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Information collection, analysis and application

2004-2005

Database for Energy Efficiency Resources (DEER) Update Study

Final Report

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Executive Summary

ES.1 Introduction

The Database for Energy Efficient Resources (DEER) provides information on a comprehensive group of energy efficiency measures commonly installed in the residential and nonresidential market sectors. The database contains estimates of a measure's natural gas and electrical gross impacts, incremental cost, and effective useful life. The savings estimates are based on either engineering calculations, building simulations, measurement studies and surveys, econometric regressions, or a combination of approaches. The DEER data serves as a starting point in the planning and forecasting of the impacts and cost-benefits analysis of energy efficiency programs in California.

The DEER Update project has been jointly developed by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC), with support and input from the Investor-Owned Utilities, and other interested stakeholders. It is funded by California ratepayers under the auspices of the CPUC. The project was completed in two phases. The first phase began in 2003 under the management of San Diego Gas & Electric. Under this phase, estimates for non-weather sensitive data were developed, an interactive website was developed for accessing the DEER data, and analysis software developed for estimating impacts from weather sensitive DSM measures. The second phase began in late 2004 under the management of Southern California Edison. Within this phase, non-weather sensitive measure analyses and results were enhanced and expanded, savings estimates for weather sensitive measures were created, and the DEER website was fully populated with both weather sensitive and non-weather sensitive data and made available to the public on August 31, 2005.

The DEER includes nearly 133,000 unique energy efficiency measure savings estimates representing just over 400 energy efficiency measures. The 133,000 records provide energy savings estimates for different California climate zones, building types, and building vintages. The data is accessible on the DEER website (http://eega.cpuc.ca.gov/deer/) through a database search tool. In addition, the entire DEER dataset can be downloaded from this website as a Microsoft Access database file[1]

[1] The Access database is about 2.4 MB in size.

For most of the 133,000 records, two types of measure energy savings estimates are provided depending on whether any energy-related Codes or Standards affect the installation of those measures: Customer Savings and Above-Code Savings. How an energy efficiency program is designed and implemented affects which baseline and hence which energy savings estimate is most appropriate to use for program planning. The customer saving estimates use the typical baseline technology found in each building vintage as identified by building survey data. An example would be older vintage homes with central A/C systems that are 8.5 SEER. Above- Code saving estimates depend on whether there are any energy-related Codes or Standards affecting the installation of those measures. The California Building Energy Code, Title 24, and the Federal Appliance Standards are examples of specific codes and standards that set the minimum code baselines. An example would be central A/C systems that are replaced at time of burnout, and must meet a minimum Standard mandate of 13 SEER. Thus, SEER 13 is the above-code baseline. All of the DEER weather sensitive measures include both customer and above-code energy savings estimates.

Many of the non-weather sensitive measures do not have customer-based impacts. This is because the non-weather sensitive measure impacts were developed during Phase 1 of this update and only minimal modifications were funded under Phase 2. The data development mandate at the time of Phase 1 was to use only code baselines in all cases unless there was no code or standard in place for the technology.

Parallel to the DEER Update project, an update to the DEER measure cost dataset was performed by Summit Blue Consulting under a separate contract. The measure cost information includes costs for the basecase, measure case, and installation labor.

ES.2 Methodology

The methodologies used to estimate the measure savings from weather sensitive measures differs from the methodology used to estimate non-weather sensitive measure savings. For weather sensitive measures, both in the residential and non-residential sectors, the building energy simulation model DOE-2 was used to estimate the measure savings. The DOE-2 model utilizes building prototype and measure characterization information by building type, vintage, and climate zone in its estimation of measure savings. Non-weather sensitive measure savings, for both the residential and non-residential sectors, utilized engineering calculations and assumptions and results from Measurement and Verification (M&V) studies.

ES.3 Website

The DEER is available on-line through the CPUC website (http://eega.cpuc.ca.gov/deer/). The DEER internet interface provides on-line read access to all elements of DEER as well as the ability to download the entire dataset as an Access database, download portions of the dataset as Excel spreadsheets, or print measure Run ID specific detailed information. Access to the data on the site does not require any kind of username or login account. Anyone browsing to the location of the home page for the site will be able to view the data.

The web site provides easy access to the data, as well as supporting information and documents. There are four main groups of data: residential and non-residential sectors; and within each sector, weather sensitive and non-weather sensitive. A User's Guide to the website is provided in Section 13.

ES.4 Available DEER Information

This most recent update of the DEER is designed to provide users the opportunity to not only access the data both on-line and in downloadable datasets, but also access to many of the assumptions and supporting documents. There are also documents available through the building simulation model website at www.DOE2.com/Download/DEER.

Expected future documents that will be available through the DEER website include a copy of this final report as well as electronic copies of literature references, as identified in Appendix F of this report. It is expected that the links to the literature references will be made through a bibliography listing of each reference.

On the DEER website, a survey link allows users to provide feedback and suggest ways to improve and enhance the database and the website interface. Also provided on the website is a notification link to provide any updated information to users of DEER 2.01.

The DOE2 website is the prime information source for the weather sensitive assumptions and analysis. The actual DOE2 software used to develop the weather sensitive measures is available on the DOE2 website as well as the input assumptions needed for the DOE2 analysis.

ES.5 Study Issues and Recommendations

An important element of the 2004-05 DEER update was inclusion of Tasks designed to help plan for future DEER updates in the light of issues faced by the current and past efforts, how to insure that future Evaluation Measurement and Verification (EM&V) studies support the DEER, and what measures should be added in future updates. Section 14 discusses each of these issues.

The approach used to meet these objectives included interviews with key DEER stakeholders, a review of EM&V studies and plans, and a review of lessons learned from current and past DEER update studies. While there are several issues and recommendations that emerged from this Task, key issues and recommendations include the following:

- Comprehensive DEER updates should be carried out at least every 3 years; however, given the number of outstanding issues in the current DEER, the next comprehensive update should be completed before the end of 2007. In addition, interim DEER updates should be enabled and carried out more frequently (e.g., every 6 months or year).
- DEER should have a clear orientation to aid and guide its decision-making. In general, DEER should strive toward an expected value orientation, neither purposefully conservative nor optimistic. In the face of significant uncertainty, however, DEER should tend toward a more conservative orientation.
- New EM&V efforts are needed for many measures to reduce uncertainties and resolve differences of opinion over measure specification, baseline parameters, and savings measurement. In addition, future evaluation studies should be designed and implemented with DEER applications also in mind. This means more attention to measure-level measurement of savings and associated parameters, as well as explicit reporting of results in DEER-friendly formats.
- Additional baseline calibration activities are needed. Key parameters in commercial sector calculations and simulations should be compared and, as appropriate, calibrated to the CEUS when it becomes available. There is also a critical need to calibrate DEER load shapes to ensure that they do not systematically over or underestimate peak and other hourly loads, and appropriately capture population diversity effects.
- DEER measure costs and measure savings projects should be integrated or conducted in parallel to ensure upfront agreement on measure specifications. Adequate time should be incorporated into project schedules to allow for thorough quality control of cost and savings integration. Future DEER projects should address custom measures (this could include verification and analysis of custom cost data collected by the program administrators). Future DEER cost studies should also address design-related new construction measures or bundles.
- Future DEER projects should continue to expand and improve documentation, particularly, electronic documentation.
- A central purpose of DEER has been, and should continue to be, maximizing the accuracy and consistency of per unit, ex ante measure data used in program planning, filings, tracking systems, cost effectiveness analyses, and energy efficiency forecasting. This is crucial to both the CPUC and utilities' processes for conducting quality control analyses of ex ante data. Both utility

and third party program proposals often contain hundreds or even thousands of ex ante values.

- To the extent that DEER is accurate and complete, it is appropriate to require its use. However, the accuracy and completeness of DEER, like any source, will likely continue to vary somewhat across measures, due to limitations in available data to support DEER and prioritization of DEER resources across measures. For these reasons, it may be appropriate to allow some deviations from DEER if certain conditions are satisfied. In cases where deviations from DEER are proposed, DEER data and documentation should be used as a benchmark to assess whether the deviations should be permitted.
- DEER used a range of methods to develop savings estimates that we organized into three broad categories (Engineering Calculations, Simulation Models, and Field and Laboratory Measurements) and discussed some of their strengths and weaknesses. Historically, all of these methods have been utilized in DEER; however, the weight of the effort in DEER has been on engineering calculations for non-weather sensitive measures and building simulation modeling for measures that are weather sensitive. Our primary recommendation is not to eliminate either of these methods but rather to increase the use of field measurement results in DEER.
- Future DEER projects should provide flexibility by offering segmented results *if differences in savings by market segment are defensible* (both in terms of savings estimation and marketing and program participation requirements) and *well documented.* Where segmented results are presented, efforts should be made to include statistically reliable population weights to indicate what fraction of the market is represented by each of the segments and provide a default weighted average result to allow users to obtain average impacts across segments if so desired.
- Traditionally, the DEER has only included energy and peak demand impact estimates along with measure costs. The 2004-05 DEER update has added effective useful life (EUL) by measure to the DEER. Future DEER should continue to focus on per unit inputs to measure-level cost-effectiveness analysis. Core per unit inputs include incremental costs and savings, including energy, peak demand, and load shape impacts, as well as effective useful lives.

1

Introduction

1.1 Scope and Objectives

This report presents the methods and results of the *2004-05 Update of the Database for Energy Efficiency Resources (DEER)*, commissioned jointly by the California Public Utilities Commission (CPUC) and the California Energy Commission (CEC). The project was completed in two phases. The first phase began in 2003 under the management of San Diego Gas & Electric. Under this phase, estimates for non-weather sensitive data were developed, an interactive website was developed for accessing the DEER data, and software was developed for estimating impacts from weather sensitive DSM measures. The second phase began in late 2004 under the management of Southern California Edison. Within this phase, non-weather sensitive measure analyses and results were enhanced and expanded, savings estimates for weather sensitive measures were created, and the DEER website was fully populated with both weather sensitive and non-weather sensitive data and made available to the public on August 31st, 2005.

The project team consisted of four consulting firms. The project team lead was Itron, Inc. with subcontractor support from JJ Hirsch & Associates, Synergy Consulting, and Quantum Consulting.

The primary objectives to the study included:

- Provide updates to the savings estimates from the original 1994 NEOS DEER study[1] (residential and non-residential) and to the 2001 Xenergy DEER update[2] (residential only).
- Review and expand on the measures included in DEER including new residential single family and multi-family measures, add mobile homes to the set of building types, expand non-residential to include both additional measures and additional building types, and add the agricultural segment.

[1] "Final Report on Technology Energy Savings: Volumes I, II, and III", prepared for the California Conservation Inventory Group, prepared by NEOS Corporation, May 1994

[2] "2001 DEER Update Study Final Report", prepared for the California Energy Commission, prepared by Xenergy Inc., August 2001

- Expand on the number of building vintages
- Incorporate the new T24 building standards to capture the effects of new building codes on savings estimates.
- Modify the weather zones used for analysis to be equivalent to the CEC's T24 building standard weather zones. The 1994 NEOS study divided the state into five climate regions and the Xenergy 2001 DEER update utilized CEC forecasting model weather zones.
- Incorporate estimates of Effective Useful Life.
- Integrate measure costs so that a measure cost can be specifically matched to a measure impact estimate. Measure costs were developed under a separate contract by Summit Blue Inc.
- Create a web-based DEER search tool where information in the database can be reviewed by browsing and searching for specific measure characteristics. The entire DEER database would be accessible and downloadable from this website.
- Create an "Update Plan" for DEER. This update plan would be used to help guide future DEER update process and its linkages with future measurement, verification, and evaluation efforts.

1.2 History

Since its inception in the mid-1970's, with the passage of the Warren Alquist Act, the California Energy Commission (CEC) has been charged with the responsibility to collect data to support energy efficiency planning and forecasting. Under the current version of the Act, the responsibility and duty of the CEC in regards to data collection is generally outlined in Division 15 of the Public Resources Code Energy Conservation and Development sub-section (d) of Section 25216.5. Sub-section (c) identifies how the development of the DEER database began. As a result of this subsection, the California Conservation Inventory Group (CCIG) was created in the early 1990s. Its purpose was to identify what type of data to collect and how it was to be collected/developed as well as populate the initial dataset. CCIG was composed of members from the CEC, the California Public Utilities Commission (CPUC), each of the state's investor-owned electric and gas utility companies (Pacific Gas and Electric, Southern California Edison, Southern California Gas, and San Diego Gas & Electric), the Natural Resources Defense Council (NRDC), the California Institute for Energy Efficiency (CIEE), and Lawrence Berkeley National Lab (LBL). The CEC chaired the CCIG.

Under the CCIG, the framework of how the data would be developed (it was at this time that the decision to use proto-typical buildings and to use the DOE-2 model to simulate building base energy use and measure impacts was made) and how cost information would be gathered were made. The initial studies to develop DSM measure impacts, cost information, and identify emerging technologies were commissioned by the CCIG. As required by the Warren Alquist Act, the CCIG ceased to exist after January 1, 1993. The CCIG fulfilled its function to develop the framework for creating DEER and commissioned studies to populate the database. Responsibility to maintain and update the database was shifted to the California DSM Measure Advisory Committee (CADMAC). This committee consisted of representatives from the same organizations as the CCIG. Under CADMAC, DEER was funded for additional measure cost updates and funding was provided to create a user-friendly database structure.

The coming of de-regulation created significant uncertainty as to the role and capability of the CEC to continue its data collection and data-warehousing mandate. The CEC's ability to require utilities to fund data collection activities to support the CEC's biennial Electricity Report (ER) process became of little value when the ER process ended in the mid-1990's. The last ER report was developed in July of 1995. Uncertainty reigned for several years with minimal data collection activity occurring. The CEC went through a hearing process on its data collection regulations that concluded with the restatement of the need for the CEC to continue to collect basic data such as what is included in DEER as well as information historically collected through customer sector surveys such as the Residential Appliance Saturation Surveys (RASS) and the Commercial End-Use Surveys (CEUS). However, funding for these efforts was uncertain.

In September of 1996 the California Legislature adopted a bill to restructure the electrical energy industry by developing a competitive wholesale generation market and transitioning to a retail market where customers would enjoy a choice of energy service providers in addition to the regulated utility provider. As part of this bill the Legislature developed a new method of funding public interest programs previously administered by electrical utilities known as the public goods surcharge. This bill delegated to the CPUC the responsibility of overseeing the expenditure of public funds used to develop and deliver energy efficiency programs to the market. In April of 1997, the CPUC created an independent Policy Advisory Board, (CBEE) to develop an organization and process to oversee the development and delivery of a new generation of energy efficiency programs designed to transform energy markets and help create self sustaining markets for energy efficiency product and service providers.

The CPUC appointed 9 public members to California Board for Energy Efficiency (CBEE) for terms of two years. CBEE was responsible for developing and managing the annual program planning process, making recommendations on funding allocation and program design, and coordinating of the development of market assessment and evaluation projects to assess the effectiveness of new programs and policies. Funding for CBEE and its activities came from the newly established Public Goods Charge (PGC), which is roughly 3% of the typical or average electricity rate charged to California ratepayers. Unfortunately, the legislation creating the PGC funds did not explicitly state that the funds could be used to support the data collection activities of the CEC. The CEC, through its data collection hearing process, determined that PGC funds were the appropriate mechanism to fund CEC required data collection activities. CEC staff was directed to develop a data collection proposal for CBEE consideration that would clearly establish the funding linkage between CEC data collection activities and PGC funds. Specifically, the proposal included funding on a continuous basis for customer end-use surveys such as RASS and CEUS and DEER. This proposal was presented to the CBEE Board by CEC staff and received CBEE approval. Work immediately began at the CEC to initiate the RASS and CEUS surveys and to update DEER.

In 2001, CPUC Commissioner Lynch discontinued funding for CEC related activities. In 2002, the CEC opened an Order Instituting Rulemaking (OIR) for updating Title 20 reporting requirements. It was the CEC expectations that the CEC would have funding to complete these studies themselves with impending budget allocation from the state. However, this funding was later pulled due to the deficit the state incurred due to the energy crisis. It was at this time that the CEC informed the IOUs that the CEC would still hold the IOUs accountable for completing the Title 20 studies. The IOUs could either complete the studies themselves or allocate funding to the CEC so they could complete the studies.

Before the demise of CBEE in 2000, oversight of measurement and evaluation had been given by the CPUC and CBEE to CADMAC with CPUC participation as an independent observer. Informal oversight of current measurement and evaluation efforts were transferred to a new organization called the CALifornia Measurement Advisory Council (CALMAC), with the same organizational membership as CADMAC. CALMAC was created to handle measurement and evaluation issues for programs fielded since January 1, 1998 and CADMAC continued to handle these issues for the older programs. After the demise of CBEE, both CADMAC and CALMAC continued these functions with the CEC related data collection coming under the informal purview of CALMAC.

The 2004-05 DEER update continues to be under the informal purview of CALMAC. In recent years, DEER has been emerging as the recognized source for deemed energy saving impacts and costs in California. With its growing importance as the source for deemed energy saving impacts and costs, the CPUC has become actively involved, along with continued involvement from the CEC, in the structure and content of DEER.

1.3 Project Management Structure

As mentioned earlier, the project consultant team was composed of Itron, JJ Hirsch and Associates, Synergy Consulting, and Quantum. Gary Cullen was the overall consulting team project manager from Itron. In addition to the consulting team, another important management component in the successful development of the 2004-05 DEER update was the Project Advisory Team and the utility project manager.

Project Advisory Team

Under Phase 1, Andrew Sickels of San Diego Gas & Electric served as utility project manager. Under Phase 2, this responsibility went to Shahana Samiullah of Southern California Edison. Once the Measure Cost Study began with Summit Blue Consulting (under separate contract), Ingrid Bran of Pacific Gas & Electric, the Measure Cost Study project manager, joined the DEER Project Advisory Team. Members of the core DEER Project Advisory Team included:

- Shahana Samiullah, SCE (Phase 2 Project Manager)
- Ingrid Bran, PG&E (MCS Project Manager)
- Tim Drew, Energy Division, CPUC
- Ariana Merlino, Energy Division, CPUC
- Christine Tam, ORA, CPUC
- Sylvia Bender, CEC
- Mike Messenger, CEC
- Andrew Sickels, SDG&E (Phase 1 Project Manager)
- Jennifer Barnes, PG&E
- Leonel Campoy, SCE
- Craig Tyler, Tyler Associates (Phase 1 PG&E representative)
- Jay Luboff (Phase 1 CPUC representative)
- Eli Kollman (Phase 1 CPUC representative)

The project advisory team filled an important role and was intimately involved with each major decision regarding development of the 2004-05 DEER update. Among the services they performed:

- Provided feedback and direction to the initial work plan,
- Provided unified and consistent advice and direction as issues appeared,
- Reviewed methodological methods and assumptions, and
- Reviewed and provided comments on study deliverables.

Consulting Team Roles

Each of the consulting firms provided distinct and specific services to the 2004-05 DEER update. Itron was the lead consulting team and fulfilled the following roles:

- Coordinated the activities of the consultant team with the project advisory team,
- Coordinated with the measure cost team to insure compatible cost data were collected,
- Developed the non-weather sensitive residential and commercial sector measure savings,
- Developed the agricultural sector measure savings,
- Coordinated, consolidated, and formatted the measure savings, cost, and EUL data for uploading to the website,
- In consultation with Synergy, helped design the web interface, and
- Developed and coordinated the development of the final report and documentation.

JJ Hirsch and Associates was responsible for developing the weather sensitive impact estimates for the 2004-05 DEER update. Specifically, they performed the following:

- Developed the analysis software based on the DOE-2 model for weather sensitive measures,
- Suggested methodological directions and solutions as needed,
- Developed the building prototype and conservation measure characteristics,
- Developed the weather sensitive residential and commercial sector measure savings,
- Responded to technical questions from DEER users,
- Coordinated data transfer format with Itron and deliver data to Itron for uploading, and
- Developed the documentation and final report sections for the weather sensitive measure impact analysis.

Synergy Consulting was responsible for the design of the DEER website. They were also responsible for receiving the final datasets, converting the data to SQL server and Access, and debugging the website.

Mike Rufo of Quantum was responsible for developing the DEER periodic update plan. This plan is provided within Section 14 of this report. To develop the plan, Mike, with assistance from Itron staff, performed the following:

- Interviewed potential DEER users,
- Identified linkages to EM&V studies,
- Identified new measures to potentially include in future DEER update, and
- Utilized this information to develop the update Plan.

1.4 Methodology Overview

The methodologies used to estimate the measure savings from weather sensitive measures differs from the methodology used to estimate non-weather sensitive measure savings. For weather sensitive measures, both in the residential and non-residential sectors, the building energy simulation model DOE-2 was used to estimate the measure savings. The DOE-2 model utilizes building prototype and measure characterization information by building type, vintage, and climate zone in its estimation of measure savings. Non-weather sensitive measure savings, for both the residential and non-residential sectors, utilized engineering calculations and assumptions and results from Measurement and Verification (M&V) studies. These results generally were the same for all weather zones and vintages. The only exception is residential water heat measures where the baseline energy use varied by utility service area.

Energy savings estimates can be estimated in two ways depending if there are any energy-related Codes or Standards affecting the installation of those measures. The California Building Energy Code, Title 24, and the Federal Appliance Standards are examples of specific codes and standards that can affect what baseline should be used to estimate energy and demand impacts. How an energy efficiency program is designed and implemented will affect which baseline is the more appropriate baseline to utilize. The two types of savings are distinguished by identifying the savings as either customer based or code based. All of the weather sensitive measures include both customer based and code based energy savings. However, many of the non-weather sensitive measures do not have customer based impacts. This is because the non-weather sensitive measure impacts were developed during Phase 1 of this update and only minimal modifications were funded under Phase 2. The data development mandate at the time of Phase 1 was to utilize a code baseline in all cases unless there was no code or standard in place for the technology.

The estimated peak demand savings are based on a broad definition of the peak demand time period. For DEER, the assumption was made that peak demand is the average demand savings between noon and 6:00 PM during the months from May through October.

Each DEER energy savings measure has a unique Measure ID. The Measure ID is a string variable with a fixed length of seven characters. The first four characters are always the same (“D03-“) and are used to indicate that the energy savings estimates are from the 2003-

2005 DEER update. The last three characters are a numerical sequence starting with "001" and ending with "999". They represent the following groupings of measures:

- Weather Sensitive Non-Res: 001-199
- Weather Sensitive Refrig: 201-399
- Weather Sensitive Res: 401-499
- Non Weather Sens Lighting: 801-899
- Non Weather Sens Other: 901-999

Although measures have unique Measure IDs, they don't necessarily have single, unique estimates of energy savings. The same measure, especially weather sensitive measures, may have different impacts by weather zone, building type, and building vintage. To accommodate the potential for multiple energy saving estimates for the same Measure ID, each measure within DEER has a unique Run ID. The Run ID is a string variable of a fixed length of 13 characters. Within the 13 characters are five separate codes that fully define each measure savings estimate uniquely. The five separate codes take the form ABBB1122CCCCC where each separate code represents the following:

- A = Sector Code. 'R' = Residential and 'C' = Commercial
- BBB = Building type abbreviation (see codes in Appendix D)
- 11 = Climate zone (see codes in Appendix D)
- 22 = Vintage (see codes in Appendix D)
- CCCCC = Measure abbreviation

1.5 Integration with DEER Measure Cost Results

Summit Blue Consulting performed an update to the DEER measure cost dataset under separate contract from this DEER measure impact study. The measure cost study was performed in parallel to the phase two portion of the 2004-05 DEER measure impact update. The objectives of the Summit Blue study were 1) to update the measure cost information of the 2001 DEER measure cost study and 2) to collect measure costs as the measures are specifically characterized in the 2004-05 DEER impact update study. Integrating the measure costs for the measures as they are specifically characterized in the 2004-05 DEER update study required significant coordination and cooperation between the two study teams.

In order to properly integrate cost information into the 2004-05 DEER update it was first important to specify the list of measures included in the study and to finalized as quickly as possible the characteristics for each measure as modeled for the energy impacts. This posed a challenge with some of the weather sensitive measures as characterizations were not finalized until late into the project.

The collection and integration of cost data was performed in two phases. Phase one was for all of the non-weather sensitive measures as well as a subset of "high priority" weather sensitive measures. This data was collected and integrated by the end of March, 2005. Phase two included collection of cost data for the remaining weather sensitive measures.

As the list of measures was being compiled and finalized, several issues beyond the mere agreement on measure characteristics became evident. These included:

- Customer baseline vs. code baseline
- Energy common units vs. cost common units
- Application and cost basis

Each of these issues provided integration challenges. How these challenges were met is covered in Section 12 of this report.

1.6 Challenges and Accomplishments

The progression of initial study ideas and goals through the phase 1 Request for Proposal (RFP) process and scope of work development to the actual study implementation for the phase 2 2004-05 DEER update provided significant challenges and major shifts in direction and emphasis. Beginning with the phase one kick-off meeting, it became apparent that the initial study ideas as presented in the RFP and corresponding consultant proposal were part of an evolutionary process. Climate zone issues, the number of building vintages, the specific building types (and number of building types) all were modified in one degree or another. The issue of the modeling methodology and form and how to address interactive effects, if at all, were discussed in detail.

The shifts in emphasis and direction experienced during phase one led to an increasing of the effort for several tasks, especially those related to building simulation and deferment to phase two of several others. The tasks deferred to phase two included:

- Relocatable Classrooms
- Agricultural Measures
- Simulation runs for all weather sensitive results
- Storage and Cataloging the 8760 Hourly Data for Weather Sensitive Measures

The issue of 8760 hourly load data is still an issue in transition after phase two and will be delayed to future DEER updates.

After the completion of phase one, it was decided that more emphasis needed to be placed into developing the DEER periodic update plan. This task was given more emphasis in phase two and results of these efforts are provided in Section 14 of this report.

The primary lesson learned in developing the 2004-05 DEER update is the constant fluidity of the issues. New information is always becoming available and ways of thinking about issues evolve. Modeling techniques are improving and as models and methodologies are implemented, it sometimes becomes apparent how the information feeding the models/methodologies or the models/methodologies themselves could be improved. However, timing and budget prevent such improvements from being implemented in most cases. We have tried to catalog many of these improvement issues within the discussions in Section 14.

To properly address this lesson may require a change in how DEER is updated in the future. Instead of a massive effort to overhaul the entire dataset every few years, it may be more cost effective and much more useful to have a team of consultants on call to provide maintenance and perform incremental changes. Major methodological updates could be spread out more over time and only done when obvious overall improvement to DEER can be assured. Please see Section 14 for a more complete discussion of the relevant issues to consider in future DEER updates

1.7 Guide to the Report

The report is split into an Executive Summary, 14 sections, and six appendices. The first section is this Introductory section. The next three sections cover the non-weather sensitive market segments. Each of these sections identifies the measures included in the 2004-05 DEER update and the methodologies used to develop the measure impacts. These three sections are as follows;

- Section 2: Residential Non-Weather Sensitive Measures
- Section 3: Non-Residential Non-Weather Sensitive Measures
- Section 4: Agricultural Measures

The next six sections cover the weather sensitive methodology and measures. This includes discussion of the software, building prototype characteristics, the weather sensitive measures modeled, and the climate zones used for the analysis. These six sections are as follows:

- Section 5: Weather Sensitive Analysis Using eQuest
- Section 6: DEER Building Prototypes
- Section 7: Residential Weather Sensitive Measures

- Section 8: Non-Residential Weather Sensitive Measures
- Section 9: DEER Processing Ruleset
- Section 10: Climate Zones

The final four sections cover information and issues that affect both the weather sensitive and non-weather sensitive portions of the 2004-05 DEER update. These include:

- Section 11: Effective Useful Life
- Section 12: Measure Costs
- Section 13: DEER Website
- Section 14: DEER Update Plan

The six appendices provide either multiple tables of information that were too numerous to include in the text of the report or information detail that is better presented separately. They include:

- Appendix A: Non-Residential CFL Measures by Building Type
- Appendix B: Non-Residential Non-CFL Interior Lighting Measures by Building Type
- Appendix C: Measure Costs
- Appendix D: DEER Glossary
- Appendix E: Example Process for Coordination and Review of Comments on the Future Database for Energy Efficient Resources (DEER)
- Appendix F: Bibliography

2

Residential Sector Non-Weather Sensitive

Savings estimates from residential conservation measures were estimated for both weather sensitive and non-weather sensitive measures. This section of the report will discuss the methodology used to calculate savings estimates for the residential non-weather sensitive measures. For each measure or group of measures, a discussion will be provided regarding the methodology used in the 2001 DEER update as well as the methodology used in the 2004-05 update. The following measures/measure groups are included in the 2004-05 DEER update for residential non-weather sensitive measures:

- CFL lighting
- High efficiency refrigerators
- High efficiency clothes dryers
- High efficiency clothes washers
- High efficiency dishwashers
- High efficiency water heating measures
- Swimming pool pumps

The methodology used to calculate electric demand, energy, and natural gas savings estimates for each of the measures is provided. In addition, the input variables used by the methodologies along with example results are provided. Where possible, the methodologies and assumptions used in the 2001 DEER update were carried forward. However, methodological modifications did occur and the number of measures covered was expanded. The peak demand savings are broadly defined as the average demand savings between noon and 6 P.M. and from May through October.

2.1 CFL Lighting

Compact fluorescent lamps (CFLs) are designed to replace standard incandescent lamps, fixtures, and halogen lamps/fixtures (such as halogen torchieres). CFL lamps are about three to four times more efficient than the lumen-equivalent incandescent and halogen lamps they are assumed to replace. Both screw-in lamps and hard-wired (pin based) lamp fixtures (table lamps, hard wired fixtures, and torchieres) are included in the database.

2001 DEER Methodology

The 2001 DEER update provided savings estimates for a limited number of CFL lamp and time usage configurations. These include:

- Three CFL bulb sizes: 7-watt, 15-watt, and 25-watt. These three bulb sizes utilized incandescent base lighting of 30W, 60W, and 100W, respectively.
- Three levels of bulb operation: 0.5, 2.5, and 6 hours/day.
- Three utility service areas: PG&E, SCE, and SDG&E.

The 2001 DEER did not include any table lamp or torchieres measures. The savings calculations were the same for all three utility service areas. The base energy use was calculated using the bulb wattage, the number of hours of use per day, and the number of days in a year. The CFL savings were based on percentage wattage reduction applied against the base usage. The savings share of base usage was calculated as 1 – CFL wattage / Incandescent wattage (for example, a 7W CFL replaces a 30W incandescent = 1 – 7/30 = 77%).

Peak demand savings were estimated using the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. The peak demand impacts were based on the following energy/peak factors being applied to the kW/unit value; 0.06 for the 0.5 hours of operation measures, 0.303 for the 2.5 hours of operation measures, and 0.727 for the 6.0 hours of operation measures.

2004-05 DEER Methodology

The methodology of calculating energy savings for CFL lamps follows a simple formula that captures wattage level changes, hours of daily use, hourly load shares, and estimates of lamp installation rate called "In Service Rate" (ISR). The formulas are:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit)\times(hours / day)\times(days / year)\times(In\ Service\ Rate)}{1{,}000\ Watt\ hours / kWh}$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit)\times(In\ Service\ Rate)\times(Peak\ Hour\ Load\ Share)$$

There is no service area, housing type, or vintage distinctions since the savings methodology is based solely on assumed bulb wattages and hours of operation. The ISR is an estimate of what percentage of bulbs purchased are actually installed. Efficiency Vermont[1] used an ISR of 90% to degrade estimated efficiency for CFL bulb programs (no ISR degradation for

[1] Efficiency Vermont, "Measure Savings Algorithms and Cost Assumptions: Technical Reference Manual", Jan. 2003.

torchiere and table lamp programs). In addition to Efficiency Vermont, estimates for California program efforts range from 71% to 99%[2]. For incentive/buydown programs, the California ISR factors were found to be 90% for PG&E, 87% for SCE, and 92% for SDG&E. The estimated ISR value used for the 2004-05 DEER database is 90%.

CFL Lamps - 2004-05

The 2001 DEER update included three bulb sizes each with three different hours of operation for each size for a total of nine CFL lamp configurations. The 2004-05 update expanded the number of lamp configurations significantly. The expansion was designed to better match what is offered through the utility programs.

Table 2-1 lists the CFL lamp measures included within the 2004-05 DEER along with the base incandescent lamp wattage each CFL is assumed to be replacing. The matching of each CFL lamp measure to an incandescent base lamp is based on a recently completed residential CFL metering study[3]. Eighteen different screw-in CFL wattage/lumen measures and 19 different pin-based CFL wattage/lumen measures are provided. [Note that for the modular, pin-based CFLs listed in DEER, all are assumed to be complete, hard-wired fixtures that are installed and not screw-in ballasts that accept modular, pin-based CFL lamps.]

Below is an example calculation done for a 14W CFL screw-in lamp replacing a 60W incandescent base lamp.

$$\textbf{Energy Savings} = \frac{(46\,Watts)\times(2.34\,hours\,/\,day)\times(365\,days\,/\,year)\times(0.9)}{1{,}000\,Watt\ hours\,/\,kWh} = 35.4\,kWh$$

$$\textbf{Demand Savings} = (46\,Watts)\times(0.9)\times(0.081) = 3.35\,Watts$$

The "hours/day" and the "peak hour load share" come from the CFL metering study.

[2] "Phase 4 Market Effects Study of California Residential Lighting and Appliance Program", prepared for San Diego Gas and Electric by Xenergy, Inc., April 26, 2002.

[3] See Table 4-1 "CFL Metering Study", prepared for Pacific Gas & Electric Company, San Diego Gas & Electric Company and Southern California Edison by KEMA, Inc., February 25, 2005

Table 2-1: 2004-05 DEER Residential CFL Lamp Measures

Measure Description	Base Description
13 Watt < 800 Lumens - screw-in	40W Incandescent
13 Watt >=800 Lumens - screw-in	60W Incandescent
14 Watt - screw-in	60W Incandescent
15 Watt - screw-in	60W Incandescent
16 Watt - screw-in	60W Incandescent
18 Watt < 1,100 Lumens - screw-in	60W Incandescent
18 Watt >=1,100 Lumens - screw-in	75W Incandescent
19 Watt >=1,100 Lumens - screw-in	75W Incandescent
20 Watt - screw-in	75W Incandescent
23 Watt - screw-in	100W Incandescent
25 Watt <1,600 Lumens - screw-in	75W Incandescent
25 Watt >=1,600 Lumens - screw-in	100W Incandescent
26 Watt <1,600 Lumens - screw-in	75W Incandescent
26 Watt >=1,600 Lumens - screw-in	100W Incandescent
28 Watt - screw-in	100W Incandescent
30 Watt - screw-in	100W Incandescent
36 Watt - screw-in	150W Incandescent
40 Watt - screw-in	150W Incandescent
13 Watt < 800 Lumens - pin based	40W Incandescent
13 Watt >=800 Lumens - pin based	60W Incandescent
14 Watt - pin based	60W Incandescent
15 Watt - pin based	60W Incandescent
16 Watt - pin based	60W Incandescent
18 Watt < 1,100 Lumens - pin based	60W Incandescent
18 Watt >=1,100 Lumens - pin based	75W Incandescent
19 Watt >=1,100 Lumens - pin based	75W Incandescent
20 Watt - pin based	75W Incandescent
23 Watt - pin based	100W Incandescent
25 Watt <1,600 Lumens - pin based	75W Incandescent
25 Watt >=1,600 Lumens - pin based	100W Incandescent
26 Watt <1,600 Lumens - pin based	75W Incandescent
26 Watt >=1,600 Lumens - pin based	100W Incandescent
28 Watt - pin based	100W Incandescent
30 Watt - pin based	120W Incandescent
40 Watt - pin based	120W Incandescent
55 Watt - pin based	200W Incandescent
65 Watt - pin based	200W Incandescent

Table 2-2 identifies the measure ID number, measure description, energy and demand savings estimates for the residential sector CFL lamps and pin-based fixtures. Note that both the base and CFL fixtures are assumed to be manually controlled and do not include any additional savings from other control options such as photo-sensors and occupancy sensors.

Table 2-2: 2004-05 DEER Residential CFL Measure IDs and Savings Estimates

Measure ID	Measure Description	Energy Savings (kWh/unit)	Peak Demand Savings - using 8.1% peak hour load shape (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	20.8	1.97
D03-802	13 Watt >=800 Lumens - screw-in	36.1	3.43
D03-803	14 Watt - screw-in	35.4	3.35
D03-804	15 Watt - screw-in	34.6	3.28
D03-805	16 Watt - screw-in	33.8	3.21
D03-806	18 Watt < 1,100 Lumens - screw-in	32.3	3.06
D03-807	18 Watt >=1,100 Lumens - screw-in	43.8	4.16
D03-808	19 Watt >=1,100 Lumens - screw-in	43.0	4.08
D03-809	20 Watt - screw-in	42.3	4.01
D03-810	23 Watt - screw-in	59.2	5.61
D03-811	25 Watt <1,600 Lumens - screw-in	38.4	3.65
D03-812	25 Watt >=1,600 Lumens - screw-in	57.7	5.47
D03-813	26 Watt <1,600 Lumens - screw-in	37.7	3.57
D03-814	26 Watt >=1,600 Lumens - screw-in	56.9	5.39
D03-815	28 Watt - screw-in	55.3	5.25
D03-816	30 Watt - screw-in	53.8	5.10
D03-817	36 Watt - screw-in	87.6	8.31
D03-818	40 Watt - screw-in	84.6	8.02
D03-819	13 Watt < 800 Lumens - pin based	20.8	1.97
D03-820	13 Watt >=800 Lumens - pin based	36.1	3.43
D03-821	14 Watt - pin based	35.4	3.35
D03-822	15 Watt - pin based	34.6	3.28
D03-823	16 Watt - pin based	33.8	3.21
D03-824	18 Watt < 1,100 Lumens - pin based	32.3	3.06
D03-825	18 Watt >=1,100 Lumens - pin based	43.8	4.16
D03-826	19 Watt >=1,100 Lumens - pin based	43.0	4.08
D03-827	20 Watt - pin based	42.3	4.01
D03-828	23 Watt - pin based	59.2	5.61
D03-829	25 Watt <1,600 Lumens - pin based	38.4	3.65
D03-830	25 Watt >=1,600 Lumens - pin based	57.7	5.47
D03-831	26 Watt <1,600 Lumens - pin based	37.7	3.57
D03-832	26 Watt >=1,600 Lumens - pin based	56.9	5.39
D03-833	28 Watt - pin based	55.3	5.25
D03-834	30 Watt - pin based	69.2	6.56
D03-835	40 Watt - pin based	61.5	5.83
D03-836	55 Watt - pin based	111.5	10.57
D03-837	65 Watt - pin based	103.8	9.84

CFL Table Lamps and Torchieres - 2004-05

The 2001 DEER update did not include any CFL table lamps or torchieres. The 2004-05 update includes four CFL table lamps and three CFL torchiere measures. The calculation method for both the energy and demand savings estimates is similar to that used for CFL lamps. However, no "in-service factor" is used to degrade the energy and demand savings estimates.

Below is an example calculation done for a 55W CFL table lamp replacing a 200W incandescent table lamp.

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit) \times (hours / day) \times (days / year)}{1{,}000\ Watt\ hours / kWh}$$

$$= \frac{(145\ Watts) \times (2.28\ hours / day) \times (365\ days / year)}{1{,}000\ Watt\ hours / kWh}$$

$$= 120.7\ kWh$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit) \times (Peak\ Hour\ Load\ Share)$$

$$= (145\ Watts) \times (0.081)$$

$$= 11.7\ Watts$$

The "hours/day" and the "peak hour load share" come from the CFL metering study. "Hours/day" is slightly lower than for CFL lamps. Table 2-3 lists the CFL table lamp and torchiere measures included within the 2004-05 DEER along with the incandescent lamp wattage being replaced.

Table 2-3: 2004-05 DEER Residential CFL Table Lamp and Torchiere Measures

Measure Description	Base Description
20W CFL Table Lamp - pin based	75W Incandescent Table Lamp
25W CFL Table Lamp - pin based	100W Incandescent Table Lamp
30W CFL Table Lamp - pin based	120W Incandescent Table Lamp
55W CFL Table Lamp - pin based	200W Incandescent Table Lamp
55W CFL Torchiere - pin based	300W Halogen Bulb Torchiere
70W CFL Torchiere (two bulbs) - pin based	300W Halogen Bulb Torchiere
70W CFL Torchiere (two bulbs) - pin based	190W Halogen Bulb Torchiere

Table 2-4 identifies the measure ID, measure description, energy savings estimates for the residential sector CFL table lamps and torchieres.

Table 2-4: 2004-05 DEER Residential CFL Table Lamp and Torchiere Measure IDs and Savings Estimates

Measure ID	Measure Description	Energy Savings (kWh/unit)	Peak Demand Savings - using 8.1% peak hour load shape (watts/unit)
D03-838	20W CFL Table Lamp - pin based	45.8	4.46
D03-839	25W CFL Table Lamp - pin based	62.4	6.08
D03-840	30W CFL Table Lamp - pin based	74.9	7.29
D03-841	55W CFL Table Lamp - pin based	120.7	11.75
D03-842	55W CFL Torchiere - pin based	203.9	19.85
D03-843	70W CFL Torchiere (two bulbs) - pin based (300W base)	191.4	18.63
D03-844	70W CFL Torchiere (two bulbs) - pin based (190W base)	99.9	9.72

2.2 Refrigerators

The measure is defined as high efficiency Energy Star refrigerators that must exceed the July 1, 2001 minimum federal standards for refrigerator energy consumption by at least 10%. Such an energy efficient refrigerator is designed to improve the various components of the cabinet and refrigeration system. These component improvements include cabinet insulation, compressor efficiency, evaporator fan efficiency, defrost controls, mullion heaters, oversized condenser coils, and improved door seals. In addition to the purchase of new Energy Star refrigerators, refrigerator and freezer recycling measures are also included in the 2004-05 DEER update. For these recycling measures, it is assumed that older refrigerators and freezers that are still operable are turned into recycling centers so that they cannot be used again and are taken off the grid.

2001 DEER Methodology

The 2001 DEER update provided savings estimates for three refrigerator measure options. Measure savings for each of these options used the 1993 National Appliance Energy Conservation Act (NAECA) for base efficiency. Energy savings were calculated as a percentage savings of rated consumption from this base efficiency. The three options were:

- Energy Star Refrigerator – 20% improved efficiency
- 2001 Compliant Refrigerator – 30% improved efficiency
- Above 2001 Compliant Refrigerator – 37% improved efficiency

Base usage in the 2001 DEER update is different between single family and multi-family with additional minor differences between the three major electric utility service areas (PG&E, SCE, and SDG&E). Peak demand savings is based on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. In all cases, the energy/peak factor for refrigerators is 0.17.

The 2001 DEER update did not include the refrigerator and freezer recycling measures.

2004-05 DEER Methodology

The 2004-05 DEER update includes measures for both new refrigerators and for refrigerator and freezer recycling measurers.

New Refrigerators

New Federal minimum efficiency standards (NAECA) for refrigerators went into effect on July 1, 2001. The new Energy Star specification, which is 10% above the new minimum efficiency standard, took effect on January 1, 2001. These appliance standard changes require a change in the baseline technology for the 2004-05 DEER update.

A spreadsheet calculator available through the Energy Star website (http://www.energystar.gov) was used to estimate refrigerator measure savings for the 2004-05 DEER update. The Energy Star calculator can be used to estimate energy impacts and dollar savings for five model types. The model types and the refrigerator and freezer volumes can be modified within the calculator. The model types available are:

- Top Mount Freezer without through-the-door ice
- Side Mount Freezer without through-the-door ice
- Bottom Mount Freezer without through-the-door ice
- Top Mount Freezer with through-the-door ice
- Side Mount Freezer with through-the-door ice

The July 1, 2001 NAECA standards serve as the base efficiency for determining the savings from buying an Energy Star refrigerator. The national average refrigerator fresh volume is cited to be 18 cubic feet (cf) and the national average refrigerator freezer volume is cited to be 5 cubic feet (cf).

The 2004-05 DEER update includes having energy savings estimates for each of the five model options and utilizes the national averages for refrigerator fresh volume of 18 cf and refrigerator freezer volume of 5 cf. These national average refrigerator capacity values are used to represent the single family option. In the 2001 DEER update, the multi-family refrigerator measure used about 13% less than the single family refrigerator measure. Based on this, the multi-family refrigerator volume is adjusted to accommodate for this 13% difference. For multi-family, the estimated refrigerator fresh volume is 12 cf and the multi-family refrigerator freezer volume is 3.5 cf.

For peak demand savings, the CEC based energy/peak factor of 0.17 used in the 2001 DEER update continues to be used for the 2004-05 DEER update. There is no differentiation by utility service area. Table 2-5 provides a listing of the 2004-05 DEER update refrigerator measure IDs and savings estimates.

Table 2-5: 2004-05 DEER New Refrigerator Measure IDs and Savings Estimates

Measure ID	Measure	Freezer Volume (cubic feet)	Fresh Area Volume (cubic feet)	Base Usage (kWh/yr)	Energy Star Usage (kWh/yr)	Energy Savings (kWh/unit)	Peak Demand Savings (Watts/unit)
D03-954	Refrigerator: Bottom Mount Freezer without through-the-door ice	3.5	14	550	495	55	9.4
D03-955	Refrigerator: Bottom Mount Freezer without through-the-door ice	5	18	579	521	58	9.9
D03-956	Refrigerator: Top Mount Freezer without through-the-door ice	3.5	12	450	405	45	7.7
D03-957	Refrigerator: Top Mount Freezer without through-the-door ice	3.5	14	469	422	47	8.0
D03-958	Refrigerator: Top Mount Freezer without through-the-door ice	5	18	532	479	53	9.0
D03-959	Refrigerator: Side Mount Freezer without through-the-door ice	3.5	12	595	535	60	10.2
D03-960	Refrigerator: Side Mount Freezer without through-the-door ice	5	18	636	572	64	10.9
D03-961	Refrigerator: Side Mount Freezer with through-the-door ice	5	18	670	603	67	11.4
D03-962	Refrigerator: Side Mount Freezer with through-the-door ice	10	18	761	685	76	12.9

Refrigerator and Freezer Recycling

Refrigerator and freezer recycling were not measures in the 2001 DEER. However, estimates of savings from the utility refrigerator/freezer recycling programs are significant. A number of measurement and evaluation studies were conducted to estimate savings for these measures. In 1996 and later in 1998, estimates of demand and energy savings for this program were developed by Athens Research for Southern California Edison's refrigerator and freezer recycling program[4]. These values were based on a metering of a sample of the refrigerators/freezers turned in at various Appliance Recyclers of America (ARCA) sites across the country, including Southern California. The 1996 and 1998 Athens Study[5] [6] relied upon the DOE protocol metering sample to develop regression parameters relating the metering consumption to various appliance characteristics 9type, configuration, defrost type, amperage, age). The full year unit energy consumption (UEC) estimates or gross savings estimates for the recycled, old units were:

- Refrigerators - 2,148 kWh/unit
- Freezers - 2,058 kWh/unit

In a report released in February of 2004[7], KEMA-Xenergy extended and updated the Athens' work. The newer study found that the refrigerator UEC dropped to 1,946 kWh/unit and the freezer UEC to 1,662 kWh/unit. The 2004-05 DEER update utilizes the refrigerator/freezer recycling impact estimates found in this 2004 Kema-Xenergy study. These savings values are as follows:

- Refrigerator: 1,946 kWh/year and 0.300 kW (Measure ID D03-964)
- Freezer: 1,662 kWh/year and 0.256 kW (Measure ID D03-965)

2.3 Clothes Dryers

A standard clothes dryer uses various temperatures and drying durations to dry clothes depending on the clothing type and size of the laundry load. In general, the dryer cylinder is spun to rotate the wet clothes, as hot air is injected into the drying cylinder. Wet moist air is then exhausted from the dryer. The cycle duration is manually set. An energy efficient

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[4] "Refrigerator/Freezer UEC Estimation, 1996 ARCA/SCE Turn-In Program", performed by Athens Research, May 1998.

[5] See www.CALMAC.org for Refrigerator/Freezer UEC estimation, 1996 ARCA/SCE Turn-in Program (In support of XENERGY Inc's Evaluation of the 1996 Appliance Recycling Program) – Study SCE 0055.01; 537.1 and Impact Evaluation of the 1996 Spare Refrigerator Recycling Program – Study SCE 0054.01; 537

[6] See www.CALMAC.org Impact Evaluation of 1994 Spare Refrigerator Recycling Program – Study ID SCE 0046.01; 515

[7] "Measurement and Evaluation Study of 2002 Statewide Residential Appliance Recycling Program", prepared for Southern California Edison, prepared by Kema-Xenergy Inc., February, 2004.

clothes dryer uses a moisture sensing device to terminate the drying cycle rather than using a timer. In addition, an energy efficient motor is used for spinning the dryer tub.

2001 DEER Methodology

The 2001 DEER update included one measure for energy efficient clothes dryers. This was the addition of a moisture sensor to the dryer so that it shuts down once a certain moisture point in the clothes is reached. The impact from energy efficient clothes dryers was estimated to be a 5% savings from base energy use. The measure was characterized separately by electric utility service area and by single family vs. multi-family. The base UEC for multi-family was estimated to be about 60% of single family.

The peak demand impact was based on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. The energy/peak factor for clothes dryers was 0.371.

2004-05 DEER Clothes Dryer Measures and Methodology

The 2004-05 DEER update utilizes the estimate of a 5% savings for energy efficient clothes dryers. The base energy use is estimated using Appliance Standards EF factors and annual drying cycle estimates. The NAECA minimum efficiency standard for standard sized residential dryers is an EF of 3.01 for electric dryers and 2.67 for gas dryers. Using the DOE test procedure for standard dryers of 416 cycles per year and energy use of 2.33 kWh/cycle for electric dryers and 9.95 kBtu/cycle for gas dryers. This gives an estimated annual use of 969 kWh/year for electric and 3.72 MMBtu/year for gas dryers meeting the NAECA standards[8]. These baseline energy use values are used in the 2004-05 DEER update as the baseline energy use for all utility service areas. Since the 416 drying cycles is an average for the entire residential sector, no distinction is made in the 2004-05 DEER update between single family and multi-family.

Table 2-6 provides a listing of the 2004-05 DEER update clothes dryer measure IDs and savings estimates.

[8] "Energy Data Sourcebook for the U.S. Residential Sector", Lawrence Berkeley National Laboratory (LBL-40297 UC-1600), September, 1997

Table 2-6: 2004-05 DEER Clothes Dryer Measure IDs and Savings Estimates

Measure ID	Measure	Base Electric UEC (kWh/yr)	Base Gas UEC (Therms/unit)	Energy Saving Fraction (%)	Energy Savings - Electric (kWh/unit)	Energy Savings Gas (Therms/unit)	Peak Demand Savings (Watts/unit)	Energy Savings - Gas (kBtu/unit)
D03-941	High Efficiency Electric Clothes Dryer with Moisture Sensor. Single Family, 416 dry cycles	969		5%	48		18.3	
D03-942	High Efficiency Gas Clothes Dryer with Moisture Sensor. Single Family, 416 dry cycles		37.20	5%		1.86		186.0

2.4 Clothes Washers

A standard clothes washer uses various temperatures, water levels, and cycle durations to wash clothes depending on the clothing type and size of the laundry load.

A high efficiency vertical axis clothes washer that eliminates the warm rinse option and utilizes a spray technology to rinse clothes can significantly reduce washer related energy use. Such machines also utilize a spin cycle that eliminates more water from the clothes than conventional clothes washers and are generally driven by more efficient motors.

A horizontal axis clothes washer utilizes a cylinder that rotates horizontally to wash, rinse, and spin the clothes. These types of washing machines can be top loading or front loading, and utilize significantly less water that the standard vertical axis machines. A vertical axis machine generally fills the tub until all of the clothes are immersed in water. In contrast, the horizontal axis machine only requires about one third of the tub to be full, since the rotation of the drum around its axis forces the clothes into the water and thus can drastically reduce the total energy use for washing.

2001 DEER Methodology

The 2001 DEER update provided energy impact estimates for two clothes washer options; one with an Energy Factor (EF) of 2.5 and the other with an EF of 3.25. Both of these options used the 1993 National Appliance Energy Conservation Act (NAECA) for base efficiency, which is an EF of 1.18. However, this federal standard changed, effective January 1, 2004. The new federal standard is now based on a modified energy factor (MEF). MEF is a new equation for EF that takes into account the amount of dryer energy used to remove the remaining moisture content. The old standard EF of 1.18 is about equal to an MEF of 0.817[9]. The new federal standard is an MEF of 1.04.

Baseline values differed between single family and multi-family and there were also some minor differences between the electric utility service areas. Peak demand impact was based

[9] "Consortium for Energy Efficiency Residential Clothes Washer Initiative Program Description", 1996, revised 2002 by the Consortium for Energy Efficiency.

on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. In all cases, the energy/peak factor for clothes washers was 0.417.

2004-05 DEER Clothes Washer Measures and Methodology

The Consortium for Energy Efficiency (CEE), a nonprofit public benefits corporation, develops national initiatives to promote the manufacture and purchase of energy-efficient products and services. Their goal is to induce lasting structural and behavioral changes in the marketplace, resulting in the increased adoption of energy-efficient technologies.

Participation in any CEE initiative is entirely voluntary and does not exclude program administrators from using additional specifications. More than 240 utilities and energy organizations are currently participating in the Initiative, including several utilities in California.

CEE's Residential Clothes Washer Initiative, launched in 1993, promotes the manufacture and sales of energy-efficient clothes washers. CEE has developed a set of specifications and a qualifying product list to define energy efficiency and works with Initiative participants (utilities and energy organizations) to promote qualifying washers through incentive, educational and promotional programs.

On Feb.1, 2002 CEE introduced a new set of efficiency specifications for its Residential Clothes Washer Initiative. These new specifications use two efficiency criteria, the Modified Energy Factor (MEF) and the Water Factor (WF). This change resulted in the creation of clothes washer specifications in four tiers (from two) based on MEF and within the fourth MEF tier, two WF tiers With the creation of the new clothes washer federal standards in January of 2004, CEE reduced the number of Tiers from four to three. The current CEE clothes washer specifications are provided in Table 2-7

The MEF is a combination of Energy Factor (EF) and remaining moisture content. It measures energy consumption of the total laundry cycle (washing and drying). Water Factor is the number of gallons needed for each cubic foot of laundry.

CEE's new Tier 1 (1.42 MEF) is aligned with the current 2004 Energy Star minimum MEF level and is 22 percent more efficient than the current federal minimum standard.

Table 2-7: CEE Residential Clothes Washer Initiative High Efficiency Specifications, Effective January 1, 2004

Specification Level	MEF	WF
Baseline	1.04	13.3
Tier 1	1.42	9.5
Tier 2	1.60	8.5
Tier 3A	1.80	7.5
Tier 3B	1.80	5.5

The new 2004 CEE Residential Clothes Washer Initiative tiers (three tiers) are included in the 2004-05 DEER update with the Energy Star calculator utilized to estimate energy savings. The energy savings are reported for different combinations of clothes dryer fuel and water heat fuel.

CEE recommends using the Energy Star on-line calculator to estimate energy savings. However, the Energy Star calculator uses EF and not MEF specifications (Energy Star has both an EF based and MEF based calculator listed, however, only the EF based calculator actually calculates energy savings.). Energy Star has on-line through their website, the full list of approved clothes washers and this list include both their EF and MEF ratings. Using this full list of approved clothes washers and sorting them into the three tiers of efficiency, estimates of average EF by tier were developed. These estimates are provided in Table 2-8 and are used to develop the 2004-05 DEER savings estimates from energy efficient clothes washers.

Table 2-8: CEE Residential Clothes Washer Initiative MEF and EF Values by Tier

Efficiency Parameter	Tier 1	Tier 2	Tier 3
Minimum MEF	1.42	1.60	1.80
Average MEF	1.50	1.68	1.94
Average EF	3.39	3.89	4.94

To represent single family homes, the Energy Star calculator utilized clothes washer capacity of 2.65 cubic feet. Multi-family representation is more complex. According to a study by ADM Associates[10], 92% of the apartment complexes in California have common area laundry facilities. These commercial washers are similar in size to standard residential clothes washers and are also part of the CEE clothes washer initiative. However, those in common areas are likely used more frequently than those found in single family homes and much more than those found within an apartment. Data is very limited on actual usage patterns within the multi-family environment. A study by the U.S. Department of Housing and Urban Development[11] cites a Canadian study that found clothes washer use of 0.37 cycles per person per day for single family and 0.1 cycles for multi-family. Another study cited in the HUD report found that in-unit multi-family washers used 3.9 times more water than common area washers. This data is not specific enough or relevant enough to the California market to support a definitive estimate of clothes washer use in the multi-family sector outside of saying in-unit clothes washers are used less frequently than common area clothes washers.

Three clothes washer options are provided in the 2004-05 DEER update. The first option represents single family homes utilizing a clothes washer capacity of 2.65 for the Energy Star calculator. The second represents in-unit multi-family clothes washers using a clothes washer capacity of 1.5 for the Energy Star calculator. The third represents common area multi-family clothes washers using a clothes washer capacity of 3.5 for the Energy Star calculator.

Efficiency Vermont, in their differentiating of savings among fuel types depending on the mix of gas dryers and gas water heat, used a Btu conversion rate for electricity of 3,412 Btu/kWh, gas water heat efficiency of 75%, and gas clothes dryer efficiency of 92%. Before adjusting for the gas water heater efficiency of 75% and the gas clothes dryer efficiency of 92%, the share of the energy savings is 71.5% water heat, 28.1% clothes dryer, and 0.4% clothes washer motor. These conversion values and shares are utilized for the 2004-05 DEER update. For peak demand savings, the same energy/peak factor of 0.417, as estimated for the 2001 DEER update is used.

Below is an example calculation done for a Tier 3 clothes washer with a capacity of 2.65 cu.ft.

[10] "Statewide Survey of multi-family Common Area Building Owners Market: Volume I: Apartment Complexes", ADM and TechMkrt Works, prepared for Southern California Edison, June 2000

[11] U.S. Department of Housing and Urban Development (HUD), "Overview of Retrofit Strategies; A Guide for Apartment Owners and Managers".

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = (cycles/\ year) \times (capacity/base\ EF) - (cycles/\ year) \times (capacity/measure\ EF)$$

$$= (392\ Watts) \times (2.65/1.58) - (392\ Watts) \times (2.65/4.94)$$
$$= 447\ kWh$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (Measure\ impact) \times Energy/Peak\ Factor$$

$$= 447\ kWh \times 0.417\ Watts/kWh$$
$$= 186.4\ Watts$$

Table 2-9 identifies the measure ID and energy savings from clothes washer measures.

