aspects of the air conditioner, the duct system and its surroundings, and the building shell. Table 4-2 describes the inputs and the sources used in this project. A more detailed description of model and data sources is provided in Appendices B and C.

Table 4-2
Model Inputs & Data Sources

Category	Model Input	Source / Assumption
Temperatures	Outdoor Temperature	Bin data for Las Vegas, peak of 115°F
	Indoor Temperature	Assumed at 75°F
	Temperature surrounding ducts	weighted average of outdoor and attic temperatures (assumed 20°F higher than outdoor) based on field-estimated location breakdown for supply and return
	Temperature of infiltrating air	assumed 40% from attic, 60% from exterior
Duct System	Supply & return leakage fractions	based on Duct Blaster™ tests, air flow test, and operating pressure measurements
	Duct leakage % of shell leakage	based on Duct Blaster™ test and blower door test
	Duct Area (square feet.)	based on # of runs, sizes- checked with manufacturers.
	Duct R-Value	R-4 based on insulation thickness - checked with mfr.
Air Conditioner	Rated capacity & EER	from nameplate information and published values
	Air Handler Flow	from field tests using flow hood and duct leakage
	Charge	from field tests - assuming under/overcharged are each 20% off[15]
Building Shell	Cooling load	Two levels of load (lower and higher) tuned to two different duty cycles
	Airtightness (CFM50)	from blower door test

MODELING RESULTS - BASELINE CONDITIONS

When applied to the 40 systems tested in the field investigation, the energy and demand models predict an average annual cooling load of 2948 kWh with 3.18 kW of diversified demand at system peak (2588 kWh and 2.99 kW for the lower cooling load model runs). The annual consumption compares favorably with the annualized consumption of 3160 kWh [16] of the primary units in Sample #1. Duct-related efficiency losses average 37% of system capacity with 23% due to leakage and 14% due to conduction. Problems with air conditioner system air flow and charge account for 12% of usage but have no net effect on peak demand.

The estimated impacts and costs of potential improvements to new residential construction in Las Vegas are summarized in Tables 4-3 and 4-4 (Appendix E contains summary tables for both sizing assumptions and detailed output tables). Table 4-3 shows the savings and peak reduction potential without resizing the air conditioners and Table 4-4 shows the same information if the air conditioners are resized to an actual 35% oversize at design. It is estimated that builders can be convinced to install air conditioners with an actual capacity that exceeds actual load by only 35%. Convincing builders and HVAC contractors will probably require additional field testing of sizing methodologies.

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[15]An assumptions of 20% under or over charge keeps the model within the range of known effects and is conservative relative to the level of incorrect charge that is measured in the field.

[16]Normalized to the connected loads of the new construction units.

Table 4-3
Estimated Program Impacts & Costs (without resizing)

Program Design Elements	Direct Cost	Savings			
		kWh	% (95% CI)[17]	kW	% (95% CI)
Baseline - Systems as found	0	2948		3.18	
A. Restrict Duct Leakage to 75 CFM25 total	\$95	544	18% (±4.5%)	0.45	14% (±2.7%)
B. Duct Lkg 75 & R-8 Duct Insulation	\$235	769	26% (±5.3%)	0.67	21% (±3.3%)
C. Correct AC charge and air flow rate	\$68	364	12% (±2.9%)	0.03	1% (±3.1%)
D. Duct Lkg 75, Charge, Air flow	\$163	870	30% (±5.6%)	0.54	17% (±4.4%)
E. Duct Lkg 75, R-8, Chg/flow	\$303	1034	35% (±6.1%)	0.71	22% (±4.7%)
F. EER 2 higher, Chg/flow	\$418	827	28% (±3.8%)	0.60	19% (±3.4%)
G. All of the above	\$653	1377	47% (±6.8%)	1.16	36% (±5.1%)
H. Shade Windows	N/A	348	12% (±1.1%)	0.19	6% (±1.2%)
I. Shade Windows + all of the above	\$653+	1578	54% (±7.2%)	1.29	41% (±5.4%)

[17]See Appendix D for a discussion of sample variability and overall uncertainty.

Table 4-4
Estimated Program Impacts & Costs (units resized to Manual J tuned to an average duty cycle of 1/1.35 @ Design)

Program Design Elements	Direct Cost	Savings kWh	% (95% CI)[18]	kW	% (95% CI)
Baseline - Systems as found	0	2948		3.18	
A. Restrict Duct Leakage to 75 CFM25 total	$95	410	14% (±4.6%)	0.70	22% (±3.0%)
B. Duct Lkg 75 & R-8 Duct Insulation	$235	691	23% (±5.1%)	1.04	33% (±3.4%)
C. Correct AC charge and air flow rate	$68	281	10% (±2.9%)	0.28	9% (±3.4%)
D. Duct Lkg 75, Charge, Air flow	$163	705	24% (±5.4%)	0.87	27% (±4.2%)
E. Duct Lkg 75, R-8, Chg/flow	$303	944	32% (±5.9%)	1.18	37% (±4.6%)
F. EER 2 higher, Chg/flow	$418	758	26% (±3.8%)	0.80	25% (±3.8%)
G. All of the above	$653	1303	44% (±6.6%)	1.54	48% (±5.1%)
H. Shade Windows	N/A	262	9% (±1.5%)	0.39	12% (±2.0%)
I. Shade Windows + all of the above	$653+	1487	50% (±6.9%)	1.72	54% (±5.3%)

These tables show that there are a number of potentially attractive options for reducing cooling usage and peak demands at reasonable incremental costs. For example from Table 4-3, Design B, which only improves the duct system, should save about 26% of the energy usage and reduce peak by about 21%. If the installed air conditioner is properly sized to the new load as shown in Table 4-4, the energy savings drops to 23% but the peak reduction increases to 33%.[19]

Design F, which involves the selection and installation of the air conditioner shows a 28% energy savings and 19% peak reduction. With resizing, this design has an energy savings of 26% and a peak reduction of 25%.

Design G, which includes all contemplated duct and air conditioner measures could reduce usage by as much as 47% and peak demand by up to 36%. If south and west facing windows are also provided with external shading the total savings is even higher (Design I).

NOTES ON THE COMPREHENSIVE MODEL

The comprehensive model used in this study is unique in modeling many of the interactions between the ducts, air conditioner, and building shell. At the same time it, like all models, is based on simplifications of the systems involved. Additional research

[18] See Appendix D for a discussion of sample variability and overall uncertainty.

[19] For a discussion of interactions see Appendix C.

is needed on air conditioner performance in hot/dry climates under peak conditions, particularly with typical field conditions (other than "correct" charge and air flow).

Actual cooling loads are highly subject to customer interactions and only metered data can accurately determine the relationship between cooling demand and cooling capacity. For that reason cooling loads were modeled at two different levels in this study. The results of this sensitivity analysis show that the percentage energy savings and percentage peak reduction is only mildly effected by assumptions about cooling load within the expected range. For example from Tables 4-3 and E-3, the energy savings under Design A (reduced duct leakage) changes from 18% to 19%. The assumption of a constant 75°F thermostat setting and cooling loads that increase linearly with outdoor temperature[20] are simplifications that effect the absolute energy consumption numbers much more than they effect the percentage savings. An analysis of hourly sub-metered usage patterns from similar newly-built houses could be used to "true-up" these percent savings estimates to typical usage levels.

The highest levels of savings are most subject to uncertainty because they result from complex interactions. Proctor Engineering Group recommends that these savings and peak reductions be verified by metering a sample of buildings.

[20] The model assumes a cooling load (including solar gain) that increases linearly with outdoor temperature from 80°F to design (106°F). The cooling load above design is assumed to have a constant solar gain component and a conductive component that is linear with outdoor temperature.

5

CONCLUSIONS AND RECOMMENDATIONS

Newly constructed homes in Nevada Power Company's service territory have substantial deficiencies in their cooling systems, similar to those found in studies from other parts of the country. Moderate cost improvements can be achieved to lower energy usage and demand while improving occupant comfort and satisfaction.

CONCLUSIONS

- Duct leakage and existing duct insulation levels cause an average loss of 37% in overall cooling efficiency. Reasonable improvements can eliminate over half of these losses (save 26% ± 5% of the cooling energy) for about $235;
- Air conditioners often have insufficient air flow across the indoor coil and are frequently overcharged, leading to a 12% ± 3% average efficiency loss. Proper installation (following the manufacturers installation instructions) and testing would remedy these problems at a cost of about $68;
- A program (Design G) which ensures tight, well-insulated ducts and properly installed efficient air conditioners could reduce cooling usage by approximately 47% and diversified peak demand by 1.2 kW. The additional cost is estimated to be $650 per unit;
- Peak demand is particularly effected by the connected load[21] of the air conditioner (for some groups of customers reducing connected load is the only way to reduce peak demand). Air conditioners can be installed with lower connected load (via lower capacity) if the systems are operating properly. Resizing the air conditioner is also a more certain change in peak than relying on the effect of duct tightness (or other program elements) alone. If air conditioners were resized to take advantage of properly installed efficient systems featuring well insulated tight ducts (Design G) peak demand would be reduced by an additional 0.4 kW.

NPC has a variety of potentially worthwhile options for improving cooling efficiency and reducing peak demand. Proper program design, training, and quality assurance are critical issues for actually achieving these improvements. These topics are the focus of a follow-up report under this project.

RECOMMENDATIONS

1) Program implementation should begin with a number of submetered houses (comparison and experimental) to verify the model results and to determine the achievable level of capacity reduction.

[21]Connected load is Capacity/EER. Connected load is not a constant for air conditioners, it increases with outdoor temperature (and other variables).

2) In order to ensure peak reduction, improvements on system installation and design should be accompanied with reductions in air conditioner capacity.
3) If air conditioner capacity is reduced, it is recommended that the duct systems remain the same size to reduce static pressures and improve air flow.
4) If recommendation #3 is followed, it is essential that duct insulation be increased.
5) Air handler manufacturers should be enlisted to work with utilities toward the common goal of building tighter air handling units, which are the cause of significant distribution system leaks and are outside the influence of the local installer;

The following additional research is recommended:

- Air conditioners on a sample of newly constructed homes in Las Vegas should be submetered. This can be combined with the first recommendation above.
- Air conditioner performance should be laboratory tested under a wide variety of operating conditions (air flow, charge, indoor temperature, and outdoor temperature) and system types. This would assist in modeling the air conditioner under peak conditions "typical" to Las Vegas.
- New construction air conditioner installation practices in Las Vegas should be observed. The results would allow refinement of program specifications.

REFERENCES

Cavalli, J. and J. Wyatt, 1993. "Interpreting Impact Evaluation Results to Defer Local T&D Investment". 1993 International Energy Program Evalution Conference, Chicago, IL.

Cummings, J., J. Tooley Jr., N. Moyer and R. Dunsmore. 1990. "Impact of Duct Leakage on Infiltration Rates and Pressure Differences in Florida Homes." Proceedings from the ACEEE 1990 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, D.C.

Cummings, J., R. K. Vieira, J. K. Sonne, and J. Klongerbo. 1994. "Residential Air Conditioning Sizing Methodology Draft Final Report". Submitted to Department of Community Affairs, Florida Energy Office, Tallahassee, FL.

Farzad, M. and D. O'Neal. 1988. "An Evaluation of Improper Refrigerant Charge of a Split-system Air Conditioner with Capillary Tube Expansion - Final Report", Energy Systems Laboratory, Texas A&M University, ESL/CON/88-1.

Gammage, R.B . et al. 1986. "Parameters Affecting Air Infiltration and Airtightness in Thirty-one East Tennessee Homes". *Measured Air Leakage of Buildings*, pp. 61-69. Trechsel/Lagus, editors, ASTM STP940.

Hammerlund, J., J. Proctor, G. Kast and T. Ward. 1990. "Enhancing the Performance of HVAC and Distribution Systems in Residential New Construction." Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, D.C.

Jacob, M. and A. Zebedee, 1994. "The Day the Engineers Were Right: Confirming the Peak Demand Reductions of FPC's Air Conditioner Duct Test and Repair Program". Proceedings from the 1994 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington D.C.

Jacobson, R., J. Proctor and A. Polak. 1992. "PG&E Appliance Doctor Pre-Production Test." Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington, D.C.

Jump, D. A., and M. Modera. 1994 "Energy Impacts of Attic Duct Retrofits in Sacramento Houses." 1993 . Proceedings from the 1994 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington D.C.

Kinert, R.C., D Engle, J. Proctor, R. Pernick. 1992. "The PG&E Model Energy Communities Program: Offsetting Localized T & D Expenditures With Targeted DSM". Proceedings from the 1992 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington D.C.

Neal, L. 1990. "Field Experiences with Central Air Conditioners and Heat Pumps", AEC North Carolina Alternative Energy Corporation.

Neal, L. and D. O'Neal. 1992. "The Impact of Residential Air Conditioner Charging and Sizing on Peak Electrical Demand." Proceedings from the 1992 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington D.C.

O'Neal, D., C. Ramsey and M. Farzad. 1989. "An Evaluation of the Effects of Refrigerant Charge on a Residential Central Air Conditioner with Orifice Expansion". Energy Systems Laboratory, Texas A&M University, ESL89-06.

Orans, R. and C. Woo, and J. Swisher. 1991. "Targeting DSM for T&D Benefits: A Case Study of PG&E's Delta District". Electric Power Research Institute, Palo Alto, CA.

Palmiter, L. and T. Bond, 1991. "Interaction of Mechanical Systems and Natural Infiltration". Proceedings from the AIVC Conference on Air Movement and Ventilation Control within Buildings.

Palmiter, L. and P. Francisco, 1994. "Measured Efficiency of Forced-Air Distribution Systems in 24 Homes". Proceedings from the 1994 ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy, Washington D.C.

Parker, D.S. 1989. "Thermal Performance Monitoring Results From the Residential Standards Demonstration Program." *Energy Buildings*, pp 231-248.

Proctor, J., B. Davids, F. Jablonski, and G. Peterson. 1990. "Pacific Gas and Electric Heat Pump Efficiency and Super Weatherization Pilot Project: Field Technical Report". Pacific Gas and Electric Company, San Francisco, CA.

Proctor, J. 1991. "Pacific Gas and Electric Appliance Doctor Pilot Project: Final Report." Pacific Gas and Electric Company, San Francisco, CA.

Proctor, J. and R. Pernick. 1992. "Getting it Right the Second Time: Measured Savings and Peak Reduction from Duct and Appliance Repair." Proceedings from the ACEEE 1992 Summer Study on Energy Efficiency in Buildings American Council for an Energy Efficient Economy, Washington, D.C.

Proctor, J. 1993. "Estimating Peak Reduction from Submetered Data." 1993 International Energy Program Evalution Conference, Chicago, IL.

Proctor, J., M. Blasnik, B. Davis, T. Downey, M. Modera, G. Nelson and J. Tooley. 1993. "Diagnosing Ducts: Finding the Energy Culprits". Sept/Oct 1993 *Home Energy* pp 26-31.

Proctor, J., Z. Katsnelson, G. Peterson, and A. Edminster. 1994. "Investigation of Peak Electric Load Impacts of High SEER Residential HVAC Units". Pacific Gas and Electric Company, San Francisco, CA.

Rice, C. 1991. "The ORNL Modulating Heat Pump Design Tool – User's Guide". Prepared for the U. S. Department of Energy.

Tooley, J. Jr. and N. Moyer. 1989. "Mechanical Air Distribution and Interacting Relationships". Proceedings from Symposium on Improving Building Systems in Hot and Humid Climates, pp. A24-31. Texas A&M University, College Station, TX.

GLOSSARY

97.5% Design - ASHRAE published values for outdoor design temperature that will be exceeded on average 73 hours of the summer months (June through September).

ACCA Manual J - Residential heating and cooling load estimation methodology published by the Air Conditioning Contractors of America.

Air Changes per Hour (ACH) - The number of times that air in the house is replaced with outdoor air in one hour.

Air Handler - The fan and cabinet assembly that moves air across a heat exchanger and through a duct system.

Blower Door - A large variable speed fan fitted with flow and pressure measuring devices. It is mounted in a doorway to measure the leakage of a structure.

Capacity - The amount of heat added to (heating) or removed from (cooling) a structure by the heating or cooling equipment.

Capillary Tube - A refrigerant metering device that utilizes fixed diameter and length of tubing to control the flow of refrigerant.

CFM50 - A measurement of the house air leakage based on the air flow necessary to maintain a 50 pascal pressure differential between the house and outside.

Charge - The quantity of refrigerant in a system.

Connected Load - The amount of power draw when the unit is running continuously.

Design Cooling Load - The heat gain of a structure at the ASHRAE 97.5% design outdoor temperature and 75°F dry bulb 62°F wet bulb indoors (expressed in Btu/hr).

Diversified Peak Demand - The amount of power draw realized by the utility during their peak period for a particular end use for the customers that have that end use.

Dry Bulb Temperature - The temperature measured using a common thermometer.

Duct Blaster™ - Similar to a small blower door, this device is used to test the leakage of a duct system.

Duct Leakage (Exterior) - The leakage of the duct system to outside the structure.

Duct Leakage (Total) - The leakage of the duct system including unintentional leakage to inside and outside the structure.

Duty Cycle - The percentage of time that an end use is on during a specified period.

EER - The Energy Efficiency Ratio. The capacity of an air conditioner (in Btu/hr) divided by the electrical input (in watt hours).

Effective Capacity - A rating of the systems true operating capacity adjusted for duct losses experienced.

Evacuation - The removal of gases from a closed refrigerant system until the pressure is below atmospheric pressure.

Evaporator - The heat exchanger (coil) in a refrigerant system that removes heat thus boiling the refrigerant.

Flow Hood - A calibrated air flow measurement device.

Group A - The group of customers shown through Model P to have their air conditioners off during peak.

Group B - The group of customers shown through Model P to have their air conditioners cycling on and off during peak due to thermostatic control.

Group C - The group of customers shown through Model P to have their air conditioners running continuously during peak, but could be in Group B if some reduction of load or increase of effective capacity were implemented.

Group D - The group of customers shown through Model P to have their air conditioners running continuously during peak.

Half -Nelson - A methodology used to estimate the ratio between total supply leakage and total return leakage based on pressure measurements with all registers blocked.

HVAC - Heating, Ventilating and Air Conditioning.

Indoor Coil - The evaporator coil, located at the air handler, on an air conditioning system.

Latent Capacity - The amount of moisture removed by a cooling appliance.

Micron Gauge - A calibrated instrument used to measure vacuum in a closed refrigerant system.

Model P - A model that examines occupant behavior patterns to make adjustments to peak effects of various DSM options.

N factor - The infiltration/leakage coefficent. A conversion factor from blower door measured leakage(CFM 50) to modeled average infiltration rates, This factor is derived from a simplification of the LBL model.

Overcharge - The condition of an air conditioning system that has more refrigerant than is specified by the manufacturer .

Package Unit - An air conditioning system with all major components located in one cabinet.

Pascal - A small metric unit of pressure. One pascal is 0.000145 PSI.

Pressure Pan - A shallow pan placed over a supply or return grill with a blower door operating. The pressure measured at the pan is a qualitative indication of duct system leakage.

Return System - The portion of the duct system used to return air from a structure to the air handler.

Saturation - The temperature/pressure at which both the refrigerant liquid and vapor are present in equilibrium

SEER - The Seasonal Energy Efficiency Ratio, a comparative measure of an air conditioners efficiency, much like EER but rated at a much cooler outdoor temperature.

Sensible Capacity - The amount of heat added to or removed from a structure measured by dry bulb temperature.

Split System - An air conditioning system that has the condenser remotely located from the evaporator.

Static Pressure - A measure of pressure that is equally exerted in all directions within a given point of the duct system.

Subcooling - The difference in temperature between liquid refrigerant and saturated refrigerant at the same pressure.

Superheat - The difference in temperature between refrigerant vapor and saturated refrigerant at the same pressure.

Supply System - The portion of the duct system used to deliver conditioned air from the air handler to individual rooms.

Hourly Temperature Bins - The number of hours during the season that the outdoor temperature falls within the specified range.

Thermostatic Expansion Valve (TXV) - A refrigerant metering device that adjusts the flow of refrigerant to maintain a constant superheat at the exit of the evaporator coil.

Ton of Cooling - The amount of heat required to melt a ton of ice at 32°F in one hour (12,000 Btu/hr).

Unconditioned Space - The part of a structure that is not intentionally heated or cooled by the heating or cooling equipment.

Undercharge - The condition of an air conditioning system that has less refrigerant than is specified by the manufacturer.

Weighing in Charge - A method of charging refrigerant systems by using a scale.

Wet Bulb Temperature - The temperature measured by a thermometer covered with a wet wick with air blowing across it. The measured temperature is lower than the dry bulb temperature and is a measure of moisture in the air.

APPENDIX A: SUMMARY OF RELATED STUDIES

A number of previous studies have been conducted on duct systems and air conditioners in both new construction and retrofit applications. These studies were completed by Cummings et al., Hammerlund et al., Jacobson et al., Jump and Modera, Neal, Proctor et al. (1990) and Proctor (1991). Five of these studies included field monitoring of energy usage (Cummings et al., Jacobson et al., Jump and Modera, Proctor et al. (1990) and Proctor (1991). All but one of these studies examined impacts of retrofit improvements to the air conditioners and/or duct systems on previously constructed houses, while Hammerlund et al. dealt solely with newly constructed homes.

CUMMINGS ET AL.

In a comprehensive study of 91 "typical" Florida houses Cummings et al. (1990) studied the energy effects of duct leakage. Blower door tests were performed on 63 houses to determine the impact of duct leakage on infiltration rates in the house. Duct repairs were made on 25 houses and 24 of these houses had their cooling energy usage monitored before and after the duct repairs.

Tracer gas testing found that infiltration rates for the houses were four times greater when the air handler was operating than when it was off. The average Air Changes per Hour (ACH) for the 91 houses was 0.21 with the air handler off and it increased to 0.93 when the air handler was turned on. Tracer gas testing found that the Return Leakage Fraction (RLF) averaged 10%. Thirty percent of the houses tested had an RLF of greater than 10%, with the majority of the leakage coming from unconditioned attic space.

The blower door testing performed on 63 houses indicated that on average 11.7% of the total house leakage area was located in the duct system. While the duct system accounted for less than 1% of the volume of the houses, it was determined to cause 71% of the total house infiltration when the air handler was on.

In the 25 houses that received duct sealing work, it was found that on average 16% of the blower door measured house leakage area was attributable to duct leakage. Blower door testing indicated that the retrofit duct repairs reduced the average duct leakage by 68%. Tracer gas testing determined that the return leakage fraction for these homes were reduced from an average of 16.7% to an average of 4.5%. Measured cooling energy usage showed that 22% of the cooling energy usage was attributable to the duct leakage and an 18% reduction in cooling energy usage was realized after duct repairs were performed.

HAMMERLUND ET AL.

In an extensive study of newly constructed residences in the Los Angeles area 66 apartments and 12 houses with ducted heat pump systems were examined for installation practices and system performance[22]. Each residence was tested for problems in three major areas; duct leakage to the exterior, air flow through the indoor coil and refrigerant charge.

Even though the residences examined were newly constructed and most had received a utility financial incentive for installation of energy efficient heat pumps, significant deficiencies were found in all three areas.

The predominate problem in single family residences was duct leakage. The blower door testing performed on these houses indicated that the vast majority of the homes had excessive duct leakage over what could be reasonably achieved. Over 85% of the houses had supply leakage in excess of 50 CFM_{50} and 90% of the return systems had duct leakage in excess of 50 CFM_{50}. This duct leakage resulted in an increased cooling load of approximately 30%.

Low air flow through the indoor coil and incorrect charge were also found to be a problem in these residences. Only 30% of the houses tested had air flow within the manufacturers specifications for proper air flow. This low air flow made the checking of charge by manufacturers recommended procedures impossible on all but five of the houses. Of those five houses one was undercharged and the remaining four were overcharged.

The duct leakage to the exterior of the building was considerably lower on the multifamily residences tested. This was due to both shorter duct runs and lower operating pressures typical of multifamily residences. However, low air flow through the indoor coil proved to be a more serious problem in the multifamily residences tested. Less than 15% of the units tested had the correct air flow through the indoor coil. Two thirds of the heat pumps in the multifamily residences were incorrectly charged with 61% being overcharged and 8% being undercharged.

With interactive effects taken into account, the average energy savings opportunities for cooling single family residences was 38% and multifamily residences had average cooling savings opportunities of 18%.

JACOBSON ET AL.

This study of 250 single family residences evaluated the potential for implementing the lessons learned in previous Appliance Doctor™ studies to full scale production programs. The retrofit program focused on the problem areas of duct leakage to the exterior, low air flow through the indoor coil, and incorrect refrigerant charge.

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22 None of the houses tested were over two years old.

The project was split into two groups of air conditioned homes; randomly selected customers and high bill complaint/high AC usage customers. Thirty of the houses were monitored pre and post retrofit to evaluate the impact of the retrofit measures.

The study design was comprised of contracting, marketing, training, diagnosis and repair, and quality assurance components.

Contracting was structured in a fixed cost performance contract with two local HVAC contractors. Job completion was based on successful completion of set criteria and payment was made after each job successfully passed a technical review process. The fixed fee contracting structure proved to work well as long as the technical process review happened in a timely fashion.

Marketing was targeted to customers that were projected to have high seasonal cooling usage based on billing history data. A "seasonal swing" algorithm was created to indicate those customers with high seasonal cooling usage. Customers were offered services at a fraction of the cost they would normally incur for the repairs and their total end cost for the service was dependent on the services received. All customers received duct sealing but, not all customers needed air flow or charge repair so the end cost to the customer was prorated based on the services received. The straight forward direct mailing piece that was mailed out resulted in all 250 slots for the project being filled within two days. A customer survey showed that customer satisfaction was high (rated 4.4 on a scale of 5) and over half of the customers felt their system was operating more efficiently and would result in lowered energy costs.

The crew configuration that worked best was a two person duct sealing crew equipped with a blower door and other diagnostic tools followed by an HVAC specialist to service the air conditioner. The testing of the systems indicated significant problems with duct system leakage.

Eighty seven percent of the high bill complaint customers had duct leakage in excess of 150 CFM_{50} while 80% of the randomly selected had duct leakage in excess of 150 CFM_{50}. Low air flow through the indoor coil was determined to be a problem on 50% of the high bill complaint customers and 29% of the random customers. Problems with undercharged units were nearly equal (36% of the high bill complaint customers and 41% of the random customers). No overcharged units were detected in the random group while 27% of the high bill complaint group had overcharged units.

Submetering showed a cooling energy savings of 16% for the high bill complaint customers (21.5% if undercharged units are excluded) and 9% for the random customers. High usage customers proved to have a higher occurrence of problems with their systems and realized a greater benefit from the services provided. The "seasonal swing" methodology proved to be reliable at indicating customers likely to benefit from the program.

Quality assurance and training played an important role in the project and proved to be successful in providing a means for insuring quality work from HVAC technicians. The testing protocol, technical process review and prompt feedback continually improved technician performance and understanding of the program. Technical process review and feedback were a crucial control feature of the project that were required to be delivered in a timely fashion.

JUMP AND MODERA

This study examined the combined energy effect of duct leakage retrofit repair and the application of additional duct insulation on thirty houses with attic located duct systems. The energy effects were monitored on a total of 5 houses during the summer season and 6 winter season houses. The 6 winter season houses were all equipped with electric heating systems. Short term (~ 2 week) monitoring took place for both pre and post retrofit periods.

The extensive diagnostic testing included duct leakage testing, system air flow measurement, and measurement of normal operating static pressures within the duct systems. The monitoring included temperatures throughout the duct system, attic, and outside, as well as power consumption of all significant HVAC system components.

Testing found that supply and return leakage areas were nearly equal. However the return system leakage reduction averaged 73% while the supply system leakage reduction was only reduced by 56%. The greater success in sealing the return system was attributed to the leakage being concentrated in a few sites. Overall, approximately 64% of the duct leakage was eliminated and this sealing work reduced the house leakage area by approximately 14%. Increasing the duct R-value to an R-6 on both the plenums and the individual duct runs reduced conduction losses by an average of 33%.

NEAL

Neal performed an investigation into measured system performance on ten central air conditioning systems in North Carolina. The study was designed to compare the actual performance of the equipment to the manufacturers rated performance.

This study found that on average the air conditioners were performing at 70% of rated efficiency. Four of the ten units did not have proper of air flow through the indoor coil and five of the ten were incorrectly charged. It was noted that all of the units examined had at least one efficiency or service life problem.

PROCTOR ET AL. (1990)

Pacific Gas & Electric Company sponsored an investigation of heat pump operating efficiency for high bill complaint customers in the winter of 1989. This study was designed to identify major problems existing with heat pump installations and to design a system to correct those deficiencies. The study focused on the problem areas of low air flow through the indoor coil, incorrect refrigerant charge, excessive use of back-up heat strips, other control problems, shell leakage, and duct system leakage.

The study examined 51 heat pumps in 49 houses. Each of the houses was visited by a heat pump technician that used a set procedure to diagnose and repair problems with the heat pump. To quantify problems with the duct system and the building shell each of the houses was inspected with the use of a blower door. Three of the retrofitted houses were chosen for pre and post retrofit short term monitoring.

Technician visits identified at least one major problem in over 90% of the houses tested. Seventy three percent of these houses had received a recent visit by professional HVAC service personnel that had not found nor solved the problems identified in the study. Table A-1 lists the major problems found at the sites.

Table A-1
Problems Identified by House

Problems	Number of Houses with Problem	Problem Solvable Through Program
Diffuse Duct Leakage > 150 CFM_{50}[23]	33	25
Low Air Flow	24	19[24]
Incorrect Charge[25]	16	16
Disconnected Ducts	16	14
Refrigerant Leaks	10	10
Recirculation Through Outdoor Coil	9	0
Auxiliary Heat on First Stage	3	3
House Leakier Than 0.75 ACH	15	15

Savings projections indicated that duct leakage repair was the best option for lowering the customers high seasonal energy usage, followed by refrigerant charge correction, sealing of shell leakage sites , installation of auxiliary strip heat cut-outs , and correction of low air flow.

PROCTOR (1991)

A comprehensive study was commissioned by Pacific Gas & Electric Company during the summer of 1990 on 15 houses in Fresno, California to determine the potential energy and peak reduction savings of a program for residential air conditioners. During the study all houses were monitored for energy usage for a period preceding repairs and

23 Duct leakage was measured after all disconnected ducts had been repaired.

24 Low air flow on these units were caused by restrictive duct design. Modification of the duct system through adding runs or increasing duct sizing was outside the scope of this program.

25 The methodology used for checking charge in this study did not indicate units that were overcharged. Additionally only units that could be brought to correct air flow were tested for charge.

after repairs. The majority of the customers selected were high bill complaint customers.

All 15 of the houses had at least one major problem with the air conditioner or the duct system. Ninety percent of the homes had duct leakage in excess of 150 CFM_{50}. Duct leakage accounted for 14.7% of the total building shell leakage area. The average cooling load increase due to the duct leakage was 25%. The average retrofit duct leakage reduction achievable was 60%, with a corresponding monitored cooling energy savings of 18%.

Sixty seven percent of the systems had low air flow through the indoor coil. Cleaning resulted in an average increase in air flow of 16% . Fifty six percent of the air conditioners had an improper level of refrigerant charge.

All of the houses in the study experienced at least a 10% reduction in monitored cooling energy usage and a number of the houses experienced savings in excess of 30%.

DUCT SEALING PEAK EFFECT STUDIES

Valid estimation of peak day electrical usage for residential air conditioners and their duct systems are intrinsically difficult due to the fact that the evaluator is trying to predict an event that occurs rarely and is usually outside the measured data set. Additionally peak usage of air conditioners is driven by numerous variables (i.e. occupant behavior, outdoor temperature, relative humidity, time of day, sky cover, etc).

Proctor (1993) examined six analytical models using submetered data from the Appliance Doctor™ Pre-Production Project to analyze the strengths and weaknesses of the models at estimating peak reduction. All six models showed consistent results that peak reduction occurred in the early evening hours (local residential distribution peak) when duct systems were sealed. Peak reduction in the early afternoon hours (system peak) could not be proven due to the small size of the sample.

Cavalli and Wyatt (1993) examined a sampling of 240 submetered air conditioners from the PG&E Model Energy Communities Project. This study was designed to determine if there was any peak effect attributable to: 1) duct sealing on residential air conditioners and 2) early replacement of air conditioners that were oversized (as determined by ACCA Manual J) and had low rated EER's (this group also received duct repairs).

The results showed negligible peak operating impact from duct sealing of 0.04 kW. Replacement of air conditioners with correctly sized more efficient air conditioners was shown to be effective at reducing the peak operating impact by approximately 1.4 kW. The authors indicate the results of their analysis is limited by the fact that the data was from a cool summer where the maximum temperature never reached 100°F.

Jacob and Zebedee (1994) examined the peak impact of duct sealing using metered data from the Florida Power Corporations duct sealing program. The analysis showed an estimated average peak demand savings of 0.5 kW.

These three studies show that there is no absolute agreement on peak reduction attributable to duct sealing alone. Together however, they support the point that duct sealing combined with sizing reductions will reduce peak.

APPENDIX B:
COMBINED MODEL AND DATA SOURCES

The combined model presented in this report is composed of three primary sub-models: a duct loss model, an air conditioner performance model, and a residential air conditioner peak load model.

