Development of Pre-Calculated Savings for Southern California Edison's 2006-2008 Retrocommissioning Program

Study ID: SCE0289.01
FINAL REPORT
Volume 1 of 1
Main Report

Prepared For:
Richard Pulliam, SCE

Prepared By:
Mugimin (Mugi) Lukito, SCE
Raad Bashar, P.E., SoCalGas
Ronald K. Ishii, P.E., AESC, Inc.
Greg Stevens, CMVP, AESC, Inc.
Dave Moser, P.E., PECI
Mark Effinger, PECI
David Wylie, P.E., ASW Engineering
Jim Davenport, McLain Instructional Design Consulting

March 30, 2010
Funded with California Public Goods Charge Energy Efficiency Funds

Blank page

TABLE OF CONTENTS

EXECUTIVE SUMMARY

With a budget of over $8 million in 2006-2008, Southern California Edison (SCE)'s commercial retrocommissioning (RCx) program was one of the largest programs of its kind. While the program achieved considerable success in enrolling customers and delivering energy savings, the process evaluation for that program found it could benefit from some systematic improvements.

An underlying issue for the program's technical assessment and quality control process is that it is perceived to be too onerous by participating RCx service providers, particularly for smaller projects where participation costs were a significant percentage of the potential incentive.

Not to ignore the countless positive aspects of the commercial RCx program, some providers found that the calculation and approval of custom savings for RCx measures required excessive labor and time, some felt the level of rigor for data requirements and calculations did not improve the accuracy of the results, some experienced excessive delays for review of service providers' findings, and others felt the review process was overly fastidious.

However, the documentation submitted by some service providers of RCx assessments was not adequate. As examples, baseline data often was not provided, project worksheets often were not very well organized, whole-building descriptions of the facilities were incomplete, descriptions of problems were too vague or were missing, and in some cases incorrect analysis led to unrealistic energy savings estimates.

To address these concerns and to improve and simplify the process and reporting, the evaluation team proposed solutions that include standardizing the methodology for data collection (the "Equipment Inventory"), standardizing energy savings calculation methodologies, ensuring consistent analysis of building systems and equipment, and creating a tiered protocol for calculating energy savings. Successfully implementing these recommendations will not only increase retention of service providers, but will also reduce overall program cost and improve the efficiency of program delivery.

In response to recommendations made in the 2006-2008 RCx program process evaluation, and with the help of several retrocommissioning (RCx) experts, SCE embarked on a collaborative process to develop and implement a simplified RCx measure calculation method for some projects with lower energy savings.

The modified approach for qualified situations uses "pre-calculated" savings for determining the energy and demand savings for certain common RCx measures, and will be adopted for the 2010-2012 program. It streamlines the calculation review process and addresses the concerns of program service providers. Using the pre-calculated savings will also reduce provider and administrator costs.

The pre-calculated savings methodologies employ pre-defined values that can be multiplied by such factors as equipment size, operating schedule hours, and building area to estimate annual electric or natural gas energy savings and electric demand reduction. The pre-calculated savings method may be used only with certain RCx measures that meet predetermined criteria and assumptions. Using a simplified calculation approach should significantly streamline the process while maintaining a sufficient level of overall program accuracy.

Custom calculation methodologies, which are required for measures that do not meet the predetermined criteria are not addressed in this report, but can be found in the RCx Program Guidelines.

Many organizations participated in this effort, including:

- Southern California Edison (SCE)
- Southern California Gas Co. (SoCalGas)
- Alternative Energy Systems Consulting, Inc. (AESC)
- Portland Energy Conservation Inc. (PECI)
- ASW Engineering (ASW)

This study was conducted at the request of Southern California Edison (SCE). This study was managed and funded by SCE using Measurement and Evaluation funding through the public goods charge (PGC) for energy efficiency and is available for download at www.calmac.org.

THE RCX PRE-CALCULATED SAVINGS DEVELOPMENT PROCESS

From an analysis of the 2006-2008 RCx program results, RCx measures were divided into two tiers. The two tiers are based on the typical annual savings of the measure:

- Tier 1 measures: ≤ 75,000 kWh or ≤ 30% of the facility's natural gas consumption
- Tier 2 measures: > 75,000 kWh or > 30% of facility's natural gas consumption

The 75,000 kWh demarcation value was chosen so that a large percentage of total measures could be addressed with pre-calculated values with a relatively low total percentage of program savings. Measures less than 75,000 kWh of savings made up 74% of all measures, but accounted for only 27% of program savings. The 30% demarcation value for natural gas annual savings was determined based on savings observed in a study of heating hot water pump (HWP) lockout for typical facilities in the Southern California Gas Co. (SoCalGas) region.

For certain Tier 1 measures, RCx service providers will be able to use pre-defined factors that can be multiplied by such parameters as equipment size (e.g., motor horsepower), operating hours, building area square feet, etc., to estimate annual electric or natural gas energy savings and DEER (Database for Energy Efficient Resources) peak kW[1] savings. In the 2010-2012 program, qualifying Tier 1 measures will be allowed to use pre-calculated savings to calculate energy savings as an alternative to the more arduous custom analysis and documentation.

Eight of the Tier 1 measures were chosen for development of pre-calculated savings and rules for using them:

- Chilled Water Pump Variable Frequency Drive
- Supply Fan Rescheduling
- Reduce Duct Static Pressure Set Point
- Duct Static Pressure Reset
- Supply Fan Variable Frequency Drive

[1] DEER peak kW savings are determined by climate zone and time of year. For DEER Peak Period definition per climate zone, please see "2010 Statewide Customized Offering Procedures Manual for Business Utility Administrator."

- Outside Air Lockout for Boiler and Heating Water Pump
- Economizer Optimization
- Condenser Water Temperature Reset with VFD

Critical steps in the development approach included:

- Definition of the RCx measure and its baseline conditions
- Identification of the primary independent variables to estimating savings
- Identification of the appropriate model or method to be used, and
- Estimating a level of effort for generating the pre-calculated look-up tables

After the Tier 1 models were developed, the team conducted sensitivity analyses to better identify dominant variables and to update the development plan accordingly.

Sensitivity analysis involves systematically changing the calculated parameters in a model and then observing and assessing the effects of making these changes. To simplify the calculation process and determine the pre-calculated factors, it is necessary to make certain assumptions. There must be balance in the assumptions—if they are too broad, then it is possible to introduce errors and the results will not be within an acceptable range of accuracy. In the process, the calculated parameters were examined to determine whether the margin of error was acceptable.

Some calculated parameters were found to be beyond an acceptable margin of error; that is, the amount of error introduced by making certain assumptions was not acceptable. In several instances, the formulas for the pre-calculated savings were adjusted to produce an improved calculation; in other instances where a desire for accuracy lost out to pragmatism, the formulas were not adjusted in order to keep things simple. For some formulas there are still elements of concern, but in the assessment it was determined that practicality is important as well, recognizing the need to weigh the benefits of simplification against the degree of accuracy of the calculations. This process has produced formulas that serve the overarching purpose, which is to simplify the savings calculation process for certain measures. However, the whole process could benefit from further review.

The pre-calculated results included energy savings, demand reduction, and natural gas savings where appropriate. In addition, equipment size limit tables were developed to help program participants determine whether specific projects qualify to use the pre-calculated methodologies.

The results were documented as part of broader program kick-off and training workshop for the RCx service providers.

Limitations of Pre-Calculated Savings

The normalized pre-calculated savings tables provide an easy and standardized way to determine savings for RCx measures that individually account for low kWh savings. However, these tables were developed using a specific set of assumptions for each measure. In addition, normalization of the savings, to allow for “scaling” as determined by project characteristics, can potentially introduce considerable error if applied to projects with out-of-range sizes or operating time.

While normalization does improve the pre-calculated savings applicability and usability, the pre-calculated approach must be used with care for extreme cases, where equipment size is extremely large or operating hours are very small, so that the assumed savings do not deviate too far from actual savings.

In every case, service providers must verify that the individual project or measure under consideration meets the general assumptions, which are defined for each RCx measure. These assumptions include such

things as maximum allowable motor horsepower, type of HVAC configuration, and the like. If they don't meet these assumptions, then custom calculations must be performed to determine savings.

Additional Research Needed

Additional work is needed to facilitate diligent use of the pre-calculated savings factors and for delivery of the information to the market. The following areas have been suggested for further research.

- Improved Tier 1 equipment size limit qualifiers. Also, there are currently three measures that incorporate operating time in the savings tables. In the future we would like to extend this application to other measures as appropriate.
- Better definition of when actual project conditions exceed allowable pre-calculated savings assumptions.
- RCx pre-calculated savings tool development. Currently the pre-calculated factors are summarized in several tables per measure. Developing a computerized software tool with dynamic inputs and associated instructions would add functionality to the current pre-calculated savings approach as well as improve calculation accuracy.
- Utilize market feedback to improve and or expand the pre-calculated savings.

1. INTRODUCTION AND BACKGROUND

Southern California Edison's commercial retrocommissioning (RCx) program is one of the largest programs of its kind. While the program achieved considerable success in enrolling customers and delivering energy savings, the process evaluation for the program found that it could benefit from some systematic improvements.

An underlying issue for the program's technical assessment and quality control process is that it is perceived to be too onerous by participating RCx service providers, particularly for smaller projects where participation costs were a significant percentage of the potential incentive. One reason the program process became onerous was due to the fact that the entire program was using a custom-calculated approach regardless of the size of the project or measure. As a result, the standardization and quality control became overly difficult.

To address this issue, the evaluation team proposed solutions that include standardizing energy savings calculation methodologies, ensuring consistent analysis of buildings systems and equipment, and creating a tiered protocol for calculating energy savings. Successfully implementing these recommendations will not only increase retention of service providers, but will also reduce overall program cost and improve the consistency and efficiency of program delivery.

With the help of several RCx experts, SCE embarked on a collaborative process to implement the recommendations from the evaluation using lessons learned and data from the 2006-2008 program. This report describes the steps taken by the SCE team:

- Identifying the most common measures
- Developing pre-calculated savings for measures identified as having a low impact on overall program savings (Tier 1)
- Delivering the results to program service providers, and
- Making suggestions for areas of future research

2. DESCRIPTION OF APPROACH

Key to the practical development of pre-calculated savings was the establishment of an approach that was comprehensive and cost effective. This section describes this approach and provides a discussion of the detailed pre-calculated savings development approach.

OVERALL APPROACH

From an analysis of 2006-2008 program results, RCx measures resulting in annual savings of ≤ 75,000 kWh or ≤ 30% of the building's natural gas consumption, depending on the measure's source fuel, were identified as having a low impact on overall program savings, and are called "Tier 1" measures. "Tier 2" measures are those that result in annual savings of >75,000 kWh or >30% of the building's natural gas consumption.

Note that not all Tier 1 (≤ 75,000 kWh) measures have a pre-calculated savings methodology—only a selected few were developed. The majority of the program will continue to use the custom calculation approach. This report focuses only on the Tier 1 measures selected for pre-calculated savings methodology.

The pre-calculated savings methodology employs pre-defined factors that can be multiplied by equipment size, operating schedule and/or building area to estimate annual electric and natural gas energy savings and DEER peak kW savings for certain measures under a specific size.

The overall approach to develop and insert pre-calculated savings into the RCx program included three steps:

- Identify significant Tier 1 measures appropriate for pre-calculated savings development
- Perform DEER savings analysis
- Develop and document the pre-calculated savings for selected RCx measures
- Train RCx providers on how to use pre-calculated methodologies to determine savings

1. Identify Significant Tier 1 Measures Appropriate For Pre-Calculated Savings Development

The team analyzed data from the 2006-2008 RCx program cycle to determine the level of individual RCx measure energy savings that, on a program-wide basis, yielded a large proportion of the number of measures yet a low proportion of the overall program energy savings. Developing a simplified savings tool for these measures would streamline the process, since they represent a majority of the measures, yet have a low impact on overall program savings.

A low impact on overall savings was desired since using a pre-calculated savings approach is likely to be not as accurate as using a custom calculated approach, but should be sufficiently accurate. The analysis showed that measures with ≤ 75,000 kWh energy savings made up 74% of the measures in the program, yet only 27% of the overall program savings. This level of savings was used to distinguish Tier 1 measures from Tier 2 measures. After determining the 75,000 kWh demarcation line, the team analyzed the program data again to determine which measures were the most common Tier 1 measures. These measures were ranked according to highest cumulative impact. (See "Dominant Program Measures" later in this report.)

2. Perform DEER Savings Analysis

For the significant Tier 1 RCx measures in the 2006-2008 program that had a corresponding DEER (2005) measure, the assessment team performed a savings comparison (see "Comparison to 2006-2008 Program and DEER Savings Analysis" in the Appendix). The comparison showed that DEER (2005) savings were typically higher. Consequently, a pre-calculated savings approach was developed that would more closely reflect historical program savings.

3. Develop and Document Pre-Calculated Savings for Selected RCx Measures

A select group of the highest savings Tier 1 measures were analyzed, and pre-calculated savings development plans were assembled for each of these RCx measures. The plans included a description of the measure, an approach to quantify it, a discussion of accounting for primary variables, normalization, and scope of work to complete each task.

Data from the 2006-2008 RCx program was used to clearly define measure baseline and proposed conditions, as well as to shape the overall development approach.

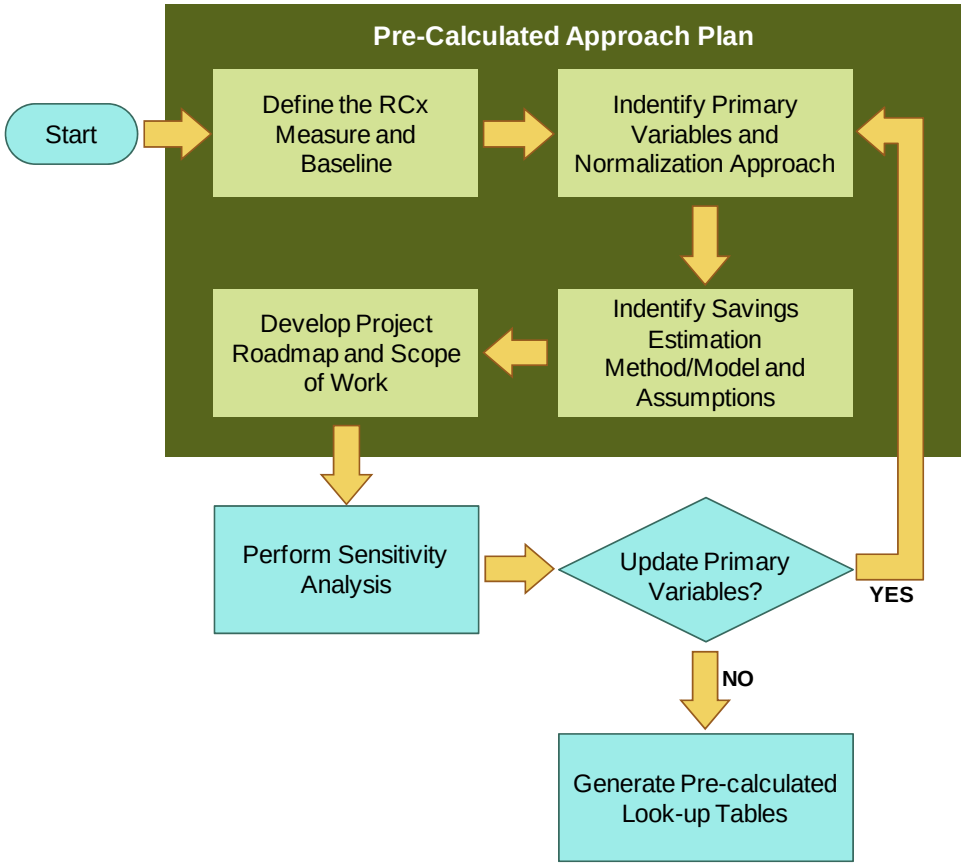
The finalized plans were used to develop the pre-calculated savings factors (normalized values) for various building types, climate zones, measure baseline conditions and proposed conditions.

4. Train RCx Providers

The pre-calculated savings were documented and delivered to participating RCx providers as part of a broader program kick-off and training event in January of 2010. The training materials ("Southern California Edison RCx Program, 2010-2012, Retrocommissioning Provider & Account Representative Training") provided a description of the RCx measures, an explanation of how to use the pre-calculated savings tables and a reference with all the tables, guidance for data collection requirements, and other resource materials used by the RCx service providers.

DETAILED PRE-CALCULATED SAVINGS DEVELOPMENT

The following process flow chart illustrates the approach to developing the pre-calculated savings.



Critical steps in the development approach included:

- Define the RCx measure and its baseline conditions
- Identify the primary independent variables to be used for estimating savings
- Identify the appropriate model or method to be used
- Develop a project roadmap and scope of work for generating the pre-calculated look-up tables

Once the models were developed, sensitivity analyses were conducted to better identify dominant variables and to update the development plan accordingly.

The pre-calculated savings approach was partially iterative to account for changes in dominant variables discovered as part of sensitivity analyses. The team recognized that the use of additional variables in the pre-calculated results could increase the number of calculations, model runs, and results tables to unmanageable levels. So a conscious effort was made to minimize the number of variables allowed in the results (building type, climate zone, baseline conditions, etc.) to only those essential to defining the pre-calculated savings, while maintaining a degree of specificity by including those variables that have major impact on the savings outcome.

Another important aspect of the development plan was the identification of the appropriate method or model to be used to develop the pre-calculated savings values. Retrocommissioning measures are unique in that they typically involve identifying and implementing operational improvements by "fixing" control algorithms, sensors, or other system deficiencies to decrease energy usage while maintaining building system functionality. So the models selected for pre-calculated savings must be able to calculate energy consumption for an impaired system (e.g., broken economizer, improperly controlled fan, etc.). The selected baseline models are based on DEER (2005) building definitions and were generated using Engage 2008 software. (The Engage software creates prototype buildings based on a specified vintage, building type, and equipment type, representative of DEER (2005) definitions. Engage is a front-end to the eQuest software, which is a Trademark of James J. Hirsch.)

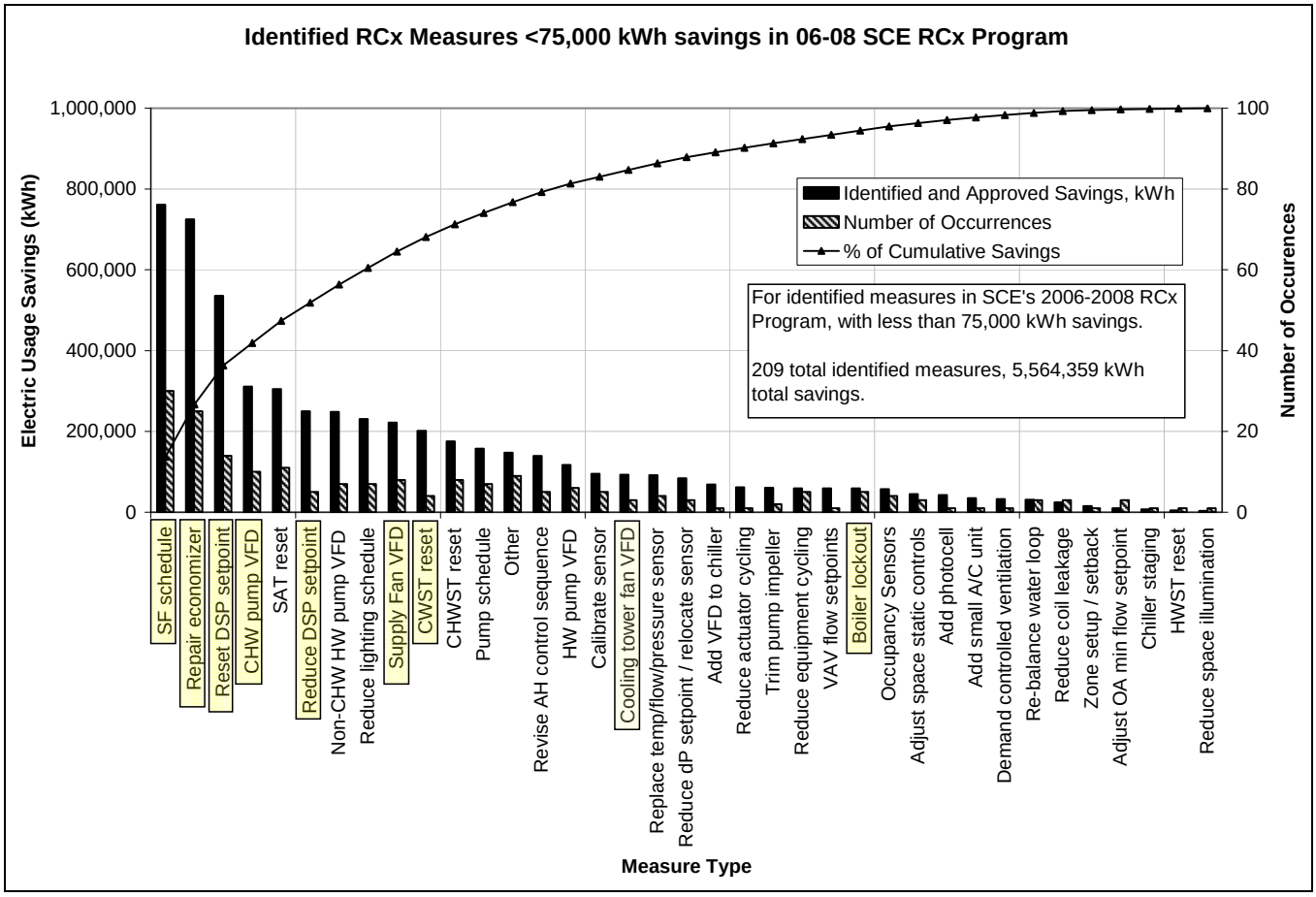
Normalization of the pre-calculated savings permits limited "scaling" of the results to account for building-specific characteristics such as the various equipment sizes and operating hours. While normalization does improve the pre-calculated savings applicability and usability, the pre-calculated approach must be used with care for extreme cases, where equipment size is extremely large or operating hours are very small, so that the assumed savings do not deviate too far from actual savings. Service providers should always consider whether the scaling effect is reasonable.

Normalization also facilitates the development of equipment size breakpoints (the maximum allowable equipment capacity, such as maximum motor horsepower, cooling capacity in tons, etc., as found in the pre-calculated look-up data tables) that can define whether an RCx measure is permitted to use the pre-calculated approach. By comparing site system equipment to the table data allows service providers to easily determine if the measure is eligible for Tier 1 pre-calculated savings.

The development team determined pre-calculated values for annual electric energy savings, electric demand reduction, and natural gas savings where appropriate. In cooperation with Southern California Gas Co., natural gas savings are included for selected Tier 1 pre-calculated measures (i.e., the Outside Air Lockout for Boiler and Heating Water Pump, Economizer Optimization, and Supply Fan Rescheduling).

3. DOMINANT PROGRAM MEASURES

As part of the development effort, the evaluation team gathered measure data from the 2006-2008 SCE RCx program and analyzed the total impact of measures saving 75,000 kWh or less (Tier 1 measures). These measures were ranked and ordered according to their associated total effect on the program, as shown in the figure below.



The Tier 1 measures to the left side of the chart are significant with respect to their total kWh savings and total effect on the program—there are generally a greater number of occurrences for each measure with considerable total identified kWh savings. Conversely, the measures to the right side of the chart are less significant, with fewer occurrences and less total savings. The evaluation team considered the rank order and forecasts of future program participation in determining the dominant program measures and in the selection of the measures best indicated for pre-calculated savings.

The selected Tier 1 measures, listed below and highlighted in the chart above, were targeted for pre-calculated savings development:

- Chilled Water Pump Variable Frequency Drive
- Supply Fan Rescheduling
- Reduce Duct Static Pressure Set Point
- Duct Static Pressure Reset
- Supply Fan Variable Frequency Drive
- Outside Air Lockout for Boiler and Heating Water Pump
- Economizer Optimization
- Condenser Water Temperature Reset with VFD

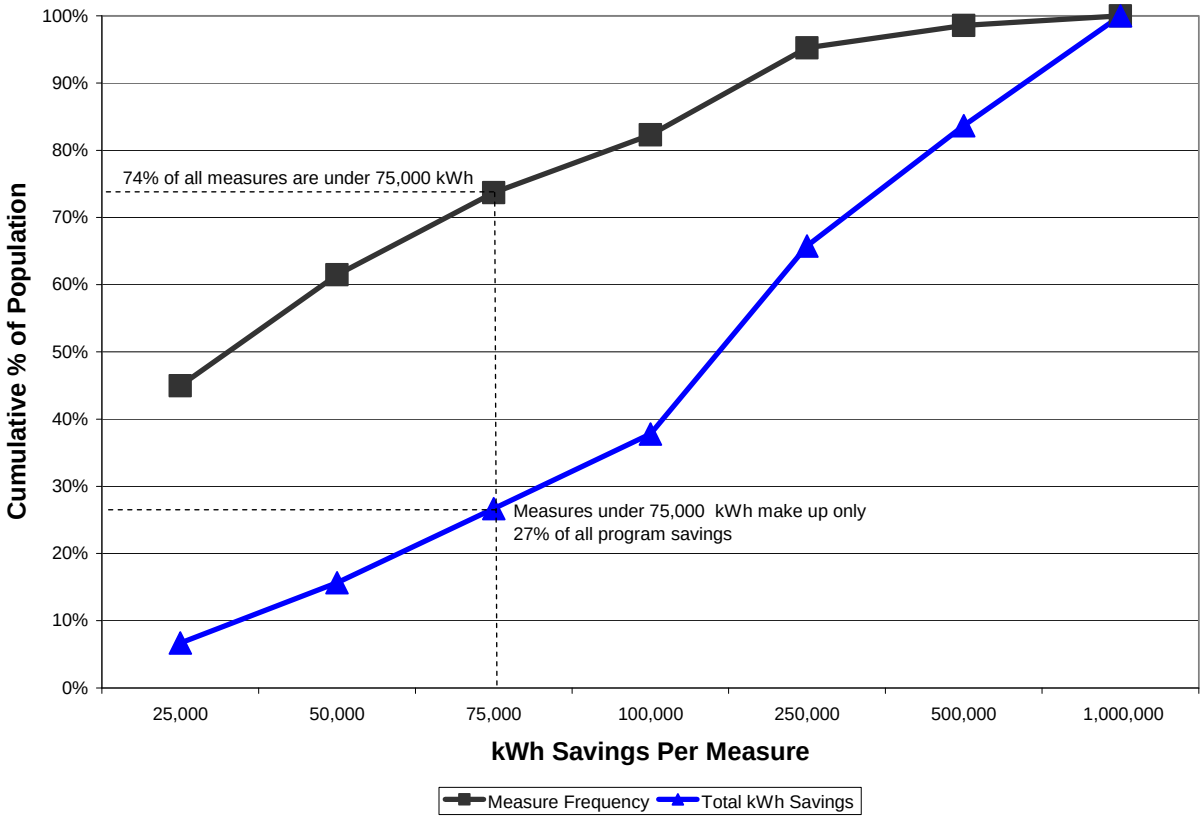
Four measures are scheduled for development of pre-calculated savings procedures and tables by Pacific Gas and Electric Company (PG&E):

- Supply Air Temperature Reset
- Reduced Lighting Schedule
- Chilled Water Supply Temperature (CHWST) reset
- Occupancy Sensors

The review team also identified other measures for possible future development:

- Pump Rescheduling
- Hot Water Pump Variable Frequency Drive
- Cooling Tower Fan with Variable Frequency Drive
- Reduced Differential Pressure Set Point, or Relocate Sensor

The chart and the table below demonstrate why the demarcation of 75,000 kWh was selected. The measures with ≤ 75,000 kWh energy savings made up 74% of the number of measures in the program, but only 27% of the overall program savings.



Bin Limits	Frequency	Total kWh Savings	Cumulative Frequency	Cumulative kWh Savings	Cumulative Frequency %	Cumulative Savings %
25000	188	1,873,077	188	1873077.064	45%	7%
50000	69	2,508,873	257	4381950.456	61%	16%
75000	**51**	**4,965,299**	**308**	**7474172.231**	**74%**	**27%**
100000	36	5,613,312	344	10578610.88	82%	38%
250000	54	12,802,090	398	18415402.3	95%	66%
500000	14	10,624,146	412	23426235.86	99%	84%
1000000	6	17,383,448	418	28007593.71	100%	100%
2500000	0					
5000000	0					

4. RCx Findings, Measures, and Symptoms

With respect to the study of measures addressed in the RCx program, a “Finding” is a broad category that describes a class of related system problems or symptoms typically found in commercial facilities.

For example, there are many possible system symptoms or causes of problems that fall under “Finding Type 1: Time of Day Enabling is Excessive.” As examples, this Finding may have symptoms such as “the HVAC is running when the building is unoccupied” or “the equipment schedule does not follow building occupancy,” and so on. In this case, a “symptom” is something that indicates the presence of a problem or inefficiency.

A “measure” is an action that can be taken to correct or improve a deficiency or problem and are the constituents of the Findings. One measure we discuss below to remediate “Time of Day Enabling is Excessive” is “Supply Fan Rescheduling.” In other words, rescheduling the supply fan run time is one way to remove the symptom or address the cause of the problem.

For an understanding of the scope of the analysis, the evaluation team studied 24 common RCx Finding Types, (electricity based) for which there were many individual measures.

- Finding Type 1: Time of Day Enabling is Excessive
- Finding Type 2: Equipment is Enabled Regardless of Need, or Such Enabling is Excessive
- Finding Type 3: Lighting Is On More Hours Than Necessary
- Finding Type 4: Economizer Operation – Inadequate Free Cooling
- Finding Type 5: Over-Ventilation
- Finding Type 6: Simultaneous Heating and Cooling is Present and Excessive
- Finding Type 7: Sensor/Thermostat Needs Calibration, Relocation/Shielding, and/or Replacement
- Finding Type 8: Controls "Hunt" and/or Need Loop Tuning or Separation of Heating/Cooling Setpoints
- Finding Type 9: Daylighting Controls or Occupancy Sensors Need Optimization
- Finding Type 10. Zone Setpoint Setup/Setback Are not Implemented or Are Sub-Optimal
- Finding Type 11: Fan Speed Doesn't Vary Sufficiently
- Finding Type 12: Pump Speed Doesn't Vary Sufficiently
- Finding Type 13: VAV Box Minimum Flow Setpoint Is Higher Than Necessary
- Finding Type 14: HW Supply Temperature Reset Is Not Implemented Or Is Sub-Optimal
- Finding Type 15: CHW Supply Temperature Reset Is Not Implemented Or Is Sub-Optimal
- Finding Type 16: Supply Air Temperature Reset Is Not Implemented Or Is Sub-Optimal
- Finding Type 17: Condenser Water Temperature Reset Is Not Implemented Or Is Sub-Optimal
- Finding Type 18: Lighting System Needs Optimization - Spaces Are Overlit
- Finding Type 19: Pump Discharge Throttled
- Finding Type 20: Over-Pumping
- Finding Type 21: Equipment is Oversized For Load
- Finding Type 22: VFD Retrofit – Fans

- Finding Type 23: VFD Retrofit – Pumps
- Finding Type 24: VFD Retrofit – Chillers

From this list of Finding Types, the evaluation team began the process of evaluating features of individual measures, and narrowed the list down to eight measures, from seven different Finding Types.

This section of the report presents a description of each of these seven Finding Types (a description of the "problem"), the typical finding symptoms or causes of the problem, suggested ways to identify the problem, an overview of calculating energy, demand and cost savings and the required data to make the calculations along with preferred and alternative data collection methods. In addition, this report provides content on the program data requirements and the Equipment Inventory data collection tool.

Finding types that have associated pre-calculated Tier 1 measures include[2]:

- Finding Type 1: Time of Day Enabling Is Excessive
  - Tier 1 Measure: Supply Fan Rescheduling
- Finding Type 2: Equipment Is Enabled Regardless Of Need, Or Such Enabling Is Excessive
  - Tier 1 Measure: Outside Air Lockout for Boiler and Heating Water Pump
- Finding Type 4: Economizer Operation – Inadequate Free Cooling.
  - Tier 1 Measure: Repair OSA Damper Operation / Raise OSA High Limit
- Finding Type 11: Fan Speed Doesn't Vary Sufficiently
  - Tier 1 Measure: Duct Static Pressure Reduction
  - Tier 1 Measure: Duct Static Pressure Reset
- Finding Type 12: Pump Speed Doesn't Vary Sufficiently
  - Tier 1 Measure: Chilled Water Pump VFD (both 3-way and 2-way valve baselines)
- Finding Type 17: Condenser Water Temperature Reset
  - Tier 1 Measure: Condenser Water Temperature Reset is Not Implemented Or Is Sub-Optimal.
- Finding Type 22: VFD Retrofit – Fans.
  - Tier 1 Measure: Supply Fan VFD (both inlet guide vane and discharge damper baselines)

[2] In this report, note that we retain the original numbering of the Findings.

PROGRAM DATA COLLECTION REQUIREMENTS

The key to attending to a Finding is to determine the "cause of the problem," then take actions to "fix the problem." Obviously, if the problem isn't fixed, then the system will revert to its previous undesired condition. It is essential for service providers to present detailed documentation—to describe accurately the type of Finding, the type of symptom, and what steps were implemented to "fix the problem."

For both custom-calculation and pre-calculated situations, program administration must have "appropriate pre-implementation baseline data and post-implementation evidence showing that measures were implemented." Certain data will be required for every Finding, regardless of size (kWh). The purpose is to provide documentation to confirm savings calculations. This is essential for program quality control and administration verification that corrective action has taken place and will remain as sustainable savings.

These requirements have led to the need for more granular data, such as an inventory list, in relation to the problem (see the Equipment Inventory described below). It is no longer acceptable to simply state, for example, "the duct pressure needs to be reset." RCx service providers now must be very specific about why a particular action is required, and document pre- and post-measure evidence.

For example, pre-implementation evidence might be a photograph of a dirty cooling coil; post-implementation evidence a photograph of the coil after cleaning. Pre-implementation requires collection of baseline energy usage data prior to any program intervention. Likewise, the post-installation data must be collected to support the derived energy savings as a result of program intervention.

In the investigation process, RCx providers must record and track key data using tools provided by the program. Also, RCx providers must describe in detail potential measures for implementation, energy savings, estimated costs, and initial payback calculations. Although measures that use pre-calculated methodologies streamline the savings calculations, the use of pre-calculated methodologies may actually require greater rigor in pre- and post- data collection.

The Equipment Inventory

Not to dismiss the acknowledged success of the 2006-2008 program, too often there was an inadequate amount of data or poor quality data, and too often critical documentation was lacking. For example, baseline data often was not available, worksheets often were not very well organized, whole-building descriptions of the facilities were incomplete, descriptions of problems were too vague or were missing, and incorrect analysis led to unrealistic energy savings estimates.

To improve program implementation and reporting, and to provide a framework for consistent data collection, the program administration team developed the "Equipment Inventory."

The Equipment Inventory is a Microsoft Excel©-based data collection tool. It provides a means for gathering the required information about the various facility systems to document the pre-implementation and post-implementation states. It also will make possible more accurate savings calculations and can be used with subsequent Measurement and Verification (M&V) activities.

The sections of the Equipment Inventory and types of data collected are:

- General information about the facility, such as facility address, conditioned and non-conditioned area square feet, etc.
- Central cooling plant—chiller original design parameters, historic monthly operations, cooling tower design parameters, system pumps data, chiller efficiency, etc.
- Central heating plant—boiler original design parameters, steam boilers, including heating hot water boilers, domestic hot water heaters, central boiler plant heating pump, etc.
- Air handling units—design parameters including such things as type of system, data about the supply and return fans and motors, heating and cooling coils, etc.
- Air-cooled package units and heat pumps—design parameters, efficiency ratings, operations data, etc.
- Exhaust fans—design parameters, areas served, operations data, duty type, etc.

FINDING TYPE 1: TIME OF DAY ENABLING IS EXCESSIVE

This Finding applies if equipment operating schedule does not follow building occupancy schedule.

Finding Examples (Causes)

Examples and possible causes of this finding include:

- Equipment operating schedule doesn't follow building occupancy
- Controls in hand position (Hand Off Auto [HOA] switch is in hand position)
- Time-clock pins are not set properly
- Over-rides are causing continuous operation
- AHU serves different floors with different occupancy times

Identifying the Problem

Begin with a review of existing systems and related documentation (drawings, submittals, etc.)

Problem identification methods include:

- Observations of existing schedule and/or printed controls logic
- Observation of HOA switch in hand position.
- Observation of improper time or date settings in controls.

Examples / Guidelines

- Determine existing schedules of equipment to be rescheduled. Measure the equipment demand.
- Determine revised schedule, and calculate savings. (Savings = equipment demand x difference between new and baseline operating hours).
- Note that other values beyond those mentioned above may need to be trended or spot measured for the savings calculations (e.g., lighting kW).

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. Then collect specific information for this Finding:

- Indicate whether the air handling units (AHUs) are event driven (conference rooms, ballroom, etc.)
- Total hours of reduced supply fan operation per year

Preferred Data Collection Method

Trend command signal and power / current during all operating modes (occupied and unoccupied operation).

Other Allowable Data Collection Method(s)

Note: When planning on using any of these non-preferred methods for baseline data, contact the program first for approval.

- Trend command signal during all operating modes, visually spot verify that equipment or lighting operation matches commanded state. Document observations.
- Provide screenshots of equipment or lighting operating schedule. Provide screenshots of equipment or lighting operating status in all operating modes.
- Provide screenshots of equipment or lighting operating schedule. Visually spot verify that equipment or lighting operation matches commanded state. Document observations.

Allowable Data Collection Method(s) for Low Savings Findings (<25,000 kWh)

- Provide screenshots of equipment or lighting operating schedule, and visually spot verify that equipment or lighting operation matches commanded state. Document observations.
- Provide relevant before and after photos.

FINDING TYPE 2: EQUIPMENT IS ENABLED REGARDLESS OF NEED, OR SUCH ENABLING IS EXCESSIVE

This Finding applies when equipment is enabled regardless of need, or such enabling is excessive.

Finding Examples (Causes)

Examples of this finding include:

- Exhaust fan controls (on/off and variable) are not integrated with AHU operation or equipment (labs, kitchens)
- Staging of equipment (e.g., multiple pumps) is not optimized
- Outdoor temperature lockouts (e.g., boiler lockout) have not been established
- CO control for parking garages is disabled

Identifying the Problem

Ways to identify the problem include:

- Observations that optimum start/stop does not exist in controls logic, or is not properly implemented.
- Observation that equipment operates when not needed (e.g., boilers operate in the summertime)
- Observation of HOA switch in hand position.
- Trends show that multiple chillers operate at low load.
- Improper latitude or longitude settings in photocell lighting controls.