Table 2-9: 2004-05 DEER Clothes Washer Measure IDs and Savings Estimates

Measure ID	Measure Characteristics	Electrcity Savings (kWh/unit)	Peak Demand Savings (Watts/unit)	Gas Savings (therms/unit)	Gas Savings (kBtu/unit)
D03-943	CEE Tier 1: MEF=1.42, 1.5 cf Capacity - Elec Water & Dry	199.0	83.0	0.0	0.0
D03-943	CEE Tier 1: MEF=1.42, 1.5 cf Capacity - Elec Water, Gas Dry	143.1	59.7	2.0	197.6
D03-943	CEE Tier 1: MEF=1.42, 1.5 cf Capacity - Gas Water, Elec Dry	56.8	23.7	6.5	646.9
D03-943	CEE Tier 1: MEF=1.42, 1.5 cf Capacity - Gas Water & Dry	0.0	0.0	8.4	844.6
D03-946	CEE Tier 1: MEF=1.42, 2.65 cf capacity - Elec Water & Dry	351.0	146.4	0.0	0.0
D03-946	CEE Tier 1: MEF=1.42, 2.65 cf capacity - Elec Water, Gas Dry	252.3	105.2	3.5	348.6
D03-946	CEE Tier 1: MEF=1.42, 2.65 cf capacity - Gas Water, Elec Dry	100.2	41.8	11.4	1,141.1
D03-946	CEE Tier 1: MEF=1.42, 2.65 cf capacity - Gas Water & Dry	0.0	0.0	14.9	1,489.7
D03-949	CEE Tier 1: MEF=1.42, 3.5 cf capacity - Elec Water & Dry	463.0	193.1	0.0	0.0
D03-949	CEE Tier 1: MEF=1.42, 3.5 cf capacity - Elec Water, Gas Dry	332.9	138.8	4.6	459.8
D03-949	CEE Tier 1: MEF=1.42, 3.5 cf capacity - Gas Water, Elec Dry	132.1	55.1	15.1	1,505.2
D03-949	CEE Tier 1: MEF=1.42, 3.5 cf capacity - Gas Water & Dry	0.0	0.0	19.7	1,965.0
D03-944	CEE Tier 2: MEF=1.60, 1.5 cf capacity - Elec Water & Dry	221.0	92.2	0.0	0.0
D03-944	CEE Tier 2: MEF=1.60, 1.5 cf capacity - Elec Water, Gas Dry	158.9	66.3	2.2	219.5
D03-944	CEE Tier 2: MEF=1.60, 1.5 cf capacity - Gas Water, Elec Dry	63.1	26.3	7.2	718.4
D03-944	CEE Tier 2: MEF=1.60, 1.5 cf capacity - Gas Water & Dry	0.0	0.0	9.4	937.9
D03-947	CEE Tier 2: MEF=1.60, 2.65 cf capacity - Elec Water & Dry	390.0	162.6	0.0	0.0
D03-947	CEE Tier 2: MEF=1.60, 2.65 cf capacity - Elec Water, Gas Dry	280.4	116.9	3.9	387.3
D03-947	CEE Tier 2: MEF=1.60, 2.65 cf capacity - Gas Water, Elec Dry	111.3	46.4	12.7	1,267.8
D03-947	CEE Tier 2: MEF=1.60, 2.65 cf capacity - Gas Water & Dry	0.0	0.0	16.6	1,655.2
D03-950	CEE Tier 2: MEF=1.60, 3.5 cf Capacity - Elec Water & Dry	515.0	214.8	0.0	0.0
D03-950	CEE Tier 2: MEF=1.60, 3.5 cf Capacity - Elec Water, Gas Dry	370.2	154.4	5.1	511.5
D03-950	CEE Tier 2: MEF=1.60, 3.5 cf Capacity - Gas Water, Elec Dry	147.0	61.3	16.7	1,674.2
D03-950	CEE Tier 2: MEF=1.60, 3.5 cf Capacity - Gas Water & Dry	0.0	0.0	21.9	2,185.7
D03-945	CEE Tier 3: MEF=1.80, 1.5 cf capacity - Elec Water & Dry	253.0	105.5	0.0	0.0
D03-945	CEE Tier 3: MEF=1.80, 1.5 cf capacity - Elec Water, Gas Dry	181.9	75.8	2.5	251.3
D03-945	CEE Tier 3: MEF=1.80, 1.5 cf capacity - Gas Water, Elec Dry	72.2	30.1	8.2	822.5
D03-945	CEE Tier 3: MEF=1.80, 1.5 cf capacity - Gas Water & Dry	0.0	0.0	10.7	1,073.7
D03-948	CEE Tier 3: MEF=1.80, 2.65 cf capacity - Elec Water & Dry	447.0	186.4	0.0	0.0
D03-948	CEE Tier 3: MEF=1.80, 2.65 cf capacity - Elec Water, Gas Dry	321.4	134.0	4.4	444.0
D03-948	CEE Tier 3: MEF=1.80, 2.65 cf capacity - Gas Water, Elec Dry	127.6	53.2	14.5	1,453.1
D03-948	CEE Tier 3: MEF=1.80, 2.65 cf capacity - Gas Water & Dry	0.0	0.0	19.0	1,897.1
D03-951	CEE Tier 3: MEF=1.80, 3.5 cf Capacity - Elec Water & Dry	590.0	246.0	0.0	0.0
D03-951	CEE Tier 3: MEF=1.80, 3.5 cf Capacity - Elec Water, Gas Dry	424.2	176.9	5.9	586.0
D03-951	CEE Tier 3: MEF=1.80, 3.5 cf Capacity - Gas Water, Elec Dry	168.4	70.2	19.2	1,918.0
D03-951	CEE Tier 3: MEF=1.80, 3.5 cf Capacity - Gas Water & Dry	0.0	0.0	25.0	2,504.0

2.5 Dishwashers

Energy Star labeled dishwashers save by using both improved technology for the primary wash cycle, and by using less hot water to clean. They include more effective washing action, energy efficient motors and other advance technology such as sensors that determine the length of the wash cycle and the temperature of the water necessary to clean the dishes.

2001 DEER Methodology

The 2001 DEER update provided energy impact estimates for two dishwasher options; one with an Energy Factor (EF) of 0.52 and the other with an EF of 0.58. Both of these options used the 1993 National Appliance Energy Conservation Act (NAECA) for base efficiency, which is an EF of 0.46. This 1993 NAECA has not changed since the 2001 DEER update.

The 2001 DEER update provided savings both for electric water heat applications and natural gas water heat applications. The natural gas savings appear to be a Btu conversion of the electric savings (3412 Btu/kWh) that is then adjusted with a water heater efficiency of 75%.

There were baseline differences between single family and multi-family and there were also some minor differences between the electric utility service areas. Multi-family savings were about 75% of single family savings. Peak demand savings were based on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. In all cases, the energy/peak factor for dishwashers was 0.317.

2004-05 DEER Dishwasher Measures and Methodology

One dishwasher measure is included in the 2004-05 DEER update, with savings estimates provided for both electricity and natural gas. The natural gas savings are at the same level as the electricity savings after converting to Btus and adjusting for a 75% natural gas water heater efficiency level (equivalent to the 2001 DEER update conversions). The single dishwasher measure has an EF of 0.58. The other 2001 DEER dishwasher measure had an EF of 0.52. However, new Energy Star specifications with a minimum EF of 0.58, took effect on January 1, 2001. This new Energy Star minimum EF eliminated the 2001 measure with an EF of 0.52.

In addition to the Energy Factor (EF), annual energy use for dishwashers is determined by the number of wash cycles. The average number of wash cycles, as identified by the DOE test procedure, has historically been 264. However, based on recent survey data[12], this estimate has been determined to be too high and the number of wash cycles utilized for the DOE test procedure for dishwashers has been lowered to 215, effective February 24, 2004.

Energy Star has on its website (http://www.energystar.gov) a calculator for Energy Star dishwashers. This calculator was utilized to estimate energy savings for the 2004-05 DEER update. The calculator utilizes the new DOE test procedure number of 215 washing cycles per year to represent single family homes. Dishwasher units in multi-family structures are likely very similar to those in single family homes with the primary difference in energy use driven by fewer wash cycles per year. Adjusting wash cycles proportionately adjusts energy use. Based on the 2001 DEER update and assuming proportion energy use/number of wash cycles, wash cycles in multi-family units should be at about 75% of single family. This would be about 160 wash cycles.

[12] "Review of Survey data to Support Revisions to DOE's Dishwasher Test Procedure", Arthur D. Little, Inc., December 18, 2001

For peak demand, the same energy/peak factor of 0.317, as used currently in the 2001 DEER, is retained. Table 2-10 identifies the measure ID and energy savings for dishwashers.

Table 2-10: 2004-05 DEER Dishwasher Measure IDs and Savings Estimates

Measure ID	Measure	Energy Savings (Elec Water) (kWh/unit)	Peak Demand (Elec Water) (Watts/unit)	Energy Savings (Gas Water) (Therms/unit)	Energy Savings (Gas Water) (KBTU/unit)
D03-952	Energy Star Dishwasher (EF=0.58, base EF=0.46), 215 wash cycles	97	30.7	4.0	400.0
D03-953	Energy Star Dishwasher (EF=0.58, base EF=0.46), 160 wash cycles	72	22.8	3.0	300.0

2.6 Water Heating

Water heating includes a number of different measures designed to reduce the amount of energy used to heat water for domestic consumption. These measures are in addition to the clothes washer and dishwasher measures discussed earlier.

2001 DEER Methodology

The 2001 DEER update included six measures that affect water heating energy use.

- High efficiency water heater
- Heat pump water heater
- Low flow showerhead
- Pipe Wrap
- Faucet aerators
- Water heater blanket

Savings estimates for each were calculated as a percentage savings from a base water heat end-use. The base water heat usage varied by housing type and electric utility service area. The multi-family base water heat UEC was between 76% and 82% of the single family base water heat UEC. Peak demand impact was based on the load shapes contained in the California Energy Commission's (CEC) peak demand forecasting model. In all cases, the energy/peak factor for water heat measures was 0.22.

The assumed energy savings fractions, as identified in the 2001 DEER update, are identified in Table 2-11. In the 2001 DEER update, the base electric water heater was defined as having an EF = 0.88 and the base gas water heater an EF = 0.54.

Table 2-11: Water Heat Measure Energy Savings Fractions from 2001 DEER Update

Measure	Energy Savings Fraction - Electricity (%)	Energy Savings Fraction - Gas (%)
High efficiency water heater - Electric, EF=0.93	5.4%	-
High efficiency water heater - Gas, EF = 0.60	-	10.0%
High efficiency water heater - Gas, EF = 0.63	-	14.3%
Heat pump water heater, EF=2.9	69.7%	-
Low flow showerhead	8.0%	8.0%
Pipe Wrap	4.0%	4.0%
Faucet aerators	3.0%	3.0%
Water heater blanket	10%	10%

2004-05 DEER Water Heating Measures and Methodology

The basic methodology used in the 2001 DEER update is utilized in the 2004-05 DEER update. This methodology involves a percentage savings by measure applied to a base water heat end-use. All of the measures included in the 2001 DEER update are included in the 2004-05 DEER update except for the water heater blanket. Hot water tank wraps are only appropriate for older, less insulated tanks and not for the newer, more efficient models that have been mandated since the early 1990s. Most older water tanks have already been replaced with the newer, post 1990 tanks.

The percentage savings applied to the base end-use also remains the same except for gas high efficiency water heaters and low-flow showerheads. New California appliance standards require modification of the base and energy efficient technology assumptions for gas high efficiency water heaters. Reduced federally mandated maximum flowrate for showerheads led to a reduction is the savings percentage for showerheads.

The assumed energy savings fractions by measure used for the 2004-05 DEER update are identified in Table 2-12.

Table 2-12: Water Heat Measure Energy Savings Fractions from 2004-05 DEER Update

Measure	Energy Savings Fraction - Electricity (%)	Energy Savings Fraction - Gas (%)
High efficiency water heater - Electric, EF=0.93	5.4%	-
High efficiency water heater - Gas, EF = 0.63	-	5.0%
Heat pump water heater, EF=2.9	69.7%	-
Low flow showerhead	4.0%	4.0%
Pipe Wrap	4.0%	4.0%
Faucet aerators	3.0%	3.0%

High Efficiency Water Heater (electric and gas)

The water heater measures involve substitution of a standard efficiency 40 gallon water heater with a high efficiency 40 gallon water heater. For the 2004-05 DEER update, the electric base EF remains at 0.88, but the base gas water heater EF is raised from an EF=0.54 to an EF=0.6. The gas EF=0.6 reflects minimum gas water heater efficiency as a result of California appliance code changes effective January of 2004.

The high efficiency electric water heater is defined as having an EF = 0.93 and the heat pump water heater an EF = 2.9. For gas, one efficient gas water heaters is identified with an EF = 0.63. The change in the baseline gas water heater EF results in a lowering of the expected percentage savings for this measure from DEER 2001 update levels. The 2004-05 DEER update percentage savings is estimated to be 5%.

Point of Use Water Heat

The point of use water heater measure has been included in the 2004-05 DEER update as a gas measure. According to a US DOE technology brief[13] on tankless or instantaneous water heaters, gas point of use water heaters are widely available. Gas fired units have a higher hot water output than electric models and electric units have the further disadvantage of requiring a relatively high electric power draw because water must be heated quickly to the desired temperature. These only gas-fired units don't use a pilot light. A pilot light would offset (about 50% based on the information in the technology brief) much of the energy savings derived from using a point of use water heater. The expected energy savings from these units will vary considerably by the amount of water usage with the greatest potential for savings

[13] U.S. Department of Energy, Energy Efficiency and Renewable Energy Clearinghouse, "Demand (Tank less or Instantaneous) Water Heaters, (www.eere.energy.gov/consumerinfo/refbriefs/bc1.html)

being in applications with low water usage. However, energy savings should be in the ten to twenty percent range (15% used).

Low Flow Showerheads

The 2001 DEER update utilized a base flow rate of about 3.3-3.5 gallons per minute (gpm) with the low flow showerhead having a flow rate of about 2.5 gpm. Current federal standards mandate that showerheads have a maximum flow rate of 2.5 gpm. The recently completed California Energy Commission Statewide Residential Appliance Saturation Survey[14] (RASS) shows a saturation of low flow showerheads at about 80%. Considering the average lifetime for a showerhead is only 9 years, the current high saturation of low flow showerheads, and that federal standards mandate showerhead flow of no more than 2.5 gpm led to the decision to modify the characteristics for this measure in the 2004-05 DEER update. The 2004-05 DEER update characterizes a base case of 2.5 gpm and an efficiency measure level of 2.0 gpm. This change led to a reduction in the expected energy savings from the 2001 DEER update level of 8% to the 2004-05 DEER update level of 4%.

Faucet Aerators and Pipe Wraps

Although the number of applications for these measures is limited, these two measures are elements of the low income program and therefore included in the 2004-05 DEER update. The expected percentage savings used in the 2001 DEER update are also used in the 2004-05 DEER update. However, for gas, the actual estimate of therms saved is lower because of the change in the gas water heater base case.

Climate Zone Issue

The original 1994 NEOS DEER study provided separate savings estimates for water heat measures for only two generic climate zones. The 2001 DEER update did not address water heat measure energy savings from the perspective of climate zone, but rather by the service territory of the three investor owned utility service areas. For the 2001 DEER update, baseline water heat energy use varied by utility service territory but the same percentage savings by measure was applied.

The 2004-05 DEER update has more climate zones than either the 1994 NEOS or 2001 DEER studies. However, there appears to be no reason to now have water heat energy savings by climate zone any more than there was in the two previous studies. For those measures that are based on a percentage savings over a base unit energy consumption value (UEC) the 2004-05 DEER update continues to utilize the 2001 DEER update methodology of differentiating by the three major service areas. These three baselines are mapped into the 16

[14] "California Statewide Residential Appliance Saturation Study", prepared by KEMA-Xenergy, prepared for the California Energy Commission, June 2004

climate zones used in this study, as shown in Table 2-13. Also shown in the table are the baseline water heat UECs by utility service area, housing type, and fuel.

Table 2-13: Water Heat Baseline UECs, Utility Service Area/Weather Zone Mapping

Utility	Title 24 Climate Zones	SF Baseline UEC (kWh)	SF Baseline UEC (Therms)	MF Baseline UEC (kWh)	MF Baseline UEC (Therms)
PG&E	1,2,3,4,5,16	2,301	111	1,896	104
SCE	9,10,11,12,13,14,15	2,512	115	1,906	104
SDG&E	6,7,8	2,340	103	1,940	97

The water heat related measures of energy efficient clothes washers and dishwashers, covered in earlier sections of this report, are not based on a methodology of a percentage savings applied to a base water heating UECs, but rather on Energy Star calculators that do not rely of base UECs. The clothes washer and dishwasher energy savings are not differentiated by either climate zone or utility service area.

Summary Tables

Table 2-14 through Table 2-16 provide the 2004-05 DEER update savings estimates by water heating fuel and housing type for each of the three investor owned utility service areas. The baseline water heat UECs do not include clothes washing water heat or dishwashing water heat UECs. These UECs are accounted for separately under the clothes washing and dish washing DSM technologies.

For peak demand, the same energy (kWh)/peak (watt) factor of 0.22, as used in the 2001 DEER update is utilized.

Table 2-14: 2004-05 DEER Water Heat Measure IDs and Savings Estimates, PG&E Baseline

Measure ID	Measure Name	Building Type	Utility	Fuel	Electrcity Impact (kWh/unit)	Peak Demand (Watts/unit)	Gas Impact (therms/unit)	Gas Impact (kBtu/unit)
D03-934	Faucet Aerators	SF	PG&E	Either	99.9	22.0	5.6	562.7
D03-935	Heat Pump Water Heater	SF	PG&E	Elec	2,320.6	510.5	0.0	0.0
D03-936	Pipe Wrap	SF	PG&E	Either	133.3	29.3	7.5	750.2
D03-937	Low Flow Showerhead	SF	PG&E	Either	133.3	29.3	7.5	750.2
D03-938	High Efficiency Water Heater	SF	PG&E	Gas	0.0	0.0	9.4	937.8
D03-939	High Efficiency Water Heater	SF	PG&E	Elec	179.1	39.4	0.0	0.0
D03-940	Point of Use Water Heat	SF	PG&E	Gas	0.0	0.0	28.1	2,813.3
D03-934	Faucet Aerators	MF	PG&E	Either	52.2	11.5	5.1	505.3
D03-935	Heat Pump Water Heater	MF	PG&E	Elec	1,211.2	266.5	0.0	0.0
D03-936	Pipe Wrap	MF	PG&E	Either	69.6	15.3	6.7	673.7
D03-937	Low Flow Showerhead	MF	PG&E	Either	69.6	15.3	6.7	673.7
D03-938	High Efficiency Water Heater	MF	PG&E	Gas	0.0	0.0	8.4	842.2
D03-939	High Efficiency Water Heater	MF	PG&E	Elec	93.5	20.6	0.0	0.0
D03-940	Point of Use Water Heat	MF	PG&E	Gas	0.0	0.0	25.3	2,526.5

Table 2-15: 2004-05 DEER Water Heat Measure IDs and Savings Estimates, SCE Baseline

Measure ID	Measure Name	Building Type	Utility	Fuel	Electrcity Impact (kWh/unit)	Peak Demand (Watts/unit)	Gas Impact (therms/unit)	Gas Impact (kBtu/unit)
D03-934	Faucet Aerators	SF	SCE	Either	90.6	19.9	6.7	673.3
D03-935	Heat Pump Water Heater	SF	SCE	Elec	2,102.5	462.5	0.0	0.0
D03-936	Pipe Wrap	SF	SCE	Either	120.7	26.6	9.0	897.8
D03-937	Low Flow Showerhead	SF	SCE	Either	120.7	26.6	9.0	897.8
D03-938	High Efficiency Water Heater	SF	SCE	Gas	0.0	0.0	11.2	1,122.2
D03-939	High Efficiency Water Heater	SF	SCE	Elec	162.3	35.7	0.0	0.0
D03-940	Point of Use Water Heat	SF	SCE	Gas	0.0	0.0	33.7	3,366.7
D03-934	Faucet Aerators	MF	SCE	Either	47.3	10.4	6.0	604.7
D03-935	Heat Pump Water Heater	MF	SCE	Elec	1,097.3	241.4	0.0	0.0
D03-936	Pipe Wrap	MF	SCE	Either	63.0	13.9	8.1	806.3
D03-937	Low Flow Showerhead	MF	SCE	Either	63.0	13.9	8.1	806.3
D03-938	High Efficiency Water Heater	MF	SCE	Gas	0.0	0.0	10.1	1,007.8
D03-939	High Efficiency Water Heater	MF	SCE	Elec	84.7	18.6	0.0	0.0
D03-940	Point of Use Water Heat	MF	SCE	Gas	0.0	0.0	30.2	3,023.5

Table 2-16: 2004-05 DEER Water Heat Measure IDs and Savings Estimates, SDG&E Baseline

Measure ID	Measure Name	Building Type	Utility	Fuel	Electrcity Impact (kWh/unit)	Peak Demand (Watts/unit)	Gas Impact (therms/unit)	Gas Impact (kBtu/unit)
D03-934	Faucet Aerators	SF	SDG&E	Either	83.2	18.3	5.6	556.5
D03-935	Heat Pump Water Heater	SF	SDG&E	Elec	1,931.0	424.8	0.0	0.0
D03-936	Pipe Wrap	SF	SDG&E	Either	110.9	24.4	7.4	742.0
D03-937	Low Flow Showerhead	SF	SDG&E	Either	110.9	24.4	7.4	742.0
D03-938	High Efficiency Water Heater	SF	SDG&E	Gas	0.0	0.0	9.3	927.5
D03-939	High Efficiency Water Heater	SF	SDG&E	Elec	149.0	32.8	0.0	0.0
D03-940	Point of Use Water Heat	SF	SDG&E	Gas	0.0	0.0	27.8	2,782.5
D03-934	Faucet Aerators	MF	SDG&E	Either	43.4	9.5	5.0	499.8
D03-935	Heat Pump Water Heater	MF	SDG&E	Elec	1,007.8	221.7	0.0	0.0
D03-936	Pipe Wrap	MF	SDG&E	Either	57.9	12.7	6.7	666.4
D03-937	Low Flow Showerhead	MF	SDG&E	Either	57.9	12.7	6.7	666.4
D03-938	High Efficiency Water Heater	MF	SDG&E	Gas	0.0	0.0	8.3	833.0
D03-939	High Efficiency Water Heater	MF	SDG&E	Elec	77.8	17.1	0.0	0.0
D03-940	Point of Use Water Heat	MF	SDG&E	Gas	0.0	0.0	25.0	2,498.9

2.7 Swimming Pool Pumps

The 2001 DEER update had no energy efficient swimming pool pump program. However, the utilities in California have offered financial incentives to promote the installation of such measures. Over the past few years, each of the three major electric utilities, SDG&E, SCE, and PG&E, offered a swimming pool timer switch program to reduce peak demand and a pump and motor rebate program. Therefore, two energy efficient swimming pool pump and motor measures are included in this 2004-05 DEER update.

The swimming pool pump and motor rebate programs offered by SDG&E, SCE, and PG&E vary. PG&E offered a $250 rebate for the replacement of a single-phase/single-speed pool pump and motor with an energy efficient rated two-speed pump/motor. SCE also offered a rebate for installation of the two-speed pump/motor but their program primarily targeted the single-speed pump/motor with a rebate of $100. San Diego only targeted the single-speed pump/motor with a rebate of $200 for replacing an existing pool pump/motor. The SDG&E program had more restrictions than the SCE and PG&E programs in that the new motor and pump assembly had to be one-half horsepower less than the existing assembly. Both the SDG&E and SCE programs sought cut-backs in pool pump hours of operation. An evaluation report[15] by ADM Associates, Inc. outlined the impacts from these three program offerings.

[15] "Evaluation of Year 2001 Summer Initiatives Pool Pump Program", ADM Associates, Inc., prepared for Pacific Gas and Electric Company, April 2002

The ADM study gathered nameplate data and conducted performance tests on a sample of pool pump installations. ADM found the largest percent saving impacts from the San Diego program (about 41% reduction) with the SCE and PG&E pool pump program savings estimates both being close to 36%. The SDG&E program appeared to have greater savings due to its motor downsizing requirements, which the other two programs did not have.

Each of the investor owned utilities have invested significant effort in assessing swimming pool pump energy efficiency options. The subject is complex due to the many interactions of non-linear variable impacts such as flow rate and head. An analysis of these issues is provided in a recently completed study for PG&E[16]. Based on the results of this analysis, engineers at SCE and PG&E[17] have estimated the savings estimates that are included in the 2004-05 DEER update.

2004-05 DEER Swimming Pool Pump Measures and Methodology

The energy efficiency of swimming pool pumps and motors is stated in terms of overall pump (wire-to-water) system efficiency. System efficiency, or *energy factor*, as called by the utilities, takes into account both the pump and motor efficiency, and the system effects - which are much more influential in determining the overall energy and demand savings than the pump and motor efficiency alone.

Within the limits of typical practice, and using the system efficiency approach, pool pump and motor energy and demand savings can be estimated through engineering calculations, according to the rules below:

For any given pump & motor:

- Energy use, and the volume of water filtered, is directly proportional to pumping hours.
- Instantaneous demand is unchanged as pumping hours are varied.

For pump & motor replacement or substitution in new construction (normalized for, or given the same volume of water filtered - meaning the pumping time is adjusted to compensate for changes in the water flow rate, so as to provide the same water volume filtered):

- High efficiency capacitor start, capacitor run (or so called 2 capacitor motors) are about 8 to 12% more efficient than standard (capacitor start, induction run) motors.

[16] "Codes and Standards Enhancement Initiative for PY2004: Title 20 Standards Development – Analysis of Standards Options for Residential Pool Pumps, Motors, and Controls", Davis Energy Group, prepared for Pacific Gas and Electric Company, May 2004.

[17] Memo from Gary Fernstrom, Pacific Gas & Electric, July 2004.

- High efficiency permanent split capacitor motors are about 5-8% more efficient than standard motors.
- Newer closed face impeller pumps are about 5 to 8% more efficient than old open face impeller pumps.
- Energy use is proportional to the square root of the motor HP, and instantaneous demand varies directly as the HP (where downsizing of 1/2 or 1/4 HP) may follow utility program rules)
- For 2-speed pumps & motors, operating on low-speed (which is 1/2 speed), the theoretical energy use is 1/4 of that used on full speed, and the theoretical instantaneous demand is 1/8 of that created at high speed. In practice, due issues with pump and motor efficiency, the energy savings is actually 2/3 to 1/2 of full speed, and the demand is actually about 1/5 of full speed.

Translating these fairly precise mathematical relationships into engineering estimates, requires assumptions about the residential single family, in-ground swimming pool market, replacement practices, and behavior. For the purpose of these estimates, the following general assumptions are made:

- Average pool size: 25,000 gallons
- Average turn-over rate: 6-8 hours
- Average pump motor demand: 1.75 kVA
- Typical filtration run time: 4 to 6 hours

For the single speed pool pump measure, it is assumed that the measure is part of an efficiency program that requires pump & motor downsizing, run time reduction of 2 hours, or operation not to exceed 4 hours per day, and off peak operation except for solar heated pools). For the two speed pool pump measure, it is assumed to be offered through an efficiency program that requires installation of 2-speed pump & motor with compatible time clock. Table 2-17 provides the 2004-05 DEER values for measure ID and energy and peak impact for the two swimming pool pump measures.

Table 2-17: 2004-05 DEER Swimming Pool Pump Measure IDs and Savings Estimates

Measure ID	Measure	Energy Savings (kWh)	Peak Demand Savings (Watts)
D03-966	Single speed pool pumps	650	104
D03-967	Two speed pool pumps	1,400	540

3

Non-Residential Sector Non-Weather Sensitive

The first DEER study to develop energy savings estimates was the 1994 NEOS[1] technology study. The non-residential portion of this 1994 study has not been updated until this 2004-05 DEER update. The 1994 NEOS study included the following non-residential non-weather sensitive measures and measure areas:

- Interior lighting – low, medium, and high load reduction cases
- Interior lighting controls – occupancy sensors
- Exterior lighting – high-pressure sodium and metal halide fixtures.
- High efficiency office copiers
- Cooking measures:
  - Electric convection oven
  - Steam oven
  - Electronic ignition
  - Infrared fryer
  - Grease extractor hood
  - Makeup air exhaust hood
  - Smoke sensor activated ventilation hood
- Hot water measures:
  - High efficiency gas water heater
  - Point of use water heating
  - Circulation pump time-clocks
  - Water tank insulation blanket

The three NEOS interior lighting cases were packages of lighting measures that varied by building type and vintage. Outside of occupancy sensors, individual measure savings estimates were not provided. However, for this update savings estimates for a number of individual measures are included. These include CFL lamps and fixtures, fluorescent tubes and fixtures, high intensity discharge lamps, dimming ballasts, LED exit signs, occupancy sensors, daylighting, and de-lamping measures.   For most measures, operating hour

[1] "Final Report on Technology Energy Savings: Volumes I, II, and III", prepared for the California Conservation Inventory Group, prepared by NEOS Corporation, May 1994

characteristics specific to each building type were used. Analysis of lighting packages in a manner similar to the 1994 NEOS study remain to be provided within the weather sensitive portion of the database.

A revised set of high efficiency copier, cooking, and domestic hot water measures are also included in this update. In addition, motors and vending machine control measures, which were not included in the 1994 NEOS study, are included.

3.1 Lighting

Federal regulations and rules have significantly changed the energy efficiency options for lighting from what existed during the development of the 1994 NEOS study, especially for fluorescent lighting. Certain wattage sizes are no longer allowed within bulb type categories and magnetic ballasts may no longer be allowed starting in 2006. The baselines utilized to estimate lighting measure energy efficiency savings take into account these new federal regulations and rules. The most significant of these federal regulations and rules are the 1992 Energy Policy Act (EPACT) and the 2000 Federal Ballast Rule, which directly affects the availability of magnetic ballasts starting in 2006 and indirectly affects the availability of certain lamp options.

The Energy Policy Act of 1992 instituted requirements for electric motors, utility distribution transformers, and lighting. The Act established minimum efficiency standards for incandescent lamps and fluorescent lamps of certain types. For fluorescent lighting, EPACT affected minimum efficacy and color rendition levels and went into effect in 1994 and 1995. Of recent importance is the Federal Ballast Rule released on September 19, 2000. This federal rule established different requirements for ballasts in new luminaries and for the ballast replacement market. According to industry assessment in the spring of 2004[2], the rule would raise the minimum Ballast Efficacy Factors (BEF) for T12 fluorescent ballasts to a level that can only be achieved by electronic ballasts. In effect, by raising the efficiency and cost criteria on T12 systems, the rule is promoting T8/electronic systems without creating efficiency standards for T8 ballasts. Luminaries sold on or after April 1, 2006 for 2ft U-tubes, 4ft rapid start, 8ft instant start, and 8ft high output must incorporate electronic ballasts. The savings estimates included in this 2004-05 DEER update are based on this industry assessment. However, since the time of this industry assessment, there have been advances in the ballast industry that may indicate a need to re-assess this interpretation. This re-assessment will need to come in the next DEER update.

[2] Sylvania website analysis on the new federal ballast rule, website address http://www.sylvania.com/press/09192000.html as reviewed on 3/19/2004

Interior Lighting

Interior lighting includes a wide array of options utilizing incandescent, CFL, fluorescent, and high intensity discharge lamps. In addition, delamping options in combination with specular reflectors, occupancy sensors, and daylighting controls are also available.

The incandescent base lighting lamps, known as “A-lamps”, are used in table lamps, wall sconces, and recessed down lights. Wattages for these lamps range from 10 to 200 Watts, and they have a medium screw-in base. Efficient alternatives for these lamps include compact fluorescent lamps and low-wattage metal-halide lamps.

CFL Interior Lighting

Table 3-1 identifies the assumptions for equivalent wattages for CFL and incandescent lamps. The matching of each CFL lamp option to an incandescent base lamp is based on a recently completed residential CFL metering study[3]. Eighteen different screw-in CFL wattage/lumen options and 19 different pin-based CFL wattage/lumen options are provided.

Other important variables for estimating lighting savings are lighting hours of operation, energy and demand interactive effects, and coincident diversity factors. The energy and demand interactive effects factors for lighting are designed to capture additional energy and demand reduction in avoided air conditioning load because of reduced internal gains from energy efficient lighting. The coincident diversity factor for lighting is the ratio of the maximum lighting demand to the sum of individual lighting demands at the time of system peak. These additional variables vary significantly by building type.

Table 3-2 provides a listing of the lighting hours of operation, energy and demand interactive effects, and coincident diversity factors by building type for interior CFL lighting. Except for the lighting hours of operation, these values are taken from the results of a Lighting Measurement and Evaluation study performed for PG&E by Quantum Consulting, Inc.[4] Most of the lighting hours of operation come from lighting profiles (as of June, 2004) by building type developed by JJ Hirsch, Inc. for the weather sensitive portion of this study.

[3] “CFL Metering Study”, prepared for Pacific Gas & Electric Company, San Diego Gas & Electric Company and Southern California Edison by KEMA, Inc., February 25, 2005

[4] “Evaluation of Pacific Gas & Electric Company’s 1997 Commercial Energy Efficiency Incentives Program: Lighting Technologies”, prepared by Quantum Consulting, Inc., for Pacific Gas & Electric Company, March 1, 1999

Table 3-1: CFL/Incandescent Bulb Wattage Equivalents

Measure Description	Base Description
13 Watt < 800 Lumens - screw-in	40W Incandescent
13 Watt >=800 Lumens - screw-in	60W Incandescent
14 Watt - screw-in	60W Incandescent
15 Watt - screw-in	60W Incandescent
16 Watt - screw-in	60W Incandescent
18 Watt < 1,100 Lumens - screw-in	60W Incandescent
18 Watt >=1,100 Lumens - screw-in	75W Incandescent
19 Watt >=1,100 Lumens - screw-in	75W Incandescent
20 Watt - screw-in	75W Incandescent
23 Watt - screw-in	100W Incandescent
25 Watt <1,600 Lumens - screw-in	75W Incandescent
25 Watt >=1,600 Lumens - screw-in	100W Incandescent
26 Watt <1,600 Lumens - screw-in	75W Incandescent
26 Watt >=1,600 Lumens - screw-in	100W Incandescent
28 Watt - screw-in	100W Incandescent
30 Watt - screw-in	100W Incandescent
36 Watt - screw-in	150W Incandescent
40 Watt - screw-in	150W Incandescent
13 Watt < 800 Lumens - pin based	40W Incandescent
13 Watt >=800 Lumens - pin based	60W Incandescent
14 Watt - pin based	60W Incandescent
15 Watt - pin based	60W Incandescent
16 Watt - pin based	60W Incandescent
18 Watt < 1,100 Lumens - pin based	60W Incandescent
18 Watt >=1,100 Lumens - pin based	75W Incandescent
19 Watt >=1,100 Lumens - pin based	75W Incandescent
20 Watt - pin based	75W Incandescent
23 Watt - pin based	100W Incandescent
25 Watt <1,600 Lumens - pin based	75W Incandescent
25 Watt >=1,600 Lumens - pin based	100W Incandescent
26 Watt <1,600 Lumens - pin based	75W Incandescent
26 Watt >=1,600 Lumens - pin based	100W Incandescent
28 Watt - pin based	100W Incandescent
30 Watt - pin based	120W Incandescent

Table 3-1: CFL/Incandescent Bulb Wattage Equivalents (Continued)

Measure Description	Base Description
40 Watt - pin based	120W Incandescent
55 Watt - pin based	200W Incandescent
65 Watt - pin based	200W Incandescent

Some of the JJ Hirsch lighting schedules were replaced by preliminary lighting logger results from a currently on-going Quantum Consulting Express Efficiency evaluation study[5]. Table 3-3 lists the five specific buildings where CFL hours of operation were updated with the new preliminary metering results from Quantum. The table also lists the different lighting schedules used in the weather sensitive savings estimates for all lighting packages.

Table 3-2: Annual Lighting Hours, Energy and Demand Diversity Factors, and Coincident Diversity Factors by Building Type for CFL Lighting

Market Sector	Annual Operating Hours	Energy Interactive Effects	Coincident Diversity Factors	Demand Interactive Effects
Education - Primary School	1,440	1.15	0.42	1.23
Education - Secondary School	2,305	1.15	0.42	1.23
Education - Community College	3,792	1.15	0.68	1.22
Education - University	3,073	1.15	0.68	1.22
Grocery	5,824	1.13	0.81	1.25
Health/Medical - Hospital	8,736	1.18	0.74	1.26
Health/Medical - Clinic	8,736	1.18	0.74	1.26
Lodging - Hotel	8,736	1.14	0.67	1.14
Lodging - Motel	8,736	1.14	0.67	1.14
Lodging - Guest Rooms	1,145*	1.14	0.67	1.14
Manufacturing - Light Industrial	2,860	1.04	0.99	1.08
Office - Large	2,739*	1.17	0.81	1.25
Office - Small	2,492*	1.17	0.81	1.25
Restaurant - Sit-Down	3,444*	1.15	0.68	1.26
Restaurant - Fast-Food	6,188	1.15	0.68	1.26
Retail - 3-Story Large	4,259	1.11	0.88	1.19
Retail - Single-Story Large	4,368	1.11	0.88	1.19
Retail - Small	3,724*	1.11	0.88	1.19
Storage - Conditioned	2,860	1.06	0.84	1.09
Storage - Unconditioned	2,860	1.06	0.84	1.09
Warehouse - Refrigerated	2,600	1.06	0.84	1.09

* Different from the values used in Table 3-5

[5] "2003 Statewide Express Efficiency Program Measurement and Evaluation Study" prepared by Quantum Consulting for Pacific Gas & Electric Company, March 21, 2005

Table 3-3: Updated Annual Hours of Operation for CFLs and Lighting Schedules Used for Weather Sensitive Interior Lighting

Market Sector	Annual Operating Hours	
	CFL Interior (non-weather sensitive)	All Interior Lighting (weather sensitive)
Lodging - Guest Rooms	1,145	not at this level
Office - Large	2,739	2,808
Office - Small	2,492	2,808
Restaurant - Sit-Down	3,444	4,368
Retail - Small	3,724	4,004

The methodology of calculating energy savings for CFL lamps follows a simple formula that captures wattage level changes, annual hours of use, interactive effects on other end-uses, coincidence factor for peak demand, and estimates of actual lamp installation. The value for lamp installation varies depending if the assumed installation is under a Standard Performance Contract (SPC) program format, i.e., programs with strict measure verification requirements, or one similar to Express Efficiency, i.e., programs with either limited or no measure verification requirements. Under an Express Efficiency type program, the installation rate is estimated to be 92% and under an SPC type program, 100%. These installation rate estimates are based on the professional judgment of utility program planners. The calculation methodology for an Express Efficiency type program is:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit) \times (annual\ hours\ of\ use) \times (Installation\ Rate) \times (Interactive\ Effects)}{1{,}000\ Watt\ hours / kWh}$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit) \times (Installation\ Rate) \times (Peak\ Coincidence\ Factor) \times (Interactive\ Effects)$$

The calculation methodology for an SPC type program is:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit) \times (annual\ hours\ of\ use) \times (Interactive\ Effects)}{1{,}000\ Watt\ hours / kWh}$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit) \times (Peak\ Coincidence\ Factor) \times (Interactive\ Effects)$$

Below is an example calculation done for a 14W CFL screw-in lamp replacing a 60W incandescent lamp in a large office under an Express Efficiency type program.

$$\textbf{Energy Savings} = \frac{(46\,Watts)\times(2{,}739\ hours)\times(0.92)\times(1.17)}{1{,}000\,Watt\ hours\ /\ kWh} = 135.6\ kWh$$

$$\textbf{Demand Savings} = (46\,Watts)\times(0.92)\times(1.25)\times(0.81) = 42.8\,Watts$$

For an SPC type program application, the example calculation for a 14W CFL screw-in lamp replacing a 60W incandescent lamp in a large office is modified as follows:

$$\textbf{Energy Savings} = \frac{(46\,Watts)\times(2{,}739\ hours)\times(1.17)}{1{,}000\,Watt\ hours\ /\ kWh} = 147.4\ kWh$$

$$\textbf{Demand Savings} = (46\,Watts)\times(1.25)\times(0.81) = 46.6\,Watts$$

Table 3-4 lists the estimated energy savings by measure for interior CFL lighting in the education-primary school building type. Estimated savings from the other building types are available in Appendix A.

Table 3-4: CFL Interior Lighting Savings Estimates - Education - Primary School

Measure ID	Measure Name	Measure Savings (kWh/unit)	SPC Measure Savings (kWh/unit)	Peak Demand Savings (watts/unit)	SPC Peak Demand Savings (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	41.1	44.7	12.8	13.9
D03-802	13 Watt >=800 Lumens - screw-in	71.6	77.8	22.3	24.3
D03-803	14 Watt - screw-in	70.1	76.2	21.9	23.8
D03-804	15 Watt - screw-in	68.6	74.5	21.4	23.2
D03-805	16 Watt - screw-in	67.0	72.9	20.9	22.7
D03-806	18 Watt < 1,100 Lumens - screw-in	64.0	69.6	20.0	21.7
D03-807	18 Watt >=1,100 Lumens - screw-in	86.8	94.4	27.1	29.4
D03-808	19 Watt >=1,100 Lumens - screw-in	85.3	92.7	26.6	28.9
D03-809	20 Watt - screw-in	83.8	91.1	26.1	28.4
D03-810	23 Watt - screw-in	117.3	127.5	36.6	39.8
D03-811	25 Watt <1,600 Lumens - screw-in	76.2	82.8	23.8	25.8
D03-812	25 Watt >=1,600 Lumens - screw-in	114.3	124.2	35.6	38.7
D03-813	26 Watt <1,600 Lumens - screw-in	74.7	81.1	23.3	25.3
D03-814	26 Watt >=1,600 Lumens - screw-in	112.7	122.5	35.2	38.2
D03-815	28 Watt - screw-in	109.7	119.2	34.2	37.2
D03-816	30 Watt - screw-in	106.6	115.9	33.3	36.2
D03-817	36 Watt - screw-in	173.7	188.8	54.2	58.9
D03-818	40 Watt - screw-in	167.6	182.2	52.3	56.8
D03-819	13 Watt < 800 Lumens - pin based	41.1	44.7	12.8	13.9
D03-820	13 Watt >=800 Lumens - pin based	71.6	77.8	22.3	24.3
D03-821	14 Watt - pin based	70.1	76.2	21.9	23.8
D03-822	15 Watt - pin based	68.6	74.5	21.4	23.2
D03-823	16 Watt - pin based	67.0	72.9	20.9	22.7
D03-824	18 Watt < 1,100 Lumens - pin based	64.0	69.6	20.0	21.7
D03-825	18 Watt >=1,100 Lumens - pin based	86.8	94.4	27.1	29.4
D03-826	19 Watt >=1,100 Lumens - pin based	85.3	92.7	26.6	28.9
D03-827	20 Watt - pin based	83.8	91.1	26.1	28.4
D03-828	23 Watt - pin based	117.3	127.5	36.6	39.8
D03-829	25 Watt <1,600 Lumens - pin based	76.2	82.8	23.8	25.8
D03-830	25 Watt >=1,600 Lumens - pin based	114.3	124.2	35.6	38.7
D03-831	26 Watt <1,600 Lumens - pin based	74.7	81.1	23.3	25.3
D03-832	26 Watt >=1,600 Lumens - pin based	112.7	122.5	35.2	38.2
D03-833	28 Watt - pin based	109.7	119.2	34.2	37.2
D03-834	30 Watt - pin based	137.1	149.0	42.8	46.5
D03-835	40 Watt - pin based	121.9	132.5	38.0	41.3
D03-836	55 Watt - pin based	220.9	240.1	68.9	74.9
D03-837	65 Watt - pin based	205.7	223.6	64.2	69.7

Non-CFL Interior Lighting

Non-CFL interior lighting measures include applications for metal halide lamps, premium T8 lamps, dimming ballasts for daylighting, and Delamping. For the most part, the methodology for calculating the energy savings for the non-CFL interior lights is the same as for interior CFL lamps. The exception is that all installation rates are assumed to be 100%.

There are some differences in the estimated annual hours of operation assumed for the non-CFL interior lighting measures vs. the CFL interior lighting measures. Table 3-3 listed the building types or application within a building type where the annual hours of operation are different between CFL and non-CFL interior lights. As stated earlier, the annual hours of lighting operation are primarily based on lighting profiles (as of June, 2004) by building type developed by JJ Hirsch, Inc. for the weather sensitive portion of this study. However, some of the CFL hours of operation were identified as being different, based on the currently on-going Quantum lighting logger study.

Table 3-5 lists the lighting hours of operation, energy and demand interactive effects, and coincident diversity factors by building type for interior Non-CFL lighting. Table 3-6 lists the estimated energy savings by measure for interior non-CFL lighting in the large office building type. Estimated savings from the other building types are available in Appendix B.

Table 3-5: Annual Lighting Hours, Energy and Demand Diversity Factors, and Coincident Diversity Factors by Building Type for Non-CFL Lighting

Market Sector	Annual Operating Hours	Energy Interactive Effects	Coincident Diversity Factors	Demand Interactive Effects
Education - Primary School	1,440	1.15	0.42	1.23
Education - Secondary School	2,305	1.15	0.42	1.23
Education - Community College	3,792	1.15	0.68	1.22
Education - University	3,073	1.15	0.68	1.22
Grocery	5,824	1.13	0.81	1.25
Health/Medical - Hospital	8,736	1.18	0.74	1.26
Health/Medical - Clinic	8,736	1.18	0.74	1.26
Lodging - Hotel (Guest Rooms)	8,736*	1.14	0.67	1.14
Lodging - Motel	8,736	1.14	0.67	1.14
Manufacturing - Light Industrial	2,860	1.04	0.99	1.08
Office - Large	2,808*	1.17	0.81	1.25
Office - Small	2,808*	1.17	0.81	1.25
Restaurant - Sit-Down	4,368*	1.15	0.68	1.26
Restaurant - Fast-Food	6,188	1.15	0.68	1.26
Retail - 3-Story Large	4,259	1.11	0.88	1.19
Retail - Single-Story Large	4,368	1.11	0.88	1.19
Retail - Small	4,004*	1.11	0.88	1.19
Storage - Conditioned	2,860	1.06	0.84	1.09
Storage - Unconditioned	2,860	1.06	0.84	1.09
Warehouse - Refrigerated	2,600	1.06	0.84	1.09

* Different from the values used in Table 3-2.

Table 3-6: Non-CFL Interior Lighting Savings Estimates – Large Office

Measure ID	Measure	Measure Savings (kWh/unit)	Peak Demand Savings (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	328.54	101.25
D03-845	75W Metal Halide - base 100W Mercury Vapor	82.13	25.31
D03-846	100W Metal Halide - base 175W Mercury Vapor	246.40	75.94
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	32.85	10.13
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	84.11	25.92
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	78.85	24.30
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	170.84	52.65

Exterior Lighting

High wattage mercury vapor lamps are relatively common in outdoor lighting applications. These lamps can be replaced with much more efficient pulse start metal halide, high-pressure sodium, or low-pressure sodium lamps. Table 3-7 lists the measures and savings estimates to be included for exterior lighting. The hours of lighting operation are assumed to be 4,100 hours for all building types, based on PG&E's PY 2004/2005 lighting working papers. For energy savings, the methodology is simply watts saved * annual hours of operation. Exterior applications are assumed to have a coincidence factor of 0.0 with a resulting 0.0 W impact on peak demand. No exterior CFL measures are provide for this update.

Table 3-7: Exterior Lighting Savings Estimates

Measure ID	Measure	Watts/Unit Saved	Annual Hours Operation*	Measure Savings (kWh/unit)	Peak Demand Savings (watts/unit)
	Baseline 400W Mercury Vapor		4,100		
	Baseline 500W Incandescent		4,100		
	Baseline 250W Metal Halide		4,100		
D03-847	From 250W Metal Halide to 175W PS Metal Halide	85	4,100	349	0.0
D03-848	From 500W Incandescent to 175W PS Metal Halide	290	4,100	1,189	0.0
D03-849	From 400W Mercury Vapor to 250W PS Metal Halide	159	4,100	652	0.0
D03-850	From 400W Mercury Vapor to 200W HPS	200	4,100	820	0.0
D03-851	From 400W Mercury Vapor to 180W LPS	220	4,100	902	0.0

* From PG&E PY2004/PY2005 Working Papers

Exit Signs

Exit signs are found in nearly all commercial and industrial buildings and are generally “on” every hour of the day. Because they are required to operate continually, the various exit sign lighting technologies have dramatic differences in terms of energy consumption as well as maintenance and replacement costs. Baseline exit signs are generally powered by two 20W incandescent bulbs. Efficiency alternatives include light emitting diodes (LED) and electroluminescent exit signs. Compact fluorescent bulb exit signs were dropped from the database due to their steeply declining market share. Table 3-8 provides a listing of the exit sign measures.

The calculation methodology for exit signs is:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit) \times (annual\ hours\ of\ use) \times (Interactive\ Effects)}{1{,}000\ Watt\ hours / kWh}$$

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit) \times (Peak\ Coincidence\ Factor) \times (Interactive\ Effects)$$

Table 3-8: Exit Signs Savings Estimates

Measure ID	Measure	Watts/ Unit Saved *	Annual Hours Operation*	Energy Interactive Effects*	Measure Savings (kWh/unit)	Demand Interactive Effects*	Coincidence Factor*	Peak Demand Savings (watts/unit)
	Baseline Incandescent Exit Sign							
D03-860	From Incandescent Exit Sign to LED Exit Sign (New)	36	8,760	1.114	351	1.18	1.00	42.5
D03-861	From Incandescent Exit Sign to LED Exit Sign (Retrofit Kit)	36	8,760	1.114	351	1.18	1.00	42.5
D03-862	From Incandescent to Electoluminescent Exit Sign (Retrofit Kit)	39	8,760	1.114	381	1.18	1.00	46.0
D03-863	From Incandescent to Electoluminescent Exit Sign (New)	39	8,760	1.114	381	1.18	1.00	46.0

* Coincidence factors based on SDG&E 2002 Energy Efficiency Proposals

Occupancy Sensor and Daylighting Controls

Occupancy sensors are motion-sensing devices that can be set to automatically turn on luminaries when motion is detected, keep luminaries on while a space is occupied, and turn off luminaries when the space is vacated after a set amount of time. The most appropriate applications for occupancy sensors is in space that is infrequently or intermittently occupied, such a meeting rooms, bathrooms, storage areas, and classrooms. Daylight controls turn off lights when there is sufficient outdoor light available.

Two types of occupancy sensors are included in the 2004-05 DEER update. The first is a wall box mounted sensor that is assumed to control three 4-foot 2-lamp fluorescent fixtures with 34 watt, T-8 lamps and electronic ballasts. Without the occupancy sensor, lights are assumed to burn during building hours of operation (~60 hours/week for 50 weeks/year) and be manually switched off 15% of the time, for a total of 2,550 hours/year. It is assumed that the occupancy sensor turns off lights for 1,050 hours/year. The second is a plug load sensor that is assumed to control 50 Watts of task lighting and a computer monitor. A weighted average demand of 40 Watts is assumed for the computer monitor, representing both CRT and LCD screens, and the likelihood that the monitor maybe in a low power sleep mode when the occupancy sensor turns off power to the controlled plug loads. This assumption is based on the findings of a 2004 LBL study[6], summarized in Table 3-9.

[6] "After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-load Equipment", Lawrence Berkeley National Laboratory, January 2004.

Table 3-9: After Hour Power Status of Computer Monitors

Monitor Type	Awake Mode (W)	Sleep Mode (W)	% of Monitors*	% That Go To Sleep Mode *	Average Off-Hour Power Draw (W)
CRT Monitor (19")	140	15	83%	75%	38.39
LCD Monitor (17")	40	3	17%	75%	2.08
Combined					40

Without the occupancy sensor, it is assumed that the equipment is on 2,500 hours/year and also left on 20% of the time when the occupant leaves for evenings or weekends for a total of 3,700 hours/year. The occupancy sensor is assumed to turn off the equipment 2,450 hours/year.

Outdoor lamps and indoor lamps adjacent to skylights and windows can be controlled through use of time clocks and photocells. For the purposes of the 2004-05 DEER update, it is assumed that time clocks control four 70-watt (95 watts including ballast) high-pressure sodium lamps that provide exterior lighting. The time clock is used to turn the lights off during the day on weekends. Without the time clock, lights are assumed to burn 12 hours/day on weekdays and 24 hours a day on weekends for a total of 5,628 hours/year. With the time clock, the weekend hours are reduced to 12 hours for a total reduction of 1,248 hours/year. Adding a photocell to this scenario allows for the turning off of the lights when there is sufficient daylight available. It is assumed that without the photocell, the time clock would operate the light for an additional 280 hours/year (about 3 months at 3 hours/day).

Table 3-10 provides the estimate of energy savings for the two occupancy sensor options and the two daylight control options. The calculation methodology for exit signs is:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit \cdot year}\right] = \frac{(\Delta Watts / unit) \times (hours\ in\ effect) \times (Interactive\ Effects)}{1{,}000\ Watt\ hours / kWh}$$

$$\textbf{Demand Impact}\left[\frac{Watts}{unit}\right] = (\Delta Watts / unit) \times (Peak\ Coincidence\ Factor) \times (Interactive\ Effects)$$

Table 3-10: Occupancy Sensors and Daylight Controls Savings Estimates

Measure ID	Measure	Watts/ Application Saved*	Hours in Effect*	Energy Interactive Effects*	Measure Savings (kWh/unit)	Demand Interactive Effects*	Coincidence Factor*	Peak Demand Savings (watts/unit)
D03-856	Occ-Sensor - Wall box: Assume control 3 2-lamp fixtures w/T8 34W EL Ballast	174	1,050	1.17	214	1.25	0.81	176.2
D03-857	Occ-Sensor - Plug loads: Assume control 50W of task lighting and a computer monitor	50	2,450	1.17	143	1.25	0.81	50.6
D03-858	Timeclock: Controling 4 70W (95W w/ballast) HPS fixtures	380	1,248	1.00	474	0.00	0.00	0.0
D03-859	Photocell: Assume in conjunction with time-clock controling 4 70W (95W w/ballast) HPS fixtures	380	280	1.00	106	0.00	0.00	0.0

* From PG&E PY2004/PY2005 Working Papers

3.2 High Efficiency Office Copier

Copiers are the most energy-intensive type of office equipment. Standard office copiers need to be ready on demand in the office environment, but generally require a warm-up period after they are turned on. For this reason, copiers are left on all day regardless of use or need. The most common energy saving technique is to have an idle-off control that shuts the copier down in stages depending on the length of time the copier has been out of use.

The 1994 NEOS study estimated the energy savings resulting from the installation of an efficient office copier based on the assumptions of the base unit having an average nameplate rated capacity of 1,100W with savings of 50% achieved through the idle off control. Savings were reported in kWh/sq.ft with an average base EUI of 0.22 kWh/sq.ft/yr.

For the 2004-05 DEER update, energy savings from office copiers are reported on a per copier basis and follow the assumptions included in the Energy Star calculator for office copiers (http://www.energystar.gov). Energy Star identifies three copier sizes: Copier #1 has a 0-20 copies per minute capacity, copier #2 a 21-44 copies per minute capacity, and copier #3 an over 45 copies per minute capacity. Table 3-11 provides information on the assumptions used by the Energy Star Calculator.

Table 3-12 provides a listing of the high efficiency office copier measures and energy efficiency savings estimates. These values are based on the information provide in the Energy Star office copier calculator.

Table 3-11: Energy Star Calculator Office Copier Assumptions

Copier Assumptions	Size #1: 0-20 copies/minute	Size #2: 21-44 copies/minute	Size #3: Over 45 copies/minute
Power			
Conventional Unit			
Average hourly energy in "on" mode (W)	115	177	313
Average hourly energy in "low-power" mode (W)	110	75	108
Average hourly energy in "off" mode (W)	8	14	33
Total average annual energy use per unit (kWh)	747	1,055	1,844
ENERGY STAR-Compliant Unit			
Average hourly energy in "on" mode (W)	NA	NA	NA
Average hourly energy in "low-power" mode (W)	21.0	117.8	209.0
Average hourly energy in "off" mode (W)	1.7	7.5	9.7
Total average annual energy use per unit (kWh)	423	732	1,702
Useage			
Conventional Unit			
Number of hours in "on" mode per day	8.9	12.61	13.2
Number of hours in "low-power" mode per day	8.9	8	7.4
Number of hours unit is "off" per day	6.2	3	3.4
ENERGY STAR-Compliant Unit			
Number of hours in "on" mode per day	9.7	9.2	12.2
Number of hours in "low-power" mode per day	1.2	2.4	3.6
Number of hours in "off" mode per day	13.4	12.4	8.2
General			
Percent of units left on overnight (non-ENERGY STAR product)	NA	NA	NA
Number of days in use per year	268	268	268
Total number of hours in use per day	9.5	24	24
Lifetime (years)	6	6	6

Table 3-12: High Efficiency Office Copiers Savings Estimates

Measure ID	Measure	Base Annual kWh/Unit	Efficient Annual kWh/Unit	Measure Savings (kWh/unit)	Average Hourly Load Difference Between "On" and "Low-Power" Modes Watts/Unit	Coincidence Factor*	Peak Demand Savings (watts/unit)
D03-901	Copier Size #1: 0-20 copies/minute	747.5	423.7	323.8	94	0.43	40.7
D03-902	Copier Size #2: 21-44 copies/minute	1,054.6	732.5	322.1	59	0.31	18.0
D03-903	Copier Size #3: Over 45 copies/minute	1,843.6	1,701.9	141.7	104	0.08	8.0

* Coincident factor based on calculation of (1 - (efficient annual kWh)/(unit/base annual kWh/unit))

3.3 Cooking

The 1994 NEOS study included a number of cooking measures. The savings from each of these NEOS measures were estimated based on a percentage savings of the cooking EUI in restaurants, expressed as kWh or kBtu/sq.ft of building area. In the 2004-05 DEER update, the NEOS methodology is not utilized. The 2004-05 DEER update methodology is based on a per unit of equipment with specified loads and operating hours. The cooking measures are modified to include those where information is readily available on cooking equipment specifications. The best sources found for cooking equipment specifications were from the PG&E technology center on-line library of technology briefs (http://www.pge.com/003_save_energy/003c_edu_train/pec/info_resource/) followed by the Federal Energy Management Program (FEMP) on-line library of technology briefs (http://www.eere.energy.gov/femp/). The PG&E and FEMP technology briefs were in general agreement but the PG&E technology briefs are utilized in that there are more of them and they provide greater levels of technical information. Savings estimates are provided for the following cooking technologies:

- Electric and gas fryers
- Hot food holding cabinets
- Connectionless steamers
- Gas Griddles

For each of these measures, the energy savings calculation methodology is of the form:

$$\text{Energy Savings} = (\text{APECR}_{\text{Base}} - \text{APECR}_{\text{Efficient}}) * \text{Daily Hours} * \text{Annual Days}$$

Where:

APECR = The Average Production Energy Consumption Rate per hour

Daily Hours = 12

Annual Days = 365

Table 3-13 provides a listing of the gas cooking measures and Table 3-14 the listing of electric cooking measures.

Table 3-13: Gas Cooking Measures Savings Estimates

Measure ID	Gas Measures	AverageProduction Energy Consumptiuon Rate - Base Efficiency (kBtu/hour)	AverageProduction Energy Consumptiuon Rate - High Efficiency (kBtu/hour)	Savings (kBtu/hour)	Annual Hours of Operation**	Measure Savings (Therms/year)	Measure Savings (kBtu/year)
D03-904	High Efficiency Gas Fryer	25	15	10	4,380	438	43,800
D03-905	High Efficiency Gas Griddle	25	20	5	4,380	219	21,900

Table 3-14: Electric Cooking Measures Savings Estimates

Measure ID	Electric Measures	AverageProduction Energy Consumptiuon Rate - Base Efficiency (kW/hour)	AverageProduction Energy Consumptiuon Rate - High Efficiency (kW/hour)	Savings (kW/hour)	Annual Hours of Operation**	Measure Savings (kWh/unit)	Coincidence Factor ***	Peak Demand Savings (watts/unit)
D03-906	High Efficiency Electric Fryer	2.8	2.4	0.4	4,380	1,752	0.9	360.00
D03-907	Hot Food Holding Cabinet	1.35	0.43	0.92	4,380	4,030	0.9	828.00
D03-908	Connectionless Steamer	1	0.5	0.5	4,380	2,190	0.9	450.00

* Values based on information contained in the PG&E Energy Information Briefs
** Annual operating hours base on 12 hours/day
*** No information found on coincidence factor. Value is based on professional judgment.

High Efficiency Fryers

Commercial deep fat fryers can be floor standing in the 35-80 lb range or countertop units in the 10-20 lb. Range. The most popular size is in the 40-50 lb size and the fryer data in Table 3-13 and Table 3-14 represent 50 lb Fryers.

The high efficiency gas fryer employs powered infrared burners, which uses a fine honeycomb matrix to disperse the fuel/air mixture evenly across the burner surface. The mixture is delivered by a forced-air blower and combustion takes place close to the burner surface. Advanced, solid state thermostatic controls are also included in the gas high efficiency fryers and the fry vat has higher levels of insulation.

The high efficiency electric fryer also has advanced solid-state thermostatic controls and the fry vat has higher levels of insulation than the base fryer. The high-performance electric fryers also save energy by incorporating more efficient electric elements to transfer greater amounts of heat to the oil.

High Efficiency Gas Griddles

Gas griddles are constructed using ½ -1 inch thick steel plates that have splash guards attached to the sides and rear. The cooking surface is usually 24 – 30 inches deep with widths that range from 3 – 8 feet. The griddle plate is heated from underneath by gas burners. High efficiency gas griddles save energy by transferring a greater percentage of the combustion heat to the griddle plate. This is done by reducing the quantity of excess air using powered burners to deliver an optimum quantity of combustion air to the burner, often including an infrared burner. More accurate solid-state thermostats and a chrome surface are also generally included in high efficiency gas griddles.

Insulated Food Holding Cabinets

Food holding cabinets are used to transport and/or temporarily store hot food. An insulated food holding cabinet helps retain heat within the cabinet area. In addition to the energy savings, insulated cabinets radiate less heat into the kitchen, thus helping to keep the work environment more comfortable.

Connectionless Steamers

Commercial food service centers include steamer cabinets and kettles that are injected with steam from steam boilers dedicated for this function. Traditional steamers have a cavity around the food that is filled with steam. Steam keeps getting pushed through the cavity and eventually cooks the food. However, the result of this process is that a lot of steam goes down the drain. With connectionless steamers, there are no drains. Therefore, the same steam stays in the cavity and does not go down the drain all the time. Since new steam is not continually being created, the connectionless streamer is much more efficient.