A schematic of these three models is shown in Figure B-1

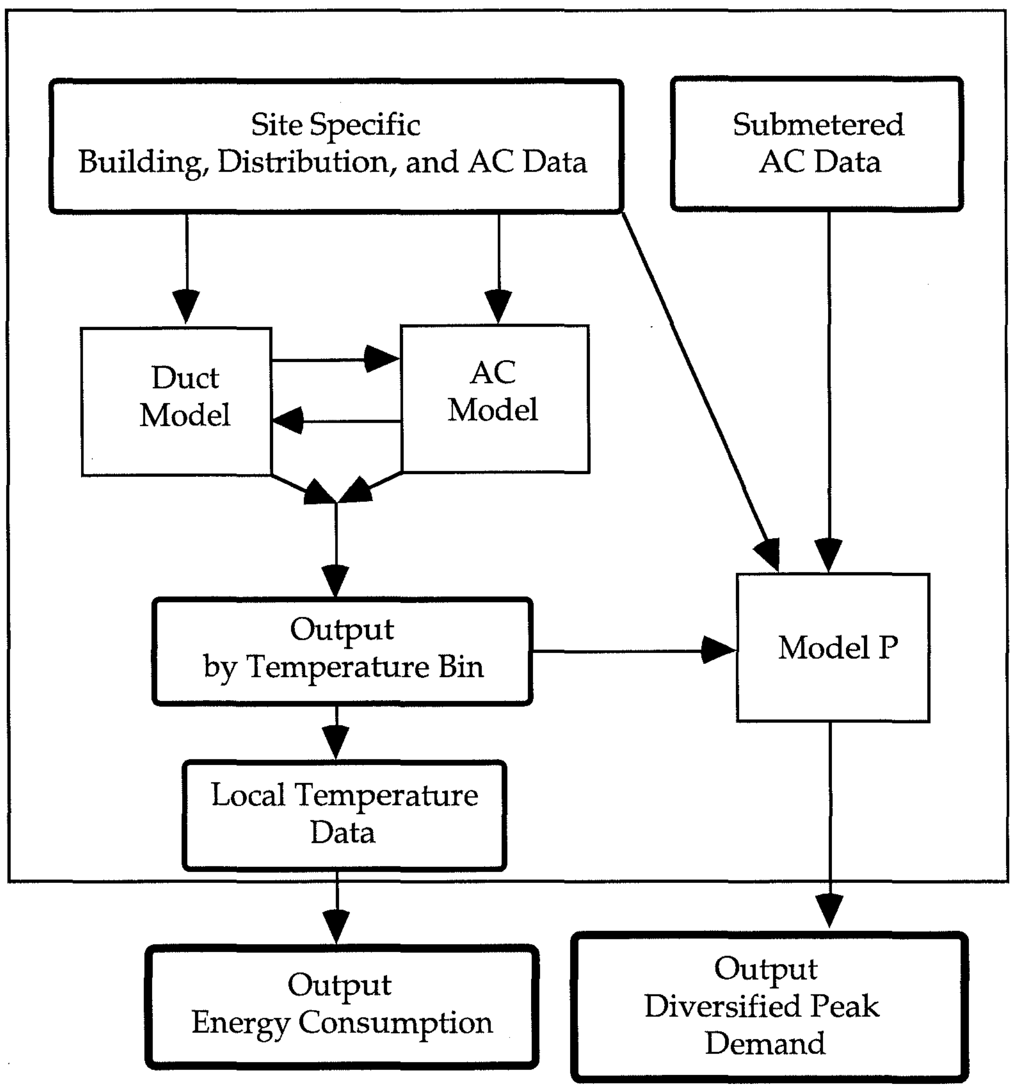

Figure B-1
Combined Model Schematic

DUCT LOSS MODEL

The duct loss model includes the impacts of direct leakage losses, induced building infiltration losses, and conductive losses. The model characterizes these losses as a loss of effective system capacity. The duct model also calculates return plenum temperatures and average supply air temperatures based on leakage and conduction rates and indoor and supply plenum temperatures.

The basic model including leakage and infiltration effects is the work of Palmiter (SOURCE: Palmiter and Bond, 1991). Proctor Engineering Group has added the effects of conduction and energy recovery (when supply leakage is mitigated by nearby return leaks and other recovery mechanisms) into that model.

The duct loss model is a steady state model. The losses are scaled to the duty cycle of the air conditioner for each temperature bin.

AIR CONDITIONER MODEL

The model calculates changes in capacity and efficiency due to:

- Outdoor temperature
- Refrigerant charge (capacity and efficiency generally peak at proper charge, but the effect is dependent on other variables)
- Return plenum wet bulb temperature (nearly dry coil)
- Return plenum dry bulb temperature
- Air flow across the indoor coil

The model also calculates the supply plenum air temperature based on the return plenum temperature, system capacity, and air flow rate.

The model draws on a variety of sources including:

- Laboratory tests of air conditioners with charge varied from 20% below to 20% above proper charge (SOURCE: Farazad and O'Neal, 1988 and 1989). These tests were conducted with outdoor coil inlet air temperatures from 82°F to 100°F.
- Simulation runs by Proctor Engineering Group for higher outdoor temperatures and lower indoor wet bulb conditions with MODCON, the air conditioner simulation program of Oak Ridge National Laboratory (SOURCE: Rice, 1991).
- Data gathered from major manufacturers on performance of air conditioners under nearly dry coil conditions.

The air conditioner model is a steady state model. The consumption is scaled by the duty cycle of the air conditioner for each temperature bin with an adjustment for cycling losses.

MODELED COOLING LOADS

Building shell loads for the combined energy consumption model were based on a constant temperature setting[1] of 75°F. These cooling loads (including solar gain) were assumed to increase linearly with temperature from 80°F to 106°F. The cooling load above 106°F was assumed to have a constant solar gain component and a conductive component that is linear with outdoor temperature. Building shell load was used to tune the model to match the average duty cycle of "thermostatically controlled" units in the submetered data. An alternative duty cycle 10% higher was also used to assess the sensitivity of the results to alternative cooling loads.

PEAK LOAD MODEL (MODEL P)

Model P includes all the impacts both known and unknown that effect occupant behavior to produce a given duty cycle at peak. These effects are nested in the empirical base for Model P - submetered air conditioner data from peak hours. The output from Model P is the diversified demand of the residential air conditioners under varying scenarios.

Model P divides residential air conditioners into four groups. Group A consists of air conditioners that are not operating on peak. On peak, Group B and C air conditioners cycled (Group B) or potentially cycled (Group C) by the thermostat. Group D air conditioners run constantly on peak and would do so even if substantial improvements were made in the effective capacity of the system. The breakdown of groups used in this study is shown in Figure B-2.

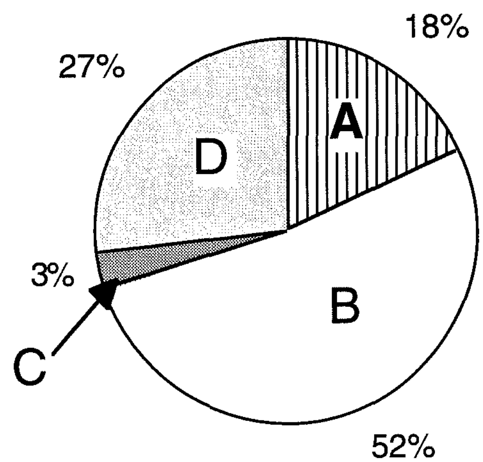

Figure B-2
Incidence of Model P Classes

[1]For the diversified peak load model (Model P) only a portion of the units were modeled as "thermostatically controlled" (Groups B and C).

In addition to differences in air conditioner control, Groups A. B/C, and D have somewhat different connected loads at peak. The connected loads for this study are illustrated in Figure B-3.

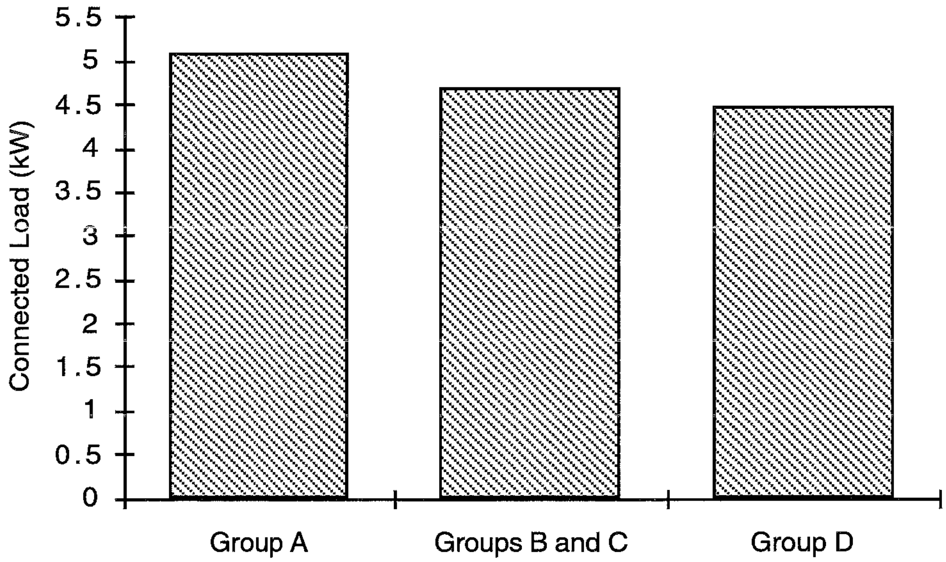

Figure B-3
Connected Load by Model P Class

The output from Model P is the diversified demand of the residential air conditioners under varying scenarios. The diversified demand is calculated as the weighted[2] sum of the demands of the four groups. The demand of the four groups are:

- Group A air conditioners have no demand at peak
- Group B and C air conditioners have a peak demand that is dependent on the ratio of the cooling load to the effective capacity of the unit (duty cycle). Under different scenarios, the duty cycle will change. The baseline condition for this study is an underlying duty cycle for B's and C's of 67.9%. The loads for the combined model were tuned to this duty cycle so the output from that model is the peak demand for Groups B and C.
- Group D demand equals their modeled connected load. The connected load (which is dependent on outdoor temperature, return plenum temperature, refrigerant charge, and indoor coil air flow) is an output from the combined air conditioning and duct model adjusted by the relative loads illustrated in Figure B-2.

Model P was developed by Proctor Engineering Group in order to improve predictions of peak effects from alternative technological options. The data used to build Model P for this study came from three sources:

[2]weighted by their occurrence in the submetered data

- Nevada Power Company Sample #1 - data from July 12 to August 20, 1992 for 40 primary air conditioners (the second unit in two air conditioner households was not metered) for customers participating in a load management program.
- Nevada Power Company Sample #2 - data for 78 primary and secondary air conditioners begun in the summer of 1994. These customers also participate in a load management program.
- EPRI Center for Electric End-Use Data Sample #3 - data for 136 air conditioners located near 18 different weather stations in hot climates. These customers do not participate in a load management program.

The duty cycles for Groups B and C from the submetered data are distributed as shown in Figure B-4.

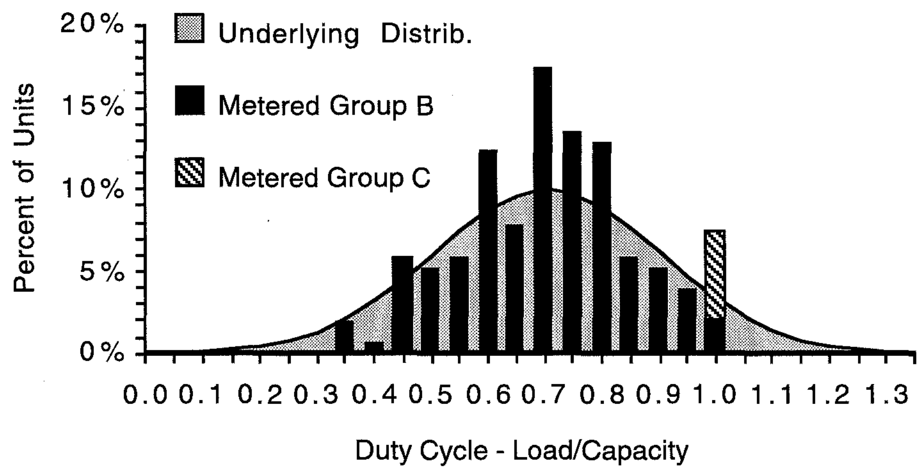

Figure B-4
Duty Cycle of Submetered Sample and Underlying Duty Cycle

The duty cycling rates for Groups B and C were used to estimate an underlying mean and standard deviation for a "normal" distribution that would approximate the observed duty cycles. The underlying mean for the baseline case was .679. The real duty cycle cannot exceed 1.0 (units that would have a duty cycle of greater than 1.0 are Group C) and therefore the "normal" curve is constrained to no greater than 1.0 giving a spike at that point. Reductions in load or increases in effective capacity will shift this distribution to the left, reducing the mean duty cycle and decreasing the percentage of units in Group C. The shift in the duty cycle distribution for Groups B and C is calculated using the combination duct/AC model.

APPENDIX C: COMBINED MODEL INTERACTIONS

The combined model presented in this report is composed of three sub-models. When the models are combined, certain interactions occur as outputs from one model are input to the others and vice-versa. These interactions can lead to some unanticipated impacts.

The primary physical connections between the duct and air conditioner models are the return plenum temperature, the supply plenum temperature, the air conditioner capacity, and the duty cycle.

Some examples of temperature-related interactions include:

- Return duct leakage and conduction increase the return plenum temperature, which increases air conditioner capacity and watt draw;
- Correcting improper refrigerant charge increases air conditioner capacity leading to lower supply air temperatures (at a given air flow rate) and increased conductive heat gain to the supply ducts.

These duct temperature interactions tend to result in relatively small impacts because the temperature ranges are fairly narrow.

The duct and air conditioner models interact in significant ways because the primary duct losses occur when the system is operating. Therefore, factors which affect how much the system must operate to meet building loads can have a large impact on the relative system efficiency losses.

DISTRIBUTION SYSTEM LOSSES

The distribution system losses on these homes are quite significant. For the average home in this sample the distribution losses increase from near 25% at 80°F to over 48% of the capacity of the unit at peak temperatures. Distribution losses are plotted against outside temperature in Figure C-1.

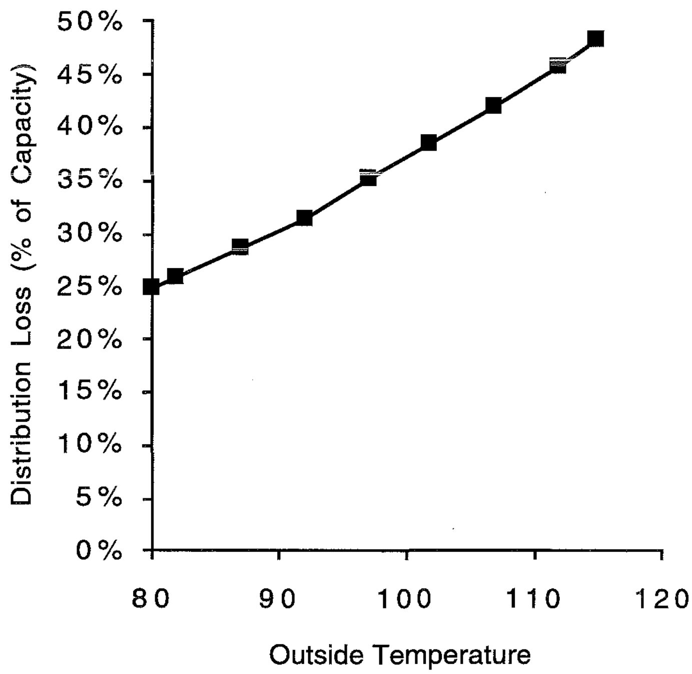

Figure C-1
Distribution Loss for Average Unit

Components of the distribution loss are supply leakage, return leakage, induced infiltration, and conduction. Each of these components has a different response to outside temperature as shown in Figure C-2. The capacity loss as a result of supply leaks is constant regardless of the outside temperature. On the other hand both induced infiltration and conduction losses increase dramatically with increases in outside temperature.

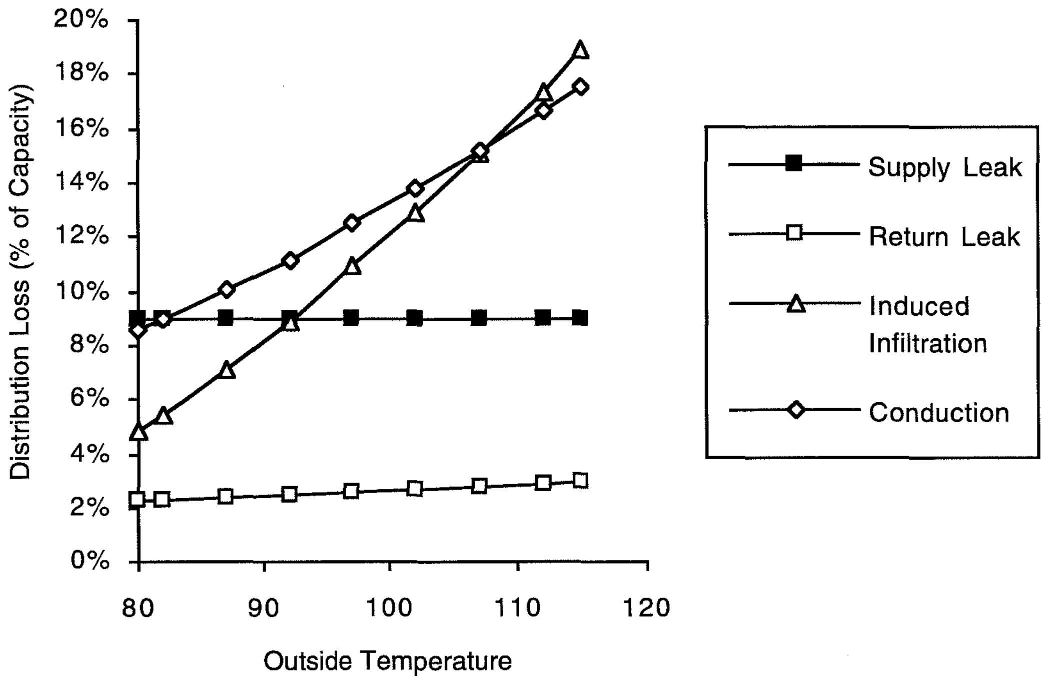

Figure C-2
Effect of Outdoor Temperature on Duct Loss Components

Reducing duct leakage or increasing the insulation levels on the ducts reduces the duct loss at all temperatures. Figure C-3 shows the effect of improved duct systems on the average home in this sample. The effective capacity of the air conditioning system is greatly improved by these changes, making a reduced capacity air conditioner a viable option on a home with well sealed and insulated ducts.

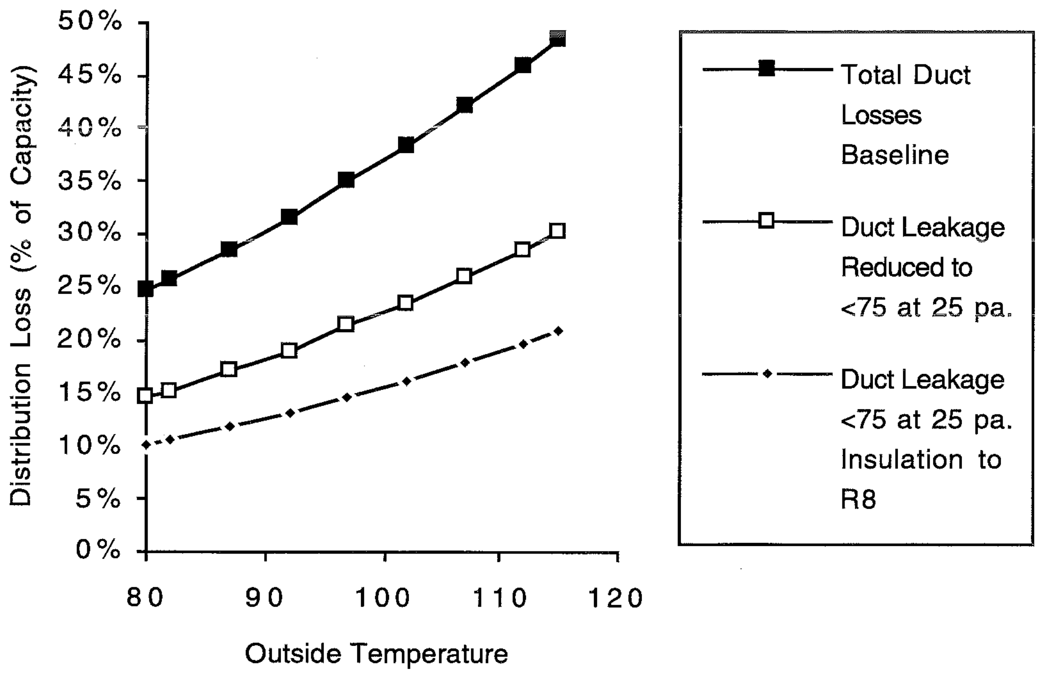

Figure C-3
Effect of Reduced Duct Leakage and Increased Duct Insulation

EFFECT OF AIR CONDITIONER SIZING

The duct and air conditioner models interact in significant ways because the primary duct losses occur when the system is operating. Therefore, factors which affect how much the system must operate to meet building loads can have a large impact on the relative system efficiency losses.

The first effect of properly sizing an air conditioner to the load is that units previously running continuously at peak (about 27% of the units) will now draw less power. The second effect of using a smaller unit is more surprising. If a smaller air conditioner is installed in place of a unit that was cycling on peak and the same duct system is used, the relative conductive loads increase and both energy consumption and peak demand increase. The increase in distribution loss from sizing alone is illustrated in Figure C-4. When smaller sized air conditioners are used either the duct system area must be reduced or the R value increased. Smaller diameter duct systems would continue to promote low flow problems, so shorter runs and higher insulation values are recommended.

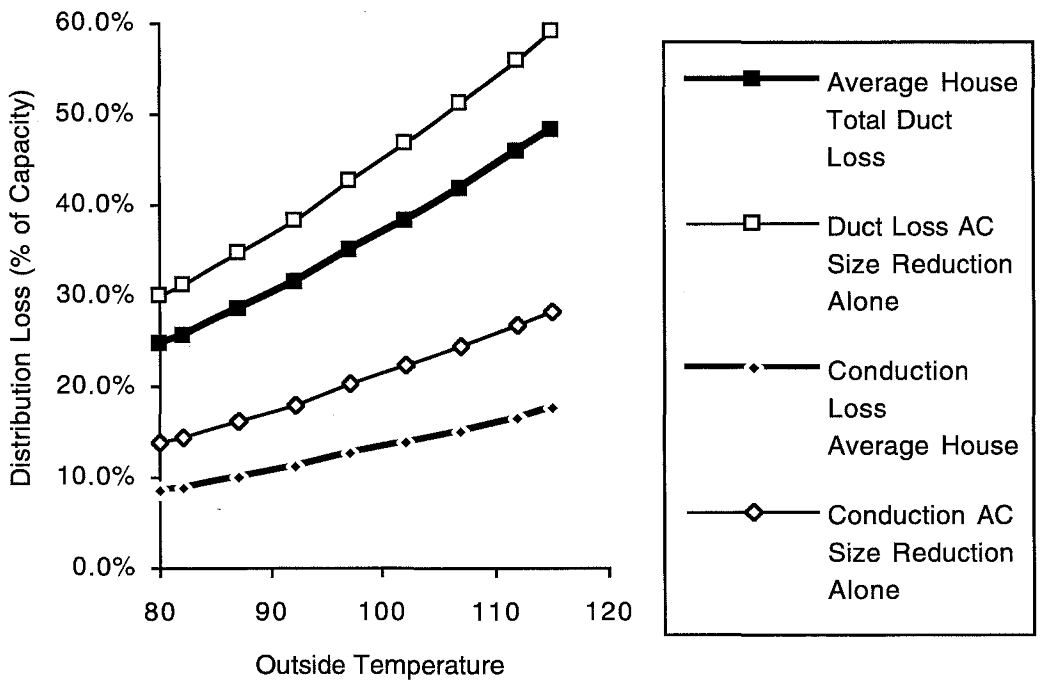

Figure C-4
Effect of Reduced AC Size on Conduction Losses (duct size held constant)

REFRIGERANT CHARGE EFFECT

Properly charging an air conditioner increases its capacity by increasing the temperature drop across the indoor coil. Therefore, duct leakage and conduction losses are both reduced. Undercharged and overcharged systems have different characteristics. At high ambient temperatures (110°F) undercharged systems perform well, having comparable capacity and somewhat higher efficiency than properly charged systems. At moderate temperatures undercharged systems suffer from large capacity and efficiency losses. At all temperatures, undercharged systems draw less power than properly charged systems. Therefore, nearly all of the benefits from avoiding undercharged systems arise as energy savings at moderate temperatures. In contrast, overcharged systems always perform worse than properly charged systems.

The modeled kW draw of an average home with an overcharged unit and a properly charged unit is shown in Figure C-5.

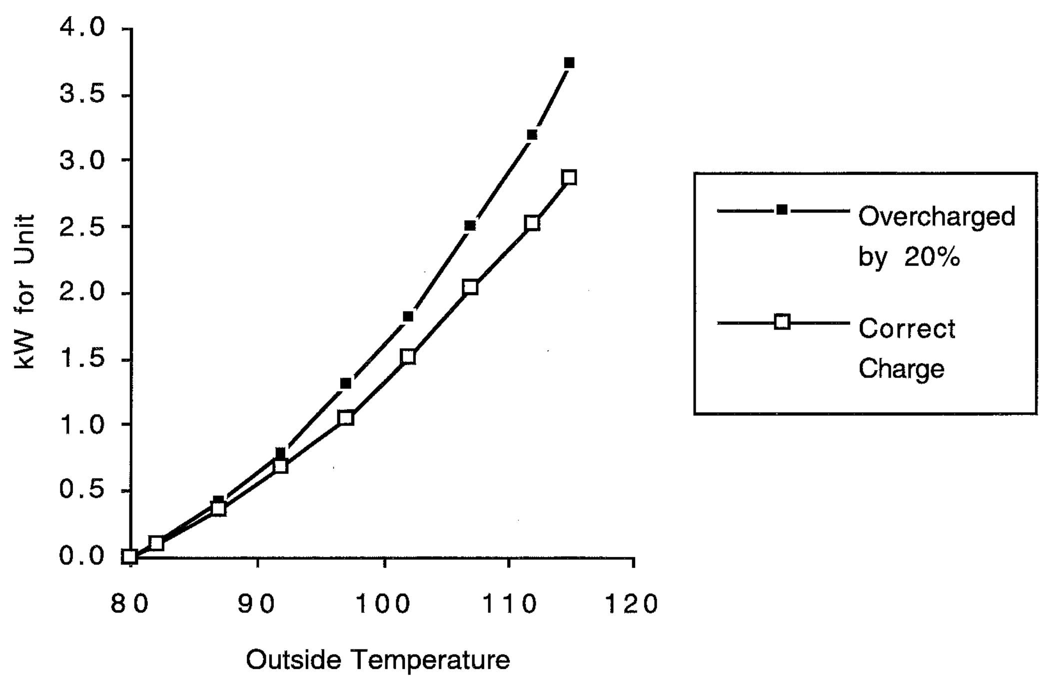

Figure C-5
Effect of Overcharge on Power Draw - Effectively Oversized Unit

APPENDIX D: SAMPLE VARIABILITY AND OVERALL UNCERTAINTY

The variability within the project sample can be assessed through standard statistical techniques. The main body of the report shows 95% confidence intervals on the energy and demand savings for each program design option. These confidence intervals are calculated from the variability in the model results within the sample of units modeled. They do not account for any of the fundamental uncertainty in the measuring or modeling of the units as described below – i.e., the measurements, modeling, and assumptions for each house are assumed to be accurate. These confidence intervals should only be interpreted as representing sample variability, not overall uncertainty in the results.

The energy usage and peak demand levels and the impacts of proposed retrofits estimated in this report are based on a combination of field measurements, assumptions, load data sets, and models. Each of these underlying quantities and relationships are, in one sense or another, estimates of actual physical characteristics and relationships between duct systems, air conditioners, building shells, and occupants. Some of these quantities, such as particular pressure or flow measurements, could have uncertainties assigned to them. However, much more of the overall uncertainty is likely due to assumptions made in lieu of measured data.

Many of the key assumptions are stated in the report, such as the simplifications embedded in the air conditioner and duct models and the characterization of occupant behavior. Some of the uncertainty introduced from these assumptions could be reduced by collecting additional data (e.g., load research data from a random sample of new homes, air conditioner performance data over a wider range of charge, air flow, and temperature conditions). This type of information would likely lead to less uncertainty with fewer assumptions. However, in order to properly assess overall accuracy, a model validation study is needed. Without such a study, the uncertainty introduced by modeling assumptions and simplifications can not be assessed in any reasonable and defensible manner. Instead, one must conclude that the results presented are correct to the extent that the measurements are accurate, the model is correct, and its assumptions are satisfied.