Examples / Guidelines

Determine existing schedules of equipment to be rescheduled. Determine equipment demand. If equipment demand varies with ambient conditions, develop relationship between demand and ambient conditions. Estimate optimum start/stop schedule for each month and compare to the original schedule to calculate energy savings (Equipment demand x Difference between new and baseline monthly operating hours).

Note that other values beyond those mentioned above may need to be trended or spot measured for the savings calculations (e.g., lighting kW).

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. For this measure, determine if the AHU at the facility is event driven (e.g., conference rooms, ballroom). Also determine the control capability for the AHUs (S/S manual, time-clock, EMS, etc.).

Preferred Data Collection Method

Trend command signal and power / current along with any independent variables (e.g., outside air temperature) during all operating modes (e.g., occupied and unoccupied operation).

Other Allowable Data Collection Methods

Note: When planning on using any of these non-preferred methods for baseline data, contact the program first for approval.

- Trend command signal and relevant independent variables during all operating modes, visually spot verify that equipment or lighting operation matches commanded state. Document observations.
- Provide screenshots of equipment or lighting operating status and relevant independent variables in all operating modes.
- Provide screenshots of equipment or lighting operating schedule, or command signal in all operating modes. Visually spot verify that equipment or lighting operation matches commanded state.

Allowable Data Collection Method(s) for Low Savings Findings (<25,000 kWh)

- Provide screenshots of control logic, and visually verify that equipment or lighting operation matches commanded state. Document observations.
- Provide relevant before and after photos.

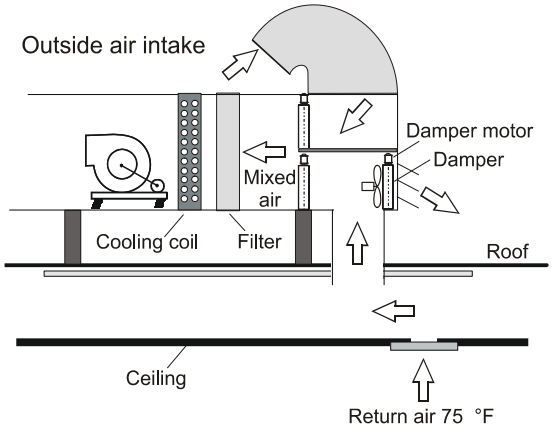
FINDING TYPE 4: ECONOMIZER OPERATION – INADEQUATE FREE COOLING

This Finding[3] relates to economizer control and addresses instances where the facility's economizers are not functioning correctly.

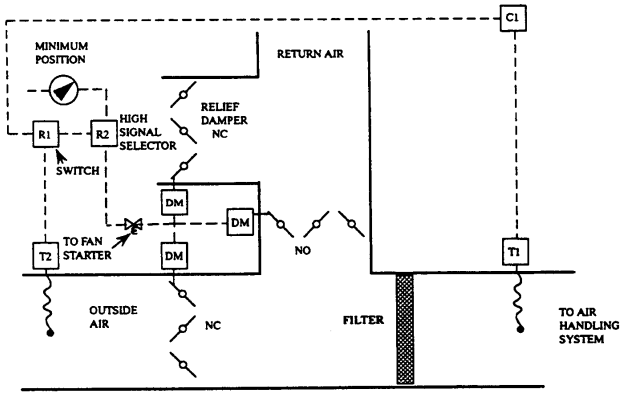
Examples of this finding are:

- The outside air damper failed in minimum or closed position
- Economizer set points are not optimized
- Economizer control sequence is sub-optimal
- Night purge is not enabled

All buildings with forced air ventilation systems provide some amount of fresh outside air to remove pollutants. The diagram on the left below shows the outside air intake components of an HVAC system. On the right is a diagram of representative economizer cycle control.



Outside air intake diagram



Representative economizer cycle control diagram

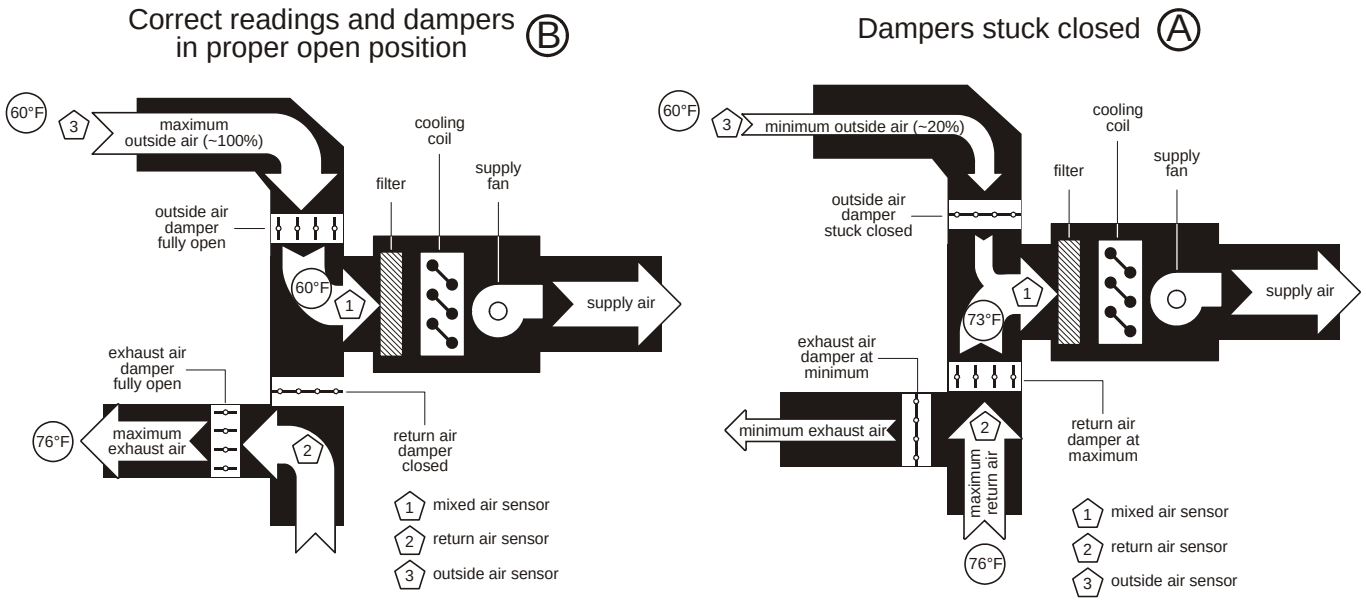
An airside economizer is an HVAC device that reduces the need for mechanical cooling by using outside air for cooling.

Outdoor air economizers have dampers on the return air and outside air intakes and controls that position the damper blades to manage the flow of outside air into the system. An air-side economizer consists of an opening in the supply air ductwork with a damper, a filter, and sometimes a fan.

It operates by substituting building return air with some outside air that is then used either directly for cooling or to enhance a conventional cooling system. This is normally done by opening the damper to the outside air to its maximum aperture and closing the return air damper, so as to allow the circulation of the most outside air possible.

[3] This Finding is not out of sequence. In this report we retain the original numbering of the Findings.

When large quantities of outdoor air are brought into the system, large quantities of indoor air must be exhausted at the same time. This exhaust is called “relief air.”



Finding Examples (Causes)

There are several possible reasons economizers malfunction. The most common are:

- OSA dampers are stuck in a given position (closed, partially closed, or fully open). This could be caused by broken linkage or a malfunctioning actuator.
- Possible air leaks around broken or missing dampers.
- For pneumatic controls, possible damper motor functionality problems or leaks in the controller or tubing. For electronic controls, possible electric actuator or control sensor functionality problems.
- Economizer setpoints need to be optimized. For example, change-over dry bulb setpoint is set too high. Outside air sensor may be in a poor location.
- If there is an existing return fan it may not be properly tracking the supply fan operation, or relief dampers are not functioning properly.
- Control sequences are less than optimal (e.g., minimum return air damper position of 30%).
- Sensors are out of calibration (enthalpy, temperature, etc.).

Additional examples of this finding include:

- Economizer is locked out whenever mechanical cooling is enabled (non-integrated economizer).
- Dampers are blocked off (e.g., plywood used as the outdoor air control, etc.).

Identifying the Problem

Methods for identifying this problem include:

- Observation of integrity of components and sensors
- Functional tests to observe actuation of dampers
- Trending to observe dynamic performance and coil load

Examples / Guidelines

Determine the air handler airflow at different independent variables (e.g., outside air temperatures). This can be estimated using design capacities and fan speed or power / current monitoring. Determine baseline and optimum economizer operation. Use bin data of outside air temperature or wet-bulb temperature to calculate savings using the difference between the baseline and optimum mixed air temperature/enthalpy, airflow, and estimated or measured cooling plant efficiency. Account for OA and RA damper leakage in the savings calculations (e.g., 5% leakage for older dampers with no seals, 1% leakage for newer dampers with blade and jamb seals).

Note that other values beyond temperatures may need to be trended or measured for the savings calculations (e.g., chiller kW/ton, fan speeds).

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. Then collect as needed specific information for this Finding.

Keep in mind that the amount a damper is open (as a percentage) may be different from the percent CFM airflow at that position. In other words, a damper that is 10% open may have an actual airflow of 25%. Because there is this non-linear relationship, be sure to record temperature data.

Preferred Data Collection Method

Trend supply air temperature (SAT), mixed air temperature (MAT), outside air temperature (OAT), return air temperature (RAT), economizer damper command, and call for cooling.

For night purge measures, trend outside air temperature, space temperature, supply fan status and the following (if available):

- Outside and return air damper position
- Building mass temperature
- Chiller power

Other Allowable Data Collection Methods

Note: When planning on using any of these non-preferred methods for baseline data, contact the program first for approval.

- Trend MAT, OAT, RAT, economizer damper command.
- For implementation verification, if OA is too high or too low to observe economizer operation, perform functional testing. Document observations. (Too often, providers functionally test economizers by actuating the dampers only. This does not show correct operation of the software, just the hardware. So, the functional test needs to include testing the controls software. This can be accomplished by temporarily re-setting setpoints to cause economizer operation.)

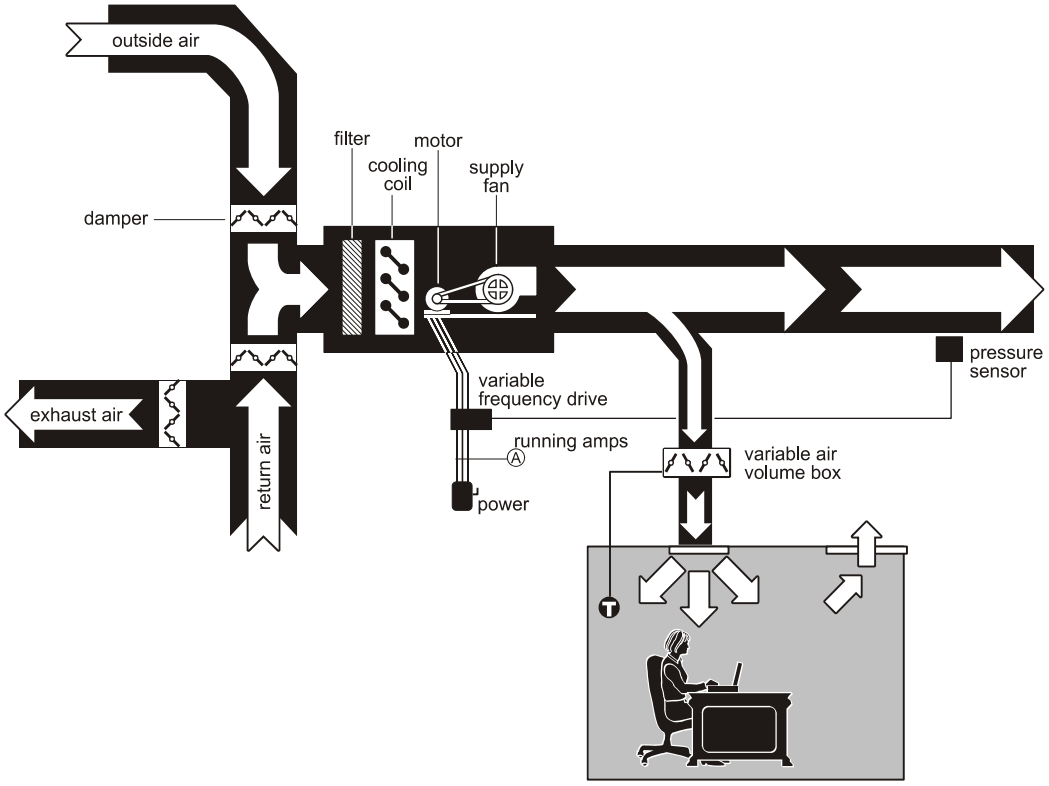
- If OA dampers are non-functional and fully closed, document conditions with a photo at different operating conditions (e.g., different OA temps). For verification, perform trending or functional testing or provide screenshots.
- Provide screenshots of system performance during all relevant operating conditions. Visually verify that system performance matches commanded state, where applicable. Document observations.
- Trend economizer damper command signal and relevant independent variables (e.g., OAT and RAT), visually spot verify that damper moves to commanded position. Perform tests at multiple damper positions and multiple fan speeds (if a variable air volume [VAV] system) to establish the relationship between damper position and outside air fraction. Document all observations.

Allowable Data Collection Method(s) for Low Savings Findings (<25,000 kWh):

- Provide screenshots of controls sequences, if measure consists solely of modifying sequences.
- Provide relevant MAT, OAT, and RAT readings.
- Provide relevant before and after photos.

FINDING TYPE 11: FAN SPEED DOESN'T VARY SUFFICIENTLY

This Finding applies if the speed of fan is not being modulated properly by its VFD. The diagram below shows a typical air system with a supply fan controlled by a VFD. The VFD is adjusted based on readings from a pressure sensor positioned down the air duct.



Example air distribution with VFD

Finding Examples (Causes)

Examples of this finding include:

- Static pressure set point is higher than necessary
- Fan is operating at higher speeds than necessary
- Fan speed does not vary much throughout the day

There are several reasons for variable air volume (VAV) systems to be running at a fairly constant speed, or operate at a higher duct static pressure than necessary. Providers will need to identify the specific reason for a specific situation. The most common reasons are:

- The supply air temperature setpoint is not being met due to high chilled water (CHW) supply temperature or malfunctioning CHW valves.
- The supply air temperature (SAT) setpoint is higher than necessary. (SAT strategies can be used for fan speed reduction. After the lowest static pressure setpoint is achieved, the SAT reset may be optimized.)
- The VFD is malfunctioning or is in bypass mode.
- The duct static pressure control is set arbitrarily too high or is malfunctioning.
- There are significant air leaks in the ductwork distribution system.
- The cooling or heating coils need to be cleaned.
- Thermostat is broken or malfunctioning.
- Poor placement of the duct static pressure sensor in the main duct. It is typically located 2/3 of the way down the length of the main duct.

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. Then collect specific information for this Finding (operating data, pre- and post-Implementation).

Identifying the Problem

Observe fan speeds during system operation. Note relevant system performance (e.g., duct static pressure, space static pressure, positions of VAV box dampers, whether fan speed is varying).

Temporarily adjust a system variable (e.g., reduce duct static pressure set point), then observe system performance (e.g., confirm that boxes will not be starved).

Perform a hot day simulation by setting the thermostat 5 degrees cooler. Then observe system performance (e.g., confirm that boxes will not be starved).

With respect to supply fans controlled by variable frequency drives (VFD) in VAV systems that are running at a constant speed, service providers need to isolate the main reasons for this occurrence, and collect the necessary operating data to establish the pre- and post- energy usage. A good reference point for this Finding is comparing the actual control set point to that indicated on the blueprints or specifications.

A typical cause of fan speed not varying sufficiently is malfunctioning capacity controls. Adjust variables and observe what happens. This measure requires the installation of VFD controls to modulate the fan speed to provide the required airflow for the VAV system.

The baseline case considered is a supply fan with non-functioning inlet guide vanes at various fixed positions. Post-installation—Supply Fan VFD is installed and is properly modulating based on control

strategy in place; for example, fixed static pressure and supply air temperature reset. To identify the problem, observe the inlet guide vanes to see whether they actuate.

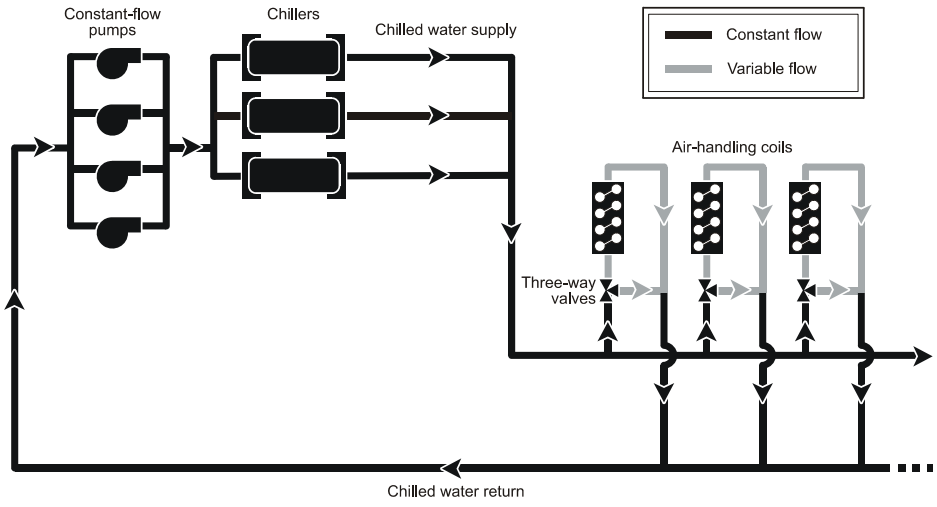
The table below describes typical observations and actions that may be taken.

Observation	Actions	
CHWS temperature is > 45° F	If constant CHWS, check the chiller's leaving chilled water temperature and record the data	If variable CHWS check the CHWS temperature leaving the secondary SCHW pumps and record the data
Cooling coil leaving air temperature is > 55° F	Check cooling coil leaving air temperature and record the data	
CHW valve not operating properly	Check auto valve operation; check the operating manual	
Malfunctioning VFD	Verify the VFD is not in bypass mode	
Ductwork has air leaks	Take infrared photos of the ceiling throughout the duct distribution system	Document pre- and post- SP set point
Cooling coil in need of cleaning	Record the pressure drop across filters and cooling coils; Record the SP drop of the VAV casing and compare results to the design parameters	Document pre- and post- SP set point
The duct static pressure (SP) is set too high	Identify the current duct SP through the EMS; Measure the current duct SP	Compare the results with the original design drawings. Trend data for two weeks

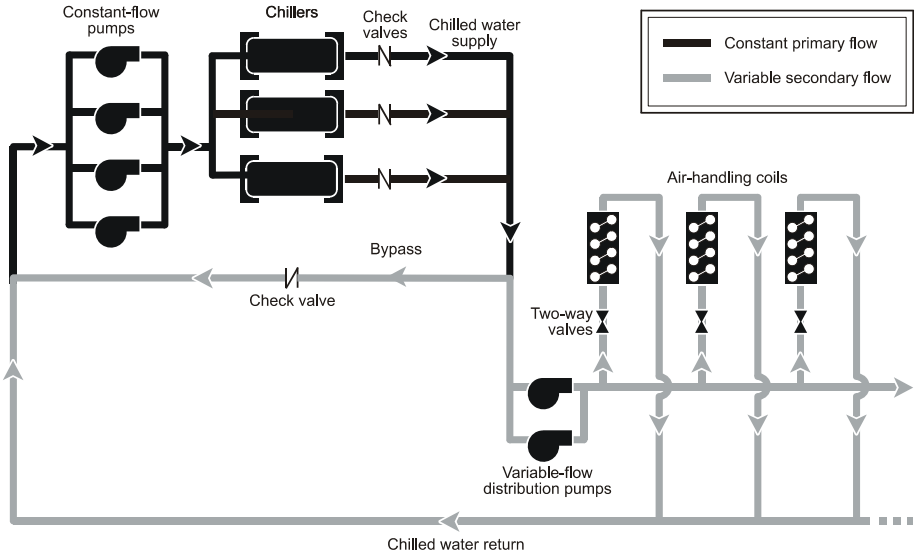
FINDING TYPE 12: PUMP SPEED DOESN'T VARY SUFFICIENTLY

This Finding applies if the speed of the chilled water pump (CHWP) is not being modulated properly by its VFD. The objective is to correct VFD control and modulate pump speed to provide proper CHW flow rate for a given cooling load.

Below is a diagram of a chilled water design with 3-way valves.



Below is a diagram of a chilled water design with 2-way valves



Finding Examples (Causes)

Examples of this finding include:

- Differential pressure setpoint is higher than necessary. For example, the pressure setpoint is found to be 15 PSI. Lowering pressure to 12 PSI does not create comfort problem and the flow is per design.
- A low change in temperature is observed across the chiller during low load conditions.

Identifying the Problem

Observe pump speeds during system operation.

Note relevant system performance (e.g., differential pressure, positions of valves).

Observe whether there is excessive flow through the bypass.

Temporarily adjust variables (e.g., differential pressure set point), and observe system performance (e.g., confirm that valves will not be starved).

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. Then collect specific information for this Finding:

- Describe the chilled water distribution system
- Indicate whether there are 2-way or 3-way valves

Preferred Data Collection Method

- Trend relevant points (e.g., differential pressure, differential pressure setpoint)
- Trend pump power / current, OSA temperatures, CHWS, CHWR, chiller kW.
- Submit results of any temporary overrides performed as part of system testing.
- For chiller plants with low ΔT, trend the primary and secondary pump flow, if available, or current and kW. Also trend primary and secondary supply and return temperatures.

There may be two different types of chilled water distribution systems: constant speed CHWP operating with a three-way bypass valve, and constant speed CHWP being throttled with a two-way valve.

Post-installation, verify that the CHWP VFD is properly modulating based on the control strategy in place.

Other Allowable Data Collection Methods

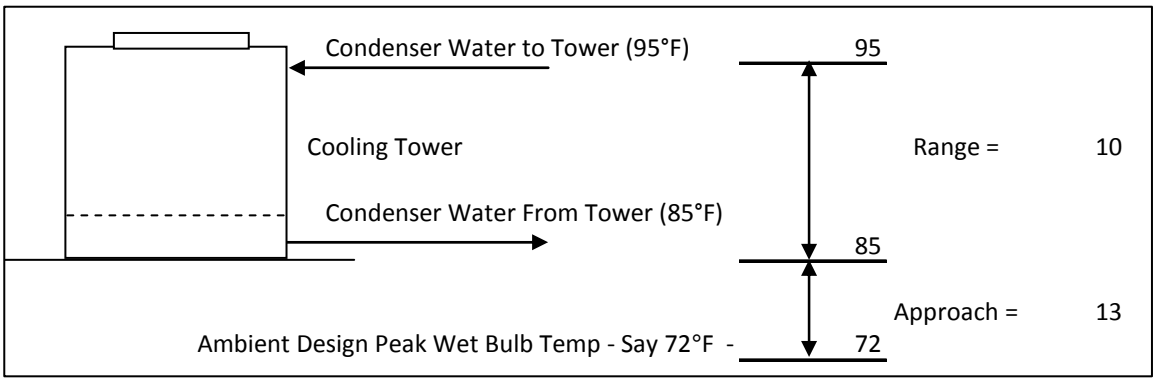
Note: when planning on using any of these non-preferred methods for baseline data, contact the program first for approval.

- Provide screenshots of relevant points (e.g., differential pressure setpoint) and pump speed. If setpoint is reset, provide screenshots at all relevant operating conditions.
- Perform functional testing, including spot measurements.

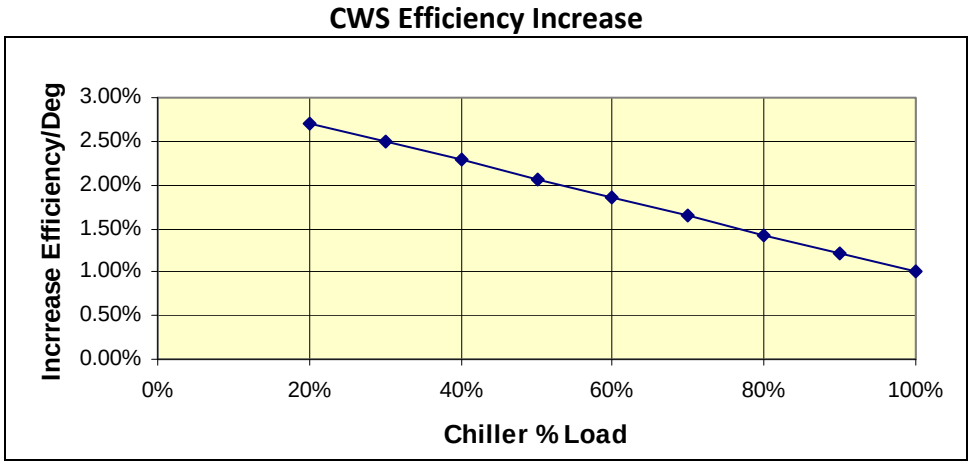
FINDING TYPE 17: CONDENSER WATER TEMPERATURE RESET IS NOT IMPLEMENTED OR IS SUB-OPTIMAL

This Finding is applicable when the condenser water temperature (CWT) setpoint is either not resetting properly, or a reset strategy is not implemented.

The diagram below demonstrates the typical range and approach of a cooling tower, for reference.



The graph below shows how a decrease in chiller load and condenser water temperature results in an increase in chiller efficiency. Note: This applies to chillers controlled by inlet guide vanes. The values will be different for a chiller controlled by VFD.



Finding Examples (Causes)

An example of this finding is the condenser water temperature is constant leaving the tower at 85° F. The temperature should be reduced to minimize the total energy use of the chiller and tower. It may be worthwhile to reset based on load and ambient conditions.

Identifying the Problem

Observations and spot measurements of condenser water supply and return temperatures.

Examples / Guidelines

Condenser water supply temperature reset based on differential with wet-bulb outside air temperature (OAT). This also may be based on load. Determine optimal reset temperature based on required system temperatures, and chiller temperature requirements. Calculate reduced energy consumption of chiller plant due to improved efficiency at lower condenser water temperatures, and subsequent increase in cooling tower fan energy.

Note that other values beyond those mentioned above may need to be trended for the savings calculations (e.g., chiller kW/ton).

Required Data

Preferred Data Collection Method

- Trend condenser water supply temperature and temperature setpoint, and whatever parameter the reset is based on (e.g., outside air dry bulb and wet bulb temperatures).
- Also perform functional testing if independent variables at the time of trending don't cover the range covered by the reset.

FINDING TYPE 22: VFD RETROFIT – FANS

This Finding applies if the air system needs to be retrofitted with VFD, or an existing VFD is not functioning properly.

Finding Examples (Causes)

Check the blueprints (or control diagrams, if they exist) for design set point information. (Be aware the installed equipment may not match the recommended set points in the blueprints. Use good judgment and consider the original intent—what was it designed to do? How is it different now?)

Examples of this finding

- Fan serves variable flow system, but does not have a VFD.
- VFD is in override mode, and was found to be not modulating.

Identifying the Problem

Observation that airflow varies, but fan speed remains constant.

Examples / Guidelines

- Use power / current as a surrogate measurement of motor load. Compare existing fan curve to VFD fan curve to estimate annual energy savings.
- Note that other values beyond those mentioned above may need to be trended for the savings calculations (e.g., temperatures, cooling load).

Required Data

Be sure to fill out all of the forms in the Equipment Inventory. Then collect specific information for this Finding. Much of the required data may be found in system blueprints.

Preferred Data Collection Method

Trend motor power / current and any other relevant independent variables (e.g., OAT, inlet guide vane [IGV] position). For verification phase, trend fan speed and other relevant independent variables.

Other Allowable Data Collection Methods

Note: When planning on using any of these non-preferred methods for baseline data, contact the program first for approval.

- For baseline, spot measure fan motor power / current. Note system performance, document observations.
- For verification, submit photo of installed VFD. Submit screenshots of system performance, showing speed of VFD.
- Perform functional testing, including spot measurements where necessary, to simulate system performance.
- Align with utility requirements for retrofits

5. PRE-CALCULATED SAVINGS RESULTS

This section presents the measures that have pre-calculated savings methodologies, and provides the instructions and data tables for using them. These measures are:

- Chilled Water Pump Variable Frequency Drive
- Supply Fan Rescheduling
- Duct Static Pressure Reset
- Reduce Duct Static Pressure Set Point
- Supply Fan Variable Frequency Drive
- Condenser Water Temperature Reset with VFD
- Economizer Optimization
- Outside Air Lockout for Boiler and Heating Water Pump

For each of these measures this section includes a description and overview of the measure, instructions for how to use the pre-calculated savings factors, and the assumptions for when using pre-calculated savings is appropriate for the measure. For each measure, with the exception of Outside Air Lockout for Boiler and Heating Water Pump, there are both Pre-Calculated Electric Energy and Demand Savings Tables. For several measures there are Pre-Calculated Gas Savings as well. Additionally, other data tables are included that provide details for specific measures, such as equipment breakpoints, etc.

WHEN TO USE THE PRE-CALCULATED SAVINGS METHODOLOGIES

The pre-calculated savings methodologies employ tables of pre-defined values that can be multiplied by such factors as equipment size, operating schedule hours, and building area to estimate annual electric or gas energy savings and electric demand reduction. So how do RCx providers determine if the pre-calculated savings can be used?

It is important to remember that the use of pre-calculated data is for measures that are “inside the norm.” That is, they conform with the basic measure assumptions.

Service providers must also remember that for Tier 1 measures that do not meet the assumptions and are “outside the norm,” providers should perform the normal custom calculations for these measures. For example, consider very inefficient equipment that would indicate more savings than pre-calculated Tier 1 results, or, conversely, indicating much less savings with very efficient equipment compared to the pre-calculated method. So, RCx providers are cautioned to review the assumptions and the pre-defined factors associated with pre-calculated savings to determine if it makes more sense to do custom calculations instead.

First of all, understand and consider the general assumptions that are made for all of the pre-calculated measures (see “Global Modeling Assumptions” below). Then for each of the measures, understand and consider the specific assumptions and baseline situations for the individual measures that will indicate when the pre-calculated savings tables may be used. If a particular situation falls outside the typical assumptions, custom calculations are required.

This is as specific as the instructions can be at this time. The evaluation team realizes there is some "gray area" for when to use the pre-calculated savings methodologies, and this is something that requires future investigation and study. A good rule of thumb—use common sense. And if there is any doubt about how to proceed, service providers should confer with the program administrator, who can provide guidance on a case-by-case basis.

Making the Decision to Use Pre-Calculated Savings Methodologies

Methodology for determining savings	Tier 1 measures (< 75,000 kWh)	Tier 2 measures (> 75,000 kWh)
Pre-calculated savings	yes [1]	no [2]
Custom calculations	yes [3]	yes [4]

In the table above:

[1] yes—pre-calculated savings methodologies were developed and are available and may be used. Even though the pre-calculated savings tables may be used with Tier 1 Findings, certain baseline data with documentation is required.

[2] no—pre-calculated savings methodologies have not been developed for Tier 2 measures

[3] yes —if using the pre-calculated savings methodology is not a good fit for this Tier 1 measure, then use custom calculations

[4] yes —using custom calculations is the only methodology for Tier 2 measures at this time

GLOBAL MODELING ASSUMPTIONS

For all Tier 1 pre-calculated savings measures there are a set of common assumptions used in the development. DEER (2005) building definitions were used for the following building types:

- Large Office
- Large Retail (Multi-story)
- Hotel
- Secondary School
- Hospital

Engage 2008 software was used to generate the DEER baseline models for each building prototype. Two DEER building vintages, 1978-1992 and post 2005, were evaluated for the California Climate Zones in SCE's service territory: CZ06, CZ08, CZ09, CZ10, CZ13, CZ14, CZ15, and CZ16.

Additionally, baseline DEER equipment types and control strategies for these building types are described in following tables.

Central Plant	1978-1992 Vintage	Post 2005 Vintage
Centrifugal Chiller	Constant Speed	Constant Speed
Chiller Control	No Reset	Load Reset
CHW Pump	Constant Speed	Constant Speed
Cooling Tower	Single Speed Fan	Two Speed Fan
Condenser Control	Fixed	Fixed
Boiler Type	HW, Atmospheric	HW, Atmospheric
Boiler Control	No Reset	Load Reset
HW Pump	Constant Speed	Constant Speed

Building Types	Air-side Types 1978-1992 & Post 2005 Vintages
Hotel	Variable Air Volume, Packaged Single Zone and Fan Coil Units
Hospital	Variable Air Volume, Packaged Single Zone and Fan Coil Units
Office	Variable Air Volume
Secondary School	Variable Air Volume, Packaged Single Zone
Large Retail	Variable Air Volume, Packaged Single Zone

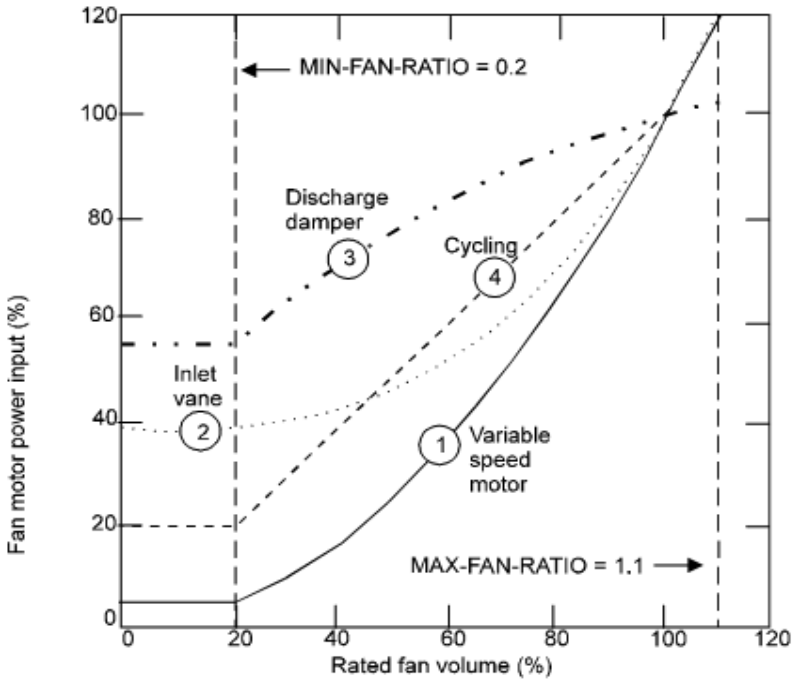
Building Types	Main AHU 1978-1992 Vintage	Main AHU Post 2005 Vintage
Hotel	Supply Fan: Forward Curve w/Inlet Guide Vanes Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO	Supply Fan: Variable Frequency Drive Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO
Hospital	Supply Fan: Forward Curve w/Inlet Guide Vanes Return Fan: Forward Curve w/Inlet Guide Vanes Economizer: OAT, 70F Limit, No Compressor LO	Supply Fan: Variable Frequency Drive Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO
Office	Supply Fan: Forward Curve w/Inlet Guide Vanes Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO	Supply Fan: Variable Frequency Drive Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO
Secondary School	Supply Fan: Forward Curve w/Inlet Guide Vanes Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO	Supply Fan: Variable Frequency Drive Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO
Large Retail	Supply Fan: Forward Curve w/Inlet Guide Vanes Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO	Supply Fan: Variable Frequency Drive Return Fan: Forward Curve w/Discharge Damper Economizer: OAT, 70F Limit, No Compressor LO

Building Schedule	1978-1992 & Post 2005 Vintages
Hotel	24/7, 8,760 hours per year
Hospital	24/7, 8,760 hours per year
Office	Mon-Fri 8AM-5PM, Sat 8AM-5PM
Secondary School	Mon-Fri 7AM-6PM, Sat 7AM-4PM during Regular Sessions: Jan 7th – Apr 5th, Apr 15th – Jun 14th, Aug 19th – Dec 13th (simulation year 1991)
Large Retail	Mon-Fri 9AM-9PM; Sat, Sun, Holidays 9AM-7PM

Motor Efficiency and Fan Capacity Control

Brake Power		MOTOR-CLASS		
HP	kW	STANDARD	HI-EFF	PREMIUM
0.083	0.064	.490	.490	.490
0.125	0.096	.550	.550	.550
0.167	0.129	.600	.600	.600
0.250	0.193	.640	.640	.640
0.333	0.256	.660	.660	.660
0.500	0.385	.700	.760	.800
0.750	0.578	.720	.770	.840
1.0	0.770	.790	.825	.855
1.5	1.16	.800	.840	.855
2.5	1.93	.800	.840	.855
3.9	3.00	.810	.865	.875
6.9	5.31	.820	.875	.902
12.9	9.93	.850	.885	.917
17.9	13.8	.860	.910	.910
20.9	16.1	.870	.910	.924
29.9	23.0	.880	.917	.930
69.9	53.8	.890	.930	.941
139.9	107.7	.900	.941	.950
1,000,000	770,000	.910	.950	.962

Motor Efficiencies (Source: eQuest version 3.63, build 6510)



Generic Fan Capacity Control Curves

CHILLED WATER PUMP VARIABLE FREQUENCY DRIVE

Measure Description and Overview

The "Chilled Water Pump Variable Frequency Drive" measure applies when the speed of the chilled water pump is not being modulated properly by its variable frequency drive (VFD). This measure entails correcting VFD control and modulating pump speed to provide proper CHW flow rate for a given chiller load.

Historical program data indicated that two baseline conditions existed:

- Baseline 1 – constant speed chilled water pump operating with three-way control valves.
- Baseline 2 – constant speed chilled water pump operating with two-way control valves.

There are two post-installation conditions:

- The chilled water pump VFD is properly modulating based on control strategy in place.
- The control valves are converted to two-way valves (if they were three-way in baseline case). Please be aware that not all three-way valves can be converted to two-way valves.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, AHU baseline chilled water valve type (2-way or 3-way), building vintage, and pump motor rated horsepower. (This step applies to all measures.)
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable horsepower size limit using the CZ, type of building, baseline valve type, and building vintage.[4] Chilled water pump motors that are equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Chilled water pump motors that are larger than the allowable horsepower size limit are ***not*** eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.
4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, baseline valve type, and building vintage. Then multiply the factor times the chilled water pump motor horsepower rating and the annual pump operating hours. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of building, baseline valve type, and building vintage. Then multiply the factor times the chilled water pump motor horsepower rating. The product will be the estimated electric demand savings.