3.4 Water Heat Measures

Four water heating measures were included in the 1994 NEOS study. These included:

- High efficiency gas water heater
- Point of use water heater
- Water circulation pump time clock
- Hot water tank wrap

All but the point of use water heater were considered as natural gas measures in the NEOS study. The point of use water heater was modeled to be electric, but with the base water heat fuel being natural gas. The methodology employed in the NEOS study was a percentage savings per measure applied to the building water heat EUI. The water heat EUIs were obtained from the California Energy Commission and represented estimated EUIs based on utility commercial building surveys up to that time (about 1993). The water heat EUIs varied by building type and vintage, but not by climate zone. Vintage differences within a building type were to reflect the stock of older, less efficient water heaters that existed at that time in older vintage buildings. The hot water tank wrap measure was only applied to the older vintage buildings.

This same basic methodology of applying an expected percentage savings by measure to a base water heat EUI value is utilized for the 2004-05 DEER update. However, some of the components to this methodology are modified.

High Efficiency Gas Water Heater

New appliance efficiency regulations went into effect in January of 2004[7] that changes the base energy factor (EF) for gas water heaters. In 1994, the base EF was 0.54 (based on a 40 gallon tank). Under the new code, the minimum EF approaches a value of 0.6 (the actual required minimum EF is 0.594 based on a 40 gallon tank). Because of this change, the gas water heater tank efficiency measure included in the 2004-05 DEER update has a base EF of 0.6 and an efficiency EF of 0.64 (based on a 40 gallon tank). The formula for estimating the minimum energy factor is volume driven and has the form:

$$\textbf{Minimum EF} = (0.67) - (0.0019 \times \textit{Tank Volume})$$

For a 40 gallon tank:

$$\textbf{Minimum EF} = (0.67) - (0.0019 \times 40) = 0.594$$

Point of Use Water Heater

The point of use water heater included in the 2004-05 DEER update is characterized as a natural gas measure rather than an electricity measure. According to a US DOE technology brief[8] on tankless or instantaneous water heaters, gas point of use water heaters are widely available. Gas fired units have a higher hot water output than electric models and electric units have the further disadvantage of requiring a relatively high electric power draw because water must be heated quickly to the desired temperature. However, only gas-fired units that don't use a pilot light should be promoted. A pilot light would offset (about 50% based on the information in the technology brief) much of the energy savings derived from using a point of use water heater. The expected energy savings from these units will vary considerably by the amount of water usage with the greatest potential for savings being in applications with low water usage. However, energy savings (assuming electronic ignition) should be in the ten to twenty percent range (10% utilized because of the new standards and higher baseline).

Water Circulation Pump Time Clock

Circulation pumps are installed on the domestic hot water line to constantly circulate the hot water. This circulation ensures hot water is immediately available at the hot water tap. If there is no circulation pump, hot water must travel from the hot water tank to the tap. This wastes the cold water that must be removed from the hot water line before the hot water reaches the tap. The circulation pump time clock is wired to the domestic hot water circulation pump to operate on only preset periods. The time clock saves energy by shutting

[7] "Appliance Efficiency Regulations", California Energy Commission, November 2002

[8] U.S. Department of Energy, Energy Efficiency and Renewable Energy Clearinghouse, "Demand (Tankless or Instantaneous) Water Heaters, (www.eere.energy.gov/consumerinfo/refbriefs/bc1.html)

off the pump during unoccupied periods or during periods when hot water usage is infrequent. This reduces the standby losses in the exposed water delivery pipes. In the 1994 NEOS study, energy saving levels were about 6% for this measure. For the 2004-05 DEER update, this same 6% savings level is utilized.

Hot Water Tank Wrap

The last measure included in the 1994 NEOS study was a hot water tank wrap. These wraps are only appropriate for older, less insulated tanks and not for the newer, more efficient models that have been mandated since the early 1990s. Most of these older tanks have been removed and therefore this measure has been dropped from the DEER database.

Water Heat Savings Estimates

Table 3-15 identifies the savings for the natural gas water heat measures by building type included in the 2004-05 DEER update. Table 3-16 provides the same type of information for point of use water heat and Table 3-17 for circulation pump timeclocks.

Table 3-15: Non-Residential Water Heating Measure Savings Estimates – Natural Gas Tank Water Heat

Measure ID	Building Types	Gas Water Heat EUI (Therms/1000 sf)*	High Eff. Water Heater Savings Fraction, EF=0.64 (%)	High Eff. Water Heater Savings, EF=0.64 (Therms/1000 sf))	High Eff. Water Heater Savings, EF=0.64 (kBtu/1000 sf))
D03-911	Education - Primary School	33.0	7.1%	2.34	234.30
D03-911	Education - Secondary School	15.4	7.1%	1.09	109.34
D03-911	Education - Community College	87.4	7.1%	6.21	620.54
D03-911	Education - University	87.4	7.1%	6.21	620.54
D03-911	Grocery	9.8	7.1%	0.70	69.58
D03-911	Health/Medical - Hospital	362.4	7.1%	25.73	2,573.04
D03-911	Health/Medical - Clinic	136.2	7.1%	9.67	967.02
D03-911	Lodging - Hotel (Guest Rooms)	123.4	7.1%	8.76	876.14
D03-911	Lodging - Motel	123.4	7.1%	8.76	876.14
D03-911	Office - Large	53.5	7.1%	3.80	379.85
D03-911	Office - Small	14.6	7.1%	1.04	103.66
D03-911	Restaurant - Sit-Down	166.9	7.1%	11.85	1,184.99
D03-911	Restaurant - Fast-Food	95.1	7.1%	6.75	675.21
D03-911	Retail - 3-Story Large	5.6	7.1%	0.40	39.76
D03-911	Retail - Single-Story Large	5.6	7.1%	0.40	39.76
D03-911	Retail - Small	3.4	7.1%	0.24	24.14
D03-911	Storage - Conditioned	6.1	7.1%	0.43	43.31
D03-911	Storage - Unconditioned	6.1	7.1%	0.43	43.31
D03-911	Warehouse - Refrigerated	24.4	7.1%	1.73	173.24

* The base gas EUIs are1994 DEER New Construction EUIs.

Table 3-16: Non-Residential Water Heating Measure Savings Estimates – Point of Use Water Heat

Measure ID	Building Types	Gas Water Heat EUI (Therms/1000 sf)*	Point of Use Water Heat (%)	Point of Use Water Heat (Therms/1000 sf)	Point of Use Water Heat (kBtu/1000 sf)
D03-909	Education - Primary School	33.0	10%	3.30	330.00
D03-909	Education - Secondary School	15.4	10%	1.54	154.00
D03-909	Education - Community College	87.4	10%	8.74	874.00
D03-909	Education - University	87.4	10%	8.74	874.00
D03-909	Grocery	9.8	10%	0.98	98.00
D03-909	Health/Medical - Hospital	362.4	10%	36.24	3,624.00
D03-909	Health/Medical - Clinic	136.2	10%	13.62	1,362.00
D03-909	Lodging - Hotel (Guest Rooms)	123.4	10%	12.34	1,234.00
D03-909	Lodging - Motel	123.4	10%	12.34	1,234.00
D03-909	Office - Large	53.5	10%	5.35	535.00
D03-909	Office - Small	14.6	10%	1.46	146.00
D03-909	Restaurant - Sit-Down	166.9	10%	16.69	1,669.00
D03-909	Restaurant - Fast-Food	95.1	10%	9.51	951.00
D03-909	Retail - 3-Story Large	5.6	10%	0.56	56.00
D03-909	Retail - Single-Story Large	5.6	10%	0.56	56.00
D03-909	Retail - Small	3.4	10%	0.34	34.00
D03-909	Storage - Conditioned	6.1	10%	0.61	61.00
D03-909	Storage - Unconditioned	6.1	10%	0.61	61.00
D03-909	Warehouse - Refrigerated	24.4	10%	2.44	244.00

* The base gas EUIs are1994 DEER New Construction EUIs.

Table 3-17: Non-Residential Water Heating Measure Savings Estimates – Circulation Pump Time Clock

Measure ID	Building Types	Gas Water Heat EUI (Therms/1000 sf)*	Circulation Pump Timeclock (%)	Circulation Pump Timeclock Savings (Therms/1000 sf)	Circulation Pump Timeclock Savings (kBtu/1000 sf)
D03-910	Education - Primary School	33.0	6%	1.98	198.00
D03-910	Education - Secondary School	15.4	6%	0.92	92.40
D03-910	Education - Community College	87.4	6%	5.24	524.40
D03-910	Education - University	87.4	6%	5.24	524.40
D03-910	Grocery	9.8	6%	0.59	58.80
D03-910	Health/Medical - Hospital	362.4	6%	21.74	2,174.40
D03-910	Health/Medical - Clinic	136.2	6%	8.17	817.20
D03-910	Lodging - Hotel (Guest Rooms)	123.4	6%	7.40	740.40
D03-910	Lodging - Motel	123.4	6%	7.40	740.40
D03-910	Office - Large	53.5	6%	3.21	321.00
D03-910	Office - Small	14.6	6%	0.88	87.60
D03-910	Restaurant - Sit-Down	166.9	6%	10.01	1,001.40
D03-910	Restaurant - Fast-Food	95.1	6%	5.71	570.60
D03-910	Retail - 3-Story Large	5.6	6%	0.34	33.60
D03-910	Retail - Single-Story Large	5.6	6%	0.34	33.60
D03-910	Retail - Small	3.4	6%	0.20	20.40
D03-910	Storage - Conditioned	6.1	6%	0.37	36.60
D03-910	Storage - Unconditioned	6.1	6%	0.37	36.60
D03-910	Warehouse - Refrigerated	24.4	6%	1.46	146.40

* The base gas EUIs are1994 DEER New Construction EUIs.

3.5 Vending Machine Control

A technology that has come into existence and acceptance since the 1994 NEOS study is the Vending Machine Control. Utilizing a custom passive infrared sensor, the Vending Machine Control completely powers down a vending machine when the area surrounding it is unoccupied for fifteen minutes. Once powered down, the Vending Machine Control will measure the ambient room temperature of the vending machine's location. Using this information, the Vending Machine Control automatically powers up the vending machine at one to three hour intervals, independent of occupancy, to ensure that the vended products stay cold. The Vending Machine Control is a simple plug-and-play product, typically requiring fifteen minutes or less for installation.

The technology can be used on all beverage vending machines and has been approved by Coke and Pepsi. The amount of electricity savings is proportional to the amount of traffic experienced in the vending machine's location. The technology can also be used for other non-cooled vending machines (e.g. candy machines).

The vending machine is plugged into the device, and the device is plugged into the wall. This allows the vending machine to go into "sleep" mode when there is no activity in the area of the vending machine. Vending machine goes into sleep mode for a maximum of 4 hours.

The Pacific Northwest Regional Technical Forum database characterizes this measure in two forms: one being a Vending Machine Controller-Large Machine w/Illuminated Front, and the other a Vending Machine Controller-Small Machine or Machine without Illuminated Front. Expected energy savings are provided for these two characterizations and are provided in Table 3-18. It is expected that the Vending Machine Control will operate primarily during off-peak hours and therefore no peak savings are estimated.

Table 3-18: Vending Machine Control Measures

Measure ID	Measure	Energy Savings (kWh/Unit)	Peak Demand Savings (watts/unit)
D03-912	Vending Machine Controller-Cold Drink Vending Machine-Lighted Front	1,612	0
D03-913	Vending machine Controller-Uncooled Snack Machine-Unlighted Front	387	0

3.6 High-Efficiency Motors

In 1989, the National Electrical Manufacturers Association (NEMA) developed a standard definition for energy-efficient motors. The definition, 12-6B, specifies nominal and minimum efficiency values that a motor must equal or exceed to be classified as "energy-efficient". The efficiency of a motor is the ratio of useful power output to its total power consumption. Two kinds of motors are covered by the analysis. Open Drip-Proof (ODP) motors allow air to blow directly through the frame but have a cover that prevents drops of liquid from entering. Totally Enclosed Fan-Cooled (TEFC) motors prevent outside air from flowing inside the frame with fins and a fan for cooling. Electric motors are also classified by their speed (RPM) and horsepower rating, which is the product of the motor's torque and speed.

Motor efficiency measures have not historically existed within the DEER database. A set of motor efficiency measures has been added for this 2004-05 DEER update. Table 3-19 through Table 3-25 outline the characterizations for motor measures by SIC classification and motor size. Efficient motors meet the Premium efficiency standards established by the Consortium for Energy Efficiency (CEE) that apply to NEMA Design A and B, three-phase induction motors rated from 1- to 200-horsepower, with synchronous speeds of 1200, 1800, and 3600 RPM, and with either Open Drip Proof (ODP) or Totally Enclosed Fan-Cooled Drip Proof (CDP) enclosures. These motors are used extensively to drive pumps, fans, compressors, and machine tools. The base motors meet EPACT efficiency standards. Estimates of hours of operation by industry group and motor size are based on a study for the U.S. Department of Energy[9] and motor loading represents industry averages as identified in the U.S. DOE Motor Master computer software. The coincidence factor is based on the coincidence factor for efficient motors included in SDG&E's 2002 Express Efficiency working papers.

The calculation of energy savings follows the form:

$$\textbf{Energy Savings}\left[\frac{kWh}{unit\cdot year}\right] = (\,Motor\ HP / EPACT\ motor\ efficiency\,)\times kW/HP\times Hours\ of\ Operation \times Motor\ Loading - (\,Motor\ HP / Premium\ Motor\ Efficiency\,)\times kW/HP \times Hours\ of\ Operation\times Motor\ Loading$$

As an example, the calculation for the 5 HP motor in SIC 20 for Open Drip Proof motors is:

[9] "Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy Inc., December 1998, for the U.S. Department of Energy

$$\textbf{Energy Savings} = (5/0.875) \times 0.746 \times 3{,}829 \times 0.75 - (5/0.875) \times 0.746 \times 3{,}829 \times 0.75 = 274\,kWh$$

The calculation for Peak kW/unit follows the form:

$$\textbf{Demand Savings}\left[\frac{Watts}{unit}\right] = ((Motor\ HP \times kW/HP \times Coincidence\ Factor\ /\ EPACT\ Motor\ Efficiency) - (Motor\ HP \times kW/HP \times Coincidence\ Factor\ /\ Premium\ Motor\ Efficiency)) \times 1{,}000\,Watt\ hours/kWh$$

Using the same example for the 5 HP motor in SIC 20 for Open Drip Proof motors:

$$\textbf{Demand Savings} = ((5 \times 0.746 \times 0.74\ /\ 0.875) - (5 \times 0.746 \times 0.74\ /\ 0.895)) \times 1{,}000 = 70.5\,Watts$$

Table 3-19: Motor Savings Estimates – SIC 20 Food & Kindred Products - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	3,829	0.75	91	0.74	23.5
D03-915	5	0.875	0.895	0.746	3,829	0.75	274	0.74	70.5
D03-916	10	0.895	0.917	0.746	3,949	0.75	592	0.74	148.0
D03-917	15	0.910	0.930	0.746	3,949	0.75	783	0.74	195.7
D03-918	20	0.910	0.930	0.746	3,949	0.75	1,044	0.74	260.9
D03-919	25	0.917	0.936	0.746	4,927	0.75	1,526	0.74	305.5
D03-920	50	0.930	0.945	0.746	4,927	0.75	2,352	0.74	471.1
D03-921	100	0.941	0.954	0.746	5,524	0.75	4,476	0.74	799.4
D03-922	150	0.950	0.958	0.746	5,055	0.75	3,729	0.74	727.9
D03-923	200	0.950	0.958	0.746	5,055	0.75	4,972	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	3,829	0.75	91	0.74	23.5
D03-925	5	0.875	0.895	0.746	3,829	0.75	274	0.74	70.5
D03-926	10	0.895	0.917	0.746	3,949	0.75	592	0.74	148.0
D03-927	15	0.910	0.924	0.746	3,949	0.75	552	0.74	137.9
D03-928	20	0.910	0.930	0.746	3,949	0.75	1,044	0.74	260.9
D03-929	25	0.924	0.936	0.746	4,927	0.75	956	0.74	191.5
D03-930	50	0.930	0.945	0.746	4,927	0.75	2,352	0.74	471.1
D03-931	100	0.945	0.954	0.746	5,524	0.75	3,085	0.74	551.1
D03-932	150	0.950	0.958	0.746	5,055	0.75	3,729	0.74	727.9
D03-933	200	0.950	0.962	0.746	5,055	0.75	7,427	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)
** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.
*** Coincidence factors based on PG&E PY2004/2005 Working Papers
\+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-20: Motor Savings Estimates – SIC 26 Paper & Allied Products - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	3,997	0.75	95	0.74	23.5
D03-915	5	0.875	0.895	0.746	3,997	0.75	286	0.74	70.5
D03-916	10	0.895	0.917	0.746	4,634	0.75	695	0.74	148.0
D03-917	15	0.910	0.930	0.746	4,634	0.75	919	0.74	195.7
D03-918	20	0.910	0.930	0.746	4,634	0.75	1,225	0.74	260.9
D03-919	25	0.917	0.936	0.746	5,481	0.75	1,697	0.74	305.5
D03-920	50	0.930	0.945	0.746	5,481	0.75	2,617	0.74	471.1
D03-921	100	0.941	0.954	0.746	6,741	0.75	5,462	0.74	799.4
D03-922	150	0.950	0.958	0.746	6,669	0.75	4,920	0.74	727.9
D03-923	200	0.950	0.958	0.746	6,669	0.75	6,560	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	3,997	0.75	95	0.74	23.5
D03-925	5	0.875	0.895	0.746	3,997	0.75	286	0.74	70.5
D03-926	10	0.895	0.917	0.746	4,634	0.75	695	0.74	148.0
D03-927	15	0.910	0.924	0.746	4,634	0.75	648	0.74	137.9
D03-928	20	0.910	0.930	0.746	4,634	0.75	1,225	0.74	260.9
D03-929	25	0.924	0.936	0.746	5,481	0.75	1,064	0.74	191.5
D03-930	50	0.930	0.945	0.746	5,481	0.75	2,617	0.74	471.1
D03-931	100	0.945	0.954	0.746	6,741	0.75	3,765	0.74	551.1
D03-932	150	0.950	0.958	0.746	6,669	0.75	4,920	0.74	727.9
D03-933	200	0.950	0.962	0.746	6,669	0.75	9,799	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)

** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.

*** Coincidence factors based on PG&E PY2004/2005 Working Papers

\+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-21: Motor Savings Estimates – SIC 28 Chemicals & Allied Products - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	4,082	0.75	97	0.74	23.5
D03-915	5	0.875	0.895	0.746	4,082	0.75	292	0.74	70.5
D03-916	10	0.895	0.917	0.746	4,910	0.75	736	0.74	148.0
D03-917	15	0.910	0.930	0.746	4,910	0.75	974	0.74	195.7
D03-918	20	0.910	0.930	0.746	4,910	0.75	1,298	0.74	260.9
D03-919	25	0.917	0.936	0.746	4,873	0.75	1,509	0.74	305.5
D03-920	50	0.930	0.945	0.746	4,873	0.75	2,327	0.74	471.1
D03-921	100	0.941	0.954	0.746	5,853	0.75	4,742	0.74	799.4
D03-922	150	0.950	0.958	0.746	5,868	0.75	4,329	0.74	727.9
D03-923	200	0.950	0.958	0.746	5,868	0.75	5,772	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	4,082	0.75	97	0.74	23.5
D03-925	5	0.875	0.895	0.746	4,082	0.75	292	0.74	70.5
D03-926	10	0.895	0.917	0.746	4,910	0.75	736	0.74	148.0
D03-927	15	0.910	0.924	0.746	4,910	0.75	686	0.74	137.9
D03-928	20	0.910	0.930	0.746	4,910	0.75	1,298	0.74	260.9
D03-929	25	0.924	0.936	0.746	4,873	0.75	946	0.74	191.5
D03-930	50	0.930	0.945	0.746	4,873	0.75	2,327	0.74	471.1
D03-931	100	0.945	0.954	0.746	5,853	0.75	3,269	0.74	551.1
D03-932	150	0.950	0.958	0.746	5,868	0.75	4,329	0.74	727.9
D03-933	200	0.950	0.962	0.746	5,868	0.75	8,622	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)
** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.
*** Coincidence factors based on PG&E PY2004/2005 Working Papers
+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-22: Motor Savings Estimates – SIC 29 Petroleum & Coal Products - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	1,582	0.75	38	0.74	23.5
D03-915	5	0.875	0.895	0.746	1,582	0.75	113	0.74	70.5
D03-916	10	0.895	0.917	0.746	1,944	0.75	292	0.74	148.0
D03-917	15	0.910	0.930	0.746	1,944	0.75	386	0.74	195.7
D03-918	20	0.910	0.930	0.746	1,944	0.75	514	0.74	260.9
D03-919	25	0.917	0.936	0.746	3,025	0.75	937	0.74	305.5
D03-920	50	0.930	0.945	0.746	3,025	0.75	1,444	0.74	471.1
D03-921	100	0.941	0.954	0.746	3,793	0.75	3,073	0.74	799.4
D03-922	150	0.950	0.958	0.746	4,170	0.75	3,076	0.74	727.9
D03-923	200	0.950	0.958	0.746	4,170	0.75	4,102	0.74	970.5

Measure ID	HP	EPACT* Closed Drip Proof (CDP)	Premium* Closed Drip Proof (CDP)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings CDP (kWh)	Coincidence Factor***	Peak Watts/unit CDP
D03-924	1	0.825	0.855	0.746	1,582	0.75	38	0.74	23.5
D03-925	5	0.875	0.895	0.746	1,582	0.75	113	0.74	70.5
D03-926	10	0.895	0.917	0.746	1,944	0.75	292	0.74	148.0
D03-927	15	0.910	0.924	0.746	1,944	0.75	272	0.74	137.9
D03-928	20	0.910	0.930	0.746	1,944	0.75	514	0.74	260.9
D03-929	25	0.924	0.936	0.746	3,025	0.75	587	0.74	191.5
D03-930	50	0.930	0.945	0.746	3,025	0.75	1,444	0.74	471.1
D03-931	100	0.945	0.954	0.746	3,793	0.75	2,119	0.74	551.1
D03-932	150	0.950	0.958	0.746	4,170	0.75	3,076	0.74	727.9
D03-933	200	0.950	0.962	0.746	4,170	0.75	6,127	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)
** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.
*** Coincidence factors based on PG&E PY2004/2005 Working Papers
+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-23: Motor Savings Estimates – SIC 33 Metals - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	4,377	0.75	104	0.74	23.5
D03-915	5	0.875	0.895	0.746	4,377	0.75	313	0.74	70.5
D03-916	10	0.895	0.917	0.746	4,140	0.75	621	0.74	148.0
D03-917	15	0.910	0.930	0.746	4,140	0.75	821	0.74	195.7
D03-918	20	0.910	0.930	0.746	4,140	0.75	1,095	0.74	260.9
D03-919	25	0.917	0.936	0.746	4,854	0.75	1,503	0.74	305.5
D03-920	50	0.930	0.945	0.746	4,854	0.75	2,318	0.74	471.1
D03-921	100	0.941	0.954	0.746	6,698	0.75	5,427	0.74	799.4
D03-922	150	0.950	0.958	0.746	7,362	0.75	5,431	0.74	727.9
D03-923	200	0.950	0.958	0.746	7,362	0.75	7,241	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	4,377	0.75	104	0.74	23.5
D03-925	5	0.875	0.895	0.746	4,377	0.75	313	0.74	70.5
D03-926	10	0.895	0.917	0.746	4,140	0.75	621	0.74	148.0
D03-927	15	0.910	0.924	0.746	4,140	0.75	579	0.74	137.9
D03-928	20	0.910	0.930	0.746	4,140	0.75	1,095	0.74	260.9
D03-929	25	0.924	0.936	0.746	4,854	0.75	942	0.74	191.5
D03-930	50	0.930	0.945	0.746	4,854	0.75	2,318	0.74	471.1
D03-931	100	0.945	0.954	0.746	6,698	0.75	3,741	0.74	551.1
D03-932	150	0.950	0.958	0.746	7,362	0.75	5,431	0.74	727.9
D03-933	200	0.950	0.962	0.746	7,362	0.75	10,817	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)

** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.

*** Coincidence factors based on PG&E PY2004/2005 Working Papers

\+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-24: Motor Savings Estimates – Other Industrial - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	2,283	0.75	54	0.74	23.5
D03-915	5	0.875	0.895	0.746	2,283	0.75	163	0.74	70.5
D03-916	10	0.895	0.917	0.746	3,043	0.75	456	0.74	148.0
D03-917	15	0.910	0.930	0.746	3,043	0.75	604	0.74	195.7
D03-918	20	0.910	0.930	0.746	3,043	0.75	805	0.74	260.9
D03-919	25	0.917	0.936	0.746	3,530	0.75	1,093	0.74	305.5
D03-920	50	0.930	0.945	0.746	3,530	0.75	1,685	0.74	471.1
D03-921	100	0.941	0.954	0.746	4,732	0.75	3,834	0.74	799.4
D03-922	150	0.950	0.958	0.746	4,174	0.75	3,079	0.74	727.9
D03-923	200	0.950	0.958	0.746	4,174	0.75	4,106	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	2,283	0.75	54	0.74	23.5
D03-925	5	0.875	0.895	0.746	2,283	0.75	163	0.74	70.5
D03-926	10	0.895	0.917	0.746	3,043	0.75	456	0.74	148.0
D03-927	15	0.910	0.924	0.746	3,043	0.75	425	0.74	137.9
D03-928	20	0.910	0.930	0.746	3,043	0.75	805	0.74	260.9
D03-929	25	0.924	0.936	0.746	3,530	0.75	685	0.74	191.5
D03-930	50	0.930	0.945	0.746	3,530	0.75	1,685	0.74	471.1
D03-931	100	0.945	0.954	0.746	4,732	0.75	2,643	0.74	551.1
D03-932	150	0.950	0.958	0.746	4,174	0.75	3,079	0.74	727.9
D03-933	200	0.950	0.962	0.746	4,174	0.75	6,133	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)
** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.
*** Coincidence factors based on PG&E PY2004/2005 Working Papers
+ Motor loading estimate based on average values listed in the Motor Master database

Table 3-25: Motor Savings Estimates – Commercial Sector - 1800 rpm 3 Phase Motor

Measure ID	HP	EPACT* Open Drip Proof (OPD)	Premium* Open Drip Proof (OPD)	kW/HP	Hours of Operation**	Motor Loading +	Energy Savings ODP (kWh)	Coincidence Factor***	Peak Watts/unit ODP
D03-914	1	0.825	0.855	0.746	2,076	0.75	49	0.74	23.5
D03-915	5	0.875	0.895	0.746	2,076	0.75	148	0.74	70.5
D03-916	10	0.895	0.917	0.746	2,076	0.75	311	0.74	148.0
D03-917	15	0.910	0.930	0.746	2,076	0.75	412	0.74	195.7
D03-918	20	0.910	0.930	0.746	2,820	0.75	746	0.74	260.9
D03-919	25	0.917	0.936	0.746	2,820	0.75	873	0.74	305.5
D03-920	50	0.930	0.945	0.746	2,820	0.75	1,346	0.74	471.1
D03-921	100	0.941	0.954	0.746	2,820	0.75	2,285	0.74	799.4
D03-922	150	0.950	0.958	0.746	2,820	0.75	2,080	0.74	727.9
D03-923	200	0.950	0.958	0.746	2,215	0.75	2,179	0.74	970.5
Measure ID	**HP**	**EPACT* Closed Drip Proof (CDP)**	**Premium* Closed Drip Proof (CDP)**	**kW/HP**	**Hours of Operation****	**Motor Loading +**	**Energy Savings CDP (kWh)**	**Coincidence Factor*****	**Peak Watts/unit CDP**
D03-924	1	0.825	0.855	0.746	2,076	0.75	49	0.74	23.5
D03-925	5	0.875	0.895	0.746	2,076	0.75	148	0.74	70.5
D03-926	10	0.895	0.917	0.746	2,076	0.75	311	0.74	148.0
D03-927	15	0.910	0.924	0.746	2,076	0.75	290	0.74	137.9
D03-928	20	0.910	0.930	0.746	2,820	0.75	746	0.74	260.9
D03-929	25	0.924	0.936	0.746	2,820	0.75	547	0.74	191.5
D03-930	50	0.930	0.945	0.746	2,820	0.75	1,346	0.74	471.1
D03-931	100	0.945	0.954	0.746	2,820	0.75	1,575	0.74	551.1
D03-932	150	0.950	0.958	0.746	2,820	0.75	2,080	0.74	727.9
D03-933	200	0.950	0.962	0.746	2,215	0.75	3,255	0.74	1,449.7

* EPACT & Premium Efficiencies from Consortium for Energy Efficiency (http://www.cee1.org/ind/motrs/Cee-nema.pdf)
** Industrial hours of operation based on "United States Industrial Electric Motor Systems Market Opportunities Assessment", Xenergy, December 1998, for the U.S. Department of Energy, and an on-site survey of commercial sector customers for Xcel Energy, spring 2002.
*** Coincidence factors based on PG&E PY2004/2005 Working Papers
+ Motor loading estimate based on average values listed in the Motor Master database

4

Agricultural Sector

The 1994 NEOS study did not include any agriculture measures. The measures listed below were chosen for consideration in the 2004-05 DEER update after review of the Express Efficiency Agriculture/Process working papers, discussion with the DEER project advisory committee, and the Efficiency Vermont Technical Reference Manual. However, not all of these measures are included in the 2004-05 DEER update. The low energy livestock waterer was deemed more appropriate to much colder climates and the plate heat exchanger for milk pre-cooling was deemed current standard practice.

- Irrigation Measures
  - Low Pressure Sprinkler Nozzle
  - Sprinkler to Micro Irrigation Conversion
- Greenhouses
  - Infrared Film for Greenhouses
  - Greenhouse Heat Curtain
- Variable Frequency Drives for Vacuum and Milk Pumps
  - VFD for Milk Pump
  - VFD for Vacuum Pump
- Low Energy Livestock Waterer
- Ventilation Measures
  - Ventilation Fans or Box Fans
  - High Volume Low Speed Fans
- Plate Heat Exchanger for Milk Pre-cooling

The following sections will describe the base case measure, the energy efficient measure, the calculations used to derive the kWh savings, and the calculations used to derive the kW savings. Where available annual kW per unit, annual kWh per unit, Therms per unit, operating hour information, coincidence factor, measure life, and cost per unit will be included.

4.1 Irrigation

There are two irrigation measures included in the 2004-05 DEER update. These include low pressure sprinkler nozzles, and conversion from sprinkler irrigation to a micro-irrigation system. Some feel that the latter is already standard practice but it is still included in this update. The calculations to estimate kWh and kW savings per year for irrigation measures are complex given that there are a variety of crops, multiple configurations, and multiple climate zones. The calculations and assumptions are shown below in the measure sections. Note that there are a large number of average values used in the calculations. These average values came from participants in the Express Efficiency program; however, these averages are only based on a limited number of participants.

Low Pressure Sprinkler Nozzles[1]

This measure encourages system operators to convert to low-pressure nozzles, thus reducing the amount of energy required to apply the same amount of water. The amount of energy saved per nozzle will depend on the actual operating pressure decrease, the pumping plant efficiency, the amount of water applied, and the number of nozzles converted. The reduction in demand per nozzle will depend on the pump flow, the operating pressure decrease, the pumping plant efficiency, and the number of nozzles converted.

Standard, impact-driven, sprinkler heads for agricultural irrigation utilize relatively high water pressure (50 PSI or higher) in conjunction with smoothbore nozzles. The high water velocity through the nozzles results in a breakup of the water stream into an acceptable distribution of small, medium, and large droplet sizes. The distribution of droplet sizes then results in an acceptable uniformity of water application, assuming correct sprinkler head spacing.

“Low-pressure” impact sprinkler nozzles use various orifice shapes (square, rectangular, octagonal, round with notches) and configurations so that the desired stream breakup will occur at a significantly lower operating pressure. A conversion to low-pressure nozzles should be investigated for any irrigation system now using standard, smoothbore, high-pressure nozzles. Low-pressure sprinkler nozzles are applicable in any situation where standard, impact-driven agricultural or turf sprinkler heads are used for irrigation. These applications include:

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[1] References for low pressure sprinkler nozzles

1. Canessa. 1992. Low Pressure Sprinkler Nozzles, San Luis Obispo, CA; updated November 1994.
2. McMillen, Charles. 1991. Rain Bird Service Center, Glendora, CA .
3. PG&E. 1992. Program database, Table TA-2.12, San Francisco, CA, February.

- Portable, hand-move systems are systems consisting of aluminum or PVC pipe that can be moved from field to field and typically where the actual sprinklers are moved several times within a field during an irrigation cycle.
- Permanent solid-set systems are systems where the sprinklers are in one place throughout a growing season.

The energy and demand savings from converting to low pressure nozzles depend on many factors. Calculations from the 2003 Express Efficiency Agriculture/Process work papers are shown below.[2]

Energy Savings:

Converting to low pressure nozzles reduces the amount of energy used to deliver the same amount of water by reducing the total dynamic head. A reduction in total dynamic head leads to a decrease in the energy required per acre-foot and thereby a reduction in annual energy use. The amount of energy saved per nozzle depends on the actual operating pressure decrease (TDH), the pumping plant efficiency (OPE), the amount of water applied, and the number of nozzles converted. The equations below result in the energy savings per nozzle, the results are summarized in Table 4-1.

Demand Savings:

Demand savings per nozzle depend on the pump flow (Q), the operating pressure decrease (TDH), the pumping plant efficiency (OPE) and the number of nozzles converted. The work papers used many assumptions and several calculations to arrive at the kW savings for two major California climate regions and two system types. These are summarized in Table 4-1.

Table 4-1: KWh and kW Savings Estimates for Different Sprinkler System Types and Regions[3]

	Energy Savings / Nozzle		Demand Savings / Nozzle	
SYSTEM/REGION	**Portable**	**Solid-Set**	**Portable**	**Solid-Set**
Central Valley	39 kWh	10 kWh	.036 kW	0.004 kW
Coast and Coastal Valleys	8 kWh	7 kWh	.008 kW	.003 kW

Note the following important assumptions and resulting energy savings calculations for Low Pressure Sprinkler Nozzles as of March 2002

[2] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

[3] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

- Operating Pressure Decrease (TDH): 20 psi (46.2 feet)
- Overall Pumping Plant Efficiency (OPE): 55%
- Net Water Applied per Acre: Varies with region
- Irrigation Efficiency: 75%. Irrigation efficiency is defined as the ratio of applied irrigation water that is beneficially used to the total amount of applied irrigation water.
- Nozzles Converted per Acre: Varies with system type
- Pump Flow: Varies with crop and region but based on 20 hours/day operation
- Cost to Retrofit: $1.24/nozzle in a portable system, $1.74/nozzle in a solid-set system
- A weighted average kWh/nozzle-yr was determined for all portable systems using the results from the Low-Density and High-Density portable systems.
- Assumptions are based on the average acre

To calculate the energy use (kWh/yr) by an irrigation system the following series of equations can be used.

[1] kWh/yr = kWh/AF x AF/yr.
where: kWh/yr =Total annual energy use.
kWh/AF = Amount of energy required to pump an acre-foot of water.
AF/yr =Total acre-feet pumped annually.

The amount of energy required per acre-feet, kWh/acre-feet, can be determined using equation 2 below.

[2] kWh/AF = 1.0241 x TDH / OPE.
where: kWh/AF = Amount of energy required to pump an acre-foot of water in the irrigation system.
TDH = Total dynamic head required to pump water through the irrigation system in feet. (46.2 feet)
OPE = Overall pumping plant efficiency expressed as a decimal (0 - 1.0). (55%)

Converting to low-pressure nozzles allows a reduction in the TDH, thus a reduction in kWh/AF, thus a reduction in kWh/yr.

Energy Savings per Nozzle per Year:

To determine energy savings per nozzle, equation [2] from above is first used again to determine the reduction in kWh/AF as follows.

[2] kWh/AF = 1.0241 x TDH / OPE
= 1.0241 x 46.2 / .55
= 86 kWh/AF

A weighted average water application was determined using crop acreages as reported by the California Department of Food and Agriculture, net crop evapotranspirations calculated using data supplied by the UC Extension, and an average 75% irrigation efficiency. Equation [1] from above is then used to determine kWh/nozzle-year:

[1] kWh/Nozzle Year = kWh/AF x AF/yr
86 kWh/AF x (AF/yr varies by crop and nozzle type)

Initially there were three scenarios developed for the number of nozzles required to complete the retrofit:

- A standard, portable, hand move system with 4 nozzles/acre, referred to as “Low-Density Portable”.
- A standard, portable, hand move system with 21 nozzles/acre, referred to as “High-Density Portable”.
- A solid-set system with 35 nozzles/acre, referred to as “Solid-Set”.

Having the different kWh/acre-yr developed using equation [2] for the different climate regions and having the number of nozzles per acre required to make the conversion allows a calculation of kWh savings per nozzle:

[3] kWh/nozzle-yr = (kWh/acre-yr) / (nozzles/acre)

A weighted average kWh/nozzle-yr was determined for all portable systems using the results from the Low-Density and High-Density portable systems and is shown in

Table 4-2. These results are also shown in Table 4-1 above.

Table 4-2: kWh/nozzle-yr savings for two major climate regions and two system types[4]

SYSTEM/REGION	Portable	Solid-Set
Central Valley	39 kWh	10 kWh
Coast and Coastal Valleys	8 kWh	7 kWh

Non-coincident Demand Savings per Nozzle:

Horsepower savings per acre are determined with a standard equation, equation 4.[5]

[4] HP = TDH x Q / (3,960 x OPE)

where: HP = Motor horsepower requirements per acre.

TDH = Reduction in total dynamic head in the system in ft of water. The TDH reduction is 20 psi (46.2 feet) as before.

Q = Pump flow in gallons/minute - acre. Q can be determined if it is assumed that a flow will be in place that is required to satisfy the crop evapotranspiration demands at peak daily water use. A weighted average Q is determined based on the different crops and their acreages within the climate regions. (7.56 gpm/acre)

OPE = Overall pumping plant efficiency as a decimal. The average overall pumping plant efficiency is assumed to be 55%.

Kilowatt demand savings per nozzle are calculated using equation 5. This equation has been used to calculate the values in Table 4-3 below, whose results are shown in Table 4-1 as well.

[5] kW/nozzle = (HP/acre x 0.746 kW/HP)/ (nozzles/acre)

where:

HP = Motor horsepower requirements per acre.

TDH = Reduction in total dynamic head in the system in feet of water. (20 PSI)

Q = Pump flow in gallons/minute / acre, assumed at peak. Q varies with crop type acreage, and climate region.

OPE = Overall pumping plant efficiency as a decimal. (55%)

Nozzles/acre = Depends the system type (portable or solid set), and the irrigation needs of the acreage. A weighted average kWh/nozzle-yr was determined for all portable systems using the results from the Low-Density and High-Density portable systems.

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[4] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

[5] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

Table 4-3: kW/nozzle-yr savings for two major climate regions and two system types[6]

SYSTEM/REGION	Portable	Solid-Set
Central Valley	.036 kW	.004 kW
Coast and Coastal Valleys	.008 kW	.003 kW

The expected measure life of low pressure nozzles is 3-5 years because they are generally rebuilt or discarded due to bearing and spring wear. The incremental measure cost for an installed low-pressure nozzle depends on the type of system being installed. An earlier estimate was $1.20. Of this, the material cost accounts for $0.57 /nozzle based on the average of three manufacturer's retail pricing. The labor cost of the retrofit accounts for $0.63/nozzle, assuming that the nozzle conversion takes place manually in the field and takes five minutes. At a "fully-loaded" cost of $7.50 ($5/hour + 50% burden). A later estimate indicates $1.24 per nozzle for a portable system, and $1.74/nozzle for a solid set system.[7] The agricultural coincident diversity factor (agriculture demand @ system peak / the maximum agricultural demand) is .78. This is an average based on PG&E's 1992-95 Agricultural rate load research data (Quantum 1996).

Sprinkler to Micro-Irrigation Conversion[8]

Micro-irrigation systems consist of systems of above and below ground pipelines and hoses that deliver water under pressure, to specialized emission devices located at, or very near, individual plants. The basic intent is to accurately supply small amounts of water on a frequent basis so as to maintain a constant, comparatively high, rootzone soil moisture. In addition, micro-irrigation provides opportunities for very precise control of fertilizer applications. Other advantages may include reduced weed growth and diseases and increased flexibility in the timing of agricultural operations. Because of all these benefits this measure may be standard practice already.

Energy may be saved by converting from a sprinkler irrigation system to a micro-irrigation system because the system operating pressure will be reduced, and because these systems have a higher potential irrigation efficiency thereby reducing the amount of water pumping required, which translates to energy savings. The increased irrigation efficiency results from a) lower wind sensitivity and b) lower evaporation losses.

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6 Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

7 Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

8 This information comes directly from the 2003 Express Efficiency Program Agriculture /Process working papers.

The energy savings depend on many factors the following detailed calculations come from the 2003 Express Efficiency Agriculture/Process work papers. That work used the following calculations to arrive at the kWh and kW savings for two major climate regions and various crop types are found in the tables below.

Calculation Methodology for Sprinkler to Micro-Irrigation Conversion

Annual energy use by an irrigation system can be calculated using equation 1, which is the same calculation used for low pressure sprinkler nozzles.

[1] kWh/yr = kWh/AF x AF/yr.
where: kWh/yr = Total annual energy use.
kWh/AF = Average amount of energy required to pump an acre-foot of water.
AF/yr = Total acre-feet pumped annually.

Equation 2 is used to calculate kWh/AF.

[2] kWh/AF =1.0241 x TDH / OPE
where: TDH = Total dynamic head required to pump water through the irrigation system in feet.
OPE = Overall pumping plant efficiency expressed as a decimal (0 - 1.0).

kWh/AF may be the summation of two or more pumps in the system. For the purposes of this measure, two "types" of kWh/AF will be identified, 1) the kWh/AF required to deliver water to the start of the actual field irrigation system ($kWh_{delivery}$/AF), and 2) the boost kWh/AF required to operate the irrigation system itself (kWh_{boost}/AF).

The acre-feet of pumped water required by a cropped field per year (AF/yr) can be determined using equation 3:

[3] AF/yr = CL + (ACRES x ((ETc - RAIN) / ((1 - LR) x IE))
where: AF/yr = Annual water pumping required to irrigate a field as acre-feet per year.
CL = Conveyance losses while delivering water to the irrigation system as acre feet per year.
ACRES = Net cropped acres in the field.
ETc = Annual net water use as acre-feet/acre per year.
RAIN = Annual rainfall effective in satisfying ETc or required leaching as acre- feet/acre per year.
LR = Leaching requirement for maintaining a salt balance in the rootzone as a decimal (0.0 - 1.0).
IE = Irrigation efficiency as a decimal (0.0 - 1.0)

Givens: 1.0241 = kWh required to lift one acre-foot of water one foot

The annual energy savings are calculated in equation 4 as follows:

[4] kWh_{saved}/year = kWh_{base}/year - $kWh_{project}$/year

Where: kWh_{saved}/year = Annual energy savings.

kWh_{base}/year = Current annual energy usage.

$kWh_{project}$/year = Predicted annual energy usage.

kWh_{base}/year and $kWh_{project}$/year are both calculated by a form of equation [1], incorporating equations [2] and [3]. As noted, kWh/AF consists of $kWh/AF_{delivery}$ and kWh/AF_{boost}. $kWh/AF_{delivery}$ remains constant, i.e., the primary water source and method of delivery for the field will not change. There will be savings in annual $kWh_{delivery}$ due to the reduction in applied water but this will be disregarded for all cases except those with a well as the water source.

A survey of the major manufacturers[9] identified average required device operating pressures for different types of micro-irrigation and sprinkler irrigation devices. The following major assumptions were made:

- Field and Vegetable crops would only be converted to drip tape or one of the three identified in-line hose products.
- Orchards and Vineyards would only be converted to on-line emitters, jets/foggers/misters, or mini-sprinklers.
- The required operating pressures of all sprinklers were averaged assuming the following weighting: sprinkler conversions would be 5% from Big Gun systems, 75% from High Pressure systems, and 20% from Low Pressure systems.
- Eight pound-per-square-inch pressure (psi) for filters, two psi for valves, and four psi for pipeline friction losses, a total of fourteen psi, would be added to the device operating pressure to calculate total required micro-irrigation system pressure.
- Four psi for filters, two psi for valves, and six psi for pipeline friction losses, a total of twelve psi, would be added to the device operating pressure for sprinkler systems.

Table 4-4 summarizes the total required system pressure, TDH in equation [2], for the two types of micro-irrigation system and sprinkler systems as averaged.

[9] Canessa, 1995. *Micro-Irrigation for Energy-Use Reduction. San Luis Obispo, CA.*

Table 4-4: Estimated required system operating pressures for various irrigation system types[10]

System	Required Operating Pressure (psi)
Sprinklers (5% Big Gun, 65% High Pressure, 30% Low Pressure)	65
Field/Vegetable Crop Micro	30
Orchard/Vineyard Micro	35
Flood	5

Since the conversion to micro-irrigation will usually involve either a new pump or a retrofit of an existing installation, the overall pumping plant efficiency of the micro system is 67.5%. This assumes a 90% motor efficiency and a 75% bowl efficiency.

The OPE of the existing pumping plant is assumed to be 55.1%. This is the average of 17,672 pump tests that are contained in the 1993-1994 agricultural pump test database.

With the sprinkler and micro-irrigation TDHs identified in Table 4-1, and the assumed OPEs, equation [2] can be used to calculate the reduction in kWh/AFboost for the conversion to micro-irrigation.

Equation [3] for calculating required annual water pumping, AF/yr, can be solved by examining the separate components of the equation:

- Conveyance Losses (CL) - Since micro-irrigation systems generally result in less water applied to the field, this means less water being pumped through the conveyance system and the conveyance losses in equation [3] (CL) should logically decrease. Another reason that CL could decrease is that micro-irrigation systems generally are a totally piped system and, many times, there are open ditches associated with water conveyance to flood irrigation systems. As a conservative assumption then, CL will not be considered in the annual energy use calculations.
- Net water requirements (ETc - RAIN) / (1- LR) - As fully explained in the report, Micro-Irrigation for Energy-Use Reduction (Canessa 1995), weighted average water applications were calculated for four types of crops in two major climate regions. Important data included a) crop acreages as reported by the California Department of Food and Agriculture, b) net crop evapotranspirations calculated using data supplied by the UC Extension, c) a 3% leaching ratio, and d) an assumed 33% of average annual gross rainfall as effective. The weighted averages are based on assumptions regarding the percentage of any one crop’s total acreage that might be drip irrigated. Crops were grouped by type. The weighted average

[10] Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.

applications for the different combinations of crop type and climate region are termed NET and are seen in Table 4-5.

- Irrigation efficiencies (IE) - average irrigation efficiencies for the various system types are assumed as per University of California Cooperative Extension recommendations contained in Publication #21454, Irrigation Scheduling (UCCE 1989). They are contained in Table 4-6.

In summary, the preceding assumptions regarding equation [3] result in the reduced equation, equation 5:

[5] AF/yr = ACRES x NET / IE
Where: AF/yr = Required annual pumping in acre-feet.
ACRES = Net cropped acres.
NET = Net required pumping, acre-feet/acre per year, as identified for the major climate regions and crop type in.
IE = Irrigation efficiency for the different irrigation system types as identified by Table 4-6.

Table 4-5: Cropped acreages, required net annual irrigation, and pump flow on a per acre basis for two major climate regions and four different crop types - micro-irrigated acreage only[1][11].

REGION	Crop	Acres	AF/Ac[12]	ETmax[13]	Flow[14]
				(in / day)	(gpm/ac)
Central Valleys	Total	769,679	2.59	0.32	6.41
Central Valleys	Field/Vege	135,616	1.92	0.38	7.73
Central Valleys	Trees	433,289	2.94	0.36	7.42
Central Valleys	Grapes	200,774	2.38	0.25	5.11
Coastal	Total	122,827	1.41	0.25	5.13
Coastal	Field/Vege	57,943	1.22	0.28	5.86
Coastal	Trees	22,290	1.96	0.27	5.62
Coastal	Grapes	42,593	1.37	0.19	3.87

11 Canessa, 1995. *Micro-Irrigation for Energy-Use Reduction. San Luis Obispo, CA.*

12 AF/Ac: the acreage-weighted, average, annual, net irrigation requirement. Note that the irrigation requirement for vegetable crops was doubled to reflect the double-cropping common to this crop rotation.

13 ETmax: the maximum expected daily crop water use, inches/day. This will set the required pump flow. This was calculated as the peak crop coefficient times 1.1 times the maximum monthly ETc divided by 31 days.

14 FLOW: this is the net required pump flow, gallons/minute per acre as calculated using equation [6].

Table 4-6: Estimated irrigation efficiencies for various irrigation system types[15]

SYSTEM	Irrigation Efficiency (%)
Micro-Irrigation	83
Sprinklers	75
Flood	70

With results and data as noted in Table 4-5, and Table 4-6, the annual kWh/acre savings are calculated and reported in Table 4-7. Note that the calculations in Table 4-7 disregard any savings due to applying a decrease in AF/yr against the kWh/AF required for water delivery.

The 1993-1994 PG&E agricultural pump test database was evaluated to estimate average kWh/AF for wells pumping water to the surface with a discharge pressure of 8 psi or less. The average for wells in the Central Valley Divisions was 274.6 kWh/AF, for wells in the Coastal Divisions, 316.6 kWh/AF. These numbers were used in conjunction with the results and data in Table 4-3, Table 4-5, and Table 4-6 to calculate annual kWh/Acre savings when the water source is a delivery well. These are reported in Table 4-7.

Table 4-7: Annual kWh/Acre-Year savings for converting from sprinkler systems to micro-irrigation for two climate regions and four crop types - projects[16]

Region	Field/Vegs kWh		Deciduous Trees kWh		Citrus Trees kWh		Grapes kWh	
	Non well	Well	Non well	Well	Non well	Well	Non well	Well
Central Valleys	422	484	643	746	603	700	522	606
Coastal	277	324	434	515	456	541	300	356

Changes in Peak kW

During the identification of annual net crop water requirements, the average, maximum daily crop water use was also identified. If a crop's water use is to be satisfied by an irrigation system at the maximum daily use rate, equation 6 is used to identify the required system flow on a per acre basis.

[6] FLOW = 452.5 x ETmax / (IE x HOURS)

Where: FLOW = Gallons/minute per acre to replace maximum daily crop water use.
ETmax = Maximum daily crop water use in inches/day (see Table 4-5).
IE = Irrigation efficiency as a decimal (0.00 - 1.00) (see Table 4-6).

15 UC Cooperative Extension. 1989. *Publication #21454, Irrigation Scheduling*

16 Canessa, 1995. *Micro-Irrigation for Energy-Use Reduction. San Luis Obispo, CA.*

HOURS = Daily hours of operation.

For this measure, the maximum daily crop water uses in Table 4-5 and the irrigation efficiencies in Table 4-6 were used, along with an assumed 22 hour/day operation. (The net calculated FLOWs, IE = 1.0, are reported in Table 4-5.)

The required connected load on a per acre basis can be calculated using equation 7.

[7] kW/Ac = .746 x FLOW x TDH / (3960 x OPE)
Where: kWh/Ac = Kilowatt-hours required per acre.
FLOW = Gallons per minute per acre in pumping plant, as calculated by Equation [6].
TDH = Total dynamic head of pumping plant in feet as identified in Table 4-3.
OPE = Overall pumping plant efficiency as a decimal (0 - 1).

The connected load reduction is calculated as follows in equation 8.

[8] $kW_{saved} = kW_{base} - kW_{project}$
where: kW_{saved} = kilowatt load reduction
kW_{base} = Base connected load in kilowatts
$kWh_{project}$ = Predicted connected load in kilowatts

kW_{base} and $kWh_{project}$ are calculated by equations [6] and [7] respectively, incorporating some of the assumptions regarding equations [2] and [3].

With required FLOWs calculated with equation [6], the assumptions concerning overall pumping plant efficiency, and the required system operating pressure (TDH, see Table 4), the kW savings on a per acre basis were identified using equations [7] and [8] and are reported in Table 4-8:

Table 4-8: kW/Acre savings for converting from sprinkler systems to micro-irrigation[17]

REGION	Field / Vegs kW	Deciduous Trees kW	Citrus Trees kW	Grapes kW
Central Valleys	0.377	0.329	0.180	0.227
Coastal	0.286	0.249	0.136	0.172

Note: The savings in Table 4-8 are peak kW savings since the systems are typically sized to operate continuously and therefore use the lowest capital cost pump and piping. The savings are the same whether the source is a well or not.

[17] Canessa, 1995. *Micro-Irrigation for Energy-Use Reduction. San Luis Obispo, CA.*

Micro-irrigation systems are a combination of many sub-systems, including a pumping plant, filters, mainline and manifold piping, and the system of distribution tubing and emission devices. It is assumed that the system life is that of the pumping system and main pipelines, which is 20 years.

The incremental cost of a micro-irrigation system over the cost of a sprinkler system will vary with the situation. PG&E agricultural consultants estimate an average incremental cost of $1000/acre[18].

4.2 Green Houses

There are two green house measures; infrared film for greenhouses and greenhouse heat curtains.

Infrared Film for Greenhouses[19]

Growers replacing plastic film greenhouse walls and roof have the option of replacing the plastic "film" walls and roof with various types of plastic. Infrared films inhibit the transfer of infrared heat through the greenhouse, resulting in an insulating quality that keeps the greenhouses warmer at night. The increased insulation quality reduces greenhouse-heating needs. The film consists of infrared anti-condensate polyethylene plastic that is at least 6 mils thick. The Effective Useful Life of this measure depends on the climate. Standard replacement of film is 4 years. In mild climates film may be replaced at 5-year increments or longer. The incremental measure cost is 3 cents per square foot of material. This figure does not include its installation. Annual energy savings depend on the location of the greenhouse, a conservative estimate is that the film saves 35% of the baseline model energy consumption. Modeling results for a 100' x 30' greenhouse with 7' walls in San Diego show annual therm savings per square foot of film installed to be 0.057 therms in Oxnard California (California Central Coast) and 0.049 therms in San Diego California.

Greenhouse Heat Curtain[20]

Greenhouse heat curtains are thermal blankets installed inside greenhouses which decrease radiation and convection heat losses. They also reduce infiltration through broken and poorly fitted windowpanes in the roof of the greenhouse. It is assumed that the heat curtains are deployed during nighttime hours, and furled during daytime hours. This measure is

18 Canessa, Peter. 2002 Review of Sprinkler to Micro Irrigation Conversion - An Express Efficiency Measure, Fresno, CA.

19 This information comes directly from the 2003 Express Efficiency Program Agriculture /Process working papers.

20 This information comes directly from the 2003 Express Efficiency Program Agriculture /Process working papers.

applicable to agricultural or commercial greenhouses involved in the production of nursery products, horticultural specialties, or ornamental products. Savings for this measure are on a therm per square foot basis and are estimated to be 0.39 therms per sqft. Measure data for cost effectiveness modeling have been developed for a prototypical 4,000 square foot greenhouse facility, and based on average characteristics for SoCalGas customer participants for Express Efficiency heat curtain measures during PY 2001. The incremental measure cost per square foot is $0.49 and these heat curtains are expected to last 5years. The assumed measure lifetime is based on the October 2001 Energy Efficiency Policy Manual for insulation measures.

4.3 Variable Frequency Drives (for Vacuum & Milk pumps only) [21]

Variable frequency drives also know as adjustable speed drives save energy by adjusting their operation to the load being served. So that when the load is minimal the drive runs at a reduced speed and when the load is greater the drive runs at higher speed. In the agriculture sector, adjustable speed drives can be attached to motors and dairy pumps.

Adjustable speed drives (VFDs) with feedback controls have the potential to save significant amounts of energy when implemented in dairy milking parlor vacuum milking systems. These drives can be used for both vacuum and milk pumps. Vacuum pumps are generally oversized and run at a constant speed in order to accommodate for any unexpected airflow stemming from events such as milking units falling off udders. A VFD with feedback controls allows the pump to run at a reduced speed most of the time and can increase the speed when necessary.

VFD for Milk Pump

Milk pumps are more efficient with VFDs since it enables the motor to speed up or slow down depending on the amount of milk in the receiver. This also allows a more uniform flow through the plate cooler which increases its effectiveness. Savings results vary, and one field test did not show any chiller energy savings from adding a VSD to a milk pump.

VFD for Diary Milking Parlor Vacuum Pump

VFDs, for vacuum systems, are essentially standard practice for new dairies or complete retrofits. In addition the payback for a retrofit installation is very short; incentives are not advised because this equipment should be adopted by all dairymen.

[21] This information comes directly from the 2003 Express Efficiency Program Agriculture /Process working papers.

The estimated annual energy savings provided by a VFD with feedback system to a vacuum pump is 2,505 kWh/hp, for vacuum pumps, (20 Hr/day x 365 days/yr x 1 HP x 0.746 kW/HP x 46% savings = 2,505) with an estimated cost of $340/hp. The data used to develop the estimates assumes the dairy operates 20 hours each day. The energy saving estimates were developed by averaging the results of many actual pumps which ranged in size.[22] It is assumed that the pumps are reasonably sized and thus the VFD provides no demand reduction. Note that a different source finds 3,431 kWh/yr-hp because it uses a 60% savings estimate and assumes 21 hours of operation per day.[23]

4.4 Low Energy Livestock Waterer (to keep water from freezing)

In freezing climates low energy livestock waterers are used to prevent livestock water from freezing. These waterers are closed super-insulated" watering containers which use super insulation, the relatively warmer ground water temperature, and the livestock's use of the waterer to keep water from freezing and thereby capable of watering the livestock. Average savings depend on the climate zone. In the Pacific Northwest this varies from 900 kWh to 1,500 kWh/year as compared to an electrically heated waterer. Demand reduction in the Pacific Northwest was determined to be .1 kW at the coincident system peak. The incremental cost is $350 - $450 per tank depending on the size and location. The average measure life is estimated to be 10 years. The energy efficient versions have at least 2 inches of insulation around them and have an adjustable thermostat.

This measure would need to be tested in California conditions, the savings listed here come from a study done by the Prairie Agricultural Machinery Institute in Alberta and Manitoba Canada.[24]

4.5 Ventilation Measures

Ventilation fans maintain a productive environment for animals in confined spaces by removing moisture and odors, refreshing the air, and cooling the livestock by creating breezes. Two options are box fans and high volume low speed (HVLS) fans. Box fans are smaller, ranging in diameter from 24 to 54 inches, whereas HVLS fans range from 16 to 24 feet. Box fans can be used in both tie stall barns and free stall barns or other loose housing applications, but HVLS fans can only be used in loose housing applications.

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[22] This information provided by Paul Williams at SCE 5/25/2005.

[23] Canessa, Peter, 2002. 2002 Express Efficiency VFDs for Dairy Milking Parlor Vacuum Pumps.

[24] Eckman, T. 2003. Energy Free Stock Watering Systems – Deemed Savings Analysis. Presentation presented at The Regional Technical Forum Meeting, Portland, Or., September 16.

Ventilation Fans or Box Fans

Box fan efficiencies rage from 8.7- 33.0 cfm per Watt for 24" – 54" diameters. The high efficiency versions are 20 % more efficient. The University of Illinois at Urbana-Champaign has conducted tests and published the results which can be found at the following web site http://www.bess.uiuc.edu.

High Volume Low Speed Fans

HVLS (high volume, low speed) fans provide an energy efficient alternative to standard box fans when ventilating free stall barns. Typically, one HVLS fan will replace six box fans. These ceiling-mounted units range from 8 to 24 feet in diameter and each has ten, 10-to 12-foot aluminum fan blades. These long blades can move four times as much air as one standard 48-inch ceiling fan rotating at the same speed. One 20-foot diameter HVLS fan can circulate air over 15,000 to 20,000 square feet. HVLS fans use much less electricity than typical ventilation fans, last longer and require less maintenance. Table 4-9 below provides variable information for free stall barns.

Table 4-9: High Volume Low Speed Fan variables: [25]

	Fan Diameter	kW Demand Load	Watts/ Fan	kWh/ Year	# Fans	Spacing (ft) to maintain 3 mph air velocity
Existing Equipment						
High speed fan	48 inches	4.1	675	6,075	6	40
Replacement Equipment High Velocity Low Speed Fans						
HVLS Fan	16 feet	1.3	325	1,950	4	35
HVLS Fan	18 feet	1.1	375	1,687	3	40
HVLS Fan	20 feet	1.3	440	1,980	3	50
HVLS Fan	24 feet	1.5	740	2,220	2	60

Assumptions:

- 1,500 hours/yr w/ ambient temp > 80*F (Tulare, California)
- 1,500 hours per year operation
- 1,100' X 100' ft Barn
- 2 fan rows

[25] The basis for this table was Wisconsin's Focus on Energy Program materials. 2005, the values have been updated with California assumptions.

- Measure Life: 10 years.[26] However, others question the 10 year measure life due to the lack of experience to draw from.