APPENDIX E:
ESTIMATED PROGRAM IMPACTS AND COSTS

SUMMARY INFORMATION: HIGHER COOLING LOADS

Table E-1
Without Resizing
Building Loads tuned to underlying duty cycle of metered sample @112F + 0.1

Program Design	Direct Cost	Savings: Energy kWh	Savings: Energy % (95%CI)	Savings: Peak Demand kW	Savings: Peak Demand % (95%CI)
Baseline - Systems as Found	$0	2948		3.18	
A. Restrict Duct Lkg to 75 CFM25 total	$95	544	18% (±4.5%)	0.45	14% (±2.7%)
B. Duct Lkg 75, R-8 Duct Insul.	$235	769	26% (±5.3%)	0.67	21% (±3.3%)
C. Correct AC Charge & Flow	$68	364	12% (±2.9%)	0.03	1% (±3.1%)
D. Charge, Flow, Duct Lkg 75	$163	870	30% (±5.6%)	0.54	17% (±4.4%)
E. Charge, Flow, Duct 75, R-8	$303	1034	35% (±6.1%)	0.71	22% (±4.7%)
F. EER 2 higher, Charge, Flow	$418	827	28% (±3.8%)	0.60	19% (±3.4%)
G. All of the Above	$653	1377	47% (±6.8%)	1.16	36% (±5.1%)
H. Shade Windows	N/A	348	12% (±1.1%)	0.19	6% (±1.2%)
I. Shade + All of the Above	$653+	1578	54% (±7.2%)	1.29	41% (±5.4%)

Table E-2
Units Resized based on Manual J tuned to average duty cycle of 1/1.35 @ Design
Building Loads tuned to underlying duty cycle of metered sample @112F + 0.1

Program Design	Direct Cost	Savings: Energy kWh	Savings: Energy % (95%CI)	Savings: Peak Demand kW	Savings: Peak Demand % (95%CI)
Baseline - Systems as Found	$0	2948		3.18	
A. Restrict Duct Lkg to 75 CFM25 total	$95	410	14% (±4.6%)	0.70	22% (±3.0%)
B. Duct Lkg 75, R-8 Duct Insul.	$235	691	23% (±5.1%)	1.04	33% (±3.4%)
C. Correct AC Charge & Flow	$68	281	10% (±2.9%)	0.28	9% (±3.4%)
D. Charge, Flow, Duct Lkg 75	$163	705	24% (±5.4%)	0.87	27% (±4.2%)
E. Charge, Flow, Duct 75, R-8	$303	944	32% (±5.9%)	1.18	37% (±4.6%)
F. EER 2 higher, Charge, Flow	$418	758	26% (±3.8%)	0.80	25% (±3.8%)
G. All of the Above	$653	1303	44% (±6.6%)	1.54	48% (±5.1%)
H. Shade Windows	N/A	262	9% (±1.5%)	0.39	12% (±2.0%)
I. Shade + All of the Above	$653+	1487	50% (±6.9%)	1.72	54% (±5.3%)

See the following pages for detailed information on each program design

SUMMARY INFORMATION: LOWER COOLING LOADS

Table E-3
Without Resizing
Building Loads tuned to underlying duty cycle of metered sample @ 112 F

Program Design	Direct Cost	Savings			
		Energy		Peak Demand	
		kWh	% (95%CI)	kW	% (95%CI)
Baseline - Systems as Found	$0	2588		2.99	
A. Restrict Duct Lkg to 75 CFM25 total	$95	497	19% (±4.9%)	0.46	15% (±2.8%)
B. Duct Lkg 75, R-8 Duct Insul.	$235	696	27% (±5.8%)	0.65	22% (±3.6%)
C. Correct AC Charge & Flow	$68	327	13% (±3.0%)	0.03	1% (±2.9%)
D. Charge, Flow, Duct Lkg 75	$163	785	30% (±5.9%)	0.53	18% (±4.5%)
E. Charge, Flow, Duct 75, R-8	$303	927	36% (±6.5%)	0.68	23% (±4.9%)
F. EER 2 higher, Charge, Flow	$418	732	28% (±3.9%)	0.56	19% (±3.2%)
G. All of the Above	$653	1225	47% (±7.1%)	1.09	36% (±5.3%)
H. Shade Windows	N/A	310	12% (±1.1%)	0.18	6% (±1.1%)
I. Shade + All of the Above	$653+	1400	54% (±7.5%)	1.21	40% (±5.5%)

Table E-4
Units Resized based on Manual J tuned to average duty cycle of 1/1.35 @ Design
Building Loads tuned to underlying duty cycle of metered sample @ 112 F

Program Design	Direct Cost	Savings			
		Energy		Peak Demand	
		kWh	% (95%CI)	kW	% (95%CI)
Baseline - Systems as Found	$0	2588		2.99 %	
A. Restrict Duct Lkg to 75 CFM25 total	$95	316	12% (±4.9%)	0.75	25% (±3.3%)
B. Duct Lkg 75, R-8 Duct Insul.	$235	591	23% (±5.3%)	1.08	36% (±3.8%)
C. Correct AC Charge & Flow	$68	203	8% (±3.0%)	0.36	12% (±3.6%)
D. Charge, Flow, Duct Lkg 75	$163	583	23% (±5.6%)	0.90	30% (±4.4%)
E. Charge, Flow, Duct 75, R-8	$303	816	32% (±6.1%)	1.21	40% (±4.8%)
F. EER 2 higher, Charge, Flow	$418	631	24% (±3.8%)	0.83	28% (±4.0%)
G. All of the Above	$653	1134	44% (±6.8%)	1.53	51% (±5.2%)
H. Shade Windows	N/A	179	7% (±1.7%)	0.45	15% (±2.3%)
I. Shade + All of the Above	$653+	1295	50% (±7.2%)	1.68	56% (±5.5%)

	House Constants					Pre-Retrofit Site Data												Results - Pre Retrofit					
						Ducts							Air Conditioner				Shell	Energy			Peak Demand		
	Load	Duct Location Info				Leakage-Oper		Leakage @50			Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		3.18
ID	ManJsh	Rint	Rbuf	Sint	Sbuf	slf1	rlf1	Q50Dt1	Q50De1	Dlkpct1	UAr1	UAs1	Capr1	EERr1	Qah1	Cha1	Q50S1	Use1	Leaks1	Total1	kW1	DlkW1	CapaPk1
1	23329	0.0	1.0	0.4	1.0	0.130	0.076	631	424	18%	12.5	64.5	46500	9.0	1588	1.00	2400	2995	29.3%	39.7%	5.71	4.20	17062
2	20420	0.0	1.0	0.4	1.0	0.073	0.106	402	334	18%	12.5	73.5	46000	9.4	1468	0.80	1825	2895	25.6%	39.6%	5.01	2.79	19729
3	12811	0.0	1.0	0.8	1.0	0.059	0.112	351	230	12%	12.5	15.5	28000	9.0	1229	1.00	1950	1386	23.7%	28.9%	3.81	1.79	14685
4	15557	0.0	1.0	0.0	1.0	0.062	0.039	291	213	11%	12.5	85.0	34000	9.1	1321	0.80	1950	2313	18.0%	39.0%	3.96	2.28	14516
5	20389	0.0	1.0	0.4	1.0	0.068	0.036	371	265	16%	12.5	69.0	46000	8.9	1586	1.00	1635	2240	15.7%	27.6%	5.64	2.86	21635
6	22482	0.0	1.0	0.6	1.0	0.062	0.049	408	267	17%	12.5	46.0	46000	8.9	1612	1.00	1550	2354	16.0%	24.3%	5.69	2.94	23466
7	22558	0.0	1.0	0.0	1.0	0.078	0.027	365	213	15%	12.5	100.0	42000	9.0	1345	0.80	1440	3391	18.0%	39.4%	4.66	3.39	16714
8	22433	0.0	1.0	0.1	1.0	0.090	0.052	344	280	16%	12.5	90.0	42500	8.9	1285	1.20	1700	3336	21.1%	39.2%	5.11	4.99	12379
9	30792	0.0	1.0	0.5	1.0	0.070	0.057	470	418	21%	12.5	76.3	58500	8.8	1681	1.20	1950	4052	17.9%	29.7%	7.08	5.43	21593
10	19497	0.0	1.0	0.0	1.0	0.137	0.139	243	210	7%	12.5	77.5	33000	9.0	785	1.00	2825	2813	30.0%	48.6%	3.74	3.74	9054
11	16661	0.0	1.0	0.0	1.0	0.188	0.128	266	251	9%	12.5	77.5	28200	9.0	751	1.00	2825	2864	37.9%	58.0%	3.29	3.29	5372
12	21048	0.0	1.0	1.0	0.0	0.023	0.121	219	153	6%	12.5	0.0	37000	9.0	1053	0.80	2400	2342	17.7%	19.7%	4.11	2.11	21998
13	16042	0.0	1.0	0.0	1.0	0.150	0.111	516	389	16%	12.5	70.0	28200	8.9	813	1.00	2400	2477	32.6%	51.1%	3.37	3.37	7150
14	17877	0.0	1.0	0.0	1.0	0.070	0.067	293	181	16%	12.5	77.5	35000	9.4	1491	0.80	1125	2663	24.0%	41.5%	4.13	2.65	15012
15	12675	0.0	1.0	0.1	1.0	0.043	0.020	152	101	10%	12.5	63.0	35000	9.4	1429	0.80	1000	1562	12.0%	28.0%	3.98	1.48	18337
16	17956	0.0	1.0	1.0	0.0	0.162	0.173	503	296	13%	12.5	0.0	35800	9.4	742	1.20	2300	2367	35.3%	37.2%	3.82	3.24	11380
17	17956	0.0	1.0	0.0	1.0	0.098	0.043	234	156	7%	12.5	85.0	35800	9.4	753	0.80	2300	2776	19.5%	44.4%	3.49	2.81	12021
18	17996	0.0	1.0	1.0	0.0	0.051	0.117	362	199	8%	12.5	0.0	35800	9.4	1082	1.20	2350	1970	20.6%	22.5%	4.17	2.50	16199
19	17996	0.0	1.0	0.0	1.0	0.080	0.036	243	148	6%	12.5	85.0	35800	9.4	1126	0.80	2350	2650	19.2%	40.8%	3.80	2.65	13919
20	37036	0.0	1.0	0.5	1.0	0.108	0.069	502	276	15%	12.5	65.0	59000	9.7	1081	1.20	1830	4514	20.7%	32.8%	5.88	5.88	19201
21	35143	0.0	1.0	0.0	1.0	0.158	0.056	473	303	12%	12.5	107.5	56900	9.3	1095	1.20	2500	5456	27.6%	46.1%	5.97	5.97	12904
22	30551	0.0	1.0	0.5	1.0	0.128	0.053	472	283	15%	12.5	53.8	58500	9.9	1225	1.20	1900	3773	23.9%	33.7%	5.86	5.10	18898
23	23692	0.0	1.0	0.0	1.0	0.155	0.052	341	240	14%	12.5	92.5	42000	9.3	958	1.20	1725	3893	28.8%	49.0%	4.53	4.53	8659
24	25671	0.0	1.0	0.5	1.0	0.058	0.085	472	269	14%	12.5	57.5	46000	9.4	1371	1.00	1900	2622	17.3%	27.7%	5.21	3.33	21632
25	23962	0.0	1.0	0.0	1.0	0.240	0.171	590	504	30%	12.5	107.5	46000	9.0	1310	1.20	1700	5667	51.4%	67.7%	5.58	5.58	3332
26	17876	0.0	1.0	1.0	0.0	0.052	0.302	337	292	13%	12.5	0.0	37000	9.0	910	1.20	2250	2284	33.0%	34.6%	4.41	3.11	13643
27	10436	0.0	1.0	0.0	1.0	0.135	0.102	216	190	8%	12.5	70.0	21600	9.0	606	1.20	2250	2091	31.6%	57.8%	2.56	2.56	3073
28	30475	0.0	1.0	0.0	1.0	0.073	0.035	507	250	12%	12.5	130.0	56500	9.0	1170	1.20	2050	4324	14.1%	36.8%	6.17	6.17	16426
29	26700	0.0	1.0	0.0	1.0	0.069	0.042	265	148	10%	12.5	122.5	56500	9.0	975	1.20	1500	3769	13.1%	36.2%	5.99	5.23	16459
30	22440	0.0	1.0	0.0	1.0	0.070	0.049	396	227	13%	12.5	107.5	50000	9.9	1187	0.80	1800	2998	16.5%	38.0%	4.74	2.91	19699
31	29625	0.0	1.0	0.0	1.0	0.111	0.044	432	311	12%	12.5	115.0	59000	9.7	1493	1.20	2700	4116	22.4%	39.9%	6.24	6.08	16360
32	23131	0.0	1.0	0.0	1.0	0.072	0.038	267	181	10%	12.5	100.0	42000	9.3	1515	1.20	1800	3200	18.1%	37.1%	5.04	4.75	13214
33	16679	0.0	1.0	0.8	1.0	0.051	0.112	259	220	9%	12.5	14.0	37000	9.0	1145	1.20	2400	1978	20.5%	25.2%	4.52	2.56	15900
34	16679	0.0	1.0	0.0	1.0	0.130	0.076	394	320	13%	12.5	92.5	37000	9.0	1142	1.00	2400	2408	28.1%	46.6%	4.42	3.68	10795
35	24383	0.0	0.0	1.0	0.0	0.022	0.393	940	620	23%	12.5	0.0	40000	8.8	1376	1.20	2700	2891	25.5%	26.2%	5.41	4.03	17610
36	17068	0.0	1.0	0.0	1.0	0.107	0.079	233	165	6%	12.5	77.5	28000	9.0	876	1.00	2700	2382	24.8%	45.4%	3.38	3.38	8457
37	21511	0.0	0.0	1.0	0.0	0.021	0.186	305	190	7%	12.5	0.0	34000	9.1	1084	0.80	2600	2117	8.2%	9.3%	3.86	1.98	22597
38	25307	0.0	1.0	0.0	1.0	0.051	0.085	267	185	7%	12.5	77.5	40000	8.8	1033	1.20	2600	3430	16.3%	34.0%	4.70	4.70	13189
39	19163	0.0	1.0	1.0	0.0	0.034	0.133	259	150	5%	12.5	0.0	40000	9.0	1015	1.20	2850	2095	17.6%	19.3%	4.66	2.60	18505
40	16768	0.0	1.0	0.0	1.0	0.045	0.053	166	106	4%	12.5	85.0	35000	9.0	694	0.80	2850	2448	11.6%	38.0%	3.53	2.37	13427
Mean	21519	0.0	1.0	0.3	0.8	0.090	0.093	369	254	12%	12.5	65.8	41278	9.2	1160	1.04	2132	2948	22.6%	37.0%	4.68	3.63	14905

Retrofits: Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
75	No	4	Same	0	Same	None

Program Design A

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.73	Usage & Duct Loss			kW @5PM		0.45
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	12.5	64.5	46500	9.00	1588	1	2055	2131	5.8%	17.4%	5.56	2.50	25930	864	23.5%	22.3%	0.15	1.70	-8869
2	0.021	0.031	6.2%	71%	12.5	73.5	46000	9.43	1468	0.8	1589	2260	8.0%	23.5%	4.88	2.05	24624	635	17.5%	16.0%	0.13	0.74	-4895
3	0.020	0.037	4.3%	66%	12.5	15.5	28000	8.97	1229	1	1797	1131	8.5%	14.2%	3.66	1.32	18067	255	15.2%	14.7%	0.15	0.48	-3382
4	0.025	0.016	4.7%	60%	12.5	85.0	34000	9.09	1321	0.8	1823	1963	7.5%	29.4%	3.91	1.84	17057	349	10.5%	9.6%	0.05	0.44	-2540
5	0.022	0.011	5.8%	68%	12.5	69.0	46000	8.90	1586	1	1454	1926	5.1%	17.5%	5.58	2.29	25599	313	10.6%	10.0%	0.06	0.57	-3965
6	0.018	0.014	5.7%	71%	12.5	46.0	46000	8.90	1612	1	1360	2027	4.8%	13.5%	5.61	2.36	27599	327	11.3%	10.8%	0.09	0.58	-4133
7	0.025	0.009	5.3%	68%	12.5	100.0	42000	9.00	1345	0.8	1296	2863	5.9%	28.3%	4.63	2.70	20332	529	12.1%	11.1%	0.03	0.69	-3618
8	0.031	0.018	6.3%	66%	12.5	90.0	42500	8.91	1285	1.2	1516	2759	7.5%	26.6%	5.05	3.61	16344	577	13.7%	12.5%	0.06	1.37	-3964
9	0.018	0.014	6.4%	75%	12.5	76.3	58500	8.76	1681	1.2	1637	3391	4.7%	17.3%	6.98	4.10	26789	661	13.2%	12.4%	0.10	1.33	-5196
10	0.067	0.068	3.8%	51%	12.5	77.5	33000	9.00	785	1	2717	2312	15.4%	35.9%	3.69	3.11	12204	501	14.6%	12.7%	0.05	0.64	-3151
11	0.083	0.057	4.1%	56%	12.5	77.5	28200	9.00	751	1	2685	2116	18.0%	40.5%	3.23	2.99	9361	749	20.0%	17.4%	0.06	0.30	-3989
12	0.013	0.065	3.5%	46%	12.5	0.0	37000	9.00	1053	0.8	2329	2151	9.9%	12.0%	4.04	1.91	23514	191	7.8%	7.7%	0.07	0.20	-1516
13	0.034	0.025	4.2%	77%	12.5	70.0	28200	8.92	813	1	2100	1690	8.1%	29.2%	3.29	2.12	12152	786	24.6%	21.9%	0.09	1.25	-5002
14	0.028	0.027	7.2%	60%	12.5	77.5	35000	9.36	1491	0.8	1016	2190	10.1%	28.8%	4.04	2.06	18416	473	13.9%	12.7%	0.09	0.59	-3405
15	0.033	0.016	8.0%	22%	12.5	63.0	35000	9.36	1429	0.8	977	1506	9.3%	25.5%	3.97	1.41	19038	57	2.6%	2.5%	0.01	0.07	-700
16	0.038	0.041	3.3%	77%	12.5	0.0	35800	9.40	742	1.2	2074	1687	9.2%	11.3%	3.75	1.95	17477	679	26.1%	25.9%	0.07	1.30	-6098
17	0.049	0.022	3.5%	50%	12.5	85.0	35800	9.40	753	0.8	2223	2422	10.0%	35.9%	3.48	2.33	14137	354	9.5%	8.4%	0.01	0.48	-2115
18	0.016	0.038	2.9%	67%	12.5	0.0	35800	9.40	1082	1.2	2216	1683	7.1%	9.1%	4.07	1.96	19410	288	13.5%	13.4%	0.11	0.54	-3211
19	0.039	0.017	3.2%	52%	12.5	85.0	35800	9.40	1126	0.8	2274	2303	9.5%	32.0%	3.78	2.19	16327	347	9.7%	8.8%	0.03	0.45	-2408
20	0.025	0.016	4.0%	77%	12.5	65.0	59000	9.69	1081	1.2	1619	3754	5.1%	18.2%	5.85	4.57	24817	759	15.6%	14.6%	0.03	1.31	-5617
21	0.039	0.014	3.3%	75%	12.5	107.5	56900	9.27	1095	1.2	2272	4188	7.1%	27.5%	5.95	5.46	20080	1269	20.5%	18.6%	0.03	0.51	-7177
22	0.032	0.013	4.2%	75%	12.5	53.8	58500	9.87	1225	1.2	1688	2999	6.2%	16.8%	5.82	3.60	25683	774	17.7%	16.9%	0.03	1.50	-6786
23	0.053	0.018	5.3%	65%	12.5	92.5	42000	9.31	958	1.2	1568	3005	10.3%	32.2%	4.50	4.10	13666	888	18.5%	16.8%	0.03	0.44	-5007
24	0.015	0.021	3.9%	75%	12.5	57.5	46000	9.43	1371	1	1698	2242	4.6%	15.8%	5.10	2.64	25715	380	12.8%	11.9%	0.11	0.69	-4083
25	0.048	0.034	7.7%	80%	12.5	107.5	46000	9.00	1310	1.2	1297	3081	11.8%	32.5%	5.37	4.18	15452	2587	39.5%	35.1%	0.21	1.40	-12121
26	0.018	0.105	4.9%	65%	12.5	0.0	37000	9.00	910	1.2	2060	1795	12.6%	14.5%	4.25	2.13	18196	488	20.4%	20.1%	0.16	0.98	-4553
27	0.073	0.055	4.8%	46%	12.5	70.0	21600	9.04	606	1.2	2164	1676	18.0%	46.3%	2.52	2.52	4904	415	13.6%	11.5%	0.03	0.03	-1831
28	0.017	0.008	3.1%	77%	12.5	130.0	56500	9.00	1170	1.2	1858	3755	3.4%	27.2%	6.15	4.90	20092	568	10.8%	9.6%	0.02	1.27	-3666
29	0.031	0.019	4.6%	56%	12.5	122.5	56500	9.00	975	1.2	1417	3440	5.9%	29.9%	5.98	4.53	18739	329	7.2%	6.3%	0.01	0.70	-2279
30	0.021	0.015	4.1%	70%	12.5	107.5	50000	9.90	1187	0.8	1641	2563	5.1%	27.8%	4.71	2.38	23183	435	11.5%	10.2%	0.03	0.52	-3484
31	0.030	0.012	3.4%	73%	12.5	115.0	59000	9.69	1493	1.2	2474	3298	6.3%	25.1%	6.19	4.23	22659	818	16.1%	14.9%	0.05	1.86	-6299
32	0.032	0.017	4.7%	56%	12.5	100.0	42000	9.31	1515	1.2	1699	2797	8.2%	27.9%	4.99	3.76	16249	403	10.0%	9.2%	0.05	0.99	-3035
33	0.023	0.051	4.4%	55%	12.5	14.0	37000	9.00	1145	1.2	2280	1731	9.8%	14.8%	4.43	2.07	18507	247	10.7%	10.4%	0.09	0.48	-2607
34	0.039	0.023	4.4%	70%	12.5	92.5	37000	9.00	1142	1	2176	1775	8.8%	29.0%	4.34	2.25	16174	633	19.3%	17.5%	0.08	1.43	-5380
35	0.003	0.049	3.6%	87%	12.5	0.0	40000	8.85	1376	1.2	2158	2165	1.8%	2.8%	4.97	2.41	24065	725	23.6%	23.4%	0.44	1.62	-6454
36	0.054	0.040	3.2%	50%	12.5	77.5	28000	8.97	876	1	2618	2016	13.0%	34.9%	3.33	2.75	10882	366	11.8%	10.5%	0.05	0.63	-2425
37	0.008	0.072	3.0%	61%	12.5	0.0	34000	9.09	1084	0.8	2483	2014	3.3%	4.5%	3.76	1.81	23441	103	4.9%	4.8%	0.10	0.17	-844
38	0.023	0.037	3.3%	56%	12.5	77.5	40000	8.85	1033	1.2	2496	3100	7.5%	26.2%	4.65	4.07	15267	331	8.9%	7.8%	0.05	0.64	-2078
39	0.016	0.061	2.5%	54%	12.5	0.0	40000	9.00	1015	1.2	2768	1899	8.4%	10.2%	4.58	2.23	20761	196	9.2%	9.1%	0.08	0.37	-2256
40	0.032	0.038	2.7%	29%	12.5	85.0	35000	9.00	694	0.8	2819	2346	8.3%	35.2%	3.52	2.24	14031	101	3.3%	2.8%	0.01	0.13	-603
	0.031	0.031	4.4%	63%	12.5	65.8	41278	9.16	1160	1.0	1960	2404	8.3%	23.7%	4.60	2.84	18924	544	14.4%	13.3%	0.08	0.78	-4019
																	%change	18.4%	63.6%	36.0%			

Retrofits: Duct@25 Shade Rduct Sizing dEER Qahpt Chg Fix
75 No 8 Same 0 Same None

Program Design B

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.51	Usage & Duct Loss			kW @5PM		0.67
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	46500	9.00	1588	1	2055	1996	5.8%	11.7%	5.556	2.27	28558	999	23.5%	28.0%	0.154	1.94	-11496
2	0.021	0.031	6.2%	71%	6.3	36.8	46000	9.43	1468	0.8	1589	2059	8.0%	16.0%	4.869	1.83	27564	836	17.5%	23.6%	0.142	0.96	-7835
3	0.020	0.037	4.3%	66%	6.3	7.8	28000	8.97	1229	1	1797	1097	8.6%	11.4%	3.65	1.25	18885	289	15.2%	17.5%	0.164	0.54	-4200
4	0.025	0.016	4.7%	60%	6.3	42.5	34000	9.09	1321	0.8	1823	1709	7.5%	18.8%	3.904	1.55	20266	603	10.5%	20.2%	0.055	0.74	-5749
5	0.022	0.011	5.8%	68%	6.3	34.5	46000	8.90	1586	1	1454	1796	5.1%	11.4%	5.568	2.06	28385	444	10.6%	16.1%	0.068	0.80	-6750
6	0.018	0.014	5.7%	71%	6.3	23.0	46000	8.90	1612	1	1360	1933	4.8%	9.2%	5.598	2.20	29574	421	11.2%	15.1%	0.096	0.74	-6108
7	0.025	0.009	5.3%	68%	6.3	50.0	42000	9.00	1345	0.8	1296	2496	5.9%	17.5%	4.62	2.26	24155	896	12.1%	21.9%	0.041	1.12	-7441
8	0.031	0.018	6.3%	66%	6.3	45.0	42500	8.91	1285	1.2	1516	2458	7.5%	17.3%	5.044	2.99	19724	878	13.7%	21.8%	0.068	2.00	-7345
9	0.018	0.014	6.4%	75%	6.3	38.1	58500	8.76	1681	1.2	1637	3160	4.7%	11.1%	6.973	3.68	29841	892	13.2%	18.6%	0.103	1.75	-8248
10	0.067	0.068	3.8%	51%	6.3	38.8	33000	9.00	785	1	2717	2022	15.4%	26.1%	3.687	2.50	15152	792	14.6%	22.5%	0.057	1.25	-6098
11	0.083	0.057	4.1%	56%	6.3	38.8	28200	9.00	751	1	2685	1808	18.0%	29.8%	3.225	2.29	12210	1057	20.0%	28.2%	0.065	1.00	-6838
12	0.013	0.065	3.5%	46%	6.3	0.0	37000	9.00	1053	0.8	2329	2130	9.9%	11.0%	4.033	1.89	23768	213	7.8%	8.8%	0.072	0.22	-1770
13	0.034	0.025	4.2%	77%	6.3	35.0	28200	8.92	813	1	2100	1483	8.1%	19.0%	3.281	1.73	14870	994	24.6%	32.1%	0.093	1.64	-7720
14	0.028	0.027	7.2%	60%	6.3	38.8	35000	9.36	1491	0.8	1016	1944	10.1%	19.7%	4.033	1.77	21350	719	13.9%	21.8%	0.1	0.88	-6338
15	0.033	0.016	8.0%	22%	6.3	31.5	35000	9.36	1429	0.8	977	1363	9.4%	17.6%	3.958	1.25	21518	199	2.6%	10.4%	0.019	0.23	-3181
16	0.038	0.041	3.3%	77%	6.3	0.0	35800	9.40	742	1.2	2074	1672	9.2%	10.3%	3.749	1.92	17752	695	26.1%	27.0%	0.069	1.33	-6372
17	0.049	0.022	3.5%	50%	6.3	42.5	35800	9.40	753	0.8	2223	2050	10.0%	23.7%	3.474	1.88	17499	726	9.5%	20.7%	0.015	0.93	-5478
18	0.016	0.038	2.9%	67%	6.3	0.0	35800	9.40	1082	1.2	2216	1668	7.2%	8.2%	4.059	1.93	19684	303	13.5%	14.3%	0.114	0.57	-3485
19	0.039	0.017	3.2%	52%	6.3	42.5	35800	9.40	1126	0.8	2274	1994	9.5%	21.1%	3.77	1.83	19582	657	9.7%	19.7%	0.033	0.82	-5663
20	0.025	0.016	4.0%	77%	6.3	32.5	59000	9.69	1081	1.2	1619	3498	5.1%	11.8%	5.852	4.10	27649	1016	15.6%	21.0%	0.028	1.78	-8448
21	0.039	0.014	3.3%	75%	6.3	53.8	56900	9.27	1095	1.2	2272	3723	7.1%	17.8%	5.943	4.51	24295	1733	20.5%	28.3%	0.03	1.46	-11391
22	0.032	0.013	4.2%	75%	6.3	26.9	58500	9.87	1225	1.2	1688	2828	6.2%	11.6%	5.82	3.30	28044	945	17.7%	22.1%	0.038	1.80	-9147
23	0.053	0.018	5.3%	65%	6.3	46.3	42000	9.31	958	1.2	1568	2622	10.3%	21.7%	4.5	3.26	17161	1270	18.5%	27.3%	0.034	1.28	-8502
24	0.015	0.021	3.9%	75%	6.3	28.8	46000	9.43	1371	1	1698	2107	4.6%	10.3%	5.095	2.41	28140	515	12.8%	17.4%	0.116	0.92	-6508
25	0.048	0.034	7.7%	80%	6.3	53.8	46000	9.00	1310	1.2	1297	2697	11.8%	22.5%	5.359	3.34	19350	2970	39.5%	45.1%	0.221	2.24	-16018
26	0.018	0.105	4.9%	65%	6.3	0.0	37000	9.00	910	1.2	2060	1780	12.6%	13.6%	4.242	2.10	18460	504	20.3%	21.0%	0.167	1.01	-4817
27	0.073	0.055	4.8%	46%	6.3	35.0	21600	9.04	606	1.2	2164	1358	18.0%	32.8%	2.518	1.84	7359	733	13.6%	25.0%	0.04	0.71	-4286
28	0.017	0.008	3.1%	77%	6.3	65.0	56500	9.00	1170	1.2	1858	3271	3.3%	15.8%	6.146	3.93	25039	1053	10.8%	21.0%	0.028	2.24	-8612
29	0.031	0.019	4.6%	56%	6.3	61.3	56500	9.00	975	1.2	1417	2977	5.9%	18.6%	5.978	3.62	23483	792	7.2%	17.7%	0.01	1.61	-7024
30	0.021	0.015	4.1%	70%	6.3	53.8	50000	9.90	1187	0.8	1641	2231	5.1%	16.9%	4.7	2.01	27447	767	11.5%	21.1%	0.039	0.90	-7748
31	0.030	0.012	3.4%	73%	6.3	57.5	59000	9.69	1493	1.2	2474	2949	6.3%	16.0%	6.187	3.54	27027	1167	16.1%	24.0%	0.055	2.54	-10667
32	0.032	0.017	4.7%	56%	6.3	50.0	42000	9.31	1515	1.2	1699	2479	8.2%	18.3%	4.98	3.06	19892	721	10.0%	18.8%	0.058	1.68	-6678
33	0.023	0.051	4.4%	55%	6.3	7.0	37000	9.00	1145	1.2	2280	1684	9.8%	12.3%	4.424	1.99	19291	294	10.7%	12.8%	0.1	0.57	-3391
34	0.039	0.023	4.4%	70%	6.3	46.3	37000	9.00	1142	1	2176	1563	8.8%	19.3%	4.33	1.85	19665	845	19.3%	27.3%	0.09	1.83	-8871
35	0.003	0.049	3.6%	87%	6.3	0.0	40000	8.85	1376	1.2	2158	2157	1.8%	2.3%	4.962	2.39	24246	734	23.6%	23.9%	0.447	1.64	-6635
36	0.054	0.040	3.2%	50%	6.3	38.8	28000	8.97	876	1	2618	1750	13.0%	24.4%	3.321	2.17	13760	632	11.8%	21.0%	0.054	1.21	-5304
37	0.008	0.072	3.0%	61%	6.3	0.0	34000	9.09	1084	0.8	2483	2003	3.3%	3.9%	3.754	1.79	23609	114	4.9%	5.4%	0.108	0.19	-1012
38	0.023	0.037	3.3%	56%	6.3	38.8	40000	8.85	1033	1.2	2496	2779	7.5%	17.2%	4.644	3.40	18257	652	8.9%	16.9%	0.061	1.31	-5067
39	0.016	0.061	2.5%	54%	6.3	0.0	40000	9.00	1015	1.2	2768	1884	8.4%	9.3%	4.574	2.20	21031	211	9.2%	10.0%	0.082	0.40	-2526
40	0.032	0.038	2.7%	29%	6.3	42.5	35000	9.00	694	0.8	2819	1975	8.3%	22.5%	3.517	1.81	17408	473	3.3%	15.5%	0.01	0.56	-3981
	0.031	0.031	4.4%	63%	6.3	32.9	41278	9.16	1160	1.0	1960	2179	8.2%	16.2%	4.598	2.44	21524	769	14.4%	20.8%	0.084	1.18	-6619
																	%change	26.1%	63.6%	56.1%			

Program Design C

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	Same	No	4	Same	0	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		3.15	Usage & Duct Loss			kW @5PM		0.03
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.130	0.076	17.7%	0%	12.5	64.5	46500	9.00	1550	1	2400	2986	29.0%	39.5%	5.671	4.18	17050	9	0.3%	0.2%	0.039	0.03	12
2	0.073	0.106	18.3%	0%	12.5	73.5	46000	9.43	1533	1	1825	2282	22.5%	34.3%	5.419	3.05	19539	613	3.1%	5.3%	-0.41	-0.26	190
3	0.059	0.112	11.8%	0%	12.5	15.5	28000	8.97	933	1	1950	1340	20.6%	26.5%	3.477	1.69	14207	47	3.1%	2.4%	0.336	0.10	478
4	0.062	0.039	10.9%	0%	12.5	85.0	34000	9.09	1133	1	1950	1829	14.7%	33.9%	4.051	2.47	13734	483	3.3%	5.1%	-0.09	-0.19	783
5	0.068	0.036	16.2%	0%	12.5	69.0	46000	8.90	1533	1	1635	2238	15.5%	27.5%	5.586	2.85	21489	1	0.2%	0.0%	0.05	0.01	146
6	0.062	0.049	17.2%	0%	12.5	46.0	46000	8.90	1533	1	1550	2349	15.7%	24.2%	5.617	2.92	23260	5	0.4%	0.2%	0.078	0.01	206
7	0.078	0.027	14.8%	0%	12.5	100.0	42000	9.00	1400	1	1440	2705	16.3%	34.4%	5.026	3.67	16616	686	1.7%	5.0%	-0.36	-0.29	98
8	0.090	0.052	16.5%	0%	12.5	90.0	42500	8.91	1417	1	1700	2782	20.6%	36.5%	5.189	3.83	16372	554	0.6%	2.7%	-0.08	1.16	-3992
9	0.070	0.057	21.4%	0%	12.5	76.3	58500	8.76	1950	1	1950	3432	17.8%	28.0%	7.276	4.38	27549	620	0.1%	1.7%	-0.2	1.05	-5955
10	0.137	0.139	7.4%	0%	12.5	77.5	33000	9.00	1100	1	2825	2939	34.7%	50.6%	4.125	4.13	8985	-125	-4.7%	-2.0%	-0.38	-0.38	68
11	0.188	0.128	8.9%	0%	12.5	77.5	28200	9.00	940	1	2825	2977	41.4%	59.5%	3.513	3.51	5079	-113	-3.5%	-1.6%	-0.22	-0.22	292
12	0.023	0.121	6.4%	0%	12.5	0.0	37000	9.00	1233	1	2400	1956	16.2%	17.7%	4.592	2.35	22150	386	1.6%	2.0%	-0.49	-0.23	-152
13	0.150	0.111	16.2%	0%	12.5	70.0	28200	8.92	940	1	2400	2525	34.7%	52.0%	3.521	3.52	7100	-48	-2.0%	-0.9%	-0.15	-0.15	50
14	0.070	0.067	16.1%	0%	12.5	77.5	35000	9.36	1167	1	1125	2064	18.5%	35.3%	4.095	2.81	14034	599	5.5%	6.3%	0.039	-0.16	978
15	0.043	0.020	10.1%	0%	12.5	63.0	35000	9.36	1167	1	1000	1276	9.6%	24.5%	4.02	1.60	17112	287	2.3%	3.5%	-0.04	-0.12	1225
16	0.162	0.173	12.9%	0%	12.5	0.0	35800	9.40	1193	1	2300	2224	40.4%	41.9%	4.336	3.10	13501	142	-5.1%	-4.7%	-0.52	0.14	-2121
17	0.098	0.043	6.8%	0%	12.5	85.0	35800	9.40	1193	1	2300	2205	21.1%	39.0%	4.132	3.12	12804	571	-1.6%	5.3%	-0.64	-0.31	-782
18	0.051	0.117	8.4%	0%	12.5	0.0	35800	9.40	1193	1	2350	1682	19.9%	21.5%	4.251	2.05	20058	288	0.8%	1.0%	-0.08	0.44	-3859
19	0.080	0.036	6.3%	0%	12.5	85.0	35800	9.40	1193	1	2350	2100	17.4%	35.6%	4.121	2.88	13879	550	1.7%	5.2%	-0.32	-0.23	40
20	0.108	0.069	15.1%	0%	12.5	65.0	59000	9.69	1967	1	1830	3999	24.9%	33.4%	6.663	5.32	24988	515	-4.2%	-0.6%	-0.78	0.56	-5787
21	0.158	0.056	12.1%	0%	12.5	107.5	56900	9.27	1897	1	2500	4829	32.3%	45.8%	6.685	6.69	17102	628	-4.7%	0.3%	-0.71	-0.71	-4198
22	0.128	0.053	14.9%	0%	12.5	53.8	58500	9.87	1950	1	1900	3317	26.9%	34.3%	6.449	4.41	24049	456	-3.1%	-0.6%	-0.59	0.69	-5152
23	0.155	0.052	13.9%	0%	12.5	92.5	42000	9.31	1400	1	1725	3366	31.7%	47.6%	4.907	4.91	11871	526	-2.9%	1.4%	-0.37	-0.37	-3212
24	0.058	0.085	14.2%	0%	12.5	57.5	46000	9.43	1533	1	1900	2640	18.3%	28.2%	5.377	3.38	22013	-18	-1.0%	-0.5%	-0.17	-0.05	-381
25	0.240	0.171	29.6%	0%	12.5	107.5	46000	9.00	1533	1	1700	4908	51.4%	65.5%	5.807	5.81	6129	760	-0.1%	2.2%	-0.23	-0.23	-2797
26	0.052	0.302	13.0%	0%	12.5	0.0	37000	9.00	1233	1	2250	2145	38.4%	39.6%	4.871	2.72	17262	139	-5.4%	-5.1%	-0.46	0.39	-3619
27	0.135	0.102	8.4%	0%	12.5	70.0	21600	9.04	720	1	2250	1722	31.8%	54.3%	2.658	2.66	4863	369	-0.1%	3.5%	-0.1	-0.10	-1791
28	0.073	0.035	12.2%	0%	12.5	130.0	56500	9.00	1883	1	2050	3588	16.1%	33.3%	6.777	4.81	23099	736	-2.0%	3.5%	-0.6	1.35	-6673
29	0.069	0.042	9.9%	0%	12.5	122.5	56500	9.00	1883	1	1500	3102	16.2%	32.4%	6.798	4.12	23730	667	-3.1%	3.8%	-0.81	1.11	-7271
30	0.070	0.049	12.6%	0%	12.5	107.5	50000	9.90	1667	1	1800	2389	17.0%	33.1%	5.485	3.19	20797	609	-0.5%	4.9%	-0.75	-0.28	-1097
31	0.111	0.044	11.5%	0%	12.5	115.0	59000	9.69	1967	1	2700	3466	23.4%	37.8%	6.598	4.81	21874	650	-1.1%	2.1%	-0.36	1.27	-5514
32	0.072	0.038	10.0%	0%	12.5	100.0	42000	9.31	1400	1	1800	2665	16.3%	34.3%	4.88	3.62	16806	535	1.8%	2.7%	0.158	1.13	-3592
33	0.051	0.112	9.2%	0%	12.5	14.0	37000	9.00	1233	1	2400	1675	19.4%	23.6%	4.577	2.07	19833	303	1.0%	1.6%	-0.05	0.48	-3933
34	0.130	0.076	13.3%	0%	12.5	92.5	37000	9.00	1233	1	2400	2422	29.0%	46.8%	4.515	3.74	10845	-14	-0.9%	-0.3%	-0.1	-0.06	-50
35	0.022	0.393	22.9%	0%	12.5	0.0	40000	8.85	1333	1	2700	2385	21.8%	22.4%	5.287	3.04	22806	505	3.7%	3.8%	0.122	0.99	-5196
36	0.107	0.079	6.1%	0%	12.5	77.5	28000	8.97	933	1	2700	2390	25.5%	45.5%	3.436	3.44	8526	-8	-0.7%	-0.1%	-0.06	-0.06	-69
37	0.021	0.186	7.3%	0%	12.5	0.0	34000	9.09	1133	1	2600	1792	7.4%	8.3%	4.179	2.15	22549	325	0.8%	1.0%	-0.32	-0.17	48
38	0.051	0.085	7.1%	0%	12.5	77.5	40000	8.85	1333	1	2600	2904	17.2%	31.8%	4.981	3.85	17626	526	-0.8%	2.3%	-0.28	0.85	-4437
39	0.034	0.133	5.3%	0%	12.5	0.0	40000	9.00	1333	1	2850	1832	18.8%	20.2%	4.986	2.23	23108	263	-1.2%	-0.9%	-0.33	0.37	-4604
40	0.045	0.053	3.7%	0%	12.5	85.0	35000	9.00	1167	1	2850	1918	13.1%	31.7%	4.235	2.54	15040	530	-1.5%	6.3%	-0.71	-0.17	-1613
	0.090	0.093	12.4%	0%	12.5	65.8	41278	9.16	1376	1.0	2132	2584	23.1%	35.3%	4.954	3.44	16986	364	-0.5%	1.7%	-0.27	0.19	-2081
																%change		12.3%	-2.0%	4.6%			