[4] Choose closest CZ, building type, horsepower size, and building vintage in the lookup tables.

Relevant Modeling Assumptions

The following relevant assumptions were used in the modeling:

- Generic pump performance curves
- Generic motor and VSD efficiency curves (see Global Modeling Assumptions above)
- Savings are normalized by the pump operating hours:
  - Large Retail: 2,808 hours/yr
  - Large Office: 4,160 hours/yr
  - Hotel: 8,760 hours/yr
  - Hospital: 8,760 hours/yr
  - Secondary School: 2,519 hours/yr

Sample Calculation

Baseline: Office Building in CZ06, Post 2005 Vintage, 50HP CHW Pump Motor with 3-way Valves, Operates 2,000 hours/yr.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 52 HP (move to Step 2)

Step 2 – Lookup kWh/HP/hr Savings Factor in Table and Calculate Savings:

50 HP x 0.517 kWh/HP/hr x 2,000 hours = 51,700 kWh/yr

Step 3 – Lookup kW/HP Savings Factor in Table and Calculate Savings:

50 HP x 0.282 kW/HP = 14.1 kW

Allowable Pump Motor Horsepower

The horsepower breakpoint for each building prototype was calculated by dividing the savings cutoff level of 75,000 kWh by the savings (normalized by horsepower), to arrive at the pump motor nameplate horsepower equivalent breakpoint capacity found in the tables below. Operating hours for these derived values follow the prototypical buildings' operating hours.

Chilled water pump motors that are equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Chilled water pump motors that are larger than the allowable horsepower size limit are ***not*** eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.

Horsepower Breakpoint (Post 2005)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	49	46	67	43	46	39	38	60
2-way Valves FS Pump	162	141	193	126	141	118	93	211

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	20	20	21	21	21	22	21	24
2-way Valves FS Pump	64	64	63	66	66	70	62	82

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	23	23	24	24	26	27	25	37
2-way Valves FS Pump	79	76	77	79	81	89	69	133

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	52	51	52	53	55	58	49	90
2-way Valves FS Pump	148	140	139	140	143	154	112	266

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	41	45	45	46	59	55	56	65
2-way Valves FS Pump	124	122	122	122	145	145	124	203

Horsepower Breakpoint (1978 – 1992)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	40	38	39	35	32	33	29	44
2-way Valves FS Pump	150	134	132	121	107	113	86	174

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	16	16	16	17	17	18	17	20
2-way Valves FS Pump	60	59	60	61	61	65	58	76

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	8	9	8	9	9	10	9	12
2-way Valves FS Pump	30	32	29	33	32	37	29	47

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	43	42	43	43	46	49	37	81
2-way Valves FS Pump	154	145	148	147	152	166	115	284

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	39	39	39	42	44	43	41	56
2-way Valves FS Pump	140	128	126	128	130	136	107	202

Pre-Calculated Electric Energy and Demand Savings Tables

Normalized savings are presented in the tables below for the aforementioned building types and climate zone categories. The first two tables represent savings for a three-way valve baseline. The second two tables represent savings for a two-way valve baseline.

To determine the savings in kWh per year for a specific building type and climate zone category, the factors listed in the table are to be multiplied by chilled water pump motor horsepower and pump operating hours.

For the kW savings, the appropriate DEER peak savings factor is to be multiplied by the chilled water pump motor rated horsepower.

Energy Savings Factors (kWh/hp-hour) (Post 2005)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.613	0.642	0.442	0.685	0.642	0.754	0.778	0.500
2-way Valves FS Pump	0.184	0.211	0.155	0.236	0.211	0.252	0.321	0.141

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.432	0.422	0.414	0.407	0.400	0.383	0.402	0.358
2-way Valves FS Pump	0.133	0.133	0.136	0.130	0.130	0.122	0.138	0.105

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.376	0.368	0.361	0.350	0.331	0.313	0.348	0.232
2-way Valves FS Pump	0.109	0.112	0.111	0.108	0.105	0.096	0.124	0.064

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.517	0.522	0.514	0.506	0.482	0.458	0.545	0.296
2-way Valves FS Pump	0.180	0.191	0.192	0.191	0.187	0.174	0.238	0.100

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.435	0.399	0.400	0.390	0.306	0.327	0.323	0.279
2-way Valves FS Pump	0.145	0.147	0.148	0.148	0.124	0.124	0.146	0.089

Energy Savings Factors (kWh/hp-hour) (1978-1992)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.752	0.793	0.765	0.844	0.930	0.915	1.037	0.681
2-way Valves FS Pump	0.198	0.222	0.225	0.245	0.277	0.263	0.344	0.171

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.539	0.534	0.528	0.509	0.507	0.475	0.511	0.429
2-way Valves FS Pump	0.143	0.146	0.143	0.140	0.141	0.132	0.148	0.113

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	1.102	0.998	1.074	0.957	0.967	0.863	0.973	0.715
2-way Valves FS Pump	0.288	0.265	0.293	0.257	0.271	0.235	0.299	0.181

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.625	0.639	0.618	0.616	0.577	0.542	0.729	0.331
2-way Valves FS Pump	0.173	0.184	0.181	0.182	0.175	0.161	0.233	0.094

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.460	0.457	0.461	0.434	0.414	0.420	0.442	0.321
2-way Valves FS Pump	0.129	0.141	0.143	0.141	0.138	0.132	0.169	0.089

DEER Peak Savings Factors (Post 2005)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.382	0.261	0.157	0.155	0.344	0.258	0.134	0.300
2-way Valves FS Pump	0.153	0.153	0.111	0.266	0.161	0.153	0.099	0.160

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.395	0.381	0.362	0.154	0.370	0.396	0.362	0.387
2-way Valves FS Pump	0.152	0.155	0.158	0.388	0.157	0.152	0.209	0.154

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.366	0.446	0.323	0.155	0.333	0.353	0.331	0.373
2-way Valves FS Pump	0.156	0.189	0.156	0.343	0.156	0.154	0.156	0.189

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.282	0.291	0.293	0.286	0.305	0.300	0.288	0.298
2-way Valves FS Pump	0.155	0.157	0.207	0.156	0.158	0.157	0.156	0.157

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.269	0.273	0.079	0.184	0.080	0.073	0.073	0.248
2-way Valves FS Pump	0.155	0.156	0.076	0.125	0.077	0.073	0.073	0.151

DEER Peak Savings Factors (1978-1992)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.445	0.405	0.344	0.356	0.329	0.295	0.316	0.388
2-way Valves FS Pump	0.144	0.162	0.163	0.165	0.167	0.163	0.164	0.163

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.519	0.509	0.498	0.168	0.631	0.497	0.635	0.506
2-way Valves FS Pump	0.160	0.170	0.169	0.501	0.248	0.169	0.317	0.166

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	1.054	0.973	0.988	0.957	0.941	0.924	0.940	0.971
2-way Valves FS Pump	0.357	0.338	0.384	0.353	0.386	0.357	0.374	0.348

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.427	0.428	0.408	0.420	0.403	0.417	0.395	0.425
2-way Valves FS Pump	0.147	0.147	0.153	0.150	0.155	0.151	0.157	0.148

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
3-way Valves FS Pump	0.415	0.389	0.331	0.308	0.269	0.285	0.266	0.373
2-way Valves FS Pump	0.157	0.163	0.167	0.165	0.158	0.162	0.158	0.166

SUPPLY FAN RESCHEDULING

Measure Description and Overview

The "Supply Fan Rescheduling" measure is a subset of Finding Type 2 and applies when the operating schedule for a fan is adjusted to better fit the building operating schedule when space cooling/heating is needed. This reduces fan run-time and saves energy when air flow is not needed.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.

2. Establish the building's California Climate Zone (CZ), type of building, building vintage, HVAC type, and fan motor rated horsepower.

3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable horsepower size limit using the CZ, type of building, HVAC system type, and building vintage.[5] Fan motors that are rated equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Fan motors that rated larger than the allowable horsepower size limit are ***not*** eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.

4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, HVAC type, and building vintage. Then multiply the factor times the fan motor horsepower rating and the amount of annual operating hours reduced. The product will be the estimated annual electric energy savings.

5. Determine annual natural gas energy savings by looking up the therm savings factor using the CZ, type of building, HVAC type, and building vintage. Then multiply the factor times the fan motor horsepower rating and the amount of annual operating hours reduced. The product will be the estimated annual gas energy savings.

Relevant Modeling Assumptions

The following assumptions were used in the modeling:

- Generic fan performance curves
- Generic motor and VSD efficiency curves (see Global Modeling Assumptions above)
- VAV w/ VFD and CAV w/o VFD
- Baseline is assumed to be 24-hour fan operation
- Four system types are specified: chilled water VAV, chilled water CAV, packaged VAV, and packaged CAV
- Seven building types which are variations of large office, large retail, educational, and hotels were incorporated. (See Table 2 "Operating Hour & Efficiency Assumptions" below.)
- Table 1 represents the "corrected" operating hours of the building's supply fans simulated in the proposed case. For modeling purposes, fan operating hours are assumed to be +2 hours per day beyond occupancy hours (fans operate an additional one hour before and one hour after the building opens and closes).

Table 1 - Fan Operating Hours

Operating Hours	Fan Hours per year
Large Retail	4,888
Large Office	3,432
Hotel	8,760
Hospital	8,760
Secondary School	2,911

[5] Choose the closest CZ, building type, horsepower size, and building vintage in the lookup tables.

The key assumptions that impact the savings are described below.

VAV systems:

1. The supply fan is located downstream of the central heating/cooling coils and draws the air through the coils, unless heat is provided by a furnace in which case the supply fan is located upstream of the central heating/cooling coils and blows the air through the coils.
2. The fan motor placement is within the air stream.
3. Air flow control with a variable speed drive.

CAV systems:

1. The supply fan is located upstream of the central heating/cooling coils and blows the air through the coils.
2. The fan motor placement is within the air stream.
3. No air flow control.

Assumptions related to the number of reduced operating hours and the total efficiency of the supply fan and motor as well as the mechanical efficiency of the supply fan for the two vintages are listed in the table below:

Table 2 - Operating Hour & Efficiency Assumptions		1978-1992		>2005	
Building and HVAC System Type	Annual Reduced Operating Hours	Total Eff.	Mechanical Eff.	Total Eff.	Mechanical Eff.
Large Office CHW VAV	5,328	0.58	0.72	0.63	0.72
Large Office CHW CAV	5,328	0.5	0.62	0.5	0.62
Large Office Packaged Unit VAV	5,328	0.51	0.62	0.53	0.62
Large Office Packaged Unit CAV	5,328	0.5	0.55	0.53	0.55
Education Primary/Secondary School Packaged Unit CAV	3528	0.5	0.55	0.53	0.55
Education Secondary School CHW VAV	3312	0.58	0.72	0.63	0.72
Education University/Community College CHW VAV	3256	0.605	0.72	0.63	0.72
Large Retail CHW VAV	3872	0.62	0.72	0.63	0.72
Large Retail Packaged Unit VAV	3872	0.51	0.62	0.53	0.62
Large Retail Packaged Unit CAV	3872	0.49	0.55	0.53	0.55
Large Retail Single Story Packaged Unit CAV	3300	0.53	0.55	0.53	0.55
Hotel CHW VAV	2208	0.624	0.72	0.63	0.72
Hotel Packaged Unit VAV	2208	0.53	0.62	0.53	0.62
Hotel Packaged Unit CAV	2208	0.519	0.55	0.53	0.55

The annual reduced operating hours were determined from the schedules defined within the DEER (2005) prototype buildings and were used to determine the normalized electric and gas savings. The fan motor horsepower breakpoint listed in the following tables, along with the annual reduced hours listed in the table above, define the fan motor size limit for Tier 1.

Sample Calculation

Baseline: Large Office in CZ06, 1978-1992 Vintage, CHW VAV System, 40HP Supply Fan Motor, Operates 5,000 hours/yr.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 346 HP (move to Step 2)

Step 2 – Lookup kWh/HP/hr$_{reduced}$ Savings Factor in Table and Calculate Savings:

40 HP x 0.0407 kWh/HP/hr$_{reduced}$ x (5,000 - 3,432) hours$_{reduced}$ = 2,553 kWh/yr

Step 3 – Lookup kW/HP Savings Factor in Table and Calculate Savings:

There are no kW Savings

Step 4 – Lookup therms/HP/hr$_{reduced}$ Savings Factor in Table and Calculate Savings:

40 HP x 0.0185 kWh/HP/hr$_{reduced}$ x (5,000 - 3,432) hours$_{reduced}$ = 1,160 therms/yr

Pre-Calculated Fan Motor Horsepower Breakpoint, Electric and Natural Gas Energy Savings

Savings factors were calculated for the building types described above and their respective HVAC systems for each Climate Zone, and are presented in the tables that follow.

To determine the savings in kWh and therms per year, multiply the factors in these tables by the nameplate horsepower rating of the supply fan motor and the number of hours of reduced fan operation per year.

The natural gas savings are based on the savings associated with space heating for each building.

The equipment breakpoint supply fan horsepower is based on 75,000 kWh of electrical energy savings and the hours of reduced operation for each building prototype. Please note that blank spaces indicate negative values.

Table 3. Climate Zone 6 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0407	0.0185	346
Large Office CHW CAV	0.7535	-	19
Large Office Packaged Unit VAV	0.0558	0.0128	252
Large Office Packaged Unit CAV	0.6208	-	23
Education Primary/Secondary School Packaged Unit CAV	0.7171	0.0167	30
Education Secondary School CHW VAV	0.0427	0.0157	531
Education University/Community College CHW VAV	0.0249	0.0156	926
Large Retail CHW VAV	0.0009	0.0129	21687
Large Retail Packaged Unit VAV	-	0.0123	-
Large Retail Packaged Unit CAV	0.6707	-	29
Large Retail Single Story Packaged Unit CAV	0.6343	0.0594	36
Hotel CHW VAV	0.0272	0.0318	1249
Hotel Packaged Unit VAV	0.0176	0.0176	1935
Hotel Packaged Unit CAV	0.5258	0.0114	65

Table 4. Climate Zone 8 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0402	0.0188	350
Large Office CHW CAV	0.7535	0.0000	19
Large Office Packaged Unit VAV	0.0557	0.0131	253
Large Office Packaged Unit CAV	0.6092	-	23
Education Primary/Secondary School Packaged Unit CAV	0.6841	0.0160	31
Education Secondary School CHW VAV	0.0350	0.0153	647
Education University/Community College CHW VAV	0.0155	0.0139	1486
Large Retail CHW VAV	-	0.0105	-
Large Retail Packaged Unit VAV	-	0.0101	-
Large Retail Packaged Unit CAV	0.6206	-	29
Large Retail Single Story Packaged Unit CAV	0.6163	0.0557	37
Hotel CHW VAV	0.0273	0.0421	1244
Hotel Packaged Unit VAV	0.0347	0.0196	978
Hotel Packaged Unit CAV	0.5203	0.0106	65

Table 5. Climate Zone 9 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0443	0.0196	318
Large Office CHW CAV	0.7535	-	19
Large Office Packaged Unit VAV	0.0559	0.0134	252
Large Office Packaged Unit CAV	0.6038	-	23
Education Primary/Secondary School Packaged Unit CAV	0.6824	0.0151	31
Education Secondary School CHW VAV	0.0520	0.0157	435
Education University/Community College CHW VAV	0.0232	0.0151	993
Large Retail CHW VAV	0.0048	0.0104	3730
Large Retail Packaged Unit VAV	-	0.0098	-
Large Retail Packaged Unit CAV	0.6207	-	29
Large Retail Single Story Packaged Unit CAV	0.6163	0.0582	37
Hotel CHW VAV	0.0284	0.0461	1197
Hotel Packaged Unit VAV	0.0356	0.0200	955
Hotel Packaged Unit CAV	0.5194	0.0110	65

Table 6. Climate Zone 10 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0448	0.0198	314
Large Office CHW CAV	0.7535	0.0004	19
Large Office Packaged Unit VAV	0.0527	0.0134	267
Large Office Packaged Unit CAV	0.5883	-	24
Education Primary/Secondary School Packaged Unit CAV	0.6712	0.0185	32
Education Secondary School CHW VAV	0.0407	0.0159	556
Education University/Community College CHW VAV	0.0199	0.0138	1159
Large Retail CHW VAV	-	0.0111	-
Large Retail Packaged Unit VAV	-	0.0107	-
Large Retail Packaged Unit CAV	0.6197	-	29
Large Retail Single Story Packaged Unit CAV	0.6162	0.0719	37
Hotel CHW VAV	0.0265	0.0481	1284
Hotel Packaged Unit VAV	0.0356	0.0215	954
Hotel Packaged Unit CAV	0.5248	0.0139	65

Table 7. Climate Zone 13 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0419	0.0184	336
Large Office CHW CAV	0.7535	0.0006	19
Large Office Packaged Unit VAV	0.0454	0.0114	310
Large Office Packaged Unit CAV	0.5590	-	25
Education Primary/Secondary School Packaged Unit CAV	0.6360	0.0158	33
Education Secondary School CHW VAV	0.0423	0.0177	535
Education University/Community College CHW VAV	0.0194	0.0135	1185
Large Retail CHW VAV	-	0.0114	-
Large Retail Packaged Unit VAV	-	0.0112	-
Large Retail Packaged Unit CAV	0.6198	-	29
Large Retail Single Story Packaged Unit CAV	0.6162	0.0779	37
Hotel CHW VAV	0.0270	0.0588	1257
Hotel Packaged Unit VAV	0.0422	0.0256	805
Hotel Packaged Unit CAV	0.5160	0.0143	66

Table 8. Climate Zone 14 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0393	0.0170	358
Large Office CHW CAV	0.7534	0.0021	19
Large Office Packaged Unit VAV	0.0399	0.0105	353
Large Office Packaged Unit CAV	0.5481	-	26
Education Primary/Secondary School Packaged Unit CAV	0.6058	0.0170	35
Education Secondary School CHW VAV	0.0424	0.0165	534
Education University/Community College CHW VAV	0.0237	0.0147	974
Large Retail CHW VAV	-	0.0130	-
Large Retail Packaged Unit VAV	-	0.0130	-
Large Retail Packaged Unit CAV	0.6205	-	29
Large Retail Single Story Packaged Unit CAV	0.6162	0.1139	37
Hotel CHW VAV	0.0241	0.0572	1411
Hotel Packaged Unit VAV	0.0724	0.0425	469
Hotel Packaged Unit CAV	0.5268	0.0210	64

Table 9. Climate Zone 15 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0381	0.0177	369
Large Office CHW CAV	0.7535	0.0003	19
Large Office Packaged Unit VAV	0.0457	0.0120	308
Large Office Packaged Unit CAV	0.5136	-	27
Education Primary/Secondary School Packaged Unit CAV	0.6310	0.0111	34
Education Secondary School CHW VAV	0.0269	0.0119	841
Education University/Community College CHW VAV	0.0052	0.0107	4428
Large Retail CHW VAV	-	0.0089	-
Large Retail Packaged Unit VAV	-	0.0089	-
Large Retail Packaged Unit CAV	0.6168	-	29
Large Retail Single Story Packaged Unit CAV	0.6163	0.0400	37
Hotel CHW VAV	0.0246	0.0666	1379
Hotel Packaged Unit VAV	0.0313	0.0217	1084
Hotel Packaged Unit CAV	0.4920	0.0088	69

Table 10. Climate Zone 16 - 1978-1992 Vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0429	0.0161	328
Large Office CHW CAV	0.7535	0.0057	19
Large Office Packaged Unit VAV	0.0375	0.0101	375
Large Office Packaged Unit CAV	0.5432	-	26
Education Primary/Secondary School Packaged Unit CAV	0.5095	0.0189	42
Education Secondary School CHW VAV	0.0489	0.0173	463
Education University/Community College CHW VAV	0.0425	0.0190	542
Large Retail CHW VAV	0.0326	0.0192	550
Large Retail Packaged Unit VAV	0.0287	0.0188	625
Large Retail Packaged Unit CAV	0.6198	-	29
Large Retail Single Story Packaged Unit CAV	0.6163	0.1983	37
Hotel CHW VAV	0.0307	0.0465	1105
Hotel Packaged Unit VAV	0.1464	0.0744	232
Hotel Packaged Unit CAV	0.5653	0.0411	60

Table 11. Climate Zone 6 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0545	0.0186	258
Large Office CHW CAV	0.7535	0.0004	19
Large Office Packaged Unit VAV	0.0535	0.0102	263
Large Office Packaged Unit CAV	0.6250	-	23
Education Primary/Secondary School Packaged Unit CAV	0.6883	0.0177	31
Education Secondary School CHW VAV	0.0621	0.0141	365
Education University/Community College CHW VAV	0.0433	0.0116	532
Large Retail CHW VAV	0.0293	0.0086	662
Large Retail Packaged Unit VAV	0.0333	0.0076	581
Large Retail Packaged Unit CAV	0.6707	-	29
Large Retail Single Story Packaged Unit CAV	0.6162	-	37
Hotel CHW VAV	0.1095	0.0227	310
Hotel Packaged Unit VAV	0.0178	0.0178	1905
Hotel Packaged Unit CAV	0.5729	0.0181	59

Table 12. Climate Zone 8 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0487	0.0168	289
Large Office CHW CAV	0.7535	0.0008	19
Large Office Packaged Unit VAV	0.0501	0.0097	281
Large Office Packaged Unit CAV	0.5802	-	24
Education Primary/Secondary School Packaged Unit CAV	0.6364	0.0163	33
Education Secondary School CHW VAV	0.0461	0.0110	491
Education University/Community College CHW VAV	0.0361	0.0104	639
Large Retail CHW VAV	0.0235	0.0076	825
Large Retail Packaged Unit VAV	0.0246	0.0066	787
Large Retail Packaged Unit CAV	0.6200	-	31
Large Retail Single Story Packaged Unit CAV	0.6161	-	37
Hotel CHW VAV	0.1057	0.0294	321
Hotel Packaged Unit VAV	0.0202	0.0202	1680
Hotel Packaged Unit CAV	0.5535	0.0173	61

Table 13. Climate Zone 9 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0508	0.0176	277
Large Office CHW CAV	0.7535	0.0006	19
Large Office Packaged Unit VAV	0.0511	0.0104	275
Large Office Packaged Unit CAV	0.5775	-	24
Education Primary/Secondary School Packaged Unit CAV	0.6523	0.0158	33
Education Secondary School CHW VAV	0.0535	0.0064	424
Education University/Community College CHW VAV	0.0384	0.0113	600
Large Retail CHW VAV	0.0226	0.0077	858
Large Retail Packaged Unit VAV	0.0234	0.0066	827
Large Retail Packaged Unit CAV	0.6200	-	31
Large Retail Single Story Packaged Unit CAV	0.6162	-	37
Hotel CHW VAV	0.1051	0.0322	323
Hotel Packaged Unit VAV	0.0208	0.0208	1635
Hotel Packaged Unit CAV	0.5499	0.0171	62

Table 14. Climate Zone 10 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0502	0.0181	280
Large Office CHW CAV	0.7535	0.0015	19
Large Office Packaged Unit VAV	0.0489	0.0105	288
Large Office Packaged Unit CAV	0.5627	-	25
Education Primary/Secondary School Packaged Unit CAV	0.6199	0.0184	34
Education Secondary School CHW VAV	0.0527	0.0132	430
Education University/Community College CHW VAV	0.0377	0.0104	611
Large Retail CHW VAV	0.0217	0.0089	893
Large Retail Packaged Unit VAV	0.0234	0.0076	828
Large Retail Packaged Unit CAV	0.6200	-	31
Large Retail Single Story Packaged Unit CAV	0.6157	-	37
Hotel CHW VAV	0.1045	0.0359	325
Hotel Packaged Unit VAV	0.0236	0.0236	1442
Hotel Packaged Unit CAV	0.5474	0.0216	62

Table 15. Climate Zone 13 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0448	0.0160	314
Large Office CHW CAV	0.7535	0.0022	19
Large Office Packaged Unit VAV	0.0428	0.0092	329
Large Office Packaged Unit CAV	0.5294	-	27
Education Primary/Secondary School Packaged Unit CAV	0.5816	0.0153	37
Education Secondary School CHW VAV	0.0503	0.0148	450
Education University/Community College CHW VAV	0.0347	0.0109	665
Large Retail CHW VAV	0.0173	0.0112	1117
Large Retail Packaged Unit VAV	0.0158	0.0095	1226
Large Retail Packaged Unit CAV	0.6193	-	31
Large Retail Single Story Packaged Unit CAV	0.6125	-	37
Hotel CHW VAV	0.1106	0.0469	307
Hotel Packaged Unit VAV	0.0290	0.0290	1171
Hotel Packaged Unit CAV	0.5325	0.0224	64

Table 16. Climate Zone 14 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0426	0.0153	331
Large Office CHW CAV	0.7535	0.0047	19
Large Office Packaged Unit VAV	0.0384	0.0086	366
Large Office Packaged Unit CAV	0.5185	-	27
Education Primary/Secondary School Packaged Unit CAV	0.5489	0.0147	39
Education Secondary School CHW VAV	0.0505	0.0144	448
Education University/Community College CHW VAV	0.0383	0.0119	601
Large Retail CHW VAV	0.0249	0.0128	779
Large Retail Packaged Unit VAV	0.0249	0.0109	776
Large Retail Packaged Unit CAV	0.6195	-	31
Large Retail Single Story Packaged Unit CAV	0.6028	-	38
Hotel CHW VAV	0.1120	0.0510	303
Hotel Packaged Unit VAV	0.0345	0.0345	986
Hotel Packaged Unit CAV	0.5391	0.0318	63

Table 17. Climate Zone 15 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0421	0.0141	334
Large Office CHW CAV	0.7535	0.0008	19
Large Office Packaged Unit VAV	0.0427	0.0087	330
Large Office Packaged Unit CAV	0.4977	-	28
Education Primary/Secondary School Packaged Unit CAV	0.5743	0.0113	37
Education Secondary School CHW VAV	0.0382	0.0093	593
Education University/Community College CHW VAV	0.0228	0.0065	1010
Large Retail CHW VAV	-	0.0070	-1163
Large Retail Packaged Unit VAV	0.0004	0.0059	54820
Large Retail Packaged Unit CAV	0.6133	-	32
Large Retail Single Story Packaged Unit CAV	0.6004	-	38
Hotel CHW VAV	0.0977	0.0463	348
Hotel Packaged Unit VAV	0.0241	0.0241	1407
Hotel Packaged Unit CAV	0.5072	0.0135	67

Table 18. Climate Zone 16 - Post 2005 vintage			
Building and HVAC System Type	**Normalized Electrical Savings (kWh/hp-hr)**	**Normalized Gas Savings (Therms/hp-hr)**	**Equipment Breakpoint (Fan hp)**
Large Office CHW VAV	0.0428	0.0158	329
Large Office CHW CAV	0.7535	0.0108	19
Large Office Packaged Unit VAV	0.0363	0.0089	387
Large Office Packaged Unit CAV	0.4963	-	28
Education Primary/Secondary School Packaged Unit CAV	0.4582	0.0157	46
Education Secondary School CHW VAV	0.0525	0.0168	431
Education University/Community College CHW VAV	0.0507	0.0179	454
Large Retail CHW VAV	0.0516	0.0205	375
Large Retail Packaged Unit VAV	0.0489	0.0167	396
Large Retail Packaged Unit CAV	0.6176	-	31
Large Retail Single Story Packaged Unit CAV	0.5748	-	40
Hotel CHW VAV	0.1274	0.0557	267
Hotel Packaged Unit VAV	0.0454	0.0454	748
Hotel Packaged Unit CAV	0.5743	0.0608	59

Pre-Calculated Electric Demand Savings

The results indicated that there were no demand savings to be gained from supply fan rescheduling.

REDUCE DUCT STATIC PRESSURE SET POINT

Measure Description

This measure, "Reduce Duct Static Pressure Set Point," addresses instances where the static pressure in a VAV HVAC system is set higher than required.

This can be due to a malfunctioning static pressure sensor, duct leaks, design flaws such as a static pressure sensor not placed in the system correctly, or setpoints that are set higher than necessary. This results in increased energy consumption by the supply fans in the HVAC system. This measure refers addressing the cause and then a one-time event of reducing the static pressure set point.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and fan motor rated horsepower.
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable fan motor horsepower size limit using the CZ, type of building, and building vintage.[6] Fan motors that are equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Fan motors that are larger than the allowable horsepower size limit are *not* eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.
4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, building vintage, and level of static pressure setpoint reduction. Then multiply the factor times the fan motor horsepower rating. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of building, building vintage, and level of static pressure setpoint reduction. Then multiply the factor times the fan motor horsepower rating. The product will be the estimated electric demand savings.

Relevant Modeling Assumptions

The pre-calculated savings factors were generated with the following major assumptions:

- Generic fan performance curves
- Generic motor and VSD efficiency curves (see Global Modeling Assumptions above)
- VAV with VFD
- Table 1 represents the operating hours of the building's supply fans. For modeling purposes, fan operating hours are assumed to be +2 hours per day beyond occupancy hours (fans operate an additional one hour before and one hour after the building opens and closes).

[6] Choose closest CZ, building type, horsepower size, and building vintage in the lookup tables.

Table 1 - Fan Operating Hours

Operating Hours	Fan Hours per year
Large Retail	4,888
Large Office	3,432
Hotel	8,760
Hospital	8,760
Secondary School	2,911

- The motor nameplate value was estimated as: Fan motor nameplate HP = Fan design BHP/0.8
- The maximum efficiency point of the fan is 74%
- The project fan design efficiency is 70%
- The air system design static pressure is 4.5 in. H_2O

Note:
The "maximum efficiency point of the fan" refers to the maximum efficiency of the fan from the fan curve.
The "project fan design efficiency" refers to the efficiency of the fan at the design flow.
The "building design static pressure" refers to the supply fan static pressure drop at the design flow.

Sample Calculation

Baseline: Office Building in CZ06, Post 2005 Vintage, 50HP Supply Fan Motor, DSP Reduction of 0.5 in. H_2O.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 507 HP (move to Step 2)

Step 2 – Lookup kWh/HP/hr Savings Factor in Table and Calculate Savings:

50 HP x 148 kWh/HP = 7,400 kWh/yr

Step 3 – Lookup kW/HP Savings Factor in Table and Calculate Savings:

50 HP x 0.0434 kW/HP = 2.2 kW

Allowable Fan Motor Horsepower

The tables below show the maximum supply fan nameplate horsepower a measure can have in order to use the pre-calculated savings tables.

For example, if the supply fan motor nameplate is 100 HP, and we apply a reduction of 1.0 in. H_2O in a Hospital (post-2005 vintage) located in Climate Zone 6, then the pre-calculated savings tables could not be used because the maximum horsepower for this project in the table below is 92 horsepower. For this example, custom calculations would be required.

Post-2005 Vintage:

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ6)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2935	1336	865	639	507	420	359	313	278	249
Large Retail	2693	1197	769	567	449	371	317	276	245	220
Education Campus	4270	1837	1171	859	678	560	477	416	368	331
Hospital	974	472	311	232	185	154	132	115	102	92
Hotel	1903	815	518	380	300	248	211	184	163	146

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ8)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3083	1378	887	654	518	429	366	319	283	254
Large Retail	2667	1197	772	569	451	373	319	278	246	221
Education Campus	4772	2018	1279	936	739	610	519	452	400	359
Hospital	984	478	315	235	188	156	134	117	104	93
Hotel	1797	777	496	364	288	238	203	176	156	140

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ9)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3115	1406	908	670	531	440	376	328	291	261
Large Retail	2786	1245	802	591	468	388	331	288	256	230
Education Campus	4312	1828	1160	849	670	553	471	410	363	326
Hospital	993	482	318	237	189	158	135	118	105	94
Hotel	1935	846	541	398	314	260	222	193	171	154

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ10)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3020	1358	876	647	512	424	362	316	280	251
Large Retail	2839	1272	819	604	479	396	338	295	261	235
Education Campus	4088	1733	1100	805	635	525	447	389	344	309
Hospital	1011	488	321	240	191	159	136	119	105	95
Hotel	1919	838	536	394	311	257	219	191	169	152

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ13)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2891	1300	839	619	491	406	347	302	268	241
Large Retail	3254	1423	911	670	530	438	373	325	288	259
Education Campus	3673	1529	965	705	556	458	390	340	301	270
Hospital	1032	494	325	242	193	160	137	120	106	95
Hotel	1998	870	556	408	323	267	227	198	176	158

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ14)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2970	1301	833	613	484	401	341	298	264	237
Large Retail	3255	1428	915	673	532	440	375	327	290	260
Education Campus	4035	1657	1042	760	598	493	420	365	323	290
Hospital	1068	501	328	243	194	161	137	120	106	96
Hotel	1963	842	536	393	310	256	219	190	169	151

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ15)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2708	1227	793	586	464	385	328	286	254	228
Large Retail	2732	1229	793	585	464	384	328	286	253	228
Education Campus	3446	1441	911	666	525	433	368	321	284	255
Hospital	1024	492	324	241	192	160	137	119	106	95
Hotel	1717	759	487	359	284	235	200	175	155	139

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ16)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3171	1353	860	630	497	411	350	305	270	242
Large Retail	3842	1640	1043	764	603	498	424	369	327	294
Education Campus	4508	1837	1153	841	661	545	463	403	357	320
Hospital	1087	509	333	247	196	163	139	122	108	97
Hotel	2209	941	598	438	346	286	243	212	188	168

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

1978-1992 Vintage:

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ6)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3010	1351	871	643	509	422	360	314	278	250
Large Retail	2639	1191	769	568	450	373	318	277	246	221
Education Campus	4495	1924	1224	897	708	585	498	434	384	345
Hospital (CV)	955	439	285	211	167	139	118	103	92	82
Hospital (VAV)	976	473	312	233	186	154	132	115	103	92
Hotel	1578	713	461	340	270	223	191	166	147	132

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ8)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3029	1354	872	643	509	422	360	314	278	250
Large Retail	2731	1219	785	579	458	379	324	282	250	225
Education Campus	4455	1897	1205	883	697	576	490	427	378	339
Hospital (CV)	955	439	285	211	167	139	118	103	92	82
Hospital (VAV)	983	477	315	235	188	156	134	117	104	93
Hotel	1667	744	479	353	279	231	197	172	152	137

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ9)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3237	1439	925	682	540	447	381	332	294	264
Large Retail	2836	1269	817	603	477	395	337	294	261	234
Education Campus	4486	1900	1206	883	696	575	490	426	377	339
Hospital (CV)	955	439	285	211	167	139	118	103	92	82
Hospital (VAV)	992	481	318	237	189	157	135	118	104	94
Hotel	1661	740	476	351	278	230	196	171	152	136

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ10)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3081	1373	883	651	516	427	364	317	281	253
Large Retail	2850	1276	822	606	480	397	339	296	262	235
Education Campus	4359	1827	1156	845	666	550	468	407	361	323
Hospital (CV)	954	438	285	211	167	139	118	103	92	82
Hospital (VAV)	984	479	317	236	189	157	134	117	104	94
Hotel	1656	737	474	349	277	229	195	170	151	136

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ13)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	3050	1344	862	635	502	415	354	309	274	246
Large Retail	2981	1327	853	629	498	412	351	306	272	244
Education Campus	3828	1604	1014	742	585	482	411	357	316	284
Hospital (CV)	954	438	285	211	167	139	118	103	92	82
Hospital (VAV)	1027	487	320	238	189	157	134	117	104	94
Hotel	1745	770	494	363	288	238	203	177	157	141

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ14)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2828	1237	792	582	460	381	324	283	251	225
Large Retail	3077	1367	879	647	513	424	362	315	280	251
Education Campus	4080	1685	1062	775	610	503	428	373	330	296
Hospital (CV)	955	439	285	211	167	139	119	103	92	82
Hospital (VAV)	1022	488	321	239	190	158	135	118	105	94
Hotel	1694	749	481	354	280	232	198	172	153	137

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ15)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2752	1240	800	591	468	388	331	289	256	230
Large Retail	2570	1170	757	560	444	368	314	274	243	218
Education Campus	3367	1414	895	654	516	426	362	316	279	251
Hospital (CV)	955	439	285	211	167	139	118	103	92	82
Hospital (VAV)	1005	482	317	236	188	156	134	117	104	93
Hotel	1587	707	455	336	266	220	188	164	145	130

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Reduce Static Pressure RCx Pre-Calculated Savings Maximum Motor Horsepower (CZ16)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	2859	1238	790	580	458	379	323	281	249	224
Large Retail	3818	1624	1031	756	596	492	419	365	323	290
Education Campus	4448	1805	1132	825	648	534	454	395	350	314
Hospital (CV)	954	438	284	211	167	139	118	103	92	82
Hospital (VAV)	1002	485	320	239	190	158	136	119	105	95
Hotel	1887	827	530	390	308	255	217	189	168	151

Note: The fan motor nameplate horsepower must be less then the value in this table to have an energy savings estimate under 75,000 kWh

Pre-Calculated Electric Energy Savings Table

Savings factors were calculated and are presented in the tables below for the building types and climate zones described earlier, with a VAV HVAC system. The savings were normalized based on the nameplate horsepower rating of the supply fans.

The columns represent a static pressure reduction in increments of 0.1 in. H_2O. Interpolation between the points is permitted. If a reduction of greater than 1.0 in. H_2O is planned, then custom calculations should be conducted.