4.6 Plate Heat Exchanger for Pre-Cooling Milk

The plate heat exchanger or plate cooler lowers dairy milk temperatures before the milk reaches the bulk tank where milk is traditionally cooled. By pre- cooling the milk, it can cut the bulk tank compressor's usage in half. Typically milk leaves a cow's body at 100 F and a plate cooler can decrease the temperature by 18 degrees Fahrenheit before the milk reaches the bulk tank. Well water at 72 degrees Fahrenheit can be used as the heat sink. The heat can then be transferred to heat water for the cows or heat the milk house. Note that this measure is considered standard practice for any large dairy and smaller dairies where a water source is available and therefore not included in the 2004-05 DEER update. Most new dairies in California dairies now use the first stage of a plate cooler with well water for pre-cooling. Very many California dairies use external chillers to provide the final stage of milk cooling. The chilled water is used in the second stage of the plate cooler.

[26] Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service

5

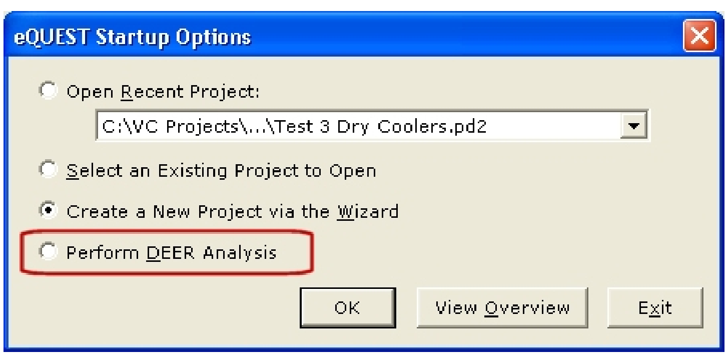
Weather Sensitive DEER Analysis

5.1 Introduction

The savings estimates for the DEER weather-sensitive measures were calculated using DOE-2 building simulation models. The analysis used the latest DOE-2 simulation engine available in the eQUEST software. The eQUEST software was customized for the DEER Update project into a special tool called the Measure Analysis Software (MAS) capable of performing either single or batch-mode runs. Both the DEER building prototypes and the energy-efficiency measure (EEM) characteristics were defined in the form of eQUEST wizard project files, look-up tables, and rule sets used at runtime by the MAS tool.

Program Start-up

The DEER Analysis option is a new startup option of eQUEST, version 3.41 and later, when both the DEER processing files and directories are present in the root eQUEST program directory, and the eQuest.ini file contains the parameter "EnableDEERProcessing" set to a value of "1" in the [preferences] section. Under these set conditions, the eQuest Startup Options dialog box displays the new "Perfrom DEER Analysis" option as shown in the figure below.



Setting the "EnableDEERProcessing" parameter to a value of "0" would disable the display of the new option in the eQuest Startup Options dialog box.

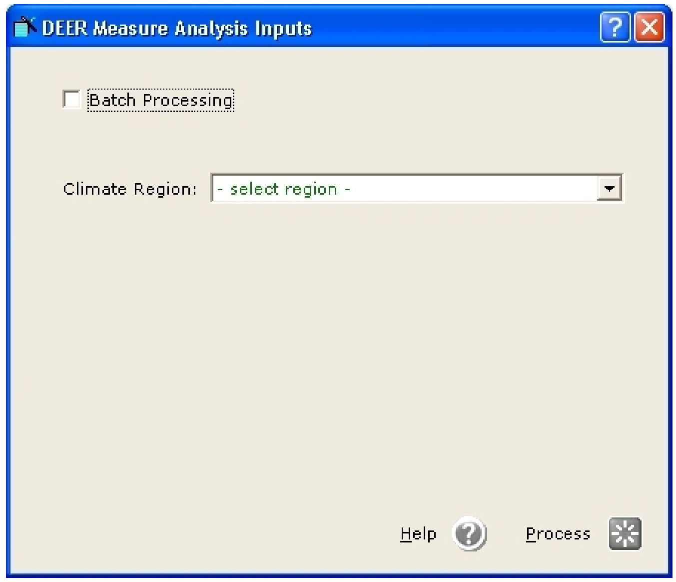
Upon selection of the "Perform DEER Analysis" option from the startup dialog, the DEER-specific database and ruleset is loaded, and the user is presented with a dialog box that facilitates either the batch or single-run processing of DEER measures.

Measure Analysis Results

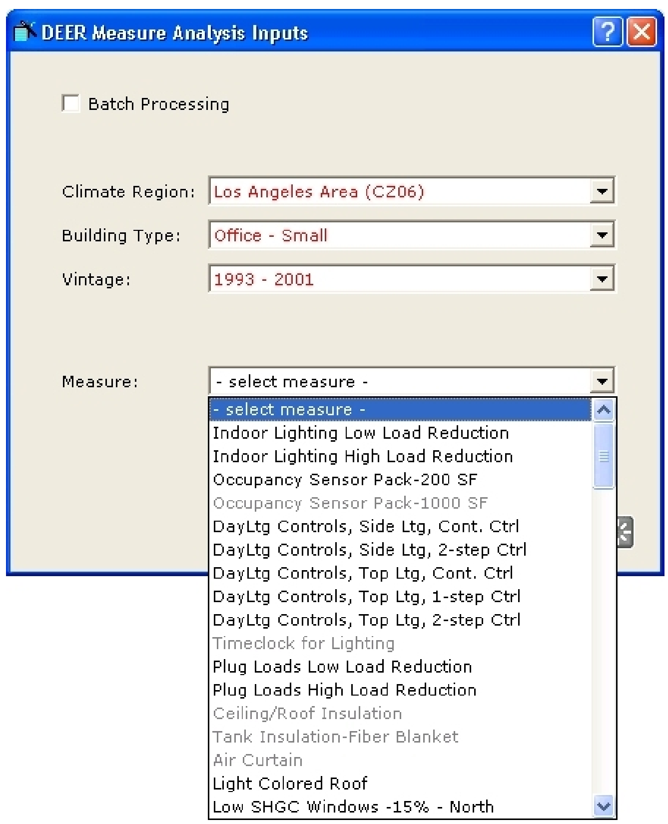
After each DEER analysis run, via either the single- or batch-run interfaces, the MAS tool writes a record of information into the file called "DEER Processing.csv" located in the eQUEST subdirectory "DEER\Processing." The file contains two rows of column header information, followed by a row of data for each DEER measure analysis performed. The file is the source of all the weather sensitive measure results posted to the DEER database. The variables written to the "DEER Processing.csv" file are summarized in the document "DEER Processing CSV Output Variables."

5.2 Single-Run Measure Analysis

Measure Analysis Inputs



The DEER Measure Analysis Input dialog box prompts the user for a single input at a time, with the presentation and/or contents of subsequent fields depending on previous inputs. Initially, only two selections are displayed: a checkbox to select batch processing, and a drop-down list to select the climate region for a single measure run, as long as the batch processing checkbox remains unchecked.

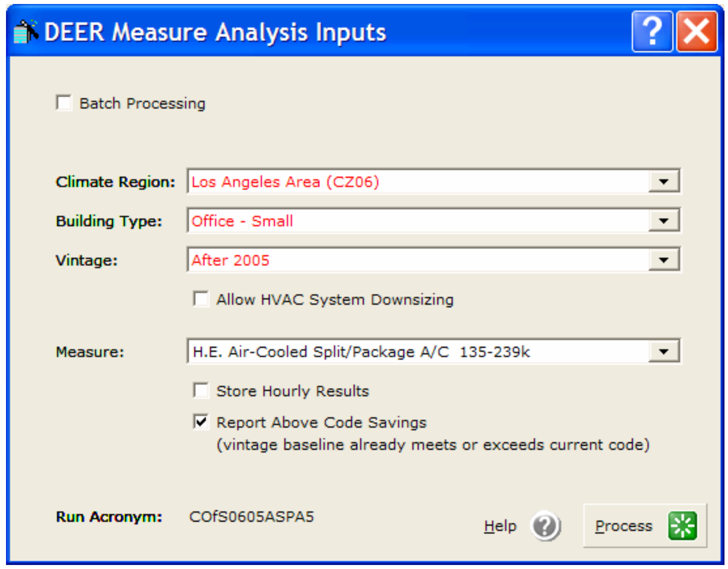


Once Climate Region, Building Type and Vintage are selected, the user picks the measure to be analyzed from the Measure drop-down list. Measures that are "grayed-out" in the list are selections that are not available due to the combination of Climate Region, Building Type, and Vintage.

A listing of the DEER non-residential "Measure Applicability" can be found in the "DEER Tables.xls" spreadsheet. The spreadsheet has three tabs summarizing which measures are available for the different combinations of Climate Region, Building Type and Vintage: the NRMsrCompat tab shows measure applicability for all non-residential building types except Grocery and Refrigerated Warehouse; the GrcMsrCompat tab shows measure applicability for Grocery building type; the RfWMsrCompat tab shows measure applicability for Refrigerated Warehouse building type.

The ResMeasureCompat tab of the "2005DEERResidentialMeasuresList_05-08-15.xls" spreadsheet contains a similar listing for residential DEER building types.

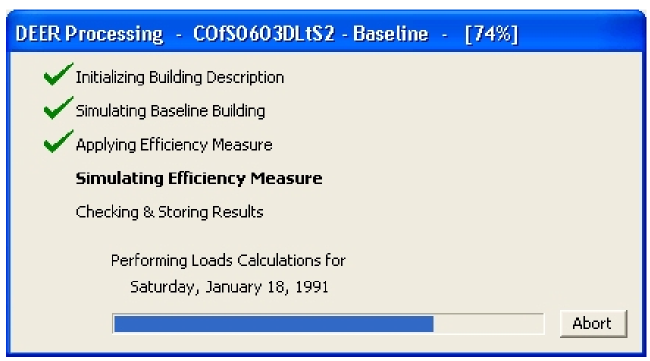
The figure to the right shows the completed DEER Measure Analysis Inputs dialog box with all selections made. Note that a new checkbox labeled "Allow HVAC System Downsizing" has appeared. This checkbox appears only when the selected Vintage represents building new construction. The option allows the DOE-2 simulation to estimate the necessary size of the building's HVAC system and downsize it in the EEM case.



Leaving the checkbox unchecked maintains the same HVAC system size between the baseline and measure runs.

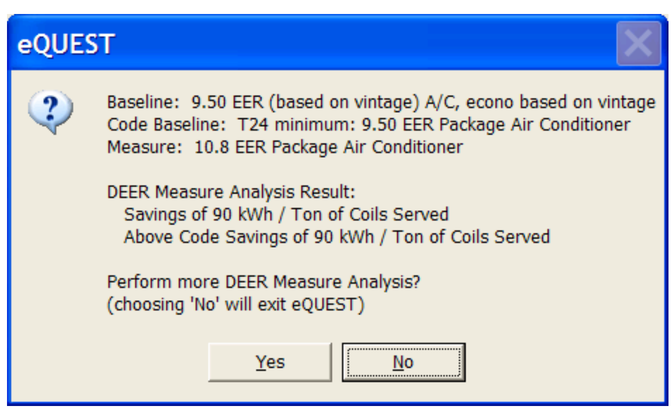
Measure Analysis Processing

Upon clicking the Process button in the DEER Measure Analysis Inputs dialog box, the analysis starts and the DEER Processing dialog box appears. This dialog box displays and updates a step-by-step check-off list and a progress bar as the analysis is carried out. An Abort button is available on the DEER Processing dialog box if the need arises to cancel the analysis before it is completed.



Measure Analysis Result

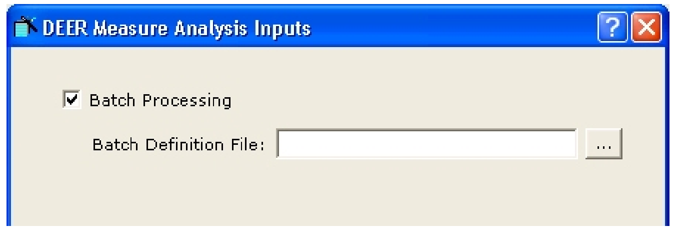
Once the analysis is completed, an analysis summary dialog box is displayed. The dialog provides a brief description of the just completed analysis and the resulting savings. The dialog also queries whether there are further DEER analyses to be run. Pressing the "Yes" button will return



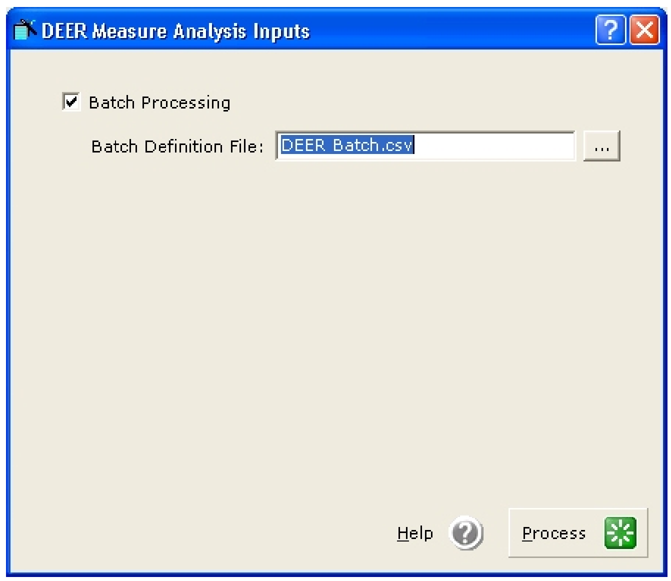
the user to the DEER Measure Analysis Inputs dialog box to define a new run. Pressing the "No" button will exit the MAS program.

5.3 Multiple-Run Measure Analysis

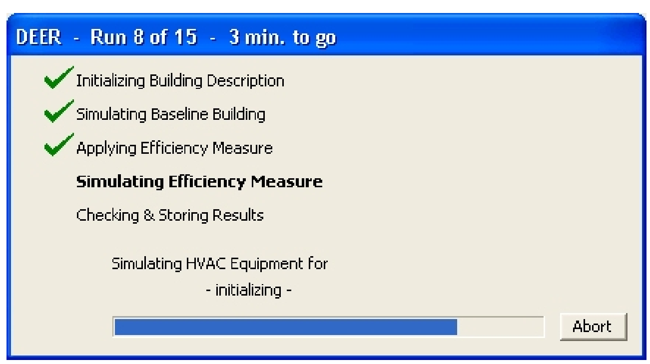
Measure Analysis Inputs



By checking the box labeled "Batch Processing" in the DEER Measure Analysis Inputs dialog box, the single run "Climate Region" drop-down list is replaced with a text input box that allows the user to specify a CSV file that lists all measure analyses to be performed. The "…" button to the right of the text input box allows the user to browse the available computer drives and folders to select a file.



The "DEER Batch Processing.xls" spreadsheet contains the detailed contents and formats that the MAS tool expects to find on the CSV files specified as the Batch Definition File specified in the DEER Measure Analysis Inputs dialog box. Note that all changeable values are shaded pale yellow and that each row of data will produce a unique measure analysis run. An example of a CSV file (created by exporting a CSV file type from excel after using the "DEER Batch Processing.xls" file to create the desired set of batch runs) can be found in the file "DEER Batch.csv."



Once the Batch Definition File is specified, pressing the Process button starts the batch processing.

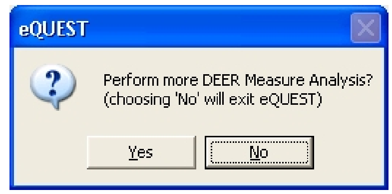
Measure Analysis Processing

The DEER processing status dialog box, shown on the right, when performing batch runs will indicate the current and final run numbers and the approximate time remaining in the caption bar.

Measure Analysis Results

Unlike the single run processing, the measure analysis results are not presented to the user in a dialog box following the completion of the batch runs. Instead, the dialog box provides the number of successful runs completed. The results for the batch runs can be found appended after the last record in the "DEER Processing.csv" output file.

The user is then prompted whether or not to perform more (single or batch) DEER processing or exit the MAS tool.



5.4 DEER Processing Details

Analysis .INI File Settings

The following table describes the default eQUEST.ini settings that affect the DEER analysis processing. These parameter settings need only be present in the eQUEST.ini file if a value other than the default is required:

Section	Property	Default Setting
files	DEERBDBaseFile	DEER\Ruleset\DEER BDBase.bin
files	DEERUserDefFile	DEER\Ruleset\DEER UserDefaults.txt
files	DEERRulesetFile	DEER\Ruleset\DEER Rules.bin
paths	DEERPrototypePath	DEER\Prototypes\
paths	DEERProcessingPath	DEER\Processing\

Analysis File Storage and Debug Output

Additional eQUEST.ini file settings can be specified that determine which (if any) files generated during the DEER measure analysis are to be saved for later review and whether or not the processing should output certain testing/debugging-related information. These options are described in the following table.

Section	Property	Default Setting
preferences	DEERDebugID	0
preferences	DEERFileStorageOption	0 (if DEERDebugID = 0, else 6)

If DEERDebugID is set to its default value of 0, then no testing/debugging output is generated by the analysis. If this value is set to 1, then records of detailed simulation and results information are written to the file "DEER\Processing\DEER Processing - DBG.csv" and detailed BDBase files (*.pd2d) are stored during the processing prior to each generation of a DOE-2 BDL input file and at the conclusion of all processing (*.pd2d-final).

DEERFileStorageOption determines which (if any) files generated during the DEER measure analysis are to be saved following the conclusion of each run. This option defaults to 0 or 6 depending on whether DEERDebugID equals 0 or 1, respectively. Valid values for DEERFileStorageOption (FSO) are 0-6, as described in the following table.

FSO Val	Files Retained Following Processing
0	None (all processing files deleted)
1	Retain only the Run Input & Processing Log files (*.pd2, inp, inc, cal, xeu & txt)
2	Retain (1) + BDL output (*.bdl)
3	Retain (2) + text simulation output (*.sim, csv)
4	Retain (3) + debugging BDL output (for022)
5	Retain (4) + binary simulation outputs (*.lin, sin, lrp, srp, erp & nhk)
6	Retain ALL Run Files

Note that the DEER batch processing feature enables DEERDebugID and DEERFileStorageOption to be specified for each individual run based on the contents of the batch processing input CSV file.

6

DEER Building Prototypes

6.1 Introduction

There are 34 DEER building prototypes, defined in the form of individual eQUEST project files with one to three models for each of the 26 DEER building types. The multiple prototypes represent differences in baseline HVAC system types and other building characteristics. Each building prototype file describes a single site configuration with either one building or multiple buildings served by one or multiple HVAC system types.

Vintages

With the exception of the manufactured home prototype, each prototype's characteristics vary by the following vintages:

- Before 1978,
- 1978 – 1992,
- 1993 – 2001,
- 2002 – 2005,
- After 2005.

The characteristics of the manufactured home prototype vary according to the following vintages:

- Before 1977,
- 1978 – 1994,
- 1995 – 2005,
- After 2005.

Nonresidential Prototypes

The following 23 nonresidential prototypes are included in the DEER analysis software:

- Assembly,
- Education – Primary School,
- Education – Secondary School,
- Education – Community College,

- Education – University,
- Education – Relocatable Classroom,
- Grocery,
- Health/Medical – Hospital,
- Health/Medical – Nursing Home,
- Lodging – Hotel,
- Lodging – Motel,
- Manufacturing – Bio/Tech,
- Manufacturing – Light Industrial,
- Office – Large,
- Office – Small,
- Restaurant – Sit-Down,
- Restaurant – Fast-Food,
- Retail – 3-Story Large,
- Retail – Single-Story Large,
- Retail – Small,
- Storage – Conditioned,
- Storage – Unconditioned, and
- Storage – Refrigerated Warehouse.

The following resources were used in development of the prototypes:

- *Final Report on Technology Energy Savings, Volume II: Building Prototypes*, Prepared for The California Conservation Inventory Group by Neos Corporation, 1994 (DEER 1994);
- *CaNCCalc Building Energy Efficiency Measure Analysis Software*, (NCC) developed by James J. Hirsch & Associates for the Savings by Design new construction energy efficiency program, offered by California's Investor Owned Utilities (IOU) as authorized by the California Public Utilities Commission (CPUC); and
- *High Performance Commercial Building Systems, Element 6, Project 2.1, Relocatable Classroom DOE-2 Analysis Report*, Prepared by Davis Energy Group, Inc. for the California Energy Commission, Public Interest Energy Research Program, 2002 (HPCBS.)

Prototype characteristics are fully described in the 2005 DEER Nonresidential Prototype Characteristics workbook (2005DEERNonresidentialPrototypeCharacteristics-051206.xls). Detailed characteristics are provided in the following tabs of the workbook:

- Nonresidential Summary contains general characteristics of each prototype that are not vintage dependent;

- Nonresidential Walls and Roofs contains wall and roof construction types including overall U-Factors by prototype and vintage;
- Nonresidential Glazing contains vertical glazing including window-to-wall ratio, solar heat gain coefficient (SHGC) and U-Factor by prototype and vintage; and
- Nonresidential HVAC contains HVAC system types, design features and efficiencies by prototype and vintage.

Thermal zoning for most prototypes is configured so that each zone in the model consists of a single activity area type or use. Each of activity area type has specific levels for occupant density and ventilation requirements. These characteristics are listed in Table 6.1. Lighting power density (LPD) and equipment power density (EPD) are dependent on the prototype, activity area type and vintage. These properties are described in LPD-EPD spreadsheet (DEER LPD-EPD Data-050801.xls).

Table 6-1: Nonresidential Space Characteristics

Activity Area Type	Occupant Density (ft^2/person)	Sensible Occupant Load (Btuh/person)	Latent Occupant Load (Btuh/person)	Ventilation Rate (cfm/person)
Auditorium	10.5	245	105	15.00
Auto Repair Workshop	150.0	275	475	225.00
Bar, Cocktail Lounge	22.5	275	275	30.00
Classroom/Lecture	30.0	245	155	15.00
Comm/Ind Work (General, High Bay)	150.0	275	475	15.00
Comm/Ind Work (General, Low Bay)	150.0	275	475	15.00
Comm/Ind Work (High Tech, Bio Tech, Lab)	150.0	250	250	20.00
Comm/Ind Work (Loading Dock)	150.0	275	475	15.00
Computer Room (Mainframe/Server)	150.0	250	200	20.00
Computer Room (Instructional/PC Lab)	75.0	245	155	15.00
Conference Room	22.5	245	155	20.00
Copy Room (photocopying equipment)	187.5	250	250	93.75
Corridor	150.0	250	250	7.50
Dining Area	22.5	275	275	20.00
Exercising Centers and Gymnasium	75.0	255	875	20.00
Hotel/Motel Guest Room (incl. toilets)	300.0	245	155	30.00
Kitchen and Food Preparation	300.0	275	475	15.00
Laboratory, Medical	150.0	250	250	20.00
Laundry	150.0	250	250	25.00
Lobby (Hotel)	150.0	250	250	15.00
Lobby (Main Entry and Assembly)	10.5	250	250	20.00
Lobby (Office Reception/Waiting)	150.0	250	250	15.00
Mechanical/Electrical Room	450.0	250	250	22.50
Medical and Clinical Care	150.0	250	200	25.00
Office (General)	150.0	250	200	20.00
Office (Executive/Private)	225.0	250	200	20.00
Office (Open Plan)	150.0	250	200	20.00
Refrigerated (Cooled Storage)	450.0	275	475	67.50
Refrigerated (Food Preparation)	300.0	275	475	15.00
Refrigerated (Frozen Storage)	450.0	275	475	67.50
Refrigerated (Walk-in Cooler)	450.0	275	475	0.00
Refrigerated (Walk-in Freezer)	450.0	275	475	0.00
Restrooms	52.5	250	250	50.00
Retail Sales, Grocery	45.0	250	200	13.50
Retail Sales and Wholesale Showroom	45.0	250	200	13.50
Storage (Conditioned)	450.0	275	475	67.50
Storage (Unconditioned)	450.0	275	475	67.50

General characteristics for nonresidential air distribution systems are described below:

- **Rooftop DX**: Packaged, rooftop, direct expansion cooling systems with natural gas heating that serves a single thermal zone.
- **Rooftop HP**: Packaged, rooftop heat pump system that serves a single thermal zone.

- **Package VAV**: Packaged, rooftop, direct expansion cooling system. A single duct distribution system serves multiple zones. Each zone has a standard variable air volume terminal unit with hot water reheat. The fan variable flow method varies by vintage.
- **VAV**: Built-up chilled water cooling system. A single duct distribution system serves multiple zones. Each zone has a standard variable air volume terminal unit with hot water reheat. The fan variable flow method varies by vintage. Chilled water is supplied by a water-cooled centrifugal or air-cooled reciprocating chiller.
- **CV Reheat**: Built-up chilled water cooling system. A single duct distribution system serves multiple zones. Each zone has terminal reheat. Total system air-flow is constant. Chilled water is supplied by a water-cooled centrifugal or air-cooled reciprocating chiller.
- **FPFC**: Four-pipe fan coil system. Each thermal zone is equipped with a non-ducted system with chilled water cooling and hot water heating. Chilled water is supplied by a water-cooled centrifugal or air-cooled reciprocating chiller.
- **PTAC**: Packaged terminal air conditioner with electric resistance heat.
- **PTHP**: Packaged terminal heat pump.
- **Unit Heater**: Natural gas fired unit heater.

General descriptions of each nonresidential prototype are provided in Table 6.2.

Table 6-2: Nonresidential Prototype Descriptions

Table 6.2 Prototype	Source	Activity Area Type	Area	% Area	Simulation Model Notes
1. Assembly	DEER	Auditorium	33,235	97.8	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Office	765	2.2	
		Total	34,000		
2. Education - Primary School	DEER	Classroom/Lecture	31,500	63.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** 1994 DEER model consisted of one building. Current model consists of two identical models, each rotated 90 degrees to achieve reasonable distribution of solar gains. **HVAC Systems:** The prototype uses Rooftop DX systems. The system is changed to Rooftop HP for the heat pump efficiency measures.
		Dining Area	7,500	15.0	
		Exercising Centers and Gymnasium	7,500	15.0	
		Kitchen and Food Preparation	3,500	7.0	
		Total	50,000		
3. Education - Secondary School	DEER	Classroom/Lecture	88,200	58.8	**Thermal Zoning:** One zone per activity area. **Model Configuration:** 1994 DEER model consisted of one building. Current model consists of four identical models that comprise that include the classroom, computer room, kitchen, dining and office areas, each rotated 90 degrees to achieve reasonable distribution of solar gains. A fifth building represents the gym. **HVAC Systems:** The prototype uses Rooftop DX systems. The system is changed to Rooftop HP for the heat pump efficiency measures. For built-up system measures applicable to this prototype, the system is VAV, except for the kitchen areas, which are served by Rooftop DX systems that are changed to Rooftop HP.
		Computer Room (Instructional/PC Lab)	3,082	2.1	
		Dining Area	22,500	15.0	
		Exercising Centers and Gymnasium	22,500	15.0	
		Kitchen and Food Preparation	10,500	7.0	
		Office (General)	3,218	2.1	
		Total	150,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
4. Education - Community College	DEER	Classroom/Lecture	150,825	50.3	**Thermal Zoning:** One zone per activity area. **Model Configuration:** 1994 DEER model consisted of one building. Current model consists of two identical models that comprise that include the classroom, computer room, kitchen, dining and office areas, each rotated 90 degrees to achieve reasonable distribution of solar gains. **HVAC Systems:** The prototype uses VAV systems, except for the kitchen areas use Rooftop DX systems that are changed to Rooftop HP systems for the heat pump efficiency measures.
		Computer Room (Instructional/PC Lab)	9,625	3.2	
		Dining Area	26,250	8.8	
		Kitchen and Food Preparation	5,625	1.9	
		Office (General)	70,175	23.4	
		Total	300,000		
5. Education - University	DEER	Classroom/Lecture	431,160	43.1	**Thermal Zoning:** Main instructional buildings use generic thermal zones with all activity area characteristics averaged across the entire zone. The dormitory buildings are zoned by individual activity area. **Model Configuration:** 1994 DEER model consisted of two buildings: one instructional building and one dormitory. Current model consists of four identical instructional buildings each rotated 90 degrees to achieve reasonable distribution of solar gains. There are also two identical buildings representing dormitories, each rotated 90 degrees. **HVAC Systems:** The prototype uses VAV systems, except for the kitchen areas use Rooftop DX systems that are changed to Rooftop HP systems for the heat pump efficiency measures.
		Comm/Ind Work (General Low Bay)	80,000	8.0	
		Computer Room (Instructional/PC Lab)	27,540	2.8	
		Corridor (Dormitory)	30,000	3.0	
		Dining Area	24,000	2.4	
		Hotel/Motel Guest Room (Dormitory)	170,000	17.0	
		Kitchen and Food Preparation	10,500	1.1	
		Office (General)	226,800	22.7	
		Total	1,000,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
27. Education - Relocatable Classroom	HPCBS	Classroom/Lecture	1,920	100.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches HPCBS prototype. **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
6. Grocery	DEER/ Vacom	Comm/Ind Work (Loading Dock)	2,860	5.7	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Vacom developed the prototype based on their experience in providing energy efficiency services to grocery stores. **HVAC Systems:** The prototype uses Rooftop DX systems for the non-refrigerated spaces. These are switched to Rooftop DX systems for heat pump efficiency measures. The refrigerated spaces use detailed refrigeration systems developed using the eQUEST refrigeration version. A complete description of grocery refrigeration systems is included in Section 7.3 Grocery Refrigeration Measures.
		Office (General)	3,500	7.0	
		Refrigerated (Food Preparation)	1,268	2.5	
		Refrigerated (Walk-in Cooler)	1,560	3.1	
		Refrigerated (Walk-in Freezer)	812	1.6	
		Retail Sales Grocery	40,000	80.0	
		Total	50,000		
7. Health/Medical - Hospital	DEER	Dining Area	4,375	1.8	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype. **HVAC Systems:** The prototype uses FPFC systems for the patient rooms. The kitchen uses a Rooftop DX system, which is changed to a Rooftop HP system for the heat pump efficiency measures. Except for the oldest vintage, VAV systems are used for all other spaces. The oldest vintage uses a CV Reheat system.
		Kitchen and Food Preparation	1,875	0.8	
		Laboratory Medical	57,917	23.2	
		Medical and Clinical Care	95,000	38.0	
		Office (General)	90,833	36.3	
		Total	250,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
8. Health/Medical - Nursing Home	DEER	Corridor	3,333	5.6	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses FPFC systems for all spaces except the kitchen. The kitchen uses a Rooftop DX system, which is changed to a Rooftop HP system for the heat pump efficiency measures. FPFC systems are changed to a VAV system for any applicable measures for built-up systems.
		Dining Area	6,300	10.5	
		Hotel/Motel Guest Room (incl. toilets) (Patient Rooms)	26,667	44.4	
		Kitchen and Food Preparation	2,700	4.5	
		Office (General)	21,000	35.0	
		Total	60,000		
9. Lodging - Hotel	DEER/ NCC	Bar Cocktail Lounge	800	0.4	**Thermal Zoning:** One zone per activity area. **Model Configuration:** The building envelope and occupancy matches 1994 DEER Prototype. Guestroom areas are divided into unoccupied rooms (40,171 ft^2/20%) and occupied rooms (120,511 ft^2/60%). HVAC systems are based on NCC. **HVAC Systems:** The kitchen is served by a Rooftop DX system which is changed to a Rooftop HP system for the heat pump efficiency measures. The remaining public areas are served by a CV Reheat system for the oldest vintage, VAV systems for the second and third vintages and Rooftop VAV systems for the latest two vintages. Guestrooms are served by FPFC systems for the first three vintages and PTHP systems for the latest two vintages.
		Corridor	20,085	10.0	
		Dining Area	1,250	0.6	
		Hotel/Motel Guest Room (incl. toilets)	160,682	80.3	
		Kitchen and Food Preparation	750	0.4	
		Laundry	4,108	2.1	
		Lobby (Hotel)	8,217	4.1	
		Office (General)	4,108	2.1	
		Total	200,00		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
10. Lodging - Motel	DEER	Corridor	3,333	11.1	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER configuration. Guestrooms are divided among 12 hour occupied (12,794 ft^2/42.6%), 24-hour occupied (6,397 ft^2/21.3%) and unoccupied rooms (6,397 ft^2/21.3%). **HVAC Systems:** The oldest vintage uses PTAC systems with electric resistance heating. All other vintages use PTHP systems.
		Hotel/Motel Guest Room (incl. toilets)	25,587	85.3	
		Laundry	480	1.6	
		Office (General)	600	2.0	
		Total	30,000		
11. Manufacturing - Bio/Tech	NCC	Comm/Ind Work (High Tech Bio Tech Lab)	90,669	45.3	**Thermal Zoning:** The model uses generic thermal zones with all activity area characteristics averaged across the entire zone. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Computer Room (Mainframe/Server)	4,000	2.0	
		Conference Room	4,000	2.0	
		Corridor	40,001	20.0	
		Dining Area	6,000	3.0	
		Kitchen and Food Preparation	2,000	1.0	
		Office (General)	53,330	26.7	
		Total	200,000		
12. Manufacturing - Light Industrial	DEER	Comm/Ind Work (General High Bay)	80,000	80.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Storage (Unconditioned)	20,000	20.0	
		Total	100,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
13. Office - Large	NCC	Conference Room	7,000	4.0	**Thermal Zoning:** The model uses generic thermal zones with all activity area characteristics averaged across the entire zone. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The oldest vintage uses a CV Reheat systems, and all other vintages us VAV systems.
		Copy Room (photocopying equipment)	3,500	2.0	
		Corridor	17,500	10.0	
		Lobby(Office Reception/Waiting)	8,750	5.0	
		Mechanical/Electrical Room	7,000	4.0	
		Office (Executive/Private)	43,750	25.0	
		Office (Open Plan)	78,750	45.0	
		Restrooms	8,750	5.0	
		Total	175,000		
14. Office - Small	NCC	Conference Room	400	4.0	**Thermal Zoning:** The model uses generic thermal zones with all activity area characteristics averaged across the entire zone. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Copy Room (photocopying equipment)	200	2.0	
		Corridor	1,000	10.0	
		Lobby (Office Reception/Waiting)	500	5.0	
		Mechanical/Electrical Room	400	4.0	
		Office (Executive/Private)	7,000	70.0	
		Restrooms	500	5.0	
		Total	10,000		
15. Restaurant - Sit-Down	DEER	Dining Area	2,000	50.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Kitchen and Food Preparation	1,200	30.0	
		Lobby (Main Entry and Assembly)	600	15.0	
		Restrooms	200	5.0	
		Total	4,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
16. Restaurant - Fast-Food	DEER	Dining Area	1,000	50.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Kitchen and Food Preparation	300	15.0	
		Lobby (Main Entry and Assembly)	600	30.0	
		Restrooms	100	5.0	
		Total	2,000		
17. Retail - 3-Story Large	DEER	Office (General)	6,000	5.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The oldest vintage uses a CV Reheat systems, and all other vintages us VAV systems.
		Retail Sales and Wholesale Showroom	96,000	80.0	
		Storage (Conditioned)	18,000	15.0	
		Total	120,000		
18. Retail - Single-Story Large	NCC	Auto Repair Workshop	5,165	4.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Kitchen and Food Preparation	1,462	1.1	
		Office (General)	4,698	3.6	
		Retail Sales and Wholesale Showroom	107,273	82.2	
		Storage (Conditioned)	11,902	9.1	
		Total	130,000		
19. Retail - Small	DEER	Retail Sales and Wholesale Showroom	6,400	80.0	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Matches 1994 DEER prototype **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
		Storage (Conditioned)	1,600	20.0	
		Total	8,000		

Table 6.2					
Prototype	**Source**	**Activity Area Type**	**Area**	**% Area**	**Simulation Model Notes**
20. Storage - Conditioned	NCC	Storage (Conditioned)	500,000	100.0	**Thermal Zoning:** The model uses generic thermal zones with all activity area characteristics averaged across the entire zone. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The prototype uses Rooftop DX systems, which are changed to Rooftop HP systems for the heat pump efficiency measures.
21. Storage - Unconditioned	NCC	Storage (Unconditioned)	500,000	100.0	**Thermal Zoning:** The model uses generic thermal zones with all activity area characteristics averaged across the entire zone. **Model Configuration:** Matches NCC prototype. **HVAC Systems:** The prototype uses UH systems only for freeze protection.
22. Storage - Refrigerated Warehouse	Vacom	Comm/Ind Work (Loading Dock) Office (Executive/Private) Refrigerated (Cooled Storage) Refrigerated (Food Preparation) Total	8,000 2,000 49,950 40,050 100,000	8.0 2.0 50.0 40.1	**Thermal Zoning:** One zone per activity area. **Model Configuration:** Vacom developed the prototype based on their experience in providing energy efficiency services to refrigerated warehouses. **HVAC Systems:** The prototype uses Rooftop DX systems for the non-refrigerated spaces. These are switched to Rooftop DX systems for heat pump efficiency measures. The refrigerated spaces use detailed refrigeration systems developed using the eQUEST refrigeration version. A complete description of grocery refrigeration systems is included in Section 7.4 Refrigerated Warehouse Measures.

Residential Prototypes

The following 3 nonresidential prototypes are available in the DEER analysis software:

- Single Family Home,
- Multi-Family Housing, and
- Manufactured Home.

The following resources were used in development of the residential prototypes:

- *2001 DEER Update Study Final Report*, Prepared for The California Energy Commission under Contract Number 300-99-008 by XENERGY Inc., August, 2001 (DEER 2001); and
- *Manufactured Home Building Simulation Prototypes and Weather-Sensitive Energy-Efficiency Measures Task 8 Working Paper*, Submitted by Itron to San Diego Gas and Electric, 2004.

Prototype characteristics are fully described in 2005 DEER Residential Prototype Characteristics workbook (2005DEERResidentialPrototypeCharacteristics-051207.xls). Detailed characteristics are provided in the following tabs of the workbook:

- Single Family Characteristics contains detailed assumptions for single family home prototype by vintage and climate zone;
- Multi-Family Characteristics contains detailed assumptions for multi-family building prototype by vintage and climate zone; and
- Mfgd Home Characteristics contains detailed assumptions for manufactured home prototype by vintage. Manufactured homes are not subject to Title 24 requirements. Instead, Federal regulations promulgated by the U.S. Department of Housing and Urban Development (HUD) cover manufactured homes. HUD requirements apply to all manufactured homes sold in California and do not contain any variations by climate zone.

6.2 Building Prototype Data

In order to facilitate review of the DEER building prototypes, the contents of each prototype along with the corresponding eQUEST DEER wizard defaults have been written to Excel spreadsheets. Each spreadsheet represents a single DEER prototype with multiple tabs, one for each major component defined within the prototype. The data contained in the prototype spreadsheets correspond to eQUEST building creation wizard inputs. Some of the prototype characteristics were developed specifically for DEER analysis and have not been added to the eQUEST wizard screens. The following links provide access to the spreadsheets describing each DEER prototype:

Assembly GasPAC

Assembly Heat Pump

Education - Primary School GasPAC

Education - Primary School Heat Pump

Education - Secondary School GasPAC

Education - Secondary School Heat Pump

Education - Secondary School VAV

Education - Community College

Education - Community College Heat Pump

Education - University

Education - Relocatable Classroom Packaged Single Zone

Education - Relocatable Classroom Packaged Heat Pump

Education - Relocatable Classroom Electric Resistance Heat

Grocery GasPAC

Grocery Heat Pump

Health/Medical - Hospital

Health/Medical - Hospital Heat Pump

Health/Medical - Nursing Home

Health/Medical - Nursing Home VAVS

Health/Medical - Nursing Home Heat Pump

Lodging - Hotel, VAV, Four-Pipe Fan Coil and Packaged Single Zone

Warehouse - Refrigerated Heat Pump

Residential - Double-Wide Mobile Home GasPAC

Residential - Double-Wide Mobile Heat Pump

Residential - Multifamily Split A/C, Furnace

Residential - Multifamily Split Heat Pump

Residential - Single Family Split A/C, Furnace

Residential - Single Family Split Heat Pump

6.3 Prototype Initialization

Once the prototype building description is loaded into the MAS, several features of the model are initialized before any measure-specific processing. The following sub-sections describe each such initialization sequence.

Single Family Residential Geometry Initialization

The single family residential geometry initialization sequence serves to specify the location and dimensions for each of the four single family homes in the model – two single-story and two two-story homes - with areas that vary by climate zone and vintage.

The area of each home's footprint is determined using the average home area divided by the average number of floors listed in the Single Family Characteristics tab of the residential prototype characteristics spreadsheet (2005DEERResidentialPrototypeCharacteristics-051207.xls). All other geometry in the single family residential models is based on values retrieved from this table.

Multifamily Residential Geometry Initialization

The multifamily home geometry varies by climate zone and vintage. The multifamily geometry is based on values listed in the Multi-Family Characteristics tab of the residential prototype characteristics spreadsheet (2005DEERResidentialPrototypeCharacteristics-051207.xls).

Double-Wide Mobile Home Geometry Initialization

The dimensions of the double-wide mobile home prototypes are based on vintage only. There is no climate zone dependence as with the single family and multifamily models. The double-wide mobile home geometry is based on values listed in the Mfgd Home

Characteristics tab of the residential prototype characteristics spreadsheet (2005DEERResidentialPrototypeCharacteristics-051207.xls)

Exterior Wall Construction Initialization

The exterior wall construction characteristics for all of the nonresidential building models are defined in the EWallUVal tab of the DEER Tables spreadsheet (DEER Tables.xls). These data include overall U-value and descriptions of the construction layers by building type, vintage and climate zone (only the u-value varies by climate zone).

For the residential building types, the principle construction is wood frame 2'x4', 16" on center with a stucco/gunite exterior for single-family and multifamily dwellings and wood/plywood exterior for double-wide mobile homes. The overall wall R-values for all residential buildings are specified in the Single Family Characteristics, Multi-Family Characteristics and Mfgd Home Characteristics tabs of the 2005 DEER Residential Prototype Characteristics workbook (2005DEERResidentialPrototypeCharacteristics-051207.xls).

Roof/Ceiling Construction Initialization

Ceiling and/or roof construction characteristics for all nonresidential building models are defined in the RoofUVal tab of the DEER Tables spreadsheet (DEER Tables.xls). These data include overall U-value and descriptions of the construction layers by building type, vintage and climate zone. Only the U-value varies by climate zone.

For the residential building types, the principle construction is wood advanced frame 24" on center with shingles or clay tiles (for single family) or wood standard frame with built-up roofing materials (for multifamily and mobile home). The overall roof R-values for all residential buildings are specified in the Single Family Characteristics, Multi-Family Characteristics and Mfgd Home Characteristics tabs of the 2005 DEER Residential Prototype Characteristics workbook (2005DEERResidentialPrototypeCharacteristics-051207.xls).

Non-Residential Lighting and Equipment Loads

Lighting and equipment power densities used in the DEER measure analysis were defined based on Title-24 code requirements by vintage and activity area type. The hourly lighting and equipment profiles used were from two main sources; CCIG data were used for all building types carried over from previous DEER projects and profiles from the CaNCCalc software were used for the new DEER building types were migrated over from CaNCCalc. Calibration factors by building type and vintage were developed and applied to the lighting and equipment profiles in order to ensure that annual energy use intensities were consistent with prior DEER projects and data from other accepted sources.

The default lighting and equipment densities, hourly profiles and calibration factors are all retrieved from DEER MAS ruleset look-up tables during prototype initialization and prior to any measure-specific building manipulations. Lighting and equipment power density characteristics are fully descriped in the DEER LPD-EPD workbook (DEER LPD-EPD Data-050801.xls). Detailed characteristics are provided in the following tabs of the workbook:

- The L-EPDs by Activity tab lists the lighting and equipment power densities used in the analysis by vintage and activity area type.
- The HourlyProfiles tab lists each of the normalized hourly profiles along with default profile minimums and maximums
- The ProfileSummary-Ltg and ProfileSummary-Eqp tabs link to data specified in the other tabs and include activity area assignments and enduse calibration factors that together are used to calculate whole building L/EPDs and EUIs by building type and vintage.

Direct Expansion HVAC System Initialization

Direct expansion system properties are defined in the DX HVAC System Baseline tab of the DEER HVAC System Properties workbook (DEER HVAC System Properties-051212.xls) Detailed characteristics are provided in the following tabs of the workbook:

- DX HVAC System Baseline tab lists all baseline direct expansion system properties by building type and vintage.
- DX System Measures tab lists all characteristics of direct expansion system measures by measure, vintage and system type. Any baseline characteristics that are modified for specific measures are also listed.
- DX SEER-to-EER tab provides corresponding EER and COP ratings for direct expansion equipment with SEER/HSPF efficiency ratings.

Chilled Water Plant Initialization

Chilled water plant properties are defined in the DEER HVAC System Properties workbook (DEER HVAC System Properties-051212.xls). Detailed characteristics are provided in the following tabs of the workbook:

- Chilled Water System Baseline tab lists all baseline chilled water circulation loop characteristics by building type and vintage.
- Chilled Water Plant Baseline tab lists the baseline chilled water plant characteristics by building type and vintage
- Chiller Efficiency Measures tab lists characteristics of chilled water plant measures including baseline characteristics that are modified for specific measures.

- Chilled Water Loop Measures tab lists characteristics of chilled water circulation loop measures including baseline characteristics that are modified for specific measures.
- Tower & CW System Measures tab lists characteristics of condenser water system and heat rejection measures including baseline characteristics that are modified for specific measures.

Hot Water Plant Initialization

Chilled water plant properties are defined in the DEER HVAC System Properties workbook. Detailed characteristics are provided in the following tabs of the workbook:

- HW System Baseline & Measures tab lists all baseline hot water plant and circulation loop characteristics. Additionally, all hot water plant and circulation loop measures are defined in this table.
- Secondary HW Loop Delta T tab lists hot water loop temperature drops due to pipe losses for all applicable building types and vintages.

Domestic Hot Water Plant Initialization

Domestic hot water plant properties are defined in the DEER DHW Properties workbook. (DEER DHW Properties-050714b.xls). Detailed characteristics are provided in the following tabs of the workbook:

- DHWProperties=f(Prototype) tab lists all DHW system design parameters including flow, storage capacity and input rating for DHW heaters.
- GasDHWBase=f(Proto,Vintage) tab properties of gas fired DHW heaters by building type and vintage.
- DHWTankInsul=f(BldgType) tab lists properties for the tank insulation measure for all applicable building types.
- DHWGasWtrHtr=f(Proto,Vintage) tab lists properties for the high efficiency small storage gas water heater measure for all applicable building types.
- DHWMedGasWtrHtr=f(Bldg,Vintage) tab lists properties for the high efficiency medium storage gas water heater measure for all applicable building types.
- DHWLrgGasWtrHtr=f(Bldg,Vintage) tab lists properties for the high efficiency large storage gas water heater measure for all applicable building types.
- DHWGasTankless=f(Bldg,Vint) tab lists properties for the gas tankless water heater measure for all applicable building types.
- DHWPointOfUse=f(Bldg,Vintage) tab lists properties for the electric point-of-use water heater measure for all applicable building types.

7

Non-Residential Weather Sensitive DEER Measure Descriptions

7.1 Introduction

This section contains a top level description of the methodology used to model each measure for all building types. Also included are the primary parameters used in the modeling of each measure and how those parameters are altered from the base case, to the code baseline to the measure; sometimes these parameters vary by climate zone and building vintage. To provide added detail of interest for the measure descriptions links are provided, when appropriate, into MAS tool spreadsheets, and other supporting documents, that contain more details of parameter values. Within this non-residential section, first the non-refrigeration building measures are covered then the refrigeration measures are covered for the grocery and then the refrigerated warehouse building types.

Code baselines have been selected from one of the following California regulations:

- *2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-001, California Energy Commission, September 2004, Effective Date October 1, 2005 (Title 24 or T24); and
- *Appliance Efficiency Regulations*, California Energy Commission, April 2005, Publication CEC 400-2005-012 (Title 20 or T20.)

Additional simulation methodologies are derived from:

- *Residential Alternative Calculation Method (ACM) Approval Manual for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-003, California Energy Commission, October 2004 (ACM Manual or ACM); and
- *Nonresidential Alternative Calculation Method (ACM) Approval Manual for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-004, California Energy Commission, October 2004 (ACM Manual or ACM.)

7.2 Non-Residential Measures

Indoor Lighting Measures

Lighting measures assume uniform reduction in installed lighting power throughout the prototype. Simulation inputs for lighting power density (LPD) are reduced by 10 percent for Measure ID D03-001 and 40 percent for D03-002. The code baseline is the maximum lighting power allowance (LPA) from Table 146-C of Title 24.

Indoor Lighting Low Load Reduction	
ID: **D03-001**	Abbreviation: **LtgLo**
Measure Description	Reduced Lighting - 10% reduction
Baseline Characteristics	existing lighting levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 maximum LPA per Table 146-C
Measure Characteristics	all lighting levels reduced by 10%
Savings Reporting Units	per kW of lighting reduction
Savings Scalable By	n/a

Indoor Lighting High Load Reduction	
ID: **D03-002**	Abbreviation: **LtgHi**
Measure Description	Reduced Lighting - 40% reduction
Baseline Characteristics	existing lighting levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 maximum LPA per Table 146-C
Measure Characteristics	all lighting levels reduced by 40%
Savings Reporting Units	per kW of lighting reduction
Savings Scalable By	n/a

MAS properties that are instrumental in determining the baseline and code baseline lighting levels:

ShellWiz:ILElecIntens[1-8]	LPD by activity area (W/SqFt) as defined in the Lighting Power Density Table (LtgPD Sheet of DEER Tables.xls) by building type and vintage.

MAS properties that are instrumental in transforming the baseline and/or code baseline building description into the measure building:

ShellWiz:ILElecIntMult	Multiplier applied to all LPDs by activity area

Occupancy Sensor Measures

Lights are normally controlled by wall on/off switches for individual lights or groups of lights. Unnecessary energy is used if lights are not turned off when occupants vacate a space or room or a business closes at the end of a day. When the automatice turn-on option is enabled, occupancy sensors detect the presence of occupants in a space and turn lights on. Occupancy sensors will keep lights on for a predetermined length of time past the point at which the sensor does not detect activity in the space or room.

The Lighting Research Center (LRC) performed research on savings of occupancy sensors in several building types. Results are published in "An Analysis of the Energy and Cost Savings Potential of Occupancy Sensors for Commercial Lighting Systems". Generally, the study presents overall reductions in equivalent full load hours due to occupancy sensors for various building and space use types. The study also divides these reductions among four periods: weekday occupied, weekday unoccupied, weekend occupied, and weekend unoccupied.

Methodology: Prototype lighting profiles for all buildings assume that lights are off or reduced to minimum levels when buildings are unoccupied. For occupancy measures, the baseline schedule was modified so that the increase in equivalent full load operating hours closely matched the savings observed in the LRC study. The baseline building description is transformed into the measure building via a routine that applies the lighting profile reductions described above in determining the baseline building description. The Occupancy Sensor Table (OccSens Sheet of DEER Tables.xls) specifies percent reduction of full load hours and fractions of full load hour reductions for weekday and weekend open and closed periods based on DEER building type, activity area type and schedule group type.

The methodology does not vary between Measure ID D03-003 and Measure ID D03-004. However, measure applicability is different for each. Measure ID D03-003 assumes that occupancy sensors are installed in smaller spaces and therefore is only applicable to buildings where spaces no greater than 200 square feet are anticipated. Measure ID D03-004 is applicable to buildings where spaces are at least 1000 square feet are anticipated.

Occupancy Sensor Pack-200 SF	
ID: **D03-003**	Abbreviation: **OcSnS**
Measure Description	Small area lighting sensor control
Baseline Characteristics	existing lighting levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 code baseline matches prototype
Measure Characteristics	lighting level reduced based on bldg type, activity area
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

Occupancy Sensor Pack-1000 SF	
ID: **D03-004**	Abbreviation: **OcSnL**
Measure Description	Large area lighting sensor control
Baseline Characteristics	existing lighting levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 code baseline matches prototype
Measure Characteristics	lighting level reduced based on bldg type, activity area
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

MAS properties that are instrumental in determining the baseline and code baseline building description:

ShellWiz:AAILShape[*]:OccSensFLHReduc	Percent Reduction of Full Load Hours
ShapeWiz:OccSensReducFracs[1-4]	Fraction of Full Load Hour Reduction for open/closed periods of weekdays & weekend days

Daylighting Control Measures

Daylighting controls turn lights off when natural light is capable of adequately lighting the space. Daylighting controls can be 1-step (all lights are controlled), 2 step (lighting is turned off in two steps based on the measured natural light in the space) or Continuous (light fixture output is continually varied by the controls depending on measured natural light in the space).

Methodology (Side Lighting): Side lighting measures are implemented as described in the methodology below. Glazing performance and area are identical for the measure and baseline runs according to the prototype characteristics for each building type and vintage. The baseline building has no daylighting controls.

Methodology (Top Lighting): Top lighting measures are implemented as described in the methodology below. Skylights are added to the baseline and measure building according to the Skylight Table (Skylts Sheet of DEER Tables.xls). Skylight to roof ratio (SRR) is 2.5 percent in all cases. The baseline building has no daylighting controls.

DayLtg Controls, Side Ltg, Continuous Ctrl	
ID: **D03-005**	Abbreviation: **DLtSC**
Measure Description	Add daylighting controls to side-lit space w/ continuous control
Baseline Characteristics	Standard glass type, window-wall fraction
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	add daylighting controls, min. lumen level based on bldg type
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

DayLtg Controls, Side Ltg, 2-step Ctrl	
ID: **D03-006**	Abbreviation: **DLtS2**
Measure Description	Add daylighting controls to side-lit space w/ 2-step control
Baseline Characteristics	Standard glass type, window-wall fraction
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	add daylighting controls, min. lumen level based on bldg type
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

DayLtg Controls, Top Ltg, Continuous Ctrl	
ID: **D03-007**	Abbreviation: **DLtTC**
Measure Description	Add daylighting controls to top-lit space w/ continuous control
Baseline Characteristics	skylights included, fraction of roof area based on bldg type
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	add daylighting controls, min. lumen level based on bldg type
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

DayLtg Controls, Top Ltg, 1-step Ctrl	
ID: **D03-008**	Abbreviation: **DLtT1**
Measure Description	Add daylighting controls to top-lit space w/ 1-step control
Baseline Characteristics	skylights included, fraction of roof area based on bldg type
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	add daylighting controls, min. lumen level based on bldg type
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

DayLtg Controls, Top Ltg, 2-step Ctrl	
ID: **D03-009**	Abbreviation: **DLtT2**
Measure Description	Add daylighting controls to top-lit space w/ 2-step control
Baseline Characteristics	skylights included, fraction of roof area based on bldg type
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	add daylighting controls, min. lumen level based on bldg type
Savings Reporting Units	per kW of lighting controlled
Savings Scalable By	n/a

The following MAS properties are instrumental in determining the baseline characteristics for all daylighting measures and are listed in the Measure Data Look-up Table (MsrInfo Sheet of DEER Tables.xls):

DEERProto:DL_DayltMethod	Set to either 2 (SideOnly), 3 (TopOnly) or -1 (no daylighting) based on the measure being analyzed via the Measure Data Look-up Table (MsrInfo Sheet of DEER Tables.xls)
DEERProto:DL_LtCtrlType	Set to either 1 (Continuous), 2 (Stepped) or 0 (none) based on the measure being analyzed via the Measure Data Look-up Table (MsrInfo Sheet of DEER Tables.xls)
DEERProto:DL_LtCtrlSteps	Set to either 1 (1-step), 2 (2-step) or -1 (not stepped) based on the measure being analyzed via the Measure Data Look-up Table (MsrInfo Sheet of DEER Tables.xls)
DEERProto:DL_LightSetPoint	The daylighting set point based on DEER building

	type from the Building Type Look-up Table (Building Sheet of DEER Tables.xls)
DEERProto:DL_MinPowerFrac	Set to 0.15 and translated directly into DOE-2's SPACE:MIN-POWER-FRAC keyword for all DEER daylighting analysis
DEERProto:DL_MinLightFrac	Set to 0.10 and translated directly into DOE-2's SPACE:MIN-LIGHT-FRAC keyword for all DEER daylighting analysis

MAS properties that are instrumental in determining the baseline characteristics for sidelighting measures:

ShellWiz:GP_BDLVisualTrans[1-2]	Visible transmittance of all side glass (based on the solar heat gain coefficient)

MAS properties that are instrumental in determining the baseline characteristics for toplighting measures:

ShellWiz:SkyltCoverage	Skylight density based on DEER building type from the Building Type Look-up Table (Building Sheet of DEER Tables.xls)
ShellWiz:GlazingCategory	Skylight glazing category set to '- specify properties -'
ShellWiz:SGP_SpecMethod	Skylight specification method set to 'NFRC Ufactor'
ShellWiz:SGP_Ufactor	Skylight NFRC Ufactor based on DEER building type, secondary building type, vintage and region from the Skylight Table (Skylts Sheet of DEER Tables.xls)
ShellWiz:SGP_SolSpecMethod	Skylight solar specification method set to 'NFRC SHGC'
ShellWiz:SGP_SHGC	Skylight NFRC SHGC based on DEER building type, secondary building type, vintage and region from the Skylight Table (Skylts Sheet of DEER Tables.xls)
ShellWiz:SGP_BDLVisualTrans	Visible transmittance of all top glass (based on the solar heat gain coefficient)

The daylighting methodology can be applied to any building space whose shape/outline and associated wall, window and skylight shapes are described as polygons (or rectangles) and positioned accurately in 3-dimensional space.

The three principle steps involved in applying this methodology begin with calculations of the amount and position of side and top daylightable areas and conclude with a determination of the appropriate number of daylighting controls and positions for those controls. Each of these steps are described in the following paragraphs.

Determination of Sidelit Area

Exterior surfaces that are within 30 degrees of vertical are classified as walls (as opposed to roofs) and as such, their windows may provide some amount of side daylighting. The sidelit area for each window is determined based on the definition of "Daylit Area" from Title 24, Section 131(c) – page 74:

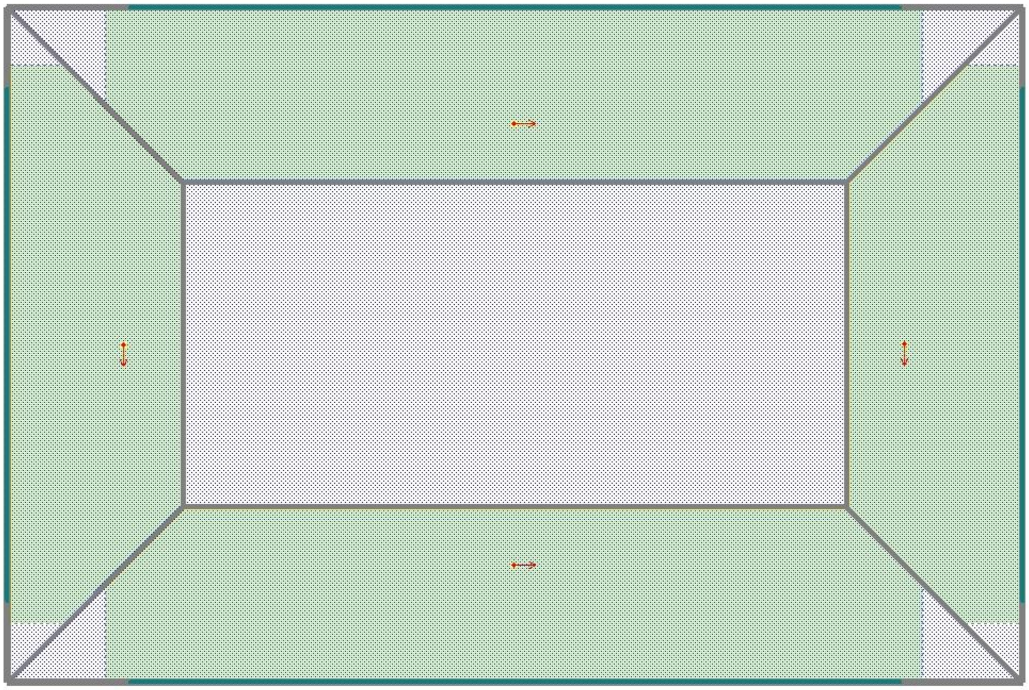
> *The daylit area illuminated by vertical glazing shall be the daylit depth multiplied by the daylit width, where the daylit depth is 15 feet, or the distance on the floor, perpendicular to the glazing, to the nearest 60-inch or higher permanent partition, which ever is less; and the daylit width is the width is the width of the window plus , on each side, either 2 feet, the distance to a permanent partition, or one half the distance to the closes skylight or vertical glazing, whichever is least.*

The Effective Aperture (EA) for vertical glazing is defined in Title 24, Section 131(c), Exception 1, page 74 as *"the visible light transmittance (VLT) times the window wall ratio."*

A polygon consistent with the sidelit area description above is constructed for each window along with an effective aperture equal to VLT * (WindowHeight / SpaceHeight) and a reference to the facing direction/orientation of the window. Intersections of all sidelit area polygons are then computed, with their resulting effective apertures set equal to the sum of the effective apertures for each contributing window. The resulting set of polygons is then reduced by eliminating those that have an overall effective aperture less than a minimum value of 0.14. The minimum of 0.14 was determined to be the most conservative value based on Table 1-L – Lighting Power Adjustment Factors in the AB-970 Standard for all products of VLT and window wall ratio that result in no possible daylit area, including 0.12 for VLT=0.6 and WWR=0.2 and 0.14 for VLT=0.35 and WWR=0.4. The minimum effective aperture of 0.14 is considerably more conservative than the minimum value of 0.1 Title 24, Section 131(c), Exception 1, page 74.