Program Design D

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	No	4	Same	0	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.64	Usage & Duct Loss			kW @5PM		0.54
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	12.5	64.5	46500	9.00	1550	1	2055	2133	5.8%	17.5%	5.532	2.50	25762	862	23.5%	22.2%	0.178	1.70	-8700
2	0.021	0.031	6.2%	71%	12.5	73.5	46000	9.43	1533	1	1589	1851	7.0%	20.1%	5.263	2.22	24614	1045	18.5%	19.5%	-0.25	0.57	-4885
3	0.020	0.037	4.3%	66%	12.5	15.5	28000	8.97	933	1	1797	1124	7.4%	13.7%	3.38	1.30	16901	262	16.4%	15.2%	0.434	0.49	-2216
4	0.025	0.016	4.7%	60%	12.5	85.0	34000	9.09	1133	1	1823	1604	6.1%	26.0%	4.013	2.02	15978	708	11.9%	13.0%	-0.05	0.27	-1462
5	0.022	0.011	5.8%	68%	12.5	69.0	46000	8.90	1533	1	1454	1929	5.0%	17.6%	5.531	2.29	25353	311	10.7%	9.9%	0.106	0.57	-3719
6	0.018	0.014	5.7%	71%	12.5	46.0	46000	8.90	1533	1	1360	2029	4.7%	13.6%	5.537	2.36	27238	325	11.4%	10.7%	0.157	0.58	-3772
7	0.025	0.009	5.3%	68%	12.5	100.0	42000	9.00	1400	1	1296	2324	5.3%	24.3%	4.988	2.90	20333	1067	12.6%	15.1%	-0.33	0.48	-3619
8	0.031	0.018	6.3%	66%	12.5	90.0	42500	8.91	1417	1	1516	2315	7.3%	24.2%	5.118	2.88	20798	1022	13.9%	15.0%	-0.01	2.11	-8418
9	0.018	0.014	6.4%	75%	12.5	76.3	58500	8.76	1950	1	1637	2872	4.6%	15.5%	7.15	3.36	33501	1180	13.2%	14.2%	-0.07	2.07	-11908
10	0.067	0.068	3.8%	51%	12.5	77.5	33000	9.00	1100	1	2717	2314	18.0%	35.7%	4.017	3.16	13067	500	12.0%	12.9%	-0.27	0.59	-4014
11	0.083	0.057	4.1%	56%	12.5	77.5	28200	9.00	940	1	2685	2113	19.8%	40.3%	3.42	3.03	9803	751	18.2%	17.7%	-0.13	0.26	-4431
12	0.013	0.065	3.5%	46%	12.5	0.0	37000	9.00	1233	1	2329	1814	9.0%	10.6%	4.496	2.10	23900	528	8.7%	9.1%	-0.39	0.02	-1902
13	0.034	0.025	4.2%	77%	12.5	70.0	28200	8.92	940	1	2100	1675	8.6%	28.5%	3.406	2.10	12697	801	24.0%	22.6%	-0.03	1.27	-5547
14	0.028	0.027	7.2%	60%	12.5	77.5	35000	9.36	1167	1	1016	1790	7.7%	25.5%	4.03	2.25	16816	873	16.3%	16.1%	0.103	0.40	-1804
15	0.033	0.016	8.0%	22%	12.5	63.0	35000	9.36	1167	1	977	1239	7.5%	22.5%	4.012	1.54	17710	324	4.5%	5.5%	-0.03	-0.05	627
16	0.038	0.041	3.3%	77%	12.5	0.0	35800	9.40	1193	1	2074	1480	10.7%	12.5%	4.128	1.69	22154	887	24.6%	24.8%	-0.31	1.55	-10774
17	0.049	0.022	3.5%	50%	12.5	85.0	35800	9.40	1193	1	2223	1900	10.9%	29.6%	4.097	2.46	15739	875	8.7%	14.8%	-0.61	0.34	-3718
18	0.016	0.038	2.9%	67%	12.5	0.0	35800	9.40	1193	1	2216	1447	6.9%	8.6%	4.124	1.64	23429	524	13.8%	13.9%	0.049	0.85	-7229
19	0.039	0.017	3.2%	52%	12.5	85.0	35800	9.40	1193	1	2274	1853	8.6%	27.5%	4.09	2.37	16388	797	10.6%	13.3%	-0.29	0.28	-2469
20	0.025	0.016	4.0%	77%	12.5	65.0	59000	9.69	1967	1	1619	3165	6.2%	15.5%	6.523	3.73	33894	1348	14.5%	17.3%	-0.64	2.15	-14694
21	0.039	0.014	3.3%	75%	12.5	107.5	56900	9.27	1897	1	2272	3465	8.4%	23.3%	6.572	4.29	28267	1991	19.2%	22.8%	-0.6	1.69	-15364
22	0.032	0.013	4.2%	75%	12.5	53.8	58500	9.87	1950	1	1688	2542	7.0%	15.0%	6.344	2.98	33861	1231	16.9%	18.7%	-0.49	2.12	-14963
23	0.053	0.018	5.3%	65%	12.5	92.5	42000	9.31	1400	1	1568	2489	11.2%	28.6%	4.84	3.19	18829	1404	17.6%	20.4%	-0.31	1.34	-10171
24	0.015	0.021	3.9%	75%	12.5	57.5	46000	9.43	1533	1	1698	2236	4.8%	15.5%	5.242	2.63	26482	387	12.5%	12.2%	-0.03	0.70	-4850
25	0.048	0.034	7.7%	80%	12.5	107.5	46000	9.00	1533	1	1297	2566	11.8%	29.7%	5.519	3.27	20343	3102	39.5%	38.0%	0.061	2.31	-17011
26	0.018	0.105	4.9%	65%	12.5	0.0	37000	9.00	1233	1	2060	1569	13.8%	15.4%	4.566	1.83	22763	714	19.1%	19.2%	-0.16	1.28	-9120
27	0.073	0.055	4.8%	46%	12.5	70.0	21600	9.04	720	1	2164	1365	18.1%	42.4%	2.611	2.00	7041	726	13.5%	15.4%	-0.05	0.56	-3969
28	0.017	0.008	3.1%	77%	12.5	130.0	56500	9.00	1883	1	1858	3050	3.8%	22.0%	6.702	3.75	28570	1273	10.3%	14.8%	-0.53	2.41	-12144
29	0.031	0.019	4.6%	56%	12.5	122.5	56500	9.00	1883	1	1417	2768	7.4%	24.3%	6.733	3.46	27604	1001	5.7%	12.0%	-0.74	1.77	-11144
30	0.021	0.015	4.1%	70%	12.5	107.5	50000	9.90	1667	1	1641	2041	5.2%	22.3%	5.408	2.51	25288	957	11.3%	15.7%	-0.67	0.39	-5588
31	0.030	0.012	3.4%	73%	12.5	115.0	59000	9.69	1967	1	2474	2745	6.6%	22.0%	6.512	3.36	29965	1371	15.8%	17.9%	-0.27	2.72	-13605
32	0.032	0.017	4.7%	56%	12.5	100.0	42000	9.31	1400	1	1699	2365	7.3%	26.1%	4.837	3.00	19749	835	10.8%	11.0%	0.201	1.75	-6536
33	0.023	0.051	4.4%	55%	12.5	14.0	37000	9.00	1233	1	2280	1478	9.3%	13.7%	4.471	1.72	22526	500	11.2%	11.4%	0.053	0.84	-6626
34	0.039	0.023	4.4%	70%	12.5	92.5	37000	9.00	1233	1	2176	1767	9.1%	28.7%	4.421	2.24	16551	641	19.0%	17.9%	-0	1.44	-5756
35	0.003	0.049	3.6%	87%	12.5	0.0	40000	8.85	1333	1	2158	1865	1.6%	2.4%	4.875	2.03	28022	1026	23.8%	23.7%	0.535	2.00	-10412
36	0.054	0.040	3.2%	50%	12.5	77.5	28000	8.97	933	1	2618	2012	13.4%	34.7%	3.384	2.74	11075	370	11.4%	10.7%	-0.01	0.63	-2618
37	0.008	0.072	3.0%	61%	12.5	0.0	34000	9.09	1133	1	2483	1714	3.0%	4.0%	4.06	1.95	23433	403	5.2%	5.3%	-0.2	0.03	-836
38	0.023	0.037	3.3%	56%	12.5	77.5	40000	8.85	1333	1	2496	2602	7.9%	23.4%	4.89	3.23	20187	829	8.4%	10.6%	-0.18	1.47	-6997
39	0.016	0.061	2.5%	54%	12.5	0.0	40000	9.00	1333	1	2768	1649	9.0%	10.6%	4.852	1.90	25798	447	8.6%	8.8%	-0.2	0.70	-7293
40	0.032	0.038	2.7%	29%	12.5	85.0	35000	9.00	1167	1	2819	1828	9.4%	28.4%	4.209	2.36	15952	620	2.2%	9.6%	-0.68	0.01	-2525
	0.031	0.031	4.4%	63%	12.5	65.8	41278	9.16	1376	1.0	1960	2077	8.4%	21.5%	4.848	2.56	21709	870	14.2%	15.5%	-0.17	1.07	-6804
																	%change	29.5%	62.9%	41.8%			

Program Design E

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	No	8	Same	0	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.47	Usage & Duct Loss			kW @5PM		0.71
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	46500	9.00	1550	1	2055	1996	5.8%	11.7%	5.523	2.27	28397	999	23.5%	28.0%	0.187	1.94	-11335
2	0.021	0.031	6.2%	71%	6.3	36.8	46000	9.43	1533	1	1589	1716	7.0%	13.7%	5.255	1.98	27534	1179	18.5%	25.9%	-0.24	0.81	-7804
3	0.020	0.037	4.3%	66%	6.3	7.8	28000	8.97	933	1	1797	1087	7.4%	10.6%	3.372	1.23	17741	299	16.4%	18.3%	0.442	0.56	-3056
4	0.025	0.016	4.7%	60%	6.3	42.5	34000	9.09	1133	1	1823	1421	6.1%	16.4%	4.004	1.68	19218	891	12.0%	22.6%	-0.04	0.61	-4702
5	0.022	0.011	5.8%	68%	6.3	34.5	46000	8.90	1533	1	1454	1796	5.0%	11.5%	5.522	2.06	28149	443	10.7%	16.1%	0.115	0.80	-6515
6	0.018	0.014	5.7%	71%	6.3	23.0	46000	8.90	1533	1	1360	1933	4.7%	9.2%	5.528	2.19	29225	421	11.4%	15.1%	0.166	0.74	-5759
7	0.025	0.009	5.3%	68%	6.3	50.0	42000	9.00	1400	1	1296	2076	5.3%	15.1%	4.979	2.44	24135	1315	12.6%	24.3%	-0.32	0.94	-7421
8	0.031	0.018	6.3%	66%	6.3	45.0	42500	8.91	1417	1	1516	2091	7.3%	16.0%	5.109	2.46	24254	1245	13.9%	23.2%	0.003	2.53	-11875
9	0.018	0.014	6.4%	75%	6.3	38.1	58500	8.76	1950	1	1637	2704	4.6%	10.2%	7.141	3.07	36590	1348	13.2%	19.5%	-0.06	2.36	-14997
10	0.067	0.068	3.8%	51%	6.3	38.8	33000	9.00	1100	1	2717	2054	18.0%	27.2%	4.009	2.59	15922	759	12.0%	21.4%	-0.26	1.16	-6868
11	0.083	0.057	4.1%	56%	6.3	38.8	28200	9.00	940	1	2685	1827	19.8%	30.4%	3.412	2.35	12606	1037	18.2%	27.6%	-0.12	0.94	-7234
12	0.013	0.065	3.5%	46%	6.3	0.0	37000	9.00	1233	1	2329	1801	9.0%	9.9%	4.488	2.07	24155	541	8.7%	9.9%	-0.38	0.04	-2157
13	0.034	0.025	4.2%	77%	6.3	35.0	28200	8.92	940	1	2100	1481	8.6%	18.9%	3.398	1.73	15383	996	24.0%	32.2%	-0.02	1.64	-8234
14	0.028	0.027	7.2%	60%	6.3	38.8	35000	9.36	1167	1	1016	1607	7.7%	16.8%	4.022	1.91	19804	1056	16.3%	24.7%	0.111	0.74	-4792
15	0.033	0.016	8.0%	22%	6.3	31.5	35000	9.36	1167	1	977	1134	7.5%	15.2%	4.004	1.34	20234	429	4.5%	12.8%	-0.03	0.14	-1897
16	0.038	0.041	3.3%	77%	6.3	0.0	35800	9.40	1193	1	2074	1468	10.7%	11.6%	4.121	1.67	22414	899	24.6%	25.6%	-0.3	1.58	-11035
17	0.049	0.022	3.5%	50%	6.3	42.5	35800	9.40	1193	1	2223	1687	10.8%	20.5%	4.089	2.04	18948	1089	8.7%	23.9%	-0.6	0.76	-6927
18	0.016	0.038	2.9%	67%	6.3	0.0	35800	9.40	1193	1	2216	1435	6.9%	7.8%	4.117	1.62	23687	535	13.7%	14.7%	0.057	0.87	-7488
19	0.039	0.017	3.2%	52%	6.3	42.5	35800	9.40	1193	1	2274	1648	8.6%	18.3%	4.081	1.97	19620	1002	10.6%	22.5%	-0.28	0.67	-5702
20	0.025	0.016	4.0%	77%	6.3	32.5	59000	9.69	1967	1	1619	3005	6.2%	10.9%	6.515	3.45	36575	1508	14.5%	21.9%	-0.64	2.43	-17375
21	0.039	0.014	3.3%	75%	6.3	53.8	56900	9.27	1897	1	2272	3170	8.4%	16.0%	6.563	3.74	32378	2287	19.3%	30.1%	-0.59	2.24	-19475
22	0.032	0.013	4.2%	75%	6.3	26.9	58500	9.87	1950	1	1688	2431	7.0%	11.1%	6.337	2.79	36135	1342	16.9%	22.7%	-0.48	2.31	-17238
23	0.053	0.018	5.3%	65%	6.3	46.3	42000	9.31	1400	1	1568	2232	11.2%	20.1%	4.831	2.69	22324	1661	17.6%	28.9%	-0.3	1.85	-13665
24	0.015	0.021	3.9%	75%	6.3	28.8	46000	9.43	1533	1	1698	2107	4.8%	10.3%	5.234	2.41	28872	515	12.5%	17.4%	-0.02	0.92	-7240
25	0.048	0.034	7.7%	80%	6.3	53.8	46000	9.00	1533	1	1297	2288	11.8%	21.0%	5.511	2.73	24320	3380	39.5%	46.7%	0.07	2.85	-20988
26	0.018	0.105	4.9%	65%	6.3	0.0	37000	9.00	1233	1	2060	1558	13.9%	14.6%	4.558	1.81	23013	726	19.1%	19.9%	-0.15	1.30	-9370
27	0.073	0.055	4.8%	46%	6.3	35.0	21600	9.04	720	1	2164	1142	18.1%	30.8%	2.603	1.47	9558	949	13.5%	27.1%	-0.05	1.09	-6486
28	0.017	0.008	3.1%	77%	6.3	65.0	56500	9.00	1883	1	1858	2744	3.8%	13.2%	6.694	3.20	33479	1579	10.3%	23.6%	-0.52	2.97	-17053
29	0.031	0.019	4.6%	56%	6.3	61.3	56500	9.00	1883	1	1417	2499	7.4%	16.1%	6.724	2.96	32210	1270	5.7%	20.2%	-0.74	2.27	-15750
30	0.021	0.015	4.1%	70%	6.3	53.8	50000	9.90	1667	1	1641	1847	5.2%	14.0%	5.4	2.16	29391	1151	11.3%	24.0%	-0.66	0.75	-9692
31	0.030	0.012	3.4%	73%	6.3	57.5	59000	9.69	1967	1	2474	2505	6.6%	14.5%	6.504	2.93	34359	1611	15.8%	25.4%	-0.26	3.16	-17999
32	0.032	0.017	4.7%	56%	6.3	50.0	42000	9.31	1400	1	1699	2110	7.3%	17.0%	4.829	2.51	23523	1090	10.8%	20.1%	0.209	2.24	-10309
33	0.023	0.051	4.4%	55%	6.3	7.0	37000	9.00	1233	1	2280	1443	9.3%	11.5%	4.463	1.66	23310	535	11.1%	13.6%	0.061	0.90	-7409
34	0.039	0.023	4.4%	70%	6.3	46.3	37000	9.00	1233	1	2176	1562	9.1%	19.2%	4.412	1.85	20020	846	19.0%	27.3%	0.008	1.83	-9225
35	0.003	0.049	3.6%	87%	6.3	0.0	40000	8.85	1333	1	2158	1859	1.6%	2.0%	4.869	2.02	28193	1032	23.8%	24.1%	0.54	2.01	-10582
36	0.054	0.040	3.2%	50%	6.3	38.8	28000	8.97	933	1	2618	1751	13.4%	24.4%	3.375	2.17	13940	631	11.4%	20.9%	1E-04	1.20	-5484
37	0.008	0.072	3.0%	61%	6.3	0.0	34000	9.09	1133	1	2483	1707	3.0%	3.5%	4.055	1.94	23602	410	5.2%	5.8%	-0.19	0.04	-1005
38	0.023	0.037	3.3%	56%	6.3	38.8	40000	8.85	1333	1	2496	2375	7.9%	15.8%	4.881	2.81	23198	1056	8.4%	18.2%	-0.18	1.90	-10009
39	0.016	0.061	2.5%	54%	6.3	0.0	40000	9.00	1333	1	2768	1637	9.1%	9.8%	4.844	1.88	26053	458	8.6%	9.5%	-0.19	0.72	-7549
40	0.032	0.038	2.7%	29%	6.3	42.5	35000	9.00	1167	1	2819	1623	9.4%	19.2%	4.201	1.96	19154	825	2.2%	18.8%	-0.67	0.41	-5727
	0.031	0.031	4.4%	63%	6.3	32.9	41278	9.16	1376	1.0	1960	1914	8.4%	15.1%	4.84	2.25	24291	1034	14.3%	21.9%	-0.16	1.38	-9386
																	%change	35.1%	63.0%	59.1%			

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	Same	No	4	Same	2	400	All

Program Design F

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.59	Usage & Duct Loss			kW @5PM		0.60
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.130	0.076	17.7%	0%	12.5	64.5	46500	11.00	1550	1	2400	2443	29.0%	39.5%	4.64	3.42	17050	552	0.3%	0.2%	1.07	0.79	12
2	0.073	0.106	18.3%	0%	12.5	73.5	46000	11.43	1533	1	1825	1883	22.5%	34.3%	4.471	2.52	19539	1012	3.1%	5.3%	0.54	0.28	190
3	0.059	0.112	11.8%	0%	12.5	15.5	28000	10.97	933	1	1950	1096	20.6%	26.5%	2.844	1.38	14207	291	3.1%	2.4%	0.97	0.41	478
4	0.062	0.039	10.9%	0%	12.5	85.0	34000	11.09	1133	1	1950	1499	14.7%	33.9%	3.32	2.02	13734	813	3.3%	5.1%	0.639	0.26	783
5	0.068	0.036	16.2%	0%	12.5	69.0	46000	10.90	1533	1	1635	1828	15.5%	27.5%	4.561	2.33	21489	412	0.2%	0.0%	1.076	0.53	146
6	0.062	0.049	17.2%	0%	12.5	46.0	46000	10.90	1533	1	1550	1918	15.7%	24.2%	4.586	2.39	23260	436	0.4%	0.2%	1.109	0.55	206
7	0.078	0.027	14.8%	0%	12.5	100.0	42000	11.00	1400	1	1440	2213	16.3%	34.4%	4.112	3.01	16616	1178	1.7%	5.0%	0.549	0.38	98
8	0.090	0.052	16.5%	0%	12.5	90.0	42500	10.91	1417	1	1700	2272	20.6%	36.5%	4.238	3.13	16372	1064	0.6%	2.7%	0.874	1.86	-3992
9	0.070	0.057	21.4%	0%	12.5	76.3	58500	10.76	1950	1	1950	2794	17.8%	28.0%	5.923	3.56	27549	1258	0.1%	1.7%	1.153	1.87	-5955
10	0.137	0.139	7.4%	0%	12.5	77.5	33000	11.00	1100	1	2825	2404	34.7%	50.6%	3.375	3.38	8985	409	-4.7%	-2.0%	0.369	0.37	68
11	0.188	0.128	8.9%	0%	12.5	77.5	28200	11.00	940	1	2825	2436	41.4%	59.5%	2.874	2.87	5079	428	-3.5%	-1.6%	0.415	0.42	292
12	0.023	0.121	6.4%	0%	12.5	0.0	37000	11.00	1233	1	2400	1601	16.2%	17.7%	3.757	1.92	22150	742	1.6%	2.0%	0.348	0.19	-152
13	0.150	0.111	16.2%	0%	12.5	70.0	28200	10.92	940	1	2400	2063	34.7%	52.0%	2.876	2.88	7100	414	-2.0%	-0.9%	0.498	0.50	50
14	0.070	0.067	16.1%	0%	12.5	77.5	35000	11.36	1167	1	1125	1701	18.5%	35.3%	3.374	2.31	14034	962	5.5%	6.3%	0.76	0.34	978
15	0.043	0.020	10.1%	0%	12.5	63.0	35000	11.36	1167	1	1000	1051	9.6%	24.5%	3.312	1.32	17112	511	2.3%	3.5%	0.665	0.16	1225
16	0.162	0.173	12.9%	0%	12.5	0.0	35800	11.40	1193	1	2300	1834	40.4%	41.9%	3.575	2.56	13501	533	-5.1%	-4.7%	0.243	0.68	-2121
17	0.098	0.043	6.8%	0%	12.5	85.0	35800	11.40	1193	1	2300	1818	21.1%	39.0%	3.407	2.57	12804	958	-1.6%	5.3%	0.082	0.23	-782
18	0.051	0.117	8.4%	0%	12.5	0.0	35800	11.40	1193	1	2350	1387	19.9%	21.5%	3.505	1.69	20058	584	0.8%	1.0%	0.668	0.80	-3859
19	0.080	0.036	6.3%	0%	12.5	85.0	35800	11.40	1193	1	2350	1732	17.4%	35.6%	3.398	2.37	13879	919	1.7%	5.2%	0.406	0.28	40
20	0.108	0.069	15.1%	0%	12.5	65.0	59000	11.69	1967	1	1830	3315	24.9%	33.4%	5.523	4.41	24988	1199	-4.2%	-0.6%	0.357	1.47	-5787
21	0.158	0.056	12.1%	0%	12.5	107.5	56900	11.27	1897	1	2500	3972	32.3%	45.8%	5.499	5.50	17102	1485	-4.7%	0.3%	0.475	0.47	-4198
22	0.128	0.053	14.9%	0%	12.5	53.8	58500	11.87	1950	1	1900	2758	26.9%	34.3%	5.362	3.67	24049	1015	-3.1%	-0.6%	0.497	1.43	-5152
23	0.155	0.052	13.9%	0%	12.5	92.5	42000	11.31	1400	1	1725	2771	31.7%	47.6%	4.04	4.04	11871	1122	-2.9%	1.4%	0.494	0.49	-3212
24	0.058	0.085	14.2%	0%	12.5	57.5	46000	11.43	1533	1	1900	2178	18.3%	28.2%	4.436	2.78	22013	444	-1.0%	-0.5%	0.775	0.54	-381
25	0.240	0.171	29.6%	0%	12.5	107.5	46000	11.00	1533	1	1700	4015	51.4%	65.5%	4.752	4.75	6129	1652	-0.1%	2.2%	0.829	0.83	-2797
26	0.052	0.302	13.0%	0%	12.5	0.0	37000	11.00	1233	1	2250	1755	38.4%	39.6%	3.986	2.22	17262	529	-5.4%	-5.1%	0.423	0.89	-3619
27	0.135	0.102	8.4%	0%	12.5	70.0	21600	11.04	720	1	2250	1410	31.8%	54.3%	2.176	2.18	4863	681	-0.1%	3.5%	0.382	0.38	-1791
28	0.073	0.035	12.2%	0%	12.5	130.0	56500	11.00	1883	1	2050	2936	16.1%	33.3%	5.545	3.94	23099	1388	-2.0%	3.5%	0.629	2.23	-6673
29	0.069	0.042	9.9%	0%	12.5	122.5	56500	11.00	1883	1	1500	2538	16.2%	32.4%	5.562	3.37	23730	1231	-3.1%	3.8%	0.427	1.86	-7271
30	0.070	0.049	12.6%	0%	12.5	107.5	50000	11.90	1667	1	1800	1987	17.0%	33.1%	4.563	2.65	20797	1011	-0.5%	4.9%	0.176	0.26	-1097
31	0.111	0.044	11.5%	0%	12.5	115.0	59000	11.69	1967	1	2700	2873	23.4%	37.8%	5.469	3.99	21874	1243	-1.1%	2.1%	0.773	2.10	-5514
32	0.072	0.038	10.0%	0%	12.5	100.0	42000	11.31	1400	1	1800	2194	16.3%	34.3%	4.017	2.98	16806	1006	1.8%	2.7%	1.021	1.77	-3592
33	0.051	0.112	9.2%	0%	12.5	14.0	37000	11.00	1233	1	2400	1370	19.4%	23.6%	3.745	1.70	19833	608	1.0%	1.6%	0.78	0.86	-3933
34	0.130	0.076	13.3%	0%	12.5	92.5	37000	11.00	1233	1	2400	1982	29.0%	46.8%	3.695	3.06	10845	426	-0.9%	-0.3%	0.725	0.62	-50
35	0.022	0.393	22.9%	0%	12.5	0.0	40000	10.85	1333	1	2700	1946	21.8%	22.4%	4.312	2.48	22806	945	3.7%	3.8%	1.097	1.55	-5196
36	0.107	0.079	6.1%	0%	12.5	77.5	28000	10.97	933	1	2700	1955	25.5%	45.5%	2.81	2.81	8526	427	-0.7%	-0.1%	0.566	0.57	-69
37	0.021	0.186	7.3%	0%	12.5	0.0	34000	11.09	1133	1	2600	1469	7.4%	8.3%	3.426	1.76	22549	648	0.8%	1.0%	0.436	0.22	48
38	0.051	0.085	7.1%	0%	12.5	77.5	40000	10.85	1333	1	2600	2369	17.2%	31.8%	4.063	3.14	17626	1062	-0.8%	2.3%	0.642	1.56	-4437
39	0.034	0.133	5.3%	0%	12.5	0.0	40000	11.00	1333	1	2850	1499	18.8%	20.2%	4.079	1.82	23108	596	-1.2%	-0.9%	0.577	0.77	-4604
40	0.045	0.053	3.7%	0%	12.5	85.0	35000	11.00	1167	1	2850	1569	13.1%	31.7%	3.465	2.08	15040	879	-1.5%	6.3%	0.062	0.29	-1613
	0.090	0.093	12.4%	0%	12.5	65.8	41278	11.16	1376	1.0	2132	2121	23.1%	35.3%	4.067	2.82	16986	827	-0.5%	1.7%	0.614	0.80	-2081
																%change		28.0%	-2.0%	4.6%			