Post-2005 Vintage:

Reduce Static Pressure RCx Pre-Calculated Savings (CZ6)

		Static Pressure Reduction (in. H2O)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Building Type	Large Office	26	56	87	117	148	178	209	240	270	301
	Large Retail	28	63	98	132	167	202	237	272	306	341
	Education Campus	18	41	64	87	111	134	157	180	204	227
	Hospital	77	159	241	323	405	487	569	650	732	814
	Hotel	39	92	145	197	250	303	355	408	460	513

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ8)

		Static Pressure Reduction (in. H2O)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Building Type	Large Office	24	54	85	115	145	175	205	235	265	295
	Large Retail	28	63	97	132	166	201	235	270	304	339
	Education Campus	16	37	59	80	102	123	144	166	187	209
	Hospital	76	157	238	319	399	480	561	642	722	803
	Hotel	42	96	151	206	261	316	370	425	480	535

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ9)

		Static Pressure Reduction (in. H2O)									
		0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Building Type	Large Office	24	53	83	112	141	170	200	229	258	287
	Large Retail	27	60	94	127	160	193	227	260	293	327
	Education Campus	17	41	65	88	112	136	159	183	207	230
	Hospital	76	156	236	316	396	476	556	636	717	797
	Hotel	39	89	139	189	239	289	338	388	438	488

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ10)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	25	55	86	116	146	177	207	238	268	298
Large Retail	26	59	92	124	157	189	222	254	287	320
Education Campus	18	43	68	93	118	143	168	193	218	243
Hospital	74	154	233	313	393	472	552	631	711	791
Hotel	39	90	140	190	241	291	342	392	443	493

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ13)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	26	58	89	121	153	185	216	248	280	312
Large Retail	23	53	82	112	142	171	201	231	260	290
Education Campus	20	49	78	106	135	164	192	221	249	278
Hospital	73	152	231	310	389	469	548	627	706	786
Hotel	38	86	135	184	232	281	330	378	427	476

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ14)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	25	58	90	122	155	187	220	252	284	317
Large Retail	23	53	82	111	141	170	200	229	259	288
Education Campus	19	45	72	99	125	152	179	205	232	259
Hospital	70	150	229	308	388	467	546	626	705	784
Hotel	38	89	140	191	242	292	343	394	445	496

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ15)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	28	61	95	128	161	195	228	262	295	329
Large Retail	27	61	95	128	162	195	229	262	296	330
Education Campus	22	52	82	113	143	173	204	234	264	294
Hospital	73	152	232	311	390	470	549	628	707	787
Hotel	44	99	154	209	264	319	374	429	485	540

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ16)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	24	55	87	119	151	183	214	246	278	310
Large Retail	20	46	72	98	124	151	177	203	229	255
Education Campus	17	41	65	89	113	138	162	186	210	234
Hospital	69	147	225	304	382	460	538	617	695	773
Hotel	34	80	125	171	217	263	308	354	400	446

Note: Savings are in kWh/fan motor nameplate HP

1978-1992 Vintage:

Reduce Static Pressure RCx Pre-Calculated Savings (CZ6)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	25	56	86	117	147	178	209	239	270	300
Large Retail	28	63	98	132	167	201	236	270	305	340
Education Campus	17	39	61	84	106	128	151	173	195	217
Hospital (CV)	79	171	263	356	448	541	633	725	818	910
Hospital (VAV)	77	159	240	322	404	486	568	650	731	813
Hotel	48	105	163	220	278	336	393	451	509	566

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ8)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	25	55	86	117	147	178	209	239	270	300
Large Retail	27	62	96	130	164	198	232	266	300	334
Education Campus	17	40	62	85	108	130	153	176	198	221
Hospital (CV)	79	171	263	356	448	541	633	725	818	910
Hospital (VAV)	76	157	238	319	400	480	561	642	723	804
Hotel	45	101	157	213	268	324	380	436	492	548

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ9)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	23	52	81	110	139	168	197	226	255	284
Large Retail	26	59	92	124	157	190	222	255	288	320
Education Campus	17	39	62	85	108	130	153	176	199	221
Hospital (CV)	79	171	263	356	448	541	633	726	818	911
Hospital (VAV)	76	156	236	316	397	477	557	638	718	798
Hotel	45	101	158	214	270	326	382	439	495	551

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ10)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	24	55	85	115	145	176	206	236	267	297
Large Retail	26	59	91	124	156	189	221	254	286	319
Education Campus	17	41	65	89	113	136	160	184	208	232
Hospital (CV)	79	171	264	356	448	541	633	726	818	911
Hospital (VAV)	76	157	237	317	398	478	558	639	719	800
Hotel	45	102	158	215	271	328	384	441	497	553

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ13)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	25	56	87	118	149	181	212	243	274	305
Large Retail	25	57	88	119	151	182	213	245	276	308
Education Campus	20	47	74	101	128	155	183	210	237	264
Hospital (CV)	79	171	264	356	448	541	633	726	818	911
Hospital (VAV)	73	154	235	316	396	477	558	639	720	801
Hotel	43	97	152	206	261	315	370	424	479	533

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ14)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	27	61	95	129	163	197	231	265	299	334
Large Retail	24	55	85	116	146	177	207	238	268	299
Education Campus	18	45	71	97	123	149	175	201	227	254
Hospital (CV)	79	171	263	356	448	540	633	725	818	910
Hospital (VAV)	73	154	234	314	394	474	555	635	715	795
Hotel	44	100	156	212	268	324	380	436	492	547

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ15)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	27	60	94	127	160	193	227	260	293	326
Large Retail	29	64	99	134	169	204	239	274	309	344
Education Campus	22	53	84	115	145	176	207	238	268	299
Hospital (CV)	79	171	263	356	448	541	633	726	818	911
Hospital (VAV)	75	156	237	318	399	480	561	642	723	804
Hotel	47	106	165	224	282	341	400	459	517	576

Note: Savings are in kWh/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated Savings (CZ16)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	26	61	95	129	164	198	232	267	301	336
Large Retail	20	46	73	99	126	152	179	205	232	258
Education Campus	17	42	66	91	116	140	165	190	214	239
Hospital (CV)	79	171	264	356	449	541	634	726	819	911
Hospital (VAV)	75	155	234	314	394	473	553	633	713	792
Hotel	40	91	142	192	243	294	345	396	447	498

Note: Savings are in kWh/fan motor nameplate HP

The savings calculations tables were designed to allow for the application of two different measures. For instance, if a static pressure reset is also proposed, then the Pre-Calculated Savings Static Pressure Reduction Tables (above) would be used to calculate the savings from the baseline static pressure set point to the maximum set point of the proposed reset schedule, then the savings from the Static Pressure Reset would be calculated from the Pre-Calculated Saving Tables for Duct Static Pressure Reset (described later). The two values are added together.

Pre-Calculated Demand Savings Table

Demand savings factors were calculated and are presented in the tables below for the building types and climate zones described earlier, with a VAV HVAC system. The demand savings were normalized based on the nameplate horsepower rating of the supply fans.

Post-2005 Vintage:

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ6)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0079	0.0168	0.0257	0.0345	0.0434	0.0529	0.0623	0.0718	0.0812	0.0907
Large Retail	0.0076	0.0162	0.0248	0.0334	0.0420	0.0513	0.0605	0.0698	0.0791	0.0884
Education Campus	0.0053	0.0073	0.0092	0.0111	0.0131	0.0176	0.0222	0.0267	0.0312	0.0358
Hospital	0.0089	0.0188	0.0286	0.0385	0.0484	0.0583	0.0682	0.0781	0.0880	0.0979
Hotel	0.0073	0.0156	0.0239	0.0322	0.0404	0.0495	0.0586	0.0677	0.0767	0.0858

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ8)

Building Type	Static Pressure Reduction (in. H2O) 0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0088	0.0185	0.0283	0.0380	0.0478	0.0577	0.0675	0.0774	0.0873	0.0971
Large Retail	0.0081	0.0172	0.0263	0.0354	0.0445	0.0541	0.0637	0.0732	0.0828	0.0924
Education Campus	0.0116	0.0227	0.0339	0.0450	0.0561	0.0616	0.0670	0.0725	0.0779	0.0834
Hospital	0.0089	0.0188	0.0287	0.0386	0.0485	0.0585	0.0684	0.0783	0.0882	0.0981
Hotel	0.0086	0.0182	0.0278	0.0374	0.0470	0.0568	0.0666	0.0763	0.0861	0.0959

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ9)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0081	0.0173	0.0264	0.0355	0.0446	0.0542	0.0638	0.0734	0.0829	0.0925
	Large Retail	0.0078	0.0165	0.0253	0.0341	0.0428	0.0522	0.0616	0.0709	0.0803	0.0897
	Education Campus	0.0066	0.0091	0.0117	0.0142	0.0168	0.0218	0.0268	0.0319	0.0369	0.0420
	Hospital	0.0088	0.0186	0.0284	0.0383	0.0481	0.0580	0.0678	0.0777	0.0876	0.0975
	Hotel	0.0088	0.0187	0.0285	0.0383	0.0482	0.0581	0.0679	0.0778	0.0877	0.0976

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ10)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0083	0.0176	0.0269	0.0362	0.0455	0.0552	0.0648	0.0745	0.0841	0.0938
	Large Retail	0.0084	0.0178	0.0272	0.0365	0.0459	0.0556	0.0653	0.0750	0.0847	0.0944
	Education Campus	0.0076	0.0108	0.0139	0.0171	0.0202	0.0257	0.0311	0.0365	0.0419	0.0473
	Hospital	0.0089	0.0188	0.0287	0.0386	0.0485	0.0584	0.0684	0.0783	0.0882	0.0981
	Hotel	0.0085	0.0180	0.0275	0.0370	0.0465	0.0563	0.0660	0.0758	0.0856	0.0953

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ13)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0088	0.0186	0.0284	0.0382	0.0480	0.0578	0.0677	0.0776	0.0874	0.0973
	Large Retail	0.0078	0.0166	0.0254	0.0342	0.0430	0.0524	0.0619	0.0713	0.0807	0.0901
	Education Campus	0.0088	0.0127	0.0167	0.0206	0.0245	0.0303	0.0360	0.0418	0.0476	0.0533
	Hospital	0.0089	0.0188	0.0287	0.0385	0.0484	0.0583	0.0682	0.0782	0.0881	0.0980
	Hotel	0.0089	0.0187	0.0286	0.0385	0.0484	0.0582	0.0681	0.0780	0.0879	0.0978

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ14)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0085	0.0179	0.0274	0.0368	0.0463	0.0560	0.0658	0.0755	0.0852	0.0950
	Large Retail	0.0082	0.0174	0.0265	0.0357	0.0449	0.0545	0.0641	0.0737	0.0833	0.0929
	Education Campus	0.0072	0.0102	0.0131	0.0160	0.0189	0.0242	0.0295	0.0347	0.0400	0.0453
	Hospital	0.0089	0.0187	0.0286	0.0385	0.0484	0.0583	0.0682	0.0780	0.0879	0.0978
	Hotel	0.0086	0.0182	0.0279	0.0375	0.0471	0.0569	0.0667	0.0765	0.0863	0.0961

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ15)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0085	0.0180	0.0274	0.0369	0.0464	0.0561	0.0659	0.0756	0.0854	0.0951
Large Retail	0.0079	0.0167	0.0256	0.0345	0.0433	0.0528	0.0622	0.0716	0.0811	0.0905
Education Campus	0.0073	0.0102	0.0131	0.0161	0.0190	0.0243	0.0296	0.0349	0.0402	0.0454
Hospital	0.0089	0.0188	0.0286	0.0385	0.0484	0.0583	0.0682	0.0781	0.0880	0.0979
Hotel	0.0090	0.0189	0.0289	0.0389	0.0489	0.0588	0.0687	0.0787	0.0886	0.0985

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ16)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0087	0.0184	0.0281	0.0377	0.0474	0.0572	0.0671	0.0769	0.0867	0.0966
Large Retail	0.0073	0.0155	0.0237	0.0320	0.0402	0.0492	0.0583	0.0673	0.0764	0.0854
Education Campus	0.0055	0.0074	0.0094	0.0114	0.0134	0.0180	0.0226	0.0272	0.0317	0.0363
Hospital	0.0088	0.0187	0.0285	0.0383	0.0482	0.0580	0.0679	0.0778	0.0877	0.0976
Hotel	0.0084	0.0177	0.0271	0.0364	0.0458	0.0555	0.0652	0.0748	0.0845	0.0942

Note: Savings are in kW/fan motor nameplate HP

1978-1992 Vintage:

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ6)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0078	0.0167	0.0255	0.0343	0.0431	0.0525	0.0619	0.0713	0.0808	0.0902
Large Retail	0.0075	0.0160	0.0245	0.0329	0.0414	0.0506	0.0598	0.0690	0.0782	0.0875
Education Campus	0.0044	0.0059	0.0074	0.0089	0.0104	0.0145	0.0186	0.0227	0.0267	0.0308
Hospital (CV)	0.0089	0.0189	0.0289	0.0388	0.0488	0.0587	0.0686	0.0786	0.0885	0.0984
Hospital (VAV)	0.0088	0.0186	0.0284	0.0382	0.0480	0.0579	0.0677	0.0776	0.0875	0.0973
Hotel	0.0084	0.0178	0.0271	0.0365	0.0459	0.0556	0.0653	0.0750	0.0847	0.0944

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ8)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0087	0.0185	0.0282	0.0380	0.0477	0.0576	0.0674	0.0773	0.0871	0.0970
Large Retail	0.0080	0.0169	0.0259	0.0348	0.0438	0.0532	0.0627	0.0722	0.0817	0.0912
Education Campus	0.0101	0.0235	0.0369	0.0504	0.0638	0.0683	0.0728	0.0773	0.0818	0.0863
Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0488	0.0588	0.0687	0.0786	0.0886	0.0985
Hospital (VAV)	0.0089	0.0188	0.0287	0.0386	0.0485	0.0584	0.0683	0.0783	0.0882	0.0981
Hotel	0.0087	0.0185	0.0283	0.0380	0.0478	0.0576	0.0675	0.0773	0.0872	0.0970

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ9)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0081	0.0172	0.0264	0.0355	0.0446	0.0542	0.0638	0.0733	0.0829	0.0925
	Large Retail	0.0077	0.0163	0.0250	0.0336	0.0422	0.0516	0.0609	0.0702	0.0795	0.0888
	Education Campus	0.0053	0.0072	0.0091	0.0110	0.0129	0.0174	0.0219	0.0264	0.0309	0.0354
	Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0488	0.0588	0.0687	0.0786	0.0885	0.0985
	Hospital (VAV)	0.0088	0.0186	0.0285	0.0383	0.0481	0.0580	0.0679	0.0777	0.0876	0.0975
	Hotel	0.0087	0.0185	0.0282	0.0380	0.0477	0.0576	0.0674	0.0773	0.0871	0.0970

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ10)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0083	0.0175	0.0268	0.0360	0.0452	0.0549	0.0645	0.0742	0.0838	0.0934
	Large Retail	0.0084	0.0177	0.0270	0.0364	0.0457	0.0554	0.0651	0.0748	0.0845	0.0941
	Education Campus	0.0059	0.0081	0.0103	0.0126	0.0148	0.0195	0.0243	0.0291	0.0339	0.0387
	Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0488	0.0588	0.0687	0.0786	0.0886	0.0985
	Hospital (VAV)	0.0089	0.0188	0.0287	0.0386	0.0485	0.0584	0.0683	0.0782	0.0881	0.0980
	Hotel	0.0088	0.0186	0.0283	0.0381	0.0479	0.0578	0.0676	0.0775	0.0874	0.0972

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ13)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0088	0.0186	0.0285	0.0383	0.0481	0.0580	0.0679	0.0778	0.0876	0.0975
	Large Retail	0.0089	0.0188	0.0287	0.0386	0.0485	0.0584	0.0683	0.0782	0.0881	0.0980
	Education Campus	0.0071	0.0099	0.0127	0.0155	0.0183	0.0235	0.0287	0.0340	0.0392	0.0444
	Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0488	0.0588	0.0687	0.0786	0.0885	0.0985
	Hospital (VAV)	0.0089	0.0188	0.0286	0.0385	0.0484	0.0583	0.0682	0.0781	0.0880	0.0979
	Hotel	0.0089	0.0189	0.0288	0.0387	0.0487	0.0586	0.0685	0.0784	0.0884	0.0983

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ14)

Building Type	Static Pressure Reduction (in. H2O)	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
	Large Office	0.0084	0.0179	0.0273	0.0368	0.0462	0.0559	0.0657	0.0754	0.0851	0.0948
	Large Retail	0.0086	0.0181	0.0277	0.0372	0.0468	0.0566	0.0663	0.0761	0.0859	0.0957
	Education Campus	0.0070	0.0097	0.0125	0.0152	0.0180	0.0232	0.0283	0.0335	0.0387	0.0439
	Hospital (CV)	0.0089	0.0189	0.0289	0.0388	0.0488	0.0587	0.0687	0.0786	0.0885	0.0984
	Hospital (VAV)	0.0089	0.0187	0.0286	0.0385	0.0484	0.0583	0.0681	0.0780	0.0879	0.0978
	Hotel	0.0089	0.0189	0.0288	0.0388	0.0487	0.0586	0.0686	0.0785	0.0884	0.0983

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ15)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0086	0.0182	0.0278	0.0374	0.0470	0.0568	0.0666	0.0764	0.0862	0.0959
Large Retail	0.0084	0.0178	0.0272	0.0366	0.0460	0.0557	0.0654	0.0751	0.0848	0.0945
Education Campus	0.0067	0.0093	0.0119	0.0145	0.0171	0.0222	0.0273	0.0324	0.0375	0.0425
Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0488	0.0588	0.0687	0.0786	0.0886	0.0985
Hospital (VAV)	0.0089	0.0188	0.0287	0.0386	0.0484	0.0583	0.0682	0.0781	0.0881	0.0980
Hotel	0.0089	0.0188	0.0288	0.0387	0.0486	0.0585	0.0684	0.0783	0.0883	0.0982

Note: Savings are in kW/fan motor nameplate HP

Reduce Static Pressure RCx Pre-Calculated kW Savings (CZ16)

Building Type	Static Pressure Reduction (in. H2O)									
	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Large Office	0.0086	0.0182	0.0277	0.0373	0.0469	0.0567	0.0665	0.0762	0.0860	0.0958
Large Retail	0.0078	0.0165	0.0252	0.0340	0.0427	0.0521	0.0614	0.0708	0.0802	0.0895
Education Campus	0.0050	0.0067	0.0085	0.0102	0.0120	0.0164	0.0208	0.0251	0.0295	0.0339
Hospital (CV)	0.0090	0.0189	0.0289	0.0389	0.0489	0.0588	0.0687	0.0787	0.0886	0.0985
Hospital (VAV)	0.0089	0.0187	0.0286	0.0385	0.0484	0.0583	0.0682	0.0781	0.0880	0.0979
Hotel	0.0089	0.0189	0.0288	0.0388	0.0487	0.0587	0.0686	0.0785	0.0884	0.0984

Note: Savings are in kW/fan motor nameplate HP

DUCT STATIC PRESSURE RESET

Measure Description

The "Duct Static Pressure Reset" measure applies when the supply fans in a VAV HVAC system are controlled by VFDs to maintain a fixed static pressure set point in the baseline case. In this case, the VFDs are functioning properly and the measure is to implement a static pressure reset strategy (e.g., OAT reset, VAV box position polling, space temperature offset polling) to reduce the fan power needed in the VAV HVAC system. This measure entails applying an automatic continuous strategy using system software.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and fan motor rated horsepower.
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable fan motor horsepower size limit using the CZ, type of building, and building vintage.[7] Fan motors that are equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Fan

[7] Choose closest CZ, building type, horsepower size, and building vintage in the lookup tables.

motors that are larger than the allowable horsepower size limit are *not* eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.

4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, building vintage, and minimum static pressure setpoint. Then multiply the factor times the fan motor horsepower rating. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of building, building vintage, and minimum static pressure setpoint. Then multiply the factor times the fan motor horsepower rating. The product will be the estimated electric demand savings.

Relevant Modeling Assumptions

The pre-calculated savings tables below were generated with the following assumptions:

- Generic fan performance curves
- Generic motor and VSD efficiency curves (see Global Modeling Assumptions above)
- VAV with VFD
- Table 1 represents the operating hours of the building's supply fans. For modeling purposes, fan operating hours are assumed to be +2 hours per day beyond occupancy hours (fans operate an additional one hour before and one hour after the building opens and closes).

Fan Operating Hours

Operating Hours	Fan Hours per year
Large Retail	4,888
Large Office	3,432
Hotel	8,760
Hospital	8,760
Secondary School	2,911

- The motor nameplate value was estimated as: Fan motor nameplate HP = Fan design BHP/0.8
- The maximum efficiency point of the fan is 74%
- The project fan design efficiency is 70%
- The air system design static pressure is 4.5 in. H_2O
- Baseline duct static pressure set point is 1.25 in. H_2O
- The sensors should be located 2/3 of the way down the longest duct run (if positioned elsewhere, the calculations will be in error)

Note:
The "maximum efficiency point of the fan" refers to the maximum efficiency of the fan from the fan curve.
The "project fan design efficiency" refers to the efficiency of the fan at the design flow.
The "building design static pressure" refers to the supply fan static pressure drop at the design flow.

The savings for this measure are determined by the change in reset.

Sample Calculation

Baseline: Office Building in CZ06, Post 2005 Vintage, 50HP Supply Fan Motor, DSP Minimum Set Point 0.5 in. H_2O.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 572 HP (move to Step 2)

Step 2 – Lookup kWh/HP/hr Savings Factor in Table and Calculate Savings:

50 HP x 131 kWh/HP = 6,550 kWh/yr

Step 3 – Lookup kW/HP Savings Factor in Table and Calculate Savings:

50 HP x 0.037 kW/HP = 1.9 kW

Allowable Fan Motor Horsepower

The horsepower breakpoint for each building prototype was calculated by dividing the savings cutoff level of 75,000 kWh by the savings (normalized by horsepower), to arrive at the fan motor nameplate horsepower equivalent breakpoint capacity found in the following tables below. Operating hours for these derived values follow the building's operating hours.

For example, if an office building (post-2005 vintage) located in Climate Zone 6 has a nameplate 100 horsepower supply fan motor and the measure is to implement a static pressure reset from the existing maximum set point to 0.5 in. H_2O, then the savings table below would be applicable because the maximum horsepower from the table below for this measure is 572 horsepower.

Post-2005 Vintage:

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ6)

		Minimum Static Pressure Reset Setpoint (in. H2O)		
		0.5	0.75	1
Building Type	Large Office	572	685	1140
	Large Retail	455	552	933
	Education Campus	637	772	1191
	Hospital	675	675	682
	Hotel	277	350	597

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ8)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	492	584	910
Large Retail	404	482	744
Education Campus	716	900	1457
Hospital	432	432	440
Hotel	276	343	569

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	531	649	1061
Large Retail	441	545	892
Education Campus	644	796	1266
Hospital	439	439	460
Hotel	290	369	626

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	485	578	883
Large Retail	467	576	924
Education Campus	653	818	1353
Hospital	441	441	485
Hotel	295	375	638

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O)		
	0.5	0.75	1
Large Office	507	621	1009
Large Retail	495	600	932
Education Campus	527	648	978
Hospital	420	420	481
Hotel	310	395	664

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O)		
	0.5	0.75	1
Large Office	518	644	1087
Large Retail	510	615	927
Education Campus	571	698	1072
Hospital	307	307	358
Hotel	339	441	781

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O)		
	0.5	0.75	1
Large Office	515	615	965
Large Retail	449	530	784
Education Campus	513	634	998
Hospital	453	453	497
Hotel	293	365	582

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	495	625	1045
Large Retail	550	696	1124
Education Campus	647	799	1220
Hospital	384	384	489
Hotel	314	395	616

1978-1992 Vintage:

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ6)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	535	618	874
Large Retail	412	491	744
Education Campus	740	887	1383
Hospital	401	401	401
Hotel	305	361	523

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ8)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	517	598	846
Large Retail	431	517	801
Education Campus	687	819	1256
Hospital	472	472	472
Hotel	279	328	471

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	638	786	1337
Large Retail	429	523	827
Education Campus	693	838	1327
Hospital	524	524	524
Hotel	319	382	588

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	557	666	1026
Large Retail	476	579	930
Education Campus	734	902	1520
Hospital	429	429	429
Hotel	331	397	617

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	565	690	1123
Large Retail	539	645	969
Education Campus	599	727	1112
Hospital	315	315	331
Hotel	339	413	657

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	450	529	774
Large Retail	553	667	1012
Education Campus	687	856	1448
Hospital	361	361	387
Hotel	342	409	627

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	570	689	1068
Large Retail	479	566	816
Education Campus	536	640	966
Hospital	339	339	344
Hotel	322	383	580

Static Pressure Reset RCx Pre-Calculated Savings Maximum Motor HP(CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	426	521	780
Large Retail	594	746	1209
Education Campus	640	794	1242
Hospital	444	444	444
Hotel	355	430	643

Pre-Calculated Electric Energy Savings Table

Savings factors were calculated and are presented in the tables below for the building types described earlier with a VAV HVAC system. The savings were normalized based on the nameplate horsepower rating of the supply fan motors.

In the tables below the energy savings for a Hospital building are relatively constant because the models show the static pressure is not able to reset below 1.0 in. H_2O in some cases and below 0.75 in. H_2O in the remaining cases.

The columns represent the minimum static pressure of the proposed reset schedule. In order to use the pre-calculated tables below, the baseline static pressure set point should be at least 1.25 in. H_2O.

If the minimum static pressure set point falls between the values below, then interpolation between the points is acceptable. Extrapolation, however, is not permitted.

Post-2005 Vintage:

Static Pressure Reset RCx Pre-Calculated Savings (CZ6)

		Minimum Static Pressure Reset Setpoint (in. H2O)		
		0.5	0.75	1
Building Type	Large Office	131	109	66
	Large Retail	165	136	80
	Education Campus	118	97	63
	Hospital	111	111	110
	Hotel	271	214	126

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ8)

		Minimum Static Pressure Reset Setpoint (in. H2O)		
		0.5	0.75	1
Building Type	Large Office	152	128	82
	Large Retail	186	156	101
	Education Campus	105	83	51
	Hospital	174	174	170
	Hotel	272	219	132

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	141	115	71
Large Retail	170	138	84
Education Campus	116	94	59
Hospital	171	171	163
Hotel	259	203	120

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	155	130	85
Large Retail	161	130	81
Education Campus	115	92	55
Hospital	170	170	155
Hotel	254	200	118

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	148	121	74
Large Retail	152	125	80
Education Campus	142	116	77
Hospital	178	178	156
Hotel	242	190	113

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	145	116	69
Large Retail	147	122	81
Education Campus	131	107	70
Hospital	244	244	209
Hotel	221	170	96

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	146	122	78
Large Retail	167	142	96
Education Campus	146	118	75
Hospital	166	166	151
Hotel	256	206	129

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	151	120	72
Large Retail	136	108	67
Education Campus	116	94	61
Hospital	195	195	153
Hotel	239	190	122

Note: Savings are in kWh/fan Nameplate HP

1978-1992 Vintage:

Static Pressure Reset RCx Pre-Calculated Savings (CZ6)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	140	121	86
Large Retail	182	153	101
Education Campus	101	85	54
Hospital	187	187	187
Hotel	246	208	144

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ8)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	145	126	89
Large Retail	174	145	94
Education Campus	109	92	60
Hospital	159	159	159
Hotel	269	229	159

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	118	95	56
Large Retail	175	143	91
Education Campus	108	89	57
Hospital	143	143	143
Hotel	235	196	128

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	135	113	73
Large Retail	157	129	81
Education Campus	102	83	49
Hospital	175	175	175
Hotel	227	189	122

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	133	109	67
Large Retail	139	116	77
Education Campus	125	103	67
Hospital	238	238	226
Hotel	221	181	114

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	167	142	97
Large Retail	136	112	74
Education Campus	109	88	52
Hospital	208	208	194
Hotel	219	183	120

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	132	109	70
Large Retail	156	133	92
Education Campus	140	117	78
Hospital	221	221	218
Hotel	233	196	129

Note: Savings are in kWh/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated Savings (CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	176	144	96
Large Retail	126	101	62
Education Campus	117	94	60
Hospital	169	169	169
Hotel	211	174	117

Note: Savings are in kWh/fan Nameplate HP

Again, the savings calculations tables were designed to allow for the application of two different measures. For instance, if a reduction in static pressure is also proposed, then the "Pre-Calculated Savings Static Pressure Reduction Tables" would be used to calculate the savings from the baseline static pressure set point to the maximum set point of the proposed reset schedule (1.25"), then the savings from the Static Pressure Reset would be calculated from the "Static Pressure Reset RCx Pre-Calculated Savings" tables (above) for the Static Pressure Reset. The two values are added together.

Pre-Calculated Demand Savings Tables

Demand savings factors were calculated and are presented in the tables below for the building types and climate zones described earlier, with a VAV HVAC system. The demand savings were normalized based on the nameplate horsepower rating of the supply fans.

In the tables below the factors are in kW/fan motor nameplate horsepower. To calculate the demand savings, multiply the appropriate factor in the table below by the nameplate horsepower of the supply fan motor. If there is no value (--) in the table, then no savings were calculated for that measure.

Post-2005 Vintage:

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ6)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.037	0.022	0.015
Large Retail	0.040	0.026	0.017
Education Campus	0.017	0.009	0.004
Hospital	0.012	--	0.003
Hotel	0.043	0.029	0.018

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ8)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.016	0.001	0.005
Large Retail	0.033	0.018	0.013
Education Campus	0.046	0.031	0.019
Hospital	0.011	--	0.003
Hotel	0.021	0.006	0.008

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.032	0.017	0.013
Large Retail	0.038	0.023	0.016
Education Campus	0.022	0.013	0.006
Hospital	0.014	--	0.004
Hotel	0.014	--	0.004

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.029	0.013	0.011
Large Retail	0.027	0.011	0.010
Education Campus	0.026	0.016	0.008
Hospital	0.011	--	0.003
Hotel	0.024	0.008	0.009

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.015	--	0.005
Large Retail	0.038	0.023	0.015
Education Campus	0.031	0.020	0.011
Hospital	0.012	--	0.003
Hotel	0.012	--	0.003

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.025	0.010	0.009
Large Retail	0.031	0.016	0.012
Education Campus	0.024	0.015	0.008
Hospital	0.012	--	0.003
Hotel	0.020	0.005	0.007

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.024	0.009	0.009
Large Retail	0.037	0.022	0.015
Education Campus	0.024	0.015	0.008
Hospital	0.012	--	0.003
Hotel	0.009	--	0.002

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.018	0.003	0.006
Large Retail	0.044	0.029	0.018
Education Campus	0.017	0.009	0.005
Hospital	0.014	--	0.004
Hotel	0.027	0.012	0.011

Note: Savings are in kW/fan Nameplate HP

1978-1992 Vintage:

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ6)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.038	0.023	0.015
Large Retail	0.042	0.027	0.017
Education Campus	0.013	0.006	0.003
Hospital	0.015	--	0.004
Hotel	0.027	0.012	0.010

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ8)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.016	0.001	0.005
Large Retail	0.035	0.020	0.014
Education Campus	0.042	0.027	0.017
Hospital	0.011	--	0.003
Hotel	0.016	0.001	0.005

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ9)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.033	0.017	0.013
Large Retail	0.040	0.025	0.016
Education Campus	0.017	0.009	0.004
Hospital	0.014	--	0.004
Hotel	0.016	0.001	0.005

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ10)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.030	0.014	0.012
Large Retail	0.027	0.012	0.011
Education Campus	0.019	0.011	0.005
Hospital	0.011	--	0.003
Hotel	0.015	--	0.005

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ13)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.014	--	0.004
Large Retail	0.012	--	0.003
Education Campus	0.024	0.014	0.007
Hospital	0.012	--	0.003
Hotel	0.010	--	0.002

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ14)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.025	0.010	0.010
Large Retail	0.022	0.007	0.008
Education Campus	0.023	0.014	0.007
Hospital	0.013	--	0.003
Hotel	0.010	--	0.002

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ15)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.021	0.006	0.007
Large Retail	0.026	0.011	0.010
Education Campus	0.022	0.013	0.007
Hospital	0.012	--	0.003
Hotel	0.010	--	0.002

Note: Savings are in kW/fan Nameplate HP

Static Pressure Reset RCx Pre-Calculated kW Savings (CZ16)

Building Type	Minimum Static Pressure Reset Setpoint (in. H2O) 0.5	0.75	1
Large Office	0.021	0.006	0.008
Large Retail	0.039	0.024	0.016
Education Campus	0.016	0.008	0.004
Hospital	0.013	--	0.003
Hotel	0.010	--	0.002

Note: Savings are in kW/fan Nameplate HP

SUPPLY FAN VARIABLE FREQUENCY DRIVE

Measure Description and Overview

This measure, "Supply Fan Variable Frequency Drive" applies to supply fans in a VAV system running at a constant speed with malfunctioning capacity controls. This measure requires the installation of variable frequency drive (VFD) controls and modulating the fan speed to provide the required airflow for the VAV system. Savings for 1978-1992 and Post 2005 vintages were developed.

Baseline – The baseline case considered was a supply fan with non-functioning inlet guide vanes (IGV) at various fixed positions. This baseline was considered most prevalent based on 2006-2008 program information. A VFD operating in bypass mode would also be an applicable baseline condition for this measure.

Post-Installation – Supply fan VFD is installed and is properly modulating based on a fixed static pressure setpoint.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and fan motor rated horsepower.
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable horsepower size limit using the CZ, type of building, percent IGV position for base case, and building vintage.[8] Supply fans with motors that are equal to or smaller than the allowable horsepower size limit are eligible for pre-calculated savings. Supply fans with motors that are larger than the allowable horsepower size limit are ***not*** eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.

[8] Choose the closest CZ, building type, horsepower size, and building vintage in the lookup tables.

4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, and building vintage. Then multiply the factor times the supply fan motor horsepower rating and the annual fan operating hours. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of building, valve type, and building vintage. Then multiply the factor times the supply fan motor horsepower rating. The product will be the estimated electric demand savings.

Relevant Modeling Assumptions

As before, relevant modeling assumptions for this measure include:

- Generic motor and VSD efficiency curves. (See Global Modeling Assumptions above.)
- Table 1 represents the operating hours of the building's supply fans. Savings are normalized by the fan operating hours, rather than the building operating hours. For modeling purposes, fan operating hours are assumed to be +2 hours per day beyond occupancy hours (fans operate an additional one hour before and one hour after the building opens and closes).

Table 1 - Fan Operating Hours

Operating Hours	Fan Hours per year
Large Retail	4,888
Large Office	3,432
Hotel	8,760
Hospital	8,760
Secondary School	2,911

Sample Calculation

Baseline: Office Building in CZ06, Post 2005 Vintage, 40HP Supply Fan Motor, 100% IGV Position, Operates 2,800 hours/yr.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 124 HP (move to Step 2)

Step 2 – Lookup kWh/HP/hr Savings Factor in Table and Calculate Savings:

40 HP x 0.176 kWh/HP/hr x 2,800 hours = 19,712 kWh/yr

Step 3 – Lookup kW/HP Savings Factor in Table and Calculate Savings:

40 HP x 0.127 kW/HP = 5.1 kW

Allowable Fan Motor Horsepower

Tables 2 through 7 below represent the horsepower breakpoint at which the pre-calculated factors described above are no longer valid. The horsepower equivalent was calculated by dividing 75,000 kWh by the kWh/HP savings factor. Operating hours for these derived values follow the fan operating hours.

Table 2 – Horsepower Breakpoint, 100% IGV Position Base Case (1978-1992)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	109	106	107	101	92	86	99	75
Secondary School	124	119	116	106	92	90	89	84
Large Retail	101	106	106	113	109	106	99	115
Hospital	53	54	54	53	53	53	54	53
Hotel	58	57	57	57	58	57	58	55

Table 3 – Horsepower Breakpoint, 90% IGV Position Base Case (1978-1992)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	110	106	108	102	93	87	99	75
Secondary School	125	119	116	107	92	90	90	84
Large Retail	103	107	106	115	109	106	99	116
Hospital	53	53	53	53	53	53	54	53
Hotel	58	57	57	57	58	58	59	56

Table 4 – Horsepower Breakpoint, 80% IGV Position Base Case (1978-1992)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	114	109	111	105	95	89	104	77
Secondary School	128	121	118	108	94	91	92	84
Large Retail	108	112	109	121	110	107	100	117
Hospital	53	53	53	53	54	54	55	53
Hotel	60	59	59	59	60	60	62	57

Table 5 – Horsepower Breakpoint, 100% IGV Position Base Case (Post 2005)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	124	123	123	120	111	106	113	97
Secondary School	124	119	116	106	92	90	89	84
Large Retail	112	116	117	117	121	117	131	107
Hospital	59	61	61	61	61	60	61	59
Hotel	62	62	62	62	62	53	68	58

Table 6 – Horsepower Breakpoint, 90% IGV Position Base Case (Post 2005)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	125	129	124	121	118	107	114	98
Secondary School	125	119	116	107	92	90	90	84
Large Retail	113	122	117	117	121	117	138	107
Hospital	59	62	62	61	60	60	61	59
Hotel	62	62	63	62	63	53	75	58

Table 7 – Horsepower Breakpoint, 80% IGV Position Base Case (Post 2005)

	Horsepower Breakpoint (<75,000 kWh)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	132	135	129	126	125	112	122	100
Secondary School	128	121	118	108	94	91	92	84
Large Retail	118	128	122	121	127	121	149	108
Hospital	58	62	63	63	62	60	63	58

Pre-Calculated Electric Energy Savings Tables

Energy savings are presented in Tables 8 through 13 below, for the aforementioned building types. The savings are normalized based on the nameplate horsepower and the operating hours for the supply fans included in the measure.