The union of all remaining sidelit area polygons (those with overall effective apertures greater than or equal to 0.14) is considered to be the overall sidelit area for the space.

The following diagram provides an example of the sidelit area (pale green shaded area) for the DEER small office building.



Determination of Toplit Area

Exterior surfaces that are greater than 30 degrees from vertical are classified as roofs (as opposed to walls) and as such, their windows (skylights) may provide some amount of top daylighting. The toplit area for each skylight is determined based on the definition of "Daylit Area" from Title 24, Section 131(c) – page 74:

> *The daylit area under skylights shall be the rough opening of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of 70% of the floor-to-ceiling height, the distance to the nearest 60-inch or higher permanent partition, or one half the horizontal distance to the edge of the closes skylight or vertical glazing.*

The Effective Aperture (EA) for a skylight is defined in Title 24, Section 146(a) 4E, Equation 146-A page 103 as:

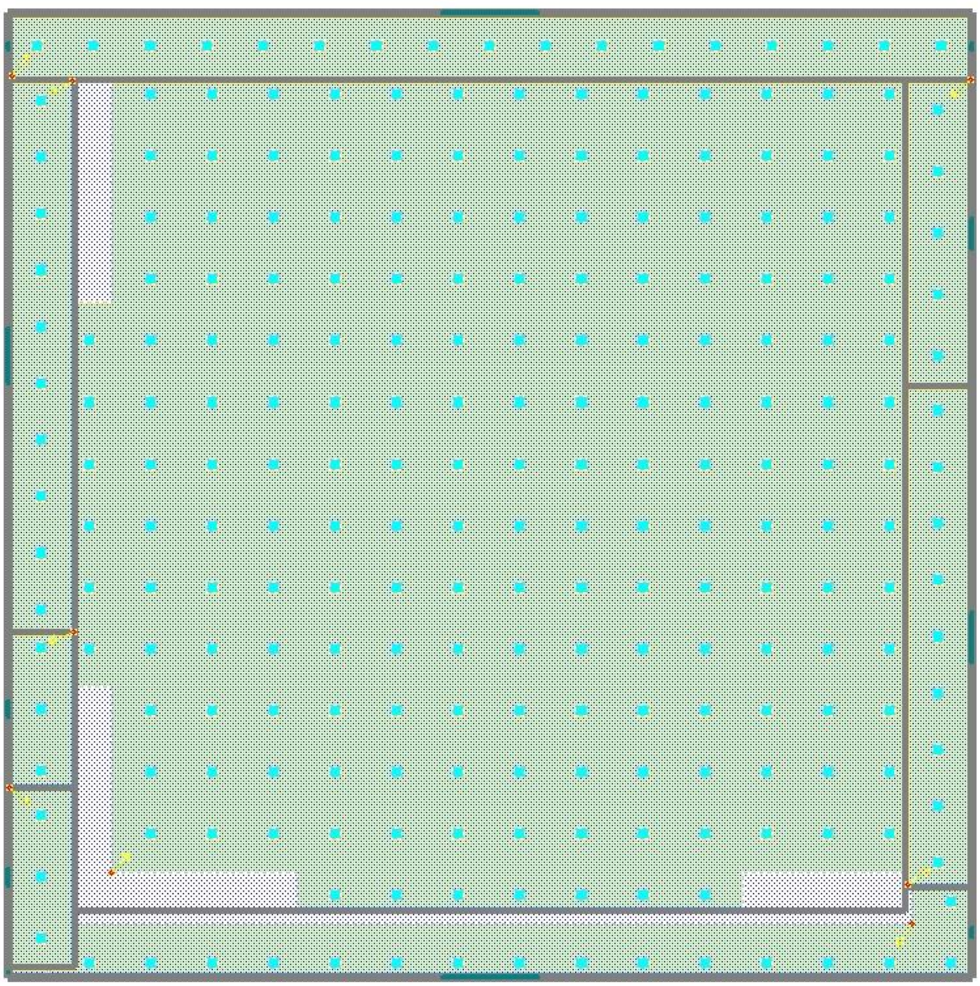
$$\text{Effective Apperture} = \frac{0.85 * \text{Total Skylight Area} * \text{Glazing Visible Transmittance} * \text{Well Efficiency}}{\text{Daylit Area Under Skylights}}$$

The minimum effective aperture for skylights using this daylighting modeling methodology is 0.01.

In order to calculate effective apertures for each individual skylight, the gross exterior roof area is replaced with the area consistent with the definition of the skylight's toplit area (described above). If the effective aperture of a skylight is found to be less than the minimum value of 0.01, then the toplit area corresponding to the skylight is reduced until the effective aperture is equal to its minimum value of 0.01. If the reduced toplit area is less than the area of the skylight itself, then that skylight is eliminated from the set of toplit area polygons.

Like with the sidelit areas, all intersections between toplit area polygons are found and their overall effective apertures are defined as the sum of the effective apertures for their contributing skylights. The union of all remaining toplit area polygons is considered to be the overall toplit area for the space.

The following diagram provides an example of the toplit area (pale green shaded area) for the DEER single story large retail building.



Number and Positioning of Daylighting Controls

The daylighting control definition and positioning algorithm calls for 2 separate controls only when a space has a combination of side and top lighting. Since all DEER daylighting measure analysis is performed for side or top lighting (never combined), all DEER daylit spaces will be modeled with a single daylighting control per space.

Positioning Controls based on Sidelit Area

The first round of sidelit control positioning starts with 10 feet back from the center of the window with the lowest effective aperture for the selected orientation and not within 10 feet of any other window or within any toplit area. If these conditions are not met, a second round of positioning evaluates several of possible control locations at varying distances away from and along each window of the selected orientation to find the one furthest from the closest window and not in any toplit area.

Positioning Controls based on Toplit Area

If the toplit area is within 3% of the total space area, then the first two rounds of analysis are skipped since their likelihood of success is minimal. The first round of toplit control positioning starts by evaluating each corner/vertex of the polygons that make up the overall toplit area, making sure that the location does not lie immediately below any skylight or within any sidelit area. Of these potentially multiple positions, the one furthest from the closest skylight is chosen. A second round of control position testing is performed which is identical to the first with the exception that all sidelit areas are ignored in the event that the first round of processing fails to yield a valid position.

If neither of the first two rounds of control positioning is successful (or if the toplit area is within 3% of the total space area), then up to two subsequent rounds of analysis are performed based on a grid of points. The point grid has spacing equal to the square root of (ToplitArea/1,000) feet but not more than 10 feet or less than 0.5 feet. The first of these three final rounds checks for points not directly under skylights and in toplit and/or sidelit areas with a minimum overall effective aperture (using a multiplier of 0.2 on sidelit effective apertures to prevent sidelit areas from dominating the decision process). If no valid positions result from this first additional round of processing, then the same mechanism is used with the exception that points found to be located directly under skylights are not excluded from consideration.

Setting Control View Azimuth

The view azimuth is set to point directly at the centroid of the nearest skylight in the event that the one and only daylighting control position was located based solely on top lighting.

If side lighting was considered in either one or both of the daylighting control positions, then up to four unique view azimuths will be analyzed to identify the most likely view azimuth practiced by occupants of the space. The view azimuths considered include the two directions that run parallel to the closest window for the one or two daylighting controls that are positioned in relation to a window or sidelit area.

The fundamental principle behind the determination of a realistic view azimuth is that an occupant will most likely orient their view in a direction that minimizes glare, which would imply that no windows be located directly in (or perhaps within +/- 22.5 degrees of) the occupants line of sight. If no view azimuth results in zero windows being located in the occupants' line of sight, then glare is best minimized by preventing the occupant from looking toward a point source of light. To prevent the view azimuth from orienting the occupant toward a point source of light, the same range of sight (+/- 22.5 degrees) is analyzed to find the direction with the widest view of windows with a secondary consideration of maintaining the furthest distance from the windows in this range of sight. An additional check is also instituted to avoid having the view azimuth point to a space boundary within five feet of in that direction, unless all potential view azimuths violate this restriction.

To apply these principles of view azimuth determination, each of the 2 or 4 view azimuths are analyzed to first choose the one with no windows located within +/- 22.5 degrees of the selected direction and not pointing toward a space boundary within 5 feet of the control position. If none of the potential view azimuths pass this test, then a secondary round of analysis is performed to select the view azimuth that does not point toward a space boundary within 5 feet and that maximizes the overall effective aperture of the windows within +/- 22.5 degrees of the selected direction and also maximizes the distance to the closest window.

Specification of DOE-2 Model Daylighting Keywords

The following table describes how each of the DOE-2 daylighting keywords (left column) of the SPACE command are defined during the course of DEER daylighting analysis.

DAYLIGHTING	Set to "YES" for all spaces to be modeled with daylighting
LIGHT-REF-POINT1	Set to the daylighting control position based on the automated procedures described above
ZONE-FRACTION1	Set to the fraction of daylightable space based on the automated procedures described above
LIGHT-SET-POINT1	Determined based on DEER building type from the Building Type Look-up Table (Building Sheet of DEER Tables.xls)
LIGHT-CTRL-TYPE1	"CONTINUOUS" for continuous lighting control measures, otherwise "STEPPED"
LIGHT-CTRL-STEPS	Set to 1 or 2 when modeling 1-step or 2-step controls and not

	defined when modeling continuous daylighting controls
VIEW-AZIMUTH	Set based on the automated procedures described above
MIN-POWER-FRAC	Set to 0.15 for all DEER daylighting analysis
MIN-LIGHT-FRAC	Set to 0.1 for all DEER daylighting analysis

Lighting Timeclock Measure

Lighting timeclock controls turn off lights at specific times, predetermined by building operators in anticipation of the building being unoccupied at these times. Current requirements for automatic shut-off controls are contained in Title 24, Section 131(d), page 75. Automatic shut-off controls have been required by Title 24 since 1992 so this measure is only applicable to the two earliest vintages. "Evaluation of Pacific Gas and Electric Company's 1995 Nonresidential Energy Efficiency Incentives Program for Commercial Sector Lighting Technologies Appendix" summarizes research performed to determine Closed Operating Factors (COFs) for a variety of building types and space uses. These values for COF range from fifty to three hundred percent higher than comparable values of COF assumed for the DEER nonresidential prototypes, depending on building type and space use.

Methodology: Prototype lighting profiles for all buildings assume that lights are off or reduced to minimum levels when buildings are unoccupied. For the Lighting Timeclock Measure, baseline unoccupied lighting power fractions were adjusted up to closely match the COFs reported in the Pacific Gas and Electric Study. Savings resulted from the decrease for these higher baseline COFs to COFs used in the typical prototype lighting schedules.

Timeclock for Lighting	
ID: **D03-010**	Abbreviation: **LtgTC**
Measure Description	EMS system reduced unoccupied lighting levels
Baseline Characteristics	unoccupied lighting power density based on bldg type
Code Baseline Characteristics	T24 lighting schedules assume automatic shut-off
Measure Characteristics	minimum unoccupied lighting power density based on bldg type
Savings Reporting Units	kW of LtgCtrl
Savings Scalable By	n/a

MAS properties that are instrumental in increasing determining the baseline characteristics for all the lighting timeclock measure:

ShellWiz:AAILShape[*]:TimeclockMinPct[*]	Set to the minimum baseline model interior lighting profile value based on building type, activity area, season and day. These values are defined in the Lighting Timeclock Look-up Table (LtgTmclck Sheet of DEER Tables.xls).
ShellWiz:AAILShape[*]:ShapeBackup[192]	This array is used to store the default lighting profile which is increased when modeling the baseline design and restored when simulating the measure building.

Once the minimum baseline lighting profile value is set a routine is called to increase all lighting profile values that are lower than the specified baseline minimum value to equal that value. All such profile adjustments are made prior to the application of profile calibration factors which are designed to calibrate annual lighting energy use to established target values by vintage.

Plug Load Reduction Measures

Methodology: Miscellaneous equipment loads in each space are reduced by 5% or 10%.

Plug Loads Low Load Reduction	
ID: **D03-011**	Abbreviation: **PlgLo**
Measure Description	Plug Loads reduced by 5%
Baseline Characteristics	existing plug levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 code baseline for plug loads matches prototype level
Measure Characteristics	all plug loads reduced by 5%
Savings Reporting Units	kW of Plug red'n
Savings Scalable By	n/a

Plug Loads High Load Reduction	
ID: **D03-012**	Abbreviation: **PlgHi**
Measure Description	Plug Loads reduced by 10%
Baseline Characteristics	existing plug levels, by activity area, reviewed/modified
Code Baseline Characteristics	T24 code baseline for plug loads matches prototype level
Measure Characteristics	all plug loads reduced by 10%
Savings Reporting Units	kW of Plug red'n
Savings Scalable By	n/a

MAS properties that are instrumental in determining the baseline and code baseline equipment levels:

ShellWiz:MiscElecLoad	Equipment power density (EPD) by activity area (W/SqFt) as defined in the Equipment Power Density Table (EqpPD Sheet of DEER Tables.xls) by building type and vintage.

MAS properties that are instrumental in transforming the baseline and/or code baseline building description into the measure building:

ShellWiz:MiscDivEIntMult	Multiplier applied to all EPDs by activity area

Ceiling/Roof Insulation Measure

Methodology: Title 24 roof insulation requirements have been similar since the first standards took effect in 1978, therefore this measure is only applicable to the oldest vintages. The prototype roof U-Factor is decreased to the maximum U-Factor allowed in Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms).

Ceiling/Roof Insulation	
ID: **D03-013**	Abbreviation: **RfIns**
Measure Description	Older building ceiling/roof insulation up to current standards
Baseline Characteristics	Ceiling R-value based on vintage and climate zone
Code Baseline Characteristics	T24 maximum overall U-Factor Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms)
Measure Characteristics	Ceiling R-value for oldest vintages increased to 'new' level
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

MAS properties that are instrumental in determining the baseline and measure ceiling/roof insulation levels:

ShellWiz: RoofOverallRVal	Roof overall R-value. Baseline and measure R-values are set to the inverse of U-Factors listed in the Roof U-Factor Table (RoofUVal Sheet of DEER Tables.xls).

Floor Insulation Measure

Methodology: The relocatable classroom is the only prototype with a raised floor. Also, Title 24 floor insulation requirements have been similar since the first standards took effect in 1978. Therefore, this measure is only applicable to the oldest vintage of the relocatable classroom prototype. The prototype roof U-Factor is decreased to the maximum U-Factor allowed in Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms).

Floor Insulation	
ID: **D03-123**	Abbreviation: **FlIns**
Measure Description	Floor insulation raised to 2005 levels
Baseline Characteristics	Floor insulation based on vintage and climate zone
Code Baseline Characteristics	T24 maximum overall U-Factor Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms)
Measure Characteristics	Floor insulation raised to 2005 levels
Savings Reporting Units	1,000 sqft footprint
Savings Scalable By	n/a

MAS properties that are instrumental in determining the baseline, code baseline and measure floor insulation levels:

ConsWiz:OverallRVal	Overall R-value. Baseline and measure R-values are set to the inverse of U-values listed in the Floor U-Factor Table (FloorIns Sheet of DEER Tables.xls).

Light Colored Roof Measure

Installing a light colored roof can reduce cooling energy by reducing the absorptance of the roof's exterior surface.

Methodology: The prototype roof absorptance for all measures except this measure is 0.6. This "typical" value assumes that across a wide range of actual buildings there will be a mixture of light- and dark-colored roofs. The Light-Colored Roof Measure assumes a baseline absorptance of 0.8 and a measure absorptance of 0.45. It is reasonable to assume that, if a building already had a light colored roof (absorptance less than 0.8), another light colored roof would probably not be considered as an energy efficiency measure. This measure would only be considered if the roof had a dark color (absorptance $\geq$ 0.8).

Light Colored Roof	
ID: **D03-016**	Abbreviation: **ClRof**
Measure Description	Light Colored Roof
Baseline Characteristics	Roof absorptivity = 0.8
Code Baseline Characteristics	T24 minimum: cool roof per Section 118(i)
Measure Characteristics	Roof absorptivity = 0.45
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Low SHGC Windows Measures

Reducing shading coefficient of glazing will reduce the amount of solar heat gain into the building. This reduced gain will decrease cooling load for the building but may increase the need for heating.

Methodology: Glazing is simulated using the "simplified" or shading-coefficient method where GLASS-CONDUCTANCE is held constant and SHADING-COEF is varied between the prototype baseline, code baseline and measure level. SHADING-COEF is calculated by dividing SHGC by 0.87, as required in the ACM Manual, Equation N2-4, Page 2-24. Prototype SHGC values by prototype and vintage are found in theWindows Look-up Table (Windows Sheet of DEER Tables.xls). Minimum SHGC requirements are found in Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms).

Low SHGC Windows - 15% - North	
ID: **D03-017**	Abbreviation: **WS15N**
Measure Description	North glass SHGC 15% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	North glass SHGC 15% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 20% - East	
ID: **D03-018**	Abbreviation: **WS20E**
Measure Description	East glass SHGC 20% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	East glass SHGC 20% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 20% - South	
ID: **D03-019**	Abbreviation: **WS20S**
Measure Description	South glass SHGC 20% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	South glass SHGC 20% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 20% - West	
ID: **D03-020**	Abbreviation: **WS20W**
Measure Description	West glass SHGC 20% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	West glass SHGC 20% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 20% - North	
ID: **D03-021**	Abbreviation: **WS20N**
Measure Description	North glass SHGC 20% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	North glass SHGC 20% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 30% - East	
ID: **D03-022**	Abbreviation: **WS30E**
Measure Description	East glass SHGC 30% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	East glass SHGC 30% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 30% - South	
ID: **D03-023**	Abbreviation: **WS30S**
Measure Description	South glass SHGC 30% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	South glass SHGC 30% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

Low SHGC Windows - 30% - West	
ID: **D03-024**	Abbreviation: **WS30W**
Measure Description	West glass SHGC 30% less than required
Baseline Characteristics	glass type as defined by location and window-wall ratio
Code Baseline Characteristics	T24 maximum SHGC matches prototype level
Measure Characteristics	West glass SHGC 30% less than required by T24
Savings Reporting Units	100 sqft window
Savings Scalable By	SHGC% reduction

MAS properties that are instrumental in determining the baseline, code baseline and measure window SHGC values:

ShellWiz:GP_SHGC[1-3]	SHGC for windows assigned to specific orientations (1-North, 2-E/S/W, 3-single non-North facing direction for measure run only). Baseline, code baseline and measure SHGC values are looked up based on DEER building type, secondary building type (dorm for university & hotel public areas vs. guest rooms), vintage and climate zone from the Windows Look-up Table (Windows Sheet of DEER Tables.xls).

High Performance Side Glass w/ Daylighting Measures

Glazing with high visible transmittance, yet still having a low shading coefficient, allows more visible light to pass into the conditioned space without increasing the cooling load. As a result, savings from automatic daylighting controls are increased. The ratio of the visible transmittance to the shading coefficient is called the Performance Index (PI).

Methodology: Glazing is simulated using the "simplified" or shading-coefficient method where GLASS-CONDUCTANCE is held constant and SHADING-COEF is varied between the prototype baseline, code baseline and measure level. SHADING-COEF is calculated by dividing SHGC by 0.87, as required in the ACM Manual, Equation N2-4, Page 2-24. Prototype SHGC values by prototype and vintage are found in the Windows Look-up Table (Windows Sheet of DEER Tables.xls). Minimum SHGC requirements are found in Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms). Visible transmittance is calculated according to the following equation:

V-T = SHGC / 0.87 * PI * 0.86

Where

0.87 is the conversion from SHGC to SC,
PI is the Performance Index of the glass alone, and
0.86 is a correction factor for opaque elements such as framing, mullions and dirt.

The baseline and code baseline PI is 1.00 for vertical glazing.

Lighting controls are implemented as described in the Daylighting Control Measures, above. The baseline building has no daylighting controls.

Hi Perf. Glass, PI=1.15, Side Ltg, Cont. Ctrl	
ID: **D03-025**	Abbreviation: **WP4SC**
Measure Description	High perf glass (PI 1.15) and continuous daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.26, Side Ltg, Cont. Ctrl	
ID: **D03-026**	Abbreviation: **WP5SC**
Measure Description	High perf glass (PI 1.26) and continuous daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.38, Side Ltg, Cont. Ctrl	
ID: **D03-027**	Abbreviation: **WP6SC**
Measure Description	High perf glass (PI 1.38) and continuous daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.15, Side Ltg, 2-Step Ctrl	
ID: **D03-028**	Abbreviation: **WP4S2**
Measure Description	High perf glass (PI 1.15) and 2-step daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.26, Side Ltg, 2-Step Ctrl	
ID: **D03-029**	Abbreviation: **WP5S2**
Measure Description	High perf glass (PI 1.26) and 2-step daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.38, Side Ltg, 2-Step Ctrl	
ID: **D03-030**	Abbreviation: **WP6S2**
Measure Description	High perf glass (PI 1.38) and 2-step daylighting controls in side-lit spaces
Baseline Characteristics	base case has std glass types, no daylighting controls
Code Baseline Characteristics	T24 glazing performance matches prototype level, no controls installed
Measure Characteristics	glass w/ indicated performance index in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

High Performance Top Glass w/ Daylighting Measures

Glazing with high visible transmittance, yet still having a low shading coefficient, allows more visible light to pass into the conditioned space without increasing the cooling load. As a result, savings from automatic daylighting controls are increased. The ratio of the visible transmittance to the shading coefficient is called the Performance Index (PI).

Methodology: Glazing is simulated using the "simplified" or shading-coefficient method where GLASS-CONDUCTANCE is held constant and SHADING-COEF is varied between the prototype baseline, code baseline and measure level. SHADING-COEF is calculated by dividing SHGC by 0.87, as required in the ACM Manual, Equation N2-4, Page 2-24. Prototype SHGC values by prototype and vintage are found in the Windows Look-up Table (Windows Sheet of DEER Tables.xls). Minimum SHGC requirements are found in Title 24, Table 143-A, Page 83 (for nonresidential buildings) and Title 24, Table 143-B, Page 84 (for hotel and motel guest rooms). Visible transmittance is calculated according to the following equation:

V-T = SHGC / 0.87 * PI * 0.86

Where

0.87 is the conversion from SHGC to SC,
PI is the Performance Index of the glass alone, and
0.86 is a correction factor for opaque elements such as framing, mullions and dirt.

The baseline and code baseline PI is 0.81 for overhead glazing.

Lighting controls are implemented as described in the Daylighting Control Measures, above. Skylights are added to the baseline and measure building according to the Skylight Table (Skylts Sheet of DEER Tables.xls). Skylight to roof ratio (SRR) is 2.5 percent in all cases. The baseline building has no daylighting controls.

Hi Perf. Glass, PI=0.81, Top Ltg, Cont. Ctrl	
ID: **D03-031**	Abbreviation: **WP1TC**
Measure Description	High perf glass (PI 0.81) and continuous daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=0.92, Top Ltg, Cont. Ctrl	
ID: **D03-032**	Abbreviation: **WP2TC**
Measure Description	High perf glass (PI 0.92) and continuous daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.03, Top Ltg, Cont. Ctrl	
ID: **D03-033**	Abbreviation: **WP3TC**
Measure Description	High perf glass (PI 1.03) and continuous daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, continuous control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=0.81, Top Ltg, 1-Step Ctrl	
ID: **D03-034**	Abbreviation: **WP1T1**
Measure Description	High perf glass (PI 0.81) and 1-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 1-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=0.92, Top Ltg, 1-Step Ctrl	
ID: **D03-035**	Abbreviation: **WP2T1**
Measure Description	High perf glass (PI 0.92) and 1-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 1-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.03, Top Ltg, 1-Step Ctrl	
ID: **D03-036**	Abbreviation: **WP3T1**
Measure Description	High perf glass (PI 1.03) and 1-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 1-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=0.81, Top Ltg, 2-Step Ctrl	
ID: **D03-037**	Abbreviation: **WP1T2**
Measure Description	High perf glass (PI 0.81) and 2-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=0.92, Top Ltg, 2-Step Ctrl	
ID: **D03-038**	Abbreviation: **WP2T2**
Measure Description	High perf glass (PI 0.92) and 2-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Hi Perf. Glass, PI=1.03, Top Ltg, 2-Step Ctrl	
ID: **D03-039**	Abbreviation: **WP3T2**
Measure Description	High perf glass (PI 1.03) and 2-step daylighting controls in top-lit spaces
Baseline Characteristics	skylights with properties based on location, no daylighting controls
Code Baseline Characteristics	T24 skylight performance matches prototype level, no controls installed
Measure Characteristics	skylight w/ indicated performance index & T24 reqmts in daylit spaces, 2-step control
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

High Efficiency & Gas Absorption Chiller Measures

Chiller efficiency varies by compressor type (centrifugal, reciprocating or screw), condenser type (water-cooled or air-cooled) and vintage (age). Newer, water-cooled centrifugal machines tend to be the most efficient (highest COP/lowest kW/ton) while older reciprocating machines tend to be the least efficient. With the exception of the absorption chiller measures, measure efficiency for electrically operated chillers is 20 percent over requirements listed in Title 24, Table 112-D, Page 44.

D03-040, 116, 117, 042, 121 & 122 High Efficiency Centrifugal Chillers						
	< 150 Tons (040, 042)		150 – 300 Tons (116,121)		> 300 Tons (117, 122)	
Vintage	COP	kW/Ton	COP	kW/Ton	COP	kW/Ton
< 1978	4.7	0.750	4.7	0.750	4.7	0.750
1978 – 1992	4.7	0.750	4.7	0.750	4.7	0.750
1993 – 2001	4.7	0.750	4.7	0.750	4.7	0.750
2002 – 2005	5.5	0.634	5.5	0.634	6.1	0.576
> 2005	5.5	0.634	5.5	0.634	6.1	0.576
Title 24	5.0	0.700	5.5	0.634	6.1	0.576
Measure	6.3	0.560	6.9	0.507	7.6	0.461

D03-041 High Efficiency Air-Cooled Reciprocating Packaged Chillers						
	All					
Vintage	COP	kW/Ton				
< 1978	2.7	1.300				
1978 – 1992	2.7	1.300				
1993 – 2001	2.7	1.300				
2002 – 2005	2.8	1.260				
> 2005	2.8	1.260				
Title 24	2.8	1.260				
Measure	3.5	1.008				

D03-115 High Efficiency Water-Cooled Reciprocating Chillers						
	All					
Vintage	COP	kW/Ton				
< 1978	4.2	0.837				
1978 – 1992	4.2	0.837				
1993 – 2001	4.2	0.837				
2002 – 2005	4.2	0.837				
> 2005	4.2	0.837				
Title 24	4.2	0.837				
Measure	5.2	0.672				

D03-114 High Efficiency Air-Cooled Screw Packaged Chillers						
	All					
Vintage	COP	kW/Ton				
< 1978	2.7	1.300				
1978 – 1992	2.7	1.300				
1993 – 2001	2.7	1.300				
2002 – 2005	2.8	1.260				
> 2005	2.8	1.260				
Title 24	2.8	1.260				
Measure	3.5	1.008				

D03-118, 119 & 120 High Efficiency Screw Chillers						
	< 150 Tons (118)		150 – 300 Tons (119)		> 300 Tons (120)	
Vintage	COP	kW/Ton	COP	kW/Ton	COP	kW/Ton
< 1978	4.7	0.750	4.7	0.750	4.7	0.750
1978 – 1992	4.7	0.750	4.7	0.750	4.7	0.750
1993 – 2001	4.7	0.750	4.7	0.750	4.7	0.750
2002 – 2005	5.5	0.634	5.5	0.634	5.5	0.634
> 2005	5.5	0.634	5.5	0.634	5.5	0.634
Title 24	4.5	0.790	4.9	0.718	5.5	0.639
Measure	5.6	0.632	6.1	0.574	6.9	0.511

D03-43 Gas Absorption Chiller						
	All					
Vintage	COP	kW/Ton				
< 1978	4.7	0.750				
1978 – 1992	4.7	0.750				
1993 – 2001	4.7	0.750				
2002 – 2005	5.5	0.634				
> 2005	5.5	0.634				
Title 24	5.5	0.634				
Measure	1.0	n/a	Gas COP – Btu/Btu			

Methodology (General): The DOE 2.2 CHILLER keyword ELEC-INPUT-RATIO is input as the inverse of chiller Coefficient of Performance (COP). The DOE 2.2 CHILLER keyword TYPE is assigned the value for the type of chiller (ELEC-HERM-CENT, ELEC-HERM-REC, ELEC-SCREW or GAS-ABSOR). The DOE 2.2 keyword CONDENSER-TYPE is assigned the value for the condenser type of the chiller (WATER-COOLED or AIR-COOLED).

Methodology (VSD Chillers): In addition to simulating a COP that is 20 percent better than requirements listed in Title 24, Table 112-D, Page 44, VSD Chillers must also operate with some form of condenser relief so that the compressor is allowed to reduce speed as the cooling load decreases. To do this, the condenser water CIRCULATION-LOOP keyword COOL-SETPT-CTRL is set to "LOAD-RESET". This allows the condenser water temperature to reset based on the cooling load placed on it by the chiller.

Methodology (Absorption Chillers): The prototype and code baselines for the absorption chiller are a water-cooled centrifugal chiller with a capacity range of 150 – 300 tons.

High Efficiency Centrifugal Chillers < 150 Tons	
ID: **D03-040**	Abbreviation: **ChlC1**
Measure Description	Centrifugal chillers (< 150 tons) with improved kW/ton
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled centrifugal chiller (0.700 kW/ton)
Measure Characteristics	Water cooled centrifugal chiller (0.560 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Centrifugal Chillers 150-299 Tons	
ID: **D03-116**	Abbreviation: **ChlC2**
Measure Description	Centrifugal chillers (150-299 tons) with improved kW/ton
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled centrifugal chiller (0.634 kW/ton)
Measure Characteristics	Water cooled centrifugal chiller (0.507 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Centrifugal Chillers >= 300 Tons	
ID: **D03-117**	Abbreviation: **ChlC3**
Measure Description	Centrifugal chillers (>= 300 tons) with improved kW/ton
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled centrifugal chiller (0.576 kW/ton)
Measure Characteristics	Water cooled centrifugal chiller (0.461 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency VSD Centrifugal Chillers < 150 Tons	
ID: **D03-042**	Abbreviation: **ChlV1**
Measure Description	VSD Centrifugal Chiller (< 150 tons) w/Load control tower
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled VSD centrifugal chiller (0.700 kW/ton), fixed temp tower
Measure Characteristics	Water cooled VSD centrifugal chiller (0.560 kW/ton), load control tower
Savings Reporting Units	Tons
Savings Scalable By	n/a

High Efficiency VSD Centrifugal Chillers 150-299 Tons	
ID: **D03-121**	Abbreviation: **ChlV2**
Measure Description	VSD Centrifugal Chiller (150-299 tons) w/Load control tower
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled VSD centrifugal chiller (0.634 kW/ton), fixed temp tower
Measure Characteristics	Water cooled VSD centrifugal chiller (0.507 kW/ton), load control tower
Savings Reporting Units	Tons
Savings Scalable By	n/a

High Efficiency VSD Centrifugal Chillers >= 300 Tons	
ID: **D03-122**	Abbreviation: **ChlV3**
Measure Description	VSD Centrifugal Chiller (>= 300 tons) w/Load control tower
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: water cooled VSD centrifugal chiller (0.576 kW/ton), fixed temp tower
Measure Characteristics	Water cooled VSD centrifugal chiller (0.461 kW/ton), load control tower
Savings Reporting Units	Tons
Savings Scalable By	n/a

High Efficiency Air-Cooled Recip Packaged Chillers	
ID: **D03-041**	Abbreviation: **ChlRA**
Measure Description	Reciprocating air-cooled chillers with improved kW/ton
Baseline Characteristics	Recip Chlr, air-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: air cooled package reciprocating chiller (1.260 kW/ton)
Measure Characteristics	Air cooled package reciprocating chiller (1.008 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Water-Cooled Recip Chillers	
ID: **D03-115**	Abbreviation: **ChlRW**
Measure Description	Reciprocating water-cooled chillers with improved kW/ton
Baseline Characteristics	Recip Chlr, water-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: water cooled reciprocating chiller (0.837 kW/ton)
Measure Characteristics	Water cooled reciprocating chiller (0.672 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Air-Cooled Screw Packaged Chillers	
ID: **D03-114**	Abbreviation: **ChlSA**
Measure Description	Air-cooled screw chiller with improved kW/ton
Baseline Characteristics	Screw Chlr, air-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: air cooled package screw chiller (1.260 kW/ton)
Measure Characteristics	Air cooled screw chiller (1.008 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Screw Chillers < 150 Tons	
ID: **D03-118**	Abbreviation: **ChlS1**
Measure Description	Water-cooled screw chiller (< 150 tons) with improved kw/ton
Baseline Characteristics	Screw Chlr, water-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: water cooled screw chiller (0.790 kW/ton)
Measure Characteristics	Water cooled screw chiller (0.632 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Screw Chillers 150-299 Tons	
ID: **D03-119**	Abbreviation: **ChlS2**
Measure Description	Water-cooled screw chiller (150-299 tons) with improved kw/ton
Baseline Characteristics	Screw Chlr, water-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: water cooled screw chiller (0.718 kW/ton)
Measure Characteristics	Water cooled screw chiller (0.574 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

High Efficiency Screw Chillers >= 300 Tons	
ID: **D03-120**	Abbreviation: **ChlS3**
Measure Description	Water-cooled screw chiller (>= 300 tons) with improved kw/ton
Baseline Characteristics	Screw Chlr, water-cooled cond (kW/ton (based on vintage))
Code Baseline Characteristics	T24 minimum: water cooled screw chiller (0.639 kW/ton)
Measure Characteristics	Water cooled screw chiller (0.511 kW/ton)
Savings Reporting Units	Tons
Savings Scalable By	Δ (kW/ton)

Gas Absorption Chiller	
ID: **D03-043**	Abbreviation: **ChlrG**
Measure Description	Gas Absorption Central Chiller (direct fired)
Baseline Characteristics	Cent Chlr, water cooled cond (kW/ton (based on vint))
Code Baseline Characteristics	T24 minimum: centrifugal chiller (0.634 kW/ton)
Measure Characteristics	Gas absorption chiller (direct fired) (1.0 COP)
Savings Reporting Units	Tons
Savings Scalable By	n/a

Prior to specifying chiller performance characteristics, any DEER model utilizing a chilled water plant goes through a process of CHW plant initialization (Section 6, Page 18).

MAS properties that are instrumental in determining the baseline, code baseline and measure chiller performance characteristics:

PrimWiz:ChillerType[1]	The chiller type is looked up from the chiller measure table based on the measure ID, vintage and processing step (0-baseline, 2-code baseline, 3-measure)

Water Loop Temperature Reset Measures

Chilled water reset controls save energy by improving chiller performance through increasing the supply chilled water temperature, which allows increased suction pressure during low load periods. Raising chilled water temperature also reduces chilled water piping losses by a small amount.

Hot water reset controls are used to change the temperature of hot water supplied to space heating coils from a hot water boiler. Energy is saved by reducing losses from piping systems, but has little impact on energy use of the boiler.

Current requirements for water temperature reset are found in Title 24, Section 144(j) 4, Page 99. For most applications, hot water and chilled water reset controls have been required by Title 24 since 1992. Therefore, results for this measure show report customer savings, but no beyond code savings.

Methodology (Chilled Water Reset): The DOE 2.2 CIRCULATION-LOOP keyword COOL-SETPT-CTRL is set to “LOAD-RESET” and MAX-RESET-T is set to 54.

Methodology (Hot Water Reset): The DOE 2.2 CIRCULATION-LOOP keyword HEAT-SETPT-CTRL is set to “LOAD-RESET” and MIN-RESET-T is set to 140.

Chilled Water Reset	
ID: **D03-044**	Abbreviation: **CHWRs**
Measure Description	Chilled Water Loop temperature control
Baseline Characteristics	Constant chilled water temperature
Code Baseline Characteristics	T24 minimum: variable flow CHW loop w/VSD pump
Measure Characteristics	Chilled water loop temperature set to 'Load Reset'
Savings Reporting Units	1000 sqft CHW-served
Savings Scalable By	n/a

Hot Water Reset	
ID: **D03-045**	Abbreviation: **HWRst**
Measure Description	Hot Water Loop temperature control
Baseline Characteristics	Constant hot water temperature
Code Baseline Characteristics	T24 minimum: variable flow HW loop w/VSD pump
Measure Characteristics	Hot water loop temperature set to 'Load Reset'
Savings Reporting Units	1000 sqft HW-served
Savings Scalable By	n/a

Variable Flow Water Loop Measures

In buildings with hot water heating or chilled water cooling, water is pumped to heating or cooling coils located throughout the building. Peak design flow rates for hot water and chilled water are rarely needed to meet space conditioning loads. Individual flow requirements for each coil will vary with load. In older systems as well as a limited number of newer systems, flow through heating and cooling coils is varied using three-way valves. Whatever amount of water is not needed is bypassed at the coil. In these cases the flow through the circulation loop remains constant.

Changing three-way valves at coils to two-way valves will cause the overall flow in a circulation loop to vary with the total load of the hot or chilled water coils. While the pump speed remains constant, there is still reduced pumping energy as the pump unloads on its curve with decrease in flow. There is also a reduction in piping losses as overall flow in the system drops.

Current requirements for variable flow hycronic systems are contained in Title 24, Section 144(j) 1, Page 99. For most systems, Title 24 has required variable flow hot and chilled water systems since 1992, so this measure will not have above code savings.

Methodology: Variable flow hot and chilled water loops are simulated in DOE 2.2 by changing the SYSTEM keywords HW-VALVE-TYPE and CHW-VALVE-TYPE from "THREE-WAY" to "TWO-WAY".

Variable Flow Chilled Water Loop	
ID: **D03-046**	Abbreviation: **CHWVF**
Measure Description	Replace 3-way valves in CHW loop with 2-way
Baseline Characteristics	3-way valves in chilled water loop
Code Baseline Characteristics	T24 minimum: variable flow CHW loop w/VSD pump
Measure Characteristics	2-way valves, with single speed pump
Savings Reporting Units	nameplate HP
Savings Scalable By	n/a

Variable Flow Hot Water Loop	
ID: **D03-048**	Abbreviation: **HWVFl**
Measure Description	Replace 3-way valves in HW loop with 2-way
Baseline Characteristics	3-way valves in hot water loop
Code Baseline Characteristics	T24 minimum: variable flow HW loop w/VSD pump
Measure Characteristics	2-way valves, with single speed pump
Savings Reporting Units	nameplate HP
Savings Scalable By	n/a

VSD Water Loop Pump Measures

While reducing required flow without changing pump speeds converting hydronic loops to variable flow (as in Measure ID D03-046 and Measure ID D03-048) will reduce pipe losses and pumping energy, the addition of a variable speed drive, or VSD, will save even more energy. VSDs vary the pump speed to meet flow requirements and therefore significantly reduce the amount of power needed to drive the pump during low load conditions. Current requirements for variable flow hydronic loops are contained in Title 24, Section 144(j) 1, Page 99. For most systems, 2005 Title 24 requires variable speed drives on hydronic loops with variable flow capability.

Methodology: Input files for buildings with hot water heating or chilled water cooling are set up as described for Measure ID D03-046 and Measure ID D03-048. Additionally, the DOE 2.2 PUMP keyword CAP-CTRL is set to “VAR-SPEED-PUMP” to simulate a variable speed drive on a pump.

VSD Chilled Water Loop Pump	
ID: **D03-047**	Abbreviation: **CHWVP**
Measure Description	Variable speed drive for chilled water loop
Baseline Characteristics	2-way valves, with single speed pump
Code Baseline Characteristics	T24 minimum: variable flow CHW loop w/VSD pump
Measure Characteristics	Add variable speed pump to chilled water loop
Savings Reporting Units	nameplate HP
Savings Scalable By	n/a

VSD Hot Water Loop Pump	
ID: **D03-049**	Abbreviation: **HWVPm**
Measure Description	Variable speed drive for hot water loop
Baseline Characteristics	2-way valves, with single speed pump
Code Baseline Characteristics	T24 minimum: variable flow HW loop w/VSD pump
Measure Characteristics	Add variable speed pump to hot water loop
Savings Reporting Units	nameplate HP
Savings Scalable By	n/a

Variable Air Volume Conversion Measure

Conversion of constant volume reheat systems to variable air volume with reheat systems saves significant heating, cooling and fan energy. A conversion involves replacing reheat coils with variable air volume boxes for each zone, controls to the fan that enable fan flow to be reduced and additional zone controls for the variable air volume dampers.

Current restrictions on simultaneous heating and cooling are contained in Title 24, Section 144(d), Page 97. Variable volume systems have been required, whenever reheat is utilized, by Title 24 since 1978. Therefore this measure is only applicable to the oldest vintage of prototypes with central VAV systems.

Methodology: Variable volume systems are simulated by converting constant volume zone terminals to variable volume. The DOE 2.2 ZONE keyword MIN-FLOW-RATIO input is changed from 1 (no VAV) to 0.3 allowing flow to the zone to drop to 30% of design flow during low cooling load and heating conditions. Additionally, fan control is changed to be a forward curved fan with discharge dampers.

Variable Air Volume Box	
ID: **D03-050**	Abbreviation: **VAVBx**
Measure Description	VAV box retrofit on constant volume system
Baseline Characteristics	Constant Volume air flow
Code Baseline Characteristics	T24 minimum: VAV w/30% min-cfm-ratio & w/VSD fans
Measure Characteristics	damper controlled VAV with 30% min-cfm-ratio
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

VSD Supply Fan Measure

Variable speed drives on supply and return fans reduce fan energy compared to flow restricting technologies such as inlet vanes and discharge dampers because the VSD will vary the fan speed with load, greatly reducing electrical input at low flow conditions.

Methodology: The baseline fans are simulated as forward curved fans with discharge dampers. The oldest vintage prototypes with central systems include constant volume reheat systems. For this measure, the oldest vintage prototypes include variable air volume systems so that a comparison is possible between VSD fans and forward curved fans with discharge dampers. Current requirements for variable flow fans are contained in Title 24, Section 144(c) 2, Page 96. Generally, Title 24 has required VSDs for larger supply fans since 1992. Therefore, no above code savings are reported for this measure.

VSD Supply Fan Motors	
ID: **D03-051**	Abbreviation: **VSDSF**
Measure Description	Variable Frequency Drive motors use on VAV fans
Baseline Characteristics	damper controlled VAV with 30% min-cfm-ratio
Code Baseline Characteristics	T24 minimum: VAV w/30% min-cfm-ratio & w/VSD fans
Measure Characteristics	VFD with 30% min-cfm-ratio
Savings Reporting Units	nameplate HP
Savings Scalable By	n/a

Fan Powered Mixing Box Measure

Fan powered zone mixing boxes operate as standard VAV boxes in cooling mode. In heating mode the fan operates to increase the flow above the minimum flow setting of the box. Additional air is drawn from the return plenum or the surrounding space. The use of the fan during heating mode provides more consistent airflow to the space and can sometimes offset the need for reheat by drawing warmer return air into the supply air stream.

Methodology: The baseline system is assumed to be a VAV system with all zone VAV boxes set to have a minimum flow rate of 30 percent of the peak design flow. The measure building has a PIU system with parallel fan powered VAV boxes where the fan operates at 50 percent of the peak design flow. Minimum VAV position is 30 percent of the peak design flow.

Fan Powered Mixing Boxes	
ID: **D03-052**	Abbreviation: **FPMBx**
Measure Description	Convert VAVS system to PIU system
Baseline Characteristics	damper controlled VAV with 30% min-cfm-ratio
Code Baseline Characteristics	T24 minimum: VAV w/30% min-cfm-ratio & w/VSD fans
Measure Characteristics	Convert VAVS sytem to PIU system
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

Evaporative Cooling Measures

Outdoor air is cooled first by an indirect add-on evaporative cooling unit. This unit provides only sensible cooling so that the humidity of the outside air is not raised by the evaporative cooling process. There are two measures in this category: Measure ID D03-053 applies to central, built-up variable air volume and constant volume reheat systems. Measure ID D03-054 applies to all direct expansion cooling systems including packaged variable air volume and packaged single zone systems.

Methodology: The add-on evaporative cooler is simulated as an indirect type with an effectiveness of 0.65. The evaporative cooling unit may run when mechanical cooling is required and the drybulb limit is 100 degrees F. The snippet from the measure DOE-2 input file is provided below:

```
EVAP-CL-TYPE     = INDIRECT
EVAP-CL+M-SUP    = TOGETHER
EVAP-CL+REC-RA   = NO
INDIR-EFF        = 0.65
EVAP-CL-LIMIT-T  = 100
EVAP-CL-AIR      = 1
```

Evap Cool Indirect - Central System	
ID: **D03-053**	Abbreviation: **EvpIC**
Measure Description	Make-up Air Indirect Evaporative cooling
Baseline Characteristics	Central system: Chlr type, eff. and cond type based on bldg/vintage
Code Baseline Characteristics	T24 HVAC matches prototype characteristics
Measure Characteristics	indirect evap cooling for make-up air only, 65% effectiveness
Savings Reporting Units	tons of coils served
Savings Scalable By	n/a

Evap Cool Indirect - Packaged Sys	
ID: **D03-054**	Abbreviation: **EvpIP**
Measure Description	Make-up Air Indirect Evaporative cooling
Baseline Characteristics	no evaporative cooling
Code Baseline Characteristics	T24 HVAC matches prototype characteristics
Measure Characteristics	indirect evap cooling for make-up air only, 65% effectiveness
Savings Reporting Units	tons of coils served
Savings Scalable By	n/a

Overventilation Reduction Measure

Methodology: Ventilation rates in all prototypes are simulated by setting outside air ventilation rates in the DOE 2.2 ZONE properties. The baseline ventilation rates for this measure are set to be 25 percent higher than ventilation rates required by Title 24, Section 121(b), Page 63. Measure ventilation rates remain at the minimum amounts required by Title 24, Section 121(b), Page 63.

Reducing Overventilation	
ID: **D03-055**	Abbreviation: **RedOV**
Measure Description	Base ventilation rate 25% higher than required
Baseline Characteristics	Ventilation rate increased by 25%
Code Baseline Characteristics	T24 ventilation matches baseline characteristics
Measure Characteristics	standard ventilation rate
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Heat Recovery Measures

Heat recovery from exhaust air can reduce heating energy by utilizing energy in warm exhaust air to preheat outside air to a building. Air to air heat exchangers recover only sensible heat from the exhaust air and are applicable to many types of exhaust applications including those with higher contaminant or humidity levels. Rotary (or wheel type) heat recovery systems recover sensible and latent heat from the exhaust stream and are less appropriate for contaminated or high humidity air streams such as in hospital and manufacturing applications.

Methodology (air to air heat exchanger): The measure building systems include air to air heat exchangers with the following characteristics:

- 70% effectiveness,
- 0.9 inches h2o static for both the exhaust and outside air,
- self-contained fans,
- active whenever exhaust to outside temperature difference is greater than 5 degrees, and
- outside air bypasses heat exchanger when heat recovery not available or when more exhaust heat recovery is available than is needed to preheat outside air stream.

Methodology (rotary heat recovery): The measure building systems include rotary heat recovery equipment with the following characteristics:

- 70% sensible and latent effectiveness,
- 0.6 inches h2o static for both the exhaust and outside air,
- Self-contained fans,
- Active whenever exhaust to outside temperature difference is greater than 5 degrees,

- The heat wheel does not rotate when heat recovery not available or when more exhaust heat recovery is available than is needed to preheat outside air stream, and
- Purge air flow rate of 7.5% of outside air flow rate.

Air To Air Heat Exchanger	
ID: **D03-056**	Abbreviation: **AAHEx**
Measure Description	heat recovery from exhaust hoods
Baseline Characteristics	no exhaust heat recovery
Code Baseline Characteristics	T24 minimum: no exhaust heat recovery
Measure Characteristics	70% heat recovery effectiveness
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Rotary Heat Recovery	
ID: **D03-057**	Abbreviation: **RotHR**
Measure Description	rotary air-to-air enthalpy heat recovery
Baseline Characteristics	no exhaust heat recovery
Code Baseline Characteristics	T24 minimum: no exhaust heat recovery
Measure Characteristics	70% sensible and latent recovery effectiveness
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Economizer Retrofit Measures

Title 24, Section 144(e), Page 97, requires air economizers on most systems. Many buildings built prior to the existence of Title 24 did not have air handling systems that were equipped with air economizers. Addition of air economizers can significantly reduce cooling energy use by utilizing cool outside air instead of mechanical cooling to meet cooling loads whenever possible.

Methodology: For the oldest vintage of buildings (< 1978) air economizers are added with the following characteristics:

- 100% maximum outside air fraction,
- Simultaneous economizer and mechanical cooling capability, and
- Dry bulb temperature control with 68 degree high limit.

Economizer - Packaged System	
ID: **D03-058**	Abbreviation: **EconP**
Measure Description	Packaged system Economizer retrofit
Baseline Characteristics	No Economizer
Code Baseline Characteristics	T24 baseline matches prototype
Measure Characteristics	Add econo with Econo-Lockout=NO, DB limit = 68, Max OSA = 100%
Savings Reporting Units	tons served
Savings Scalable By	n/a

Economizer - Central system	
ID: **D03-059**	Abbreviation: **EconC**
Measure Description	Central HVAC system Economizer retrofit
Baseline Characteristics	No Economizer
Code Baseline Characteristics	T24 baseline matches prototype
Measure Characteristics	Add ecomizer with Econo-Lockout=NO, DB limit = 68, Max OSA = 100%
Savings Reporting Units	tons served
Savings Scalable By	n/a

Economizer Maintenance Measure

Methodology:The baseline economizer operation is assumed to have degraded over time and has a high limit of 55 degrees and 60 percent maximum outside air fraction. The measure economizer has a high limit of 68 degrees and 100 percent maximum outside air fraction.

Economizer Maintenance	
ID: **D03-060**	Abbreviation: **EconM**
Measure Description	Restore degraded economizer performance
Baseline Characteristics	degraded base econo performance, DB limit = 55, Max OSA = 60%
Code Baseline Characteristics	T24 minimum: economizer matches baseline characteristics
Measure Characteristics	ecomizer with Econo-Lockout=NO, DB limit = 68, Max OSA = 100%
Savings Reporting Units	tons served
Savings Scalable By	n/a

Condenser Coil Cleaning Measure

Cleaning air-cooled condenser coils on direct expansion cooling equipment restores heat rejection capabilities and system efficiency.

Methodology: For the measure, cooling equipment efficiency is maintained at the prototype levels. Baseline efficiency is "degraded" by fifteen percent. This is accomplished by increasing it's cooling electric input ratio (COOLING-EIR) by fifteen percent over prototype levels. Note that the EER of direct expansion cooling equipment includes the contribution of the supply fan to system energy use. This contribution must be removed to determine the portion of energy due to compressor and condenser operation. The DOE 2.2 SYSTEM keyword COOLING-EIR represents the efficiency of the compressor and condenser.

Clean Condenser Coils	
ID: **D03-061**	Abbreviation: **ClnCC**
Measure Description	Dirty Air-cooled condenser coils are cleaned
Baseline Characteristics	cooling equipment efficiency is degraded by 15%
Code Baseline Characteristics	T24 minimum matches baseline HVAC
Measure Characteristics	standard equipment efficiency
Savings Reporting Units	tons served
Savings Scalable By	n/a

Cooling Tower For Packaged System Measure

Water cooled direct expansion cooling equipment is more efficient than air-cooled equipment due to the improved heat rejection capabilities of the water cooled condensers. Even though additional energy use is needed for pumps and cooling towers, the overall energy use of water cooled systems is usually lower than comparable air cooled systems.

Methodology: It is unlikely that only the condenser portion of an air cooled air conditioner would be replaced with a water cooled condenser. Therefore the measure includes replacement of all air conditioning equipment with water cooled equipment with an EER of 13.8. This value is 20% better than the requirement found in Title 20, Table C-5, Page 78 for equipment in the 65,000 to 135,000 Btuh capacity range. The added condenser water loop operates at a constant flow rate at a fixed head of 30 feet. A fluid cooler is also be added that operates at an electric input ratio of 0.035 Btu in/Btu out.

Cooling Tower for Packaged System	
ID: **D03-062**	Abbreviation: **CTwrP**
Measure Description	Convert Air-Cooled Condenser to Water-Cooled
Baseline Characteristics	Packaged system with air-cooled condenser
Code Baseline Characteristics	T24 minimum: air-cooled package A/C EER = 10.1
Measure Characteristics	packaged system with water cooled condenser
Savings Reporting Units	tons served cooling cap
Savings Scalable By	n/a

Two Speed Cooling Tower Fan Measure

Methodology: The cooling tower for the measure building is identical to the baseline building except the measure building has a two speed fan. Title 24, Section 144(h) 2, Page 98 requires two speed fans for most cooling towers so this measure has no reportable above code savings.

Two-Speed Cooling Tower Fans	
ID: **D03-063**	Abbreviation: **TF2Sp**
Measure Description	Two-Speed Tower Fans replace Single-Speed
Baseline Characteristics	Single-speed tower fans on all central plants
Code Baseline Characteristics	T24 minimum: two-speed tower fans
Measure Characteristics	Two-speed tower fans on all central plants
Savings Reporting Units	tons served cooling cap
Savings Scalable By	n/a

Variable Speed Drive Cooling Tower Fan Measure

Methodology: The cooling tower for the measure building is identical to the baseline building except the measure building has a variable speed fan and the baseline building has a two speed fan. Title 24, Section 144(h) 2, Page 98 requires two speed fans for most cooling towers so this measure has only reportable above code savings.

VSD Cooling Tower Fans	
ID: **D03-064**	Abbreviation: **TFVSD**
Measure Description	Variable-Speed Tower Fans replace Two-Speed
Baseline Characteristics	Two-speed tower fans on all central plants
Code Baseline Characteristics	T24 minimum: two-speed tower fans
Measure Characteristics	Variable-speed tower fans on all central plants
Savings Reporting Units	tons served cooling cap
Savings Scalable By	n/a

High Efficiency Furnace Measure

Methodology: Baseline AFUE is 78% and Measure AFUE is 94%. AFUE is converted to the DOE 2.2 SYSTEM keyword FURNACE-HIR using the following equation (ACM Manual, Equation N2-26, Page 2-64):

$$\text{FURNACE-HIR} = 1 / (0.005163 \text{ X AFUE} + 0.4033)$$

This results in values for FURNACE-HIR of 1.24067 and 1.12534 for the baseline and measure buildings respectively.

Efficient Gas Furnace	
ID: **D03-065**	Abbreviation: **GFEff**
Measure Description	High efficiency gas furnace replace std efficiency
Baseline Characteristics	packaged system with 78 AFUE furnace
Code Baseline Characteristics	T24 minimum: furnace AFUE = 78
Measure Characteristics	packaged system with 94 AFUE furnace
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/AFUE)

High Efficiency Large Boiler Measure

Methodology: Baseline thermal efficiency is 80% and measure thermal efficiency is 85%. Boiler efficiency is simulated in DOE 2.2 using the BOILER keyword HEAT-INPUT-RATIO, which is equal to the inverse of thermal efficiency.

High Efficiency Large Boilers	
ID: **D03-066**	Abbreviation: **BLHEf**
Measure Description	High efficiency Large boiler (>300 kBTU/hr)
Baseline Characteristics	Central boiler with efficiency of 80% (Thermal Efficiency)
Code Baseline Characteristics	T24 minimum: boiler thermal efficiency = 75%
Measure Characteristics	Central boiler with efficiency of 85% (Thermal Efficiency)
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/Eff)

High Efficiency Small Boiler Measure

Methodology: Baseline AFUE is 80% and Measure AFUE is 84.5%. AFUE is converted to the DOE 2.2 BOILER keyword HEAT-INPUT-RATIO using the following equation (ACM Manual, Equation N2-30, Page 2-66):

$$\text{HEAT-INPUT-RATIO} = 100 / (0.875 \times \text{AFUE} + 10.5)$$

This results in values for HEAT-INPUT-RATIO of 1.24224 and 1.18431 for the baseline and measure buildings respectively.

High Efficiency Small HW Boilers	
ID: **D03-067**	Abbreviation: **BSHHE**
Measure Description	High efficiency Small boiler (<300 kBTU/hr)
Baseline Characteristics	Central hot water boiler with efficiency of 80% (AFUE)
Code Baseline Characteristics	T24 minimum: boiler AFUE = 80%
Measure Characteristics	Central boiler with efficiency of 84.5% (AFUE)
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/Eff)

High Efficiency Steam Boiler Measure

Methodology: Baseline thermal efficiency is 80% and measure thermal efficiency is 82%. Boiler efficiency is simulated in DOE 2.2 using the BOILER keyword HEAT-INPUT-RATIO, which is equal to the inverse of thermal efficiency.

High Efficiency Small Steam Boilers	
ID: **D03-068**	Abbreviation: **BSSHE**
Measure Description	High efficiency Steam boiler (<300 kBTU/hr)
Baseline Characteristics	Central steam boiler with efficiency of 80%
Code Baseline Characteristics	T24 minimum: boiler combustion = 80%
Measure Characteristics	Central steam boiler with efficiency of 82%
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/Eff)

High Efficiency Water Source Heat Pump Measure

Methodology: This measure assumes only existing zonal water source heat pumps are removed and replaced with water source heat pumps with 14.0 EER and 4.6 COP. Equipment efficiencies by prototype vintage are:

- Before 1978: 8.7 EER/3.0 COP,
- 1978 – 1992: 8.7 EER/3.0 COP,
- 1993 – 2001: 10.5 EER/3.8 COP,
- 2002 – 2005: 12.0 EER/4.2 COP, and
- After 2005: 12.0 EER/4.2 COP.

Current requirements for water source heat pumps are contained in Title 20, Table C-5, Page 78. These requirements have not changed since 2002 so only above code savings are reported for the latest two vintages.

Efficient Water Source Heat Pump	
ID: **D03-069**	Abbreviation: **WSHtP**
Measure Description	High efficiency WLHP system for Large Office

Baseline Characteristics	WLHP system with EER / COP based on vintage
Code Baseline Characteristics	T24 minimum: WLHP EER = 12.0, COP = 4.2
Measure Characteristics	WLHP system with 14.0 EER / 4.6 COP
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (1/COP)

Variable Flow Hydronic Heat Pump Loop Measure

Methodology: Variable circulation loop flow is accomplished by installing two-way valves on all water loop heat pumps. The input for the DOE 2.2 SYSTEM keyword CW-VALVE is changed from "THREE-WAY" to "TWO-WAY". Additionally, the DOE 2.2 PUMP keyword CAP-CTRL is set to "VAR-SPEED-PUMP" to simulate a variable speed drive on a pump.

Current requirements for water source heat pump circulation loops are contained in Title 24, Sections 144 (j) 5&6, Pages 99,100. Title 24 requires variable flow loops with VSDs for most water source heat pump systems so no above code savings are reported for this measure.

Hydronic Heat Pump Var Flow Valve	
ID: **D03-070**	Abbreviation: **HHPVF**
Measure Description	Variable flow hydronic water loop
Baseline Characteristics	constant flow hydronic water loop
Code Baseline Characteristics	T24 minimum: variable flow WLHP loop w/VSD pump
Measure Characteristics	2-way valves, with VSD pumping
Savings Reporting Units	tons cooling
Savings Scalable By	n/a

Heating/Cooling Time Clock Measure

Methodology: The baseline for this measure assumes that fans are always on, even during night setback periods. The measure building changes fan operation during night setback periods so that the fan only turns on to heat or cool the space.

Current requirements for automatic fan control are contained in Title 24, Section 122(e), Page 66. Title 24 has always required automatic fan control. Therefore this measure is only applicable to the earliest vintage of prototypes and has no reported above code savings.