Program Design G

Retrofits:	Duct@25	Shade	Rduct		Sizing	dEER	Qahpt	Chg Fix
	75	No	8		Same	2	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.03	Usage & Duct Loss			kW @5PM		1.16
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	46500	11.00	1550	1	2055	1634	5.8%	11.7%	4.519	1.85	28397	1361	23.5%	28.0%	1.191	2.35	-11335
2	0.021	0.031	6.2%	71%	6.3	36.8	46000	11.43	1533	1	1589	1415	7.0%	13.7%	4.335	1.63	27534	1480	18.5%	25.9%	0.675	1.16	-7804
3	0.020	0.037	4.3%	66%	6.3	7.8	28000	10.97	933	1	1797	889	7.4%	10.6%	2.757	1.01	17741	498	16.4%	18.3%	1.056	0.78	-3056
4	0.025	0.016	4.7%	60%	6.3	42.5	34000	11.09	1133	1	1823	1165	6.1%	16.4%	3.282	1.37	19218	1148	12.0%	22.6%	0.678	0.91	-4702
5	0.022	0.011	5.8%	68%	6.3	34.5	46000	10.90	1533	1	1454	1467	5.0%	11.5%	4.508	1.68	28149	773	10.7%	16.1%	1.128	1.18	-6515
6	0.018	0.014	5.7%	71%	6.3	23.0	46000	10.90	1533	1	1360	1578	4.7%	9.2%	4.514	1.79	29225	776	11.4%	15.1%	1.18	1.15	-5759
7	0.025	0.009	5.3%	68%	6.3	50.0	42000	11.00	1400	1	1296	1699	5.3%	15.1%	4.074	2.00	24135	1693	12.6%	24.3%	0.587	1.39	-7421
8	0.031	0.018	6.3%	66%	6.3	45.0	42500	10.91	1417	1	1516	1708	7.3%	16.0%	4.172	2.01	24254	1629	13.9%	23.2%	0.94	2.98	-11875
9	0.018	0.014	6.4%	75%	6.3	38.1	58500	10.76	1950	1	1637	2201	4.6%	10.2%	5.814	2.50	36590	1851	13.2%	19.5%	1.263	2.93	-14997
10	0.067	0.068	3.8%	51%	6.3	38.8	33000	11.00	1100	1	2717	1681	18.0%	27.2%	3.28	2.12	15922	1133	12.0%	21.4%	0.464	1.63	-6868
11	0.083	0.057	4.1%	56%	6.3	38.8	28200	11.00	940	1	2685	1495	19.8%	30.4%	2.792	1.92	12606	1369	18.2%	27.6%	0.498	1.37	-7234
12	0.013	0.065	3.5%	46%	6.3	0.0	37000	11.00	1233	1	2329	1474	9.0%	9.9%	3.673	1.69	24155	869	8.7%	9.9%	0.433	0.42	-2157
13	0.034	0.025	4.2%	77%	6.3	35.0	28200	10.92	940	1	2100	1210	8.6%	18.9%	2.776	1.42	15383	1267	24.0%	32.2%	0.598	1.96	-8234
14	0.028	0.027	7.2%	60%	6.3	38.8	35000	11.36	1167	1	1016	1324	7.7%	16.8%	3.314	1.57	19804	1339	16.3%	24.7%	0.819	1.08	-4792
15	0.033	0.016	8.0%	22%	6.3	31.5	35000	11.36	1167	1	977	934	7.5%	15.2%	3.299	1.10	20234	628	4.5%	12.8%	0.678	0.38	-1897
16	0.038	0.041	3.3%	77%	6.3	0.0	35800	11.40	1193	1	2074	1210	10.7%	11.6%	3.397	1.37	22414	1156	24.6%	25.6%	0.421	1.87	-11035
17	0.049	0.022	3.5%	50%	6.3	42.5	35800	11.40	1193	1	2223	1391	10.8%	20.5%	3.371	1.68	18948	1385	8.7%	23.9%	0.118	1.12	-6927
18	0.016	0.038	2.9%	67%	6.3	0.0	35800	11.40	1193	1	2216	1183	6.9%	7.8%	3.394	1.34	23687	787	13.7%	14.7%	0.779	1.16	-7488
19	0.039	0.017	3.2%	52%	6.3	42.5	35800	11.40	1193	1	2274	1359	8.6%	18.3%	3.365	1.63	19620	1291	10.6%	22.5%	0.438	1.02	-5702
20	0.025	0.016	4.0%	77%	6.3	32.5	59000	11.69	1967	1	1619	2491	6.2%	10.9%	5.4	2.86	36575	2023	14.5%	21.9%	0.479	3.02	-17375
21	0.039	0.014	3.3%	75%	6.3	53.8	56900	11.27	1897	1	2272	2607	8.4%	16.0%	5.398	3.07	32378	2849	19.3%	30.1%	0.575	2.90	-19475
22	0.032	0.013	4.2%	75%	6.3	26.9	58500	11.87	1950	1	1688	2021	7.0%	11.1%	5.269	2.32	36135	1752	16.9%	22.7%	0.59	2.78	-17238
23	0.053	0.018	5.3%	65%	6.3	46.3	42000	11.31	1400	1	1568	1837	11.2%	20.1%	3.977	2.21	22324	2056	17.6%	28.9%	0.557	2.32	-13665
24	0.015	0.021	3.9%	75%	6.3	28.8	46000	11.43	1533	1	1698	1738	4.8%	10.3%	4.318	1.99	28872	884	12.5%	17.4%	0.893	1.34	-7240
25	0.048	0.034	7.7%	80%	6.3	53.8	46000	11.00	1533	1	1297	1872	11.8%	21.0%	4.509	2.23	24320	3796	39.5%	46.7%	1.072	3.35	-20988
26	0.018	0.105	4.9%	65%	6.3	0.0	37000	11.00	1233	1	2060	1275	13.9%	14.6%	3.73	1.48	23013	1009	19.1%	19.9%	0.679	1.63	-9370
27	0.073	0.055	4.8%	46%	6.3	35.0	21600	11.04	720	1	2164	935	18.1%	30.8%	2.132	1.20	9558	1156	13.5%	27.1%	0.426	1.36	-6486
28	0.017	0.008	3.1%	77%	6.3	65.0	56500	11.00	1883	1	1858	2245	3.8%	13.2%	5.477	2.62	33479	2078	10.3%	23.6%	0.697	3.55	-17053
29	0.031	0.019	4.6%	56%	6.3	61.3	56500	11.00	1883	1	1417	2045	7.4%	16.1%	5.502	2.43	32210	1724	5.7%	20.2%	0.487	2.80	-15750
30	0.021	0.015	4.1%	70%	6.3	53.8	50000	11.90	1667	1	1641	1536	5.2%	14.0%	4.493	1.80	29391	1462	11.3%	24.0%	0.246	1.11	-9692
31	0.030	0.012	3.4%	73%	6.3	57.5	59000	11.69	1967	1	2474	2077	6.6%	14.5%	5.391	2.43	34359	2039	15.8%	25.4%	0.851	3.66	-17999
32	0.032	0.017	4.7%	56%	6.3	50.0	42000	11.31	1400	1	1699	1737	7.3%	17.0%	3.975	2.07	23523	1463	10.8%	20.1%	1.063	2.68	-10309
33	0.023	0.051	4.4%	55%	6.3	7.0	37000	11.00	1233	1	2280	1181	9.3%	11.5%	3.652	1.36	23310	797	11.1%	13.6%	0.873	1.20	-7409
34	0.039	0.023	4.4%	70%	6.3	46.3	37000	11.00	1233	1	2176	1278	9.1%	19.2%	3.61	1.51	20020	1130	19.0%	27.3%	0.81	2.16	-9225
35	0.003	0.049	3.6%	87%	6.3	0.0	40000	10.85	1333	1	2158	1516	1.6%	2.0%	3.971	1.65	28193	1375	23.8%	24.1%	1.438	2.38	-10582
36	0.054	0.040	3.2%	50%	6.3	38.8	28000	10.97	933	1	2618	1432	13.4%	24.4%	2.76	1.78	13940	950	11.4%	20.9%	0.615	1.60	-5484
37	0.008	0.072	3.0%	61%	6.3	0.0	34000	11.09	1133	1	2483	1399	3.0%	3.5%	3.323	1.59	23602	718	5.2%	5.8%	0.538	0.39	-1005
38	0.023	0.037	3.3%	56%	6.3	38.8	40000	10.85	1333	1	2496	1937	7.9%	15.8%	3.981	2.29	23198	1494	8.4%	18.2%	0.723	2.41	-10009
39	0.016	0.061	2.5%	54%	6.3	0.0	40000	11.00	1333	1	2768	1340	9.1%	9.8%	3.964	1.54	26053	756	8.6%	9.5%	0.693	1.06	-7549
40	0.032	0.038	2.7%	29%	6.3	42.5	35000	11.00	1167	1	2819	1328	9.4%	19.2%	3.437	1.61	19154	1120	2.2%	18.8%	0.09	0.77	-5727
	0.031	0.031	4.4%	63%	6.3	32.9	41278	11.16	1376	1.0	1960	1571	8.4%	15.1%	3.973	1.84	24291	1377	14.3%	21.9%	0.708	1.78	-9386
																	%change	46.7%	63.0%	59.1%			

Program Design H

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	Same	Yes	4	Same	0	Same	None

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.99	Usage & Duct Loss			kW @5PM		0.19
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DikW2	CapaPk2	kWh	Leaks	Total	kW	DikW	CapaPk
1	0.130	0.076	17.7%	0%	12.5	64.5	46500	9.00	1588	1	2400	2627	29.3%	39.7%	5.71	3.68	17062	368	0.0%	0.0%	0	0.53	0
2	0.073	0.106	18.3%	0%	12.5	73.5	46000	9.43	1468	0.8	1825	2537	25.6%	39.6%	5.011	2.44	19729	359	0.0%	0.0%	0	0.35	0
3	0.059	0.112	11.8%	0%	12.5	15.5	28000	8.97	1229	1	1950	1213	23.7%	28.9%	3.814	1.57	14685	173	0.0%	0.0%	0	0.22	0
4	0.062	0.039	10.9%	0%	12.5	85.0	34000	9.09	1321	0.8	1950	2027	18.0%	39.0%	3.96	2.00	14516	285	0.0%	0.0%	0	0.29	0
5	0.068	0.036	16.2%	0%	12.5	69.0	46000	8.90	1586	1	1635	1960	15.7%	27.6%	5.637	2.50	21635	280	0.0%	0.0%	0	0.36	0
6	0.062	0.049	17.2%	0%	12.5	46.0	46000	8.90	1612	1	1550	2060	16.0%	24.3%	5.694	2.57	23466	294	0.0%	0.0%	0	0.37	0
7	0.078	0.027	14.8%	0%	12.5	100.0	42000	9.00	1345	0.8	1440	2990	18.0%	39.4%	4.661	2.96	16714	402	0.0%	0.0%	0	0.42	0
8	0.090	0.052	16.5%	0%	12.5	90.0	42500	8.91	1285	1.2	1700	2934	21.2%	39.2%	5.112	4.36	12379	402	0.0%	0.0%	0	0.62	0
9	0.070	0.057	21.4%	0%	12.5	76.3	58500	8.76	1681	1.2	1950	3559	17.9%	29.7%	7.076	4.75	21593	493	0.0%	0.0%	0	0.68	0
10	0.137	0.139	7.4%	0%	12.5	77.5	33000	9.00	785	1	2825	2491	30.0%	48.7%	3.744	3.74	9054	322	0.0%	-0.1%	0	0.00	0
11	0.188	0.128	8.9%	0%	12.5	77.5	28200	9.00	751	1	2825	2560	38.1%	58.1%	3.29	3.29	5372	305	-0.1%	-0.2%	0	0.00	0
12	0.023	0.121	6.4%	0%	12.5	0.0	37000	9.00	1053	0.8	2400	2050	17.7%	19.7%	4.105	1.85	21998	292	0.0%	0.0%	0	0.26	0
13	0.150	0.111	16.2%	0%	12.5	70.0	28200	8.92	813	1	2400	2195	32.7%	51.2%	3.374	3.37	7150	281	-0.1%	-0.1%	0	0.00	0
14	0.070	0.067	16.1%	0%	12.5	77.5	35000	9.36	1491	0.8	1125	2339	24.1%	41.6%	4.133	2.32	15012	324	0.0%	0.0%	0	0.33	0
15	0.043	0.020	10.1%	0%	12.5	63.0	35000	9.36	1429	0.8	1000	1367	12.0%	28.0%	3.977	1.30	18337	195	0.0%	0.0%	0	0.19	0
16	0.162	0.173	12.9%	0%	12.5	0.0	35800	9.40	742	1.2	2300	2080	35.3%	37.3%	3.818	2.84	11380	286	0.0%	0.0%	0	0.41	0
17	0.098	0.043	6.8%	0%	12.5	85.0	35800	9.40	753	0.8	2300	2453	19.6%	44.4%	3.489	2.46	12021	322	0.0%	0.0%	0	0.35	0
18	0.051	0.117	8.4%	0%	12.5	0.0	35800	9.40	1082	1.2	2350	1725	20.7%	22.5%	4.173	2.18	16199	245	0.0%	0.0%	0	0.31	0
19	0.080	0.036	6.3%	0%	12.5	85.0	35800	9.40	1126	0.8	2350	2332	19.2%	40.8%	3.803	2.32	13919	318	0.0%	0.0%	0	0.33	0
20	0.108	0.069	15.1%	0%	12.5	65.0	59000	9.69	1081	1.2	1830	3992	20.7%	32.8%	5.88	5.34	19201	522	0.0%	0.0%	0	0.54	0
21	0.158	0.056	12.1%	0%	12.5	107.5	56900	9.27	1095	1.2	2500	4859	27.7%	46.2%	5.973	5.97	12904	597	-0.1%	-0.1%	0	0.00	0
22	0.128	0.053	14.9%	0%	12.5	53.8	58500	9.87	1225	1.2	1900	3317	23.9%	33.8%	5.859	4.46	18898	457	0.0%	0.0%	0	0.64	0
23	0.155	0.052	13.9%	0%	12.5	92.5	42000	9.31	958	1.2	1725	3463	28.9%	49.1%	4.534	4.53	8659	430	-0.1%	-0.1%	0	0.00	0
24	0.058	0.085	14.2%	0%	12.5	57.5	46000	9.43	1371	1	1900	2297	17.3%	27.7%	5.211	2.91	21632	326	0.0%	0.0%	0	0.42	0
25	0.240	0.171	29.6%	0%	12.5	107.5	46000	9.00	1310	1.2	1700	5148	51.6%	68.0%	5.58	5.58	3332	519	-0.2%	-0.3%	0	0.00	0
26	0.052	0.302	13.0%	0%	12.5	0.0	37000	9.00	910	1.2	2250	2001	33.0%	34.6%	4.409	2.72	13643	282	0.0%	0.0%	0	0.39	0
27	0.135	0.102	8.4%	0%	12.5	70.0	21600	9.04	606	1.2	2250	1862	31.7%	58.0%	2.558	2.56	3073	229	-0.1%	-0.2%	0	0.00	0
28	0.073	0.035	12.2%	0%	12.5	130.0	56500	9.00	1170	1.2	2050	3811	14.1%	36.8%	6.174	5.40	16426	513	0.0%	0.0%	0	0.77	0
29	0.069	0.042	9.9%	0%	12.5	122.5	56500	9.00	975	1.2	1500	3313	13.1%	36.3%	5.988	4.58	16459	456	0.0%	0.0%	0	0.65	0
30	0.070	0.049	12.6%	0%	12.5	107.5	50000	9.90	1187	0.8	1800	2632	16.6%	38.0%	4.739	2.54	19699	366	0.0%	0.0%	0	0.36	0
31	0.111	0.044	11.5%	0%	12.5	115.0	59000	9.69	1493	1.2	2700	3619	22.4%	40.0%	6.242	5.32	16360	497	0.0%	0.0%	0	0.76	0
32	0.072	0.038	10.0%	0%	12.5	100.0	42000	9.31	1515	1.2	1800	2814	18.2%	37.1%	5.038	4.15	13214	386	0.0%	0.0%	0	0.59	0
33	0.051	0.112	9.2%	0%	12.5	14.0	37000	9.00	1145	1.2	2400	1731	20.5%	25.2%	4.525	2.24	15900	247	0.0%	0.0%	0	0.32	0
34	0.130	0.076	13.3%	0%	12.5	92.5	37000	9.00	1142	1	2400	2117	28.2%	46.6%	4.42	3.22	10795	291	0.0%	0.0%	0	0.46	0
35	0.022	0.393	22.9%	0%	12.5	0.0	40000	8.85	1376	1.2	2700	2538	25.5%	26.2%	5.409	3.53	17610	353	0.0%	0.0%	0	0.50	0
36	0.107	0.079	6.1%	0%	12.5	77.5	28000	8.97	876	1	2700	2105	24.9%	45.4%	3.376	3.21	8457	277	0.0%	-0.1%	0	0.17	0
37	0.021	0.186	7.3%	0%	12.5	0.0	34000	9.09	1084	0.8	2600	1853	8.2%	9.3%	3.862	1.73	22597	264	0.0%	0.0%	0	0.25	0
38	0.051	0.085	7.1%	0%	12.5	77.5	40000	8.85	1033	1.2	2600	3030	16.4%	34.1%	4.705	4.25	13189	400	0.0%	-0.1%	0	0.45	0
39	0.034	0.133	5.3%	0%	12.5	0.0	40000	9.00	1015	1.2	2850	1833	17.6%	19.3%	4.656	2.27	18505	262	0.0%	0.0%	0	0.32	0
40	0.045	0.053	3.7%	0%	12.5	85.0	35000	9.00	694	0.8	2850	2153	11.6%	38.0%	3.527	2.07	13427	295	0.0%	0.0%	0	0.30	0
	0.090	0.093	12.4%	0%	12.5	65.8	41278	9.16	1160	1.0	2132	2600	22.7%	37.1%	4.681	3.28	14905	348	0.0%	0.0%	0	0.35	0
																	%change	11.8%	-0.1%	-0.1%			

Program Design I

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	Yes	8	Same	2	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		1.89	Usage & Duct Loss			kW @5PM		1.29
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	46500	11.00	1550	1	2055	1419	5.8%	11.7%	4.519	1.60	28397	1576	23.5%	28.0%	1.191	2.60	-11335
2	0.021	0.031	6.2%	71%	6.3	36.8	46000	11.43	1533	1	1589	1232	7.0%	13.7%	4.335	1.42	27534	1664	18.5%	25.9%	0.675	1.38	-7804
3	0.020	0.037	4.3%	66%	6.3	7.8	28000	10.97	933	1	1797	773	7.4%	10.6%	2.757	0.88	17741	613	16.4%	18.3%	1.056	0.92	-3056
4	0.025	0.016	4.7%	60%	6.3	42.5	34000	11.09	1133	1	1823	1015	6.1%	16.4%	3.282	1.19	19218	1297	12.0%	22.6%	0.678	1.09	-4702
5	0.022	0.011	5.8%	68%	6.3	34.5	46000	10.90	1533	1	1454	1278	5.0%	11.4%	4.508	1.46	28149	962	10.7%	16.1%	1.128	1.40	-6515
6	0.018	0.014	5.7%	71%	6.3	23.0	46000	10.90	1533	1	1360	1376	4.7%	9.2%	4.514	1.56	29225	979	11.4%	15.1%	1.18	1.38	-5759
7	0.025	0.009	5.3%	68%	6.3	50.0	42000	11.00	1400	1	1296	1483	5.3%	15.1%	4.074	1.74	24135	1908	12.6%	24.3%	0.587	1.64	-7421
8	0.031	0.018	6.3%	66%	6.3	45.0	42500	10.91	1417	1	1516	1490	7.3%	16.0%	4.172	1.75	24254	1847	13.9%	23.2%	0.94	3.24	-11875
9	0.018	0.014	6.4%	75%	6.3	38.1	58500	10.76	1950	1	1637	1917	4.6%	10.2%	5.814	2.17	36590	2135	13.2%	19.5%	1.263	3.26	-14997
10	0.067	0.068	3.8%	51%	6.3	38.8	33000	11.00	1100	1	2717	1469	18.0%	27.2%	3.28	1.85	15922	1345	12.0%	21.4%	0.464	1.90	-6868
11	0.083	0.057	4.1%	56%	6.3	38.8	28200	11.00	940	1	2685	1307	19.8%	30.4%	2.792	1.67	12606	1558	18.2%	27.5%	0.498	1.62	-7234
12	0.013	0.065	3.5%	46%	6.3	0.0	37000	11.00	1233	1	2329	1287	9.0%	9.9%	3.673	1.48	24155	1055	8.7%	9.9%	0.433	0.64	-2157
13	0.034	0.025	4.2%	77%	6.3	35.0	28200	10.92	940	1	2100	1049	8.6%	18.9%	2.776	1.22	15383	1428	24.0%	32.3%	0.598	2.15	-8234
14	0.028	0.027	7.2%	60%	6.3	38.8	35000	11.36	1167	1	1016	1156	7.7%	16.8%	3.314	1.37	19804	1507	16.3%	24.7%	0.819	1.28	-4792
15	0.033	0.016	8.0%	22%	6.3	31.5	35000	11.36	1167	1	977	817	7.5%	15.2%	3.299	0.97	20234	746	4.5%	12.8%	0.678	0.51	-1897
16	0.038	0.041	3.3%	77%	6.3	0.0	35800	11.40	1193	1	2074	1053	10.7%	11.6%	3.397	1.19	22414	1314	24.6%	25.6%	0.421	2.05	-11035
17	0.049	0.022	3.5%	50%	6.3	42.5	35800	11.40	1193	1	2223	1215	10.8%	20.5%	3.371	1.47	18948	1561	8.7%	23.9%	0.118	1.34	-6927
18	0.016	0.038	2.9%	67%	6.3	0.0	35800	11.40	1193	1	2216	1032	6.9%	7.8%	3.394	1.16	23687	939	13.7%	14.7%	0.779	1.33	-7488
19	0.039	0.017	3.2%	52%	6.3	42.5	35800	11.40	1193	1	2274	1187	8.6%	18.3%	3.365	1.42	19620	1464	10.6%	22.5%	0.438	1.23	-5702
20	0.025	0.016	4.0%	77%	6.3	32.5	59000	11.69	1967	1	1619	2174	6.2%	10.9%	5.4	2.49	36575	2340	14.5%	21.9%	0.479	3.39	-17375
21	0.039	0.014	3.3%	75%	6.3	53.8	56900	11.27	1897	1	2272	2276	8.4%	16.0%	5.398	2.68	32378	3180	19.3%	30.1%	0.575	3.29	-19475
22	0.032	0.013	4.2%	75%	6.3	26.9	58500	11.87	1950	1	1688	1763	7.0%	11.1%	5.269	2.02	36135	2010	16.9%	22.7%	0.59	3.08	-17238
23	0.053	0.018	5.3%	65%	6.3	46.3	42000	11.31	1400	1	1568	1604	11.2%	20.1%	3.977	1.93	22324	2289	17.6%	28.9%	0.557	2.60	-13665
24	0.015	0.021	3.9%	75%	6.3	28.8	46000	11.43	1533	1	1698	1515	4.8%	10.3%	4.318	1.73	28872	1107	12.5%	17.4%	0.893	1.60	-7240
25	0.048	0.034	7.7%	80%	6.3	53.8	46000	11.00	1533	1	1297	1627	11.8%	21.0%	4.509	1.93	24320	4040	39.5%	46.7%	1.072	3.65	-20988
26	0.018	0.105	4.9%	65%	6.3	0.0	37000	11.00	1233	1	2060	1110	13.9%	14.6%	3.73	1.28	23013	1174	19.1%	19.9%	0.679	1.83	-9370
27	0.073	0.055	4.8%	46%	6.3	35.0	21600	11.04	720	1	2164	815	18.1%	30.7%	2.132	1.05	9558	1276	13.5%	27.1%	0.426	1.51	-6486
28	0.017	0.008	3.1%	77%	6.3	65.0	56500	11.00	1883	1	1858	1960	3.8%	13.2%	5.477	2.28	33479	2363	10.3%	23.6%	0.697	3.88	-17053
29	0.031	0.019	4.6%	56%	6.3	61.3	56500	11.00	1883	1	1417	1787	7.4%	16.1%	5.502	2.12	32210	1982	5.7%	20.2%	0.487	3.11	-15750
30	0.021	0.015	4.1%	70%	6.3	53.8	50000	11.90	1667	1	1641	1341	5.2%	14.0%	4.493	1.56	29391	1657	11.3%	24.0%	0.246	1.34	-9692
31	0.030	0.012	3.4%	73%	6.3	57.5	59000	11.69	1967	1	2474	1812	6.6%	14.5%	5.391	2.11	34359	2304	15.8%	25.4%	0.851	3.97	-17999
32	0.032	0.017	4.7%	56%	6.3	50.0	42000	11.31	1400	1	1699	1517	7.3%	17.0%	3.975	1.81	23523	1683	10.8%	20.1%	1.063	2.94	-10309
33	0.023	0.051	4.4%	55%	6.3	7.0	37000	11.00	1233	1	2280	1030	9.3%	11.5%	3.652	1.18	23310	948	11.1%	13.6%	0.873	1.37	-7409
34	0.039	0.023	4.4%	70%	6.3	46.3	37000	11.00	1233	1	2176	1111	9.1%	19.2%	3.61	1.31	20020	1297	19.0%	27.3%	0.81	2.37	-9225
35	0.003	0.049	3.6%	87%	6.3	0.0	40000	10.85	1333	1	2158	1312	1.6%	2.0%	3.971	1.42	28193	1579	23.8%	24.1%	1.438	2.62	-10582
36	0.054	0.040	3.2%	50%	6.3	38.8	28000	10.97	933	1	2618	1252	13.4%	24.4%	2.76	1.55	13940	1130	11.4%	20.9%	0.615	1.83	-5484
37	0.008	0.072	3.0%	61%	6.3	0.0	34000	11.09	1133	1	2483	1221	3.0%	3.5%	3.323	1.38	23602	896	5.2%	5.8%	0.538	0.60	-1005
38	0.023	0.037	3.3%	56%	6.3	38.8	40000	10.85	1333	1	2496	1692	7.9%	15.8%	3.981	2.00	23198	1738	8.4%	18.2%	0.723	2.71	-10009
39	0.016	0.061	2.5%	54%	6.3	0.0	40000	11.00	1333	1	2768	1170	9.0%	9.8%	3.964	1.34	26053	925	8.6%	9.5%	0.693	1.26	-7549
40	0.032	0.038	2.7%	29%	6.3	42.5	35000	11.00	1167	1	2819	1161	9.4%	19.2%	3.437	1.40	19154	1287	2.2%	18.8%	0.09	0.97	-5727
	0.031	0.031	4.4%	63%	6.3	32.9	41278	11.16	1376	1.0	1960	1370	8.4%	15.1%	3.973	1.60	24291	1578	14.3%	21.9%	0.708	2.02	-9386
																	%change	53.5%	63.0%	59.1%			

Program Design A with Resizing

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	No	4	1.33	0	Same	None

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.48	Usage & Duct Loss			kW @5PM		0.70
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DikW	CapaPk
1	0.024	0.014	3.8%	81%	12.5	64.5	32188	9.00	1099	1	2055	2254	5.8%	22.3%	3.86	2.74	16387	741	23.5%	17.4%	1.85	1.46	675
2	0.021	0.031	6.2%	71%	12.5	73.5	28175	9.43	899	0.8	1589	2506	8.0%	32.5%	2.99	2.40	12916	389	17.6%	7.0%	2.02	0.39	6813
3	0.020	0.037	4.3%	66%	12.5	15.5	16830	8.97	738	1	1797	1178	8.5%	17.8%	2.21	1.40	10217	209	15.2%	11.1%	1.61	0.39	4468
4	0.025	0.016	4.7%	60%	12.5	85.0	22600	9.09	878	0.8	1823	2231	7.5%	39.4%	2.61	2.25	9306	82	10.6%	-0.4%	1.35	0.03	5210
5	0.022	0.011	5.8%	68%	12.5	69.0	28132	8.90	970	1	1454	2100	5.1%	24.9%	3.42	2.64	13586	140	10.6%	2.7%	2.22	0.22	8049
6	0.018	0.014	5.7%	71%	12.5	46.0	30259	8.90	1061	1	1360	2126	4.8%	17.9%	3.69	2.55	16840	229	11.3%	6.4%	2.00	0.39	6626
7	0.025	0.009	5.3%	68%	12.5	100.0	32772	9.00	1050	0.8	1296	3050	5.9%	34.1%	3.61	3.00	14269	342	12.1%	5.3%	1.05	0.39	2445
8	0.031	0.018	6.3%	66%	12.5	90.0	32165	8.91	972	1.2	1516	2929	7.5%	32.2%	3.83	3.83	10807	407	13.7%	6.9%	1.28	1.16	1572
9	0.018	0.014	6.4%	75%	12.5	76.3	41957	8.76	1206	1.2	1637	3549	4.7%	21.9%	5.01	4.50	17550	503	13.2%	7.8%	2.07	0.94	4043
10	0.067	0.068	3.8%	51%	12.5	77.5	28325	9.00	674	1	2717	2391	15.4%	38.9%	3.17	3.17	9688	422	14.6%	9.7%	0.57	0.57	-634
11	0.083	0.057	4.1%	56%	12.5	77.5	24205	9.00	645	1	2685	2196	17.9%	43.8%	2.78	2.78	7275	669	20.0%	14.2%	0.51	0.51	-1904
12	0.013	0.065	3.5%	46%	12.5	0.0	27004	9.00	768	0.8	2329	2150	9.9%	12.7%	2.95	1.93	17025	192	7.9%	7.0%	1.15	0.18	4973
13	0.034	0.025	4.2%	77%	12.5	70.0	23305	8.92	671	1	2100	1777	8.1%	33.2%	2.72	2.33	9149	700	24.6%	17.9%	0.65	1.04	-1999
14	0.028	0.027	7.2%	60%	12.5	77.5	25971	9.36	1106	0.8	1016	2353	10.1%	34.8%	3.00	2.31	12211	310	13.9%	6.7%	1.13	0.34	2801
15	0.033	0.016	8.0%	22%	12.5	63.0	18173	9.36	742	0.8	977	1794	9.3%	39.2%	2.07	1.84	7631	-231	2.7%	-11.2%	1.91	-0.36	10706
16	0.038	0.041	3.3%	77%	12.5	0.0	23038	9.40	477	1.2	2074	1689	9.1%	12.4%	2.42	1.98	11053	677	26.2%	24.8%	1.40	1.26	327
17	0.049	0.022	3.5%	50%	12.5	85.0	26087	9.40	548	0.8	2223	2645	10.0%	44.2%	2.54	2.54	8625	131	9.5%	0.2%	0.95	0.27	3396
18	0.016	0.038	2.9%	67%	12.5	0.0	23088	9.40	698	1.2	2216	1689	7.1%	10.2%	2.63	1.99	12325	281	13.5%	12.3%	1.55	0.51	3874
19	0.039	0.017	3.2%	52%	12.5	85.0	26144	9.40	823	0.8	2274	2508	9.5%	39.4%	2.76	2.55	10267	143	9.7%	1.4%	1.04	0.09	3652
20	0.025	0.016	4.0%	77%	12.5	65.0	50465	9.69	925	1.2	1619	3807	5.0%	20.2%	5.01	4.75	20437	706	15.6%	12.6%	0.87	1.13	-1237
21	0.039	0.014	3.3%	75%	12.5	107.5	51055	9.27	982	1.2	2272	4262	7.1%	29.6%	5.34	5.34	17196	1194	20.5%	16.5%	0.64	0.64	-4292
22	0.032	0.013	4.2%	75%	12.5	53.8	41628	9.87	872	1.2	1688	3100	6.1%	20.8%	4.15	3.88	16963	673	17.7%	12.9%	1.71	1.22	1935
23	0.053	0.018	5.3%	65%	12.5	92.5	34420	9.31	785	1.2	1568	3128	10.3%	36.4%	3.69	3.69	10013	764	18.6%	12.6%	0.84	0.84	-1355
24	0.015	0.021	3.9%	75%	12.5	57.5	34979	9.43	1042	1	1698	2323	4.5%	19.2%	3.88	2.80	18428	299	12.8%	8.5%	1.33	0.53	3204
25	0.048	0.034	7.7%	80%	12.5	107.5	34812	9.00	991	1.2	1297	3294	11.8%	38.5%	4.06	4.06	9908	2373	39.5%	29.2%	1.52	1.52	-6576
26	0.018	0.105	4.9%	65%	12.5	0.0	22934	9.00	564	1.2	2060	1799	12.5%	15.6%	2.64	2.17	11079	485	20.4%	19.0%	1.77	0.94	2563
27	0.073	0.055	4.8%	46%	12.5	70.0	15160	9.04	425	1.2	2164	1841	17.8%	55.9%	1.78	1.78	2107	250	13.8%	1.9%	0.78	0.78	965
28	0.017	0.008	3.1%	77%	12.5	130.0	44274	9.00	917	1.2	1858	3983	3.3%	32.9%	4.82	4.82	13756	341	10.8%	3.9%	1.35	1.35	2670
29	0.031	0.019	4.6%	56%	12.5	122.5	38789	9.00	669	1.2	1417	3790	5.9%	39.1%	4.11	4.11	10177	-21	7.2%	-2.9%	1.88	1.12	6282
30	0.021	0.015	4.1%	70%	12.5	107.5	32600	9.90	774	0.8	1641	2893	5.1%	38.4%	3.07	2.91	12378	105	11.5%	-0.4%	1.67	-0.01	7321
31	0.030	0.012	3.4%	73%	12.5	115.0	43038	9.69	1089	1.2	2474	3523	6.3%	31.4%	4.52	4.52	14301	592	16.1%	8.6%	1.72	1.56	2059
32	0.032	0.017	4.7%	56%	12.5	100.0	33603	9.31	1212	1.2	1699	2939	8.2%	32.4%	3.99	3.99	11607	261	10.0%	4.6%	1.04	0.75	1607
33	0.023	0.051	4.4%	55%	12.5	14.0	21910	9.00	678	1.2	2280	1782	9.7%	18.1%	2.63	2.21	10330	196	10.7%	7.0%	1.89	0.35	5571
34	0.039	0.023	4.4%	70%	12.5	92.5	24230	9.00	748	1	2176	2014	8.8%	38.5%	2.85	2.85	8352	394	19.3%	8.0%	1.57	0.83	2443
35	0.003	0.049	3.6%	87%	12.5	0.0	31282	8.85	1076	1.2	2158	2168	1.8%	3.0%	3.89	2.43	18742	723	23.6%	23.1%	1.52	1.61	-1131
36	0.054	0.040	3.2%	50%	12.5	77.5	24796	8.97	776	1	2618	2079	13.0%	37.4%	2.95	2.94	9010	303	11.8%	7.9%	0.43	0.44	-553
37	0.008	0.072	3.0%	61%	12.5	0.0	27598	9.09	880	0.8	2483	2013	3.3%	4.8%	3.05	1.81	18964	105	4.9%	4.5%	0.81	0.16	3633
38	0.023	0.037	3.3%	56%	12.5	77.5	36766	8.85	950	1.2	2496	3139	7.5%	27.7%	4.28	4.21	13568	291	8.9%	6.3%	0.43	0.50	-378
39	0.016	0.061	2.5%	54%	12.5	0.0	24586	9.00	624	1.2	2768	1903	8.4%	11.3%	2.82	2.27	12554	192	9.3%	8.0%	1.84	0.33	5951
40	0.032	0.038	2.7%	29%	12.5	85.0	24360	9.00	483	0.8	2819	2609	8.3%	45.1%	2.45	2.45	7903	-161	3.3%	-7.1%	1.07	-0.08	5525
	0.031	0.031	4.4%	63%	12.5	65.8	30093	9.16	837	1.0	1960	2538	8.2%	28.7%	3.36	2.97	12373	410	14.4%	8.3%	1.33	0.66	2533
																	%change	13.9%	63.7%	22.4%			