Table 8 - Savings, 100% IGV Position Base Case (1978-1992)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.161	0.161	0.162	0.161	0.161	0.160	0.161	0.162
Secondary School	0.172	0.171	0.172	0.176	0.175	0.178	0.172	0.178
Large Retail	0.149	0.145	0.146	0.135	0.141	0.145	0.156	0.133
Hospital	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.162
Hotel	0.149	0.149	0.150	0.150	0.149	0.150	0.146	0.155

Table 9 - Savings, 90% IGV Position Base Case (1978-1992)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.160	0.161	0.161	0.160	0.160	0.159	0.160	0.161
Secondary School	0.171	0.171	0.172	0.175	0.175	0.177	0.171	0.178
Large Retail	0.147	0.144	0.145	0.134	0.141	0.145	0.155	0.133
Hospital	0.162	0.162	0.161	0.161	0.161	0.160	0.160	0.163
Hotel	0.147	0.149	0.149	0.149	0.148	0.148	0.145	0.154

Table 10 - Savings, 80% IGV Position Base Case (1978-1992)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.154	0.156	0.156	0.156	0.156	0.155	0.153	0.158
Secondary School	0.167	0.168	0.169	0.173	0.172	0.174	0.167	0.178
Large Retail	0.140	0.137	0.142	0.127	0.140	0.144	0.154	0.132
Hospital	0.161	0.160	0.160	0.161	0.159	0.159	0.157	0.162
Hotel	0.142	0.146	0.146	0.146	0.143	0.144	0.139	0.151

Table 11 - Savings, 100% IGV Position Base Case (Post 2005)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.176	0.177	0.177	0.183	0.197	0.206	0.194	0.225
Secondary School	0.172	0.171	0.172	0.176	0.175	0.178	0.172	0.178
Large Retail	0.137	0.132	0.132	0.132	0.127	0.131	0.118	0.143
Hospital	0.146	0.139	0.139	0.141	0.141	0.142	0.141	0.146
Hotel	0.137	0.138	0.138	0.139	0.138	0.162	0.126	0.148

Table 12 - Savings, 90% IGV Position Base Case (Post 2005)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.174	0.170	0.176	0.181	0.185	0.204	0.191	0.223
Secondary School	0.171	0.171	0.172	0.175	0.175	0.177	0.171	0.178
Large Retail	0.136	0.125	0.131	0.131	0.126	0.131	0.112	0.143
Hospital	0.146	0.138	0.139	0.141	0.142	0.143	0.141	0.146
Hotel	0.137	0.137	0.137	0.138	0.137	0.160	0.115	0.148

Table 13 - Savings, 80% IGV Position Base Case (Post 2005)

	Savings (kWh/hp-hour)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.165	0.162	0.169	0.173	0.176	0.195	0.179	0.218
Secondary School	0.167	0.168	0.169	0.173	0.172	0.174	0.167	0.178
Large Retail	0.130	0.120	0.125	0.127	0.121	0.127	0.103	0.142
Hospital	0.146	0.137	0.135	0.137	0.138	0.142	0.136	0.146
Hotel	0.136	0.132	0.135	0.136	0.134	0.155	0.105	0.148

Pre-Calculated Electric Demand Savings Tables

Tables 14 and 15 below present DEER peak savings factors. Savings are based on the nine-hour averages for the DEER defined peak period for each respective climate zone. Factors are only valid at a 100% IGV position base case. It is assumed that a lower IGV position baseline would yield a negative savings value as HVAC equipment typically operates at its peak during this time period.

Table 14 – DEER Peak Savings, 100% IGV Position Base Case (1978-1992)

	DEER Peak Savings (kW/hp)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.153	0.147	0.154	0.152	0.143	0.146	0.151	0.149
Secondary School	0.151	0.137	0.153	0.161	0.168	0.167	0.168	0.155
Large Retail	0.132	0.111	0.116	0.090	0.088	0.095	0.112	0.104
Hospital	0.311	0.306	0.305	0.301	0.294	0.295	0.298	0.307
Hotel	0.116	0.109	0.110	0.107	0.090	0.094	0.099	0.110

Table 15 – DEER Peak Savings, 100% IGV Position Base Case (Post 2005)

	DEER Peak Savings (kW/hp)							
Building Type	CZ06	CZ08	CZ09	CZ 10	CZ 13	CZ 14	CZ 15	CZ 16
Large Office	0.127	0.110	0.121	0.119	0.106	0.112	0.119	0.114
Secondary School	0.151	0.137	0.153	0.161	0.168	0.167	0.168	0.155
Large Retail	0.105	0.079	0.084	0.067	0.052	0.058	0.059	0.093
Hospital	0.280	0.272	0.274	0.270	0.261	0.264	0.266	0.277
Hotel	0.095	0.074	0.011	0.023	0.006	0.067	0.001	0.084

OUTSIDE AIR LOCKOUT FOR BOILER AND HEATING WATER PUMP

Measure Description and Overview

In the baseline case, the heating water pump serving the HVAC system was active all the time regardless of the outside air temperature. This measure controls the heating water pumps through local/central system control (EMS) and shutting them off (as well as the boilers) when the outside air temperature is above 70° F.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and building conditioned floor area.
3. Determine annual natural gas savings by looking up the therms savings factor using the CZ, type of building, and building vintage. Then multiply the factor times the conditioned floor area. The product will be the estimated annual natural gas savings.
4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of building, and building vintage. Then multiply the factor times the conditioned floor area. The product will be the estimated annual electric energy savings.
5. The measure is eligible for pre-calculated savings only when the natural gas savings (for this measure) is less than 30% of the total natural gas consumption.

Modeling Results

Building Vintage 1978 to 1992

The pre-calculated savings tables were determined using eQuest parametric run results using the 1978 to 1992 vintage Engage prototypical building simulation models. In the baseline models, heating plant operation was changed from "demand" based operation to "schedule" (time of day) based operation with the following operating schedules:

Large Office runs 5 am to 6 pm on weekdays, 5 am to 6 pm on Saturdays, and off on Sundays and holidays

1. Hotel runs 24/7.
2. Hospital runs 24/7.
3. Large Retail runs from 8 am to 10 pm on weekdays, and from 8 am to 8 pm on weekends and holidays.
4. Education – High School model runs from 6 am to 7 pm on weekdays, and from 6 am to 5 pm on Saturdays and off on Sundays. School Sessions are:
    - From Monday January 7 through Friday April 5
    - From Monday April 15 through Friday June 14 and
    - From Monday August 19 through Friday December 13

Building Vintage 2005+

The pre-calculated savings tables were determined using eQuest parametric run results using the 2005+ vintage Engage prototypical building simulation models. In the baseline models, heating plant operation was changed from "demand" based operation to "schedule" (time of day) based operation with the following operating schedules:

1. Large Office runs 5 am to 6pm on weekdays, 5 am to 6pm on Saturdays, and off on Sundays and holidays
2. Hotel runs 24/7.
3. Hospital runs 24/7.
4. Large Retail runs from 8 am to 10 pm on weekdays, and from 8 am to 8 pm on weekends and holidays.
5. Education – High School model runs from 6 am to 7 pm on weekdays, and from 6 am to 5 pm on Saturdays and Off on Sundays.
   School Sessions are:
   - From Monday January 7 through Friday April 5
   - From Monday April 15 through Friday June 14 and
   - From Monday August 19 through Friday December 13

Sample Calculation

Baseline: Hospital in CZ08, 1978-1992 Vintage, 200,000 sq-ft, Boiler Operates Continuously.

Step 1 – Lookup therms/sq-ft Savings Factor in Table and Calculate Savings:

200,000 sq-ft x 0.0835 therms/sq-ft = 16,700 therms/yr

Step 2 – Check for Measure Eligibility

therms savings < 30% of facility's annual consumption (move to Step 3)

Step 3 – Lookup kWh/sq-ft Savings Factor in Table and Calculate Savings:

200,000 sq-ft x 0.1384 kWh/sq-ft = 27,680 kWh/yr

Pre-Calculated Natural Gas Consumption Savings Table

Tables 1 – 4 below show the pre-calculated natural gas consumption savings derived from implementing this measure.

Building Vintage 1978 to 1992

Table 1: Time-of-Day Schedule to 70°F Lockout Schedule

Existing Boiler Plant Operates Continuously change to Lockout @ 70°F

THERMS Saved Per Square Foot

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0177	0.0252	0.0395	0.0457	0.0500	0.0525	0.0468	0.0897	0.0203
Retail	0.0103	0.0141	0.0241	0.0347	0.0923	0.0396	0.0361	0.0672	0.0144
Hotel	0.0093	0.0129	0.0215	0.0271	0.0340	0.0410	0.0381	0.0744	0.0139
Hospital	0.0399	0.0565	0.0835	0.1060	0.1202	0.1743	0.1376	0.2935	0.0451
Education -High School	0.0046	0.0052	0.0103	0.0118	0.0139	0.0147	0.0124	0.0280	0.0042

Table 2: 85°F Lockout Schedule to 70°F Lockout Schedule

Existing Boiler Plant has a Lockout @ 85°F, change to Lockout @ 70°F

THERMS Saved Per Square Foot

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0174	0.0251	0.0349	0.0355	0.0315	0.0298	0.0258	0.0429	0.0163
Retail	0.0102	0.0140	0.0214	0.0256	0.0634	0.0246	0.0218	0.0317	0.0122
Hotel	0.0092	0.0129	0.0193	0.0220	0.0249	0.0280	0.0252	0.0409	0.0118
Hospital	0.0392	0.0561	0.0749	0.0854	0.0907	0.1253	0.0964	0.1781	0.0385
Education -High School	0.0045	0.0052	0.0093	0.0099	0.0106	0.0106	0.0083	0.0152	0.0039

Building Vintage 2005+

Table 3: Time-of-Day Schedule to 70°F Lockout Schedule

Existing Boiler Plant Operates Continuously change to Lockout @ 70°F

THERMS Saved Per Square Feet

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0101	0.0169	0.0266	0.0297	0.0324	0.0358	0.0323	0.0614	0.0132
Retail	0.0044	0.0065	0.0119	0.0138	0.0181	0.0213	0.0193	0.0363	0.0076
Hotel	0.0043	0.0062	0.0106	0.0135	0.0173	0.0215	0.0199	0.0397	0.0070
Hospital	0.0297	0.0409	0.0602	0.0678	0.0782	0.1029	0.0851	0.1793	0.0297
Education -High School	0.0022	0.0027	0.0055	0.0064	0.0076	0.0082	0.0068	0.0158	0.0023

Table 4: 85°F Lockout Schedule to 70°F Lockout Schedule

Existing Boiler Plant have a Lockout @ 85°F change to Lockout @ 70°F

THERMS Saved Per Square Feet

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0100	0.0168	0.0230	0.0232	0.0197	0.0197	0.0172	0.0277	0.0106
Retail	0.0044	0.0065	0.0108	0.0115	0.0137	0.0136	0.0119	0.0175	0.0066
Hotel	0.0042	0.0062	0.0096	0.0112	0.0131	0.0150	0.0134	0.0226	0.0061
Hospital	0.0293	0.0407	0.0547	0.0561	0.0606	0.0759	0.0614	0.1096	0.0259
Education -High School	0.0022	0.0027	0.0050	0.0054	0.0059	0.0060	0.0046	0.0087	0.0021

Pre-Calculated Electric Energy Savings Table

Tables 5 – 8 below show the pre-calculated electric energy savings derived from implementing this measure based on the same criteria as the pre-calculated natural gas consumption savings tables. The electric energy savings shown only accounts for heating hot water (HHW) pump electric energy savings, and does not include any interactive electric energy savings such as reduced cooling and/or reduced/increased ventilation fan energy.

Building Vintage 1978 to 1992

Table 5: Time-of-Day Schedule to 70°F Lockout Schedule

Existing Boiler Plant Operates Continuously, change to Lockout @ 70°F

kWh Saved Per Square Foot (HHW pump energy only)

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0645	0.0775	0.1188	0.1337	0.1415	0.1436	0.1347	0.2469	0.0539
Retail	0.0322	0.0448	0.0718	0.0806	0.0282	0.0995	0.0933	0.1631	0.0396
Hotel	0.0404	0.0485	0.0735	0.0998	0.1144	0.1265	0.1236	0.2209	0.0512
Hospital	0.0720	0.0899	0.1384	0.1630	0.1898	0.2211	0.1995	0.3659	0.0837
Education -High School	0.0171	0.0186	0.0323	0.0363	0.0401	0.0376	0.0325	0.0675	0.0129

Table 6: 85°F Lockout Schedule to 70°F Lockout Schedule

Existing Boiler Plant have a Lockout @ 85°F, change to Lockout @ 70°F

kWh Saved Per Square Foot (HHW pump energy only)

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0625	0.0770	0.1029	0.1001	0.0891	0.0816	0.0757	0.1053	0.0393
Retail	0.0313	0.0443	0.0621	0.0606	0.0229	0.0523	0.0503	0.0635	0.0313
Hotel	0.0385	0.0481	0.0634	0.0771	0.0778	0.0757	0.0746	0.1110	0.0409
Hospital	0.0702	0.0889	0.1208	0.1220	0.1228	0.1354	0.1189	0.1785	0.0666
Education -High School	0.0163	0.0185	0.0284	0.0289	0.0284	0.0257	0.0217	0.0345	0.0101

Building Vintage 2005+

Table 7: Time-of-Day Schedule to 70°F Lockout Schedule

Existing Boiler Plant Operates Continuously, change to Lockout @ 70°F

kWh Saved Per Square Foot (HHW pump energy only)

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0488	0.0594	0.0909	0.0973	0.1044	0.1000	0.0968	0.1729	0.0424
Retail	0.0293	0.0388	0.0596	0.0668	0.0764	0.0804	0.0753	0.1304	0.0337
Hotel	0.0351	0.0431	0.0688	0.0845	0.1005	0.1012	0.1085	0.1917	0.0429
Hospital	0.0670	0.0827	0.1248	0.1486	0.1611	0.1951	0.1798	0.3209	0.0746
Education -High School	0.0141	0.0155	0.0272	0.0301	0.0327	0.0315	0.0272	0.0560	0.0097

Table 8: 85°F Lockout Schedule to 70°F Lockout Schedule

Existing Boiler Plant have a Lockout @ 85°F, change to Lockout @ 70°F

kWh Saved Per Square Foot (HHW pump energy only)

Building type	zone 5	zone 6	zone 8	zone 9	zone 10	zone 13	zone 14	zone 15	zone 16
Large Office	0.0472	0.0590	0.0784	0.0714	0.0641	0.0517	0.0530	0.0708	0.0309
Retail	0.0287	0.0383	0.0518	0.0506	0.0506	0.0447	0.0417	0.0518	0.0269
Hotel	0.0342	0.0427	0.0599	0.0647	0.0688	0.0541	0.0650	0.0960	0.0346
Hospital	0.0655	0.0821	0.1106	0.1184	0.1172	0.1318	0.1181	0.1740	0.0615
Education -High School	0.0137	0.0153	0.0237	0.0244	0.0231	0.0218	0.0180	0.0281	0.0086

ECONOMIZER OPTIMIZATION

Measure Description and Overview

The "Economizer Optimization" measure applies when OSA dampers are stuck at a fixed position allowing too much or too little OSA and/or dry-bulb high limit is set too low. This measure entails restoring to restore failed economizer dampers and/or increase the dry-bulb high limit. Savings are for each properly functioning economizer. If the economizer is controlled using enthalpy control, then custom calculations must be performed.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and sensible cooling coil capacity (tons).
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable horsepower size limit using the CZ, type of building, and building vintage.[9] Cooling coil capacities that are equal to or smaller than the allowable tons size limit are eligible for pre-calculated savings. Sensible cooling coil capacities that are larger than the allowable tons size limit are ***not*** eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.
4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of baseline economizer symptom (outside air lockout or percent fixed OSA), type of building, and building vintage. Then multiply the factor times the sensible cooling coil rated capacity. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of baseline economizer symptom (outside air lockout or percent fixed OSA), type of building, and building vintage. Then multiply the factor times the sensible cooling coil rated capacity. The product will be the estimated peak demand savings.

[9] Choose closest CZ, building type, horsepower size, and building vintage in the lookup tables.

6. Determine annual natural gas energy savings by therm savings factor using the CZ, type of building, and building vintage. Then multiply the factor times the sensible cooling coil rated capacity. The product will be the estimated annual natural gas energy savings.

Relevant Modeling Assumptions

The following relevant assumptions were used in the modeling:

- Economizer is controlled based on OA DB temperature. Simulated baseline dry-bulb high limit is between 55-65 °F.
- Generic fan performance curves
- Generic motor and VSD efficiency curves (See Global Modeling Assumptions above)
- Both VAV and CAV systems
- Generic constant speed centrifugal chiller performance curves

ARI Chiller Efficiencies kW/ton

Type	1978-1992	Post 2005
Water cooled	0.750	0.644
Air cooled	1.300	1.260

Sample Calculation

Baseline: Hospital in CZ15, Post 2005 Vintage, 100 tons Cooling Coil Capacity (sensible), Outside Air Fixed at 40%.

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 160 tons (move to Step 2)

Step 2 – Lookup kWh/tons Savings Factor in Table and Calculate Savings:

100 tons x 469 kWh/tons = 46,900 kWh/yr

Step 3 – Lookup kW/tons Savings Factor in Table and Calculate Savings:

100 tons x 0.14 kW/tons = 14 kW

Step 4 – Lookup therms/tons Savings Factor in Table and Calculate Savings:

100 tons x 0.14 therms/tons = 547 therms/yr

Pre-Calculated Electric Energy Savings Table

The energy savings for this measure are normalized based on the sensible cooling coil rated capacity (tons) per air handler. The following five tables represent the "breakpoint" value, beyond which the pre-calculated savings factors are no longer valid for this measure. The breakpoint value was calculated by dividing 75,000 kWh by the kWh/tons savings factor.

Post 2005 Vintage:

Breakpoint Coil Capacity (Sensible Tons)

Education	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	2,007	1,435	2,358	1,883	2,289	2,811	2,608	5,442
	60 Deg Lockout	2,423	1,636	2,714	2,283	2,782	3,523	2,856	7,672
	65 Deg Lockout	4,679	2,813	4,658	4,072	4,668	6,274	4,074	15,050
	0% OA	129	114	277	160	246	154	-	122
	10% OA	154	142	364	222	361	265	-	176
	20% OA	188	184	499	330	591	588	-	293
	30% OA	234	248	703	523	1,155	2,048	-	584
	40% OA	300	342	991	854	2,984	-	-	1,595
	50% OA	396	488	1,350	1,398	10,355	-	-	-
	60% OA	2,423	739	1,751	2,154	12,083	-	-	-
	70% OA	817	1,254	2,057	2,844	4,905	-	2,911	-
	80% OA	1,494	2,762	2,239	2,984	2,275	3,752	411	-
	90% OA	5,361	62,148	2,212	2,492	1,301	1,454	225	-
	100% OA	-	-	2,284	1,922	1,002	957	158	9,318

Hotel	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	446	509	529	673	847	1,051	974	1,342
	60 Deg Lockout	738	798	870	1,171	1,412	1,750	1,507	2,420
	65 Deg Lockout	2,414	2,426	2,689	3,242	3,590	4,656	3,448	6,659
	0% OA	147	154	190	150	164	127	307	113
	10% OA	170	177	203	177	190	157	375	143
	20% OA	197	200	218	207	221	182	389	182
	30% OA	231	228	240	240	255	205	385	229
	40% OA	281	269	270	281	294	228	374	289
	50% OA	355	328	306	331	338	252	357	372
	60% OA	472	413	348	388	384	275	340	470
	70% OA	662	544	392	459	423	294	321	588
	80% OA	1,019	723	441	540	440	311	301	728
	90% OA	1,921	1,020	500	632	457	323	285	941
	100% OA	-	2,025	626	950	521	563	281	-

Hospital	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	163	509	208	228	290	319	332	392
	60 Deg Lockout	606	798	676	770	843	878	855	1,208
	65 Deg Lockout	6,284	2,426	4,023	3,498	3,536	3,287	2,692	4,667
	0% OA	71	154	80	59	66	47	101	33
	10% OA	69	177	75	64	65	52	108	37
	20% OA	67	200	72	67	65	57	109	42
	30% OA	69	228	73	73	69	68	116	53
	40% OA	73	269	77	84	79	92	130	80
	50% OA	81	328	86	104	97	133	148	141
	60% OA	96	413	101	134	122	196	160	272
	70% OA	122	544	121	183	148	312	173	563
	80% OA	165	723	145	264	169	504	182	2,008
	90% OA	236	1,020	171	397	181	800	187	-
	100% OA	358	2,025	205	686	190	1,672	185	-

Office	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	333	416	512	473	546	570	838	639
	60 Deg Lockout	704	795	978	1,042	1,371	1,349	1,498	1,524
	65 Deg Lockout	2,837	2,382	2,787	2,813	3,724	3,532	3,224	4,192
	0% OA	158	196	343	165	162	83	711	47
	10% OA	177	224	278	197	148	99	849	53
	20% OA	197	225	237	203	139	103	612	59
	30% OA	215	238	218	215	136	115	540	68
	40% OA	227	256	205	227	138	129	418	83
	50% OA	244	277	193	234	136	139	323	95
	60% OA	267	305	184	239	133	148	262	108
	70% OA	297	348	178	247	132	158	218	124
	80% OA	348	416	178	258	134	171	186	140
	90% OA	432	549	178	281	140	189	162	157
	100% OA	681	1,134	196	374	164	273	149	229

Retail	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	2,988	2,195	2,673	2,403	6,194	4,660	4,285	3,129
	60 Deg Lockout	4,498	3,461	4,572	4,009	8,497	6,501	7,515	5,344
	65 Deg Lockout	9,189	7,886	9,740	7,498	14,944	11,883	14,743	10,335
	0% OA	191	125	273	90	127	69	-	49
	10% OA	192	139	278	107	133	85	-	56
	20% OA	197	157	284	130	142	109	-	66
	30% OA	204	177	285	161	153	131	12,448	79
	40% OA	215	200	285	195	165	152	1,207	99
	50% OA	234	230	288	206	179	168	546	133
	60% OA	264	274	298	229	200	200	351	194
	70% OA	316	341	317	271	237	245	253	315
	80% OA	419	471	341	348	264	274	198	409
	90% OA	680	789	395	443	292	298	165	602
	100% OA	5,363	5,696	563	874	420	495	147	-

Electric energy savings factors (kWh/tons) were calculated and are presented in the tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

Electric Energy Savings (kWh/tons)

Education	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	37.36	52.25	31.81	39.82	32.77	26.68	28.76	13.78
	60 Deg Lockout	30.95	45.86	27.64	32.85	26.96	21.29	26.26	9.78
	65 Deg Lockout	16.03	26.67	16.10	18.42	16.07	11.95	18.41	4.98
	0% OA	582.35	658.56	271.15	469.17	304.73	487.85	-	616.40
	10% OA	485.59	526.97	206.22	337.18	207.97	282.95	-	425.65
	20% OA	398.61	408.59	150.30	227.04	127.00	127.59	-	255.84
	30% OA	320.11	302.34	106.64	143.43	64.96	36.62	-	128.53
	40% OA	250.20	219.45	75.70	87.79	25.13	-	-	47.02
	50% OA	189.30	153.75	55.55	53.65	7.24	-	-	-
	60% OA	30.95	101.44	42.84	34.82	6.21	-	-	-
	70% OA	91.76	59.83	36.45	26.37	15.29	-	25.76	-
	80% OA	50.21	27.15	33.50	25.14	32.97	19.99	182.65	-
	90% OA	13.99	1.21	33.91	30.10	57.64	51.58	333.33	-
	100% OA	-	-	32.84	39.03	74.83	78.37	473.71	8.05

Hotel	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	168.18	147.23	141.74	111.48	88.53	71.39	77.02	55.89
	60 Deg Lockout	101.57	93.96	86.19	64.02	53.12	42.85	49.75	30.99
	65 Deg Lockout	31.07	30.91	27.89	23.13	20.89	16.11	21.75	11.26
	0% OA	510.34	487.41	395.18	501.58	457.72	591.80	244.69	665.68
	10% OA	442.16	424.16	369.90	424.62	394.48	476.58	200.05	524.26
	20% OA	380.79	375.22	343.55	363.07	339.72	410.98	192.94	412.90
	30% OA	324.27	328.82	312.23	312.70	293.87	365.42	194.58	327.03
	40% OA	267.16	278.80	277.96	267.34	255.01	329.21	200.78	259.70
	50% OA	211.18	228.70	245.10	226.85	221.93	297.52	209.84	201.49
	60% OA	158.98	181.54	215.39	193.14	195.44	272.56	220.30	159.45
	70% OA	113.30	137.87	191.25	163.50	177.34	254.90	233.64	127.53
	80% OA	73.59	103.69	170.10	138.77	170.36	241.30	249.02	103.05
	90% OA	39.05	73.53	150.10	118.63	164.12	232.19	263.60	79.72
	100% OA	-	37.05	119.79	78.96	143.83	133.26	266.53	-

Hospital	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	458.80	147.23	360.28	329.07	258.58	235.27	225.85	191.26
	60 Deg Lockout	123.69	93.96	110.99	97.41	88.94	85.45	87.77	62.07
	65 Deg Lockout	11.93	30.91	18.64	21.44	21.21	22.82	27.86	16.07
	0% OA	1,055.34	487.41	938.26	1,273.56	1,128.91	1,606.94	741.15	2,261.97
	10% OA	1,088.01	424.16	1,001.31	1,165.32	1,158.69	1,455.34	692.35	2,049.70
	20% OA	1,111.56	375.22	1,042.90	1,121.25	1,152.39	1,305.36	687.63	1,778.48
	30% OA	1,093.70	328.82	1,031.10	1,022.62	1,080.77	1,097.24	648.97	1,418.50
	40% OA	1,032.26	278.80	975.57	890.12	955.40	811.54	578.45	935.44
	50% OA	930.49	228.70	872.92	718.24	772.32	564.71	507.45	531.36
	60% OA	782.69	181.54	745.72	558.73	616.70	381.70	469.26	275.72
	70% OA	614.26	137.87	621.79	409.48	508.15	240.76	433.38	133.20
	80% OA	455.50	103.69	515.75	284.03	443.31	148.68	412.15	37.36
	90% OA	317.75	73.53	437.49	189.08	415.05	93.80	401.41	-
	100% OA	209.68	37.05	366.58	109.28	394.76	44.87	404.79	-

Office	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	224.93	180.36	146.51	158.48	137.31	131.61	89.47	117.37
	60 Deg Lockout	106.55	94.35	76.73	71.98	54.72	55.60	50.05	49.21
	65 Deg Lockout	26.44	31.49	26.91	26.66	20.14	21.24	23.26	17.89
	0% OA	474.41	382.14	218.75	455.89	462.86	899.86	105.45	1,607.37
	10% OA	424.87	335.40	270.14	381.27	505.29	755.79	88.29	1,420.78
	20% OA	380.88	332.99	316.15	369.84	539.04	728.31	122.62	1,278.46
	30% OA	348.45	314.74	343.62	349.14	552.70	653.40	138.79	1,099.12
	40% OA	329.70	293.10	366.64	330.24	541.90	582.41	179.41	901.48
	50% OA	307.69	270.57	389.46	320.47	551.71	540.09	232.22	787.66
	60% OA	281.10	245.78	407.02	313.28	562.94	507.27	286.27	691.46
	70% OA	252.75	215.58	420.26	303.95	566.21	473.36	344.08	603.81
	80% OA	215.49	180.20	422.03	290.28	560.80	437.43	402.34	536.05
	90% OA	173.56	136.74	420.67	266.45	537.43	396.37	464.16	476.98
	100% OA	110.14	66.13	381.82	200.33	457.35	275.04	504.98	326.80

Retail	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	25.10	34.17	28.06	31.21	12.11	16.09	17.50	23.97
	60 Deg Lockout	16.67	21.67	16.40	18.71	8.83	11.54	9.98	14.03
	65 Deg Lockout	8.16	9.51	7.70	10.00	5.02	6.31	5.09	7.26
	0% OA	393.28	601.58	275.10	834.48	590.47	1,092.45	-	1,530.65
	10% OA	390.28	537.67	269.57	703.54	562.42	879.98	-	1,342.34
	20% OA	381.66	477.97	264.40	577.19	527.95	690.24	-	1,136.11
	30% OA	368.30	423.94	263.46	467.22	489.20	570.63	6.03	950.11
	40% OA	348.15	374.25	263.60	384.30	453.50	494.59	62.13	760.10
	50% OA	320.76	325.45	260.45	364.47	419.61	446.99	137.35	563.62
	60% OA	284.49	274.21	251.80	327.55	374.25	374.29	213.97	386.56
	70% OA	237.60	219.74	236.86	276.31	316.56	306.69	296.85	237.77
	80% OA	178.98	159.21	220.20	215.47	284.55	273.88	378.19	183.36
	90% OA	110.21	95.01	189.99	169.17	257.04	251.83	454.14	124.66
	100% OA	13.98	13.17	133.16	85.86	178.49	151.41	510.37	-

DEER peak savings factors (kW/tons) were calculated and are presented in the five tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

DEER Peak Savings (kW/tons)

Education	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	0.00	-	-	-	-	-	-	-
	70% OA	-	-	-	-	-	-	-	-
	80% OA	-	0.01	-	0.00	0.00	0.00	0.02	-
	90% OA	-	0.06	0.03	0.06	0.04	0.06	0.10	-
	100% OA	-	0.13	0.07	0.11	0.07	0.13	0.17	0.01

Hotel	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	0.01	-	-	-	0.00	-	0.00
	50% OA	-	0.02	0.00	0.01	-	0.02	-	0.01
	60% OA	-	0.03	0.01	0.02	-	0.01	0.02	0.02
	70% OA	0.00	0.04	0.03	0.04	0.01	0.04	0.02	0.03
	80% OA	0.00	0.06	0.04	0.05	0.03	0.06	0.04	0.04
	90% OA	0.00	0.06	0.05	0.06	0.03	0.07	0.05	0.05
	100% OA	0.01	0.07	0.07	0.07	0.04	0.09	0.06	0.06

Hospital	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	0.01	-	0.01	0.00	0.02	0.00	0.01	0.00
	40% OA	0.03	0.01	0.06	0.03	0.07	0.04	0.05	0.02
	50% OA	0.05	0.02	0.11	0.07	0.12	0.07	0.09	0.04
	60% OA	0.06	0.03	0.15	0.10	0.16	0.03	0.14	0.06
	70% OA	0.08	0.04	0.19	0.13	0.21	0.12	0.18	0.08
	80% OA	0.10	0.06	0.23	0.16	0.25	0.17	0.22	0.10
	90% OA	0.11	0.06	0.26	0.18	0.29	0.20	0.27	0.12
	100% OA	0.13	0.07	0.30	0.21	0.33	0.23	0.40	0.13

Office	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	0.02	0.04	0.02	0.05	0.04	0.05	0.02
	40% OA	0.01	0.05	0.11	0.06	0.13	0.09	0.12	0.05
	50% OA	0.03	0.08	0.17	0.11	0.19	0.14	0.20	0.08
	60% OA	0.05	0.11	0.23	0.15	0.25	0.06	0.27	0.11
	70% OA	0.06	0.14	0.28	0.19	0.30	0.22	0.51	0.14
	80% OA	0.08	0.17	0.32	0.24	0.36	0.30	0.56	0.17
	90% OA	0.10	0.20	0.38	0.28	0.42	0.35	0.62	0.20
	100% OA	0.11	0.23	0.43	0.33	0.61	0.39	0.69	0.23

Retail	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	-	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	-	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	-	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	-	-	0.03	0.09	0.01	0.04	-
	70% OA	-	0.02	0.04	0.12	0.14	0.06	0.10	0.02
	80% OA	0.01	0.04	0.09	0.25	0.19	0.34	0.18	0.05
	90% OA	0.02	0.06	0.21	0.41	0.24	0.44	0.29	0.07
	100% OA	0.03	0.09	0.34	0.47	0.32	0.47	0.33	0.10

Gas savings factors (therms/tons) factors were calculated and are presented in the tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

Natural Gas Savings (therms/tons)

Education	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	-	-	-	-	-	-	-
	70% OA	-	-	-	-	-	-	3.22	-
	80% OA	-	3.27	2.97	6.67	10.95	9.97	7.77	-
	90% OA	1.94	11.13	8.09	15.41	26.33	33.83	12.58	19.80
	100% OA	8.12	19.42	13.63	24.61	42.50	60.46	17.57	76.94

Hotel	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	0.00	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	1.18	1.93	2.56	3.70	1.09	1.81
	60% OA	0.87	2.00	3.11	4.71	6.50	8.73	2.75	10.83
	70% OA	3.58	4.73	6.02	8.18	11.15	14.40	4.75	20.86
	80% OA	6.81	8.07	9.53	12.34	16.25	20.72	7.17	31.98
	90% OA	10.63	11.81	13.15	16.75	21.80	27.69	9.85	44.34
	100% OA	14.82	16.01	17.27	21.61	27.77	35.63	12.80	58.45

Hospital	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	1.49	-	3.34
	50% OA	-	-	-	3.16	4.47	14.03	1.55	28.92
	60% OA	1.60	2.00	3.52	10.36	14.69	30.98	5.47	61.93
	70% OA	6.35	4.73	9.74	20.42	28.56	51.65	11.32	99.96
	80% OA	13.81	8.07	18.60	33.27	45.19	75.34	18.96	142.39
	90% OA	24.06	11.81	29.85	48.47	63.98	101.93	28.17	190.92
	100% OA	36.63	16.01	42.94	65.71	84.43	133.17	38.62	246.73

Office	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	0.27	-	-	-
	60% OA	0.30	-	0.26	0.78	2.81	5.25	0.38	8.81
	70% OA	0.60	0.48	0.76	1.95	6.04	11.77	1.10	26.71
	80% OA	1.21	1.26	1.38	3.40	9.70	20.13	1.78	51.04
	90% OA	2.00	1.99	2.39	5.19	14.33	32.48	2.75	86.99
	100% OA	3.35	3.23	3.50	7.43	19.04	50.61	3.66	136.54

Retail	Symptom	CZ06	CZ08	CZ09	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	-	-	-	-	-	-	-
	70% OA	-	-	-	-	-	-	-	-
	80% OA	-	-	-	-	-	-	-	-
	90% OA	-	-	-	-	-	-	-	-
	100% OA	0.02	0.06	0.03	0.37	1.75	4.26	0.13	19.42

1978-1992 Vintage:

The following five tables represent the "breakpoint" value, beyond which the pre-calculated savings factors are no longer valid for this measure. The breakpoint value was calculated by dividing 75,000 kWh by the kWh/tons savings factor.