Time Clocks (heating/cooling)	
ID: **D03-071**	Abbreviation: **HCTmC**
Measure Description	time clocks control packaged system operation
Baseline Characteristics	Supply fan runs continuously
Code Baseline Characteristics	T24 minimum: supply fan operation matches building

	operation
Measure Characteristics	Supply fan operation matches building operation
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Energy Management System Measure

Methodology: This measure combines Measure ID D03-044 (Chilled Water Reset), Measure ID D03-045 (Hot Water Reset), Measure ID D03-071 (Heating/Cooling Time Clock) and Measure ID D03-010 (Lighting Timeclock) into a single measure that represents installation of a comprehensive building energy management system

Energy Management System	
ID: **D03-072**	Abbreviation: **HCEMS**
Measure Description	Suite of EMS measures
Baseline Characteristics	Central plant systems with no timeclock in OLD vintage
Code Baseline Characteristics	T24 minimum: CHW & HW reset, timeclock, reduced nighttime lighting levels
Measure Characteristics	CHW & HW reset, heating/cooling timeclocks and/or reduced nighttime lighting levels (depending on baseline & applicability)
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Setback Programmable Thermostat Measure

Methodology: The baseline for this measure assumes that temperature setpoints do not change during closed hours, but fan operation cycles during closed hours to meet heating and cooling loads. The measure building utilizes night/closed setback thermostats and fans cycle during night setback to meet heating and cooling loads.

Current requirements for automatic fan control are contained in Title 24, Section 122(e), Page 66. Title 24 has always required setback thermostats. Therefore this measure is only applicable to the earliest vintage of prototypes and has no reported above code savings.

Setback Programmable Thermostats	
ID: **D03-073**	Abbreviation: **PrTSt**
Measure Description	Install programmable thermostats in older bldgs
Baseline Characteristics	Standard building operation, no thermostat setback/setup
Code Baseline Characteristics	T24 minimum: setback programmable thermostat
Measure Characteristics	unoccupied period has heating setback/cooling setup
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

Duct Insulation Material Measure

Methodology: The addition of duct insulation to current Title 24 requirements of R-8 (Title 24, Section 124(a), Page 69) is simulated by changing the overall duct temperature loss from prototype values to the values for the 2005 vintage in all buildings.

Duct Insulation Material	
ID: **D03-075**	Abbreviation: **DctIn**
Measure Description	Increased duct insulation in older vintages
Baseline Characteristics	Duct insulation level a function of Vintage/System type
Code Baseline Characteristics	T24 minimum: duct insulation level, R-8
Measure Characteristics	Old vintage increases duct insulation to R-8
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

High Efficiency Air Conditioner Measures (SEER Rated Equipment)

The challenge of simulating direct expansion cooling equipment rated with SEER is that SEER is not directly translatable to any DOE 2.2 inputs while EER can be directly translated to the DOE 2.2 SYSTEM keyword COOLING-EIR. This is discussed in the report published by Southern California Edison: “EER & SEER as Predictors of Seasonal Cooling Performance.” Some of the research and results presented in this report establish a reasonable typical relationship between SEER and EER for packaged equipment used in typical small commercial applications, shown in the table below:

SEER	EER
8.30*	7.76
8.50*	7.93
9.30*	8.60
9.50*	8.76
9.70	8.92
10.00	9.17
12.00	10.41
13.00	11.09
14.00	12.15

*Values for SEER < 9.7 are extrapolated down from the larger values.

Methodology: EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

H.E. Air-Cooled Package A/C < 65k (single phase)	
ID: **D03-078**	Abbreviation: **APA11**
Measure Description	High eff. packaged unitary system A/C (< 65k, single phase)
Baseline Characteristics	8.3 – 13.0 SEER (based on prototype and vintage) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 13 SEER(11.09 EER) Package Air Conditioner
Measure Characteristics	14 SEER (12.15 EER) Package Air Conditioner
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Package A/C < 65k (12 SEER, 3 phase before 2008)	
ID: **D03-109**	Abbreviation: **APA32**
Measure Description	High eff. packaged unitary system A/C (< 65k, 12 SEER, 3 phase before 2008)
Baseline Characteristics	8.3 – 10.0 SEER (based on prototype and vintage) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10 SEER(9.17 EER) Package Air Conditioner
Measure Characteristics	12 SEER(10.41 EER) three phase package A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Package A/C < 65k (13 SEER, 3 phase before 2008)	
ID: **D03-110**	Abbreviation: **APA33**
Measure Description	High eff. packaged unitary system A/C (< 65k, 13 SEER, 3 phase before 2008)
Baseline Characteristics	8.3 – 10.0 SEER (based on prototype and vintage) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10 SEER(9.17 EER) Package Air Conditioner
Measure Characteristics	13 SEER(11.09 EER) three phase package A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Split A/C < 65k (single phase)	
ID: **D03-076**	Abbreviation: **ASA11**
Measure Description	High eff. packaged split system A/C (< 65k, single phase)
Baseline Characteristics	8.3 – 13.0 SEER (based on prototype and vintage) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 13 SEER(11.09 EER) Split System Air Conditioner
Measure Characteristics	14 SEER (12.15 EER) Split-System Air Conditioner
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Split A/C < 65k (3 phase before 2008)	
ID: **D03-108**	Abbreviation: **ASA32**
Measure Description	High eff. packaged split system A/C (< 65k, 3 phase before 2008)
Baseline Characteristics	8.3 – 10.0 SEER (based on prototype and vintage) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10 SEER(9.17 EER) Split System Air Conditioner
Measure Characteristics	12 SEER(10.41 EER) three phase split-system A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

High Efficiency Central Air Conditioner Measures (EER Rated Equipment)

Methodology: Measure efficiencies generally align with utility program levels and Consortium for Energy Efficiency (CEE) guidelines. Equipment efficiencies for each measure are listed in the table below:

	Measure			
Vintage	**D03-079 (65k-134k)**	**D03-103 (135-239k)**	**D03-104 (240-759k)**	**D03-105 >=760k**
< 1978	7.70	7.70	7.70	7.70
1978 – 1992	8.90	8.30	8.30	8.00
1993 – 2001	8.90	8.30	8.30	8.00
2002 – 2005 *	10.10	9.50	9.30	9.00
> 2005 *	10.10	9.50	9.30	9.00
Measure *	11.00	10.80	10.00	9.70
Title 24 Baseline *	10.10	9.50	9.30	9.00

*Add 0.2 to all efficiencies for package VAV prototype systems since they do not have a central heating coil.

EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

H.E. Air-Cooled Split/Package A/C 65k-134k	
ID: **D03-079**	Abbreviation: **ASPA4**
Measure Description	High eff. packaged unitary system A/C (65-134k)
Baseline Characteristics	7.7 – 10.3 EER (based on prototype, vintage and system type) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10.1 EER Package Air Conditioner
Measure Characteristics	11 EER Package Air Conditioner
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package A/C 135-239k	
ID: **D03-103**	Abbreviation: **ASPA5**
Measure Description	High eff. packaged unitary system A/C (135-239k)
Baseline Characteristics	7.7 – 10.3 EER (based on prototype, vintage and system type) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10.8 EER Package Air Conditioner
Measure Characteristics	10.8 EER Package Air Conditioner
Savings Reporting Units	Tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package A/C 240-759k	
ID: **D03-104**	Abbreviation: **ASPA6**
Measure Description	High eff. packaged unitary system A/C (240-759k)
Baseline Characteristics	7.7 – 10.3 EER (based on prototype, vintage and system type) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 10.0 EER Package Air Conditioner
Measure Characteristics	10.0 EER Package Air Conditioner
Savings Reporting Units	Tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package A/C >= 760k	
ID: **D03-105**	Abbreviation: **ASPA7**
Measure Description	High eff. packaged unitary system A/C (>= 760k)
Baseline Characteristics	7.7 – 10.3 EER (based on prototype, vintage and system type) A/C, no economizer
Code Baseline Characteristics	T24 minimum: 9.7 EER Package Air Conditioner
Measure Characteristics	10.0 EER Package Air Conditioner
Savings Reporting Units	Tons served
Savings Scalable By	Δ (3.413/EER)

High Efficiency Water-Cooled Central Air Conditioner Measures

Methodology: Measure efficiencies generally align with utility program levels and Consortium for Energy Efficiency (CEE) guidelines. Equipment efficiencies for each measure are listed in the table below:

Vintage	D03-082 (65k-134k)	D03-83 (135-239k)
< 1978	9.30	10.50
1978 – 1992	9.30	10.50
1993 – 2001	9.30	10.50
2002 – 2005 *	9.30	10.50
> 2005 *	12.10	11.30
Measure *	14.00	14.00
Title 24 Baseline *	12.10	11.30

*Add 0.2 to all efficiencies for package VAV prototype systems since they do not have a central heating coil.

EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

H.E. Evap/Water-Cooled Pkg A/C < 65k	
ID: **D03-082**	Abbreviation: **EWCAS**
Measure Description	High eff. packaged system with evap cooled cond (< 65k)
Baseline Characteristics	Water-cooled packaged system (9.3 – 12.1 EER (based on vintage)), no economizer
Code Baseline Characteristics	T24 minimum: 12.1 EER Water-Cooled Package Air Conditioner
Measure Characteristics	14 EER Water-Cooled Package Air Conditioner
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Evap/Water-Cooled Pkg A/C >=65k	
ID: **D03-083**	Abbreviation: **EWCAL**
Measure Description	High eff. packaged system with evap cooled cond (>= 65k)
Baseline Characteristics	Water-cooled packaged system 10.5 – 11.3 EER (based on vintage)), no economizer
Code Baseline Characteristics	T24 minimum: 11.3 EER Water-Cooled Package Air Conditioner
Measure Characteristics	14 EER Water-Cooled Package Air Conditioner
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

High Efficiency Package Terminal Air Conditioner Measures

Measure efficiencies generally align with utility program levels and Consortium for Energy Efficiency (CEE) guidelines. Equipment efficiencies (EER) for each measure are listed in the table below:

	EER by Measure		
Vintage	**D03-084 (< 7k)**	**D03-099 (7-15k)**	**D03-100 (>15k)**
< 1978	6.80	6.80	6.80
1978 – 1992	7.80	7.80	7.80
1993 – 2001	8.50	8.50	8.50
2002 – 2005	8.88	8.50	8.50
> 2005	11.01	10.16	9.31
Measure (> 2005 vintage)	13.21	12.19	10.28
Measure (<= 2005 vintages)	11.29	10.27	9.25
Title 24 Baseline (> 2005 vintage)	11.01	10.16	9.31
Title 24 Baseline (<= 2005 vintages)	9.41	8.56	7.71

EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

$$\text{COOLING-EIR} = (1/\text{EER} - 0.012167)/0.30516$$

H.E. Package Terminal A/C < 7k	
ID: **D03-084**	Abbreviation: **PTAC1**
Measure Description	High eff. packaged terminal air-conditioner (< 7k)
Baseline Characteristics	6.8 – 11.01 EER (based on vintage) package terminal A/C
Code Baseline Characteristics	T24 minimum: 11.01 or 9.41 EER (based on vintage) package terminal A/C
Measure Characteristics	13.21 or 11.29 EER (based on vintage) package terminal A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Package Terminal A/C 7k-15k	
ID: **D03-099**	Abbreviation: **PTAC2**
Measure Description	High eff. packaged terminal air-conditioner (7-15k)
Baseline Characteristics	6.8 – 10.16 EER (based on vintage) package terminal A/C
Code Baseline Characteristics	T24 minimum: ##.## EER (based on vintage) package terminal A/C
Measure Characteristics	10.16 or 8.56 EER (based on vintage) package terminal A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Package Terminal A/C > 15k	
ID: **D03-100**	Abbreviation: **PTAC3**
Measure Description	High eff. packaged terminal air-conditioner (> 15k)
Baseline Characteristics	6.8 – 9.31 EER (based on vintage) package terminal A/C
Code Baseline Characteristics	T24 minimum: 9.31 or 7.71 EER (based on vintage) package terminal A/C
Measure Characteristics	10.28 or 9.25 EER (based on vintage) package terminal A/C
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

High Efficiency Central Heat Pump Measures (SEER/HSPF Rated Equipment)

The challenge of simulating direct expansion cooling equipment rated with SEER is that SEER is not directly translatable to any DOE 2.2 inputs while EER can be directly translated to the DOE 2.2 SYSTEM keyword COOLING-EIR. This is discussed in the report published by Southern California Edison: "EER & SEER as Predictors of Seasonal Cooling Performance." Some of the research and results presented in this report establish a reasonable typical relationship between SEER and EER for packaged equipment used in typical small commercial applications, shown in the table below:

SEER/HSPF	EER/COP
8.3/4.6*	8.08/2.08
8.5/4.6*	8.25/2.08
9.3/5.6*	8.94/2.48
9.5/5.6*	9.12/2.48
9.7/7.0	9.29/3.02
10.0/7.2	9.54/3.10
12.0/7.7	10.40/3.20
13.0/8.1	11.07/3.28
14.0/8.6	12.19/3.52

* Values for SEER < 9.7 are extrapolated down from the larger values.

Methodology: EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

COP is converted to the DOE 2.2 SYSTEM keyword HEATING-EIR using the following equation (based on ACM Manual, Section 2.5.2.9, Page 2-63 with capacity dependent terms removed):

HEATING-EIR = (1/(COP + 0.012167))/0.30516

H.E. Air-Cooled Package HP < 65k (single phase)	
ID: **D03-080**	Abbreviation: **APH11**
Measure Description	High eff. packaged unitary system HP (< 65k, single phase)
Baseline Characteristics	8.3 – 13.0 SEER / 4.6 – 8.1 HSPF (based on vintage) Heat Pump, no economizer
Code Baseline Characteristics	T24 minimum: 13 SEER (11.07 EER) / 8.1 HSPF (3.28 COP) A/C Heat pump
Measure Characteristics	14 SEER (12.19 EER) / 8.6 HSPF (3.52 COP) Package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Package HP < 65k (12 SEER, 3 phase before 2008)	
ID: **D03-112**	Abbreviation: **APH32**
Measure Description	High eff. packaged unitary system HP (< 65k, 12 SEER, 3 phase before 2008)
Baseline Characteristics	8.3 – 9.7 SEER / 4.6 – 6.6 HSPF (based on vintage) Heat Pump, no economizer
Code Baseline Characteristics	T24 minimum: 9.7 SEER / 6.6 HSPF A/C Heat pump
Measure Characteristics	12 SEER / 7.4 HSPF three phase package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Package HP < 65k (13 SEER, 3 phase before 2008)	
ID: **D03-113**	Abbreviation: **APH33**
Measure Description	High eff. packaged unitary system HP (< 65k, 13 SEER, 3 phase before 2008)
Baseline Characteristics	8.3 – 9.7 SEER / 4.6 – 6.6 HSPF (based on vintage) Heat Pump, no economizer
Code Baseline Characteristics	T24 minimum: 9.7 SEER / 6.6 HSPF A/C Heat pump
Measure Characteristics	13 SEER / 7.7 HSPF three phase package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Split HP < 65k (single phase)	
ID: **D03-077**	Abbreviation: **ASH11**
Measure Description	High eff. packaged split system HP (< 65k, single phase)
Baseline Characteristics	8.3 – 13.0 SEER / 4.6 – 8.1 HSPF (based on vintage) Heat Pump, no economizer
Code Baseline Characteristics	T24 minimum: 13 SEER (11.07 EER) / 8.1 HSPF (3.28 COP) A/C Heat pump
Measure Characteristics	14 SEER (12.19 EER) / 8.6 HSPF (3.52 COP) A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

H.E. Air-Cooled Split HP < 65k (3 phase before 2008)	
ID: **D03-111**	Abbreviation: **ASH32**
Measure Description	High eff. packaged split system HP (< 65k, 3 phase before 2008)
Baseline Characteristics	8.3 – 10.0 SEER / 4.6 – 6.8 HSPF (based on vintage) Heat Pump, no economizer
Code Baseline Characteristics	T24 minimum: 10 SEER / 6.8 HSPF A/C Heat pump
Measure Characteristics	12 SEER / 7.4 HSPF three phase split-system A/C heat pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/SEER)

High Efficiency Heat Central Pump Measures (EER/COP Rated Equipment)

Measure efficiencies generally align with utility program levels and Consortium for Energy Efficiency (CEE) guidelines. Equipment efficiencies (EER/COP) for each measure are listed in the table below:

	Measure			
Vintage	D03-081 (65k-134k)	D03-106 (135-239k)	D03-107 (240-759k)	D03-124 >=760k
< 1978	7.7/2.25	7.7/2.25	7.7/2.25	7.7/2.25
1978 – 1992	8.9/2.6	8.5/2.6	8.5/2.6	8.2/2.6
1993 – 2001	8.9/3	8.5/2.9	8.5/2.9	8.2/2.9
2002 – 2005 *	10.1/3.2	9.3/3.1	9/3.1	9/3.1
> 2005 *	10.1/3.2	9.3/3.1	9/3.1	9/3.1
Measure *	11/3.4	10.8/3.4	10/3.4	9.7/3.3
Title 24 Baseline *	10.1/3.2	9.3/3.1	9/3.1	9/3.1

Methodology: EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

COP is converted to the DOE 2.2 SYSTEM keyword HEATING-EIR using the following equation (based on ACM Manual, Section 2.5.2.9, Page 2-63 with capacity dependent terms removed):

HEATING-EIR = (1/(COP + 0.012167))/0.30516

H.E. Air-Cooled Split/Package HP 65k-134k	
ID: **D03-081**	Abbreviation: **ASPH4**
Measure Description	High eff. packaged unitary system HP (65-134k)
Baseline Characteristics	7.7 – 10.1 EER / 2.25 – 3.2 COP (based on vintage) Heat Pump, econo based on vintage
Code Baseline Characteristics	T24 minimum: 10.1 EER / 3.2 COP Split/Package A/C Heat Pump
Measure Characteristics	11 EER / 3.4 COP Split/Package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package HP 135-239k	
ID: **D03-106**	Abbreviation: **ASPH5**
Measure Description	High eff. packaged unitary system HP (135-239k)
Baseline Characteristics	7.7 – 9.3 EER / 2.25 – 3.1 COP (based on vintage) Heat Pump, econo based on vintage
Code Baseline Characteristics	T24 minimum: 9.3 EER / 3.1 COP Split/Package A/C Heat Pump
Measure Characteristics	10.8 EER / 3.4 COP Package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package HP 240-759k	
ID: **D03-107**	Abbreviation: **ASPH6**
Measure Description	High eff. packaged unitary system HP (240-759k)
Baseline Characteristics	7.7 – 9.0 EER / 2.25 – 3.1COP (based on vintage) Heat Pump, econo based on vintage
Code Baseline Characteristics	T24 minimum: 9.0 EER / 3.1 COP Split/Package A/C Heat Pump
Measure Characteristics	10.0 EER / 3.4 COP Package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Air-Cooled Split/Package HP >= 760k	
ID: **D03-124**	Abbreviation: **ASPH7**
Measure Description	High eff. packaged unitary system HP (>= 760k)
Baseline Characteristics	7.7 – 9.0 EER / 2.25 – 3.1COP (based on vintage) Heat Pump, econo based on vintage
Code Baseline Characteristics	T24 minimum: 9.0 EER / 3.1 COP Split/Package A/C Heat Pump
Measure Characteristics	9.7 EER / 3.3 COP Package A/C Heat Pump
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

High Efficiency Package Terminal Heat Pump

Measure efficiencies generally align with utility program levels and Consortium for Energy Efficiency (CEE) guidelines. Equipment efficiencies (EER) for each measure are listed in the table below:

	EER/COP by Measure		
Vintage	D03-084 (< 7k)	D03-099 (7-15k)	D03-100 (>15k)
< 1978	6.8/2.1	6.8/2.1	6.8/2.1
1978 – 1992	7.8/2.4	7.8/2.4	7.8/2.4
1993 – 2001	8.5/2.72	8.5/2.72	8.5/2.72
2002 – 2005	8.9/2.72	8.9/2.72	8.9/2.72
> 2005	10.81/3.02	9.96/2.91	9.11/2.81
Measure (> 2005 vintage)	12.97/3.62	11.95/3.49	10.93/3.37
Measure (<= 2005 vintages)	11.17/3.26	10.15/3.13	9.13/3.01
Title 24 Baseline (> 2005 vintage)	10.81/3.02	9.96/2.91	9.11/2.81
Title 24 Baseline (<= 2005 vintages)	9.31/2.72	8.46/2.61	7.61/2.51

Methodology: EER is converted to the DOE 2.2 SYSTEM keyword COOLING-EIR using the following equation (based on ACM Manual, Equation N2-31, Page 2-66 with capacity dependent terms removed):

COOLING-EIR = (1/EER - 0.012167)/0.30516

COP is converted to the DOE 2.2 SYSTEM keyword HEATING-EIR using the following equation (based on ACM Manual, Section 2.5.2.9, Page 2-63 with capacity dependent terms removed):

HEATING-EIR = (1/(COP + 0.012167))/0.30516

H.E. Package Terminal HP < 7k	
ID: **D03-085**	Abbreviation: **PTHP1**
Measure Description	High eff. packaged terminal heat pump (< 7k)
Baseline Characteristics	6.8 – 10.81 EER / 2.1 – 3.02 COP (based on vintage) package terminal HP
Code Baseline Characteristics	T24 minimum: 10.81 or 9.31 EER / 3.02 or 2.72 COP (based on vintage) package terminal HP
Measure Characteristics	12.97 or 11.17 EER / 3.62 or 3.26 COP (based on vintage) package terminal HP
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Package Terminal HP 7k-15k	
ID: **D03-101**	Abbreviation: **PTHP2**
Measure Description	High eff. packaged terminal heat pump (7-15k)
Baseline Characteristics	6.8 – 9.96 EER / 2.1 – 2.61COP (based on vintage) package terminal HP
Code Baseline Characteristics	T24 minimum: 9.96 or 8.46 EER / 2.91 or 2.61 COP (based on vintage) package terminal HP
Measure Characteristics	11.95 or 10.15 EER / 3.49 or 3.13 COP (based on vintage) package terminal HP
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

H.E. Package Terminal HP > 15k	
ID: **D03-102**	Abbreviation: **PTHP3**
Measure Description	High eff. packaged terminal heat pump (> 15k)
Baseline Characteristics	6.8 – 9.11 EER / 2.1 – 2.81 COP (based on vintage) package terminal HP
Code Baseline Characteristics	T24 minimum: 9.11 or 7.61 EER / 2.81 or 2.51 COP (based on vintage) package terminal HP
Measure Characteristics	10.93 or 9.13 EER / 3.37 or 3.01 COP (based on vintage) package terminal HP
Savings Reporting Units	tons served
Savings Scalable By	Δ (3.413/EER)

Efficient Supply & Return Fan Motor Measures

The challenge in estimating savings from replacing older motors with NEMA Premium motors is that EPACT and NEMA Premium efficiency requirements vary with motor horsepower, enclosure and speed. Efficiency improvements between EPACT and NEMA Premium motors tend to be greater at for motors with lower nameplate horsepower. The efficiency improvements between EPACT and NEMA Premium levels is about 3.5 percent for small motors (< 5 horsepower) gradually decreasing to about 1.5 percent for larger motors (> 20 horsepower)

Methodology: The eQUEST wizard automatically calculates a default supply fan or return fan motor nameplate horsepower

Efficient HVAC Motors - Supply Fans	
ID: **D03-086**	Abbreviation: **EMSFn**
Measure Description	Premium efficiency or better motors used for application
Baseline Characteristics	0.63 Fan+Motor Efficiency
Code Baseline Characteristics	T24 minimum: 0.63 Fan+Motor Eff. ~ EPACT std
Measure Characteristics	0.645 Fan+Motor Efficiency ~ NEMA premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Efficient HVAC Motors - Return Fans	
ID: **D03-087**	Abbreviation: **EMRFn**
Measure Description	Premium efficiency of better motors used for application
Baseline Characteristics	base motor efficiency based on typical motor size
Code Baseline Characteristics	T24 minimum: EPACT/NEMA std
Measure Characteristics	premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Efficient HVAC Motors – Cooling Tower Fans Measure

Methodology: The DOE 2.2 HEAT-REJECTION keyword ELEC-INPUT-RATIO represents a cooling towers efficiency in terms of the ratio of electricity input to heat rejection benefit. Savings for this measure are based on improving ELEC-INPUT-RATIO by three percent over the Title 24 baseline from Title 24, Table 112-G, Page 46. Values for ELEC-INPUT-RATIO by vintage are:

- Before 1978 is 0.0108,
- 1978 – 1992 is 0.0108,
- 1993 – 2001 is 0.0105,
- 2002 – 2005 is 0.0105,

- After 2005 is 0.0105,
- Measure is 0.0102, and
- Code Baseline is 0.0105.

Efficient HVAC Motors – Clg Tower Fans	
ID: **D03-088**	Abbreviation: **EMCTF**
Measure Description	Premium efficiency of better motors used for application
Baseline Characteristics	base motor efficiency based on typical motor size
Code Baseline Characteristics	T24 minimum: EPACT/NEMA std
Measure Characteristics	premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Efficient HVAC Motors – Circulation Pump Measures

The challenge in estimating savings from replacing older motors with NEMA Premium motors is that EPACT and NEMA Premium efficiency requirements vary with motor horsepower, enclosure and synchronous speed.

Methodology: The DOE 2.2 PUMP keyword MOTOR-EFF, represents the pump motor efficiency. Motor efficiency is assumed to improve by approximately one-and-a-half percent from standard to EPACT efficiency and from EPACT to NEMA Premium efficiency such that baseline values are

- Before 1978 is 91%,
- 1978 – 1992 is 91%,
- 1993 – 2001 is 92.3%,
- 2002 – 2005 is 92.3%,
- After 2005 is 92.3%,
- Measure is 93.6%, and
- Code Baseline is 92.3%.

Effic. Motors - Chilled Water Loop Pumps	
ID: **D03-089**	Abbreviation: **EMCLP**
Measure Description	Premium efficiency of better motors used for application
Baseline Characteristics	base motor efficiency based on typical motor size
Code Baseline Characteristics	T24 minimum: EPACT/NEMA std
Measure Characteristics	premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Effic. Motors - Hot Water Loop Pumps	
ID: **D03-089**	Abbreviation: **EMHLP**
Measure Description	Premium efficiency of better motors used for application
Baseline Characteristics	base motor efficiency based on typical motor size
Code Baseline Characteristics	T24 minimum: EPACT/NEMA std
Measure Characteristics	premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Effic. Motors – Cond. Water Loop Pumps	
ID: **D03-089**	Abbreviation: **EMTLP**
Measure Description	Premium efficiency of better motors used for application
Baseline Characteristics	base motor efficiency based on typical motor size
Code Baseline Characteristics	T24 minimum: EPACT/NEMA std
Measure Characteristics	premium motor efficiency based on typical motor size
Savings Reporting Units	nameplate HP
Savings Scalable By	Δ Eff

Water Side Economizer Measure

A plate and frame heat exchanger is installed between the condenser and chilled water loops. Whenever the condenser water is adequate to meet the required chilled water temperature, chillers are turned off, valves reroute chilled and condenser water through the heat exchanger and the cooling tower serves as the only source of cooling for the chilled water loops. By definition, the water-side economizer is “non-integrated” that is the heat exchanger and chiller(s) cannot operate at the same time.

Methodology: In the measure building, a plate and frame heat exchanger is added to the DOE 2.2 input file. The measure plant has the following characteristics:

- Heat exchanger capacity = 60% of total chiller plant capacity at rated conditions, and
- Chilled water loop temperature control changed to “LOAD-RESET” with a maximum reset temperature of 54 degrees F.

Water Side Economizer	
ID: **D03-098**	Abbreviation: **WSEcn**
Measure Description	Add water economizer heat exchanger to CW Loop
Baseline Characteristics	No water economizer
Code Baseline Characteristics	T24 minimum: no water economizer
Measure Characteristics	Non integrated evaporator precooler heat exchanger
Savings Reporting Units	tons served cooling cap
Savings Scalable By	n/a

Water Heating Measures

Methodology: A single water heater and DHW circulation loop were simulated in all buildings. Efficiency and performance descriptors were based typical capacity and input rating for each prototype. However, the actual simulated storage capacity and input rating were adequate to meet the building DHW demands therefore simulating the use of multiple water heaters where necessary to meet the load. Applicable efficiency requirements vary with storage and input capacity. In some cases, it was necessary to change the "typical" storage capacity to reflect the applicable efficiency requirements. For example, the Secondary School prototype has a water heater with a typical capacity of 500 gallons. However, the definition of Small Storage Water Heaters limits the storage capacity to 120 gallons. In order to simulate this measure for the Secondary School, the efficiency (DOE 2.2 DW-HEATER keyword HEAT-INPUT-RATIO) of the water heater was calculated for a 100 gallon water heater. Standby loss (DOE 2.2 DW-HEATER keyword TANK-UA) was calculated for a 100 gallon water heater and multiplied by the ratio of simulated storage capacity to 100 gallons.

Typical water heating characteristics for the 2005 vintage (properties used for all non-DHW Measure runs) are provided in the table below:

Prototype	Typical Storage (gallons)	Modeled Storage (gallons)	Modeled Input (kBtuh)	Eff. Reqmt.	Energy Factor	Therm. Eff.	Stby Loss Frac
Assembly	200	200	232	eff/sby	--	0.80	0.792
Primary School	120	120	140	eff/sby	--	0.80	0.986
Secondary School	500	500	583	eff/sby	--	0.80	0.547
Community College	500	705	822	eff/sby	--	0.80	0.480
University – Instruction	500	1356	1581	eff/sby	--	0.80	0.381
University – Dormitory	500	500	466	eff/sby	--	0.80	0.652
Relocatable Classroom	10	10	12	e.f.	0.509	--	--
Grocery	100	100	117	eff/sby	--	0.80	1.068
Hospital	500	869	1013	eff/sby	--	0.80	0.445
Nursing Home	200	200	233	eff/sby	--	0.80	0.792
Hotel – Public Area	120	120	140	eff/sby	--	0.80	0.986
Hotel – Guest Rooms	450	450	420	eff/sby	--	0.80	0.681
Motel	50	50	58	e.f.	0.554	--	--
Manufacturing – BioTech	200	200	233	eff/sby	--	0.80	0.792
Manufacturing – Light	100	100	117	eff/sby	--	0.80	1.068
Large Office	100	100	117	eff/sby	--	0.80	1.068
Small Office	30	30	35	e.f.	0.487	--	--
Sit Down Restaurant	60	60	70	e.f.	0.487	--	--
Fast Food Restaurant	60	60	70	e.f.	0.487	--	--
3-Story Retail	60	60	70	e.f.	0.487	--	--
1-Story Retail	60	60	70	e.f.	0.487	--	--
Small Retail	10	10	12	e.f.	0.598	--	--

HEAT-INPUT-RATIO is calculated as follows:

For gas water heaters rated with Energy Factor (ACM Manual, Section 2.6.1.1, Page 2-102):

HEAT-INPUT-RATIO = 1 / (0.37896 * Energy Factor + 0.56024)

For all others:

HEAT-INPUT-RATIO = 1 / Thermal Efficiency

TANK-UA is calculated as follows:

For gas water heaters rated with Energy Factor (derived from [ACM Manual, Equation N2-63, Page 2-102]):

TANK-UA = (1440.104 * (1 / Energy Factor - 1 / (0.37896 * Energy Factor + 0.56024))) / (1 - 1701.941 / (Input) * 1000 * (0.37896 * Energy Factor + 0.56024))) / 67.5

For electric water heaters rated with Energy Factor (derived from [ACM Manual, Equation N2-63, Page 2-102]):

TANK-UA= (1440.104 * (1 / Local(NResDHWEnergyFactor) – 1 / (1 / 3))) / (1 - 1701.941 / (Local(DHWInputRating) * 1000 * 0.98)) / 67.5

For all others:

TANK-UA= Standby Loss Fraction / 100 * Modeled Storage Capacity * 8.34

Tank Insulation Water Heating Measure

Methodology: TANK-UA for the measure building is half that of the baseline building.

DHW Tank Insulation-Fiber Blanket	
ID: **D03-014**	Abbreviation: **WHTIn**
Measure Description	Insulation added to poorly insulated DHW tanks
Baseline Characteristics	Approximately R-6 tank insulation, based on tank size
Code Baseline Characteristics	T24 code baseline for DHW tank insulation matches prototype level
Measure Characteristics	Approximately R-12 tank insulation, based on tank size
Savings Reporting Units	1,000 sqft building
Savings Scalable By	n/a

High Efficiency Small Storage Water Heating Measure

Methodology: The typical water heater storage capacity was adjusted so that the capacity did not exceed 100 gallons. Energy factors for each vintage are based on Title 24 requirements applying to the vintage for the typical storage capacity. Measure energy factor is determined from the following equation:

Energy Factor = 0.72 – 0.0019 * Typical Storage Capacity

High Efficiency Gas Water Heater	
ID: **D03-092**	Abbreviation: **WHGas**
Measure Description	Improved gas water heater EF
Baseline Characteristics	gas water heater with EF based on tank size and vintage
Code Baseline Characteristics	T20 minimum: EF of based on tank size as in equation above
Measure Characteristics	Improved EF of based on tank size
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ EF

Tankless Water Heating Measure

The benefit of tankless water heating is the elimination of standby losses. Small instantaneous water heaters rated have higher energy factors than storage water heaters. Large water heaters have no standby losses and have slightly higher thermal efficiencies than storage water heaters.

Methodology: The large office building uses a large instantaneous water heater with 83% efficiency and no standby losses. All other buildings use a small instantaneous water heater with an energy factor of 0.667 and no standby losses.

Gas Tankless Water Heating	
ID: **D03-093**	Abbreviation: **WHTls**
Measure Description	tankless gas water heater used
Baseline Characteristics	gas water heater with (energy factor or efficiency) based on tank size and vintage
Code Baseline Characteristics	T20 or T24 minimum: energy factor or efficiency based on tank size and vintage
Measure Characteristics	zero tank loss, improved energy factor (.667) or efficiency (83%)
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

Point of Use Water Heating Measure

Methodology: This measure is simulated similar to Tankless Water Heater except the water heating fuel is electricity. Baseline storage water heaters are electric with revised energy factors and standby loss values that are representative of prototype vintage and typical storage capacity. All measure buildings have instantaneous electric water heaters with no standby losses.

Point of Use Water Heating	
ID: **D03-094**	Abbreviation: **WHPUs**
Measure Description	tankless electric hot water system
Baseline Characteristics	electric water heater with energy factor or standby loss based on tank size and vintage
Code Baseline Characteristics	T20 or T24 minimum: electric water heater with energy factor or standby loss based on tank size
Measure Characteristics	zero tank loss
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

Circulation Pump Timeclock Water Heating Measure

Methodology: For prototypes with circulation pumps on the DHW loop, this measure adds a timeclock to the circulation pump that turns the pump off when the building is unoccupied.

Circulation Pump Timeclock Retrofit	
ID: **D03-095**	Abbreviation: **WHTCl**
Measure Description	DHW circulation pump contolled by timeclock
Baseline Characteristics	DHW circulation pump runs continuously
Code Baseline Characteristics	DHW circulation pump turns off during low operation hours
Measure Characteristics	DHW circulation pump turns off during low operation hours
Savings Reporting Units	1,000 sqft served
Savings Scalable By	n/a

High Efficiency Large and Medium Storage Water Heating Measures

Methodology: Measure water heaters have 90% efficiency and standby losses are reduced by 10% beyond requirements found in Title 20, Table F-3, Page 82.

High Eff Large Size Gas Water Heater	
ID: **D03-096**	Abbreviation: **WHGsL**
Measure Description	Improved eff. large water heater (> 155k BTU/hr)
Baseline Characteristics	Tank size and burner capacity, efficiency and standby loss a function of building type
Code Baseline Characteristics	T24 minimum: DHW = 80%, standby loss per current standards
Measure Characteristics	Same tank size/capacity with improved efficiency burner (90%), standby losses reduced by 10%
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/Eff)

High Eff Med Size Gas Water Heater	
ID: **D03-097**	Abbreviation: **WHGsM**
Measure Description	Improved eff. medium water heater (> 75k BTU/hr)
Baseline Characteristics	Tank size and burner capacity, efficiency and standby loss a function of building type
Code Baseline Characteristics	T24 minimum: DHW = 80%, standby loss per current standards
Measure Characteristics	Same tank size/capacity with improved efficiency burner (90%), standby losses reduced by 10%
Savings Reporting Units	1,000 sqft served
Savings Scalable By	Δ (1/Eff)

7.3 Grocery Refrigeration Measures

General Measure Description

Many of the grocery refrigeration measures are actually packages of several measures. In addition, the base case efficiency of the condenser may vary according to vintage. The following sections describe the differences between single-compressor and multiplex systems, and summarize the performance assumptions for air-cooled vs. evaporative condensers.

Multiplex-Compressor Systems

A multiplex-compressor system consists of multiple compressors drawing from a common suction header (suction-group), and serving any number of display fixtures. The suction group is controlled to satisfy the lowest temperature required by any of the attached display fixtures. For this reason the display fixtures served by a given suction group usually have similar temperature requirements; separate suction-groups are typically used for low-temperature and medium-temperature demands.

Unless otherwise noted in a specific measure, the default refrigeration system is a multiplex-compressor system with the following characteristics:

- Two multiplex systems; one having a medium temperature (MT) suction group served by its own condenser, and the other having a low-temperature (LT) suction group with its own condenser.
- The low-temperature multiplex system is subcooled, with subcooling provided by the medium-temperature system. The medium temperature system is not subcooled.

- The LT and MT condensers are typically air-cooled in all climate zones except CZ15, which defaults to evaporative. Various EEMs may require the condensers to be either air-cooled or evaporative. Condenser sizing and efficiency is summarized in the tables immediately following this section. When air-cooled, each condenser has four fans, with fans staged based on condensing temperature. When evaporative, each condenser has a single fan, which defaults to 2-speed, but may be variable-speed depending on the EEM. The condensing temperature setpoint varies by the vintage of the building, and is included in the condenser tables.
- For air-cooled condensers, the specific efficiency (Btu/Watt) is converted to the DOE-2 keyword FAN-EIR-TD using:

  FAN-EIR-TD (Btu-elec/(Btu-cap/TD) = 3.413 * 10TD / (specific efficiency Btu/Watt)
- For fixed suction control, the suction setpoint is based on the design suction temperature, but adjusted lower using the formula:

  Setpoint = DESIGN-SST - (3F +1/2 the throttling range),

  This approximates a mechanic setting up the system and then walking away. The throttling range is assumed to be 2F.

<u>*Single-Compressor Systems*</u>

In a single-compressor system, each display fixture or other refrigeration load has a dedicated compressor. The compressor cycles on/off according to its fixture's temperature controller. While most of the grocery measures assume a multiplex system, a few measures require a single-compressor system as the base case, as noted in those measures. The single-compressor base case has the following characteristics:

- One suction-group/compressor for each walk-in box and/or display fixture.
- All compressors utilize a single air-cooled multi-circuit condenser with 8 fans. The fans are staged in pairs based on ambient temperature.
- The program does not exactly model the staging of a compressor directly on the basis of a thermostat in a display fixture. To approximate the inefficiency that results from an oversized compressor matched to a coil, either the suction-group setpoint can be lowered, or the throttling range broadened (which, because of the suction-ctrl macro, also acts to lower the setpoint). This model uses the latter approach, and uses a 6F throttling range for all single-compressor suction groups. For an oversized compressor, this will cause the suction temperature to be lower on average.
- The suction setpoint for each fixture is then calculated as

Setpoint = DESIGN-SST - (3F +1/2 the throttling range),
where the throttling range is 6F.

- No subcooling exists.

Condenser Summary - Sizing vs. Vintage

The grocery measures may utilize either an air-cooled or evaporative condenser. Most measures assume the base case condenser is air-cooled, with the exception of stores in climate zone CZ15 (high desert) which assume evaporative. The base-case size and efficiency of both air-cooled and evaporative condensers varies with the vintage of the store. Various measures may also call for a more efficient condenser. The following tables summarize the various condenser configurations assumed in the analysis.

Air-Cooled Condensers, separate condensers serving LT & MT refrigeration systems			
Vintage	Size, kBtu @ TD; SCT control		Efficiency, Btu/Watt @ TD; Cap control
	Low temperature	Medium Temperature	
<1978	464 kBtu @15TD, 90 setpoint	782 kBtu @20TD, 90 setpoint	45 Btu/W @ 10FTD, 4 cycling fans (each cond)
<1992	464 kBtu @15TD, 90 setpoint	782 kBtu @20TD, 90 setpoint	45 Btu/W @ 10FTD, 4 cycling fans
<2001	464 kBtu @10TD, 90 setpoint	782 kBtu @15TD, 90 setpoint	53 Btu/W @ 10FTD, 4 cycling fans
>2000	464 kBtu @10TD, 85 setpoint	782 kBtu @15TD, 85 setpoint	53 Btu/W @ 10FTD, 4 cycling fans
Current "T24" equivalent	464 kBtu @10TD, 80 setpoint	782 kBtu @15TD, 80 setpoint	53 Btu/W @ 10FTD, 4 cycling fans
EEM - Energy Efficient	464 kBtu @10TD, control varies	782 kBtu @15TD, control varies	85 Btu/W @ 10FTD, 4 fans, cycleor VFD
Note 1: Condenser is sized for the heat rejection indicated, at the sizing TD indicated. The condenser efficiency is based on the same condenser selection as the size, but the "Btu" in the "Btu/Watt" term is based on the heat-rejection capacity when a 10°F TD exists.			

Air-Cooled Condenser, single multi-circuit condenser serving single-compressor systems		
Vintage	Size, kBtu @ TD; SCT control	Efficiency, Btu/Watt @ TD
<1978	1,250 kBtu @ 18TD, drybulb-staged	45 Btu/W @ 10FTD, 8 staging fans
<1992	1,250 kBtu @ 18TD, drybulb-staged	45 Btu/W @ 10FTD, 8 staging fans
<2001	1,250 kBtu @ 13TD, drybulb-staged	53 Btu/W @ 10FTD, 8 staging fans
>2000	1,250 kBtu @ 13TD, drybulb-staged	53 Btu/W @ 10FTD, 8 staging fans
Current "T24" equivalent	n/a	
EEM - Energy Efficient	n/a	
Note 1: Condenser is sized for the heat rejection indicated, at the sizing TD indicated. The condenser efficiency is based on the same condenser selection as the size, but the "Btu" in the "Btu/Watt" term is based on the heat-rejection capacity when a 10°F TD exists.		

Evaporative Condensers, separate condensers serving LT & MT refrigerations systems			
Vintage	Size, kBtu @ SCT/WB; SCT control		Efficiency, Btu/Watt @ SCT/WB
	Low temperature	Medium Temperature	
<1978	527 kBtu @100/72, 95 setpoint	1360 kBtu @100/72, 95 setpoint	120 Btu/W @ 100/70, 2-speed fan
<1992	527 kBtu @100/72, 95 setpoint	1360 kBtu @100/72, 95 setpoint	120 Btu/W @ 100/70, 2-speed fan
<2001	527 kBtu @95/72, 90 setpoint	1360 kBtu @95/72, 90 setpoint	120 Btu/W @ 100/70, 2-speed fan
>2000	527 kBtu @Note2, 85 setpoint	1360 kBtu @Note2, 85 setpoint	140 Btu/W @ 100/70, 2-speed fan
Current "T24" equivalent	527 kBtu @Note2, 80 setpoint	1360 kBtu @Note2, 80 setpoint	140 Btu/W @ 100/70, 2-speed fan
EEM - Energy Efficient	527 kBtu @Note3, control varies	1360 kBtu @Note3, 80 setpoint	200 Btu/W @ 100/70, 2-speed or VFD
Note 1: Condenser is sized for the heat rejection indicated, at the rated condensing temperature and wetbulb. The condenser efficiency is based on the same condenser selection as the size, but the "Btu" in the "Btu/Watt" term is based on the heat-rejection capacity when a 100SCT/70WB condition exists. Note 2: Rated WB by climate zone, Rated SCT = 59.0 + RatedWB*0.5 Note 3: Rated WB by climate zone, Rated SCT = 60.8 + RatedWB*0.4 Note 4: Power is split 85%/15% between the fan and the spray pump			

<u>Vintage Information & "Title 24 Design"</u>

Vintage definitions represent the average of the members in a particular vintag. Some members of an older vintage may have original equipment, which is less efficient due to deterioration over time and inefficient system additions; whereas others may have been remodeled with new systems and are as efficient as new vintage. Accordingly, the vintage performance is intended to represent the vintage as a class, and is not intended to represent a particular location.

For the purposes of the refrigeration system models, a “Title 24 design” was defined as standard practice in 2005. At this time, Title 24 does not apply to grocery refrigeration components. However, for DEER purposes, it is necessary to define a Title 24 reference case for program planning purposes and to determine the portion of the EEM savings that are above standard practice.

Grocery Retrocommissioning Measure

Recommissioning or retrocommissioning is very active with supermarket chains and as a component of maintenance offers by refrigeration contractors in California, having originated here approximately eight years ago. The work activities and expected results have been reasonably well identified through experience. Permanence is a significant issue, requiring some form of monitoring to be considered as part of the EEM (e.g. automated setpoint verification).

<u>Methodology</u>: The base case are the low-temperature and medium-temperature multiplex systems. To simulate poor maintenance, the suction temperature setpoints are depressed by 3F, and the condenser SCT setpoint is raised by 3°F. The EEM is then the same system with "normal" setpoints.

The "needs maintenance" flag is set only for this EEM, and only for the base case run. T24 and the EEM runs turn the flag off, so no incentive is ever paid; only owner savings accrue.

All other EEMs assume a well-maintained system in the base case.

Base Case by Vintage

- <1978: Unmaintained
- 1978-1991: Unmaintained
- 1992-2000: Unmaintained
- >2000: Unmaintained

<u>“T24” design:</u> EEM is N/A; assumed to be commissioned properly
All other EEMs assume a well-maintained system, for all vintages.

Retrocommissioning	
ID: **D03-201**	Abbreviation: **Grtro**
Measure Description	Air-cooled multiplex system w/extensive refrigeration equipment maintenance
Baseline Characteristics	Standard air-cooled multiplex, SST setpoint reduced 3°F, SCT setpoint raised 3°F
Code Baseline Characteristics	Normal setpoints, representing a properly commissioned system
Measure Characteristics	Normal setpoints, representing tighter control
Savings Reporting Units	Design cooling tons
Savings Scalable By	Design cooling tons

High Efficiency Fan Motors

All manufacturers either offer Electronically Commutated Motors (ECMs) in lieu of shaded pole motors, or have standardized on ECMs in their refrigerated display cases. Most grocery store chains now specify ECMs, after the reliability issues experienced in the mid-90's were addressed. In some instances, chains specify that display cases with high wash-down activity, i.e., produce cases, have shaded pole motors.

Potentially, display case manufacturers would standardize on ECMs in all fixtures, were it not for the need to show it as an "option" to qualify for utility incentives. The payback on new fixtures is short. Retrofits of existing cases, however are more expensive, and offer a significant untapped potential for savings.

PSC motors are standard on some unit coolers and have been an option for 15+ years in lieu of shaded pole motors. Since the cost premium is small, most chains use PSC motors on new construction. A concern exists that the "option" only exists to capture the incentive.

EC motors are available and are being evaluated for unit coolers, but are not currently defined by manufacturers, sufficient to allow analysis.

Base Case by Vintage

- <1978: Shaded pole
- 1978-1991: Shaded pole
- 1992-2000: Shaded pole
- >2000: Shaded pole

<u>"T24" design:</u> Efficient motors are Included in current practice
All other EEMs assume inefficient motors for all vintages <2005, and efficient motors for >=2005.

High Efficiency Walk-in Fan Motors

Methodology: For walk-ins, PSC motors are simulated by applying multipliers of 0.35, 0.51, and 0.76 to the SUPPLY-KW/FLOW for the freezer, cooler, and prep room; respectively.

High Efficiency Walk-in Fan Motors	
ID: **D03-202**	Abbreviation: **GEWFM**
Measure Description	Substitute high efficiency motors for standard efficiency
Baseline Characteristics	Utilizes a shaded-pole motor
Code Baseline Characteristics	Utilizes a PSC motor
Measure Characteristics	Utilizes a PSC motor
Savings Reporting Units	number of motors
Savings Scalable By	number of motors

High Efficiency Display Fan Motors

Methodology: For display fixtures, EC motors are simulated by applying a multiplier ranging between 0.47 to 0.19 to the FAN-KW/LEN or /DOOR of various fixtures, depending on the fixture.

High Efficiency Display Fan Motors	
ID: **D03-203**	Abbreviation: **GEDFM**
Measure Description	Substitute high efficiency motors for standard efficiency
Baseline Characteristics	Utilizes a shaded-pole motor
Code Baseline Characteristics	Utilizes an EC motor
Measure Characteristics	Utilizes an EC motor
Savings Reporting Units	fixture linear feet
Savings Scalable By	fixture linear feet

Heat Recovery from Central Refrigeration System

Heat recovery to the space from the compressor discharge refrigerant was commonplace in supermarkets from the early 1980's until the CFC phase-out led to increased refrigerant cost and penalties for excessive leaks, resulting in many chains eliminating heat recovery entirely, or using only desuperheating. Space heat recovery using only superheat has limited net value in that only a small portion of the heat of rejection is recovered, yet both the refrigeration system and the air handling system incur parasitic pressure drop.

Heat recovery should be an EEM, with qualifications that insure proper performance; especially that condensing occurs in the heat recovery coil.

Methodology: The base case assumes multiplex systems without heat reclaim. The EEM is heat reclaim with holdback valves on the MT suction group only (not LT), set to 85F with a

5F valve pressure drop. Holdback is active only during hours when heat is needed. During heat recovery, up to 850,000 Btuh is available.

When heat reclaim is enabled, the program calculates whether superheat and/or condensing occurs based on the hourly supply air temperature and the refrigerant temperature and saturated temperature; superheat only cannot be specified.

Note: Some chains have eliminated heat reclaim entirely, due to concerns regarding refrigerant charge or because design has changed to packaged rooftop units and conventional direct-refrigerant heat reclaim is not feasible.

Base Case by Vintage

- <1978: No heat reclaim
- 1978-1991: No heat reclaim
- 1992-2000: No heat reclaim
- >2000: No heat reclaim

"T24" design: No heat reclaim
All other EEMs assume no heat reclaim

Heat Recovery from Central Refrigeration System	
ID: **D03-204**	Abbreviation: **GCRHR**
Measure Description	Adds an 85°F holdback valve, active only when needed
Baseline Characteristics	Standard air-cooled multiplex system, no heat reclaim
Code Baseline Characteristics	Standard air-cooled multiplex system, no heat reclaim
Measure Characteristics	Heat reclaim with SCT controlled to 85°F via holdback valve when heat is needed
Savings Reporting Units	1,000 square feet of sales area
Savings Scalable By	n/a

Night Covers for Display Cases (medium temperature)

The majority of the heat loss of an open display fixture is via infiltration. Covering open fixtures during hours the store is closed can reduce convection by 50% or more during this time; thereby reducing refrigeration loads.

Methodology: The base case assumes constant infiltration all hours. The EEM applies a multiplier of 0.50 to the infilration for the hours (2,5).

This measure applies to all vintages, but for vintages >=2005, night covers will be restricted to fixtures that don't have doors (i.e., fewer fixtures will be covered, because newer stores typically have more fixtures with doors).

Base Case by Vintage

- <1978: No night covers
- 1978-1991: No night covers
- 1992-2000: No night covers
- >2000: No night covers

"T24" design: No night covers
All other EEMs assume no night covers.

Night Covers for Display Cases (medium temp)	
ID: **D03-205**	Abbreviation: **GDCNC**
Measure Description	Cover open MT cases between 1-5 a.m.
Baseline Characteristics	Open cases with no night cover
Code Baseline Characteristics	Open cases with no night cover, qty of open cases varies by vintage
Measure Characteristics	Night cover reduces infiltration by 50% for 4 hours/night
Savings Reporting Units	display case length (feet)
Savings Scalable By	n/a

Medium Temperature Glass Doors (open display cases)

Since most medium temperature multi-deck cases are currently open cases, the retrofit or replacement of open fixtures with glass doors offers significant opportunity. Chains have been hesitant to risk the reduction in sales appeal, but have recently indicated greater interest.

Methodology: The base case fixtures are swapped for similar fixtures with glass doors. Additional case lighting is added to improve product visibility; the amount of new lighting is assumed to be the same as for a new fixture.

Base Case by Vintage

- <1978: No doors on open multi-deck cases
- 1978-1991: No doors on open multi-deck cases
- 1992-2000: No doors on open multi-deck cases
- >2000: No doors on open multi-deck cases

"T24" design: No doors on open multi-deck cases. EEM is N/A – glass door cases would be purchased rather than retrofitting to open cases.

Retrofit Medium Temperature Glass Doors (open display cases)

This measure retrofits glass doors onto existing MT open multi-deck cases.

Methodology: Swap base case fixture for similar fixture w/ glass doors. Additional case lighting is added to improve product visibility; amount same as for a new fixture.

Medium Temp Glass Doors (open display cases)	
ID: **D03-206**	Abbreviation: **GMTGD**
Measure Description	Retrofit glass doors on open MT cases; additional lighting
Baseline Characteristics	Open cases with no night cover
Code Baseline Characteristics	Open cases with no night cover
Measure Characteristics	Open fixture is retrofitted with doors and additional lighting
Savings Reporting Units	Linear feet
Savings Scalable By	n/a

New Medium Temperature Refrigeration Display Case with Doors

This measure replaces existing open fixtures with new fixtures having glass doors. The new fixture is assumed to have standard doors, ECM motors, T8/EB lighting.

New Medium Temp Refrig Display Case with Doors	
ID: **D03-207**	Abbreviation: **GMTDC**
Measure Description	Replace open MT case with new case with doors
Baseline Characteristics	Open cases with no night cover
Code Baseline Characteristics	Open cases with no night cover
Measure Characteristics	Replace open fixtures with fixtures having doors
Savings Reporting Units	Linear feet
Savings Scalable By	n/a

Auto-Closers on Cooler Doors

Auto-closers on walk-in freezers and coolers can reduce the amount of time that doors are open, thereby reducing infiltration and refrigeration loads. These measures are limited to the retrofit of doors not previously equipped with auto-closers, and assume the doors have strip curtains.

Methodology: Infiltration into the coolers is modeled as a SOURCE load in the SPACE command. The EEM applies a multiplier of 0.60 to the base case source load; effectively reducing infiltration by 40% on average.

Base Case by Vintage

- <1978: No auto-closers
- 1978-1991: No auto-closers
- 1992-2000: No auto-closers
- >2000: No auto-closers

"T24" design: No auto-closers

Auto-Closers on Main Cooler Doors

Auto-Closers on Main Cooler Doors	
ID: **D03-208**	Abbreviation: **GMCAC**
Measure Description	Install automatic door closer on walk-in cooler doors
Baseline Characteristics	No door closer
Code Baseline Characteristics	No door closer
Measure Characteristics	Applies a multiplier of 60% to the base-case infiltration
Savings Reporting Units	Per cooler
Savings Scalable By	n/a

Auto-Closers on Main Freezer Doors

Auto-Closers on Main Freezer Doors	
ID: **D03-209**	Abbreviation: **GMFAC**
Measure Description	Install automatic door closer on walk-in freezer doors
Baseline Characteristics	No door closer
Code Baseline Characteristics	No door closer
Measure Characteristics	Applies a multiplier of 60% to the base-case infiltration
Savings Reporting Units	Per freezer
Savings Scalable By	n/a

Evaporator Fan Control on Walk-in Coolers & Freezers

The evaporator fans in walk-in freezers and coolers typically run continuously, even when the evaporator is inactive. This provides the air circulation needed for the temperature sensor to work properly. This measure is defined as cycling off the evaporator fans at least 75% of the time during off-cycle, with a limited on-cycle for sensor operation.

Methodology: Applies to the freezer and cooler only, not the meat preparation area. The base case assumes the fans run continuously all hours. The EEM uses FAN-CONTROL = CYCLING, INDOOR-FAN-MODE = INTERMITTENT, MIN-FLOW-RATIO = 0.01, MIN-DUTY-CYCLE = 0.1 (6 minutes run time/hour if no load), and MAX-DUTY-CYCLE = 0.5

Base Case by Vintage

- <1978: Fans run continuously; shaded pole motors
- 1978-1991: Fans run continuously; shaded pole motors
- 1992-2000: Fans run continuously; shaded pole motors
- >2000: Fans run continuously; shaded pole motors

"T24" design: Fans run continuously; efficient motors
For vintages <2005, this EEM assumes standard motors. For vintages >=2005, this EEM assumes efficient motors.
All other EEMs assume no duty fan cycling, for all vintages.

Evaporator Fan Control on Walk-in Coolers & Freezers	
ID: **D03-210**	Abbreviation: **GWEFC**
Measure Description	Cycle fan off with thermostat; duty cycle occasionally when off
Baseline Characteristics	Evaporator fan runs continuously, psc or sp motor based on vintage
Code Baseline Characteristics	Evaporator fan runs continuously, psc or sp motor based on vintage
Measure Characteristics	Evaporator fan cycles w/ thermostat; when off cycles on peridoically
Savings Reporting Units	motor
Savings Scalable By	n/a

Air-Cooled Condenser to Evaporative Condenser

This measure replaces existing low temperature (LT) and medium temperature (MT) refrigeration system air-cooled condensers with evaporative condensers. This measure is defined for application on a multiplex system.

Methodology: Refer to the condenser tables. The base case is air-cooled, with vintage-dependent size and efficiency. The SCT control setpoint is also vintage-dependent. The EEM is the "T24" evaporative condenser, controlled to 80°F.

Base Case by Vintage

- <1978: Air-cooled, vintage dependent
- 1978-1991: Air-cooled, vintage dependent
- 1992-2000: Air-cooled, vintage dependent
- >2000: Air-cooled, vintage dependent

"T24" design: Air-cooled; EEM is N/A for this vintage
All other EEMs assume an air-cooled condenser using the vintage-dependent size, efficiency, and control setpoint; except CZ15, which assumes evaporative.

Air-Cooled Condenser to Evaporative Condenser	
ID: **D03-211**	Abbreviation: **GEvCn**
Measure Description	Replace multiplex air-cooled condenser with evaporative condenser
Baseline Characteristics	Multiplex air cooled condenser of vintage-dependent size, efficiency and SCT setpoint
Code Baseline Characteristics	Multiplex air cooled condenser of T24 efficiency, 80°F SCT
Measure Characteristics	Evaporative condenser of T24 efficiency, 2-speed fan, 80°SCT
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Energy Efficient Condensers

This measure replaces the existing LT and MT condensers with energy efficient condensers of the same type (air-cooled or evaporative). This measure is defined for application on a multiplex system only.

Methodology: Refer to the condenser tables for both the base case and energy-efficient evaporators. The base case is either air-cooled or evaporative, with vintage-dependent size and efficiency. The SCT control setpoint is also vintage-dependent. The EEM is the energy efficient condenser of the same types as the base case (air-cooled or evaporative), controlled to 80°F.

Base Case by Vintage

- <1978: Air-cooled or evaporative, vintage dependent
- 1978-1991: Air-cooled or evaporative, vintage dependent
- 1992-2000: Air-cooled or evaporative, vintage dependent
- >2000: Air-cooled or evaporative, vintage dependent

"T24" design: Air-cooled or evaporative, T24 efficiency, 80°F SCT setpoint

Energy Efficient Air-Cooled Condenser

This measure replaces the existing LT and MT air-cooled condensers with energy efficient air-cooled condensers.

Energy Efficient Air-Cooled Condenser	
ID: **D03-212**	Abbreviation: **GEArC**
Measure Description	Upgrade from 53 Btu/Watt @ 10°F TD to 85 Btu/Watt
Baseline Characteristics	Multiplex air cooled condenser of vintage-dependent size, efficiency and SCT setpoint
Code Baseline Characteristics	Multiplex air cooled condenser of T24 efficiency, 80°F SCT
Measure Characteristics	Same capacity condenser, sized at 10°F TD, and efficiency of 85 Btu/Watt, 80°F SCT
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Energy Efficient Evaporatively-Cooled Condenser

This replaces the existing LT and MT evaporative condensers with energy efficient evaporative condensers.

Note: recent information indicates there may be a large gap between rated and realized condenser capacity in supermarket applications, largely due to poor piping practice. As much as 30-40% of condenser capacity may not be realized, particularly during part-load, off-design conditions. Addressing or adjusting for this is not within the current scope, but is noted as a reference for needed future study and improvement.

Energy Efficient Evaporative-Cooled Condenser	
ID: **D03-213**	Abbreviation: **GEEvC**
Measure Description	Reduce design SCT by ~5°F and improve efficiency
Baseline Characteristics	Multiplex evaporative condenser of vintage-dependent size, efficiency and SCT setpoint
Code Baseline Characteristics	Multiplex evaporative condenser of T24 efficiency, 80°F SCT
Measure Characteristics	Same capacity condenser but ~5°F lower SCT, 200 Btu/Watt, 80°F SCT
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Replacement of Single-Compressor Systems with Multiplex

This set of measures replaces existing single-compressor systems, which were typically designed prior to 1980, with multiplex systems. The measures include the specification of floating head pressure and condenser control method.

Methodology: The base case is a single-compressor system, either air-cooled or evaporative. As described in the general notes, the suction temperature throttling range is broadened to 6F to model the effect of an oversized compressor pulling down the suction temperature. (The multiplex EEMs have a narrower throttling range to simulate staging multiple compressors.) Partial reed style compressors are used, which have 6% less pumping efficiency for the same power. This effect is modeled by multiplying the compressor kW curve-fit coefficients by 1./(1-0.06) = 1.064

The base case air-cooled condenser has 8 fans staged in pairs directly on ambient temperature, with vintage-dependent size and efficiency (see condenser tables). Backflood control is set to 93°F.