Program Design B with Resizing

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	No	8	1.14	0	Same	None

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.14	Usage & Duct Loss			kW @5PM		1.04
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	27557	9.00	941	1	2055	2076	5.8%	15.6%	3.296	2.42	15847	919	23.5%	24.1%	2.414	1.78	1214
2	0.021	0.031	6.2%	71%	6.3	36.8	24121	9.43	770	0.8	1589	2193	8.0%	22.8%	2.557	2.03	13053	703	17.6%	16.8%	2.454	0.76	6677
3	0.020	0.037	4.3%	66%	6.3	7.8	14409	8.97	632	1	1797	1125	8.5%	14.0%	1.883	1.31	9321	261	15.2%	14.9%	1.931	0.48	5364
4	0.025	0.016	4.7%	60%	6.3	42.5	19349	9.09	752	0.8	1823	1858	7.5%	26.8%	2.226	1.76	10140	454	10.6%	12.2%	1.734	0.52	4376
5	0.022	0.011	5.8%	68%	6.3	34.5	24085	8.90	831	1	1454	1900	5.1%	16.9%	2.92	2.27	13532	339	10.6%	10.6%	2.717	0.59	8102
6	0.018	0.014	5.7%	71%	6.3	23.0	25906	8.90	908	1	1360	1995	4.8%	12.6%	3.157	2.32	15790	360	11.3%	11.8%	2.538	0.62	7676
7	0.025	0.009	5.3%	68%	6.3	50.0	28057	9.00	899	0.8	1296	2617	5.9%	22.9%	3.089	2.46	14846	775	12.1%	16.5%	1.572	0.92	1868
8	0.031	0.018	6.3%	66%	6.3	45.0	27537	8.91	832	1.2	1516	2563	7.5%	22.4%	3.271	3.27	11573	773	13.7%	16.8%	1.841	1.72	807
9	0.018	0.014	6.4%	75%	6.3	38.1	35921	8.76	1032	1.2	1637	3249	4.6%	15.0%	4.285	3.94	17136	803	13.2%	14.7%	2.792	1.49	4457
10	0.067	0.068	3.8%	51%	6.3	38.8	24250	9.00	577	1	2717	2084	15.4%	29.7%	2.711	2.69	10331	730	14.6%	18.9%	1.033	1.05	-1277
11	0.083	0.057	4.1%	56%	6.3	38.8	20723	9.00	552	1	2685	1874	17.9%	33.7%	2.372	2.37	8195	991	20.0%	24.3%	0.918	0.92	-2823
12	0.013	0.065	3.5%	46%	6.3	0.0	23119	9.00	658	0.8	2329	2104	9.9%	11.6%	2.523	1.91	14756	238	7.9%	8.2%	1.583	0.21	7242
13	0.034	0.025	4.2%	77%	6.3	35.0	19953	8.92	575	1	2100	1552	8.0%	23.3%	2.324	1.88	9708	925	24.6%	27.8%	1.051	1.50	-2559
14	0.028	0.027	7.2%	60%	6.3	38.8	22235	9.36	947	0.8	1016	2046	10.1%	24.9%	2.566	1.93	12483	617	13.9%	16.6%	1.568	0.72	2529
15	0.033	0.016	8.0%	22%	6.3	31.5	15559	9.36	635	0.8	977	1510	9.3%	27.3%	1.765	1.46	8195	52	2.7%	0.6%	2.213	0.02	10142
16	0.038	0.041	3.3%	77%	6.3	0.0	19723	9.40	409	1.2	2074	1651	9.1%	11.1%	2.067	1.94	9657	715	26.2%	26.2%	1.751	1.30	1723
17	0.049	0.022	3.5%	50%	6.3	42.5	22334	9.40	469	0.8	2223	2173	10.0%	31.1%	2.169	2.13	9627	603	9.5%	13.3%	1.32	0.67	2394
18	0.016	0.038	2.9%	67%	6.3	0.0	19767	9.40	598	1.2	2216	1657	7.1%	8.9%	2.245	1.95	10746	313	13.5%	13.6%	1.929	0.55	5453
19	0.039	0.017	3.2%	52%	6.3	42.5	22383	9.40	704	0.8	2274	2113	9.5%	27.6%	2.36	2.03	11007	538	9.7%	13.2%	1.444	0.61	2912
20	0.025	0.016	4.0%	77%	6.3	32.5	43205	9.69	792	1.2	1619	3523	5.0%	14.1%	4.286	4.27	19476	991	15.6%	18.7%	1.594	1.61	-275
21	0.039	0.014	3.3%	75%	6.3	53.8	43710	9.27	841	1.2	2272	3787	7.1%	20.7%	4.566	4.57	17656	1669	20.5%	25.4%	1.407	1.41	-4753
22	0.032	0.013	4.2%	75%	6.3	26.9	35640	9.87	746	1.2	1688	2873	6.1%	14.9%	3.548	3.49	16156	900	17.7%	18.8%	2.311	1.61	2742
23	0.053	0.018	5.3%	65%	6.3	46.3	29468	9.31	672	1.2	1568	2708	10.2%	26.2%	3.159	3.16	10972	1184	18.6%	22.8%	1.375	1.38	-2313
24	0.015	0.021	3.9%	75%	6.3	28.8	29947	9.43	892	1	1698	2164	4.5%	13.3%	3.319	2.53	17466	459	12.8%	14.5%	1.891	0.80	4166
25	0.048	0.034	7.7%	80%	6.3	53.8	29804	9.00	848	1.2	1297	2829	11.8%	27.9%	3.475	3.47	11142	2839	39.6%	39.7%	2.105	2.11	-7810
26	0.018	0.105	4.9%	65%	6.3	0.0	19635	9.00	483	1.2	2060	1759	12.6%	14.3%	2.254	2.13	9672	525	20.4%	20.2%	2.155	0.98	3971
27	0.073	0.055	4.8%	46%	6.3	35.0	12979	9.04	364	1.2	2164	1464	17.8%	41.5%	1.516	1.52	3425	627	13.8%	16.3%	1.042	1.04	-353
28	0.017	0.008	3.1%	77%	6.3	65.0	37904	9.00	785	1.2	1858	3419	3.3%	21.4%	4.125	4.12	15130	905	10.8%	15.3%	2.049	2.04	1297
29	0.031	0.019	4.6%	56%	6.3	61.3	33208	9.00	573	1.2	1417	3178	5.9%	26.5%	3.515	3.51	11815	591	7.2%	9.7%	2.474	1.72	4644
30	0.021	0.015	4.1%	70%	6.3	53.8	27910	9.90	662	0.8	1641	2413	5.1%	25.5%	2.626	2.30	13422	585	11.5%	12.5%	2.113	0.61	6278
31	0.030	0.012	3.4%	73%	6.3	57.5	36846	9.69	932	1.2	2474	3084	6.2%	21.4%	3.866	3.87	15216	1032	16.1%	18.5%	2.375	2.22	1144
32	0.032	0.017	4.7%	56%	6.3	50.0	28769	9.31	1038	1.2	1699	2574	8.1%	22.7%	3.414	3.35	12459	626	10.0%	14.4%	1.624	1.39	754
33	0.023	0.051	4.4%	55%	6.3	7.0	18758	9.00	581	1.2	2280	1700	9.7%	14.7%	2.247	2.07	9393	278	10.7%	10.5%	2.278	0.48	6507
34	0.039	0.023	4.4%	70%	6.3	46.3	20744	9.00	640	1	2176	1703	8.8%	26.9%	2.431	2.15	9480	705	19.3%	19.6%	1.989	1.53	1315
35	0.003	0.049	3.6%	87%	6.3	0.0	26782	8.85	922	1.2	2158	2150	1.8%	2.5%	3.324	2.40	16174	741	23.6%	23.6%	2.085	1.63	1437
36	0.054	0.040	3.2%	50%	6.3	38.8	21229	8.97	665	1	2618	1806	13.0%	27.8%	2.52	2.33	9718	576	11.8%	17.6%	0.856	1.05	-1261
37	0.008	0.072	3.0%	61%	6.3	0.0	23628	9.09	753	0.8	2483	1986	3.3%	4.2%	2.61	1.80	16355	131	4.9%	5.1%	1.252	0.18	6241
38	0.023	0.037	3.3%	56%	6.3	38.8	31476	8.85	813	1.2	2496	2821	7.5%	19.6%	3.655	3.56	13714	609	8.9%	14.4%	1.049	1.15	-524
39	0.016	0.061	2.5%	54%	6.3	0.0	21049	9.00	534	1.2	2768	1864	8.4%	10.1%	2.41	2.23	10939	231	9.3%	9.3%	2.246	0.37	7566
40	0.032	0.038	2.7%	29%	6.3	42.5	20856	9.00	413	0.8	2819	2122	8.3%	31.2%	2.097	2.09	8985	325	3.3%	6.8%	1.43	0.28	4442
	0.031	0.031	4.4%	63%	6.3	32.9	25763	9.16	717	1.0	1960	2257	8.2%	20.6%	2.869	2.57	12368	691	14.4%	16.4%	1.813	1.05	2537
																	%change	23.4%	63.7%	44.2%			

Program Design C with Resizing

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	Same	No	4	1.42	0	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.90	Usage & Duct Loss			kW @5PM		0.28
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DikW2	CapaPk2	kWh	Leaks	Total	kW	DikW	CapaPk
1	0.130	0.076	17.7%	0%	12.5	64.5	34298	9.00	1143	1	2400	3106	28.9%	43.0%	4.187	4.19	11343	-111	0.3%	-3.3%	1.523	0.02	5719
2	0.073	0.106	18.3%	0%	12.5	73.5	30022	9.43	1001	1	1825	2462	22.4%	40.1%	3.542	3.54	10935	434	3.2%	-0.5%	1.469	-0.75	8794
3	0.059	0.112	11.8%	0%	12.5	15.5	17934	8.97	598	1	1950	1386	20.6%	29.5%	2.232	1.80	8534	1	3.2%	-0.7%	1.581	-0.01	6150
4	0.062	0.039	10.9%	0%	12.5	85.0	24082	9.09	803	1	1950	2014	14.7%	41.0%	2.874	2.87	8002	298	3.3%	-2.0%	1.086	-0.59	6514
5	0.068	0.036	16.2%	0%	12.5	69.0	29977	8.90	999	1	1635	2413	15.4%	33.5%	3.646	3.28	12200	-174	0.2%	-6.0%	1.99	-0.42	9435
6	0.062	0.049	17.2%	0%	12.5	46.0	32243	8.90	1075	1	1550	2442	15.7%	27.6%	3.942	3.14	15188	-88	0.4%	-3.3%	1.753	-0.20	8278
7	0.078	0.027	14.8%	0%	12.5	100.0	34921	9.00	1164	1	1440	2823	16.3%	37.8%	4.182	4.02	12633	568	1.7%	1.6%	0.479	-0.63	4081
8	0.090	0.052	16.5%	0%	12.5	90.0	34274	8.91	1142	1	1700	2907	20.5%	40.0%	4.188	4.19	11980	429	0.6%	-0.8%	0.924	0.80	399
9	0.070	0.057	21.4%	0%	12.5	76.3	44708	8.76	1490	1	1950	3550	17.7%	30.9%	5.564	4.68	19704	502	0.1%	-1.2%	1.512	0.75	1889
10	0.137	0.139	7.4%	0%	12.5	77.5	30183	9.00	1006	1	2825	2976	34.6%	51.9%	3.774	3.77	7783	-163	-4.6%	-3.3%	-0.03	-0.03	1271
11	0.188	0.128	8.9%	0%	12.5	77.5	25792	9.00	860	1	2825	2984	41.3%	60.8%	3.214	3.21	4229	-120	-3.3%	-2.9%	0.075	0.08	1143
12	0.023	0.121	6.4%	0%	12.5	0.0	28775	9.00	959	1	2400	1961	16.1%	18.1%	3.575	2.37	17116	382	1.6%	1.6%	0.531	-0.25	4882
13	0.150	0.111	16.2%	0%	12.5	70.0	24834	8.92	828	1	2400	2582	34.6%	54.0%	3.102	3.10	5698	-106	-1.9%	-2.9%	0.272	0.27	1452
14	0.070	0.067	16.1%	0%	12.5	77.5	27674	9.36	922	1	1125	2175	18.5%	39.3%	3.241	3.13	9950	488	5.5%	2.2%	0.892	-0.48	5062
15	0.043	0.020	10.1%	0%	12.5	63.0	19365	9.36	646	1	1000	1473	9.6%	35.5%	2.231	2.07	7365	89	2.4%	-7.5%	1.746	-0.59	10972
16	0.162	0.173	12.9%	0%	12.5	0.0	24548	9.40	818	1	2300	2200	40.2%	42.4%	2.977	2.98	9098	167	-4.9%	-5.2%	0.841	0.27	2282
17	0.098	0.043	6.8%	0%	12.5	85.0	27797	9.40	927	1	2300	2344	21.1%	43.7%	3.212	3.21	8626	432	-1.6%	0.7%	0.277	-0.41	3396
18	0.051	0.117	8.4%	0%	12.5	0.0	24602	9.40	820	1	2350	1688	19.8%	22.2%	2.926	2.08	13627	283	0.8%	0.4%	1.247	0.42	2572
19	0.080	0.036	6.3%	0%	12.5	85.0	27859	9.40	929	1	2350	2233	17.4%	40.3%	3.21	3.21	9477	418	1.8%	0.5%	0.593	-0.56	4442
20	0.108	0.069	15.1%	0%	12.5	65.0	53774	9.69	1792	1	1830	4030	24.8%	34.2%	6.074	5.42	22338	483	-4.2%	-1.4%	-0.19	0.46	-3137
21	0.158	0.056	12.1%	0%	12.5	107.5	54403	9.27	1813	1	2500	4848	32.2%	46.3%	6.393	6.39	16029	609	-4.6%	-0.2%	-0.42	-0.42	-3125
22	0.128	0.053	14.9%	0%	12.5	53.8	44358	9.87	1479	1	1900	3388	26.9%	36.5%	4.893	4.67	17224	385	-3.0%	-2.8%	0.965	0.43	1673
23	0.155	0.052	13.9%	0%	12.5	92.5	36677	9.31	1223	1	1725	3426	31.4%	49.5%	4.287	4.29	9572	466	-2.6%	-0.5%	0.247	0.25	-913
24	0.058	0.085	14.2%	0%	12.5	57.5	37272	9.43	1242	1	1900	2704	18.3%	30.3%	4.36	3.54	16999	-82	-1.0%	-2.6%	0.851	-0.22	4634
25	0.240	0.171	29.6%	0%	12.5	107.5	37095	9.00	1236	1	1700	4890	51.0%	68.0%	4.686	4.69	3715	777	0.4%	-0.3%	0.895	0.89	-383
26	0.052	0.302	13.0%	0%	12.5	0.0	24438	9.00	815	1	2250	2036	35.1%	37.0%	3.221	2.76	11247	247	-2.1%	-2.5%	1.188	0.35	2395
27	0.135	0.102	8.4%	0%	12.5	70.0	16155	9.04	538	1	2250	1850	31.5%	60.5%	1.991	1.99	2522	241	0.1%	-2.6%	0.566	0.57	551
28	0.073	0.035	12.2%	0%	12.5	130.0	47177	9.00	1573	1	2050	3734	16.1%	36.4%	5.661	5.22	17801	590	-2.0%	0.4%	0.512	0.95	-1375
29	0.069	0.042	9.9%	0%	12.5	122.5	41332	9.00	1378	1	1500	3334	16.2%	37.9%	4.977	4.74	15083	435	-3.1%	-1.6%	1.011	0.49	1376
30	0.070	0.049	12.6%	0%	12.5	107.5	34738	9.90	1158	1	1800	2606	17.0%	39.6%	3.815	3.79	12176	392	-0.4%	-1.6%	0.924	-0.88	7523
31	0.111	0.044	11.5%	0%	12.5	115.0	45860	9.69	1529	1	2700	3635	23.4%	41.6%	5.132	5.13	15232	480	-1.0%	-1.7%	1.11	0.95	1129
32	0.072	0.038	10.0%	0%	12.5	100.0	35807	9.31	1194	1	1800	2764	16.3%	37.2%	4.163	3.90	13295	436	1.8%	-0.1%	0.875	0.85	-81
33	0.051	0.112	9.2%	0%	12.5	14.0	23347	9.00	778	1	2400	1716	19.4%	25.9%	2.893	2.17	11965	262	1.1%	-0.7%	1.631	0.38	3935
34	0.130	0.076	13.3%	0%	12.5	92.5	25819	9.00	861	1	2400	2662	28.9%	53.6%	3.156	3.16	5742	-254	-0.8%	-7.0%	1.264	0.52	5053
35	0.022	0.393	22.9%	0%	12.5	0.0	33333	8.85	1111	1	2700	2295	18.7%	19.4%	4.407	2.79	20724	596	6.8%	6.7%	1.002	1.24	-3113
36	0.107	0.079	6.1%	0%	12.5	77.5	26422	8.97	881	1	2700	2420	25.5%	46.6%	3.243	3.24	7750	-38	-0.7%	-1.2%	0.132	0.13	707
37	0.021	0.186	7.3%	0%	12.5	0.0	29408	9.09	980	1	2600	1793	7.4%	8.4%	3.616	2.15	19460	324	0.8%	0.9%	0.246	-0.17	3137
38	0.051	0.085	7.1%	0%	12.5	77.5	39176	8.85	1306	1	2600	2914	17.2%	32.0%	4.879	3.88	17148	517	-0.8%	2.0%	-0.17	0.83	-3958
39	0.034	0.133	5.3%	0%	12.5	0.0	26198	9.00	873	1	2850	1840	18.8%	20.9%	3.27	2.25	14964	255	-1.1%	-1.6%	1.386	0.34	3540
40	0.045	0.053	3.7%	0%	12.5	85.0	25958	9.00	865	1	2850	2074	13.1%	37.6%	3.145	2.95	9611	374	-1.5%	0.5%	0.382	-0.58	3816
	0.090	0.093	12.4%	0%	12.5	65.8	32066	9.16	1069	1.0	2132	2667	22.9%	38.3%	3.852	3.50	12102	281	-0.2%	-1.3%	0.829	0.13	2803
																	%change	9.5%	-1.0%	-3.4%			

Program Design D with Resizing

Retrofits:	Duct@25	Shade	Rduct		Sizing	dEER	Qahpt	Chg Fix
	75	No	4		1.16	0	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.31	Usage & Duct Loss			kW @5PM		0.87
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	12.5	64.5	27931	9.00	931	1	2055	2310	5.8%	24.7%	3.329	2.88	13460	685	23.5%	15.0%	2.381	1.32	3602
2	0.021	0.031	6.2%	71%	12.5	73.5	24448	9.43	815	1	1589	2088	7.0%	30.6%	2.805	2.77	10503	807	18.6%	9.0%	2.206	0.02	9226
3	0.020	0.037	4.3%	66%	12.5	15.5	14604	8.97	487	1	1797	1187	7.3%	19.2%	1.771	1.43	8030	199	16.4%	9.7%	2.043	0.36	6655
4	0.025	0.016	4.7%	60%	12.5	85.0	19611	9.09	654	1	1823	1882	6.1%	39.0%	2.321	2.32	6686	431	12.0%	0.0%	1.638	-0.04	7830
5	0.022	0.011	5.8%	68%	12.5	69.0	24411	8.90	814	1	1454	2162	5.0%	27.9%	2.943	2.82	10973	78	10.7%	-0.3%	2.694	0.04	10662
6	0.018	0.014	5.7%	71%	12.5	46.0	26257	8.90	875	1	1360	2166	4.7%	20.0%	3.168	2.64	13900	188	11.4%	4.4%	2.526	0.29	9566
7	0.025	0.009	5.3%	68%	12.5	100.0	28438	9.00	948	1	1296	2550	5.3%	32.4%	3.383	3.38	11458	841	12.6%	7.0%	1.278	0.00	5256
8	0.031	0.018	6.3%	66%	12.5	90.0	27911	8.91	930	1	1516	2534	7.3%	32.2%	3.367	3.37	11418	802	13.9%	6.9%	1.745	1.62	961
9	0.018	0.014	6.4%	75%	12.5	76.3	36408	8.76	1214	1	1637	3065	4.6%	21.7%	4.456	3.77	18606	987	13.2%	8.0%	2.62	1.66	2987
10	0.067	0.068	3.8%	51%	12.5	77.5	24579	9.00	819	1	2717	2456	18.0%	41.1%	2.996	3.00	8352	358	12.0%	7.5%	0.748	0.75	702
11	0.083	0.057	4.1%	56%	12.5	77.5	21004	9.00	700	1	2685	2266	19.7%	46.4%	2.552	2.55	5957	598	18.3%	11.5%	0.738	0.74	-586
12	0.013	0.065	3.5%	46%	12.5	0.0	23433	9.00	781	1	2329	1819	9.0%	11.5%	2.853	2.13	14950	523	8.7%	8.2%	1.252	-0.01	7048
13	0.034	0.025	4.2%	77%	12.5	70.0	20223	8.92	674	1	2100	1822	8.6%	35.5%	2.448	2.45	7672	654	24.0%	15.6%	0.927	0.93	-523
14	0.028	0.027	7.2%	60%	12.5	77.5	22536	9.36	751	1	1016	1983	7.7%	34.3%	2.601	2.60	8828	680	16.3%	7.2%	1.533	0.05	6184
15	0.033	0.016	8.0%	22%	12.5	63.0	15770	9.36	526	1	977	1510	7.5%	38.8%	1.817	1.82	5425	52	4.5%	-10.8%	2.161	-0.34	12912
16	0.038	0.041	3.3%	77%	12.5	0.0	19991	9.40	666	1	2074	1490	10.7%	13.8%	2.312	1.73	12142	877	24.6%	23.5%	1.506	1.52	-762
17	0.049	0.022	3.5%	50%	12.5	85.0	22637	9.40	755	1	2223	2131	10.8%	39.2%	2.596	2.60	7748	644	8.7%	5.1%	0.893	0.21	4273
18	0.016	0.038	2.9%	67%	12.5	0.0	20035	9.40	668	1	2216	1457	6.9%	9.9%	2.315	1.68	12885	514	13.8%	12.6%	1.858	0.82	3314
19	0.039	0.017	3.2%	52%	12.5	85.0	22687	9.40	756	1	2274	2079	8.6%	37.2%	2.598	2.60	8172	571	10.6%	3.6%	1.206	0.05	5747
20	0.025	0.016	4.0%	77%	12.5	65.0	43791	9.69	1460	1	1619	3258	6.1%	18.6%	4.846	3.94	23810	1256	14.5%	14.2%	1.034	1.94	-4609
21	0.039	0.014	3.3%	75%	12.5	107.5	44303	9.27	1477	1	2272	3608	8.4%	27.3%	5.12	4.66	20260	1849	19.3%	18.8%	0.853	1.31	-7357
22	0.032	0.013	4.2%	75%	12.5	53.8	36123	9.87	1204	1	1688	2665	7.0%	19.7%	3.924	3.24	19217	1108	16.9%	14.0%	1.935	1.86	-319
23	0.053	0.018	5.3%	65%	12.5	92.5	29868	9.31	996	1	1568	2670	11.2%	34.9%	3.446	3.45	11477	1222	17.6%	14.1%	1.088	1.09	-2818
24	0.015	0.021	3.9%	75%	12.5	57.5	30353	9.43	1012	1	1698	2358	4.8%	20.7%	3.464	2.89	15903	265	12.5%	7.0%	1.746	0.43	5729
25	0.048	0.034	7.7%	80%	12.5	107.5	30208	9.00	1007	1	1297	2841	11.8%	38.1%	3.63	3.63	10797	2827	39.6%	29.6%	1.95	1.95	-7465
26	0.018	0.105	4.9%	65%	12.5	0.0	19901	9.00	663	1	2060	1579	13.8%	16.6%	2.462	1.87	12013	705	19.2%	17.9%	1.946	1.24	1629
27	0.073	0.055	4.8%	46%	12.5	70.0	13155	9.04	439	1	2164	1593	17.9%	55.3%	1.597	1.60	2502	498	13.7%	2.6%	0.961	0.96	571
28	0.017	0.008	3.1%	77%	12.5	130.0	38418	9.00	1281	1	1858	3328	3.8%	29.7%	4.563	4.43	16465	996	10.3%	7.1%	1.611	1.73	-38
29	0.031	0.019	4.6%	56%	12.5	122.5	33659	9.00	1122	1	1417	3126	7.4%	34.6%	4.018	4.02	12964	643	5.8%	1.6%	1.971	1.21	3496
30	0.021	0.015	4.1%	70%	12.5	107.5	28289	9.90	943	1	1641	2349	5.2%	34.1%	3.067	3.07	10991	649	11.3%	3.9%	1.673	-0.16	8709
31	0.030	0.012	3.4%	73%	12.5	115.0	37346	9.69	1245	1	2474	3013	6.6%	30.2%	4.128	4.01	15918	1103	15.8%	9.7%	2.114	2.07	442
32	0.032	0.017	4.7%	56%	12.5	100.0	29159	9.31	972	1	1699	2571	7.3%	33.5%	3.363	3.36	11537	629	10.8%	3.5%	1.675	1.38	1677
33	0.023	0.051	4.4%	55%	12.5	14.0	19013	9.00	634	1	2280	1534	9.3%	17.8%	2.305	1.84	10826	444	11.2%	7.4%	2.219	0.71	5074
34	0.039	0.023	4.4%	70%	12.5	92.5	21026	9.00	701	1	2176	2087	9.1%	41.8%	2.519	2.52	6648	321	19.0%	4.8%	1.901	1.16	4147
35	0.003	0.049	3.6%	87%	12.5	0.0	27145	8.85	905	1	2158	1869	1.6%	2.8%	3.312	2.05	18907	1022	23.8%	23.3%	2.098	1.98	-1297
36	0.054	0.040	3.2%	50%	12.5	77.5	21516	8.97	717	1	2618	2143	13.4%	40.4%	2.604	2.60	7259	239	11.5%	5.0%	0.772	0.77	1198
37	0.008	0.072	3.0%	61%	12.5	0.0	23948	9.09	798	1	2483	1713	3.0%	4.3%	2.863	1.97	16406	404	5.2%	5.0%	0.999	0.01	6191
38	0.023	0.037	3.3%	56%	12.5	77.5	31903	8.85	1063	1	2496	2701	7.9%	27.0%	3.903	3.49	14928	730	8.5%	7.0%	0.801	1.21	-1739
39	0.016	0.061	2.5%	54%	12.5	0.0	21335	9.00	711	1	2768	1658	9.0%	11.8%	2.595	1.94	13522	437	8.6%	7.5%	2.061	0.66	4983
40	0.032	0.038	2.7%	29%	12.5	85.0	21138	9.00	705	1	2819	2088	9.4%	39.4%	2.549	2.55	7279	360	2.2%	-1.4%	0.978	-0.18	6148
	0.031	0.031	4.4%	63%	12.5	65.8	26113	9.16	870	1.0	1960	2243	8.4%	28.4%	3.073	2.79	11920	705	14.3%	8.7%	1.608	0.83	2985
																	%change	23.9%	63.1%	23.4%			

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	No	8	0.99	0	400	All

Program Design E with Resizing

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.00	Usage & Duct Loss			kW @5PM		1.18
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	23955	9.00	799	1	2055	2094	5.7%	17.1%	2.849	2.49	13350	901	23.5%	22.6%	2.861	1.72	3712
2	0.021	0.031	6.2%	71%	6.3	36.8	20968	9.43	699	1	1589	1842	7.0%	21.2%	2.4	2.27	10969	1053	18.6%	18.4%	2.611	0.52	8761
3	0.020	0.037	4.3%	66%	6.3	7.8	12525	8.97	418	1	1797	1116	7.3%	14.4%	1.513	1.31	7473	270	16.4%	14.5%	2.301	0.48	7212
4	0.025	0.016	4.7%	60%	6.3	42.5	16820	9.09	561	1	1823	1570	6.1%	26.1%	1.985	1.99	7871	742	12.0%	12.9%	1.975	0.30	6645
5	0.022	0.011	5.8%	68%	6.3	34.5	20937	8.90	698	1	1454	1920	5.0%	18.7%	2.518	2.34	11295	319	10.7%	8.8%	3.119	0.52	10340
6	0.018	0.014	5.7%	71%	6.3	23.0	22520	8.90	751	1	1360	2004	4.7%	13.8%	2.711	2.37	13294	351	11.4%	10.6%	2.983	0.57	10172
7	0.025	0.009	5.3%	68%	6.3	50.0	24390	9.00	813	1	1296	2208	5.3%	21.7%	2.895	2.76	12407	1183	12.6%	17.7%	1.766	0.62	4307
8	0.031	0.018	6.3%	66%	6.3	45.0	23938	8.91	798	1	1516	2216	7.3%	22.3%	2.881	2.77	12142	1120	13.9%	16.9%	2.231	2.21	238
9	0.018	0.014	6.4%	75%	6.3	38.1	31226	8.76	1041	1	1637	2809	4.6%	14.8%	3.816	3.32	18087	1243	13.2%	14.9%	3.26	2.11	3506
10	0.067	0.068	3.8%	51%	6.3	38.8	21081	9.00	703	1	2717	2135	18.0%	31.9%	2.564	2.56	9126	679	12.0%	16.7%	1.18	1.18	-72
11	0.083	0.057	4.1%	56%	6.3	38.8	18014	9.00	600	1	2685	1914	19.7%	35.9%	2.183	2.18	7024	951	18.3%	22.1%	1.107	1.11	-1652
12	0.013	0.065	3.5%	46%	6.3	0.0	20097	9.00	670	1	2329	1787	9.0%	10.5%	2.442	2.09	13004	556	8.7%	9.2%	1.664	0.02	8994
13	0.034	0.025	4.2%	77%	6.3	35.0	17345	8.92	578	1	2100	1570	8.6%	24.9%	2.093	1.95	8415	906	24.1%	26.2%	1.281	1.42	-1265
14	0.028	0.027	7.2%	60%	6.3	38.8	19329	9.36	644	1	1016	1716	7.7%	23.8%	2.225	2.18	9591	947	16.3%	17.8%	1.909	0.47	5420
15	0.033	0.016	8.0%	22%	6.3	31.5	13525	9.36	451	1	977	1272	7.5%	26.5%	1.552	1.55	6292	291	4.5%	1.4%	2.425	-0.07	12045
16	0.038	0.041	3.3%	77%	6.3	0.0	17145	9.40	572	1	2074	1460	10.7%	12.5%	1.978	1.69	10599	907	24.6%	24.7%	1.841	1.55	781
17	0.049	0.022	3.5%	50%	6.3	42.5	19415	9.40	647	1	2223	1814	10.8%	28.0%	2.221	2.22	8800	962	8.7%	16.3%	1.268	0.58	3222
18	0.016	0.038	2.9%	67%	6.3	0.0	17183	9.40	573	1	2216	1430	6.9%	8.7%	1.98	1.65	11235	541	13.8%	13.8%	2.193	0.85	4964
19	0.039	0.017	3.2%	52%	6.3	42.5	19457	9.40	649	1	2274	1773	8.6%	25.9%	2.222	2.22	9181	877	10.6%	14.9%	1.581	0.43	4738
20	0.025	0.016	4.0%	77%	6.3	32.5	37558	9.69	1252	1	1619	3051	6.1%	13.5%	4.15	3.61	22302	1462	14.5%	19.3%	1.729	2.27	-3101
21	0.039	0.014	3.3%	75%	6.3	53.8	37997	9.27	1267	1	2272	3260	8.3%	19.6%	4.386	4.00	20238	2196	19.3%	26.5%	1.588	1.98	-7334
22	0.032	0.013	4.2%	75%	6.3	26.9	30981	9.87	1033	1	1688	2491	7.0%	14.5%	3.36	2.95	18065	1282	16.9%	19.2%	2.499	2.14	832
23	0.053	0.018	5.3%	65%	6.3	46.3	25616	9.31	854	1	1568	2337	11.2%	25.5%	2.95	2.95	12238	1556	17.6%	23.5%	1.584	1.58	-3579
24	0.015	0.021	3.9%	75%	6.3	28.8	26032	9.43	868	1	1698	2173	4.8%	14.3%	2.965	2.58	15298	449	12.5%	13.4%	2.245	0.75	6334
25	0.048	0.034	7.7%	80%	6.3	53.8	25908	9.00	864	1	1297	2442	11.8%	27.7%	3.107	3.11	11948	3225	39.6%	40.0%	2.473	2.47	-8616
26	0.018	0.105	4.9%	65%	6.3	0.0	17068	9.00	569	1	2060	1548	13.8%	15.5%	2.107	1.83	10481	736	19.2%	19.1%	2.302	1.28	3162
27	0.073	0.055	4.8%	46%	6.3	35.0	11283	9.04	376	1	2164	1273	18.0%	41.1%	1.364	1.36	3786	818	13.6%	16.7%	1.194	1.19	-714
28	0.017	0.008	3.1%	77%	6.3	65.0	32950	9.00	1098	1	1858	2909	3.8%	19.4%	3.907	3.58	17461	1415	10.3%	17.3%	2.266	2.59	-1034
29	0.031	0.019	4.6%	56%	6.3	61.3	28868	9.00	962	1	1417	2694	7.3%	23.8%	3.44	3.44	14202	1075	5.8%	12.4%	2.549	1.79	2258
30	0.021	0.015	4.1%	70%	6.3	53.8	24262	9.90	809	1	1641	2013	5.2%	22.7%	2.625	2.54	12153	985	11.3%	15.3%	2.115	0.37	7546
31	0.030	0.012	3.4%	73%	6.3	57.5	32030	9.69	1068	1	2474	2657	6.6%	20.8%	3.535	3.29	16636	1459	15.8%	19.1%	2.707	2.80	-276
32	0.032	0.017	4.7%	56%	6.3	50.0	25009	9.31	834	1	1699	2231	7.3%	23.1%	2.879	2.83	12465	969	10.8%	13.9%	2.159	1.92	749
33	0.023	0.051	4.4%	55%	6.3	7.0	16306	9.00	544	1	2280	1464	9.3%	14.3%	1.972	1.74	9835	514	11.2%	10.9%	2.553	0.82	6065
34	0.039	0.023	4.4%	70%	6.3	46.3	18033	9.00	601	1	2176	1733	9.1%	29.0%	2.155	2.15	7982	675	19.0%	17.5%	2.265	1.52	2813
35	0.003	0.049	3.6%	87%	6.3	0.0	23281	8.85	776	1	2158	1853	1.6%	2.3%	2.836	2.03	16338	1038	23.9%	23.8%	2.573	2.00	1273
36	0.054	0.040	3.2%	50%	6.3	38.8	18454	8.97	615	1	2618	1832	13.4%	29.7%	2.227	2.23	8193	550	11.5%	15.6%	1.148	1.15	264
37	0.008	0.072	3.0%	61%	6.3	0.0	20539	9.09	685	1	2483	1696	3.0%	3.8%	2.452	1.95	14191	421	5.2%	5.5%	1.41	0.03	8406
38	0.023	0.037	3.3%	56%	6.3	38.8	27362	8.85	912	1	2496	2440	7.9%	19.3%	3.342	2.99	14904	990	8.5%	14.7%	1.363	1.71	-1714
39	0.016	0.061	2.5%	54%	6.3	0.0	18298	9.00	610	1	2768	1627	9.0%	10.7%	2.22	1.90	11779	468	8.6%	8.7%	2.436	0.69	6726
40	0.032	0.038	2.7%	29%	6.3	42.5	18130	9.00	604	1	2819	1764	9.4%	27.6%	2.18	2.18	8375	684	2.2%	10.4%	1.347	0.19	5052
	0.031	0.031	4.4%	63%	6.3	32.9	22396	9.16	747	1.0	1960	2003	8.4%	20.4%	2.63	2.43	11976	944	14.3%	16.6%	2.052	1.20	2929
																	%change	32.0%	63.1%	44.8%			