Breakpoint Coil Capacity (Sensible Tons)

Education	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	716	640	1,023	794	1,086	1,098	1,302	1,754
	60 Deg Lockout	883	752	1,232	1,054	1,463	1,631	1,455	2,635
	65 Deg Lockout	2,102	1,528	2,441	2,250	2,800	3,362	2,264	6,198
	0% OA	131	115	303	155	299	126	-	84
	10% OA	154	146	382	216	431	200	-	113
	20% OA	181	186	482	310	664	335	-	157
	30% OA	217	242	595	441	1,020	513	-	216
	40% OA	265	321	594	573	1,330	642	-	281
	50% OA	329	434	774	698	1,266	685	-	346
	60% OA	421	623	807	777	998	645	3,016	408
	70% OA	571	920	796	793	724	565	406	448
	80% OA	845	1,421	764	757	541	474	203	461
	90% OA	1,530	2,524	723	678	420	398	137	456
	100% OA	9,050	12,715	715	659	406	452	105	1,198

Hotel	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	316	385	405	472	629	767	772	979
	60 Deg Lockout	618	698	786	983	1,215	1,442	1,352	2,011
	65 Deg Lockout	2,446	2,609	2,865	3,268	3,610	4,440	3,519	6,143
	0% OA	131	156	144	127	136	100	243	67
	10% OA	149	165	166	145	152	120	306	78
	20% OA	166	175	184	164	169	131	308	88
	30% OA	189	189	208	181	189	145	314	98
	40% OA	220	209	240	204	212	161	320	109
	50% OA	265	235	283	233	234	177	325	120
	60% OA	331	267	339	265	258	194	326	130
	70% OA	433	306	413	304	280	210	325	140
	80% OA	604	352	506	346	297	224	319	148
	90% OA	911	408	644	394	313	236	315	156
	100% OA	-	1,167	-	7,306	1,610	5,146	532	-

Hospital	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	120	149	154	164	217	228	249	286
	60 Deg Lockout	495	523	557	132	680	600	624	862
	65 Deg Lockout	13,099	4,602	3,770	2,462	2,402	1,769	1,670	2,684
	0% OA	61	47	68	44	52	35	98	26
	10% OA	59	53	63	50	52	40	94	29
	20% OA	57	57	60	54	50	44	85	32
	30% OA	56	62	57	58	50	51	78	40
	40% OA	55	70	57	66	56	75	75	71
	50% OA	58	89	62	90	70	134	78	168
	60% OA	67	130	74	132	88	231	84	461
	70% OA	85	239	92	211	109	436	87	8,722
	80% OA	116	556	109	329	121	715	83	-
	90% OA	144	3,994	119	527	122	1,114	76	-
	100% OA	181	-	126	1,015	120	1,529	69	-

Office	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	162	213	267	245	273	258	543	283
	60 Deg Lockout	453	518	683	703	918	821	1,105	962
	65 Deg Lockout	2,000	1,773	2,418	2,256	3,028	2,503	2,653	3,207
	0% OA	107	134	188	107	89	51	335	30
	10% OA	114	134	147	118	80	55	311	32
	20% OA	120	128	124	113	74	57	234	34
	30% OA	119	127	112	112	70	62	193	39
	40% OA	122	134	104	114	71	69	172	47
	50% OA	129	143	100	117	72	75	154	55
	60% OA	136	157	98	118	73	82	139	63
	70% OA	148	178	97	122	74	90	125	70
	80% OA	168	216	97	127	75	97	113	74
	90% OA	206	285	99	133	75	103	104	78
	100% OA	280	507	107	159	85	147	100	135

Retail	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	135	171	184	204	289	311	388	348
	60 Deg Lockout	434	493	600	713	1,043	1,004	1,240	1,100
	65 Deg Lockout	1,327	1,290	1,719	1,876	2,744	2,740	2,986	2,865
	0% OA	79	72	116	64	84	52	310	37
	10% OA	80	76	114	72	87	63	334	41
	20% OA	80	82	112	81	91	75	311	46
	30% OA	81	88	110	90	94	86	244	54
	40% OA	84	95	109	101	99	92	200	67
	50% OA	88	104	109	112	107	102	168	87
	60% OA	96	117	111	125	119	117	143	114
	70% OA	110	135	117	143	131	132	124	142
	80% OA	139	167	128	170	140	144	108	167
	90% OA	204	219	145	204	144	160	95	206
	100% OA	378	341	167	300	164	233	86	-

Electric energy savings factors (kWh/tons) were calculated and are presented in the tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

Electric Energy Savings (kWh/tons)

Education	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	104.71	117.14	73.32	94.46	69.08	68.28	57.58	42.76
	60 Deg Lockout	84.95	99.77	60.89	71.17	51.26	45.98	51.55	28.46
	65 Deg Lockout	35.68	49.08	30.72	33.34	26.79	22.31	33.13	12.10
	0% OA	570.73	650.13	247.56	482.42	251.22	593.50	-	891.35
	10% OA	488.52	515.35	196.25	347.54	174.02	374.93	-	664.52
	20% OA	413.89	402.50	155.48	241.82	112.89	224.05	-	477.94
	30% OA	345.29	309.88	125.99	169.96	73.56	146.13	-	346.81
	40% OA	283.18	233.47	126.30	130.89	56.40	116.77	-	267.20
	50% OA	228.23	172.79	96.88	107.46	59.23	109.42	-	216.65
	60% OA	178.08	120.36	92.94	96.58	75.13	116.32	24.87	183.99
	70% OA	131.42	81.56	94.22	94.58	103.59	132.85	184.95	167.50
	80% OA	88.76	52.79	98.19	99.11	138.75	158.25	369.80	162.81
	90% OA	49.02	29.71	103.78	110.70	178.66	188.44	548.41	164.48
	100% OA	8.29	5.90	104.88	113.73	184.83	165.86	713.22	62.61

Hotel	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	237.59	194.87	185.38	158.76	119.24	97.84	97.14	76.58
	60 Deg Lockout	121.43	107.50	95.44	76.31	61.75	52.00	55.47	37.29
	65 Deg Lockout	30.66	28.75	26.18	22.95	20.78	16.89	21.31	12.21
	0% OA	572.70	481.31	522.43	591.73	552.25	749.39	308.51	1,114.93
	10% OA	502.99	454.25	452.49	515.94	493.89	626.32	245.24	956.11
	20% OA	452.87	428.11	406.62	458.48	443.28	571.34	243.63	853.54
	30% OA	397.46	396.04	360.48	415.11	396.91	516.86	238.62	765.32
	40% OA	340.96	358.70	312.66	367.69	354.53	467.00	234.03	689.43
	50% OA	283.39	319.11	265.12	322.35	320.36	423.90	231.02	623.46
	60% OA	226.43	281.32	221.01	283.25	290.62	386.05	230.11	574.80
	70% OA	173.23	244.94	181.54	246.62	268.20	357.88	230.88	536.62
	80% OA	124.17	212.77	148.34	216.74	252.74	335.49	235.19	507.24
	90% OA	82.34	183.94	116.54	190.33	239.61	318.47	237.80	481.17
	100% OA	-	64.28	-	10.27	46.59	14.57	140.92	-

Hospital	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	627.58	504.27	486.63	456.02	345.62	329.55	301.68	262.09
	60 Deg Lockout	151.58	143.30	134.53	570.24	110.25	124.98	120.11	86.97
	65 Deg Lockout	5.73	16.30	19.89	30.46	31.23	42.40	44.91	27.94
	0% OA	1,228.89	1,606.27	1,108.32	1,691.19	1,435.15	2,129.55	762.73	2,881.18
	10% OA	1,264.01	1,426.66	1,182.79	1,489.69	1,453.47	1,866.46	796.97	2,543.36
	20% OA	1,305.44	1,306.97	1,258.28	1,401.46	1,489.43	1,715.17	883.02	2,324.32
	30% OA	1,349.93	1,205.63	1,318.02	1,297.19	1,488.38	1,462.33	964.31	1,878.98
	40% OA	1,360.94	1,070.13	1,316.78	1,131.29	1,350.12	1,001.89	997.29	1,056.09
	50% OA	1,288.54	840.48	1,206.43	837.41	1,064.71	560.12	956.39	446.36
	60% OA	1,126.36	576.43	1,019.77	570.24	849.48	324.13	890.35	162.77
	70% OA	878.12	314.10	816.21	356.19	686.40	171.92	864.52	8.60
	80% OA	648.89	134.77	687.17	227.86	619.35	104.94	905.33	-
	90% OA	519.35	18.78	629.80	142.27	612.96	67.32	985.73	-
	100% OA	413.26	-	594.18	73.92	626.75	49.04	1,085.72	-

Office	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	462.65	351.64	281.41	306.30	275.00	290.41	138.06	265.13
	60 Deg Lockout	165.40	144.69	109.73	106.69	81.67	91.33	67.87	77.97
	65 Deg Lockout	37.51	42.30	31.01	33.24	24.77	29.97	28.27	23.38
	0% OA	698.25	558.29	399.62	699.71	838.92	1,457.29	223.94	2,520.55
	10% OA	660.62	558.85	511.53	635.93	942.03	1,355.13	241.31	2,307.87
	20% OA	623.68	585.78	603.40	665.94	1,019.86	1,314.09	320.43	2,181.50
	30% OA	630.83	588.52	671.68	671.24	1,065.01	1,201.18	388.94	1,915.63
	40% OA	613.72	561.60	719.46	655.04	1,049.50	1,080.97	435.52	1,590.69
	50% OA	583.40	524.01	749.74	642.27	1,041.42	1,000.08	486.48	1,359.77
	60% OA	550.71	479.11	769.17	633.00	1,022.19	911.98	540.10	1,195.07
	70% OA	505.18	420.52	776.28	614.20	1,013.71	830.92	597.83	1,073.87
	80% OA	445.17	347.78	773.14	592.30	1,002.37	770.51	661.23	1,016.47
	90% OA	364.12	262.85	761.08	562.03	999.00	727.65	720.90	955.48
	100% OA	268.29	147.79	703.37	470.33	882.37	509.56	748.09	556.95

Retail	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	555.26	437.42	407.31	366.99	259.52	241.47	193.24	215.48
	60 Deg Lockout	172.66	152.18	124.92	105.13	71.88	74.70	60.46	68.16
	65 Deg Lockout	56.52	58.14	43.62	39.99	27.33	27.38	25.12	26.18
	0% OA	943.70	1,047.76	646.33	1,169.56	896.72	1,432.36	242.22	2,028.92
	10% OA	942.81	982.35	657.67	1,043.52	857.31	1,186.81	224.68	1,832.30
	20% OA	939.75	915.47	668.11	928.85	827.91	996.62	241.19	1,634.79
	30% OA	924.40	851.65	681.74	831.53	796.06	867.44	307.94	1,393.03
	40% OA	894.54	787.89	691.04	743.20	755.36	816.98	375.87	1,116.42
	50% OA	848.20	722.48	689.34	670.94	699.40	737.80	446.00	857.60
	60% OA	780.04	641.41	673.30	602.18	628.25	643.18	525.48	655.05
	70% OA	681.44	554.10	641.66	526.11	572.23	566.71	606.72	529.10
	80% OA	539.17	447.78	587.57	441.23	536.27	521.90	695.01	450.43
	90% OA	368.16	342.77	516.39	367.96	519.22	468.78	787.76	363.30
	100% OA	198.43	219.78	449.78	249.89	456.19	321.69	869.65	-

DEER peak savings factors (kW/tons) were calculated and are presented in the five tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

DEER Peak Savings (kW/tons)

Education	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	-	0.00	-	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	-	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	0.03	-	-	-	-	-	-
	70% OA	-	0.11	-	-	-	-	0.00	-
	80% OA	-	0.19	-	0.03	0.06	0.05	0.12	-
	90% OA	-	0.26	0.05	0.09	0.11	0.12	0.22	-
	100% OA	0.00	0.33	0.11	0.15	0.17	0.19	0.33	0.03

Hotel	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	0.00	-	-	-	0.00	-	-
	50% OA	0.00	0.01	-	0.01	0.01	0.02	-	0.00
	60% OA	0.00	0.02	-	0.02	0.02	0.01	0.01	0.01
	70% OA	0.01	0.03	0.00	0.03	0.04	0.03	0.02	0.01
	80% OA	0.01	0.04	0.01	0.04	0.06	0.06	0.03	0.02
	90% OA	0.01	0.05	0.01	0.05	0.06	0.07	0.04	0.03
	100% OA	0.01	0.06	0.01	0.06	0.07	0.08	0.06	0.03

Hospital	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.20	0.00	0.00	-	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00
	30% OA	0.04	0.03	0.09	0.05	0.09	0.06	0.09	0.02
	40% OA	0.07	0.06	0.17	0.10	0.17	0.10	0.17	0.05
	50% OA	0.10	0.09	0.24	0.15	0.25	0.15	0.25	0.08
	60% OA	0.13	0.13	0.32	0.20	0.33	0.06	0.34	0.10
	70% OA	0.16	0.16	0.40	0.25	0.41	0.22	0.58	0.13
	80% OA	0.18	0.19	0.48	0.30	0.59	0.32	0.72	0.16
	90% OA	0.21	0.22	0.60	0.35	0.80	0.37	0.79	0.19
	100% OA	0.24	0.26	0.80	0.40	0.87	0.47	0.86	0.22

Office	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	-	0.00
	65 Deg Lockout	-	0.00	0.00	0.00	0.00	0.00	-	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	0.02	0.05	0.02	0.06	0.03	0.05	0.02
	30% OA	0.03	0.06	0.14	0.07	0.15	0.08	0.14	0.05
	40% OA	0.07	0.09	0.23	0.13	0.25	0.14	0.23	0.08
	50% OA	0.09	0.13	0.32	0.18	0.35	0.20	0.33	0.11
	60% OA	0.12	0.16	0.40	0.23	0.44	0.08	0.49	0.15
	70% OA	0.14	0.19	0.49	0.28	0.54	0.27	0.69	0.18
	80% OA	0.16	0.23	0.57	0.34	0.79	0.37	0.77	0.21
	90% OA	0.18	0.26	0.66	0.39	0.95	0.44	0.85	0.24
	100% OA	0.20	0.30	0.87	0.45	1.04	0.50	0.96	0.28

Retail	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	0.00	0.00	0.00	0.00	0.00	-	-	0.00
	60 Deg Lockout	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
	65 Deg Lockout	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	0.00	0.02	0.01	0.03	0.00
	50% OA	0.01	0.02	0.07	0.05	0.10	0.07	0.19	0.01
	60% OA	0.03	0.06	0.16	0.11	0.39	0.04	0.41	0.03
	70% OA	0.04	0.09	0.32	0.17	0.46	0.15	0.47	0.05
	80% OA	0.06	0.12	0.55	0.22	0.52	0.25	0.54	0.08
	90% OA	0.07	0.15	0.62	0.34	0.59	0.43	0.61	0.11
	100% OA	0.09	0.18	0.73	0.51	0.66	0.64	0.77	0.13

Gas savings factors (therms/tons) factors were calculated and are presented in the tables below for the five building prototypes and both vintages. The savings were normalized based on sensible cooling coil rated capacity per air handler.

Natural Gas Savings (therms/tons)

Education	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	0.09	-	0.00	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	-	-	-	-	-	0.16	-
	70% OA	-	-	1.07	2.14	3.18	1.89	4.05	-
	80% OA	0.31	6.20	5.63	9.42	16.03	20.42	8.21	5.31
	90% OA	5.46	13.20	10.32	17.28	29.42	40.06	12.50	50.72
	100% OA	11.15	20.68	15.62	25.47	43.10	60.64	16.92	99.36

Hotel	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	0.04	-
	40% OA	0.21	0.41	0.48	0.87	1.26	1.39	0.62	1.31
	50% OA	1.06	1.27	1.46	2.19	3.46	4.33	1.47	6.86
	60% OA	2.10	2.54	2.69	4.02	6.27	7.85	2.66	13.29
	70% OA	3.68	4.22	4.34	6.35	9.43	11.89	4.10	20.35
	80% OA	5.60	6.29	6.81	8.99	13.02	16.29	5.86	27.87
	90% OA	7.94	8.63	9.41	11.96	16.96	21.15	7.74	35.90
	100% OA	10.60	11.18	12.32	15.18	20.94	25.87	9.68	43.38

Hospital	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	3.46
	50% OA	-	-	-	-	-	9.79	-	53.72
	60% OA	-	-	-	-	16.16	46.45	-	118.65
	70% OA	-	-	7.67	22.70	44.34	89.05	8.05	190.53
	80% OA	17.24	21.07	27.68	50.72	76.88	135.24	22.64	265.21
	90% OA	40.10	48.13	51.67	81.82	112.15	183.55	39.10	340.66
	100% OA	66.75	78.13	78.43	115.20	149.04	232.81	56.82	415.64

Office	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	-	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	0.34	-	-	2.26
	50% OA	-	-	-	0.08	2.96	5.09	-	14.02
	60% OA	-	-	0.67	1.98	6.63	11.65	0.45	28.18
	70% OA	-	-	1.73	3.95	10.77	18.75	1.50	44.84
	80% OA	0.53	0.85	2.94	6.53	15.70	27.94	2.59	64.00
	90% OA	2.09	2.61	4.53	9.62	21.22	38.58	3.76	87.35
	100% OA	4.22	4.89	6.50	12.73	26.92	49.51	4.95	113.73

Retail	Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
	55 Deg Lockout	-	-	-	-	-	-	-	-
	60 Deg Lockout	-	-	-	-	-	-	-	-
	65 Deg Lockout	-	-	-	-	-	-	0.07	-
	0% OA	-	-	-	-	-	-	-	-
	10% OA	-	-	-	-	-	-	-	-
	20% OA	-	-	-	-	-	-	-	-
	30% OA	-	-	-	-	-	-	-	-
	40% OA	-	-	-	-	-	-	-	-
	50% OA	-	-	-	-	-	-	-	-
	60% OA	-	-	-	-	-	-	-	-
	70% OA	-	-	-	-	-	-	-	-
	80% OA	0.27	-	0.02	0.40	-	-	-	-
	90% OA	1.15	0.42	0.77	1.77	0.40	2.13	0.58	4.06
	100% OA	2.12	1.69	1.56	2.75	3.45	6.08	1.35	15.29

CONDENSER WATER TEMPERATURE RESET WITH VFD

Measure Description

The "Condenser Water Temperature Reset with VFD" measure is applicable when the condenser water temperature (CWT) is either not resetting properly or reset is not implemented. This measure entails either re-instating or installing reset control so that CWT resets lower when cooling load and/or outdoor conditions are less than peak.

The pre-calculated savings for CWT Reset with VFD are provided as two tables: kWh/yr and DEER Peak kW savings. Both tables are normalized based on tons of rated chiller capacity **served** per building type in each climate zone. It is important to note that the term "served" indicates how much of the chiller capacity should be used when calculating the savings. In instances where there are multiple chillers with dedicated cooling towers, the chiller capacity served would be limited to the cooling tower(s) that have been retrofitted.

How to Use the Pre-Calculated Savings Factors

The following steps describe how to use the pre-calculated savings factors.

1. Establish that the assumptions used for the pre-calculated savings (summarized below) are similar to the proposed project. If the model building characteristics do not sufficiently match the project building's characteristics, then a custom analysis is required.
2. Establish the building's California Climate Zone (CZ), type of building, building vintage, and "connected" chiller rated capacity (tons). It is important to note that the eligible chiller capacity is limited to the cooling tower(s) that is being retrofitted.
3. Determine if the measure is eligible for pre-calculated savings by looking up the allowable chiller capacity size limit using the CZ, type of building, and building vintage. Chiller capacities that are equal to or smaller than the allowable tons size limit are eligible for pre-calculated savings. Chiller capacities that are larger than the allowable tons size limit are not eligible for pre-calculated savings and must use a customized calculation approach to estimate savings.
4. Determine annual electric energy savings by looking up the kWh savings factor using the CZ, type of baseline cooling tower scenario, type of building, and building vintage. Then multiply the factor times the "connected" chiller rated capacity. The product will be the estimated annual electric energy savings.
5. Determine peak demand savings by looking up the kW savings factor using the CZ, type of baseline cooling tower scenario, type of building, and building vintage. Then multiply the factor times the "connected" chiller rated capacity. The product will be the estimated peak demand savings.

Relevant Modeling Assumptions

The pre-calculated savings tables were generated with the following assumptions:

- Open cooling tower with centrifugal fan
- Cooling tower efficiency: 0.0369 kW/ton (1978-1992 vintage) and 0.0352 kW/ton (2005 vintage)
- CWT floats with the load and wet-bulb temperature
- Condenser water loop head and delta T: 40 ft. and 10˚F
- Generic constant speed centrifugal chiller performance curves

ARI Chiller Efficiencies kW/ton

Type	1978-1992	Post 2005
Water cooled	0.750	0.644
Air cooled	1.300	1.260

CWT Reset with VFD Pre-Calculated Savings Tables

The chiller capacity "breakpoint" value for each building prototype and vintage was calculated by dividing the savings cutoff level of 75,000 kWh per measure by the normalized savings (per tons). The breakpoint values are contained in Tables 1 – 10. Projects with chiller capacities beyond what is listed in these tables can not use the pre-calculated savings approach for this measure.

The legend for all tables in this section is as follows:

Symptom	Description
Baseline FS Fan 80°F (1)	Constant Speed Fan, Fixed Condenser Water Temperature 80°F
Baseline FS Fan 85°F (2)	Constant Speed Fan, Fixed Condenser Water Temperature 85°F
Baseline FS Fan 90°F (3)	Constant Speed Fan, Fixed Condenser Water Temperature 90°F
Baseline VS Fan 80°F (4)	Variable Speed Fan, Fixed Condenser Water Temperature 80°F
Baseline VS Fan 85°F (5)	Variable Speed Fan, Fixed Condenser Water Temperature 85°F
Baseline VS Fan 90°F (6)	Variable Speed Fan, Fixed Condenser Water Temperature 90°F
Proposed VS Fan Reset min 70°F (A)	Variable Speed Fan, Condenser Water Temperature Reset, min 70°F
Proposed VS Fan Reset min 75°F (B)	Variable Speed Fan, Condenser Water Temperature Reset, min 70°F

The numbers and letters in parenthesis have been matched up to represent likely measures, for instance:

- Scenario 2A: going from "Constant Speed Fan, Fixed Condenser Water Temperature 85°F" to "Variable Speed Fan, Condenser Water Temperature Reset, min 70°F"
- Scenario 5B: going from "Variable Speed Fan, Fixed Condenser Water Temperature 85°F" to "Variable Speed Fan, Condenser Water Temperature Reset, min 75°F"

Sample Calculation

Baseline: Office Building in CZ06, Post 2005 Vintage, 400-ton Constant Speed Centrifugal Chiller, Variable Speed Cooling Tower Fan, Fixed Condenser Water Temperature 85°F. Implementing Scenario 5A: going from "Variable Speed Fan, Fixed Condenser Water Temperature 85°F" to "Variable Speed Fan, Condenser Water Temperature Reset, min 70°F"

Step 1 – Check Measure Eligibility:

Breakpoint Capacity = 427 tons (move to Step 2)

Step 2 – Lookup kWh/tons Savings Factor in Table and Calculate Savings:

400 tons x 176 kWh/tons = 70,400 kWh/yr

Step 3 – Lookup kW/tons Savings Factor in Table and Calculate Savings:

400 tons x 0.057 kW/tons = 22.8 kW

Post 2005 Vintage:

Table 1. Office CWT Reset Pre-Calculated Savings Breakpoint (tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	786	733	683	694	681	719	546	1,364
Scenario 1B	2,207	1,860	1,807	1,924	1,725	2,535	1,350	4,597
Scenario 2A	413	384	357	368	360	383	291	709
Scenario 2B	625	564	530	558	529	619	427	1,118
Scenario 3A	259	241	224	233	227	245	185	444
Scenario 3B	329	300	281	297	284	324	231	576
Scenario 4A	859	819	757	762	758	765	619	1,458
Scenario 4B	2,907	2,532	2,436	2,561	2,329	3,231	1,902	5,868
Scenario 5A	427	400	371	381	374	392	306	726
Scenario 5B	656	598	560	588	561	644	458	1,160
Scenario 6A	263	245	227	237	231	247	189	449
Scenario 6B	335	307	286	303	290	329	237	584

Table 2. Retail CWT Reset Pre-Calculated Savings Breakpoint (tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	1,628	1,622	1,467	1,544	1,500	1,547	1,052	1,087
Scenario 1B	4,376	3,555	3,452	3,413	3,061	4,227	2,199	2,179
Scenario 2A	849	853	767	834	804	864	560	678
Scenario 2B	1,264	1,195	1,098	1,183	1,105	1,338	774	987
Scenario 3A	529	536	480	532	510	566	344	480
Scenario 3B	664	653	592	655	618	737	415	616
Scenario 4A	1,795	1,858	1,665	1,747	1,724	1,684	1,207	1,111
Scenario 4B	5,831	4,922	4,795	4,588	4,161	5,434	3,005	2,276
Scenario 5A	880	899	805	876	849	896	592	681
Scenario 5B	1,333	1,286	1,176	1,270	1,194	1,416	837	992
Scenario 6A	537	549	491	545	524	577	353	480
Scenario 6B	678	673	608	675	638	756	428	617

Table 3. Hotel CWT Reset Pre-Calculated Savings Breakpoint (tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	872	853	840	830	843	835	683	1,227
Scenario 1B	3,154	2,757	2,754	2,789	2,593	3,555	1,930	5,719
Scenario 2A	436	428	421	422	428	424	355	598
Scenario 2B	682	656	646	656	652	694	535	969
Scenario 3A	265	261	257	260	264	264	223	361
Scenario 3B	340	332	326	333	334	348	282	470
Scenario 4A	921	915	901	887	911	873	751	1,274
Scenario 4B	3,911	3,530	3,530	3,563	3,377	4,353	2,590	6,896
Scenario 5A	443	438	431	432	440	431	368	605
Scenario 5B	701	679	669	680	680	712	564	988
Scenario 6A	267	264	259	263	267	266	226	363
Scenario 6B	343	336	330	338	339	351	288	473

Table 4. Education CWT Reset Pre-Calculated Savings Breakpoint (tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	1,108	1,156	1,031	966	844	914	502	2,323
Scenario 1B	2,026	1,861	1,717	1,704	1,395	1,808	800	4,625
Scenario 2A	691	728	647	616	539	583	324	1,442
Scenario 2B	962	955	864	851	721	851	427	2,087
Scenario 3A	484	507	451	433	378	414	228	1,018
Scenario 3B	604	609	546	538	460	533	274	1,301
Scenario 4A	1,174	1,336	1,164	1,052	960	948	600	2,379
Scenario 4B	2,257	2,375	2,120	1,992	1,743	1,944	1,082	4,849
Scenario 5A	699	757	667	627	556	586	341	1,449
Scenario 5B	979	1,006	899	872	752	857	456	2,102
Scenario 6A	485	512	453	435	381	414	231	1,019
Scenario 6B	605	616	550	540	463	534	279	1,303

Table 5. Hospital CWT Reset Pre-Calculated Savings Breakpoint (tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	279	268	265	277	275	305	213	523
Scenario 1B	1,057	877	908	991	890	1,479	630	2,619
Scenario 2A	140	137	134	142	142	153	113	253
Scenario 2B	222	213	210	224	220	255	174	412
Scenario 3A	86	85	82	88	88	95	71	152
Scenario 3B	111	109	106	113	112	126	91	198
Scenario 4A	305	302	297	307	311	324	247	554
Scenario 4B	1,560	1,392	1,423	1,525	1,415	2,053	1,058	3,624
Scenario 5A	144	143	139	146	147	156	118	257
Scenario 5B	231	226	221	235	233	263	187	423
Scenario 6A	86	86	83	88	89	96	72	153
Scenario 6B	112	110	107	115	114	127	93	199

1978 - 1992 Vintage:

Table 6. Office CWT Reset Pre-Calculated Savings Breakpoint (tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	568	523	542	528	262	628	409	1,091
Scenario 1B	1,219	1,010	1,068	1,096	339	1,634	752	2,675
Scenario 2A	361	341	352	341	362	384	273	669
Scenario 2B	547	498	518	511	527	617	392	1,051
Scenario 3A	258	246	253	246	550	273	199	472
Scenario 3B	340	317	328	323	1,050	373	255	634
Scenario 4A	772	758	778	735	804	791	625	1,399
Scenario 4B	2,810	2,513	2,650	2,621	2,644	3,510	2,048	5,790
Scenario 5A	408	397	408	390	423	422	326	738
Scenario 5B	663	626	648	631	668	720	512	1,231
Scenario 6A	271	263	270	260	281	284	215	492
Scenario 6B	364	347	358	350	371	394	283	670

Table 7. Retail CWT Reset Pre-Calculated Savings Breakpoint (tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	523	448	457	428	454	486	339	351
Scenario 1B	1,059	765	815	742	748	1,042	551	463
Scenario 2A	335	299	301	286	304	311	231	501
Scenario 2B	496	413	424	398	413	474	313	766
Scenario 3A	239	218	219	210	223	223	170	351
Scenario 3B	311	273	277	264	276	296	211	463
Scenario 4A	734	710	707	663	741	667	570	1,091
Scenario 4B	2,535	2,058	2,201	1,924	2,063	2,492	1,621	4,419
Scenario 5A	385	366	364	348	380	359	293	565
Scenario 5B	614	552	561	531	566	593	439	925
Scenario 6A	254	239	238	230	247	239	190	370
Scenario 6B	337	307	309	297	314	325	243	496

Table 8. Hotel CWT Reset Pre-Calculated Savings Breakpoint (tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	329	320	319	319	322	352	272	464
Scenario 1B	915	801	796	818	769	1,141	577	1,673
Scenario 2A	190	189	189	188	193	199	170	253
Scenario 2B	301	293	292	295	295	327	254	417
Scenario 3A	127	128	128	128	132	135	119	167
Scenario 3B	169	168	168	170	173	184	155	226
Scenario 4A	401	409	409	403	420	414	380	531
Scenario 4B	1,843	1,743	1,760	1,767	1,753	2,226	1,454	3,086
Scenario 5A	204	207	207	206	213	212	195	265
Scenario 5B	338	338	338	340	347	364	313	453
Scenario 6A	131	133	133	133	137	138	126	170
Scenario 6B	176	177	177	179	183	190	167	232

Table 9. Education CWT Reset Pre-Calculated Savings Breakpoint (tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	770	559	606	493	459	491	285	1,032
Scenario 1B	1,448	941	1,044	888	783	991	469	2,068
Scenario 2A	481	353	381	314	292	310	183	644
Scenario 2B	679	474	518	438	397	456	244	937
Scenario 3A	338	248	267	222	206	221	129	456
Scenario 3B	426	302	328	277	252	285	156	585
Scenario 4A	804	626	670	530	512	502	333	1,054
Scenario 4B	1,573	1,148	1,251	1,018	948	1,039	614	2,161
Scenario 5A	485	363	390	319	300	311	191	646
Scenario 5B	687	493	535	447	411	458	258	942
Scenario 6A	339	249	268	222	207	221	130	456
Scenario 6B	426	304	329	278	254	285	158	585

Table 10. Hospital CWT Reset Pre-Calculated Savings Breakpoint (tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	292	280	290	293	301	348	250	514
Scenario 1B	670	600	639	661	641	981	511	1,655
Scenario 2A	193	186	190	191	199	209	162	295
Scenario 2B	306	289	296	301	307	342	243	488
Scenario 3A	129	126	127	129	134	141	111	191
Scenario 3B	171	165	168	171	176	190	144	257
Scenario 4A	415	410	417	419	442	450	368	636
Scenario 4B	2,088	1,868	1,958	2,037	1,991	2,743	1,506	4,300
Scenario 5A	210	186	211	213	224	228	188	312
Scenario 5B	353	289	349	356	370	394	306	536
Scenario 6A	136	134	136	137	145	148	122	197
Scenario 6B	184	180	182	186	194	203	163	269

Normalized energy savings (kWh/tons) are presented in Tables 11 through 20 for all building types, vintages, and climate zone categories. To determine the savings in kWh per year for a specific building type and climate zone category, multiply the factors listed in the table by the "connected" chiller capacity rating.

Post 2005 Vintage:

Table 11. Office CWT Reset Pre-Calculated Savings (kWh/tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	95	102	110	108	110	104	137	55
Scenario 1B	34	40	42	39	43	30	56	16
Scenario 2A	182	195	210	204	209	196	257	106
Scenario 2B	120	133	142	134	142	121	176	67
Scenario 3A	290	312	336	322	331	306	406	169
Scenario 3B	228	250	267	252	264	232	325	130
Scenario 4A	87	92	99	98	99	98	121	51
Scenario 4B	26	30	31	29	32	23	39	13
Scenario 5A	176	187	202	197	200	191	245	103
Scenario 5B	114	125	134	128	134	117	164	65
Scenario 6A	286	306	330	317	325	303	398	167
Scenario 6B	224	244	262	247	258	228	316	128

Table 12. Retail CWT Reset Pre-Calculated Savings (kWh/tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	46	46	51	49	50	48	71	69
Scenario 1B	17	21	22	22	24	18	34	34
Scenario 2A	88	88	98	90	93	87	134	111
Scenario 2B	59	63	68	63	68	56	97	76
Scenario 3A	142	140	156	141	147	133	218	156
Scenario 3B	113	115	127	114	121	102	181	122
Scenario 4A	42	40	45	43	44	45	62	68
Scenario 4B	13	15	16	16	18	14	25	33
Scenario 5A	85	83	93	86	88	84	127	110
Scenario 5B	56	58	64	59	63	53	90	76
Scenario 6A	140	137	153	138	143	130	212	156
Scenario 6B	111	112	123	111	118	99	175	122

Table 13. Hotel CWT Reset Pre-Calculated Savings (kWh/tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	86	88	89	90	89	90	110	61
Scenario 1B	24	27	27	27	29	21	39	13
Scenario 2A	172	175	178	178	175	177	211	125
Scenario 2B	110	114	116	114	115	108	140	77
Scenario 3A	283	287	292	288	285	284	337	208
Scenario 3B	220	226	230	225	224	216	266	160
Scenario 4A	81	82	83	85	82	86	100	59
Scenario 4B	19	21	21	21	22	17	29	11
Scenario 5A	169	171	174	174	170	174	204	124
Scenario 5B	107	110	112	110	110	105	133	76
Scenario 6A	281	284	289	286	281	282	332	207
Scenario 6B	219	223	227	222	221	214	261	159

Table 14. Education CWT Reset Pre-Calculated Savings (kWh/tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	68	65	73	78	89	82	149	32
Scenario 1B	37	40	44	44	54	41	94	16
Scenario 2A	109	103	116	122	139	129	231	52
Scenario 2B	78	78	87	88	104	88	176	36
Scenario 3A	155	148	166	173	198	181	329	74
Scenario 3B	124	123	137	139	163	141	274	58
Scenario 4A	64	56	64	71	78	79	125	32
Scenario 4B	33	32	35	38	43	39	69	15
Scenario 5A	107	99	113	120	135	128	220	52
Scenario 5B	77	75	83	86	100	88	164	36
Scenario 6A	155	146	165	172	197	181	324	74
Scenario 6B	124	122	136	139	162	141	269	58

Table 15. Hospital CWT Reset Pre-Calculated Savings (kWh/tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	269	280	283	270	272	246	352	143
Scenario 1B	71	86	83	76	84	51	119	29
Scenario 2A	535	546	558	530	529	489	665	297
Scenario 2B	338	352	358	335	341	294	432	182
Scenario 3A	876	885	910	857	855	788	1,057	493
Scenario 3B	678	691	710	662	667	593	824	379
Scenario 4A	246	248	253	244	241	232	304	135
Scenario 4B	48	54	53	49	53	37	71	21
Scenario 5A	522	526	540	513	510	480	634	292
Scenario 5B	324	332	340	319	322	285	400	177
Scenario 6A	869	875	901	849	846	785	1,040	491
Scenario 6B	672	681	701	654	657	590	807	377

1978 - 1992 Vintage:

Table 16. Office CWT Reset Pre-Calculated Savings (kWh/tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	132	143	138	142	286	119	183	69
Scenario 1B	62	74	70	68	221	46	100	28
Scenario 2A	207	220	213	220	207	195	275	112
Scenario 2B	137	151	145	147	142	122	191	71
Scenario 3A	291	305	296	305	136	275	378	159
Scenario 3B	220	236	228	232	71	201	294	118
Scenario 4A	97	99	96	102	93	95	120	54
Scenario 4B	27	30	28	29	28	21	37	13
Scenario 5A	184	189	184	192	177	178	230	102
Scenario 5B	113	120	116	119	112	104	146	61
Scenario 6A	276	286	278	288	267	264	348	153
Scenario 6B	206	216	210	215	202	190	265	112

Table 17. Retail CWT Reset Pre-Calculated Savings (kWh/tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	143	167	164	175	165	154	221	214
Scenario 1B	71	98	92	101	100	72	136	162
Scenario 2A	224	251	249	262	246	241	325	150
Scenario 2B	151	182	177	188	181	158	239	98
Scenario 3A	314	344	343	358	336	336	440	214
Scenario 3B	241	275	271	284	271	253	355	162
Scenario 4A	102	106	106	113	101	112	132	69
Scenario 4B	30	36	34	39	36	30	46	17
Scenario 5A	195	205	206	215	197	209	256	133
Scenario 5B	122	136	134	141	132	127	171	81
Scenario 6A	295	314	315	326	304	313	394	203
Scenario 6B	223	244	243	252	239	231	309	151

Table 18. Hotel CWT Reset Pre-Calculated Savings (kWh/tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	228	234	235	235	233	213	275	162
Scenario 1B	82	94	94	92	98	66	130	45
Scenario 2A	395	396	398	398	390	377	441	297
Scenario 2B	249	256	257	254	254	229	295	180
Scenario 3A	589	586	588	584	570	556	629	449
Scenario 3B	443	445	447	440	434	409	484	332
Scenario 4A	187	183	183	186	178	181	197	141
Scenario 4B	41	43	43	42	43	34	52	24
Scenario 5A	368	362	363	364	352	354	385	283
Scenario 5B	222	222	222	220	216	206	240	166
Scenario 6A	572	564	565	563	546	543	593	441
Scenario 6B	425	424	424	419	410	395	448	324

Table 19. Education CWT Reset Pre-Calculated Savings (kWh/tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	97	134	124	152	163	153	263	73
Scenario 1B	52	80	72	84	96	76	160	36
Scenario 2A	156	213	197	239	257	242	411	116
Scenario 2B	110	158	145	171	189	164	307	80
Scenario 3A	222	303	281	339	365	340	583	165
Scenario 3B	176	248	229	271	297	263	480	128
Scenario 4A	93	120	112	141	147	149	225	71
Scenario 4B	48	65	60	74	79	72	122	35
Scenario 5A	155	207	192	235	250	241	393	116
Scenario 5B	109	152	140	168	182	164	290	80
Scenario 6A	221	301	280	338	363	340	577	165
Scenario 6B	176	247	228	270	295	263	474	128

Table 20. Hospital CWT Reset Pre-Calculated Savings (kWh/tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	257	268	259	256	249	216	301	146
Scenario 1B	112	125	117	113	117	76	147	45
Scenario 2A	389	402	395	392	376	359	463	254
Scenario 2B	245	259	253	249	244	219	309	154
Scenario 3A	582	597	589	582	558	533	676	392
Scenario 3B	438	455	447	439	426	394	522	291
Scenario 4A	181	183	180	179	170	166	204	118
Scenario 4B	36	40	38	37	38	27	50	17
Scenario 5A	357	402	356	353	335	329	399	241
Scenario 5B	212	259	215	211	202	190	245	140
Scenario 6A	553	559	553	546	519	508	615	380
Scenario 6B	408	416	412	403	387	369	461	279

Normalized DEER kW savings (kWh/tons) are presented in Tables 21 through 30 for all building types, vintages, and climate zone categories. To determine the DEER kW savings for a specific building type and climate zone category, multiply the factors listed in the table by the "connected" chiller capacity rating.