Unless otherwise noted, the EEM is the "T24" air-cooled multiplex system normally used as the "base case" for other EEMs. In addition, mechanical subcooling is provided for both the LT and MT liquid circuits. Subcooling is controlled to 50F. Subcooling is provided by a new HT suction group.

Unless otherwise noted, the EEM condensers are the "T24" LT and MT condensers of the same type (air-cooled or evaporative), but have floating head controlled to fixed 70°F (two speed fan). The "T24 multiplex" system uses backflood control at 2°F less than the SCT control setpoint; with floating head the setpoint is reduced to 68°F.

Base Case by Vintage

- <1978: Single compressor system
- 1978-1991: Single compressor system
- 1992-2000: Single compressor system
- >2000: Single compressor system

"T24" design: Multiplex system, T24 compressors, T24 air-cooled condensers, SCT controlled to 80°F, LT subcooling to 50°F.

Multiplex System with Mechanical Subcooling (air-cooled)

This measure replaces an existing air-cooled single-compressor system with an air-cooled multiplex system of "Title 24" efficiency; including both LT and MT subcooling.

Multiplex System with Mechanical Subcooling (air-cooled)	
ID: **D03-214**	Abbreviation: **GMMSa**
Measure Description	Replace single-compressor system with subcooled multiplex
Baseline Characteristics	Single-compressor system, air-cooled condensers of vintage-dependent size/eff
Code Baseline Characteristics	Standard air-cooled multiplex system, 80°F SCT, 50°F LT subcooling
Measure Characteristics	Multiplex system, air-cooled, subcooler on both LT & MT circuits, floating head
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Multiplex System with Mechanical Subcooling (Evaporative-cooled)

Like Measure ID D03-214, this measure replaces an existing air-cooled single-compressor system with an air-cooled multiplex system of "Title 24" efficiency; including both LT and MT subcooling. In addition, an evaporative condenser is substituted for air-cooled. The evaporative condensers are the "T24" condensers, but have floating head controlled to fixed 70°F (two speed fan). The "T24 multiplex" system uses backflood control at 2°F less than the SCT control setpoint; with floating head the setpoint is reduced to 68°F.

Multiplex System with Mechanical Subcooling (evaporative-cooled)	
ID: **D03-215**	Abbreviation: **GMMSe**
Measure Description	Replace single-compressor system with subcooled multiplex
Baseline Characteristics	Single-compressor system, air-cooled condensers of vintage-dependent size/eff
Code Baseline Characteristics	Standard air-cooled multiplex system, 80°F SCT, 50°F LT subcooling
Measure Characteristics	Multiplex system, evap-cooled, subcooler on both LT & MT circuits, floating head
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Multiplex System with Mechanical Subcooling (high efficiency air-cooled)

This measure is a combination of Measure ID D03-212 and Measure ID D03-214.

Methodology: The base case is the same as defined in Measure ID D03-214 (air-cooled single-compressor system). The EEM is the same as Measure ID D03-214 (air-cooled multiplex), but also upgrades the condensers to a higher efficiency per Measure ID D03-212 (see also the condenser tables).

Multiplex System with Mech Subcooling (high eff air-cooled)	
ID: **D03-216**	Abbreviation: **GMSEa**
Measure Description	Replace single-compressor system with subcooled multiplex (high efficiency)
Baseline Characteristics	Single-compressor system, air-cooled condensers of vintage-dependent size/eff
Code Baseline Characteristics	Standard air-cooled multiplex system, 80°F SCT, 50°F LT subcooling
Measure Characteristics	Multiplex system, hi-eff air-cooled, subcooler on both LT and MT circuits
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Multiplex System with Mechanical Subcooling (high efficiency evaporative-cooled)

This measure is a combination of Measure ID D03-213 and Measure ID D03-215.

Methodology: The base case is the same as defined in Measure ID D03-215 (air-cooled single-compressor system). The EEM is the same as Measure ID D03-215 (evap-cooled multiplex), but also upgrades the condenser to a higher efficiency per Measure ID D03-213 (see also the condenser tables).

Multiplex System with Mechanical Subcooling (high efficiency evaporative-cooled)	
ID: **D03-217**	Abbreviation: **GMSEe**
Measure Description	Replace single-compressor system with subcooled multiplex (high efficiency)
Baseline Characteristics	Single-compressor system, air-cooled condensers of vintage-dependent size/eff
Code Baseline Characteristics	Standard air-cooled multiplex system, 80°F SCT, 50°F LT subcooling
Measure Characteristics	Multiplex system, hi-eff evap-cooled, subcooler on both LT and MT circuits
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Low Temperature Mechanical Subcooling

Subcooling of LT systems only, from an existing medium temperature suction group

Methodology: Base case is standard base case (air-cooled multiplex), vintage dependent. The base case may or may not already have LT subcooling, depending on vintage.

EEM is the addition of a 50°F subcooler on the LT liquid line; powered by the MT suction group.

Base Case by Vintage

- <1978: no subcooling
- 1978-1991: no subcooling
- 1992-2000: LT subcooling included to 70°F
- >2000: LT subcooling included to 50°F

"T24" design: LT subcooling included to 50°F

Low Temperature Mechanical Subcooling	
ID: **D03-218**	Abbreviation: **GLTMS**
Measure Description	Addition of a LT subcooler to an air-cooled multiplex
Baseline Characteristics	Standard air-cooled multiplex system, no subcool <1992, 70F subool 1992-2000
Code Baseline Characteristics	Low-temp subcooler (50°F) powered by medium-temp suction group
Measure Characteristics	Low-temp subcooler (50°F) powered by medium-temp suction group
Savings Reporting Units	Design cooling tons for LT suction group only
Savings Scalable By	n/a

Low and Medium Temperature Mechanical Subcooling

This measure provides subcooling for both the LT and MT systems, using a new high temperature (+35°F) suction group.

Methodology: Base case is standard base case (air-cooled multiplex), vintage dependent. The base case may or may not already have LT subcooling, depending on vintage.

EEM is the addition of a 50°F subcooler on the LT liquid line, and another on the MT liquid line. Both are powered by a new high temperature (HT) suction group. The new HT suction group does not serve any other loads.

Base Case by Vintage

- <1978: no subcooling
- 1978-1991: no subcooling
- 1992-2000: LT subcooling included to 70°F using MT suction group
- >2000: LT subcooling included to 50°F using MT suction group

"T24" design: LT subcooling included to 50°F using MT suction group

Low and Medium Temp Mechanical Subcooling	
ID: **D03-219**	Abbreviation: **GLMTS**
Measure Description	Addition of LT and MT subcoolers to an air-cooled multiplex
Baseline Characteristics	Standard air-cooled multiplex system, no subcool <1992, 70F subool 92-2000
Code Baseline Characteristics	Low-temp subcooler (50°F) powered by medium-temp suction group
Measure Characteristics	Low- and medium-temp subcoolers powered by a new high-temp suction group
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Suction Pressure

For multiplex suction-groups, this measure adds controls to reset the suction pressure setpoint during periods of low loads.

Methodology: The base case is the standard base case (air-cooled multiplex), vintage dependent. The suction pressure is controlled to a fixed setpoint all hours, regardless of fixture load.

The EEM consists of the addition of floating suction head controls to both the MT and LT suction groups. The minimum suction setpoint is the same as the base-case setpoint; the maximum is 5°F above the design temperature. This measure allows the suction temperature to increase during periods of low fixture loads, thereby allowing increased compressor efficiency.

Base Case by Vintage

- <1978: no floating suction pressure
- 1978-1991: no floating suction pressure
- 1992-2000: no floating suction pressure
- >2000: no floating suction pressure

“T24” design: no floating suction pressure

Floating Suction Pressure	
ID: **D03-220**	Abbreviation: **GFlSP**
Measure Description	Floating SST control on LT and MT suction groups
Baseline Characteristics	Standard air-cooled multiplex system, SST controlled to fixed setpoint
Code Baseline Characteristics	SST controlled to fixed setpoint
Measure Characteristics	SST setpoint reset based on worst-case demand
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure

For multiplex suction-groups, these measures add controls to float the head pressure down to a lower temperature when conditions permit.

<u>Methodology:</u> The base case is the standard multiplex system, either air-cooled or evaporative, vintage dependent, and having a fixed condensing setpoint per vintage and condenser type (see condenser tables).

The EEM is the addition of a lower setpoint control, which varies by EEM. The backflood control setpoint is reduced from 83°F to 68°F.

<u>Floating Head Pressure, Fixed Setpoint (Air-cooled)</u>

This measure applies to an air-cooled condenser, and sets the head pressure setpoint at a fixed 70 °F SCT.
<u>Methodology:</u> The base case is the standard air-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a fixed 70°F condensing temperature setpoint. The backflood control setpoint is reduced from 83°F to 68°F.

Base Case by Vintage

- <1978: Fixed setpoint at 90°F SCT
- 1978-1991: Fixed setpoint at 90°F SCT
- 1992-2000: Fixed setpoint at 90°F SCT
- >2000: Fixed setpoint at 85°F SCT

“T24” design: Fixed setpoint at 80°F SCT (reflects average)

Floating Head Pressure, Fixed Setpoint (Air-cooled)	
ID: **D03-221**	Abbreviation: **GFFSa**
Measure Description	Floating SCT controlled to 70°F
Baseline Characteristics	Standard air-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	SCT controlled to 80°F
Measure Characteristics	SCT controlled to 70°F
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure, Fixed Setpoint (Evaporative-cooled)

This measure applies to an evaporative condenser, and sets the head pressure setpoint at a fixed 70°F SCT.

Methodology: The base case is an evaporative-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a fixed 70°F condensing temperature setpoint. The backflood control setpoint is reduced from 83°F to 68°F.

Base Case by Vintage

- <1978: Fixed setpoint at 95°F SCT (higher due to use of sump stat)
- 1978-1991: Fixed setpoint at 95°F SCT (higher due to use of sump stat)
- 1992-2000: Fixed setpoint at 90°F SCT
- >2000: Fixed setpoint at 85°F SCT

"T24" design: Fixed setpoint at 80°F SCT

Floating Head Pressure, Fixed Setpoint (Evap-cooled)	
ID: **D03-222**	Abbreviation: **GFFSe**
Measure Description	Floating SCT controlled to 70°F
Baseline Characteristics	Standard evap-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	Standard evap-cooled multiplex system, SCT controlled to 80°F
Measure Characteristics	SCT controlled to 70°F
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure, Variable Setpoint (Air-cooled)

This measure applies to an air-cooled condenser, and resets the head pressure setpoint down to 70°F SCT minimum, using an ambient following setpoint.

<u>Methodology:</u> The base case is an air-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of an drybulb-following condensing setpoint, with a 12°F temperature difference (TD) between ambient and setpoint (TD optimized for CZ12). The backflood control setpoint is reduced from 83°F to 68°F.

Base Case by Vintage

- <1978: Fixed setpoint at 90°F SCT
- 1978-1991: Fixed setpoint at 90°F SCT
- 1992-2000: Fixed setpoint at 90°F SCT
- >2000: Fixed setpoint at 85°F SCT

"T24" design: Fixed setpoint at 80°F SCT

Floating Head Pressure, Variable Setpoint (Air-cooled)	
ID: **D03-223**	Abbreviation: **GFVSa**
Measure Description	Ambient following SCT setpoint, 70°F minimum
Baseline Characteristics	Standard air-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	Standard air-cooled multiplex system, SCT controlled to 80°F
Measure Characteristics	Control SCT to ambient + 12°F TD, 70°F min, backflood setpoint of 68°F
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

<u>Floating Head Pressure, Variable Setpoint (Evaporative-cooled)</u>

This measure applies to an evaporative condenser, and resets the head pressure setpoint down to 70°F SCT minimum, using an ambient following setpoint.

<u>Methodology:</u> The base case is an evaporative-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a wetbulb-following condensing setpoint, with a 17°F TD between wetbulb and setpoint (TD optimized for CZ12) The backflood control setpoint is reduced from 83°F to 68°F.

Base Case by Vintage

- <1978: Fixed setpoint at 95°F SCT (higher due to use of sump stat)
- 1978-1991: Fixed setpoint at 95°F SCT (higher due to use of sump stat)
- 1992-2000: Fixed setpoint at 90°F SCT
- >2000: Fixed setpoint at 85°F SCT

"T24" design: Fixed setpoint at 80°F SCT

Floating Head Pressure, Variable Setpoint (Evap-cooled)	
ID: **D03-224**	Abbreviation: **GFVSe**
Measure Description	Wetbulb following SCT setpoint, 70°F minimum
Baseline Characteristics	Standard evap-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	Standard evap-cooled multiplex system, SCT controlled to 80°F
Measure Characteristics	Control SCT to wetbulb + 17°F TD, 70°F min, backflood setpoint of 68°F
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure, Variable Setpoint & Speed (Air-cooled)

This measure is like Measure ID D03-223, with the addition of variable-speed fan control.

Methodology: The base case is an air-cooled multiplex, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of an drybulb-following condensing setpoint, with a 12°F TD between ambient and setpoint. (The 12° TD was chosen based on optimization runs in climate CZ12; the actual TD used may vary by a few degrees with negligible difference in savings.) The backflood control setpoint is reduced from 83°F to 68°F. In addition, the fans are controlled using a variable-speed drive.

Floating Head Pressure, Variable Setpoint & Speed (Air-cooled)	
ID: **D03-225**	Abbreviation: **GFSSA**
Measure Description	Ambient following SCT setpoint, 70°F minimum, variable-spd condenser fan
Baseline Characteristics	Standard air-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	Standard air-cooled multiplex system, SCT controlled to 80°F
Measure Characteristics	Control SCT to ambient + 12°F TD, 70°F min, backflood setpt of 68°F, var-spd cond
Savings Reporting Units	
Savings Scalable By	Design cooling tons

Floating Head Pressure, Variable Setpoint & Speed (Evaporative-cooled)

This measure is like Measure ID D03-224, with the addition of variable-speed fan control.

Methodology: The base case is an evaporative-cooled multiplex system, vintage dependent, and having a fixed condensing setpoint per vintage. The EEM is the addition of a wetbulb-following condensing setpoint, with a 17°F TD between wetbulb and setpoint. (The 17° TD was chosen based on optimization runs in climate CZ12; the actual TD used may vary by a few degrees with negligible difference in savings.) The backflood control setpoint is reduced from 83°F to 68°F. In addition, the base-case two-speed fan is replaced with variable-speed.

Floating Head Pressure, Variable Setpoint & Speed (Evaporative-cooled)	
ID: **D03-226**	Abbreviation: **GFSSE**
Measure Description	Wetbulb following SCT setpoint, 70°F minimum, variable-spd condenser fan
Baseline Characteristics	Standard evap-cooled multiplex system, SCT control temp by vintage
Code Baseline Characteristics	Standard evap-cooled multiplex system, SCT controlled to 80°F
Measure Characteristics	Control SCT to wetbulb + 17°F TD, 70°F min, backflood setpt of 68°F, var-spd cond
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Display Case Lighting Control

This measure adds timeclock controls to shut off display case lighting six hours at night.

Methodology: Turn off lights in fixtures between midnight and 6 a.m.

Base Case by Vintage

- <1978: lights on 24 hours
- 1978-1991: lights on 24 hours
- 1992-2000: lights on 24 hours
- >2000: lights on 24 hours

"T24" design: lights on 24 hours
Note: this measure usually only applies to non-24 hour stores.

Display Case Lighting Control	
ID: **D03-227**	Abbreviation: **GDCLC**
Measure Description	Turn off fixture lights when store closed
Baseline Characteristics	Standard air-cooled multiplex, lights on all hours
Code Baseline Characteristics	Standard air-cooled multiplex, lights on all hours
Measure Characteristics	Turn off lights between midnight and 6 a.m.
Savings Reporting Units	Fixture linear feet (fixtures with lighting)
Savings Scalable By	n/a

Zero Heat Reach-in Glass Doors

This measure replaces conventional low temperature reach-in glass door display cases, utilizing doors with both door heaters and frame heaters, with doors having frame heaters only (no door heaters).

Methodology: For fixtures with doors, the HEATER-KW/DOOR is reduced to 54 Watts.

Base Case by Vintage

- <1978: Conventional doors with antisweat heater control (retrofitted)
- 1978-1991: Conventional doors with antisweat heater control (retrofitted)
- 1992-2000: Conventional doors with antisweat heater control (retrofitted)
- >2000: Conventional doors with antisweat heater control

"T24" design: Conventional doors with antisweat heater control or low wattage doors (considered equivalent) simulated using the first option

Zero Heat Reach-in Glass Doors	
ID: **D03-228**	Abbreviation: **GNHGD**
Measure Description	Eliminate anti-sweat heaters from doors
Baseline Characteristics	Standard air-cooled multiplex, with door and frame heaters, 214W/door, humidity controlled
Code Baseline Characteristics	Standard air-cooled multiplex, with door and frame heaters, 214W/door, humidity controlled
Measure Characteristics	Eliminate door heaters, 54W/door frame heat only, fixed output
Savings Reporting Units	Per door
Savings Scalable By	n/a

7.4 Refrigerated Warehouse Measures

Vintage Information & "Title 24 Design"

Vintage definitions represent the average of the members in a particular vintage. Some members of an older vintage may have original equipment, which is less efficient due to deterioration over time and inefficient system additions; whereas others may have been remodeled with new systems and are as efficient as new vintage. Accordingly, the vintage performance is intended to represent the vintage as a class, and is not intended to represent a particular location.

For the purposes of the refrigeration system models, a "Title 24 design" was defined as standard practice in 2005. At this time, Title 24 does not apply to grocery refrigeration components. However, for DEER purposes, it is necessary to define a Title 24 reference case for program planning purposes and to determine the portion of the EEM savings that are above standard practice.

Retrocommissioning

Refrigerated warehouses offer potential for recommissioning in that many facilities were set according to the original design conditions (which included various safety factors), rather than adjusting to the actual needs. This EEM adjusts the suction and condensing setpoints to the temperatures required.

Permanence is a significant issue, requiring some form of monitoring to be considered as part of the EEM such as automated setpoint verification.

Methodology: When suction control is fixed, the base-case setpoint is depressed 3°F to approximate the lost savings that would accrue if the setpoint was more closely calibrated. Similarly, the condensing setpoint is raised by 2°F. The EEM then raises the setpoints back to the normal "base case" condition

Base Case by Vintage

- <1978: Vintage-dependent condenser and control setpoint
- 1978-1991: Vintage-dependent condenser and control setpoint
- 1992-2000: Vintage-dependent condenser and control setpoint
- >2000: Vintage-dependent condenser and control setpoint

"T24" design: EEM is N/A

Retrocommissioning	
ID: **D03-301**	Abbreviation: **WRtro**
Measure Description	Extensive refrigeration equipment maintenance
Baseline Characteristics	Standard evap-cooled multiplex, SST setpoint reduced 3°F, SCT setpoint raised 2°F
Code Baseline Characteristics	n/a
Measure Characteristics	Normal setpoints, representing tighter control
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

High-Efficiency Condensers

These measures size the condenser to the same heat-rejection capacity as the base case, but at a lower rated TD and higher specific efficiency; effectively increasing the condenser size while using less power.

Methodology: The base case is the vintage-dependent condenser, controlled to the vintage-dependent setpoint. The EEM condenser has same capacity as base case, but at a lower rated TD (approximately 5F lower than base case); given by the equation

RatedSCT = 60.8 + WB*0.4. (20F TD at 68F WB, 14F TD at 78F WB)

The EEM condenser efficiency is increased from 330 Btu/Watt to 400 Btu/Watt, where the EIRs are rated at 70F wetbulb and 100F SCT. Like the base case, the condenser has two fans that cycle to maintain setpoint. The EEM condenser is controlled to 85°F

Base Case by Vintage - See Condenser Table

- <1978: Vintage-dependent condenser and control setpoint
- 1978-1991: Vintage-dependent condenser and control setpoint
- 1992-2000: Vintage-dependent condenser and control setpoint
- >2000: Vintage-dependent condenser and control setpoint

“T24” design: “T24” condenser and control setpoint
Older vintages reflect effect of system changes and piping practice, as it impacts actual performance compared with nominal catalog ratings, and average age.

Oversized Evaporative Condenser

This EEM consists of the high-efficiency evaporative condenser described above.

Oversized Evaporative Condenser	
ID: **D03-302**	Abbreviation: **WOvEC**
Measure Description	Size condenser to ~5°F lower TD, 400 Btu/Watt
Baseline Characteristics	Condenser of vintage dependent size and efficiency
Code Baseline Characteristics	Condenser sized at ~23°F TD, 330 Btu/watt fan & pump, 95°F SCT setpoint
Measure Characteristics	Condenser sized at ~18°F TD, 400 Btu/watt fan & pump, 80°F SCT setpoint
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Oversized Evaporative Condenser & Floating Head, Variable-speed

This measure consists of the high-efficiency evaporative condenser described above, with the addition of floating head controls and a variable-speed drive on the condenser fan.

The base case and the EEM case are the same as described above. The EEM also includes the addition of a wetbulb-following condensing setpoint, with a 9°F TD between wetbulb and setpoint. The backflood control setpoint is reduced from 78°F to 68°F. A variable-speed drive replaces the cycling fan control.

Oversized Evaporative Condenser & Floating Head	
ID: **D03-303**	Abbreviation: **WOECF**
Measure Description	Size condenser to ~5°F lower TD, efficient fans & pump, WB following setpt
Baseline Characteristics	Condenser of vintage dependent size and efficiency
Code Baseline Characteristics	Condenser sized at ~23°F TD, 330 Btu/watt fan & pump, 95°F SCT setpoint
Measure Characteristics	Condenser sized at ~ 18°F TD, 400 Btu/watt fan & pump, WB-following SCT setpnt, variable-speed fan
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Variable-Speed Compressors

This measure adds a variable speed drive to one compressor in each suction group. This compressor is used to trim capacity, with all other compressors running at full capacity. The inefficiency of the slide valves used otherwise is eliminated.

Methodology: The base-case slide valves on all compressors are replaced with a variable-speed drive. The part-load performance curves are modified accordingly. In practice, one compressor in of each suction-group is all that is required, provided that it be used to trim the load, and all other compressors are staged and fully loaded.

Note: Variable speed compressor control may often be implemented with improved supervisory control of multiple compressors, vs. frequent practice of enabling compressors but allowing them to independently control load. Accordingly, on a case-by-case basis the base case may be significantly worse, and therefore the savings higher, than would be achieved strictly from a VFD vs. slide valve control EEM.

Base Case by Vintage

- <1978: Slide valve control
- 1978-1991: Slide valve control
- 1992-2000: Slide valve control
- >2000: Slide valve control

"T24" design: Slide valve control

Variable-Speed Compressors	
ID: **D03-304**	Abbreviation: **WVSCm**
Measure Description	Add variable-speed control to one compressor in each suction group
Baseline Characteristics	All compressors have slide valve control
Code Baseline Characteristics	All compressors have slide valve control
Measure Characteristics	Variable-speed drive to trim one compressor, remainder stage fully loaded
Savings Reporting Units	Per design tons of one compressor in each suction-group
Savings Scalable By	n/a

Low-Temperature Subcooling

This measure adds a subcooler to the low-temperature suction group, with subcooling provided by the medium-temperature suction group.

Methodology: The EEM adds a mechanical subcooler on the LT liquid circuit. Subcooling is controlled to 50°F Subcooling is provided by the MT suction group.

Base Case by Vintage

- <1978: no subcooling/flash cooling
- 1978-1991: no subcooling/flash cooling
- 1992-2000: no subcooling/flash cooling
- >2000: no subcooling/flash cooling

"T24" design: subcooling/flash cooling included

Note: On large ammonia industrial systems, flash cooling is standard practice since it reduces overall equipment size. On medium size systems, however, this is often not included in current design. The refrigerated warehouse prototype is somewhat smaller than the size of an industrial system that would have incorporated this feature as standard design (in previous vintages).

Low-Temperature Subcooling	
ID: **D03-305**	Abbreviation: **WLTSc**
Measure Description	Add mechanical subcooler to LT liquid line, fed by MT system
Baseline Characteristics	No subcooling on LT system
Code Baseline Characteristics	Subcooling/flash cooling included
Measure Characteristics	Subcooler on LT liquid circuit, provided by MT circuit, controlled to 50°F
Savings Reporting Units	Design cooling tons, LT
Savings Scalable By	n/a

Floating Suction Pressure

This measure adds controls to reset the suction pressure setpoint based on zone temperature. The compressors then operate more efficiently during periods of low load.

Methodology: The EEM consists of the addition of floating suction head controls to both the MT and LT suction groups. The minimum suction setpoint is the same as the base-case setpoint; the maximum is 5°F above the design temperature.

Base Case by Vintage

- <1978: no floating suction pressure
- 1978-1991: no floating suction pressure
- 1992-2000: no floating suction pressure
- >2000: no floating suction pressure

"T24" design: no floating suction pressure

Note: Active suction pressure control (FSP) has not been common practice in industrial refrigeration, in part because in many instances, implementation of FSP also requires achieving proper staging and loading of multiple compressors. Improving part-load performance of multiple screw compressors with better overall system control provides additional savings, potentially larger than the nominal FSP savings, on a case-by-case basis.

Floating Suction Pressure	
ID: **D03-306**	Abbreviation: **WFSPr**
Measure Description	Floating SST control on LT and MT suction groups
Baseline Characteristics	SST controlled to vintage-dependent fixed setpoint
Code Baseline Characteristics	SST controlled to 85°F fixed setpoint
Measure Characteristics	SST setpoint reset based on worst-case demand
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure Controls

This measure adds controls to reset the head pressure setpoint to 70°F minimum, using either a fixed or variable-setpoint.

Methodology: The base case uses the vintage-dependent condenser and SCT control setpoint. The EEM floats the SCT setpoint to a minimum of 70°F. The backflood control setpoint is reduced accordingly (2°F below the control setpoint).

Base Case by Vintage - See Condenser Table

- <1978: Vintage-dependent condenser and control setpoint
- 1978-1991: Vintage-dependent condenser and control setpoint
- 1992-2000: Vintage-dependent condenser and control setpoint
- >2000: Vintage-dependent condenser and control setpoint

<u>"T24" design:</u> "T24" condenser and control setpoint
Note: Older vintages include consideration of system design practice as it impacts head pressure settings.

<u>Floating Head Pressure, Fixed Setpoint (evaporative-cooled)</u>

This measure floats the head pressure using a fixed 70°F setpoint. Some energy may be wasted during periods when ambient conditions prevent this setpoint from being achieved.

Floating Head Pressure, Fixed Setpoint (evaporative-cooled)	
ID: **D03-307**	Abbreviation: **WFFSe**
Measure Description	Floating SCT controlled to 70°F
Baseline Characteristics	SST controlled to vintage-dependent fixed setpoint
Code Baseline Characteristics	SST controlled to 85°F fixed setpoint
Measure Characteristics	SCT controlled to 70°F, 68°F backflood control setpoint
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

<u>Floating Head Pressure, Variable Setpoint (evaporative-cooled)</u>

This measure floats the head pressure to 70°F SCT minimum, using an ambient following setpoint. The EEM resets the setpoint using a 9°F TD between wetbulb and setpoint. As this measure will not attempt to achieve 70°F when conditions do not permit, some additional savings may be achieved.

Floating Head Pressure, Variable Setpoint (evaporative-cooled)	
ID: **D03-308**	Abbreviation: **WFVSe**
Measure Description	Wetbulb following SCT setpoint, 70°F minimum
Baseline Characteristics	SST controlled to vintage-dependent fixed setpoint
Code Baseline Characteristics	SST controlled to 85°F fixed setpoint
Measure Characteristics	Control SCT to wetbulb + 9°F TD, 70°F minimum, backflood setpoint of 68°F
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

Floating Head Pressure, Variable Setpoint & Speed (evap-cooled)

This measure floats the head pressure to 70°F SCT minimum, using an ambient following setpoint. In addition, the fan is modulated using a variable-speed drive in place of 2 cycling fans.

The EEM resets the setpoint using a 9°F TD between wetbulb and setpoint.

Floating Head Pressure, Variable Setpoint & Speed (evaporative-cooled)	
ID: **D03-309**	Abbreviation: **WFVSS**
Measure Description	Wetbulb following SCT setpoint, 70°F min, variable-speed condenser fan
Baseline Characteristics	SST controlled to vintage-dependent fixed setpoint, cycling condenser fans
Code Baseline Characteristics	SST controlled to 85°F fixed setpoint
Measure Characteristics	Control SCT to wetbulb + 9°F TD, 70°F min, backflood setpt of 68°F, var-speed cond
Savings Reporting Units	Design cooling tons
Savings Scalable By	n/a

8

Residential Weather Sensitive DEER Measure Descriptions

8.1 Residential Measures

This section contains a top level description of the methodology used to model each measure for all residential building types. Also included are the primary parameters used in the modeling of each measure and how those parameters are altered from the base case, to the code baseline to the measure; sometimes these parameters vary by climate zone and building vintage. To provide added detail of interest for the measure descriptions links are provided, when appropriate, into MAS tool spreadsheets, and other supporting documents, that contain more details of parameter values.

Code baselines have been selected from one of the following California regulations:

- *2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-001, California Energy Commission, September 2004, Effective Date October 1, 2005 (Title 24 or T24); and
- *Appliance Efficiency Regulations*, California Energy Commission, April 2005, Publication CEC 400-2005-012 (Title 20 or T20.)

Additional simulation methodologies are derived from:

- *Residential Alternative Calculation Method (ACM) Approval Manual for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-003, California Energy Commission, October 2004 (Res ACM Manual or Res ACM); and
- *Nonresidential Alternative Calculation Method (ACM) Approval Manual for the 2005 Building Energy Efficiency Standards for Residential and Nonresidential Buildings*, Publication #P400-03-004, California Energy Commission, October 2004 (ACM Manual or ACM.)

Programmable Thermostat Measure

The measure estimates savings due to the use of a programmable thermostat.

Programmable Thermostat	
ID: **D03-401**	Abbreviation: **RPTST**
Measure Description	Programmable Thermostat
Baseline Characteristics	Occupant behavior with Manual Thermostat
Code Baseline Characteristics	Title 24 minimum, programmable thermostat
Measure Characteristics	Occupant behavior with Programmable Thermostat
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

The analysis methodology for the programmable thermostat measure is unique among all the DEER measures in that it is based on a statistical analysis of occupant's behavior. A wide variety of thermostat schedules are simulated and the DOE2 results are then weighted based upon the likelihood of each thermostat schedule being used. The weight assigned to the results of each thermostat schedule is a function of climate and thermostat type. The analysis procedure is documented in the 2004 SCE report "Programmable Thermostats Installed into Residential Buildings: Predicting Energy Saving Using Occupant Behavior & Simulation". An overview of the methodology is given here.

RASS Database Analysis

The Residential Appliance Saturation Survey (RASS) asked homeowners how they used their cooling and heating thermostat throughout the day. These data were filtered based on thermostat type (manual operation and programmable) and climate region to quantify how homes with and without programmable thermostats differ with regard to their thermostat use. In the cooling mode, the survey results offer the potential for cooling energy savings: the set point temperature is typically slightly higher throughout the day when programmable thermostats are used, though fewer programmable thermostats are set to "off" than manual thermostats. In the heating mode, the survey results are less ambiguous: the set point is typically slightly higher and fewer units are set to "off" for programmable thermostats compared to manual thermostats, invariably leading to higher heating energy use.

The results for the RASS analysis is a series of tables that describe what fraction of homes utilize a particular thermostat schedule throughout the day based on the type of thermostat they have. One example of these tables is given below. The table presents the weights for a programmable thermostat in the heating mode for north coast climate zone:

North Coast				
Programmable Heating Thermostat				
T-stat Setting	Morn	Day	Evening	Night
Off	17.2%	27.9%	8.1%	39.9%
Off -> Vlo/Lo	15.9%	2.9%	10.8%	1.5%
Remain Vlo	4.3%	3.6%	2.8%	2.5%
Remain Low	7.2%	10.5%	9.8%	5.0%
Med -> Vlo/Lo	2.0%	20.1%	1.8%	28.3%
High/Vhi -> Vlo/lo	0.4%	1.1%	0.0%	2.4%
Off -> Med	12.9%	1.7%	10.7%	0.7%
Vlo/Lo -> Med	18.2%	3.5%	18.9%	2.2%
Remain Med	9.7%	18.0%	20.9%	9.5%
High/Vhi -> Med	0.7%	1.2%	0.6%	1.8%
Off -> High/Vhi	3.8%	0.9%	4.2%	0.2%
Vlo/Lo -> High/Vhi	2.2%	0.6%	1.2%	0.0%
Med -> High/Vhi	1.6%	0.9%	1.7%	0.4%
Remain High	3.2%	7.2%	7.9%	4.6%
Remain Very Hi	0.4%	0.0%	0.6%	1.2%

Each value in this table is the likelihood of the heating thermostat being set to a particular value (off, medium, high, etc.), coming from a previous setpoint throughout the day.

DOE2 Simulations

Seventeen separate combinations of heating and cooling thermostat schedules are created to capture the thermostat setpoints described by the RASS analysis. For this measure, the base case and measure case simulations are the same. The multiple DOE2 runs are used to describe the range of potential occupant behaviors. The measure savings is derived by applying the statistical weights from the manual (baseline) and programmable (measure) thermostat tables to the simulation results and then comparing the energy use of these two scenarios.

A lot of special processing happens “behind the scene” with this measure. First, seventeen separate simulations are created and executed using unique combinations of heating and cooling thermostat schedules that vary throughout the day. Next, the heating and cooling simulation results are extracted for four separate periods throughout the day (morning, day, evening and night). These individual results are then weighted together based on the thermostat and climate zone specific RASS thermostat tables to arrive at energy estimates for homes with and without programmable thermostats. Because of this required processing, the DEER results database does not include end-use information nor demand impacts for this measure.

Measure Results

The thermostat tables derived from the RASS database dictate the savings potential of programmable thermostats under this procedure. As was shown in the earlier study, the reported behavior of people with and without programmable thermostats does not support the application of programmable thermostats as an energy saving measure. When both heating and cooling are accounted for, energy use increases in nearly all climate zones and in all residential building types.

High Efficiency Air Conditioner and Heat Pump Measures

The following twelve measures are modeled by specifying detailed HVAC performance characteristics for the given SEER level and heating type. The development of the performance characteristics is documented in the 2005 SCE report "DEER Residential SEER-Rated Units Performance Maps" and its accompanying detail data spreadsheet "UnitSelectionAndEnergySavingsForResidentialSplitSystems"..

13 SEER (11.09 EER) Split System Air Conditioner	
ID: **D03-403**	Abbreviation: **RSA13**
Measure Description	13 SEER, Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	13 SEER (11.09 EER), Single-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

14 SEER (11.99 EER) Split System Air Conditioner	
ID: **D03-404**	Abbreviation: **RSA14**
Measure Description	14 SEER, Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	14 SEER (11.99 EER), Single-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

15 SEER (12.72 EER) Split System Air Conditioner	
ID: **D03-463**	Abbreviation: **RSA15**
Measure Description	15 SEER, Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	15 SEER (12.72 EER), Single-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

16 SEER (11.61 EER) Split System Air Conditioner	
ID: **D03-464**	Abbreviation: **RSA16**
Measure Description	16 SEER, Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	16 SEER (11.61 EER), Two-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

17 SEER (12.28 EER) Split System Air Conditioner	
ID: **D03-465**	Abbreviation: **RSA17**
Measure Description	17 SEER (12.28 EER), Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	17 SEER (12.28 EER), Two-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

18 SEER (13.37 EER) Split System Air Conditioner	
ID: **D03-40**	Abbreviation: **RSA18**
Measure Description	18 SEER (13.37 EER), Residential Air Conditioner
Baseline Characteristics	Vintage specific SEER, Residential Air Conditioner
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Air Conditioner
Measure Characteristics	18 SEER (13.37 EER), Two-Speed, Residential Air Conditioner
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

13 SEER (11.07 EER) / 8.1 HSPF (3.28 COP) A/C Heat pump	
ID: **D03-414**	Abbreviation: **RHP13**
Measure Description	13 SEER, Residential Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	13 SEER (11.07 EER) / 8.1 HSPF (3.28 COP), Single Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

14 SEER (12.19 EER) / 8.6 HSPF (3.52 COP) A/C Heat pump	
ID: **D03-415**	Abbreviation: **RHP14**
Measure Description	14 SEER (12.19 EER) / 8.6 HSPF (3.52 COP) A/C Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	14 SEER (12.19 EER) / 8.6 HSPF (3.52 COP) , Single Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

15 SEER (12.70 EER) / 8.8 HSPF (3.74 COP) A/C Heat pump	
ID: **D03-416**	Abbreviation: **RHP15**
Measure Description	15 SEER (12.70 EER) / 8.8 HSPF (3.74 COP) A/C Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	15 SEER (12.70 EER) / 8.8 HSPF (3.74 COP) , Single Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

16 SEER (12.06 EER) / 8.4 HSPF (3.48 COP) A/C Heat pump	
ID: **D03-466**	Abbreviation: **RHP16**
Measure Description	16 SEER (12.06 EER) / 8.4 HSPF (3.48 COP) A/C Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	16 SEER (12.06 EER) / 8.4 HSPF (3.48 COP) , Two-Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

17 SEER (12.52 EER) / 8.6 HSPF (3.26 COP) A/C Heat pump	
ID: **D03-467**	Abbreviation: **RHP17**
Measure Description	17 SEER (12.52 EER) / 8.6 HSPF (3.26 COP) A/C Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	17 SEER (12.52 EER) / 8.6 HSPF (3.26 COP) , Two-Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

18 SEER (12.8 EER) / 9.2 HSPF (3.66 COP) A/C Heat pump	
ID: **D03-417**	Abbreviation: **RHP18**
Measure Description	18 SEER (12.8 EER) / 9.2 HSPF (3.66 COP) A/C Heat pump
Baseline Characteristics	Vintage specific SEER, Residential Heat Pump
Code Baseline Characteristics	T24 minimum: 13 SEER, Residential Heat Pump
Measure Characteristics	18 SEER (12.8 EER) / 9.2 HSPF (3.66 COP) , Two-Speed, Residential Heat pump
Savings Reporting Units	tons cooling
Savings Scalable By	Δ (3.413/SEER)

The SCE report details these steps taken to arrive at the detailed performance specifications:

Unit Selection

Performance data for more than 500 units were analyzed. Units grouped by SEER level and unit type (cooling only and heat pump) were further categorized by the slope of the EIR curve and the cycling degradation coefficient (C_d).

Performance Characteristics

Detailed DOE2 inputs were then developed based on manufacturer's expanded engineering data. These detailed performance specifications were developed for a range of performance within each SEER level (13, 14, 15, 16, 17 and 18 SEER) and for both air-conditioners and heat pumps. The DX Equipment Table (DXEquip Sheet of DEER Tables.xls) provides the inputs used by DOE2 to model each of these units.

DOE2 modifications

The simulation program was modified to properly model two-speed residential heat pumps and air-conditioners utilizing the detailed specifications developed. This work was an expansion of modifications created for an earlier examination of SEER-rated HVAC performance documented in the SCE report "EER & SEER As Predictors Of Seasonal Cooling Performance" and summarized in "EER & SEER As Predictors Of Seasonal Cooling

Performance Summary of Research". At this writing these two documents are being updated to incorporate the expanded and up-to-date performance analysis, used in this DEER work, for equipment with SEER ratings of 13 and 15 for single speed units and 16, 17 and 18 for two-speed units.

Determination of "median" unit

The range of unit performance within a given SEER level was explored by simulating each unit for a range of residential building descriptions within each climate zone. The median unit within a SEER level (e.g. SEER 14 AC) is defined as the unit whose energy use was closest to the average energy use for all units with that SEER level across all building vintages and climate zones.

Median Unit Selection				
Unit	**Efficiency**			**Median**
Type	**Level**	**Type**	**EER**	**Unit ID**
AC	SEER 10	1-Speed	9.2	SA-10-HH
AC	SEER 13	1-Speed	11.1	SA-13-ML
AC	SEER 14	1-Speed	12.2	SA-14-ML
AC	SEER 15	1-Speed	12.7	SA-15-ML
AC	SEER 16	2-Speed	11.6	SA-16-LL
AC	SEER 17	2-Speed	12.3	SA-17-LL
AC	SEER 18	2-Speed	13.4	SA-18-TM
HP	SEER 10	1-Speed	9.0	SH-10-MM
HP	SEER 13	1-Speed	11.1	SH-13-MM
HP	SEER 14	1-Speed	12.2	SH-14-HM
HP	SEER 15	1-Speed	12.7	SH-15-ML
HP	SEER 16	2-Speed	12.1	SH-16-LM
HP	SEER 17	2-Speed	12.5	SH-17-TH
HP	SEER 18	2-Speed	12.9	SH-18-LM

The final result of this earlier work is a set DOE2 inputs that model typical units for each SEER level for both air conditioners and heat pumps. The performance characteristics are for actual units and are derived from manufacturers published engineering data. This procedure is a significant improvement over previous analyses that relied on default performance curves and single-point adjustments to energy efficiency.

The following table shows the SEER level used for the baseline simulations. Unless otherwise specified, these are the same vintage specific SEER levels use for all other measure analyses.

AC - Base SEER by Vintage and Residential Building Type

Single and Multi-Family		Double-Wide Mobile	
Vintage	**SEER**	**Vintage**	**SEER**
Before 1978	8.5	Before 1976	6.65
1978 - 1992	9.0	1976 - 1994	6.65
1993 - 2001	10	1995 - 2005	10
2002 - 2005	10	After 2005	13
After 2005	13		

HP - Base SEER by Vintage and Residential Building Type

Single and Multi-Family			Double-Wide Mobile		
Vintage	**SEER**	**HSPF**	**Vintage**	**SEER**	**HSPF**
Before 1978	8.5	4.7	Before 1976	6.65	4.7
1978 - 1992	9.0	5.7	1976 - 1994	6.65	5.7
1993 - 2001	10	6.8	1995 - 2005	10	6.8
2002 - 2005	10	6.8	After 2005	13	6.8
After 2005	13	7.7			

Since expanded engineering data is unavailable for units with SEER levels less than 10, the specification of those units are derived from the median SEER 10 unit, using the same performance curves and adjusting the energy-input-ratio to reflect the desired SEER.

The DOE2 system type modified and used for these simulations is the commercial PVVT (packaged variable-volume variable-temperature) system. Since the default values for inputs such as economizer control, outside air fraction and fan placement for this system type are not necessarily appropriate for residential HVAC systems, all default values are replaced with appropriate residential values.

The following snippet of BDL code shows the system commands that are specific to the AC unit being modeled. These specifications are for a SEER 10 AC unit with a gas furnace:

```
"SEER10-Res-AC Sys1" = SYSTEM
   TYPE             = PVVT          $required system type
   HEAT-SOURCE      = FURNACE       $AC system with gas furnace
   …
   AIR/TEMP-CONTROL = TWO-SPEED     $ required for modeling single or 2-speed units
   MIN-FLOW-RATIO   = 0.9989        $ cooling minimum flow ratio (single speed)
   HMIN-FLOW-RATIO  = 0.9989        $ heating minimum flow ratio (single speed)
   COOL-STAGES      = ( 0.9989, 1 ) $ single stage only
   HEAT-STAGES      = ( 0.9989, 1 )
   MIN-UNLOAD-RATIO = 1.0
   MIN-HGB-RATIO    = 1.0
   SUPPLY-FLOW      = 732.366       $ supply flow is a function of capacity and unit specs
   SUPPLY-KW/FLOW   = 0.000365      $ unit spec
   SUPPLY-DELTA-T   = 1.1534        $ a function of the supply-kW/flow only
   COOLING-CAPACITY = 24306.9       $ set based on conditioned area, climate zone and vintage
   COOL-SH-CAP      = 16292.9       $ a function of the cooling-capacity and the unit specs
   COOLING-EIR      = 0.3208        $ unit spec
   COIL-BF          = 0.2947        $ unit spec
   $ the following performance curves are unit specific:
   COOL-CAP-FT      = "SA-10-HH - Cool Cap f(T)"
   COOL-EIR-FT      = "SA-10-HH - EIR f(T)"
   COOL-EIR-FPLR    = "SA-10-HH - EIR f(PLR)"
   COOL-SH-FT       = "SA-10-HH - Sens Cap f(T)"
   COIL-BF-FFLOW    = "SA-10-HH - BF f(Flow)"
   COIL-BF-FT       = "SA-10-HH - Coil BF f(T)"
   COOL-CLOSS-FPLR  = "SA-10-HH - C-Loss f(PLR)"
   …
```

This BDL snippet is an example specification for a 2-speed, SEER-16 heat pump:

```
"SEER16-Res-HP Sys1" = SYSTEM
   TYPE             = PVVT          $required system type
   HEAT-SOURCE      = HEAT-PUMP
   …
   AIR/TEMP-CONTROL = TWO-SPEED     $ required for modeling single or 2-speed units
   MIN-FLOW-RATIO   = 0.75          $ cooling minimum flow ratio
   HMIN-FLOW-RATIO  = 0.75          $ heating minimum flow ratio
   COOL-STAGES      = ( 0.7389, 1 ) $ cooling capacity ratios
   HEAT-STAGES      = ( 0.7389, 1 ) $ heating capacity ratios
   MIN-UNLOAD-RATIO = 0.73889
   MIN-HGB-RATIO    = 0.73889
   SUPPLY-FLOW      = 785.97        $ supply flow is a function of capacity and unit specs
   SUPPLY-KW/FLOW   = 0.000321      $ unit spec
   SUPPLY-DELTA-T   = 1.01436       $ a function of the supply-kW/flow only
   COOLING-CAPACITY = 23581.4       $ set based on conditioned area, climate zone and vintage
   COOL-SH-CAP      = 18393.5       $ a function of the cooling-capacity and the unit specs
   COOLING-EIR      = 0.2361        $ unit spec
   HEATING-EIR      = 0.287356      $ unit spec
   COIL-BF          = 0.0991        $ unit spec
   $ the following performance curves are unit specific:
   COOL-CAP-FT      = "SH-16-LM - Cool Cap f(T)"
   COOL-EIR-FT      = "SH-16-LM - EIR f(T)"
   COOL-EIR-FPLR    = "SH-16-LM - EIR f(PLR)"
   COOL-SH-FT       = "SH-16-LM - Sens Cap f(T)"
   COIL-BF-FFLOW    = "SH-16-LM - BF f(Flow)"
   COIL-BF-FT       = "SH-16-LM - Coil BF f(T)"
   HEAT-CAP-FT      = "SH-16-LM - Heat Cap f(T)"
   HEAT-EIR-FT      = "SH-16-LM - Heat EIR f(T)"
   HEAT-EIR-FPLR    = "SH-16-LM - Heat EIR f(PLR)"
   COOL-CLOSS-FPLR  = "SH-16-LM - C-Loss f(PLR)"
   …
```

High Efficiency Furnace Measures

Methodology: Baseline furnace efficiencies are listed in the able below:

Vintage	Single Family	Multi Family	Vintage	Mobile Home
< 1978	70	70	< 1976	72
1978 – 1992	74	74	1976 – 1994	72
1993 – 2001	78	73	1995 – 2005	78
2002 – 2005	78	73	> 2005	78
> 2005	78	73		

AFUE is converted to the DOE 2.2 SYSTEM keyword FURNACE-HIR according to the following equations (ACM Manual, Section 2.5.2.10, Page 2-64):

For AFUE <= 83.5:

FURNACE-HIR = 1 / (0.002908 * AFUE + 0.5787)

For AFUE > 83.5:

FURNACE-HIR = 1 / (0.011116 * AFUE – 0.098185)

Basic Furnace Upgrade to 81% AFUE	
ID: **D03-461**	Abbreviation: **RFC81**
Measure Description	Basic Furnace Upgrade to 81% AFUE
Baseline Characteristics	70 – 78 AFUE Furnace (depending on vintage and residential building type)
Code Baseline Characteristics	Title 24 minimum furnace AFUE = 78%
Measure Characteristics	Basic Furnace Upgrade to 81% AFUE
Savings Reporting Units	kBtu furnace capacity
Savings Scalable By	Δ (1/AFUE)

Condensing 90 AFUE (1.11 HIR) Furnace	
ID: **D03-410**	Abbreviation: **RFC90**
Measure Description	Condensing 90 AFUE (1.11 HIR) Furnace
Baseline Characteristics	70 – 78 AFUE Furnace (depending on vintage and residential building type)
Code Baseline Characteristics	Title 24 minimum furnace AFUE = 78%
Measure Characteristics	Condensing 90 AFUE (1.11 HIR) Furnace
Savings Reporting Units	kBtu furnace capacity
Savings Scalable By	Δ (1/AFUE)

Condensing 92 AFUE (1.08 HIR) Furnace	
ID: **D03-411**	Abbreviation: **RFC92**
Measure Description	Condensing 92 AFUE (1.08 HIR) Furnace
Baseline Characteristics	70 – 78 AFUE Furnace (depending on vintage and residential building type)
Code Baseline Characteristics	Title 24 minimum furnace AFUE = 78%
Measure Characteristics	Condensing 92 AFUE (1.08 HIR) Furnace
Savings Reporting Units	kBtu furnace capacity
Savings Scalable By	Δ (1/AFUE)

Condensing 94 AFUE (1.06 HIR) Furnace	
ID: **D03-412**	Abbreviation: **RFC94**
Measure Description	Condensing 94 AFUE (1.06 HIR) Furnace
Baseline Characteristics	70 – 78 AFUE Furnace (depending on vintage and residential building type)
Code Baseline Characteristics	Title 24 minimum furnace AFUE = 78%
Measure Characteristics	Condensing 94 AFUE (1.06 HIR) Furnace
Savings Reporting Units	kBtu furnace capacity
Savings Scalable By	Δ (1/AFUE)

Condensing 96 AFUE (1.03 HIR) Furnace	
ID: **D03-413**	Abbreviation: **RFC96**
Measure Description	Condensing 96 AFUE (1.03 HIR) Furnace
Baseline Characteristics	70 – 78 AFUE Furnace (depending on vintage and residential building type)
Code Baseline Characteristics	Title 24 minimum furnace AFUE = 78%
Measure Characteristics	Condensing 96 AFUE (1.03 HIR) Furnace
Savings Reporting Units	kBtu furnace capacity
Savings Scalable By	Δ (1/AFUE)

Evaporative Cooler Measures

Central evaporative cooling systems can save significant cooling energy compared to direct expansion cooling systems. However, this savings often comes at the expense of comfort within the space. In most applications, evaporative cooling will not be able to provide adequate cooling during peak cooling conditions when conventional direct expansion cooling would satisfy cooling loads. Additionally, when using direct and direct-indirect systems, humidity in the conditioned space could reach uncomfortably high levels. These effects, unmet cooling loads and high humidity levels, are not reflected in the savings values for evaporative cooling. This is not to say that evaporative cooling does not offer substantial savings opportunities. For many conditions throughout a typical cooling season, evaporative cooling is adequate to meeting cooling loads and still maintain reasonable humidity levels within the space and much lower energy use, compared to direct expansion systems, will result. During peak cooling conditions, however, most evaporative cooling systems are inadequate to maintain temperature set points and reasonable humidity levels.

Methodology: The measure building has only evaporative cooling (no direct expansion cooling) with the following characteristics:

- Cooling supply flow is three times the flow used for the baseline and code baseline buildings
- Direct effectiveness = 0.85, and
- Indirect effectiveness = 0.65.

Direct Evaporative Cooler	
ID: **D03-405**	Abbreviation: **RDEvp**
Measure Description	Direct Evaporative Cooler
Baseline Characteristics	6.65 – 13.0 SEER Split-System Air Conditioner (depending on vintage and residential building type)
Code Baseline Characteristics	T24 minimum: 13 SEER(11.09 EER) Split System Air Conditioner
Measure Characteristics	Direct Evaporative Cooler
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

Indirect Evaporative Cooler	
ID: **D03-406**	Abbreviation: **RIEvp**
Measure Description	Indirect Evaporative Cooler
Baseline Characteristics	6.65 – 13.0 SEER Split-System Air Conditioner (depending on vintage and residential building type)
Code Baseline Characteristics	T24 minimum: 13 SEER(11.09 EER) Split System Air Conditioner
Measure Characteristics	Indirect Evaporative Cooler
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

Direct-Indirect Evaporative Cooler	
ID: **D03-407**	Abbreviation: **RDIEv**
Measure Description	Direct-Indirect Evaporative Cooler
Baseline Characteristics	6.65 – 13.0 SEER Split-System Air Conditioner (depending on vintage and residential building type)
Code Baseline Characteristics	T24 minimum: 13 SEER(11.09 EER) Split System Air Conditioner
Measure Characteristics	Direct-Indirect Evaporative Cooler
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

Refrigerant Charge Measures

These four EEMs model the range of refrigerant charge measures typically encountered in the field. The refrigerant charge measure is often combined with duct sealing, so these measures are run as a package to demonstrate the combined savings potential.

Typical Refrigerant Charge Adjustment	
ID: **D03-408**	Abbreviation: **RRCh1**
Measure Description	Typical Refrigerant Charge Adjustment (< ±20% rated charge)
Baseline Characteristics	Cooling capacity and EIR degraded based on need for "typical" refrigerant charge adjustment
Code Baseline Characteristics	Code Baseline matches Baseline characteristics
Measure Characteristics	Standard Cooling Performance (proper refrigerant charge)
Savings Reporting Units	tons cooling
Savings Scalable By	n/a

High Refrigerant Charge Adjustment	
ID: **D03-409**	Abbreviation: **RRCh2**
Measure Description	High Refrigerant Charge Adjustment (>= ±20% rated charge)
Baseline Characteristics	Cooling capacity and EIR degraded based on need for "high" refrigerant charge adjustment
Code Baseline Characteristics	Code Baseline matches Baseline characteristics
Measure Characteristics	Standard Cooling Performance (proper refrigerant charge)
Savings Reporting Units	tons cooling
Savings Scalable By	n/a

Typical Refrigerant Charge Adjustment + Duct Sealing	
ID: **D03-459**	Abbreviation: **RRC1D**
Measure Description	Typical Refrigerant Charge Adjustment (< ±20% rated charge) + Duct Sealing
Baseline Characteristics	Cooling capacity and EIR degraded based on need for “typical” refrigerant charge adjustment, 24% total duct leakage
Code Baseline Characteristics	Code Baseline matches Baseline characteristics
Measure Characteristics	Standard Cooling Performance, 12% total duct leakage
Savings Reporting Units	tons cooling
Savings Scalable By	n/a

High Refrigerant Charge Adjustment + Duct Sealing	
ID: **D03-460**	Abbreviation: **RRC2D**
Measure Description	High Refrigerant Charge Adjustment (>= ±20% rated charge) + Duct Sealing
Baseline Characteristics	Cooling capacity and EIR degraded based on need for “high” refrigerant charge adjustment, 24% total duct leakage
Code Baseline Characteristics	Code Baseline matches Baseline characteristics
Measure Characteristics	Standard Cooling Performance, 12% total duct leakage
Savings Reporting Units	tons cooling
Savings Scalable By	n/a

A “typical” refrigerant charge adjustment is defined as one where the refrigerant added or removed is less than 20% of unit’s rated charge. A “high” refrigerant charge adjustment is defined as one where the refrigerant added or removed is at or above 20% of the unit’s rated charge. The typical residential split system may not always require a refrigerant charge adjustment; numerous papers have been published showing that varying percentages, typically between 50% and 80%, of HVAC systems require this adjustment (“Field Measurements of Air Conditioners with and without TXVs,” Mowris, et.al., 2004 ACEEE Summer Study Proceedings.) These DEER measures, however, are defined as the impacts that can be expected when a charge adjustment is required. Use of these measure should take into account that only a fraction of the participating units will require this adjustment.

Data gathered during a refrigerant-charge program implementation was used to derive the effect of the improved refrigerant charge on cooling capacity and cooling energy input; Robert Mowris Associates supplied James J. Hirsch & Associates raw data for the analysis, which can be found in the spreadsheet RCA_DataForRefrigerantChange-FinalVersion_05-08-08.xls. The data set includes refrigerant charge, calculated cooling capacity and electric use before and after a refrigerant adjustment. The HVAC units documented include both new and old units and cover the range of typical residential air conditioners: 2.5 – 5 tons nominal capacity, with and without thermal expansion valves, using R-22 and R-410a refrigerant.

An analysis of the data shows that before the required refrigerant charge adjustment, the typical HVAC unit has decreased total and sensible cooling capacity and a higher electric energy-input-ratio, as compared to the same performance parameters after the refrigerant charge. Not surprisingly, units whose refrigerant charge is more than 20% outside of its rated charge have worse performance than units that are within 20% of rated charge. Currently, there is insufficient data to further refine this relationship between refrigerant charge and energy performance. The following table shows the multipliers to cooling capacity and the electric input ratio that define a unit with an improper refrigerant charge.

Refrigerant Adjustment needed	Capacity Multiplier		EIR Multiplier
	Total	Sensible	
Typical (<20%)	0.886	0.929	1.146
High (>20%)	0.834	0.897	1.304

For these four measures, the HVAC performance of the baseline simulation is degraded, since the unit is in need of a refrigerant charge adjustment. The measure simulation brings the HVAC performance back to the SEER-specific HVAC performance level. The HVAC parameters affected by this measure are the total and sensible cooling capacities and the electric input ratio. See the description of the Duct Sealing measures for more information on how the ducts parameters are modeled.

The results for this measure do not apply to the average building stock, but rather apply to a sub-set of buildings that have HVAC units with refrigerant charges outside the manufacturer's specifications.

Duct Sealing Measures

All of the residential models used for this analysis utilize explicit duct modeling (as opposed to HVAC equipment efficiency multipliers). These measures modify the specified duct leakage values to determine savings potential. Included here is a general description of the duct modeling as well as details on the duct sealing measures.

Duct Sealing (28% Total Leakage Reduction)	
ID: **D03-418**	Abbreviation: **RDct1**
Measure Description	Duct Sealing (Total Leakage Reduced from 40% of AHU flow to 12%)
Baseline Characteristics	Total measured supply air leakage of 40%
Code Baseline Characteristics	Duct leakage code baseline matches measure baseline
Measure Characteristics	Total measured supply air leakage of 12%
Savings Reporting Units	1,000 sqft house
Savings Scalable By	Δ%leakage

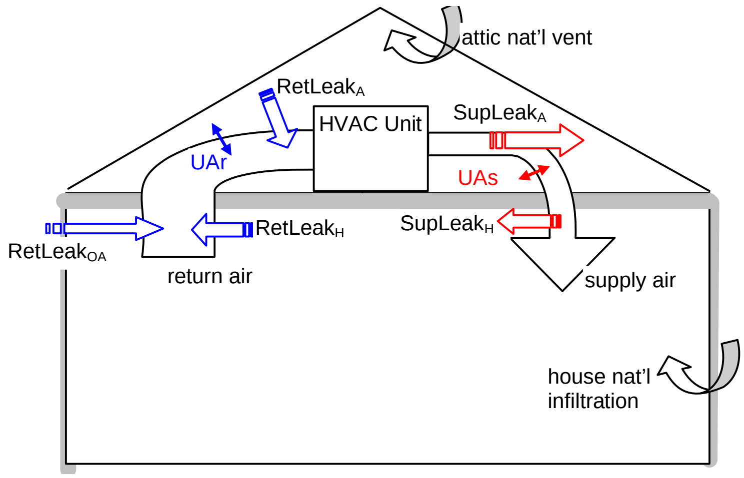
Duct Sealing (12% Total Leakage Reduction)	
ID: **D03-458**	Abbreviation: **RDct2**
Measure Description	Duct Sealing (Total Leakage Reduced from 24% of AHU flow to 12%)
Baseline Characteristics	Total measured supply air leakage of 24%
Code Baseline Characteristics	Duct leakage code baseline matches measure baseline
Measure Characteristics	Total measured supply air leakage of 12%
Savings Reporting Units	1,000 sqft house
Savings Scalable By	Δ%leakage

Duct Sealing (20% Supply Leakage Reduction)	
ID: **D03-462**	Abbreviation: **RDct3**
Measure Description	Mobile Home Duct Sealing (Supply Leakage Reduced from 35% of AHU flow to 15%)
Baseline Characteristics	Measures supply leakage is 35% of AHU flow
Code Baseline Characteristics	Duct leakage code baseline matches measure baseline
Measure Characteristics	Measures supply leakage is 15% of AHU flow
Savings Reporting Units	1,000 sqft house
Savings Scalable By	Δ%leakage

Duct Sealing (10% Supply Leakage Reduction)	
ID: **D03-468**	Abbreviation: **RDct4**
Measure Description	Mobile Home Duct Sealing (Supply Leakage Reduced from 25% of AHU flow to 15%)
Baseline Characteristics	Measures supply leakage is 25% of AHU flow
Code Baseline Characteristics	Duct leakage code baseline matches measure baseline
Measure Characteristics	Measures supply leakage is 15% of AHU flow
Savings Reporting Units	1,000 sqft house
Savings Scalable By	Δ%leakage

The DOE2 program allows for the specification of supply and return duct conductive loss (UA_S and UA_R in the diagram below) as well as supply air leakage and return air leakage.