Program Design F with Resizing

Retrofits: Duct@25 Shade Rduct Sizing dEER Qahpt Chg Fix

Same No 4 1.42 2 400 All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.38	Usage & Duct Loss			kW @5PM		0.80
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.130	0.076	17.7%	0%	12.5	64.5	34298	11.00	1143	1	2400	2541	28.9%	43.0%	3.426	3.43	11343	454	0.3%	-3.3%	2.284	0.78	5719
2	0.073	0.106	18.3%	0%	12.5	73.5	30022	11.43	1001	1	1825	2031	22.4%	40.1%	2.922	2.92	10935	865	3.2%	-0.5%	2.089	-0.13	8794
3	0.059	0.112	11.8%	0%	12.5	15.5	17933	10.97	598	1	1950	1133	20.6%	29.5%	1.826	1.48	8534	253	3.2%	-0.7%	1.988	0.32	6150
4	0.062	0.039	10.9%	0%	12.5	85.0	24082	11.09	803	1	1950	1651	14.7%	41.0%	2.356	2.36	8002	661	3.3%	-2.0%	1.604	-0.07	6514
5	0.068	0.036	16.2%	0%	12.5	69.0	29977	10.90	999	1	1635	1970	15.4%	33.5%	2.977	2.68	12200	269	0.2%	-6.0%	2.66	0.18	9435
6	0.062	0.049	17.2%	0%	12.5	46.0	32243	10.90	1075	1	1550	1994	15.7%	27.6%	3.218	2.56	15188	361	0.4%	-3.3%	2.476	0.37	8278
7	0.078	0.027	14.8%	0%	12.5	100.0	34921	11.00	1164	1	1440	2310	16.3%	37.8%	3.421	3.29	12633	1081	1.7%	1.6%	1.24	0.10	4081
8	0.090	0.052	16.5%	0%	12.5	90.0	34274	10.91	1142	1	1700	2374	20.5%	40.0%	3.42	3.42	11980	962	0.6%	-0.8%	1.692	1.57	399
9	0.070	0.057	21.4%	0%	12.5	76.3	44708	10.76	1490	1	1950	2890	17.7%	30.9%	4.53	3.81	19704	1162	0.1%	-1.2%	2.547	1.62	1889
10	0.137	0.139	7.4%	0%	12.5	77.5	30182	11.00	1006	1	2825	2435	34.6%	51.9%	3.088	3.09	7783	378	-4.6%	-3.3%	0.656	0.66	1271
11	0.188	0.128	8.9%	0%	12.5	77.5	25792	11.00	860	1	2825	2442	41.3%	60.8%	2.63	2.63	4229	423	-3.3%	-2.9%	0.66	0.66	1143
12	0.023	0.121	6.4%	0%	12.5	0.0	28775	11.00	959	1	2400	1604	16.1%	18.1%	2.925	1.94	17116	738	1.6%	1.6%	1.181	0.18	4882
13	0.150	0.111	16.2%	0%	12.5	70.0	24834	10.92	828	1	2400	2109	34.6%	54.0%	2.534	2.53	5698	367	-1.9%	-2.9%	0.84	0.84	1452
14	0.070	0.067	16.1%	0%	12.5	77.5	27674	11.36	922	1	1125	1792	18.5%	39.3%	2.67	2.58	9950	871	5.5%	2.2%	1.463	0.07	5062
15	0.043	0.020	10.1%	0%	12.5	63.0	19365	11.36	646	1	1000	1214	9.6%	35.5%	1.838	1.70	7365	349	2.4%	-7.5%	2.139	-0.22	10972
16	0.162	0.173	12.9%	0%	12.5	0.0	24548	11.40	818	1	2300	1814	40.2%	42.4%	2.455	2.45	9098	553	-4.9%	-5.2%	1.363	0.79	2282
17	0.098	0.043	6.8%	0%	12.5	85.0	27797	11.40	927	1	2300	1933	21.1%	43.7%	2.648	2.65	8625	843	-1.6%	0.7%	0.841	0.16	3396
18	0.051	0.117	8.4%	0%	12.5	0.0	24602	11.40	820	1	2350	1392	19.8%	22.2%	2.413	1.72	13627	579	0.8%	0.4%	1.761	0.78	2572
19	0.080	0.036	6.3%	0%	12.5	85.0	27859	11.40	929	1	2350	1841	17.4%	40.3%	2.647	2.65	9477	810	1.8%	0.5%	1.157	0.00	4442
20	0.108	0.069	15.1%	0%	12.5	65.0	53774	11.69	1792	1	1830	3341	24.8%	34.2%	5.035	4.49	22338	1173	-4.2%	-1.4%	0.845	1.39	-3137
21	0.158	0.056	12.1%	0%	12.5	107.5	54402	11.27	1813	1	2500	3987	32.2%	46.3%	5.258	5.26	16028	1469	-4.6%	-0.2%	0.715	0.72	-3125
22	0.128	0.053	14.9%	0%	12.5	53.8	44358	11.87	1479	1	1900	2817	26.9%	36.5%	4.069	3.89	17224	956	-3.0%	-2.8%	1.79	1.21	1673
23	0.155	0.052	13.9%	0%	12.5	92.5	36677	11.31	1223	1	1725	2821	31.4%	49.5%	3.529	3.53	9572	1072	-2.6%	-0.5%	1.005	1.00	-913
24	0.058	0.085	14.2%	0%	12.5	57.5	37272	11.43	1242	1	1900	2231	18.3%	30.3%	3.596	2.92	16999	392	-1.0%	-2.6%	1.614	0.41	4634
25	0.240	0.171	29.6%	0%	12.5	107.5	37095	11.00	1236	1	1700	4001	51.0%	68.0%	3.834	3.83	3715	1666	0.4%	-0.3%	1.747	1.75	-383
26	0.052	0.302	13.0%	0%	12.5	0.0	24438	11.00	815	1	2250	1666	35.1%	37.0%	2.636	2.26	11247	618	-2.1%	-2.5%	1.773	0.85	2395
27	0.135	0.102	8.4%	0%	12.5	70.0	16155	11.04	538	1	2250	1515	31.5%	60.5%	1.63	1.63	2522	576	0.1%	-2.6%	0.927	0.93	551
28	0.073	0.035	12.2%	0%	12.5	130.0	47177	11.00	1573	1	2050	3055	16.1%	36.4%	4.632	4.27	17801	1269	-2.0%	0.4%	1.542	1.90	-1375
29	0.069	0.042	9.9%	0%	12.5	122.5	41332	11.00	1378	1	1500	2728	16.2%	37.9%	4.072	3.88	15083	1041	-3.1%	-1.6%	1.916	1.35	1376
30	0.070	0.049	12.6%	0%	12.5	107.5	34738	11.90	1158	1	1800	2168	17.0%	39.6%	3.174	3.15	12176	830	-0.4%	-1.6%	1.565	-0.24	7523
31	0.111	0.044	11.5%	0%	12.5	115.0	45860	11.69	1529	1	2700	3013	23.4%	41.6%	4.254	4.25	15232	1103	-1.0%	-1.7%	1.988	1.83	1129
32	0.072	0.038	10.0%	0%	12.5	100.0	35807	11.31	1194	1	1800	2275	16.3%	37.2%	3.427	3.21	13295	924	1.8%	-0.1%	1.611	1.54	-81
33	0.051	0.112	9.2%	0%	12.5	14.0	23347	11.00	778	1	2400	1404	19.4%	25.9%	2.367	1.78	11965	574	1.1%	-0.7%	2.157	0.78	3935
34	0.130	0.076	13.3%	0%	12.5	92.5	25819	11.00	861	1	2400	2178	28.9%	53.6%	2.582	2.58	5742	230	-0.8%	-7.0%	1.838	1.09	5053
35	0.022	0.393	22.9%	0%	12.5	0.0	33333	10.85	1111	1	2700	1872	18.7%	19.4%	3.595	2.28	20724	1019	6.8%	6.7%	1.815	1.76	-3113
36	0.107	0.079	6.1%	0%	12.5	77.5	26422	10.97	881	1	2700	1979	25.5%	46.6%	2.652	2.65	7750	403	-0.7%	-1.2%	0.723	0.72	707
37	0.021	0.186	7.3%	0%	12.5	0.0	29408	11.09	980	1	2600	1470	7.4%	8.4%	2.964	1.76	19460	647	0.8%	0.9%	0.898	0.22	3137
38	0.051	0.085	7.1%	0%	12.5	77.5	39176	10.85	1306	1	2600	2377	17.2%	32.0%	3.98	3.16	17148	1054	-0.8%	2.0%	0.725	1.54	-3958
39	0.034	0.133	5.3%	0%	12.5	0.0	26198	11.00	873	1	2850	1506	18.8%	20.9%	2.676	1.84	14964	589	-1.1%	-1.6%	1.98	0.75	3540
40	0.045	0.053	3.7%	0%	12.5	85.0	25957	11.00	865	1	2850	1697	13.1%	37.6%	2.573	2.42	9611	751	-1.5%	0.5%	0.953	-0.05	3816
	0.090	0.093	12.4%	0%	12.5	65.8	32066	11.16	1069	1.0	2132	2189	22.9%	38.3%	3.162	2.87	12102	758	-0.2%	-1.3%	1.519	0.75	2803
																	%change	25.7%	-1.0%	-3.4%			

Retrofits: Duct@25 Shade Rduct Sizing dEER Qahpt Chg Fix

75 No 8 0.99 2 400 All

Program Design G with Resizing

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		1.64	Usage & Duct Loss			kW @5PM		1.54
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	23949	11.00	798	1	2055	1713	5.7%	17.1%	2.331	2.035	13346	1282	23.5%	22.6%	3.379	2.1687	3716
2	0.021	0.031	6.2%	71%	6.3	36.8	20963	11.43	699	1	1589	1519	7.0%	21.2%	1.979	1.872	10965	1376	18.6%	18.4%	3.032	0.9204	8764
3	0.020	0.037	4.3%	66%	6.3	7.8	12522	10.97	417	1	1797	913	7.3%	14.4%	1.237	1.075	7470	474	16.4%	14.5%	2.577	0.7163	7214
4	0.025	0.016	4.7%	60%	6.3	42.5	16815	11.09	561	1	1823	1287	6.1%	26.1%	1.627	1.627	7868	1025	12.0%	12.9%	2.333	0.658	6648
5	0.022	0.011	5.8%	68%	6.3	34.5	20931	10.90	698	1	1454	1568	5.0%	18.7%	2.055	1.911	11291	672	10.7%	8.8%	3.581	0.9487	10344
6	0.018	0.014	5.7%	71%	6.3	23.0	22514	10.90	750	1	1360	1636	4.7%	13.8%	2.213	1.932	13290	718	11.4%	10.6%	3.482	1.0052	10176
7	0.025	0.009	5.3%	68%	6.3	50.0	24383	11.00	813	1	1296	1807	5.3%	21.7%	2.368	2.261	12403	1585	12.6%	17.7%	2.293	1.1261	4311
8	0.031	0.018	6.3%	66%	6.3	45.0	23932	10.91	798	1	1516	1810	7.3%	22.3%	2.353	2.265	12138	1526	13.9%	16.9%	2.759	2.722	242
9	0.018	0.014	6.4%	75%	6.3	38.1	31217	10.76	1041	1	1637	2287	4.6%	14.8%	3.106	2.705	18082	1765	13.2%	14.9%	3.971	2.7275	3511
10	0.067	0.068	3.8%	51%	6.3	38.8	21075	11.00	702	1	2717	1747	18.0%	31.9%	2.097	2.097	9122	1067	12.0%	16.7%	1.647	1.6472	-69
11	0.083	0.057	4.1%	56%	6.3	38.8	18009	11.00	600	1	2685	1566	19.7%	35.9%	1.785	1.785	7021	1299	18.3%	22.1%	1.504	1.5044	-1649
12	0.013	0.065	3.5%	46%	6.3	0.0	20092	11.00	670	1	2329	1462	9.0%	10.5%	1.997	1.712	13000	880	8.7%	9.2%	2.108	0.4026	8998
13	0.034	0.025	4.2%	77%	6.3	35.0	17340	10.92	578	1	2100	1283	8.6%	24.9%	1.71	1.594	8412	1194	24.1%	26.2%	1.665	1.78	-1262
14	0.028	0.027	7.2%	60%	6.3	38.8	19323	11.36	644	1	1016	1414	7.7%	23.8%	1.833	1.796	9588	1249	16.3%	17.8%	2.301	0.8543	5424
15	0.033	0.016	8.0%	22%	6.3	31.5	13522	11.36	451	1	977	1048	7.5%	26.5%	1.279	1.279	6290	515	4.5%	1.4%	2.699	0.2015	12047
16	0.038	0.041	3.3%	77%	6.3	0.0	17141	11.40	571	1	2074	1204	10.7%	12.5%	1.63	1.395	10596	1163	24.6%	24.7%	2.188	1.8484	784
17	0.049	0.022	3.5%	50%	6.3	42.5	19409	11.40	647	1	2223	1496	10.8%	28.0%	1.831	1.831	8796	1280	8.7%	16.3%	1.658	0.975	3225
18	0.016	0.038	2.9%	67%	6.3	0.0	17179	11.40	573	1	2216	1179	6.9%	8.7%	1.632	1.356	11232	792	13.8%	13.8%	2.541	1.1396	4967
19	0.039	0.017	3.2%	52%	6.3	42.5	19452	11.40	648	1	2274	1462	8.6%	25.9%	1.832	1.832	9177	1188	10.6%	14.9%	1.972	0.816	4742
20	0.025	0.016	4.0%	77%	6.3	32.5	37548	11.69	1252	1	1619	2529	6.1%	13.5%	3.439	2.99	22295	1984	14.5%	19.3%	2.44	2.8898	-3095
21	0.039	0.014	3.3%	75%	6.3	53.8	37986	11.27	1266	1	2272	2681	8.3%	19.7%	3.606	3.287	20232	2775	19.3%	26.5%	2.367	2.6867	-7328
22	0.032	0.013	4.2%	75%	6.3	26.9	30973	11.87	1032	1	1688	2071	7.0%	14.5%	2.793	2.457	18060	1702	16.9%	19.2%	3.066	2.6427	838
23	0.053	0.018	5.3%	65%	6.3	46.3	25610	11.31	854	1	1568	1924	11.2%	25.5%	2.428	2.428	12234	1969	17.6%	23.5%	2.106	2.1063	-3575
24	0.015	0.021	3.9%	75%	6.3	28.8	26025	11.43	868	1	1698	1793	4.8%	14.3%	2.446	2.125	15293	829	12.5%	13.4%	2.765	1.2041	6339
25	0.048	0.034	7.7%	80%	6.3	53.8	25901	11.00	863	1	1297	1998	11.8%	27.7%	2.542	2.542	11944	3669	39.6%	40.0%	3.039	3.0387	-8612
26	0.018	0.105	4.9%	65%	6.3	0.0	17064	11.00	569	1	2060	1266	13.8%	15.5%	1.723	1.5	10478	1017	19.2%	19.1%	2.686	1.61	3164
27	0.073	0.055	4.8%	46%	6.3	35.0	11280	11.04	376	1	2164	1042	18.0%	41.1%	1.116	1.116	3785	1049	13.6%	16.7%	1.441	1.4412	-712
28	0.017	0.008	3.1%	77%	6.3	65.0	32941	11.00	1098	1	1858	2380	3.8%	19.4%	3.196	2.93	17455	1943	10.3%	17.3%	2.978	3.2365	-1028
29	0.031	0.019	4.6%	56%	6.3	61.3	28860	11.00	962	1	1417	2204	7.3%	23.8%	2.814	2.814	14197	1565	5.8%	12.4%	3.175	2.4164	2263
30	0.021	0.015	4.1%	70%	6.3	53.8	24256	11.90	809	1	1641	1675	5.2%	22.7%	2.183	2.11	12149	1323	11.3%	15.3%	2.556	0.7962	7550
31	0.030	0.012	3.4%	73%	6.3	57.5	32022	11.69	1067	1	2474	2202	6.6%	20.8%	2.929	2.725	16631	1914	15.8%	19.1%	3.313	3.3601	-270
32	0.032	0.017	4.7%	56%	6.3	50.0	25002	11.31	833	1	1699	1837	7.3%	23.2%	2.369	2.327	12460	1363	10.8%	13.9%	2.669	2.4209	754
33	0.023	0.051	4.4%	55%	6.3	7.0	16302	11.00	543	1	2280	1198	9.3%	14.3%	1.613	1.421	9832	780	11.2%	10.9%	2.912	1.1343	6068
34	0.039	0.023	4.4%	70%	6.3	46.3	18028	11.00	601	1	2176	1418	9.1%	29.0%	1.763	1.763	7979	990	19.0%	17.5%	2.657	1.9141	2816
35	0.003	0.049	3.6%	87%	6.3	0.0	23275	10.85	776	1	2158	1511	1.6%	2.3%	2.313	1.656	16333	1379	23.9%	23.8%	3.097	2.3761	1277
36	0.054	0.040	3.2%	50%	6.3	38.8	18449	10.97	615	1	2618	1498	13.4%	29.7%	1.821	1.821	8190	884	11.5%	15.6%	1.555	1.5545	267
37	0.008	0.072	3.0%	61%	6.3	0.0	20534	11.09	684	1	2483	1390	3.0%	3.8%	2.009	1.596	14187	727	5.2%	5.5%	1.853	0.383	8409
38	0.023	0.037	3.3%	56%	6.3	38.8	27355	10.85	912	1	2496	1990	7.9%	19.3%	2.725	2.442	14899	1440	8.5%	14.7%	1.98	2.2628	-1710
39	0.016	0.061	2.5%	54%	6.3	0.0	18293	11.00	610	1	2768	1332	9.0%	10.7%	1.816	1.558	11776	764	8.6%	8.7%	2.84	1.0381	6729
40	0.032	0.038	2.7%	29%	6.3	42.5	18125	11.00	604	1	2819	1443	9.4%	27.6%	1.783	1.783	8372	1005	2.2%	10.4%	1.744	0.5881	5055
	0.031	0.031	4.4%	63%	6.3	32.9	22390	11.16	746	1.0	1960	1645	8.4%	20.4%	2.158	1.994	11972	1303	14.3%	16.6%	2.523	1.6316	2933
																	%change	44.2%	63.1%	44.8%			

Retrofits: Duct@25 Shade Rduct Sizing dEER Qahpt Chg Fix

Same Yes 4 1.48 0 Same None

Program Design H with Resizing

Post-Retrofit Site Data / Results - Post Retrofit

	Ducts						Air Conditioner				Shell	Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		2.79
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DikW2	CapaPk2
1	0.130	0.076	17.7%	0%	12.5	64.5	35847	9.00	1224	1	2400	2736	29.3%	42.6%	4.405	4.009	12076
2	0.073	0.106	18.3%	0%	12.5	73.5	31378	9.43	1001	0.8	1825	2757	25.5%	45.6%	3.422	2.794	11781
3	0.059	0.112	11.8%	0%	12.5	15.5	18743	8.97	822	1	1950	1253	23.7%	31.3%	2.559	1.657	9322
4	0.062	0.039	10.9%	0%	12.5	85.0	25170	9.09	978	0.8	1950	2239	18.0%	45.7%	2.936	2.337	9207
5	0.068	0.036	16.2%	0%	12.5	69.0	31330	8.90	1080	1	1635	2103	15.7%	32.8%	3.845	2.822	13084
6	0.062	0.049	17.2%	0%	12.5	46.0	33699	8.90	1181	1	1550	2139	16.0%	27.2%	4.176	2.731	16196
7	0.078	0.027	14.8%	0%	12.5	100.0	36498	9.00	1169	0.8	1440	3105	18.0%	42.4%	4.052	3.167	13599
8	0.090	0.052	16.5%	0%	12.5	90.0	35822	8.91	1083	1.2	1700	3052	21.1%	42.3%	4.311	4.311	9466
9	0.070	0.057	21.4%	0%	12.5	76.3	46727	8.76	1343	1.2	1950	3674	17.9%	32.5%	5.655	5.091	16114
10	0.137	0.139	7.4%	0%	12.5	77.5	31545	9.00	751	1	2825	2516	30.0%	49.4%	3.58	3.58	8425
11	0.188	0.128	8.9%	0%	12.5	77.5	26957	9.00	718	1	2825	2588	38.0%	58.9%	3.145	3.145	4917
12	0.023	0.121	6.4%	0%	12.5	0.0	30074	9.00	856	0.8	2400	2056	17.7%	20.2%	3.339	1.861	17788
13	0.150	0.111	16.2%	0%	12.5	70.0	25955	8.92	748	1	2400	2237	32.7%	52.6%	3.107	3.107	6207
14	0.070	0.067	16.1%	0%	12.5	77.5	28924	9.36	1232	0.8	1125	2457	24.0%	45.0%	3.419	2.512	11461
15	0.043	0.020	10.1%	0%	12.5	63.0	20240	9.36	826	0.8	1000	1594	12.0%	38.8%	2.307	1.597	8625
16	0.162	0.173	12.9%	0%	12.5	0.0	25657	9.40	532	1.2	2300	2062	35.2%	37.9%	2.738	2.738	8006
17	0.098	0.043	6.8%	0%	12.5	85.0	29052	9.40	611	0.8	2300	2620	19.5%	49.4%	2.833	2.78	8619
18	0.051	0.117	8.4%	0%	12.5	0.0	25713	9.40	777	1.2	2350	1731	20.6%	23.2%	3.001	2.215	11486
19	0.080	0.036	6.3%	0%	12.5	85.0	29117	9.40	916	0.8	2350	2480	19.2%	45.3%	3.096	2.574	10198
20	0.108	0.069	15.1%	0%	12.5	65.0	56202	9.69	1030	1.2	1830	4007	20.7%	33.4%	5.601	5.415	18047
21	0.158	0.056	12.1%	0%	12.5	107.5	56859	9.27	1094	1.2	2500	4860	27.7%	46.2%	5.969	5.969	12889
22	0.128	0.053	14.9%	0%	12.5	53.8	46361	9.87	971	1.2	1900	3394	23.8%	36.2%	4.645	4.645	14086
23	0.155	0.052	13.9%	0%	12.5	92.5	38333	9.31	875	1.2	1725	3526	28.8%	50.8%	4.139	4.139	7364
24	0.058	0.085	14.2%	0%	12.5	57.5	38955	9.43	1161	1	1900	2349	17.3%	29.5%	4.415	3.028	17633
25	0.240	0.171	29.6%	0%	12.5	107.5	38770	9.00	1104	1.2	1700	5075	51.1%	70.1%	4.705	4.705	1841
26	0.052	0.302	13.0%	0%	12.5	0.0	25541	9.00	628	1.2	2250	1984	32.4%	34.7%	3.046	2.767	9270
27	0.135	0.102	8.4%	0%	12.5	70.0	16884	9.04	474	1.2	2250	1974	31.4%	63.7%	2.002	2.002	1468
28	0.073	0.035	12.2%	0%	12.5	130.0	49307	9.00	1021	1.2	2050	3949	14.1%	39.7%	5.389	5.389	13204
29	0.069	0.042	9.9%	0%	12.5	122.5	43199	9.00	745	1.2	1500	3580	13.1%	42.4%	4.58	4.58	10604
30	0.070	0.049	12.6%	0%	12.5	107.5	36306	9.90	862	0.8	1800	2904	16.5%	45.2%	3.444	2.98	12217
31	0.111	0.044	11.5%	0%	12.5	115.0	47931	9.69	1213	1.2	2700	3791	22.3%	43.6%	5.073	5.073	11824
32	0.072	0.038	10.0%	0%	12.5	100.0	37424	9.31	1350	1.2	1800	2897	18.1%	39.3%	4.491	4.435	11034
33	0.051	0.112	9.2%	0%	12.5	14.0	24401	9.00	755	1.2	2400	1773	20.4%	27.5%	2.989	2.353	9980
34	0.130	0.076	13.3%	0%	12.5	92.5	26985	9.00	833	1	2400	2331	28.1%	52.7%	3.227	3.227	6227
35	0.022	0.393	22.9%	0%	12.5	0.0	34839	8.85	1199	1.2	2700	2450	22.9%	23.7%	4.712	3.248	16666
36	0.107	0.079	6.1%	0%	12.5	77.5	27615	8.97	864	1	2700	2113	24.9%	45.7%	3.329	3.238	8268
37	0.021	0.186	7.3%	0%	12.5	0.0	30736	9.09	980	0.8	2600	1854	8.2%	9.4%	3.492	1.735	20397
38	0.051	0.085	7.1%	0%	12.5	77.5	40946	8.85	1058	1.2	2600	3016	16.4%	33.7%	4.816	4.211	13633
39	0.034	0.133	5.3%	0%	12.5	0.0	27381	9.00	695	1.2	2850	1840	17.6%	20.1%	3.191	2.304	12503
40	0.045	0.053	3.7%	0%	12.5	85.0	27130	9.00	538	0.8	2850	2351	11.6%	44.6%	2.735	2.393	9030
	0.090	0.093	12.4%	0%	12.5	65.8	33514	9.16	932	1.0	2132	2685	22.5%	39.9%	3.798	3.322	11119

Savings

	Energy			Peak Demand		
	Usage & Duct Loss			kW @5PM		0.39
Site ID	kWh	Leaks	Total	kW	DlkW	CapaPk
1	259	0.0%	-2.9%	1.305	0.1942	4986
2	139	0.0%	-6.0%	1.589	-0.002	7949
3	133	0.0%	-2.4%	1.255	0.1348	5362
4	73	0.0%	-6.7%	1.024	-0.052	5309
5	137	0.0%	-5.2%	1.792	0.0376	8551
6	216	0.0%	-2.9%	1.518	0.2064	7270
7	286	0.0%	-3.0%	0.609	0.2202	3115
8	284	0.0%	-3.1%	0.801	0.6763	2914
9	377	0.0%	-2.8%	1.421	0.3421	5479
10	298	0.0%	-0.8%	0.165	0.1646	629
11	276	-0.1%	-1.0%	0.145	0.1445	454
12	286	0.0%	-0.4%	0.766	0.2535	4210
13	240	0.0%	-1.5%	0.268	0.2676	942
14	206	0.0%	-3.4%	0.715	0.138	3551
15	-32	0.0%	-10.8%	1.67	-0.117	9712
16	304	0.1%	-0.6%	1.08	0.5054	3374
17	156	0.0%	-5.0%	0.656	0.0254	3403
18	240	0.0%	-0.7%	1.172	0.281	4713
19	170	0.0%	-4.5%	0.707	0.0738	3721
20	506	0.0%	-0.6%	0.279	0.4646	1154
21	597	-0.1%	-0.1%	0.004	0.0043	15
22	380	0.0%	-2.4%	1.214	0.4547	4812
23	367	0.0%	-1.8%	0.395	0.395	1295
24	273	0.0%	-1.8%	0.796	0.3014	3999
25	592	0.2%	-2.5%	0.875	0.8753	1491
26	300	0.6%	-0.1%	1.363	0.3433	4372
27	117	0.2%	-5.9%	0.556	0.5557	1605
28	375	0.0%	-3.0%	0.785	0.7778	3223
29	189	0.0%	-6.1%	1.409	0.6504	5855
30	94	0.0%	-7.2%	1.295	-0.073	7482
31	325	0.0%	-3.7%	1.169	1.0121	4537
32	303	0.0%	-2.2%	0.547	0.3129	2180
33	204	0.0%	-2.3%	1.536	0.2024	5920
34	77	0.0%	-6.1%	1.192	0.4492	4567
35	440	2.6%	2.5%	0.697	0.7845	944
36	269	0.0%	-0.3%	0.046	0.1378	189
37	263	0.0%	-0.1%	0.37	0.2444	2200
38	414	0.0%	0.3%	-0.11	0.4934	-443
39	255	0.0%	-0.7%	1.465	0.2922	6002
40	97	0.0%	-6.6%	0.792	-0.022	4398
	262	0.1%	-2.9%	0.883	0.3038	3786
%change	8.9%	0.4%	-7.7%			

Program Design I with Resizing

Retrofits:	Duct@25	Shade	Rduct	Sizing	dEER	Qahpt	Chg Fix
	75	Yes	8	0.88	2	400	All