Post 2005 Vintage:

Table 21. Office CWT Reset Pre-Calculated Savings (DEER kW/tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.034	0.044	0.017	0.040	0.022	0.047	0.019	0.043
Scenario 1B	0.021	0.019	0.017	0.024	0.017	0.024	0.018	0.019
Scenario 2A	0.061	0.075	0.037	0.071	0.045	0.080	0.039	0.074
Scenario 2B	0.048	0.050	0.037	0.055	0.040	0.057	0.038	0.049
Scenario 3A	0.095	0.112	0.074	0.108	0.084	0.119	0.077	0.110
Scenario 3B	0.082	0.087	0.074	0.092	0.079	0.096	0.076	0.086
Scenario 4A	0.028	0.039	0.006	0.033	0.012	0.040	0.008	0.038
Scenario 4B	0.015	0.014	0.006	0.017	0.007	0.017	0.007	0.013
Scenario 5A	0.057	0.071	0.028	0.066	0.036	0.075	0.031	0.070
Scenario 5B	0.043	0.046	0.028	0.050	0.031	0.052	0.030	0.045
Scenario 6A	0.092	0.109	0.067	0.104	0.078	0.115	0.070	0.107
Scenario 6B	0.079	0.084	0.067	0.088	0.073	0.092	0.069	0.083

Table 22. Retail CWT Reset Pre-Calculated Savings (DEER kW/tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.015	0.021	0.007	0.019	0.010	0.023	0.008	0.039
Scenario 1B	0.010	0.010	0.007	0.015	0.009	0.016	0.008	0.020
Scenario 2A	0.028	0.035	0.017	0.035	0.023	0.040	0.045	0.063
Scenario 2B	0.023	0.024	0.017	0.031	0.022	0.033	0.045	0.045
Scenario 3A	0.043	0.051	0.036	0.054	0.058	0.060	0.094	0.091
Scenario 3B	0.039	0.040	0.036	0.049	0.057	0.052	0.094	0.072
Scenario 4A	0.012	0.018	0.001	0.016	0.005	0.019	0.004	0.038
Scenario 4B	0.007	0.008	0.001	0.012	0.004	0.012	0.004	0.019
Scenario 5A	0.025	0.033	0.013	0.032	0.018	0.037	0.042	0.063
Scenario 5B	0.021	0.022	0.013	0.028	0.017	0.030	0.042	0.045
Scenario 6A	0.041	0.049	0.032	0.051	0.055	0.057	0.091	0.091
Scenario 6B	0.037	0.038	0.032	0.047	0.054	0.050	0.091	0.072

Table 23. Hotel CWT Reset Pre-Calculated Savings (DEER kW/tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.017	0.023	0.008	0.021	0.010	0.025	0.010	0.021
Scenario 1B	0.009	0.010	0.008	0.012	0.008	0.012	0.009	0.009
Scenario 2A	0.030	0.039	0.017	0.037	0.021	0.042	0.020	0.036
Scenario 2B	0.022	0.026	0.017	0.028	0.019	0.029	0.020	0.024
Scenario 3A	0.047	0.058	0.034	0.056	0.040	0.062	0.038	0.055
Scenario 3B	0.039	0.045	0.034	0.047	0.038	0.049	0.038	0.042
Scenario 4A	0.014	0.020	0.003	0.018	0.006	0.022	0.005	0.019
Scenario 4B	0.006	0.007	0.003	0.009	0.003	0.009	0.004	0.006
Scenario 5A	0.028	0.037	0.013	0.034	0.017	0.040	0.016	0.035
Scenario 5B	0.021	0.024	0.013	0.025	0.015	0.027	0.015	0.022
Scenario 6A	0.046	0.056	0.031	0.054	0.037	0.060	0.035	0.053
Scenario 6B	0.038	0.043	0.031	0.045	0.034	0.047	0.034	0.041

Table 24. Education CWT Reset Pre-Calculated Savings (DEER kW/tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.019	0.060	0.026	0.032	0.033	0.041	0.029	0.021
Scenario 1B	0.012	0.036	0.026	0.021	0.029	0.025	0.027	0.011
Scenario 2A	0.035	0.086	0.033	0.047	0.047	0.059	0.046	0.034
Scenario 2B	0.027	0.062	0.033	0.036	0.043	0.043	0.044	0.024
Scenario 3A	0.051	0.119	0.050	0.068	0.070	0.083	0.068	0.048
Scenario 3B	0.044	0.095	0.050	0.057	0.066	0.067	0.066	0.038
Scenario 4A	0.019	0.051	0.005	0.027	0.010	0.035	0.005	0.021
Scenario 4B	0.012	0.027	0.005	0.015	0.006	0.019	0.004	0.011
Scenario 5A	0.035	0.084	0.024	0.046	0.035	0.058	0.032	0.034
Scenario 5B	0.027	0.059	0.024	0.035	0.031	0.041	0.031	0.024
Scenario 6A	0.051	0.119	0.047	0.068	0.064	0.083	0.063	0.048
Scenario 6B	0.044	0.094	0.047	0.057	0.060	0.067	0.062	0.038

Table 25. Hospital CWT Reset Pre-Calculated Savings (DEER kW/tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.055	0.063	0.053	0.067	0.063	0.071	0.058	0.059
Scenario 1B	0.029	0.024	0.053	0.032	0.051	0.031	0.050	0.022
Scenario 2A	0.098	0.112	0.076	0.116	0.093	0.123	0.084	0.106
Scenario 2B	0.072	0.073	0.076	0.081	0.081	0.083	0.077	0.069
Scenario 3A	0.155	0.169	0.131	0.176	0.151	0.186	0.136	0.161
Scenario 3B	0.129	0.130	0.131	0.142	0.139	0.146	0.128	0.124
Scenario 4A	0.042	0.054	0.023	0.053	0.037	0.058	0.032	0.050
Scenario 4B	0.015	0.014	0.023	0.018	0.025	0.018	0.024	0.013
Scenario 5A	0.089	0.105	0.055	0.106	0.073	0.114	0.064	0.100
Scenario 5B	0.063	0.066	0.055	0.071	0.061	0.073	0.057	0.062
Scenario 6A	0.149	0.167	0.118	0.170	0.138	0.179	0.126	0.159
Scenario 6B	0.123	0.127	0.118	0.135	0.126	0.139	0.118	0.122

1978-1992 Vintage:

Table 26. Office CWT Reset Pre-Calculated Savings (DEER kW/tons)

Office								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.050	0.053	0.046	0.053	0.075	0.055	0.047	0.053
Scenario 1B	0.036	0.030	0.046	0.038	0.071	0.036	0.045	0.030
Scenario 2A	0.067	0.074	0.052	0.071	0.057	0.075	0.055	0.073
Scenario 2B	0.053	0.051	0.052	0.056	0.054	0.055	0.054	0.051
Scenario 3A	0.086	0.094	0.068	0.092	0.049	0.095	0.073	0.094
Scenario 3B	0.073	0.072	0.068	0.077	0.045	0.075	0.071	0.071
Scenario 4A	0.026	0.034	0.007	0.028	0.012	0.032	0.008	0.033
Scenario 4B	0.012	0.011	0.007	0.013	0.008	0.012	0.006	0.011
Scenario 5A	0.050	0.059	0.021	0.053	0.028	0.058	0.024	0.059
Scenario 5B	0.036	0.037	0.021	0.038	0.024	0.038	0.022	0.036
Scenario 6A	0.075	0.086	0.046	0.080	0.053	0.085	0.050	0.086
Scenario 6B	0.062	0.064	0.046	0.065	0.049	0.065	0.048	0.064

Table 27. Retail CWT Reset Pre-Calculated Savings (DEER kW/tons)

Retail								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.052	0.062	0.049	0.065	0.055	0.069	0.054	0.109
Scenario 1B	0.042	0.038	0.049	0.055	0.053	0.054	0.054	0.085
Scenario 2A	0.070	0.084	0.060	0.086	0.070	0.087	0.069	0.086
Scenario 2B	0.060	0.061	0.060	0.076	0.068	0.072	0.069	0.062
Scenario 3A	0.092	0.107	0.075	0.117	0.090	0.123	0.090	0.109
Scenario 3B	0.081	0.084	0.075	0.107	0.088	0.108	0.090	0.085
Scenario 4A	0.025	0.037	0.002	0.030	0.009	0.035	0.007	0.038
Scenario 4B	0.014	0.014	0.002	0.020	0.007	0.020	0.006	0.014
Scenario 5A	0.050	0.065	0.021	0.060	0.030	0.067	0.029	0.066
Scenario 5B	0.039	0.042	0.021	0.051	0.028	0.051	0.029	0.042
Scenario 6A	0.077	0.096	0.053	0.095	0.066	0.103	0.065	0.097
Scenario 6B	0.067	0.073	0.053	0.086	0.064	0.087	0.065	0.073

Table 28. Hotel CWT Reset Pre-Calculated Savings (DEER kW/tons)

Hotel								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.045	0.055	0.043	0.052	0.046	0.055	0.046	0.052
Scenario 1B	0.030	0.032	0.043	0.038	0.043	0.036	0.045	0.030
Scenario 2A	0.062	0.076	0.048	0.071	0.055	0.075	0.054	0.073
Scenario 2B	0.047	0.053	0.048	0.056	0.051	0.055	0.053	0.051
Scenario 3A	0.082	0.097	0.064	0.091	0.072	0.094	0.072	0.093
Scenario 3B	0.067	0.074	0.064	0.076	0.069	0.075	0.070	0.071
Scenario 4A	0.026	0.035	0.005	0.028	0.008	0.032	0.008	0.033
Scenario 4B	0.011	0.012	0.005	0.013	0.005	0.013	0.006	0.011
Scenario 5A	0.048	0.060	0.019	0.052	0.024	0.057	0.023	0.059
Scenario 5B	0.033	0.038	0.019	0.038	0.021	0.038	0.022	0.036
Scenario 6A	0.073	0.088	0.043	0.079	0.050	0.085	0.049	0.086
Scenario 6B	0.058	0.066	0.043	0.064	0.047	0.065	0.048	0.064

Table 29. Education CWT Reset Pre-Calculated Savings (DEER kW/tons)

Education								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.030	0.085	0.038	0.056	0.048	0.065	0.048	0.041
Scenario 1B	0.018	0.048	0.038	0.036	0.042	0.038	0.045	0.021
Scenario 2A	0.051	0.125	0.054	0.083	0.073	0.094	0.077	0.067
Scenario 2B	0.039	0.088	0.054	0.063	0.067	0.067	0.074	0.047
Scenario 3A	0.075	0.172	0.085	0.119	0.111	0.133	0.116	0.095
Scenario 3B	0.063	0.135	0.085	0.099	0.105	0.106	0.113	0.075
Scenario 4A	0.028	0.075	0.006	0.047	0.014	0.056	0.009	0.040
Scenario 4B	0.017	0.038	0.006	0.027	0.008	0.030	0.006	0.021
Scenario 5A	0.051	0.121	0.039	0.081	0.055	0.092	0.056	0.067
Scenario 5B	0.039	0.084	0.039	0.061	0.049	0.066	0.053	0.047
Scenario 6A	0.075	0.172	0.078	0.119	0.102	0.133	0.109	0.095
Scenario 6B	0.063	0.135	0.078	0.099	0.096	0.106	0.106	0.075

Table 30. Hospital CWT Reset Pre-Calculated Savings (DEER kW/tons)

Hospital								
Symptom	CZ6	CZ8	CZ9	CZ10	CZ13	CZ14	CZ15	CZ16
Scenario 1A	0.057	0.050	0.033	0.047	0.039	0.049	0.039	0.060
Scenario 1B	0.039	0.026	0.032	0.028	0.033	0.027	0.034	0.037
Scenario 2A	0.069	0.075	0.050	0.076	0.057	0.077	0.057	0.072
Scenario 2B	0.051	0.052	0.050	0.056	0.051	0.055	0.053	0.050
Scenario 3A	0.097	0.105	0.080	0.106	0.088	0.108	0.088	0.102
Scenario 3B	0.079	0.082	0.079	0.086	0.081	0.086	0.084	0.079
Scenario 4A	0.029	0.033	0.014	0.031	0.020	0.033	0.018	0.032
Scenario 4B	0.010	0.009	0.013	0.011	0.014	0.011	0.014	0.009
Scenario 5A	0.054	0.075	0.029	0.058	0.036	0.060	0.035	0.059
Scenario 5B	0.036	0.052	0.029	0.038	0.030	0.038	0.031	0.036
Scenario 6A	0.083	0.091	0.057	0.089	0.065	0.091	0.064	0.088
Scenario 6B	0.064	0.067	0.057	0.069	0.059	0.069	0.060	0.065

6. CONCLUSIONS AND RECOMMENDATIONS

The pre-calculated savings approach has the potential to significantly improve RCx program application processes and decrease participation as well as administrative costs. However, this approach has limitations:

- The pre-calculated savings were developed with specific assumptions, which may create large errors when applied to some projects.
- The numerous tables may be difficult to use by program participants and could cause errors in submitted application documentation.
- Tier 1 equipment size limit qualifiers can result in cases where the actual project savings, as calculated with the pre-calculated savings, may exceed the 75,000 kWh limit. This especially may be an issue in cases where operating time is used in the normalization of the savings.

The following are recommendations for further research to improve the pre-calculated savings approach.

- Improved Tier 1 equipment size limit qualifiers. Qualifying measures for Tier 1 should, in some cases, include operating time.
- Better user guidance for how to proceed when actual project conditions are significantly different from the pre-calculated savings assumptions.
- RCx pre-calculated savings tool development. Currently the pre-calculated factors are summarized in several tables per measure. Developing a computerized software tool with dynamic inputs and associated instructions would limit the errors associated with the tables.
- Utilize market feedback to improve and or expand the pre-calculated savings.

7. APPENDICES

ANALYSIS OF RETROCOMMISSIONING MEASURES REPORT

Below is reproduced the report titled "Analysis of Retrocommissioning Measures from SCE's 2006-2008 Retrocommissioning Program, Measure Type Prevalence, Comparison of Custom and DEER Savings Calculations," by Portland Energy Conservation, Inc., by Dave Moser, Mark Effinger, Chris Morales, August 7, 2009.

Analysis of Retrocommissioning Measures from SCE's 2006-2008 Retrocommissioning Program

Measure Type Prevalence

Comparison of Custom and DEER Savings Calculations

Prepared for SCE by:

Portland Energy Conservation, Inc.

Dave Moser, Mark Effinger, Chris Morales

August 7, 2009

Measure Type Prevalence

The analyses in this report were conducted using Master List of Findings (MLF) approved savings from findings identified in the 2006-2008 SCE retrocommissioning (RCx) program. The measure types in Figure 1 below are ranked in order of electric kWh savings. SCE identified 18 common measures for a more detailed analysis (indicated in the red box on the left in Figure 1). These 18 measures account for 80% of program kWh savings.

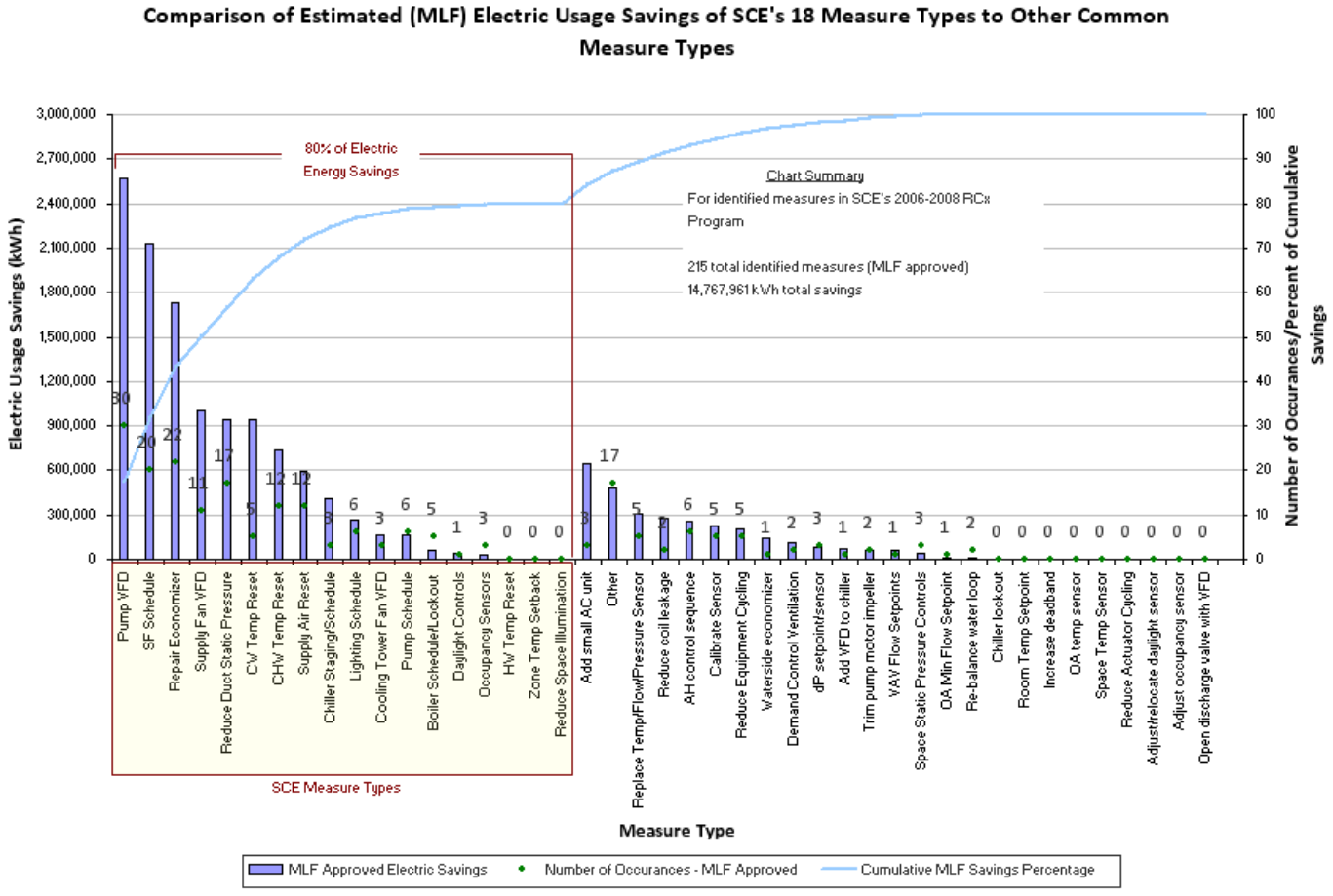


Figure 1: SCE common measures (ranked by savings)

Comparison of Custom and DEER Savings Calculations

The calculation and approval of custom savings for RCx measures proved to be labor and time intensive during the 2006-2008 RCx program cycle, which was noted in the recently published process evaluation for the Program. SCE is looking to use a deemed savings methodology (DEER or otherwise) as an option for providing a faster and less contentious method for claiming savings, with a minimal impact on program-wide accuracy. In order to help determine the validity of using a deemed savings method, an analysis was conducted on the differences between the original approved savings and the savings calculated from the DEER database.

Figure 2 is a zoomed-in view of the 18 measures SCE selected, from Figure 1. Nine of these measures are included in the DEER database, and were included in this custom to DEER savings comparison study. The DEER savings were calculated using inputs from the original calculation files.

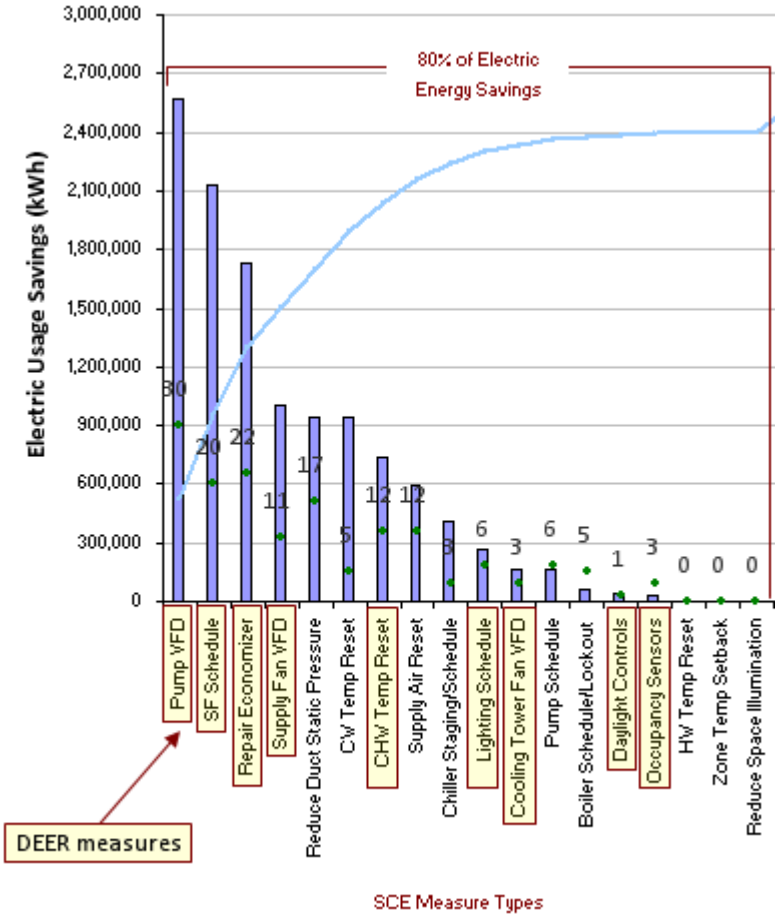


Figure 2: SCE measures identified for further study

Not all of the DEER measures were easily mapped directly to the SCE measures – additional analysis was required. For example, the SCE pump VFD retrofit included all pumps (chilled water, heating hot water, domestic water), while DEER had separate values reported for each pump type. The applicable pump was determined from the project files and compared with the matching DEER measure. Additional notes are provided in the project-specific results later in the report.

Figure 3 shows the overall results from the DEER vs. custom savings comparison. DEER reported significantly more savings than the custom calculations when all project samples were used (up to 12 project samples per measure, wherever available).

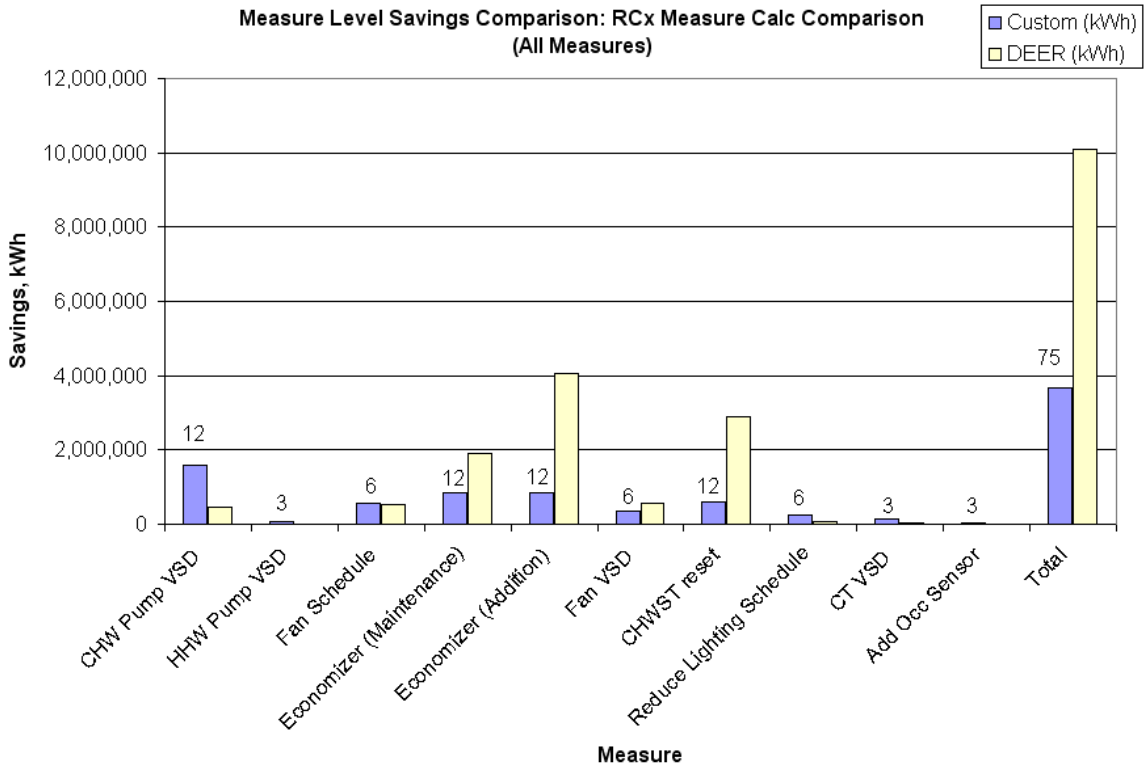


Figure 3: All measure comparison

SCE expressed a desire to cap the use of deemed savings at 75,000 kWh. This cap was chosen to incorporate a large percentage of measures and a relatively low percentage of total program savings. Measures less than 75,000 kWh of savings make up 68% of all measures, but account for only 23% of program savings. Figure 4 shows the results of the capped measure comparison. Notice that the cumulative DEER savings is now more conservative than the custom when the 75,000 kWh cap is used.

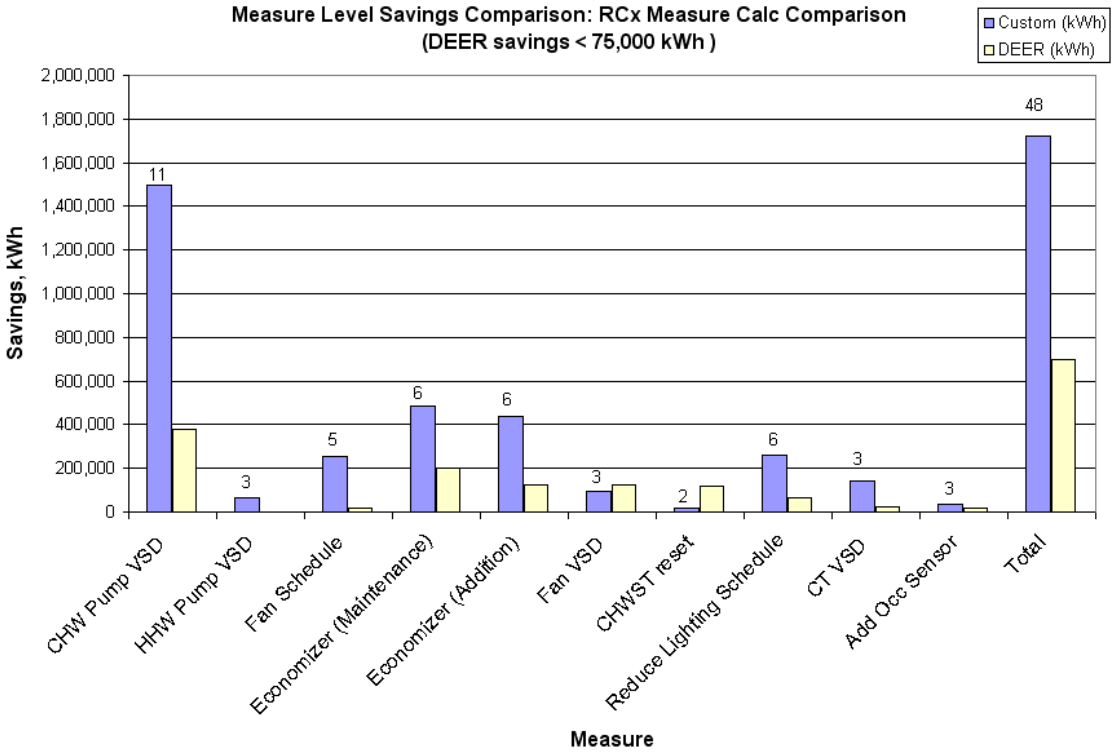


Figure 4: Measure comparison (per-project DEER measure savings capped at 75,000 kWh)

The results show that, in general, DEER savings estimates do not agree with the custom savings estimates. For measures less than 75,000 kWh, the average DEER savings and the average custom savings are off by at least a factor of two for each measure with the exception of supply fan VSDs – this measure seems to agree more closely. And on average, again for measures less than 75,000 kWh, the DEER savings are less than the custom savings with the exception of the following two measures:

- Supply fan VSD
- CHWST reset

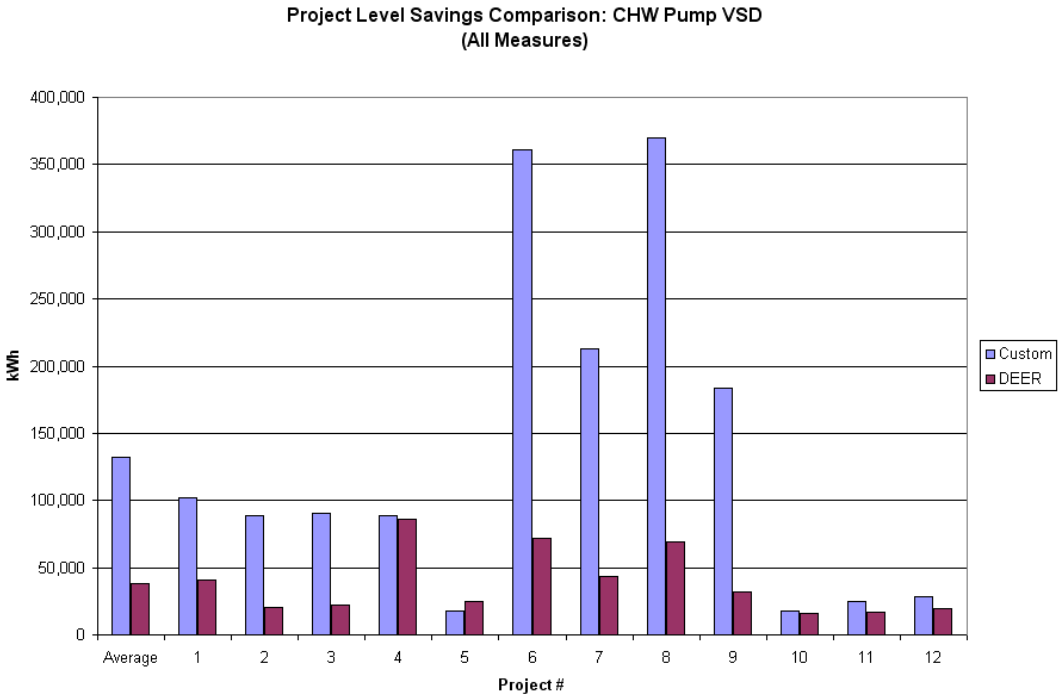
If DEER estimates are used for the measures where DEER savings are lower than custom savings, there's a chance that the actual realized savings will be greater than the DEER estimates. This may be acceptable as a conservative approach. However, there's a chance that a lower number of measures would be selected for implementation since the estimated payback periods may increase using the more conservative DEER estimates.

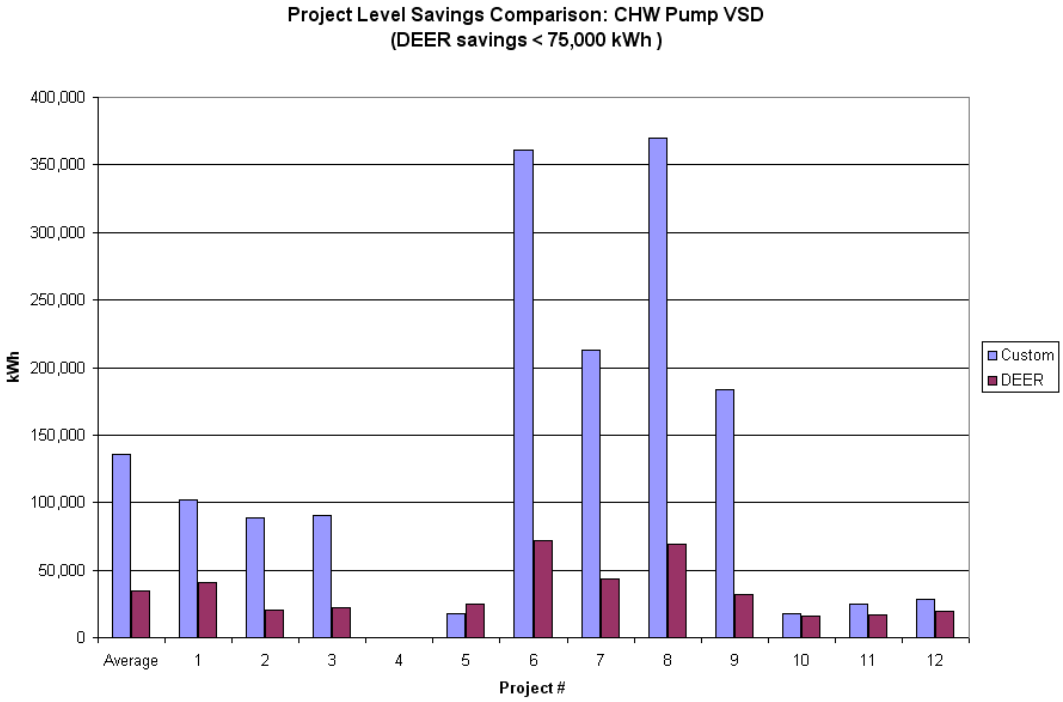
There was only one project in the 2006-2008 RCx program dataset that had a daylighting control measure. Since the sample size for this measure would be one, this measure was excluded from the analysis. In addition, the project measure related to exterior lights, not interior, which may not be the intent of the SCE measure. The table on the next page includes a summary of the analysis and our recommendations.

Following the table are the results of the measure-by-measure analysis, showing the difference between the DEER savings and the custom savings for each measure analyzed (on a project-by-project basis).

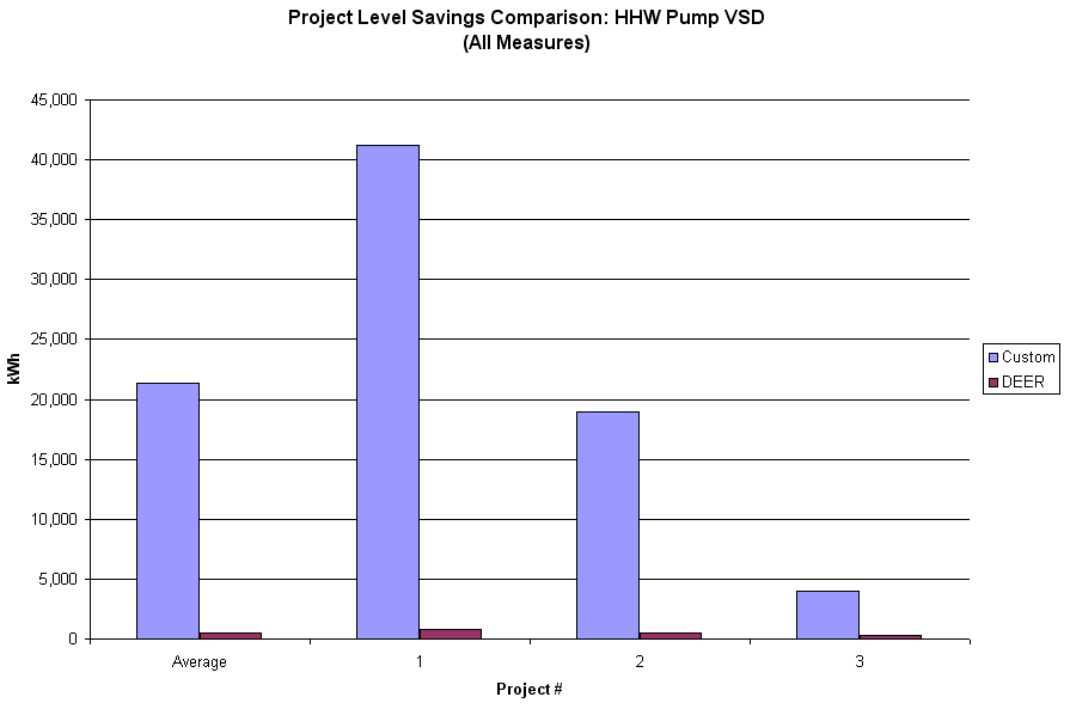
Measure (Savings Rank out of 18)	Difference between Custom and DEER calcs	Recommendation
Pump VSD (1)	For chilled water pumps, DEER savings are consistently less than custom savings, on average by a factor of three. For heating water pumps, DEER savings are much less than custom savings.	For CHW pumps, if the difference is acceptable, use DEER estimates. If not, develop a different calculator. For heating water pumps, investigate DEER assumptions to see why there's such a difference.
Fan scheduling (2)	DEER savings are consistently much lower than custom savings, on average by a factor of 15.	Develop a different calculator for this measure, or rerun the DEER models with the correct system type and reevaluate.
Economizer dampers (3)	On average, DEER savings are lower than custom savings by a factor of two, for both 'economizer maintenance' and 'add economizer'. However, there is significant variation from project to project.	Develop a different calculator for this measure.
Supply fan VSD (4)	DEER savings are consistently slightly higher than the custom savings, on average about 30% higher.	If the difference is acceptable, use DEER for this measure. If not, develop a different calculator for this measure.
CHWST reset (7)	DEER savings are consistently greater than the custom savings by a factor of six for low savings measures (<75,000 kWh).	Develop a different calculator for this measure.
Lighting scheduling (10)	DEER savings are consistently lower than custom savings by a factor of four.	If the difference is acceptable, use DEER for this measure. If not, either develop a different calculator, or investigate DEER assumptions to see why there's such a difference.
Cooling tower VSD (11)	DEER savings are consistently lower than custom savings by a factor of four to eight (factor of five on average).	If the difference is acceptable, use DEER for this measure. If not, either develop a different calculator, or investigate DEER assumptions to see why there's such a difference.
Occupancy sensors (15)	DEER savings are lower than the custom savings by a factor of two on average, with variability from project to project.	If the difference is acceptable, use DEER for this measure. If not, either develop a different calculator, or investigate DEER assumptions to see why there's such a difference. Savings are usually low for this measure (<15,000 kWh)

Chilled Water Pump VSD



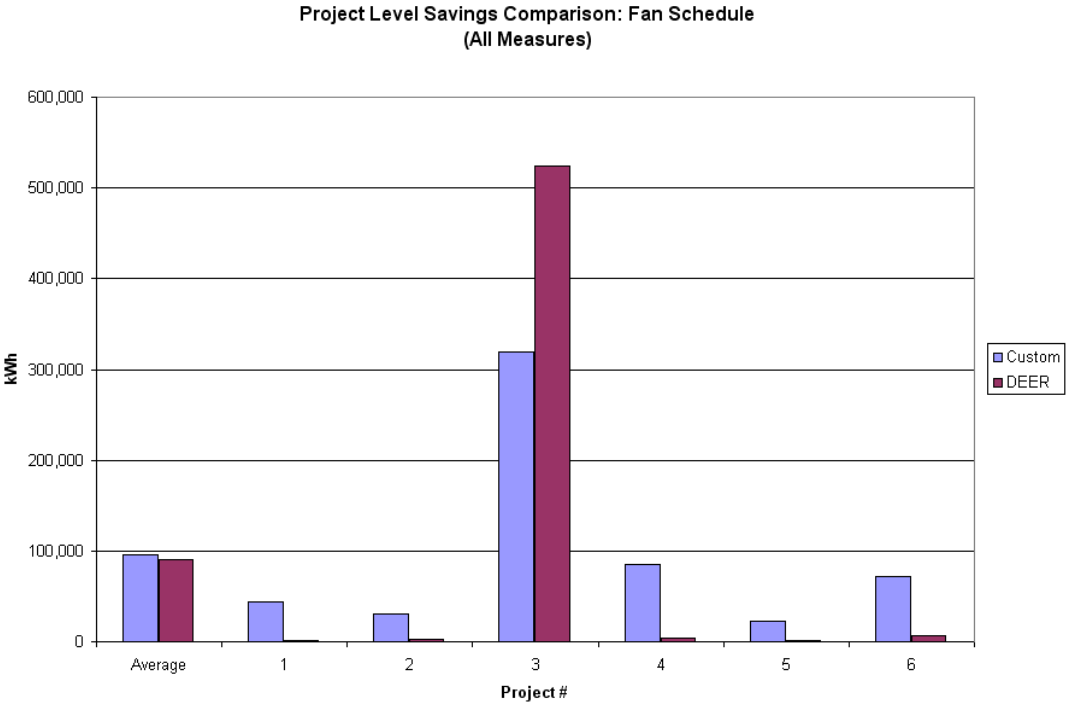


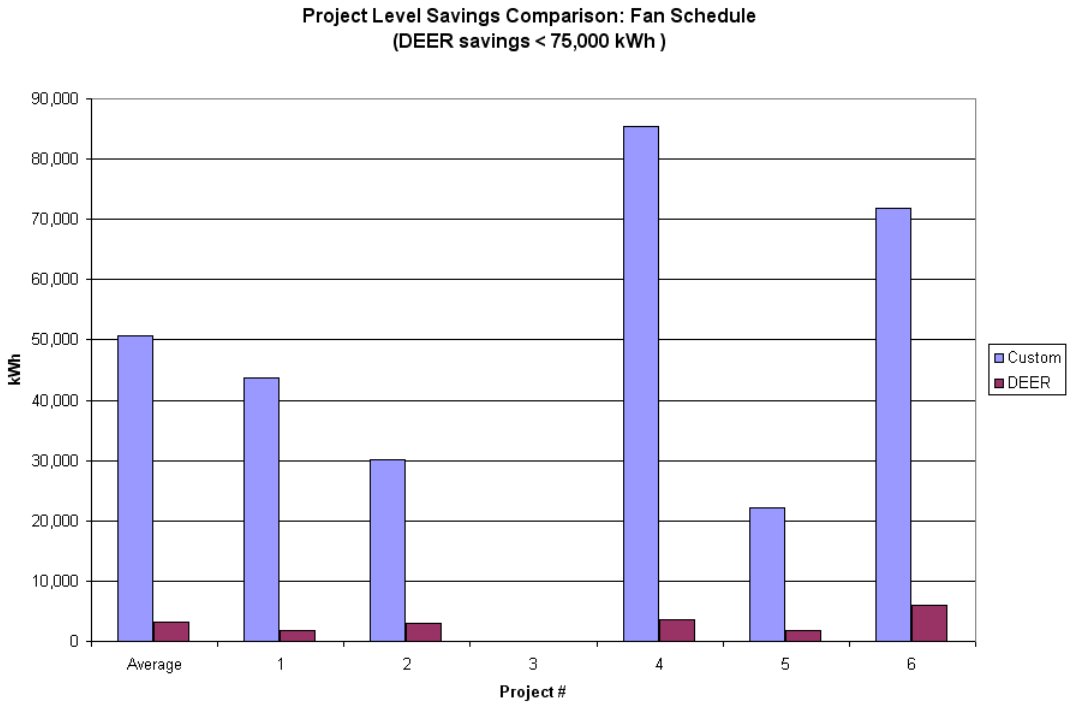
Heating Hot Water Pump VSD



- All measures were less than 75,000 kWh, so there is no change with the 75,000 kWh cap.
- The three projects were hotels (there were no other building types in the dataset for this measure).
- The HHW Pump VSD savings from DEER were almost non-existent. DEER reports a savings of 1,017 kWh/HP for large hotels constructed before 1978, and the savings drops to the 36 kWh/HP range for more recently constructed hotels. The three projects in the dataset were all constructed after 1978.