	Post-Retrofit Site Data											Results - Post Retrofit						Savings					
	Ducts						Air Conditioner				Shell	Energy			Peak Demand			Energy			Peak Demand		
	Leakage- Oper		Leakage @50		Conduction		Ratings		AirFlow	Charge	Leakage	Usage & Duct Loss			kW @5PM		1.46	Usage & Duct Loss			kW @5PM		1.72
Site ID	slf2	rlf2	Dlkpct2	Dlkred%	UAr2	UAs2	Capr2	EERr2	Qah2	Cha2	Q50S2	Use2	Leaks2	Total2	kW2	DlkW2	CapaPk2	kWh	Leaks	Total	kW	DlkW	CapaPk
1	0.024	0.014	3.8%	81%	6.3	32.3	21380	11.00	713	1	2055	1513	5.7%	18.4%	2.082	1.803	11637	1482	23.5%	21.3%	3.628	2.4004	5424
2	0.021	0.031	6.2%	71%	6.3	36.8	18714	11.43	624	1	1589	1350	7.0%	22.8%	1.768	1.676	9487	1545	18.6%	16.7%	3.243	1.1161	10243
3	0.020	0.037	4.3%	66%	6.3	7.8	11179	10.97	373	1	1797	802	7.3%	15.2%	1.105	0.946	6580	584	16.4%	13.7%	2.709	0.8458	8104
4	0.025	0.016	4.7%	60%	6.3	42.5	15012	11.09	500	1	1823	1155	6.1%	28.4%	1.453	1.453	6691	1157	12.0%	10.6%	2.507	0.8317	7825
5	0.022	0.011	5.8%	68%	6.3	34.5	18686	10.90	623	1	1454	1393	5.0%	20.3%	1.836	1.711	9790	847	10.7%	7.2%	3.801	1.1486	11845
6	0.018	0.014	5.7%	71%	6.3	23.0	20099	10.90	670	1	1360	1444	4.7%	14.8%	1.976	1.711	11655	910	11.4%	9.5%	3.718	1.2264	11811
7	0.025	0.009	5.3%	68%	6.3	50.0	21768	11.00	726	1	1296	1614	5.3%	23.6%	2.115	2.045	10673	1777	12.6%	15.8%	2.546	1.3414	6041
8	0.031	0.018	6.3%	66%	6.3	45.0	21365	10.91	712	1	1516	1614	7.3%	24.0%	2.101	2.042	10473	1723	13.9%	15.1%	3.011	2.9456	1906
9	0.018	0.014	6.4%	75%	6.3	38.1	27869	10.76	929	1	1637	2020	4.6%	16.0%	2.773	2.398	15816	2032	13.2%	13.7%	4.303	3.0344	5777
10	0.067	0.068	3.8%	51%	6.3	38.8	18814	11.00	627	1	2717	1560	18.0%	33.5%	1.873	1.873	7841	1254	12.0%	15.1%	1.871	1.8714	1213
11	0.083	0.057	4.1%	56%	6.3	38.8	16078	11.00	536	1	2685	1403	19.7%	37.7%	1.595	1.595	5971	1461	18.3%	20.2%	1.695	1.6953	-599
12	0.013	0.065	3.5%	46%	6.3	0.0	17937	11.00	598	1	2329	1281	9.0%	10.7%	1.784	1.499	11578	1061	8.7%	9.1%	2.322	0.6161	10420
13	0.034	0.025	4.2%	77%	6.3	35.0	15480	10.92	516	1	2100	1140	8.6%	26.7%	1.527	1.43	7225	1337	24.1%	24.4%	1.847	1.9447	-76
14	0.028	0.027	7.2%	60%	6.3	38.8	17251	11.36	575	1	1016	1264	7.7%	25.6%	1.637	1.626	8247	1399	16.3%	15.9%	2.497	1.0242	6765
15	0.033	0.016	8.0%	22%	6.3	31.5	12071	11.36	402	1	977	942	7.5%	28.7%	1.142	1.142	5360	620	4.5%	-0.7%	2.835	0.338	12977
16	0.038	0.041	3.3%	77%	6.3	0.0	15302	11.40	510	1	2074	1051	10.7%	12.7%	1.456	1.213	9431	1316	24.6%	24.5%	2.362	2.0301	1948
17	0.049	0.022	3.5%	50%	6.3	42.5	17327	11.40	578	1	2223	1341	10.8%	30.0%	1.635	1.635	7518	1435	8.7%	14.4%	1.854	1.1707	4503
18	0.016	0.038	2.9%	67%	6.3	0.0	15336	11.40	511	1	2216	1032	6.9%	8.9%	1.458	1.184	9999	939	13.8%	13.6%	2.716	1.3118	6200
19	0.039	0.017	3.2%	52%	6.3	42.5	17366	11.40	579	1	2274	1310	8.6%	27.9%	1.636	1.636	7856	1340	10.6%	12.9%	2.168	1.0118	6063
20	0.025	0.016	4.0%	77%	6.3	32.5	33520	11.69	1117	1	1619	2231	6.1%	14.4%	3.071	2.644	19618	2282	14.5%	18.4%	2.809	3.2357	-417
21	0.039	0.014	3.3%	75%	6.3	53.8	33912	11.27	1130	1	2272	2379	8.3%	21.0%	3.22	2.937	17623	3077	19.3%	25.2%	2.753	3.0362	-4719
22	0.032	0.013	4.2%	75%	6.3	26.9	27651	11.87	922	1	1688	1827	7.0%	15.4%	2.494	2.172	15882	1947	16.9%	18.3%	3.365	2.9275	3016
23	0.053	0.018	5.3%	65%	6.3	46.3	22862	11.31	762	1	1568	1716	11.2%	27.1%	2.168	2.168	10552	2177	17.6%	21.9%	2.366	2.3659	-1893
24	0.015	0.021	3.9%	75%	6.3	28.8	23234	11.43	774	1	1698	1584	4.8%	15.4%	2.184	1.884	13399	1038	12.5%	12.3%	3.027	1.4449	8233
25	0.048	0.034	7.7%	80%	6.3	53.8	23123	11.00	771	1	1297	1781	11.8%	29.5%	2.27	2.27	10246	3887	39.6%	38.2%	3.311	3.3106	-6914
26	0.018	0.105	4.9%	65%	6.3	0.0	15233	11.00	508	1	2060	1107	13.8%	15.7%	1.539	1.307	9328	1177	19.2%	18.9%	2.87	1.8036	4315
27	0.073	0.055	4.8%	46%	6.3	35.0	10070	11.04	336	1	2164	941	17.9%	43.6%	0.997	0.997	3121	1150	13.7%	14.2%	1.56	1.5603	-48
28	0.017	0.008	3.1%	77%	6.3	65.0	29408	11.00	980	1	1858	2124	3.8%	21.2%	2.854	2.643	15066	2200	10.3%	15.6%	3.32	3.5238	1360
29	0.031	0.019	4.6%	56%	6.3	61.3	25764	11.00	859	1	1417	1973	7.3%	25.7%	2.513	2.513	12196	1796	5.8%	10.5%	3.476	2.7175	4263
30	0.021	0.015	4.1%	70%	6.3	53.8	21654	11.90	722	1	1641	1498	5.2%	24.7%	1.949	1.914	10423	1500	11.3%	13.3%	2.79	0.9922	9277
31	0.030	0.012	3.4%	73%	6.3	57.5	28587	11.69	953	1	2474	1961	6.6%	22.4%	2.615	2.45	14387	2155	15.8%	17.5%	3.626	3.6346	1974
32	0.032	0.017	4.7%	56%	6.3	50.0	22320	11.31	744	1	1699	1642	7.3%	24.9%	2.116	2.107	10726	1558	10.8%	12.1%	2.922	2.6409	2488
33	0.023	0.051	4.4%	55%	6.3	7.0	14553	11.00	485	1	2280	1053	9.3%	14.9%	1.44	1.249	8695	925	11.2%	10.3%	3.084	1.3059	7206
34	0.039	0.023	4.4%	70%	6.3	46.3	16094	11.00	536	1	2176	1271	9.1%	31.3%	1.574	1.574	6767	1137	19.0%	15.3%	2.846	2.1024	4027
35	0.003	0.049	3.6%	87%	6.3	0.0	20778	10.85	693	1	2158	1310	1.6%	2.4%	2.065	1.426	14563	1580	23.9%	23.8%	3.344	2.6063	3047
36	0.054	0.040	3.2%	50%	6.3	38.8	16470	10.97	549	1	2618	1342	13.4%	31.6%	1.626	1.626	7007	1040	11.5%	13.8%	1.749	1.7492	1450
37	0.008	0.072	3.0%	61%	6.3	0.0	18331	11.09	611	1	2483	1216	3.0%	3.9%	1.794	1.394	12647	901	5.2%	5.4%	2.068	0.5856	9949
38	0.023	0.037	3.3%	56%	6.3	38.8	24421	10.85	814	1	2496	1767	7.9%	20.6%	2.433	2.184	12979	1663	8.5%	13.4%	2.271	2.5207	211
39	0.016	0.061	2.5%	54%	6.3	0.0	16331	11.00	544	1	2768	1167	9.0%	10.8%	1.622	1.363	10485	928	8.6%	8.5%	3.034	1.2329	8019
40	0.032	0.038	2.7%	29%	6.3	42.5	16181	11.00	539	1	2819	1297	9.4%	29.7%	1.593	1.593	7142	1151	2.2%	8.3%	1.934	0.7786	6285
	0.031	0.031	4.4%	63%	6.3	32.9	19988	11.16	666	1.0	1960	1460	8.4%	21.8%	1.927	1.776	10417	1487	14.3%	15.2%	2.754	1.8495	4488
																%change		50.5%	63.1%	41.1%			

APPENDIX F:
AC TESTING PROCEDURE FORMS

AIR CONDITIONER TESTING PROCEDURE

Subdivision Name ________________________ General Contractor ________________________

Address ____ Date ______________

AIR FLOW TEST PREPARATION

1.	Open ALL windows and doors in the house.
2.	Turn off all breakers except the main service disconnect, the air handler and the outdoor AC unit.
3.	Turn on the AC system at the thermostat to check if the breakers are marked correctly. If they are not, then determine the correct breakers and mark them. Leave all breakers turned off except those that are for the air handler and the outdoor AC unit. **Turn the AC system off.**

INSIDE UNIT FAMILIARIZATION & PREPARATION

4. Non-TXV TXV	What type refrigerant metering device does the indoor coil have?
5. ___________ Manf. ___________ Mod.	Record the manufacturer and model number of the indoor coil.
6. ___________ Manf. ___________ Mod.	Record the manufacturer and model number of the air handler.
7.	Prepare thermocouples to measure wet bulb and dry bulb temperatures in both the return and supply plenums. Place the wet bulb thermocouples in water to ensure they are saturated when needed. **Do not get the dry bulb thermocouples wet**.
8.	Prepare thermocouples to measure dry bulb temperatures at three supply registers. Use the same registers chosen in the duct leakage test procedure.
9.	Prepare a thermocouple to measure dry bulb temperature at the return grille that is the furthest away from the air handler.
10.	Prepare a thermocouple to measure the attic temperature. Ensure that the thermocouple is at least 6" above the insulation. Make sure the thermocouple will sense the true attic temperature. Keep it away from the attic hatch if it is open.

OUTSIDE UNIT FAMILIARIZATION & PREPARATION

11. Yes No	Is the outdoor unit installed in a location that will cause air to recirculate through the coil?
12. _______ lbs. _______ oz. _______ ft. _______ L Line dia. _______ S Line dia.	Record the factory nameplate rated refrigerant charge for the system and the **measured** line set length and liquid line diameter and suction line diameter.
13.	Install thermocouples to read the temperature of the air **into** the outdoor unit (3" away from the coil) and to read the temperature of the air **out of** the outdoor unit (3 to 6" from the top of the fan).
14.	Install thermocouples to measure temperatures at the following locations: • On the suction line just before it enters the outside cabinet (for package units 6 to 8 inches from the compressor). • On the liquid line just as it leaves the outside cabinet (for package units 6 to 8 inches from the outside coil). • On the hot gas discharge line 6 to 8 inches from the compressor. **Be sure all thermocouple measurement points are insulated and all cabinet panels that effect air flow are back in place.**
15.	Install your ammeter to measure the amperage to the compressor at the outdoor unit (use the common leg for this measurement).
16. ___________ Manf. ___________ Mod.	Record the manufacturer and model number from the outdoor unit nameplate.
17. ______ Fan FLA ______ Comp. RLA ______ Volts	Record the rated FLA of the outdoor unit fan motor, the RLA of the compressor and the rated voltage from the outdoor unit nameplate.

AIR FLOW AND CHARGE TESTS - PREPARATION

18.	Set thermostat at coolest setting and **start your stop watch to measure time when compressor starts**.
19.	Check the amps at the compressor, and access the system with your gages. **At ten minutes** install the thermocouple set up in the return plenum.
20.	At fifteen minutes measure and record all of the information needed to complete step # 21.

AIR FLOW AND CHARGE TESTS

21. _______ Reading #1 _______ Reading #2 _______ Reading #3 _______ Reading #4 **A**________ Total	Measure every return grille with the flow hood and record the results. **DIVIDE THE GRILLES AND TAKE AT LEAST TWO READINGS AT EACH GRILLE.**

22. Record:	
TIME & TEMPERATURE	**CONDENSER**
Elapsed time _________	Condenser Pressure _________
Return wet bulb _________	Saturation temp. _________
Return dry bulb _________	- Liquid line temp. _________
Outdoor coil entering dry bulb _________	= Subcooling _________
- Outdoor coil exiting dry bulb _________	**EVAPORATOR**
= Outdoor coil ΔT _________	Evaporator Pressure _________
COMPRESSOR	Suction line temp. _________
Compressor amps. _________	- Evap saturation temp. _________
Compressor volts. _________	= Superheat _________
Hot gas discharge temp _________	Target Superheat _________

COOLING EFFICIENCY TEST

23. ________ °F Attic	While waiting, measure and record the attic temperature.
24. ________ Minutes	Remove the return wet bulb thermocouple and wet the wick again. Install thermocouple set ups in both the supply and return plenums. Record the time elapsed since the beginning of the test.
25. **B** ______ Sup WB. **C** ______ Sup DB. **D** ______ Ret WB. **E** ______ Ret DB.	**Allow thermocouple temperatures to stabilize and record:** The supply and return wet bulb and dry bulb temperatures. Temperatures are stabilized when they do not change during the course of three cycles of the digital thermometer.
26. ________ Near Reg. ________ Mid Reg. ________ Far Reg.	Measure and record the three supply dry bulb temperatures at the supply registers.
27. ________ Ret. Grille	Record the return dry bulb temperature at the return grille.
28. **F** _____ Meter Kh **G** _____ # of rev **H** _____ Seconds	Measure the watts from the house meter by counting the number of revolutions of the disc. Clock for at least 90 seconds.

COOLING EFFICIENCY TEST (Cont).

29. ______ F° Outdoors	Record the temperature of the air entering the outdoor coil. **DO NOT SHUT THE AC SYSTEM OFF**

SENSIBLE AND LATENT CAPACITY

30.

SENSIBLE CAPACITY (H_S)

(E) _______ Ret dry bulb - **(C)** _______ Sup dry bulb = _______ Temp. Split

(A) _______ CFM **X** _______ Temp. Split **X** 1.08 = **(H_S)** _______ Btu/hr.

LATENT CAPACITY (H_L)

(D) _______ Return wet **(E)** _______ dry _______ Return Grains/lb (from chart)

(B) _______ Supply wet **(C)** _______ dry - _______ Supply Grains/lb (from chart)

= _______ Change in Grains per lb

(A) _______ CFM **X** _______ Change in Grains **X** .68 = **(H_L)**_______ Btu/hr.

CHECK CALCULATION

_____________ **(H_L)** + _____________ **(H_S)** = ______________ **(H_{T1})**

TOTAL CAPACITY

31.

ENTHALPY CHANGE

(D) _______ Return wet bulb _______ Return Enthalpy (from table)

(B) _______ Supply wet bulb -_______ Supply Enthalpy (from table)

= _______ Change in Enthalpy

TOTAL CAPACITY (H_{T2})

(A) _______ CFM **X** _______ Change in Enthalpy **X** 4.5 = **(H_{T2})**_______ Btu/hr.

If H_{T1} is not within 10% of H_{T2} the Final Cooling Efficiency test must be redone.

INPUT AND EER

32.

ACTUAL INPUT

(F) (___ Kh **X** **(G)** ____ # of Revs. **X** 3600) ÷ **(H)** ____ seconds = _____ INPUT (Watts)

ENERGY EFFICIENCY RATIO

(H_{T2})___________ CAPACITY ÷ _______ INPUT = _______ **EER**

CAPACITY CHECK AND RETEST

33.	If the total **OR** sensible cooling capacity measured in step # 30 is not within 10% of the total capacity measured in step # 31, steps # 34 thru 42 **MUST** be completed. If the capacities came out within 10% of each other skip to step # 43.
34. _______ Minutes	Remove the return wet bulb thermocouple and wet the wick again. Install thermocouple set ups in both the supply and return plenums. Record the time elapsed since the beginning of the test.
35. **B** ______ Sup WB. **C** ______ Sup DB. **D** ______ Ret WB. **E** ______ Ret DB.	**Allow thermocouple temperatures to stabilize and record:** The supply and return wet bulb and dry bulb temperatures. Temperatures are stabilized when they do not change during the course of three cycles of the digital thermometer.
36. _______ Near Reg. _______ Mid Reg. _______ Far Reg.	Measure and record the three supply dry bulb temperatures at the supply registers.
37. _______ Ret. Grille	Measure and record the return dry bulb temperature at the return grille.
38. **F** _____ Meter Kh **G** _____ # of rev **H** _____ Seconds	Turn off **ALL** breakers except those to the air conditioner and the air handler. Measure the watts from the house meter by counting the number of revolutions of the disc. Clock for at least 90 seconds. **WHEN DONE WITH TEST TURN ALL BREAKERS BACK ON.**
39. ______ F° Outdoors	Record the temperature of the air entering the outdoor coil.

SENSIBLE AND LATENT CAPACITY

40.

SENSIBLE CAPACITY (H_S)

(E) _______ Ret dry bulb - **(C)** _______ Sup dry bulb = _______ Temp. Split

(A) _______ CFM **X** _______ Temp. Split **X** 1.08 = **(H_S)** _______ Btu/hr.

LATENT CAPACITY (H_L)

(D) _______ Return wet **(E)** _______ dry _______ Return Grains/lb (from chart)

(B) _______ Supply wet **(C)** _______ dry - _______ Supply Grains/lb (from chart)

= _______ Change in Grains per lb

(A) _______ CFM **X** _______ Change in Grains **X** .68 = **(H_L)**_______ Btu/hr.

CHECK CALCULATION

_____________ **(H_L)** + _____________ **(H_S)** = _____________ **(H_{T1})**

TOTAL CAPACITY

41.

ENTHALPY CHANGE

(D) _______ Return wet bulb _______ Return Enthalpy (from table)

(B) _______ Supply wet bulb -_______ Supply Enthalpy (from table)

= _______ Change in Enthalpy

TOTAL CAPACITY (H_{T2})

(A) _______ CFM **X** _______ Change in Enthalpy **X** 4.5 = **(H_{T2})**_______ Btu/hr.

If **H_{T1}** is not within 10% of **H_{T2}** the Final Cooling Efficiency test must be redone.

INPUT AND EER

42.

ACTUAL INPUT

(F) (___ Kh **X** **(G)** ____ # of Revs. **X** 3600) ÷ **(H)** ____ seconds = _____ INPUT (Watts)

ENERGY EFFICIENCY RATIO

(H_{T2})___________ CAPACITY ÷ _______ INPUT = _______ **EER**

SUPPLY SIDE AIR FLOW TEST

43.	Start at the front door of the house and move to the right (clockwise). Follow the same circuit used during the duct leakage test procedure. Record the register flow measured with the flow hood in the spaces provided below. Use open flaps measurement with the flow hood.				
Register Flow	1	2	3	4	5
Register Flow	6	7	8	9	10
Register Flow	11	12	13	14	15
Register Flow	16	17	18	19	20
44.	Set the thermostat back to it's original setting recorded in the duct leakage test procedure.				
45.	Turn off power to the outdoor unit, remove all test equipment at the outdoor unit and restore power to the outdoor unit.				
46.	Remove all test equipment from the indoor unit and the registers.				
47.	Turn all breakers back on for the house and test the operation of the AC system.				

COMMENTS

APPENDIX G: DUCT TESTING PROCEDURE FORMS

DUCT TESTING PROCEDURE

Subdivision Name ______________________ General Contractor ______________________

Address ____ City ______________

Plan Type ________________ Technician __________________ Date ________________

1. ________ ° F Cool Off	Record the current thermostat setting.
2.	Drill holes to measure pressures in both the supply and return plenums. **THIS MUST BE SOMEWHAT DISTANT FROM THE COIL AS WELL AS WHERE THE AIR IS THOROUGHLY MIXED AND HAS GOOD VELOCITY.** Install and secure the static pressure probes (with tubing into house) for pressure measurements.
3.	Turn on the air handler fan only (not the AC) at the thermostat fan switch. Wait 10 minutes before measuring pressures if AC was on when you arrived.
4. **DRY COIL** ________ S. Plenum ________ R. Plenum	Measure the pressures in the return and supply plenums and in the supply system. Use low range and long term averaging on the digital manometer for this measurement.
5.	Turn off the air handler fan and turn on the air conditioner at the thermostat.
6.	Starting at the front door and moving to the right (clockwise), prepare for tests by: • Closing all exterior windows and doors and fireplace dampers. • Opening all interior room doors. • Record the register locations in step # 9 of this form. **OPEN ALL SUPPLY REGISTERS NOW.**
7. ________ House ΔP	Once the blower door is set up, perform the house pressure imbalance test by measuring the ΔP in the house WRT outdoors.
8. ________ Return ΔP ________ House ΔP	Block all return grilles with plastic or tape and measure the pressure across the return grille WRT the house. Then measure the house pressure imbalance measuring the ΔP in the house WRT outdoors.
9. **WET COIL** ________ S. Plenum ________ R. Plenum	After the air conditioner has run for at least fifteen minutes, measure the pressures in the return plenum and in the supply system. Use low range and long term averaging on the digital manometer for this measurement. **TURN THE AIR CONDITIONER OFF.**

10.	Remove all HVAC system filters.
11. **SHELL LEAKAGE** _______ House Pressure _______ Fan Pressure _______ True Fan Flow _______ Corr. Fan Flow Open A B Flow Ring	As soon as the blower door gauges are zeroed, T 2 will pressurize the house to 50 pascals. Record the house pressure, fan pressure, fan flow and flow ring configuration. If you are not able to pressurize the house to 50 pa. use the correction factors on the blower door fan control to determine the corrected fan flow. **T2 MAINTAINS PRESSURE AT THE BLOWER DOOR.**
12.	Starting at the front door of the house and moving to the right (clockwise). Record the pressure pan measurements in the spaces provided below.

Register Location	1	2	3	4	5
Pressure Pan ΔP					
Register Location	6	7	8	9	10
Pressure Pan ΔP					
Register Location	11	12	13	14	15
Pressure Pan ΔP					
Register Location	16	17	18	19	20
Pressure Pan ΔP					

13.	While T 2 installs the Duct Blaster at a return grille, cover **all** registers with paper and/or masking tape.
14. **PRESS TAP LOCATION** _______ Register #	Based on the leakage indications of the pressure pan test and register proximity, pick a supply register that is located close to the air handler and not excessively leaky for the location of the supply system pressure tap (pressure pan reading should be < 1 PA.). Use the 50′ blue tube for the duct reference pressure.
15. **TOTAL LEAKAGE** **DUCT BLASTER™** _______ S. Duct Pres. _______ Fan Pressure _______ True Fan Flow _______ Corr. Fan Flow 0 1 2 3 Flow Ring	Pressurize the duct system to 25 pa (WRT outside) with the Duct Blaster™. As soon as the supply is at 25 pa (WRT outside), **T 2 will check every register seal to ensure an air tight seal**. Record the supply duct pressure, fan pressure, fan flow, and flow ring configuration. If the ducts can not be pressurized to 25 pa (WRT outside), adjust to highest duct pressure possible. Use the correction factors table to adjust the Duct Blaster™ fan flow to 25 pa.

16. **DUCT PRESSURES** _____ S. Plen Pres **Reg #** _____ R. Plen Pres _____ _____ S. Reg Near _____ _____ S. Reg Mid _____ _____ S. Reg Far	With the ducts still pressurized to 25 pa. measure the pressures in the supply and return plenums WRT outside. Also measure the pressures in three supply registers. Choose the supply register closest to the air handler, the supply register furthest away from the air handler and a supply register that is located half way between the other two supply registers chosen. Record the corresponding number from step # 10 with the registers chosen. **Once all measurements have been made turn off the Duct Blaster™.**
17. **OUTSIDE LEAKAGE** **DUCT BLASTER™** _______ S. Duct Pres. _______ Fan Pressure _______ True Fan Flow _______ Corr. Fan Flow 0 1 2 3 Flow Ring	Pressurize the house to 25 pa (WRT outside) with the blower door and duct system to 25 pa (WRT outside) with the Duct Blaster™. As soon as both the supply and the house are at 25 pa (WRT outside), **T 2 will check every register seal to ensure an air tight seal**. Record the supply duct pressure, fan pressure, fan flow, and flow ring configuration. If the ducts can not be pressurized to 25 pa (WRT outside), adjust to highest duct pressure possible and adjust blower door to bring house pressure to zero differential (WRT) ducts. Use the correction factors table to adjust the Duct Blaster™ fan flow to 25 pa.
18. **SUPPLY SYSTEM DUCT PRESSURES** _______ S. Plenum Pres _______ R. Plenum Pres _______ S. Register Near _______ S. Register Mid _______ S. Register Far	With the house and ducts still pressurized to 25 pa. measure the pressure in the supply and return plenums WRT outside and the pressures in the same supply registers selected in step # 13.
19. **HALF NELSON** ______ S. Pressure ______ R. Pressure	Once the duct leakage tests are completed cover the opening of the Duct Blaster™. Perform the Half Nelson by turning on the fan switch at the thermostat. Record the return and supply plenum pressures. Do not leave the fan on any longer than necessary. Once test is completed uncover the Duct Blaster™ fan opening and turn off fan at the thermostat. **ALL REGISTERS SHOULD STILL BE COVERED.**
20. _______ ΔP to Attic _______ ΔP to Floors	Measure and record the ΔP from the house to the attic and if this is a two story house measure the ΔP to the space between the floors. Once all measurements have been made turn off the Duct Blaster™ and blower door.

Test Pressure	Correction Factor	Test Pressure	Correction Factor
5	2.42	15	1.32
7	2.01	17	1.24
9	1.75	19	1.16
11	1.57	21	1.10
13	1.43	23	1.05

21.	With T 2's assistance, visually inspect the duct system and record in the comments section any problems that are seen.
22.	**Reinstall all the system filters**. Upon completion remove tape from registers and pack up the blower door. Take the Duct Blaster™ to the air handler and complete the AC testing procedure.

COMMENTS

DUCT TESTING PROCEDURE

Address ________________________________ Technician ________________________

1.	Unload all tools needed to complete testing on the house. This includes Duct Blaster™, blower door, masking gun and tape, etc...
2.	Put down drop cloths (if necessary) and set up the blower door. Attach the 50′ green tube to the tube on the top blower door gauge.
3.	As soon as T 1 has the house closed up for testing, zero the blower door gauges (with fan cover in place).
4.	Assist T 1 in performing the house pressure imbalance tests.
5.	Pressurize the house to 50 pa. and report the pressure and flow readings to T 1. Keep the house pressure at 50 pa. while T 1 does the pressure pan testing.
6.	Install the Duct Blaster™ at the return closest to the air handler. The return selected should not be excessively leaky.
7.	Once all of the registers have been covered, assist T 1 in performing the total system duct leakage test by **checking every register covering to ensure an air tight seal.**
8.	During the duct leakage to outside test, the house should be maintained at 25 pa. (WRT outside). If the duct system can not be pressurized to 25 pa. adjust the blower door to achieve zero pressure differential in the house (WRT) ducts.
9.	Assist T 1 in performing the half nelson test by controlling the thermostat.
10.	While T 1 reinstalls the filter, remove tape from registers and pack up the blower door. Once finished, gather the Manual J data.

APPENDIX H: MANUAL J FORMS

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HEAT GAIN CALCULATION PROCEDURE

Subdivision Name ____________________ General Contractor ____________________

Address ____ 3 City ____________

Technician ______________________________ 174 Date ____________________

1. Yes No 4	Is the outside unit shaded during the afternoon?			
2. ________ CFM 5	Record the shell leakage of the house			
3.	Record the duct location by percentage for total system(s).			
Duct Location by %	Supply Ducts	Insulated?	Return Ducts	Insulated?
Attic Space	6	0 2 4 6 7	8	0 2 4 6 9
Crawl Space	10	0 2 4 6 11	12	0 2 4 6 13
In Slab	14	0 2 4 6 15	16	0 2 4 6 17
In Walls or Between Floors	18	0 2 4 6 19	20	0 2 4 6 21
In Exterior Walls	22	0 2 4 6 23	24	0 2 4 6 25
Garage	26	0 2 4 6 27	28	0 2 4 6 29
Hall Platform	30	0 2 4 6 31	32	0 2 4 6 33
Garage Platform	34	0 2 4 6 35	36	0 2 4 6 37
4. ________ Bedrooms 38	Record the number of bedrooms in the house.			
5. ________ 1st Floor 39 ________ 2nd Floor 40 ________ 3rd Floor 41 ________ Total 42	Record the square footage of the living space in the house on all levels.			
6. ________ Ft² 43	Record the square footage of the ceiling area exposed to the attic.			
7. ________ Ft 44	Record the average ceiling height.			
8. ________ Ft² 45	Record the total raised floor area of the house (area over crawl space or unconditioned basement).			
9. ________ Ft² Carpet 46 ________ Ft² Other 47	Record the total raised floor area of the house that is covered by carpeting and the area that is covered by other materials (hardwood, tile, etc...)			

10.	________ Ft^2	48	Record the total slab on grade area of the house.
11.	________ Ft^2 Carpet ________ Ft^2 Other	49 50	Record the total slab on grade floor area of the house that is covered by carpeting and the area that is covered by other materials (hardwood, tile, etc...)
12.	Yes No ________ Inches	51	Are the exterior wall cavities insulated?. If yes, record the exterior wall cavity depth.
13.	Yes No ________ R-value	52 53	Is the raised floor area of the house insulated? If yes, record the R-value.
14.	Yes No ________ R-value	54 55	Is the attic of the house insulated? If yes, record the R-value. Use the following R-values for each inch of insulation. Blown fiberglass = R-2.2 Batt fiberglass = R-3.2 Blown cellulose = R-3.5 Blown rockwool = R-2.2
15.	Yes No	56	Based on visual inspection, does the attic ventilation appear to be adequate? (1 Ft^2 of free vent area for every 300 Ft^2 of attic area).
16.	Light Dark	57 57	Record the roofing material color.
17.	Composition Wood Wood	58 58 58	Record the roofing material type.
18.	________ Stories	59	Record the building height in number of stories.
19.	________ CFM	60	Record the measured duct leakage to outside for both the supply and return duct systems.

COMMENTS 175

____

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94.114

LEVEL 1

Glazing type: Single pane Double pane Triple pane 67

Orientation N NE	65
Length of Wall (LF)	68
Total Exposed Wall Area (Ft^2)	69
Door Area (Ft^2)	70
Door Code	71
Glass Door Area (Ft^2)	72
Glass Door Code	73
Winow Glazing Area (Ft^2)	74
Glazing Code	75

Orientation E SE	
Length of Wall (LF)	76
Total Exposed Wall Area (Ft^2)	77
Door Area (Ft^2)	78
Door Code	79
Glass Door Area (Ft^2)	80
Glass Door Code	81
Winow Glazing Area (Ft^2)	82
Glazing Code	83

Draw House Plan

Label The Front

N E

W S

Orientation W NW	
Length of Wall (LF)	84
Total Exposed Wall Area (Ft^2)	85
Door Area (Ft^2)	86
Door Code	87
Glass Door Area (Ft^2)	88
Glass Door Code	89
Winow Glazing Area (Ft^2)	90
Glazing Code	91
% of Shading @ 4:00 PM	92

Orientation S SW	
Length of Wall (LF)	93
Total Exposed Wall Area (Ft^2)	94
Door Area (Ft^2)	95
Door Code	96
Glass Door Area (Ft^2)	97
Glass Door Code	98
Winow Glazing Area (Ft^2)	99
Glazing Code	100
% of Shading @ 4:00 PM	101

Door Codes:
1 Wood without storm door
2 Wood with storm door
3 Metal without storm door
4 Metal with storm door

Glazing Codes:
1 No shading
2 External shade screens
3 Internal shading
4 Reflective film
5 Tinted glass
6 Other external shading

LEVEL 2

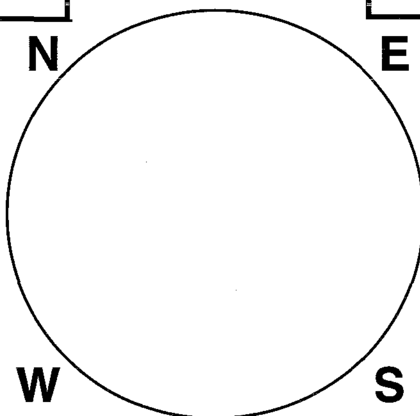
Glazing type: Single pane Double pane Triple pane 103

Orientation N NE	
Length of Wall (LF)	104
Total Exposed Wall Area (Ft^2)	105
Door Area (Ft^2)	106
Door Code	107
Glass Door Area (Ft^2)	108
Glass Door Code	109
Winow Glazing Area (Ft^2)	110
Glazing Code	111

Orientation E SE	
Length of Wall (LF)	112
Total Exposed Wall Area (Ft^2)	113
Door Area (Ft^2)	114
Door Code	115
Glass Door Area (Ft^2)	116
Glass Door Code	117
Winow Glazing Area (Ft^2)	118
Glazing Code	119

Draw House Plan

Label The Front



Orientation W NW	
Length of Wall (LF)	120
Total Exposed Wall Area (Ft^2)	121
Door Area (Ft^2)	122
Door Code	123
Glass Door Area (Ft^2)	124
Glass Door Code	125
Winow Glazing Area (Ft^2)	126
Glazing Code	127
% of Shading @ 4:00 PM	128

Orientation S SW	
Length of Wall (LF)	129
Total Exposed Wall Area (Ft^2)	130
Door Area (Ft^2)	131
Door Code	132
Glass Door Area (Ft^2)	133
Glass Door Code	134
Winow Glazing Area (Ft^2)	135
Glazing Code	136
% of Shading @ 4:00 PM	137

Door Codes:
1 Wood without storm door
2 Wood with storm door
3 Metal without storm door
4 Metal with storm door

Glazing Codes:
1 No shading
2 External shade screens
3 Internal shading
4 Reflective film
5 Tinted glass
6 Other external shading

94.114

LEVEL 3

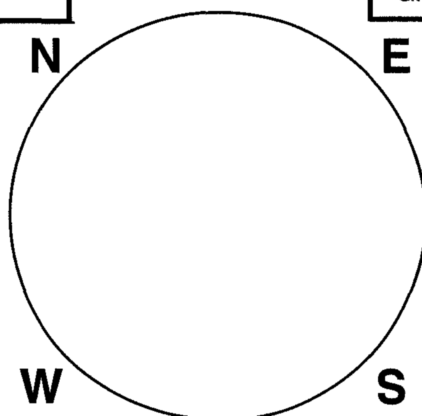
Glazing type: Single pane Double pane Triple pane 139

Orientation N NE	
Length of Wall (LF)	140
Total Exposed Wall Area (Ft^2)	141
Door Area (Ft^2)	142
Door Code	143
Glass Door Area (Ft^2)	144
Glass Door Code	145
Winow Glazing Area (Ft^2)	146
Glazing Code	147

Orientation E SE	
Length of Wall (LF)	148
Total Exposed Wall Area (Ft^2)	149
Door Area (Ft^2)	150
Door Code	151
Glass Door Area (Ft^2)	152
Glass Door Code	153
Winow Glazing Area (Ft^2)	154
Glazing Code	155

Draw House Plan

Label The Front



Orientation W NW	
Length of Wall (LF)	156
Total Exposed Wall Area (Ft^2)	157
Door Area (Ft^2)	158
Door Code	159
Glass Door Area (Ft^2)	160
Glass Door Code	161
Winow Glazing Area (Ft^2)	162
Glazing Code	163
% of Shading @ 4:00 PM	164

Orientation S SW	
Length of Wall (LF)	165
Total Exposed Wall Area (Ft^2)	166
Door Area (Ft^2)	167
Door Code	168
Glass Door Area (Ft^2)	169
Glass Door Code	170
Winow Glazing Area (Ft^2)	171
Glazing Code	172
% of Shading @ 4:00 PM	173

Door Codes:
1 Wood without storm door
2 Wood with storm door
3 Metal without storm door
4 Metal with storm door

Glazing Codes:
1 No shading
2 External shade screens
3 Internal shading
4 Reflective film
5 Tinted glass
6 Other external shading