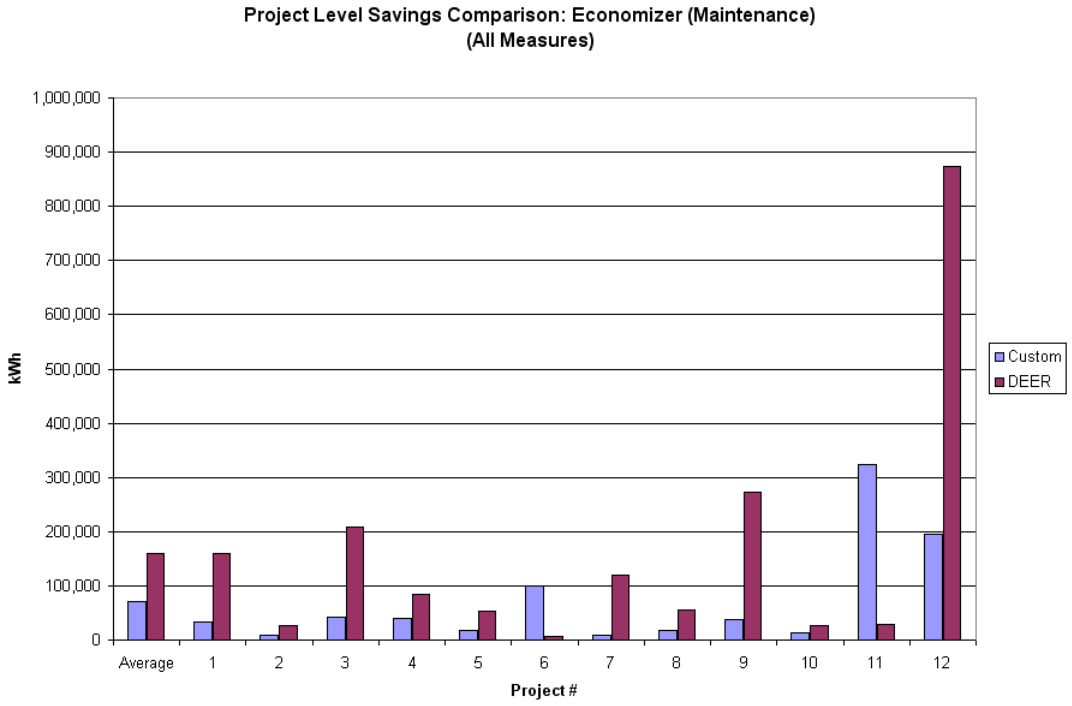
Fan Scheduling

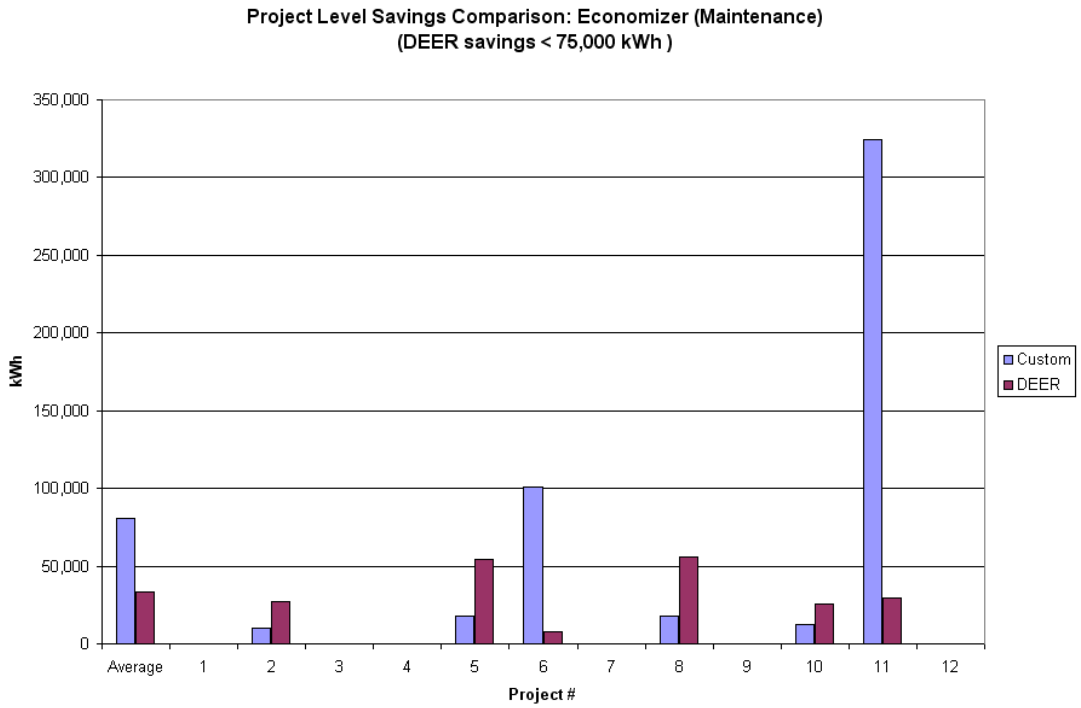




- The closest DEER measure for this measure ("Adjust schedule of supply fans") is D03-071, Heating/Cooling Time Clock Measure. The DEER measure applies to packaged roof-top units only, so may not be representative of the 'built-up' air handling systems seen in the program.
- Most large offices are conditioned from a central plant and do not use packaged systems. Therefore, the DEER database does not contain savings for a large office building type.
- The projects used for this measure analysis included only large hotels and a large retail building. The inability to use our large office data reduced the sample size significantly.
- DEER savings for large retail are six times greater large hotel building types.

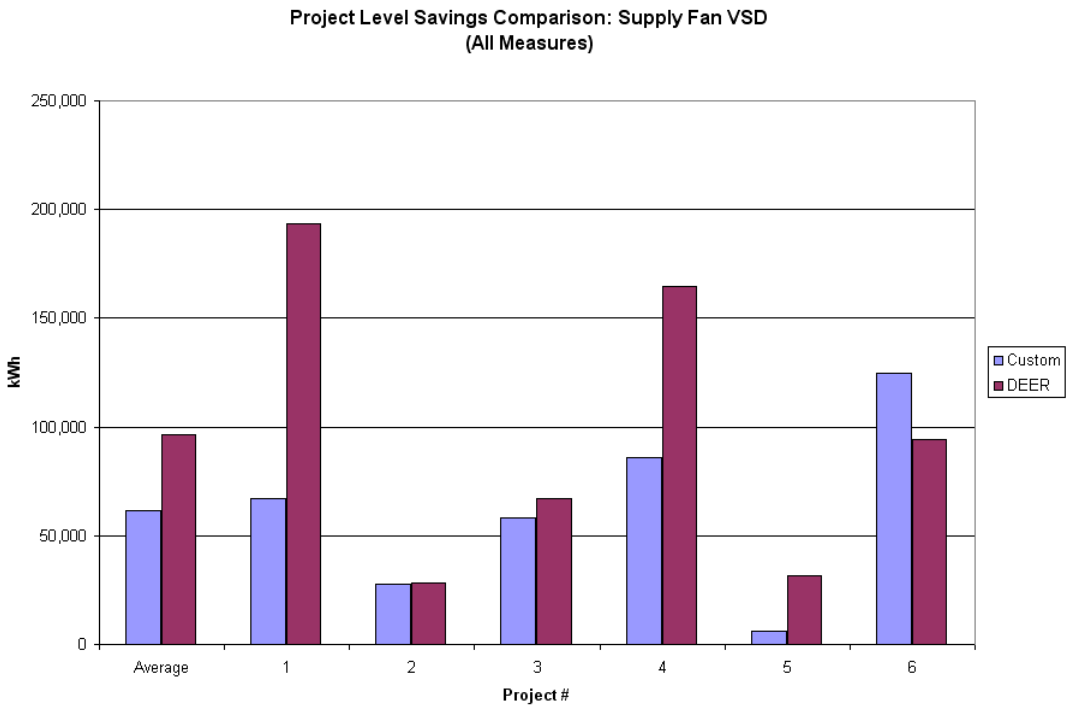
Economizer Dampers

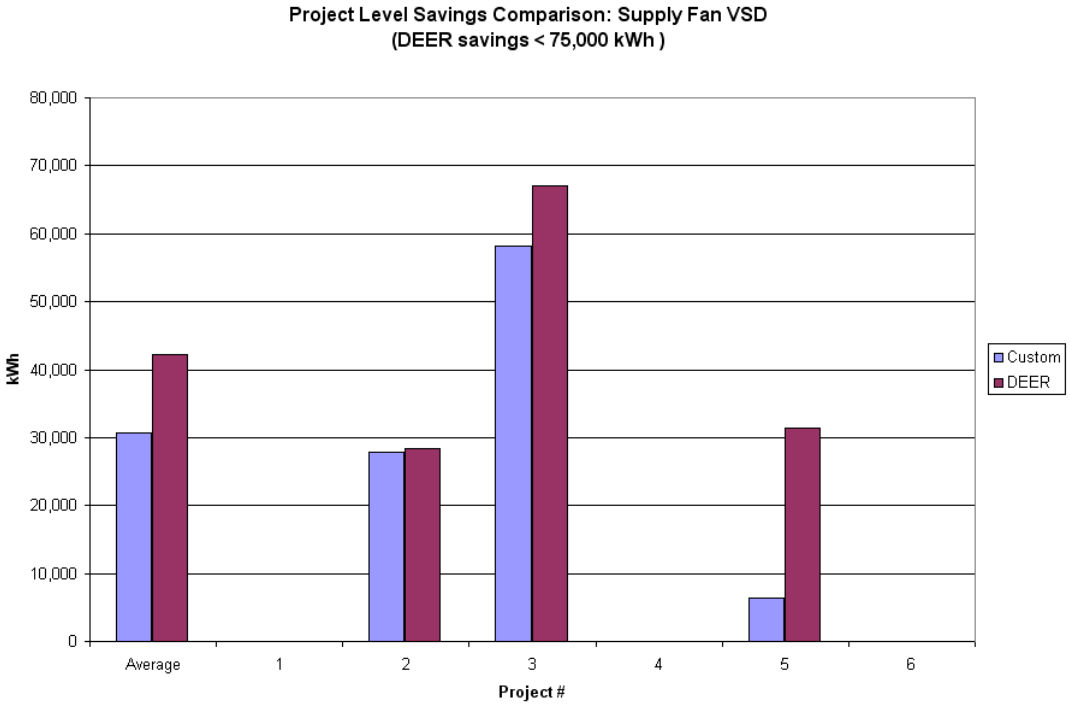




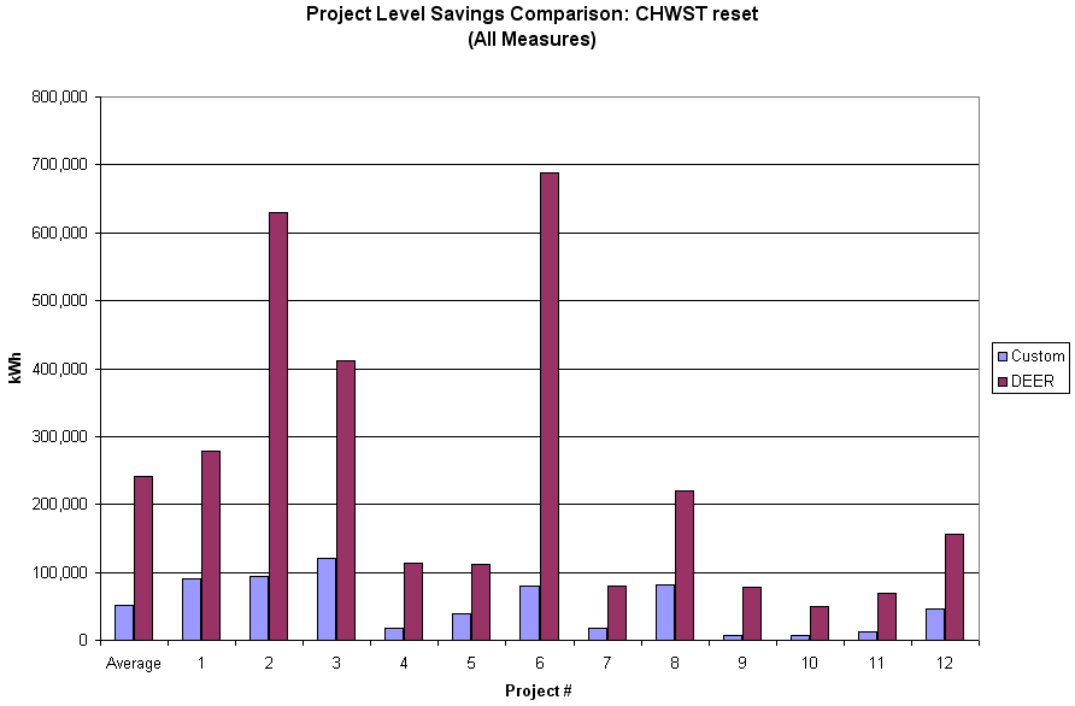
- The DEER per-ton economizer maintenance savings for large hotels is greater than the savings for large offices by a factor of 10. Projects 5 and 8 in the chart above are large hotels, projects 2, 10 and 11 are large offices, and project 6 is a large retail facility.
- The results are similar for adding economizers. For that measure, projects 2, 6 & 11 are included in the <75,000 kWh data set. The DEER savings for that measure for those projects increase by about a factor of two.

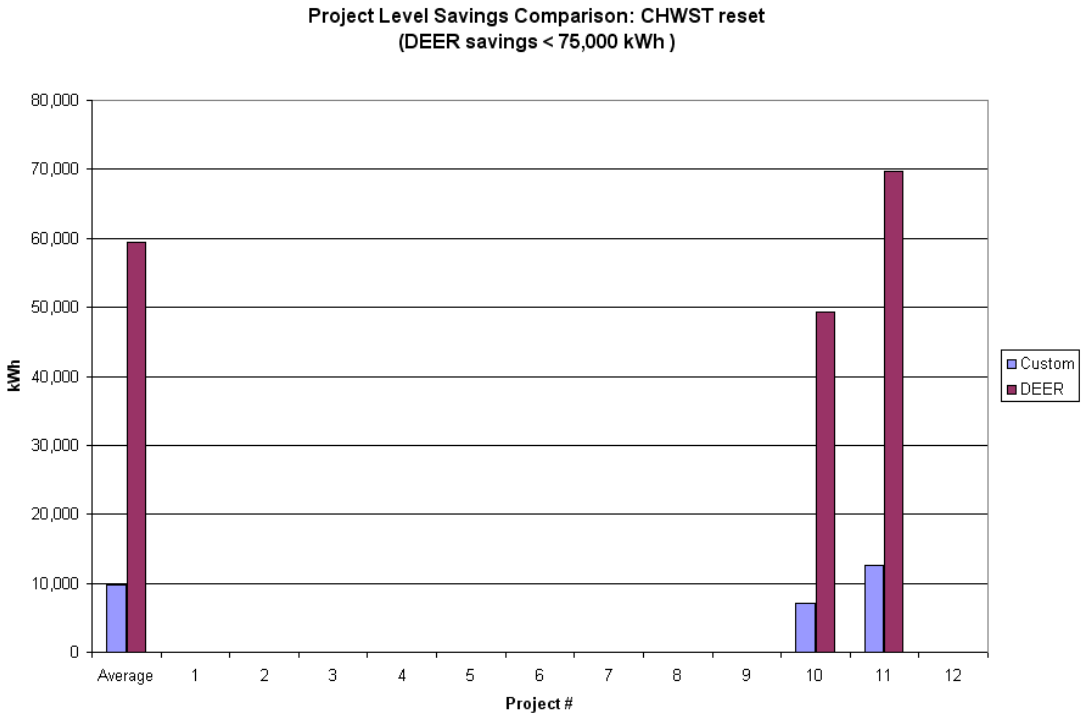
Supply Fan VSD





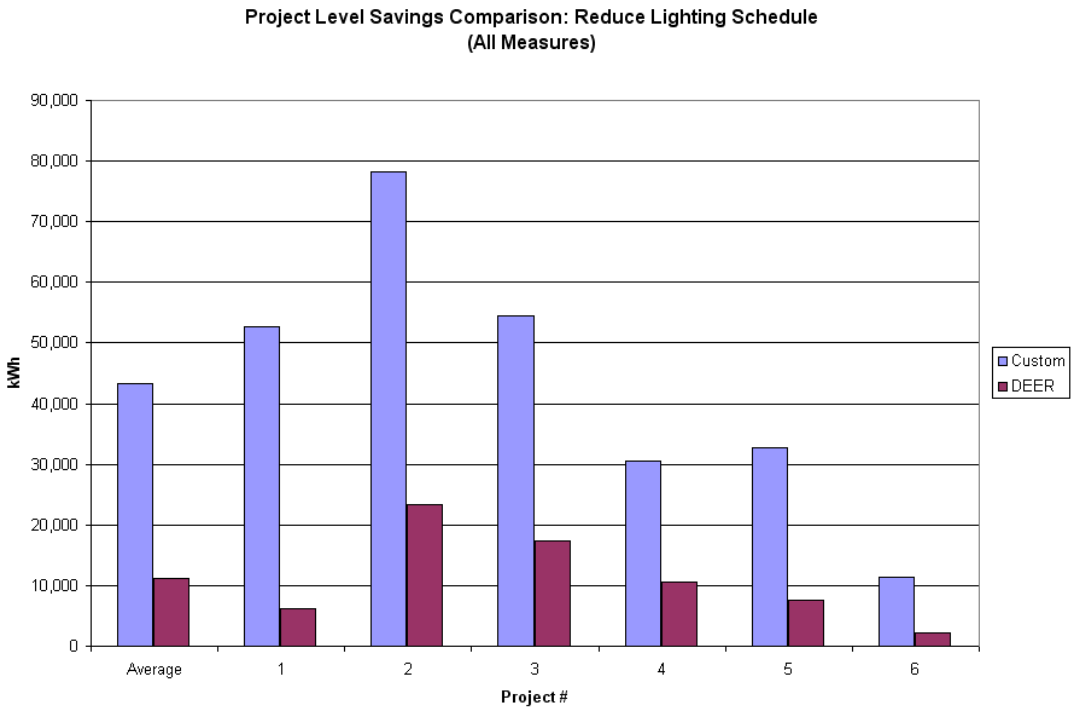
Chilled Water Supply Temperature (CHWST) Reset





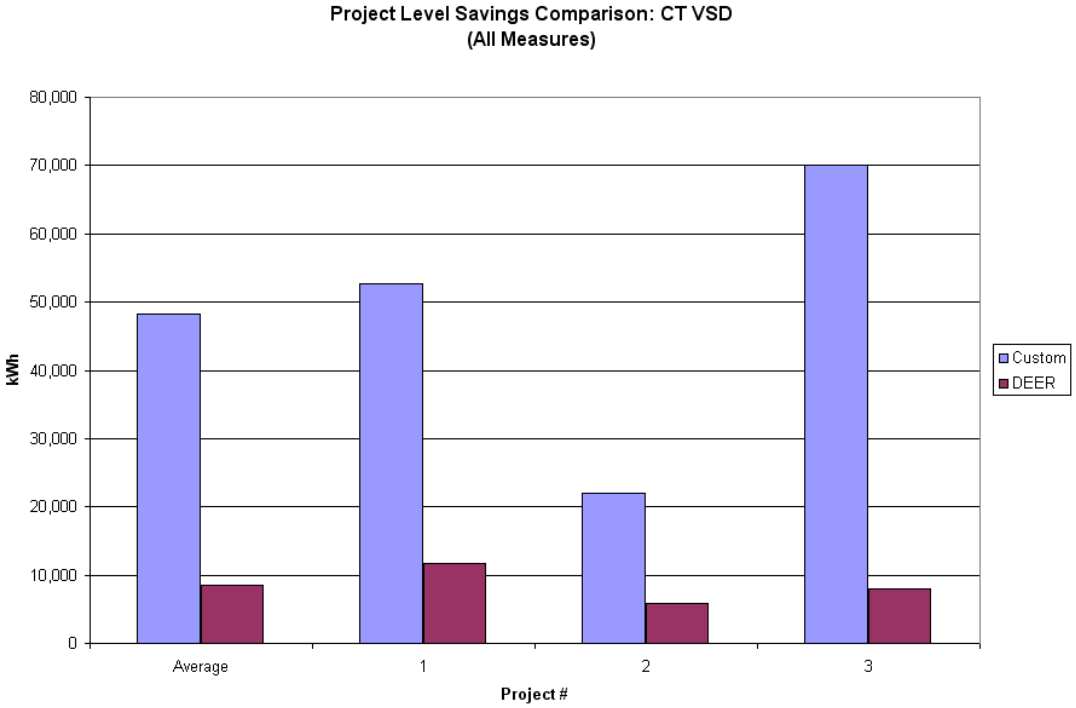
Most CHWST reset measures from the 2006-2008 program were over the 75,000 kWh cap. DEER appears to significantly overstate savings, and is not likely suitable to determine savings for this measure type.

Lighting Scheduling



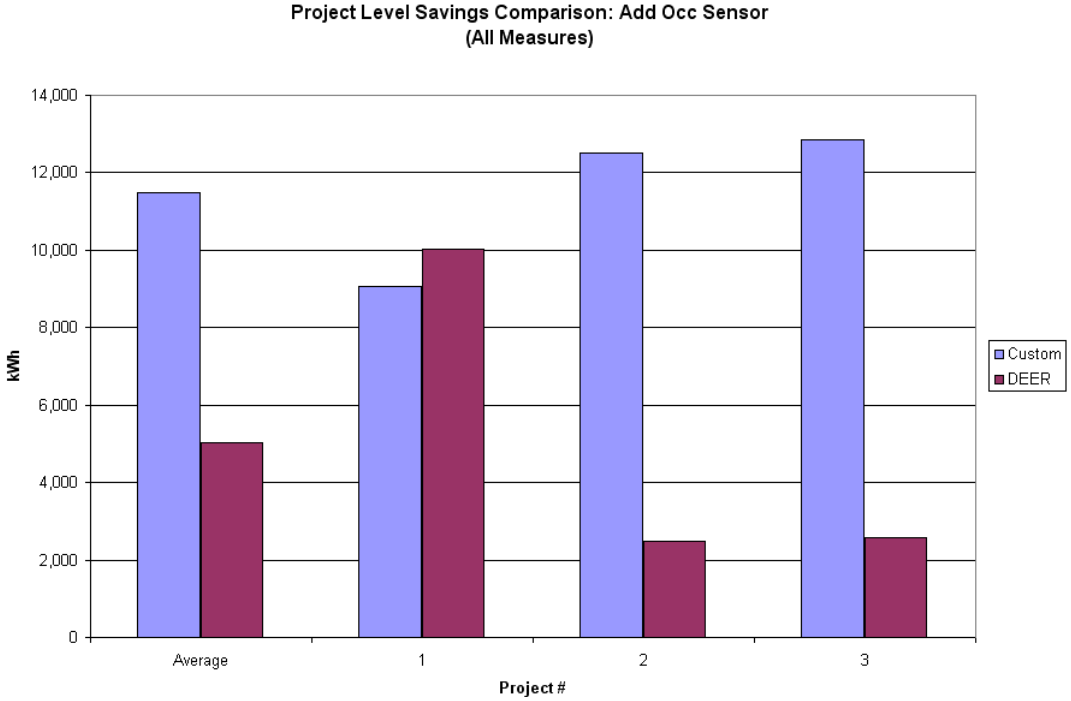
All measures were less than 75,000 kWh, so there is no change with the 75,000 kWh cap.

Cooling Tower VSD



All measures were less than 75,000 kWh, so there is no change with the 75,000 kWh cap.

Occupancy Sensors

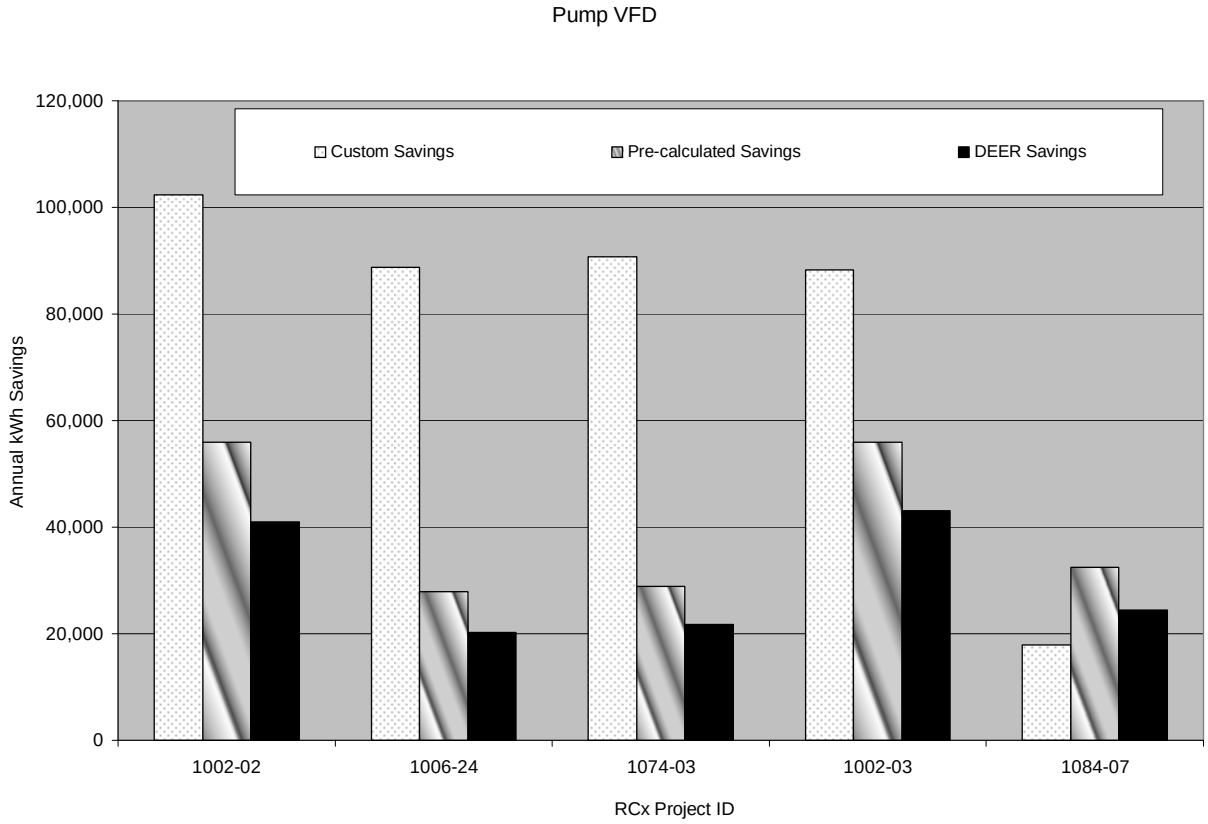


All measures were less than 75,000 kWh, so there is no change with the 75,000 kWh cap.

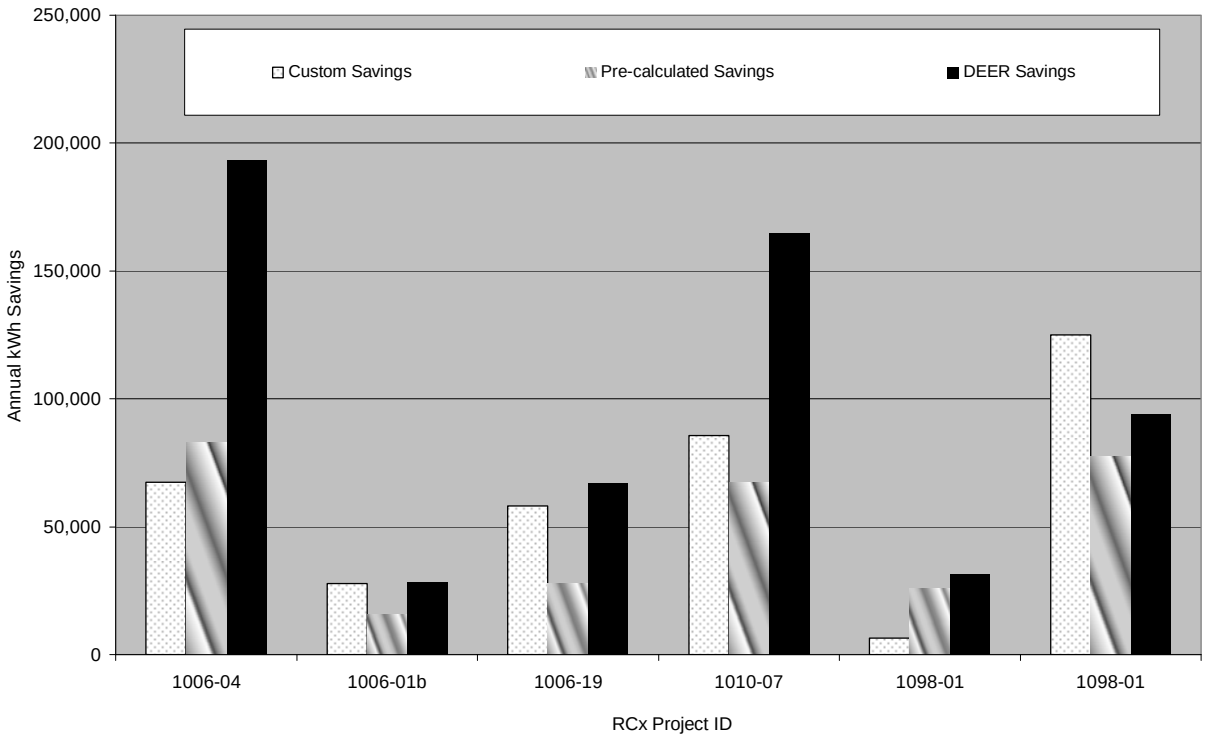
COMPARISON TO 2006-2008 PROGRAM AND DEER SAVINGS ANALYSIS

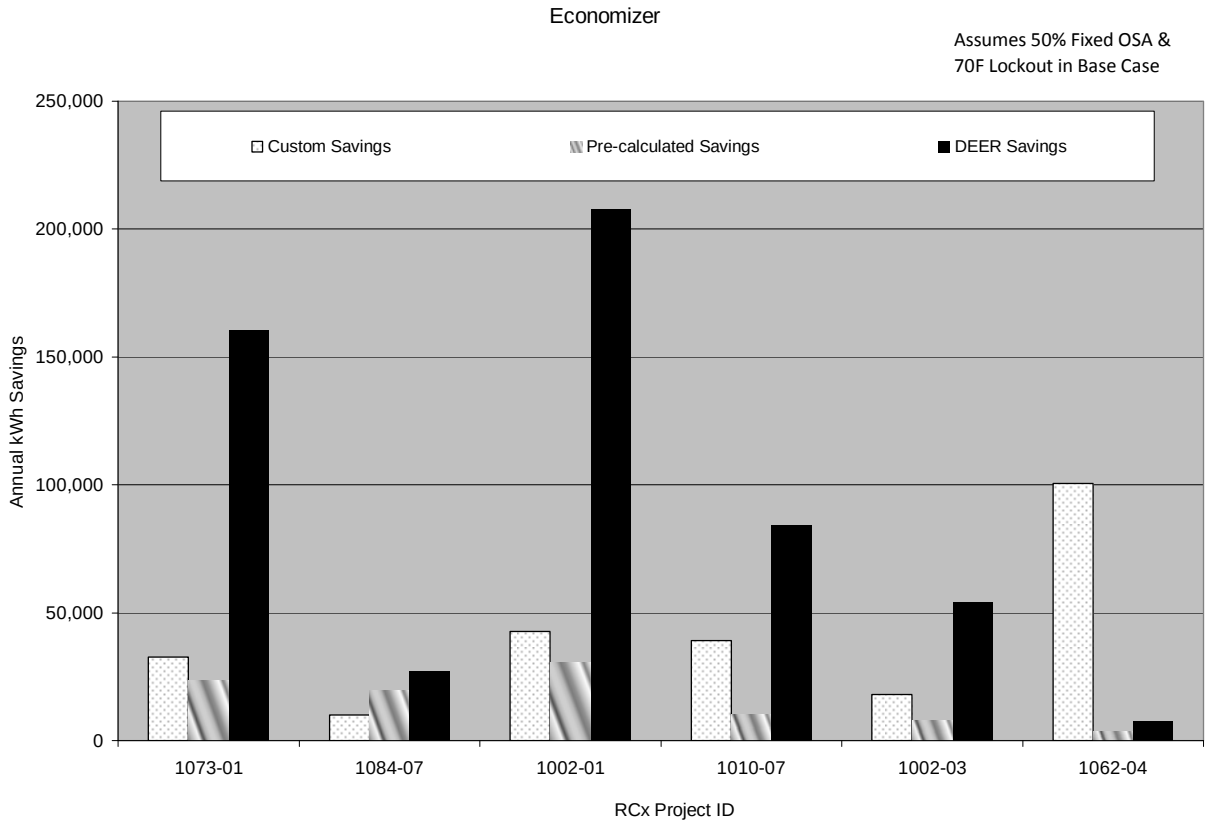
DEER savings estimates for the following measures were compared to similar 2006-08 Program projects along with the Pre-calculated savings proposed in this report:

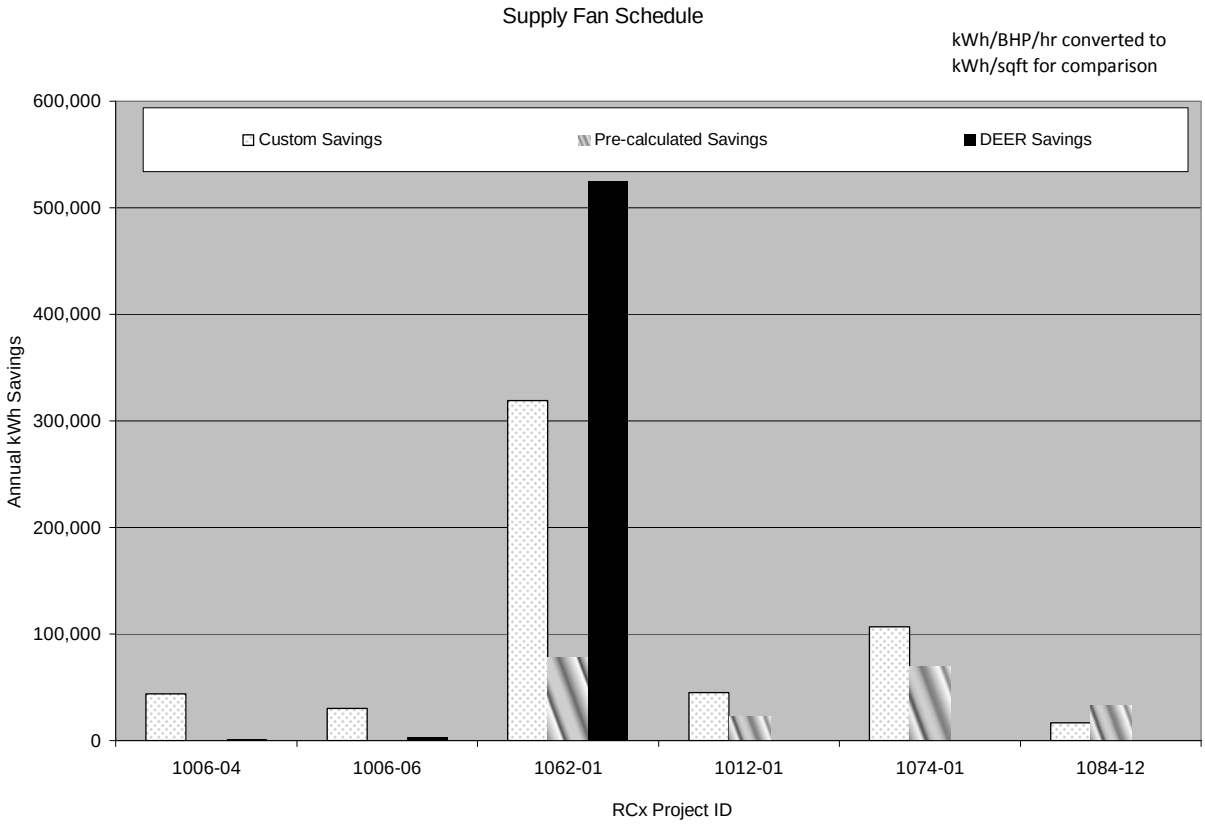
- Chilled Water Pump VFD
- Supply Fan VFD
- Economizer
- Supply Fan Schedule



Supply Fan VFD




Economizer
Assumes 50% Fixed OSA &
70F Lockout in Base Case
Custom Savings
Pre-calculated Savings
DEER Savings
250,000
200,000
150,000
100,000
50,000
0
Annual kWh Savings
1073-01
1084-07
1002-01
1010-07
1002-03
1062-04
RCx Project ID


Supply Fan Schedule
kWh/BHP/hr converted to
kWh/sqft for comparison
Custom Savings
Pre-calculated Savings
DEER Savings
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual kWh Savings
1006-04
1006-06
1062-01
1012-01
1074-01
1084-12
RCx Project ID