The difference between the flow rate of supply leakage and return leakage is made up by increased house infiltration, which is added to the return air stream.



Duct loss and gain components in DOE2.2

Duct conductive losses are specified by an overall UA (BTU/hr-°F) for the supply duct and return ducts. The duct UA values are a function of the house conditioned floor area (CFA), the number of stories (1 or 2 for single-family, 1 for multi-family and mobile home) and the "Effective Supply Duct R-value" (ESDR) and the "Effective Return Duct R-value" (ERDR), which are both a function of vintage and building type.

The Supply Duct UA is calculated as:

$$UA_S = CFA * 0.27 * (1.35 - 0.35*NumFloors) / ESDR$$

and the Return Duct UA is calculated as:

$$UA_R = CFA * 0.05 * NumFloors / ERDR.$$

Single Family Duct Leakage

The base case for the first duct leakage measure is "40% total air leakage". Of this total, half is supply leakage. For single-story houses, 75% of the supply leakage is assumed to go to the unconditioned attic ($SupLeak_A$), with the remainder leaking to the conditioned spaces ($SupLeak_H$). Duct leakage to the conditioned spaces, while typically part of most duct loss measurements, is not actually "lost" and is treated as supply CFM for the simulation. Return duct leakage in the single family house is assumed to be 80% of the volume of the supply duct leakage. This would imply that 20% of the supply duct loss is made up with outside air ($RetLeak_{OA}$), but due to interactions with existing natural infiltration, it is assumed that only half of this value (10% of supply duct loss) is actually brought in from the outside. The balance of (supply air lost to attic) minus (outdoor air induced into the space) is return leakage, or air that is sucked into the return ducts from either the attic ($RetLeak_A$) or house($RetLeak_H$).

The BDL code for a single-story house that models this situation is:

```
DUCT-ZONE          = "Bldg 1 Attic"
DUCT-UA            = 122.9
RETURN-UA          = 22.8
DUCT-AIR-LOSS      = 0.15  $ 20% total leakage * 75% to attic
DUCT-AIR-LOSS-OA = 0.1    $ fraction of supply air loss as outdoor air flow to return
```

Since more of the ducts are assumed to be located within the conditioned space for a two-story house, the fraction of total supply leakage that goes to the attic is lowered to 67%.

The measure case of the first duct measure specifies 12% total duct leakage. All of the same fractional air flows of the base case are carried through to the measure case, leading to a supply air loss of 6% times 0.75 for single-story houses and 6% times 0.67 for two-story houses.

The second duct measure, which lowers total duct leakage from 24% to 12%, has a base case supply duct leakage of 12% times 0.75 for single-story houses, and 12% times 0.67 for two-story houses. The measure case is the same as the first duct EEM.

The higher value of fractional duct leakage into the unconditioned attic used for single story homes (75%) and this lower value used for two story homes (67%) was taken from the range of field measurement results that current exist for California houses ("Development of a New Duct Leakage Test: Delta Q," Walker, et.al., LBNL publication 47308, 2001, see the section Compliance Testing on page 25); this same report confirms that the two duct sealing measures well represent the range of duct leakage variation found in typical existing California homes (LBNL publication 47308, see tables 7 & 8, page 24.)

Multi-Family Duct Leakage Measures

The specifications of the multi-family duct measures are similar to the single-family. In this case, all of the models are one-story. The apartment building configuration has much less opportunity for leakage to the outside and, on average; it is assumed that supply air leakage to an unconditioned space is only half of the fraction assumed for single-family homes. For the first duct leakage EEM (40% total leakage to 12% total leakage), the base case has a total supply air leakage to the unconditioned space of 7.5% (half of that specified for the one-story single family house) and the measure case of 2.25% (6% x 0.75 x 0.5).

For the second duct EEM (24% total leakage to 12% total leakage), the base case has a total supply air leakage to the unconditioned space of 4.5% (half of that specified for the one-story single family house).

Mobile Home Duct Leakage Measures

The typical mobile home air handler has little opportunity for return duct losses, mainly due to the lack of substantial return ductwork. For these models, all of the supply air flow lost to the attic is assumed to be made up with outside air to the space. The specified 35% total duct loss for the first mobile home duct measure is all measured supply air duct loss. 75% of the duct loss is assumed to flow to the attic, which in this case is a small cavity space above the mobile home. The remainder of the air flow goes to the conditioned space and is treated as supply air.

The second mobile home duct EEM assumes a baseline supply duct loss of 25%, three quarters of which is lost to the attic.

Whole House Fans Measure

Whole house fans can be used to draw in cooler outside air to help cool the house. Additional energy is needed to operate the whole house fan. In previous versions of the DEER study, this additional fan energy was not considered in determining savings of whole house fans, therefore the savings from those studies were too high.

Methodology: The DOE 2.2 natural ventilation feature was used to estimate savings of whole house fans. Assumptions for whole house fans are provided in the table below:

Property	Single Family	Multi Family	Mobile Home
Baseline Natural Ventilation Rate	3.0 ACH	1.5 ACH	1.5 ACH
Measure Natural Ventilation Rate	6.0 ACH	4.0 ACH	4.0 ACH
Whole House Fan Ventilation Rate	4.0 ACH	2.5 ACH	2.5 ACH
Whole House Fan Power	0.125 W/cfm	0.125 W/cfm	0.125 W/cfm

Whole House Fans	
ID: **D03-441**	Abbreviation: **RWHFn**
Measure Description	Whole House Fans
Baseline Characteristics	No Night Ventilation/Economizer
Code Baseline Characteristics	Night ventilation code baseline matches measure baseline
Measure Characteristics	Whole House Fans
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

Low-Income Weatherization Measures

This measure decreases the infiltration of a fairly leaky house to the standard infiltration assumptions.

Low-Income Weatherization w/out Evaporative Cooler	
ID: **D03-439**	Abbreviation: **RLIWr**
Measure Description	Low-Income Weatherization w/out Evaporative Cooler
Baseline Characteristics	Infiltration of 0.45 Air Changes per Hour
Code Baseline Characteristics	Weatherization code baseline matches measure baseline
Measure Characteristics	Infiltration of 0.35 Air Changes per Hour
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

Low-Income Weatherization w/ Evaporative Cooler	
ID: **D03-440**	Abbreviation: **RLIWE**
Measure Description	Low-Income Weatherization w/ Evaporative Cooler
Baseline Characteristics	Direct Evap Cooling with Infiltration of 0.47 Air Changes per Hour
Code Baseline Characteristics	Weatherization code baseline matches measure baseline
Measure Characteristics	Direct Evap Cooling with Infiltration of 0.35 Air Changes per Hour
Savings Reporting Units	1,000 sqft house
Savings Scalable By	n/a

A number of weatherization applications are assumed to make up this measure, including:

- Attic access weather-stripping,
- Caulking,
- Door weather-stripping, and
- Installation of outlet gaskets.

The base simulation for the first measure has an increased infiltration rate of 0.45 ACH based on the premise that it is in need of weatherization. The Low-Income Weatherization with Evaporative Cooler measure assumes as slightly higher base infiltration value (0.47 ACH) that is brought back down to the standard infiltration level by applying a cover over the unit during the non-cooling months along with the other weatherization applications listed above.

The results for this measure do not apply to the average building stock, but rather apply to a sub-set of buildings that are in need of weatherization.

Ceiling Insulation Measures

Ceiling insulation measures are divided into two categories:

- Addition of R-30 or R-38 to an uninsulated attic/ceiling. In some cases, these measures will show no above code savings because the current Title 24 requirements (Title 24, Table 151-C, Page 134) is either the same or greater than the measure insulation level; and
- Increasing vintage insulation level to R-30, R-38 or R-49. For the R-30 and R-38 cases, some vintages will show no above code savings because the current Title 24 requirements (Title 24, Table 151-C, Page 134) is either the same or greater than the measure insulation level. R-49 has above code savings in all climate zones.

Overall ceiling U-Factors for the measure, baseline and code baseline are listed in the Residential Roof Insulation Table (ResRoofInsMeasures Sheet of 2005DEERResidentialMeasuresList_05-08-15.xls).

Ceiling R-0 to R-30 Insulation-Batts	
ID: **D03-420**	Abbreviation: **RC030**
Measure Description	Ceiling R-0 to R-30 Insulation-Batts
Baseline Characteristics	R-0 Ceiling Insulation
Code Baseline Characteristics	Overall ceiling U-factor based on climate zone
Measure Characteristics	Ceiling R-0 to R-30 Insulation-Batts
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Ceiling R-0 to R-38 Insulation-Batts	
ID: **D03-421**	Abbreviation: **RC038**
Measure Description	Ceiling R-0 to R-38 Insulation-Batts
Baseline Characteristics	R-0 Ceiling Insulation
Code Baseline Characteristics	Overall ceiling U-factor based on climate zone
Measure Characteristics	Ceiling R-0 to R-38 Insulation-Batts
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Ceiling Vintage to R-30 Insulation-Batts	
ID: **D03-422**	Abbreviation: **RCV30**
Measure Description	Ceiling Vintage to R-30 Insulation-Batts
Baseline Characteristics	Per prototype description
Code Baseline Characteristics	Overall ceiling U-factor based on climate zone
Measure Characteristics	Ceiling Vintage to R-30 Insulation-Batts
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Ceiling Vintage to R-38 Insulation-Batts	
ID: **D03-423**	Abbreviation: **RCV38**
Measure Description	Ceiling Vintage to R-38 Insulation-Batts
Baseline Characteristics	Per prototype description
Code Baseline Characteristics	Overall ceiling U-factor based on climate zone
Measure Characteristics	Ceiling Vintage to R-38 Insulation-Batts
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Ceiling Vintage to R-49 Insulation-Batts	
ID: **D03-424**	Abbreviation: **RCV49**
Measure Description	Ceiling Vintage to R-49 Insulation-Batts
Baseline Characteristics	Per prototype description
Code Baseline Characteristics	Overall ceiling U-factor based on climate zone
Measure Characteristics	Ceiling Vintage to R-49 Insulation-Batts
Savings Reporting Units	1,000 sqft roof
Savings Scalable By	n/a

Floor Insulation Measures

Floor insulation measures are only applicable to mobile homes and the oldest vintage of single family homes since these are the only two prototypes with raised floors. Overall floor U-Factors for the measure, baseline and code baseline are listed in the Residential Floor Insulation Table (ResFloorInsMeasures Sheet of 2005DEERResidentialMeasuresList_05-08-15.xls).

Floor R-0 to R-19 Insulation Batts	
ID: **D03-426**	Abbreviation: **RF019**
Measure Description	Floor R-0 to R-19 Insulation Batts
Baseline Characteristics	R-0 Floor Insulation
Code Baseline Characteristics	Overall floor U-factor based on climate zone
Measure Characteristics	Floor R-0 to R-19 Insulation Batts
Savings Reporting Units	1,000 sqft footprint
Savings Scalable By	n/a

Floor R-0 to R-30 Insulation Batts	
ID: **D03-427**	Abbreviation: **RF030**
Measure Description	Floor R-0 to R-30 Insulation Batts
Baseline Characteristics	R-0 Floor Insulation
Code Baseline Characteristics	Overall floor U-factor based on climate zone
Measure Characteristics	Floor R-0 to R-30 Insulation Batts
Savings Reporting Units	1,000 sqft footprint
Savings Scalable By	n/a

Floor R-19 to R-30 Insulation Batts	
ID: **D03-428**	Abbreviation: **RF130**
Measure Description	Floor R-19 to R-30 Insulation Batts
Baseline Characteristics	R-19 Floor Insulation
Code Baseline Characteristics	Overall floor U-factor based on climate zone
Measure Characteristics	Floor R-19 to R-30 Insulation Batts
Savings Reporting Units	1,000 sqft footprint
Savings Scalable By	n/a

Wall Insulation Measures

All wall insulation measures except for Measure ID D03-048 apply only to the new vintage. Measure ID D03-048, R-13 Blown-in Insulation, applies only to the oldest vintage. Overall wall U-Factors for the measure, baseline and code baseline are listed in the Residential Wall Insulation Table (ResWallInsMeasures Sheet of 2005DEERResidentialMeasuresList_05-08-15.xls).

Wall 2x4 R-15 Insulation-Batts	
ID: **D03-429**	Abbreviation: **RW015**
Measure Description	Wall 2x4 R-15 Insulation-Batts
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x4 R-15 Insulation-Batts
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall 2x6 R-19 Insulation-Batts	
ID: **D03-430**	Abbreviation: **RW019**
Measure Description	Wall 2x6 R-19 Insulation-Batts
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x6 R-19 Insulation-Batts
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall 2x6 R-21 Insulation-Batts	
ID: **D03-431**	Abbreviation: **RW021**
Measure Description	Wall 2x6 R-21 Insulation-Batts
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x6 R-21 Insulation-Batts
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall 2x4 R-13 Batts + R-5 Rigid	
ID: **D03-435**	Abbreviation: **RW313**
Measure Description	Wall 2x4 R-13 Batts + R-5 Rigid
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x4 R-13 Batts + R-5 Rigid
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall 2x6 R-19 Batts + R-5 Rigid	
ID: **D03-436**	Abbreviation: **RW319**
Measure Description	Wall 2x6 R-19 Batts + R-5 Rigid
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x6 R-19 Batts + R-5 Rigid
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall 2x6 R-21 Batts + R-5 Rigid	
ID: **D03-437**	Abbreviation: **RW321**
Measure Description	Wall 2x6 R-21 Batts + R-5 Rigid
Baseline Characteristics	Per 2005 Vintage Description
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall 2x6 R-21 Batts + R-5 Rigid
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Wall Blow-In R-0 to R-13 Insulation	
ID: **D03-438**	Abbreviation: **RW413**
Measure Description	Wall Blow-In R-0 to R-13 Insulation
Baseline Characteristics	2x4 Wall w/R-0 Insulation
Code Baseline Characteristics	Overall wall U-factor based on climate zone
Measure Characteristics	Wall Blow-In R-0 to R-13 Insulation
Savings Reporting Units	1,000 sqft wall (excl. windows)
Savings Scalable By	n/a

Sunscreen and Window Film Measures

Sunscreen and film measures are only applicable to prototypes with either single-pane clear (SHGC = 0.87) or double-pane clear (SHGC = 0.79) glazing. It is unlikely that sunscreens or film would be applied to tinted glass. Overall window SHGC values for the measure, baseline and code baseline are listed in the Residential Window Table (ResWindowMeasures Sheet of 2005DEERResidentialMeasuresList_05-08-15.xls).

Sunscreen on Clear Glass Window	
ID: **D03-442**	Abbreviation: **RSScn**
Measure Description	Sunscreen on Clear Glass Window
Baseline Characteristics	U / SHGC (clear) Window based on climate zone, vintage and prototype
Code Baseline Characteristics	Window code baseline matches measure baseline
Measure Characteristics	Sunscreen reduces SHGC by ~62%
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Reflective Film on Clear Glass Window	
ID: **D03-443**	Abbreviation: **RSGRF**
Measure Description	Reflective Film on Clear Glass Window
Baseline Characteristics	U/ SHGC (clear) Window based on climate zone, vintage and prototype
Code Baseline Characteristics	Window code baseline matches measure baseline
Measure Characteristics	Reflective Film reduces SHGC by ~74%
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Spectrally Selective Film on Clear Glass Window	
ID: **D03-444**	Abbreviation: **RSGSS**
Measure Description	Spectrally Selective Film on Clear Glass Window
Baseline Characteristics	U / SHGC (clear) Window based on climate zone, vintage and prototype
Code Baseline Characteristics	Window code baseline matches measure baseline
Measure Characteristics	Spectrally Selective Film reduces SHGC by ~43%
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

Standard Film on Clear Glass Window	
ID: **D03-445**	Abbreviation: **RSGSF**
Measure Description	Standard Film on Clear Glass Windows
Baseline Characteristics	U / SHGC (clear) Window based on climate zone, vintage and prototype
Code Baseline Characteristics	Window code baseline matches measure baseline
Measure Characteristics	Standard Film reduces SHGC by ~59%
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

High Performance Window Measures

Typical glazing and frame type for high performance window measures are provided in the table below:

Measure	Description	Typical Window Description
D03-446	U-0.50/SHGC-0.65	Double Low-e(e3=0.4), 0.25” Air Space, Vinyl Frame, Metal Spacer
D03-447	U-0.40/SHGC-0.65	Double Low-e(e3=0.4), 0.50” Air Space, Vinyl Frame, Metal Spacer
D03-448	U-0.35/SHGC-0.55	Double Low-e(e2=0.1), 0.50” Air Space, Vinyl Frame, Metal Spacer
D03-449	U-0.25/SHGC-0.35	Triple Low-e Film, 0.50” Air Space, Vinyl Frame, Metal Spacer
D03-450	U-0.50/SHGC-0.40	Double Low-e(e2=0.1) Tint, 0.25” Air Space, Aluminum w/Thermal Break Frame, Metal Spacer
D03-451	U-0.40/SHGC-0.40	Double Low-e(e2=0.1) Tint, 0.50” Air Space, Aluminum w/Thermal Break Frame, Metal Spacer
D03-452	U-0.35/SHGC-0.32	Double Low-e(e2=0.1) Tint, 0.50” Air Space, Vinyl Frame, Metal Spacer
D03-453	U-0.25/SHGC-0.22	Triple Low-e Film Tint, 0.50” Air Space, Vinyl Frame, Metal Spacer

Overall window U-Factor and SHGC values for the measure, baseline and code baseline are listed in the Residential Window Table (ResWindowMeasures Sheet of 2005DEERResidentialMeasuresList_05-08-15.xls).

U-0.50 / SHGC-0.65 Window	
ID: **D03-446**	Abbreviation: **RG11C**
Measure Description	U-0.50 / SHGC-0.65 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.50 / SHGC-0.65 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.40 / SHGC-0.65 Window	
ID: **D03-447**	Abbreviation: **RG21C**
Measure Description	U-0.40 / SHGC-0.65 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.40 / SHGC-0.65 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.35 / SHGC-0.55 Window	
ID: **D03-448**	Abbreviation: **RG32C**
Measure Description	U-0.35 / SHGC-0.55 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.35 / SHGC-0.55 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.25 / SHGC-0.35 Window	
ID: **D03-449**	Abbreviation: **RG43C**
Measure Description	U-0.25 / SHGC-0.35 (clear) Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.25 / SHGC-0.35 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.50 / SHGC-0.40 Window	
ID: **D03-450**	Abbreviation: **RG11T**
Measure Description	U-0.50 / SHGC-0.40 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.50 / SHGC-0.40 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.40 / SHGC-0.40 Window	
ID: **D03-451**	Abbreviation: **RG21T**
Measure Description	U-0.40 / SHGC-0.40 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.40 / SHGC-0.40 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.35 / SHGC-0.32 Window	
ID: **D03-452**	Abbreviation: **RG33T**
Measure Description	U-0.35 / SHGC-0.32 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.35 / SHGC-0.32 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

U-0.25 / SHGC-0.22 Window	
ID: **D03-453**	Abbreviation: **RG44T**
Measure Description	U-0.25 / SHGC-0.22 Window
Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Code Baseline Characteristics	U / SHGC Window based on climate zone, vintage and prototype
Measure Characteristics	U-0.25 / SHGC-0.22 Window
Savings Reporting Units	100 sqft window
Savings Scalable By	n/a

9

DEER Processing Ruleset

9.1 Introduction

Central to the DEER prototype defaulting and measure analysis software is a ruleset that serves to manipulate the DEER baseline and measure building descriptions. The rules contained in the ruleset are organized into rule lists, of which there are 295 (54 are DEER-specific) containing a total of 13,283 rules (385 are DEER-specific). The ruleset also includes 95 look-up tables of data (8 are DEER-specific) containing a total of 20,480 rows of data (676 are DEER-specific).

While the format in which the rules are defined is not conducive to review in the context of this document, this section does provide a description and links to all DEER-specific look-up tables as well as the most pertinent non-DEER-specific tables.

Ruleset Look-Up Table Format

Two properties are used to describe the format/structure of each look-up table, the number of independent and number of dependent variables that the look-up table contains. The data portion of the look-up table consists of an unlimited number of rows, each containing a fixed number of columns of numeric values, equal to the number of independent + dependent variables described therein.

The following example table contains one independent and three dependent variables.

;--

; DEER - eQUEST Wizard Defaults: Defaults by DEER Buidling Type

;--

; Column Key:

Column ID	Col #	Type	Description
Independent	1	int	Building Type
Dependents	1	int	Sector Abreviation
	2	float	Daylighting Measures - LIGHT-SET-POINT values
	3	float	Percent Skylights (only for top daylting measures)

; Indep. 1 **; Bldg ; Type**	**Dependents** 1 **Sector Abrev**	2 **Dayltng LtSetPt**	3 **Skylt Percent**		**DEER Building Type**	**Sector Abrev**
1	2	50	3	;	Assembly	C
2	2	**70**	3	;	Education - Primary School	C
3	2	**70**	3	;	Education - Secondary School	C
4	2	50	3	;	Education - Community College	C
5	2	50	3	;	Education - University	C
6	2	50	3	;	Grocery	C
7	2	50	3	;	Health/Medical - Hospital	C
8	2	50	3	;	Health/Medical - Nursing Home	C
9	2	50	3	;	Lodging - Hotel	C
10	2	50	3	;	Lodging - Motel	C
11	2	50	3	;	Manufacturing - Bio/Tech	C
12	2	50	3	;	Manufacturing - Light Industrial	C
13	2	50	3	;	Office - Large	C
14	2	50	3	;	Office - Small	C
15	2	50	3	;	Restaurant - Sit-Down	C
16	2	50	3	;	Restaurant - Fast-Food	C
17	2	50	3	;	Retail - 3-Story Large	C
18	2	**44**	3	;	Retail - Single-Story Large	C
19	2	50	3	;	Retail - Small	C
20	2	**20**	3	;	Storage - Conditioned	C
21	2	**20**	3	;	Storage - Unconditioned	C
22	2	50	3	;	Warehouse - Refrigerated	C
23	1	50	3	;	Residential - Single Family	R
24	1	50	3	;	Residential - Multifamily	R
25	1	50	3	;	Residential - Single-Wide Mobile	R
26	1	50	3	;	Residential - Double-Wide Mobile	R
; ERROR - No Match Found						
-99	0	0	0	;	(all others)	--- ERROR ---

For any given row in the table, all data and/or text located to the right of the first cell that begins with a ';' character is ignored by the look-up table mechanism. This feature enables each look-up table to list documentation on table structure and contents at the top (with each cell in the first row beginning with ';') as well as providing information on the contents of each row of table data, by listing row documentation/information following a cell containing ';' to the right of each row of table data. In the example table above, Excel's VLOOKUP() function is utilized to translate the first column of data (independent – DEER building type value) into its text representation, displayed in the column immediately to the right of the columns containing ';'. Many tables are also conditionally formatted to highlight data that may be inconsistent with surrounding data, such as all light setpoint values contained in the third column of the above example table, highlighting those values that are not equal to 50 (the default for most DEER building types).

When a rule retrieves a value from a look-up table, each independent value specified in the rule is checked against the independent values for each individual record of that table from the first to last row. When a match across all independents is found, the specified dependent value is returned. If multiple matching rows are present in the table, then the dependent from the first matching row is returned. Values of -99 present in the independent columns of look-up tables serve as wild cards, meaning that a match for that independent value is not required in order for that record's dependent to be returned.

Climate Zone Data Table

The Climate Zone Data Table (ClimZones Sheet of DEER Tables.xls) is used to set the following properties based solely on the CTZ (California thermal zone) for which the analysis is being performed:

- eQUEST Location Code,
- Primary Demand Period Start Date,
- Primary Demand Period End Date,
- Alternate Demand Period Start Date, and
- Alternate Demand Period End Date.

Building Data Table

The Building Type Look-up Table (Building Sheet of DEER Tables.xls) is used to set the following properties based solely on the DEER building type:

- Sector abbreviation code;
- Value used in daylighting modeling (LIGHT-SET-POINT);
- Percent skylights (only used when modeling top daylighting measures);
- Version of DOE-2 to simulate the building model with (standard vs. refrigeration);
- Demand period flag - determining whether to use the primary or alternate demand period;
- Design day flag - whether to use the default (7/21) or demand period start date as the start date of the design day simulation period.

Prototype and HVAC Sizing Data Table

The Prototype and HVAC Sizing Data Table (ProtoMap Sheet of DEER Tables.xls) is used to set the following properties based on the DEER building type, vintage and measure being analyzed:

- Prototype to utilize in the analysis (all prototypes are described above,) and
- Flag value indicating whether or not an HVAC sizing run is required.

Energy Code Applicability Table

The Energy Code Applicability Table (AboveCode Sheet of DEER Tables.xls) determines whether or not the code applies to a particular DEER analysis run, and if so, whether or not a separate code baseline simulation need be run. This table is the source of code applicability data for most non-residential and refrigeration measures. Code applicability data for all other measures are located in other tables specific to each measure topic.

The energy code applicability table sets the following property based on the DEER measure, building type and vintage being analyzed:

- Above code flag value:
  1 => Code baseline run must be performed to determine above-code savings
  0 => Current code doesn't apply to the measure, so no code baseline run is required
  -1 => Measure building model equals or does not quite meet current code
  -2 => Vintage baseline already meets or exceeds current code

Non-Residential Measure Compatibility Table

The Non-Residential Measure Compatibility Table (NRMsrCompat Sheet of DEER Tables.xls) is used to determine which non-residential measures are compatible with each combination of DEER (non-residential) building type and vintage including:

1. Measure compatibility flag for measure #1 (Indoor Lighting Low Load Reduction);
2. Measure compatibility flag for measure #2 (Indoor Lighting High Load Reduction);
3. Measure compatibility flag for measure #3 (Occupancy Sensor Pack-200 SF);
4. and etc…

- Key to Flag Values:
  - 0: Measure IS Compatible
  - 1: Table Look-up Error - no matching building type / vintage found
  - 2: Measure not compatible with building type / vintage combination
  - 3: Non-Residential measures cannot be applied to Residential prototypes

Grocery Refrigeration Measure Compatibility Table

The Grocery Refrigeration Measure Compatibility Table (GrcMsrCompat Sheet of DEER Tables.xls) is used to determine which grocery refrigeration measures are compatible with each DEER vintage including:

1. Measure compatibility flag for measure #201 (Retrocommissioning);

2. Measure compatibility flag for measure #202 (High Efficiency Walk-in Fan Motors);
3. Measure compatibility flag for measure #203 (High Efficiency Display Fan Motors);
4. And etc…

- Key to Flag Values:

  - 0: Measure IS Compatible
  - 1: Table Look-up Error - no matching building type / vintage found
  - 2: Measure not compatible with building type / vintage combination
  - 3: Grocery measures cannot be applied to Non-Grocery buildings

Refrigerated Warehouse Measure Compatibility Table

The Refrigerated Warehouse Measure Compatibility Table (RfWMsrCompat Sheet of DEER Tables.xls) is used to determine which refrigerated warehouse measures are compatible with ach DEER vintage including:

1. Measure #301 compatibility (Retrocommissioning);
2. Measure #302 compatibility (Oversized Evaporative Condenser);
3. Measure #303 compatibility (Oversized Evaporative Condenser & Floating Head);
4. And etc…

- Key to Flag Values:

  - 0: Measure IS Compatible
  - 1: Table Look-up Error - no matching building type / vintage found
  - 2: Measure not compatible with building type / vintage combination
  - 3: Refrigerated warehouse measures cannot be applied to other building types

Measure Data Table

The Measure Data Look-up Table (MsrInfo Sheet of DEER Tables.xls) is used to set the following properties based solely on the DEER measure type:

1. Measure Subcategory - Column D of measure definitions spreadsheet;
2. Value identifying which DOE-2 enduses are considered "primary" measure enduses;
3. Value identifying which simulation results are tracked (and ultimately used to determine the final analysis result(s));
4. Chiller Replacement - causes measure chiller to be resized, regardless of whether or not user chose to allow HVAC system resizing;
5. Boiler Replacement - causes measure boiler to be resized, regardless of whether or not user chose to allow HVAC system resizing;
6. Common Unit - Normalizing units (column I) from measure definitions spreadsheet;
7. Measure Category - Column C of measure definitions spreadsheet;
8. Primary Measure Fuel (electricity, natural gas or both);
9. Daylighting Application/Methodology (sidelit, toplit, both or neither);
10. Daylighting Control Type (continuous vs. stepped);
11. Daylighting Control Steps (valid only for stepped daylighting controls);
12. Window/Skylight Glass Performance Index (VT/SHGC.)

Lighting Power Density Table

The Lighting Power Density Table (LtgPD Sheet of DEER Tables.xls), provides lighting power densities by activity area type and vintage.

Occupancy Sensor Table

The Occupancy Sensor Table (OccSens Sheet of DEER Tables.xls) is used to set the following properties based on DEER building type, activity area type and schedule group type:

1. Percent Reduction of Full Load Hours;
2. Weekday Open - Fraction of Full Load Hour Reduction;
3. Weekday Closed - Fraction of Full Load Hour Reduction;
4. Weekend Open - Fraction of Full Load Hour Reduction; and
5. Weekend Closed - Fraction of Full Load Hour Reduction

Lighting Timeclock Table

The Lighting Timeclock Look-up Table (LtgTmclck Sheet of DEER Tables.xls) defines revised baseline minimum hourly profile values by schedule group and day-of-week for all schedules that are flagged for lighting timeclock measure applicability.

Equipment Power Density Table

The Equipment Power Density Table (EqpPD Sheet of DEER Tables.xls) provides equipment power densities by activity area type and vintage.

Window Glass Properties Table

The window glass properties Windows Glass Properties Table (Windows Sheet of DEER Tables.xls) is used to set the following properties based on the DEER building type, secondary building type (used to differentiate separate shells within the site), vintage and return variable (1-U-factor, 2-North SHGC, 3-Non-North SHGC):

1. Window glass performance value for climate zone #1 (CTZ01);
2. Window glass performance value for climate zone #2 (CTZ02);
3. Window glass performance value for climate zone #3 (CTZ03);
4. And etc…
5. Energy Code Applicability flag indicating whether or not the vintage baseline meets or exceeds current code (CTZ01);
6. Energy Code Applicability flag indicating whether or not the vintage baseline meets or exceeds current code (CTZ02);
7. And etc…

Skylight Glass Properties Table

The Skylight Table (Skylts Sheet of DEER Tables.xls) is used to set the following properties based on the DEER building type, secondary building type (used to differentiate separate shells within the site), vintage and return variable (1-U-factor, 2-SHGC):

1. Skylight glass performance value for climate zone #1 (CTZ01);
2. Skylight glass performance value for climate zone #2 (CTZ02);
3. Skylight glass performance value for climate zone #3 (CTZ03);
4. And etc…

Exterior Wall U-value and Construction Table

The Exterior Wall U-Value and Construction Table (EWallUVal Sheet of DEER Tables.xls) is used to set the following exterior wall performance characteristics based on DEER building type and vintage:

1. Overall assembly U-value for climate zone #1 (CTZ01);

2. Overall assembly U-value for climate zone #1 (CTZ02);
3. Overall assembly U-value for climate zone #1 (CTZ03);
4. And etc…
5. Wall Construction Type;
6. Exterior Insulation;
7. Additional Insulation;
8. Interior Insulation;
9. Exterior Finish.

Roof U-value and Construction Table

The Roof U-Factor Table (RoofUVal Sheet of DEER Tables.xls) is used to set the following roof performance characteristics based on DEER building type and vintage:

1. Overall assembly U-value for climate zone #1 (CTZ01);
2. Overall assembly U-value for climate zone #1 (CTZ02);
3. Overall assembly U-value for climate zone #1 (CTZ03);
4. And etc…
5. Wall Construction Type;
6. Board Insulation;
7. Batt Insulation;

Refrigeration Construction Insulation Thickness Table

The Refrigeration Construction Insulation Thickness Table (InsThcknss Sheet of DEER Tables.xls) is used to set the insulation thickness for a variety of walls modeled in the grocery and refrigerated warehouse buildings.

Floor Insulation Table

The Floor Insulation Table (FloorIns Sheet of DEER Tables.xls) is used to set the baseline, code baseline and measure run overall floor R-value based on building type (only relocatable classrooms), vintage and climate zone.

Floor Insulation Above Code Table

The floor insulation above code Floor Insulation Above Code Table (FlrInsAbvCd Sheet of DEER Tables.xls) provides flag values indicating which combinations of building type (only relocatable classrooms), vintage and climate zone require the simulation of a code baseline building model to determine above-code savings results.

DX Equipment Details Table

The DX Equipment Details Table (DXEquip Sheet of DEER Tables.xls) is used to set the parameters used to describe the performance of split-system SEER rated AC and AC/HP systems. These parameters include total and sensible capacity and how these vary with outdoor and unit entering conditions, fan power and flow as they relate to unit capacity, outdoor unit power consumption its variation based upon outdoor and entering conditions as well as partial loading performance.

Non-Residential Hourly Profile Multiplier Table

The Hourly Profile Multiplier Table (ProfileMults Sheet of DEER Profiles.xls) provides lighting and equipment hourly profile multipliers by building type and vintage. The multipliers supplied by this table serve as a calibration factor, ensuring that annual lighting and equipment EUIs are consistent with prior DEER projects and data from other accepted sources (also refer to lighting load and equipment load information provided above).

Non-Residential Hourly Profile ID Table

The Hourly Profile ID Table (ProfileID Sheet of DEER Profiles.xls) provides occupancy, lighting and equipment hourly profile IDs by schedule group, enduse and day-of week. Data in this table also serve to make day-specific adjustments in the specified hourly profiles.

Non-Residential DHW Hourly Profile ID Table

The DHW Hourly Profile ID Table (DHWProfileID Sheet of DEER Profiles.xls) provides domestic water heating hourly load profile IDs by building type, season and day-of week. Data in this table also serve to make day-specific adjustments in the specified hourly profiles.

10

DEER Climate Zones

10.1 Introduction

Climate zone mapping has changed with each DEER study over the years. The first DEER DSM measure savings study performed by NEOS[1] in 1994 divided the state into five climate regions. These regions were defined as the North Coast, Central Valley, South Coast, South Inland, and Desert climate zones. This was done as a cost minimizing method to reduce the number of weather sensitive building prototypes to be developed and the number of DOE-2 runs to be performed. Computing power in the early 1990's was both slower and more expensive than it is today. Both the Title 24 (T24) building standards climate zones and the CEC forecasting model utility area based climate zones were mapped into these five general regions. Table 10-1 provides a listing of the mapping into these five general regions.

Table 10-1: Mapping of CEC T24 and Forecasting Model Climate Zones Into the Five Climate Regions Utilized in the 1994 NEOS Study

Climate Region	T24 Building Standard Climate Zones	CEC Forecasting Model Climate Zones	CEC Forecasting Model Utility Areas
North Coast	1,2,3,4,5	1,4,5	PG&E
Central Valley	11,12,13	2,3,6,7	PG&E, SMUD, SCE
South Coast	6,7,8	8,11,13	SCE, LADWP, SDG&E
South Inland	9,10	9,12,16	SCE, LADWP, BGP
Desert	14,15	10,15	SCE, Other

The first update to the NEOS 1994 measure impact study was limited to the residential sector and was completed in 2001 by Xenergy Inc[2]. The climate zones used in the 2001 DEER update moved away from the five general climate regions used in the 1994 NEOS study and utilized the CEC Forecasting Model Climate Zones. This was a major step forward from the five climate regions, but the 2001 study did not utilize the T24 building standard climate zones used by most utility DSM program planners. The primary reason for utilizing the CEC

[1] "Final Report on Technology Energy Savings: Volumes I, II, and III", prepared for the California Conservation Inventory Group, prepared by NEOS Corporation, May 1994

[2] "2001 DEER Update Study Final Report", prepared for the California Energy Commission, prepared by Xenergy Inc., August 2001

Forecasting model zones was because the forecasting model section of the CEC was and had been the sponsor for the database. The primary purpose of DEER at that time was to support DSM program planning within the framework of the CEC Electricity Report. The CEC Electricity Report was based on the results of the CEC and utility long term electricity forecasts, which incorporated energy conservation as a resource.

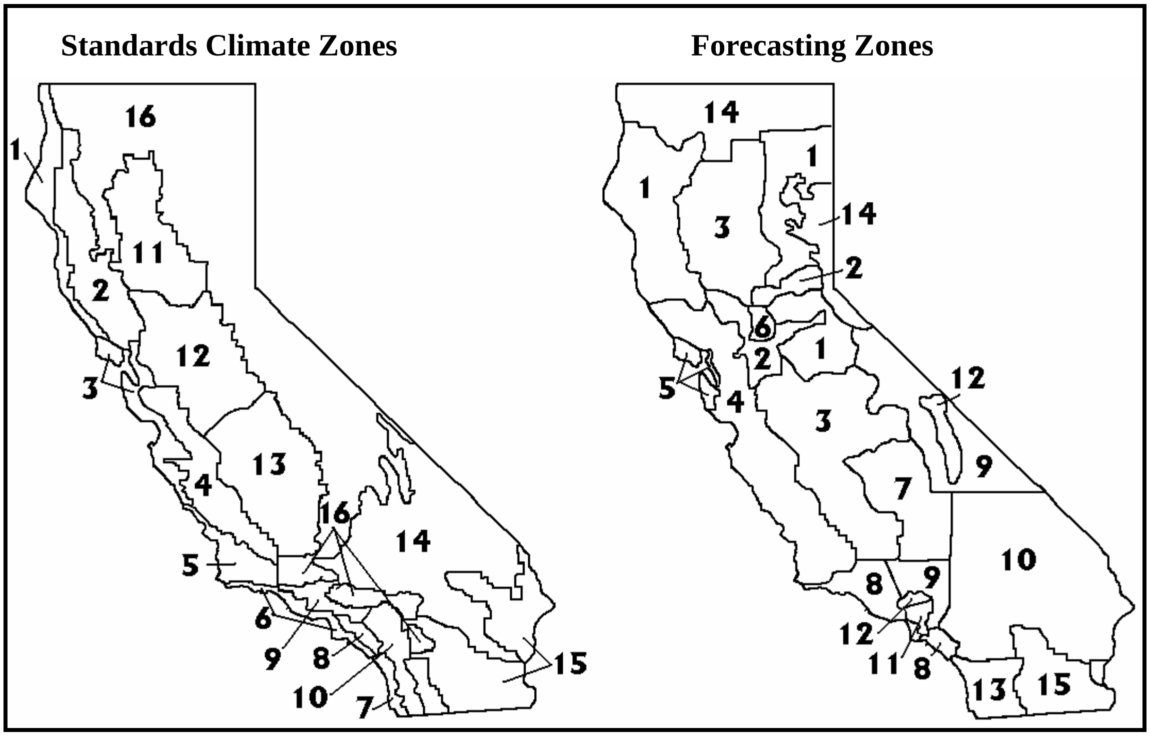
The 2004-05 DEER update has gone the next step and utilizes the T24 building standard climate zones as its basis for weather sensitive analysis. In addition, the CPUC has taken a more active role in the DEER. Both the CPUC and the CEC support the effort to update and enhance the database. Starting with the first phase of the current update effort in 2003-2004, the database was re-designed to be more usable to utility and third party DSM program planners. Even though program planners were targeted as the primary user group of the DEER, with mapping to the CEC forecasting zones, the database is still useful to the CEC long-term energy forecasters and others.

These differences in climate zone definitions need to be noted by users of DEER; especially if the user compares current estimates of savings to past estimates. The climate zones are different and database results are not directly comparable in all instances.

10.2 2004-05 DEER Update Climate Zones

The CEC forecasting model is based on CEC forecasting model weather zones and these are not the same as Title 24 building standard weather zones. These two sets of CEC climate zones are designed to serve two separate purposes with the building standards climate zones providing greater breadth of climate diversity. The forecasting climate zones serve the purpose of disaggregating utility service territory into zones while the building standards climate zones are blind to utility service boundaries. However, there is overlap between the two sets of zones in terms of weather stations used and when there is not a direct overlap; a station with similar weather is available. Figure 10-1 illustrates the two sets of CEC climate zones.

Figure 10-1: Comparing Climate Zones



As mentioned above, the T24 building standard climate zones provide the greater breadth of climate diversity when compared to the forecasting model climate zones. The CEC utilizes and makes available weather files with weather station information for each of the 16 T24 building standard climate zones. Table 10-2 identifies these 16 weather stations for the T24 building standard climate zones along with the appropriate or recommended forecasting climate zone. Many of the forecasting model climate zones utilize the same weather station (such as Sacramento used by forecasting climate zones 2 and 6). Two of the forecasting weather stations are not among the 16 building standards weather stations. However, the prototype nature of this project doesn't require exact calibration of results and the weather from the San Francisco Airport weather station is not significantly different from the Oakland weather station nor the Riverside weather station from the March AFB weather station.

Table 10-2: Weather Stations by Title 24 and Forecasting Climate Zones

Building Standards Zone	T24 Weather Stations	Forecasting Weather Zones (station used)
1	Arcata	1
2	Santa Rosa	N/A
3	Oakland	5 (San Francisco Airport)
4	Sunnyvale	4
5	Santa Maria	N/A
6	Long Beach	8, 11
7	San Diego	13
8	El Toro	N/A
9	Burbank	9, 12, 16
10	Riverside	10 (March AFB)
11	Red Bluff	N/A
12	Sacramento	2, 6
13	Fresno	3, 7
14	China Lake	N/A
15	El Centro	15
16	Mt. Shasta	14

11

Effective Useful Life

11.1 Introduction

Historically, the DEER has not explicitly included estimates of Effective Useful Life (EUL) within its database. The closest it has come is in the 1996 version maintained by the CEC. Within this version was a dataset accumulation of the measure life estimates used by each utility. This dataset was not fully populated and was only a listing of what value each utility used by measure or measure family. It did not provide a single point estimate that could be used by DEER users.

The first attempt to include a fully populated dataset that provides a single point estimate for effective useful life was begun under Phase 1 of this update. This effort was limited to non-weather sensitive measures with EUL estimates gathered from a number of different data sources.

Under Phase 2 of the 2004-05 DEER update, a more concerted effort was made to provide EUL estimates for the full population of both weather sensitive and non-weather sensitive measures. It was the goal to utilize the results of as many of the CPUC supported Retention and Persistence studies as possible. These Retention and Persistence studies proved to be a good source for many EUL estimates, but not a source for all of the measures. The consultant team and the Project Advisory Group considered other sources for EUL values and rank ordered them in importance. The list of sources is provided below in the order of importance. If a reasonable EUL estimate could not be found in the first source, then the next and the next, etc. were reviewed until all measures had an EUL estimate.

- SERA (“Revised/updated EULs Based on Retention and Persistence Studies Results”, prepared by SERA, Inc., July 9, 2005)
- Lighting Metering Studies (“CFL Metering Study”, prepared for Pacific Gas & Electric Company, San Diego Gas & Electric Company and Southern California Edison by KEMA, Inc., February 25, 2005, and an on-going Quantum evaluation of the Express Efficiency program)
- CALMAC Protocols (“CALMAC Protocols, Appendix F, Effective Useful Live Values for Major Energy Efficiency Measures”, September 2000, available on the CALMAC website)

- US DOE Technical Briefs
- Energy Star (http://www.energystar.gov)
- Efficiency Vermont (Efficiency Vermont, "Measure Savings Algorithms and Cost Assumptions: Technical Reference Manual", Jan. 2003)
- DEER 4.0 1996 (California Energy Commission)
- ASHRAE
- Manufacturer Data
- XENERGY 2002 Statewide Potential Study ("California Statewide Commercial Sector Energy Efficiency Potential Study", prepared for Pacific Gas and Electric, prepared by Xenergy, Inc., July 9, 2002)
- Various Utility Agricultural Working Papers
- Engineering Judgment

11.2 SERA study

The SERA study was specifically commissioned to identify Retention and Persistence study EULs with documentation for the sources of the EUL estimate and the reasons for its selection. This SERA study was a follow-on analysis to the work SERA did for the CPUC in reviewing the utilities' retention and persistence studies for the 1994-97 energy efficiency programs[1]. The SERA analysis consisted of four phases:

- Review new 9th year studies that have become available since the completion of the original CPUC review,
- Inventory the measure lifetimes addressed in the studies,
- Assess the *ex post* estimates to identify the most reliable of the EUL estimates, and
- Review analysis results with DEER working committee to develop new EUL recommendations.

The study inventoried EULs for a variety of measures and only included those with an evaluation score of C or better. The grading of the EUL estimate was based on an evaluation of:

- Conformance with CPUC protocols,

[1] Based on review of retention studies conducted by SERA with assistance from Quantec. Skumatz, Woods, and Dimetrosky, "Review of Retention and Persistence Studies for the California Public Utilities Commission (CPUC)", October 2004, prepared for California Public Utilities Commission, San Francisco, CA. Work conducted by SERA and subcontractor Quantec, LLC.

- Sampling approach, sample sizes and data collection procedures,
- Modeling approach, estimation method, and consideration of alternative models, and
- Results and implications.

Although all results were inventoried, only studies with a "C" or better score were considered a potentially reliable source for updated EULs. The recommended EULs were compared to the Protocol EULs and to the previous DEER EULs. These recommended EULs were provided to the DEER Project Advisory Group for consideration for inclusion in the 2004-05 DEER update. The EULs that came from this SERA review were considered the highest level source for the EUL values included in the 2004-05 DEER update.

11.3 Included EULs

The EUL values included in the 2004-05 DEER update came from the 12 sources previously identified. Although results from the SERA study were given the highest priority, only about 15% of the EULs in the 2004-05 DEER update come from this source. A little over 50% of the EULs came from the CALMAC protocols from 2000. The third largest source for EULs after the CALMAC protocols and the SERA study was engineering judgment at 9%.

Table 11-1 through Table 11-6 identify the EUL value and source by measure ID for the 2004-05 DEER update. The Tables are grouped by measure type with the following headings:

- Table 11-1: Weather Sensitive – Non Residential Measure EULs
- Table 11-2: Weather Sensitive – Refrigeration EULs
- Table 11-3: Weather Sensitive – Residential Measure EULs
- Table 11-4: Non-Weather Sensitive – Lighting EULs
- Table 11-5: Non-Weather Sensitive – Other EULs
- Table 11-6: Agricultural EULs

Table 11-1: Weather Sensitive – Non Residential Measure EULs

Measure ID	Measure Name	EUL	EUL Source
D03-001	Indoor Lighting Low Load Reduction	NA	see specific lighting technologies
D03-002	Indoor Lighting High Load Reduction	NA	see specific lighting technologies
D03-003	Occupancy Sensor Pack-200 SF	8.0	CALMAC Report - September 2000
D03-004	Occupancy Sensor Pack-1000 SF	8.0	CALMAC Report - September 2000
D03-005	DayLtg Controls, Side Ltg, Cont. Ctrl	16.0	CALMAC Report - September 2000
D03-006	DayLtg Controls, Side Ltg, 2-step Ctrl	16.0	CALMAC Report - September 2000
D03-007	DayLtg Controls, Top Ltg, Cont. Ctrl	16.0	CALMAC Report - September 2000
D03-008	DayLtg Controls, Top Ltg, 1-step Ctrl	16.0	CALMAC Report - September 2000
D03-009	DayLtg Controls, Top Ltg, 2-step Ctrl	16.0	CALMAC Report - September 2000
D03-010	Timeclock for Lighting	8.0	CALMAC Report - September 2000
D03-011	Plug Loads Low Load Reduction	10.0	CALMAC Report - September 2000
D03-012	Plug Loads High Load Reduction	10.0	CALMAC Report - September 2000
D03-013	Ceiling/Roof Insulation	20.0	CALMAC Report - September 2000
D03-014	Tank Insulation-Fiber Blanket	10.0	Engineering Judgement
D03-016	Light Colored Roof	15.0	Manufacturer Data
D03-017	Low SHGC Windows -15% - North	20.0	CALMAC Report - September 2000
D03-018	Low SHGC Windows -20% - East	20.0	CALMAC Report - September 2000
D03-019	Low SHGC Windows -20% - South	20.0	CALMAC Report - September 2000
D03-020	Low SHGC Windows -20% - West	20.0	CALMAC Report - September 2000
D03-021	Low SHGC Windows -20% - North	20.0	CALMAC Report - September 2000
D03-022	Low SHGC Windows -30% - East	20.0	CALMAC Report - September 2000
D03-023	Low SHGC Windows -30% - South	20.0	CALMAC Report - September 2000
D03-024	Low SHGC Windows -30% - West	20.0	CALMAC Report - September 2000
D03-025	Hi Perf. Glass, PI=1.15, Side Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-026	Hi Perf. Glass, PI=1.26, Side Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-027	Hi Perf. Glass, PI=1.38, Side Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-028	Hi Perf. Glass, PI=1.15, Side Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-029	Hi Perf. Glass, PI=1.26, Side Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-030	Hi Perf. Glass, PI=1.38, Side Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-031	Hi Perf. Glass, PI=0.81, Top Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-032	Hi Perf. Glass, PI=0.92, Top Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-033	Hi Perf. Glass, PI=1.03, Top Ltg, Cont. Ctrl	20.0	CALMAC Report - September 2000
D03-034	Hi Perf. Glass, PI=0.81, Top Ltg, 1-Step Ctrl	20.0	CALMAC Report - September 2000
D03-035	Hi Perf. Glass, PI=0.92, Top Ltg, 1-Step Ctrl	20.0	CALMAC Report - September 2000
D03-036	Hi Perf. Glass, PI=1.03, Top Ltg, 1-Step Ctrl	20.0	CALMAC Report - September 2000
D03-037	Hi Perf. Glass, PI=0.81, Top Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-038	Hi Perf. Glass, PI=0.92, Top Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-039	Hi Perf. Glass, PI=1.03, Top Ltg, 2-Step Ctrl	20.0	CALMAC Report - September 2000
D03-040	High Efficiency Centrifugal Chillers < 150 Tons	20.0	CALMAC Report - September 2000
D03-041	High Efficiency Air-Cooled Recip Packaged Chillers	20.0	CALMAC Report - September 2000
D03-042	High Efficiency VSD Centrifugal Chillers < 150 Tons	20.0	CALMAC Report - September 2000
D03-043	Gas Absorption Chiller	20.0	CALMAC Report - September 2000
D03-044	Chilled Water Reset	10.0	Engineering Judgement
D03-045	Hot Water Reset	10.0	Engineering Judgement
D03-046	Variable Flow Chilled Water Loop	10.0	Engineering Judgement
D03-047	VSD Chilled Water Loop Pump	10.0	Engineering Judgement
D03-048	Variable Flow Hot Water Loop	10.0	Engineering Judgement
D03-049	VSD Hot Water Loop Pump	10.0	Engineering Judgement
D03-050	Variable Air Volume Box	10.0	Engineering Judgement
D03-051	VSD Supply Fan Motors	10.0	Engineering Judgement
D03-052	Fan Powered Mixing Boxes	10.0	Engineering Judgement
D03-053	Evap Cool Indirect - Central System	15.0	CALMAC Report - September 2000
D03-054	Evap Cool Indirect - Packaged Sys	15.0	CALMAC Report - September 2000
D03-055	Reducing Overventilation	10.0	Engineering Judgement
D03-056	Air To Air Heat Exchanger	10.0	Engineering Judgement
D03-057	Rotary Heat Recovery	10.0	Engineering Judgement

Table 11-1: Weather Sensitive – Non Residential Measure EULs (cont.)

Measure ID	Measure Name	EUL	EUL Source
D03-058	Economizer - Packaged System	15.0	ASHRAE/DEER 4.0 1996
D03-059	Economizer - Central system	15.0	ASHRAE
D03-060	Economizer Maintenance	3.0	Engineering Judgement
D03-061	Clean Condenser Coils	3.0	Engineering Judgement
D03-062	Cooling Tower for Packaged System	15.0	CALMAC Report - September 2000
D03-063	Two-Speed Cooling Tower Fans	10.0	ASHRAE
D03-064	VSD Cooling Tower Fans	10.0	Engineering Judgement
D03-065	Efficient Gas Furnace	18.0	SERA Report - May 2005/07-14-05
D03-066	High Efficiency Large Boilers	20.0	CALMAC Report - September 2000
D03-067	High Efficiency Small HW Boilers	20.0	CALMAC Report - September 2000
D03-068	High Efficiency Small Steam Boilers	20.0	CALMAC Report - September 2000
D03-069	Efficient Water Source Heat Pump	15.0	Engineering Judgement/DEER 4.0 1996
D03-070	Hydronic Heat Pump Var Flow Valve	10.0	Engineering Judgement
D03-071	Time Clocks (heating/cooling)	10.0	CALMAC Report - September 2000
D03-072	Energy Management System	14.0	SERA Report - May 2005/07-14-05
D03-073	Setback Programmable Thermostats	11.0	CALMAC Report - September 2000
D03-075	Duct Insulation Material	20.0	Engineering Judgement/DEER 4.0 1996
D03-076	H.E. Air-Cooled Split A/C < 65k (single phase)	15.0	CALMAC Report - September 2000
D03-077	H.E. Air-Cooled Split HP < 65k (single phase)	15.0	CALMAC Report - September 2000
D03-078	H.E. Air-Cooled Package A/C < 65k (single phase)	15.0	CALMAC Report - September 2000
D03-079	H.E. Air-Cooled Split/Package A/C 65k-134k	15.0	CALMAC Report - September 2000
D03-080	H.E. Air-Cooled Package HP < 65k (single phase)	15.0	CALMAC Report - September 2000
D03-081	H.E. Air-Cooled Split/Package HP 65k-134k	15.0	CALMAC Report - September 2000
D03-082	H.E. Evap/Water-Cooled Pkg A/C < 65k	15.0	CALMAC Report - September 2000
D03-083	H.E. Evap/Water-Cooled Pkg A/C >=65k	15.0	CALMAC Report - September 2000
D03-084	H.E. Package Terminal A/C < 7k	15.0	CALMAC Report - September 2000
D03-085	H.E. Package Terminal HP < 7k	15.0	CALMAC Report - September 2000
D03-086	Efficient HVAC Motors - Supply Fans	15.0	CALMAC Report - September 2000
D03-087	Efficient HVAC Motors - Return Fans	15.0	CALMAC Report - September 2000
D03-088	Efficient HVAC Motors - Clg Tower Fans	15.0	CALMAC Report - September 2000
D03-089	Effic. Motors - Chilled Water Loop Pumps	15.0	CALMAC Report - September 2000
D03-090	Effic. Motors - Hot Water Loop Pumps	15.0	CALMAC Report - September 2000
D03-091	Effic. Motors - Cond. Water Loop Pumps	15.0	CALMAC Report - September 2000
D03-092	High Efficiency Gas Water Heater	15.0	CALMAC Report - September 2000
D03-093	Gas Tankless Water Heating	20.0	US DOE Technical Brief: 1/6/04
D03-094	Point of Use Water Heating	20.0	US DOE Technical Brief: 1/6/04
D03-095	Circulation Pump Timeclock Retrofit	15.0	CALMAC Report - September 2000
D03-096	High Eff Large Size Gas Water Heater	15.0	CALMAC Report - September 2000
D03-097	High Eff Med Size Gas Water Heater	15.0	CALMAC Report - September 2000
D03-098	Water Side Economizer	10.0	Engineering Judgement
D03-099	H.E. Package Terminal A/C 7k-15k	15.0	CALMAC Report - September 2000
D03-100	H.E. Package Terminal A/C > 15k	15.0	CALMAC Report - September 2000
D03-101	H.E. Package Terminal HP 7k-15k	15.0	CALMAC Report - September 2000
D03-102	H.E. Package Terminal HP > 15k	15.0	CALMAC Report - September 2000
D03-103	H.E. Air-Cooled Split/Package A/C 135-239k	15.0	CALMAC Report - September 2000
D03-104	H.E. Air-Cooled Split/Package A/C 240-759k	15.0	CALMAC Report - September 2000
D03-105	H.E. Air-Cooled Split/Package A/C >= 760k	15.0	CALMAC Report - September 2000
D03-106	H.E. Air-Cooled Split/Package HP 135-239k	15.0	CALMAC Report - September 2000
D03-107	H.E. Air-Cooled Split/Package HP 240-759k	15.0	CALMAC Report - September 2000
D03-108	H.E. Air-Cooled Split A/C < 65k (3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-109	H.E. Air-Cooled Package A/C < 65k (12 SEER, 3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-110	H.E. Air-Cooled Package A/C < 65k (13 SEER, 3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-111	H.E. Air-Cooled Split HP < 65k (3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-112	H.E. Air-Cooled Package HP < 65k (12 SEER, 3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-113	H.E. Air-Cooled Package HP < 65k (13 SEER, 3 phase before 2008)	15.0	CALMAC Report - September 2000
D03-114	High Efficiency Air-Cooled Screw Packaged Chillers	20.0	CALMAC Report - September 2000
D03-115	High Efficiency Water-Cooled Recip Chillers	20.0	CALMAC Report - September 2000

Table 11-1: Weather Sensitive – Non Residential Measure EULs (cont.)

Measure ID	Measure Name	EUL	EUL Source
D03-116	High Efficiency Centrifugal Chillers 150-299 Tons	20.0	CALMAC Report - September 2000
D03-117	High Efficiency Centrifugal Chillers >= 300 Tons	20.0	CALMAC Report - September 2000
D03-118	High Efficiency Screw Chillers < 150 Tons	20.0	CALMAC Report - September 2000
D03-119	High Efficiency Screw Chillers 150-299 Tons	20.0	CALMAC Report - September 2000
D03-120	High Efficiency Screw Chillers >= 300 Tons	20.0	CALMAC Report - September 2000
D03-121	High Efficiency VSD Centrifugal Chillers 150-299 Tons	20.0	CALMAC Report - September 2000
D03-122	High Efficiency VSD Centrifugal Chillers >= 300 Tons	20.0	CALMAC Report - September 2000
D03-123	Floor Insulation	20.0	CALMAC Report - September 2000
D03-124	H.E. Air-Cooled Split/Package HP >= 760k	20.0	CALMAC Report - September 2000

Table 11-2: Weather Sensitive – Refrigeration EULs

MeasureID	Measure Name	EUL	EUL Source
D03-201	Retrocommissioning	4.0	Engineering Judgement
D03-202	High Efficiency Walk-in Fan Motors	15	CALMAC Report - September 2000
D03-203	High Efficiency Display Fan Motors	15	CALMAC Report - September 2000
D03-204	Heat Recovery from Central Refrigeration System	16	CALMAC Report - September 2000
D03-205	Night Covers for Display Cases (medium temp)	5	CALMAC Report - September 2000
D03-206	Medium Temp Glass Doors (open display cases)	12	CALMAC Report - September 2000
D03-207	New Medium Temp Refrig Display Case with Doors	12	CALMAC Report - September 2000
D03-208	Auto-Closers on Main Cooler Doors	8	CALMAC Report - September 2000
D03-209	Auto-Closers on Main Freezer Doors	8	CALMAC Report - September 2000
D03-210	Evaporator Fan Control on Walk-in Coolers & Freezers	16	CALMAC Report - September 2000
D03-211	Air-Cooled Condenser to Evaporative Condenser	15	CALMAC Report - September 2000
D03-212	Energy Efficient Air-Cooled Condenser	15	CALMAC Report - September 2000
D03-213	Energy Efficient Evap-Cooled Condenser	15	CALMAC Report - September 2000
D03-214	Multiplex System with Mech Subcooling (air-cooled)	10	XENERGY 2002 Statwide Potential Study
D03-215	Multiplex System with Mech Subcooling (evap-cooled)	10	XENERGY 2002 Statwide Potential Study
D03-216	Multiplex System with Mech Subcooling (high eff air-cooled)	10	XENERGY 2002 Statwide Potential Study
D03-217	Multiplex System with Mech Subcooling (high eff evap-cooled)	10	XENERGY 2002 Statwide Potential Study
D03-218	Low Temperature Mechanical Subcooling	10	XENERGY 2002 Statwide Potential Study
D03-219	Low and Medium Temp Mechanical Subcooling	10	XENERGY 2002 Statwide Potential Study
D03-220	Floating Suction Pressure	16	CALMAC Report - September 2000
D03-221	Floating Head Pressure, Fixed Setpoint (air-cooled)	16	CALMAC Report - September 2000
D03-222	Floating Head Pressure, Fixed Setpoint (evap-cooled)	16	CALMAC Report - September 2000
D03-223	Floating Head Pressure, Variable Setpoint (air-cooled)	16	CALMAC Report - September 2000
D03-224	Floating Head Pressure, Variable Setpoint (evap-cooled)	16	CALMAC Report - September 2000
D03-225	Floating Head Pressure, Variable Setpt & Speed (air-cooled)	16	CALMAC Report - September 2000
D03-226	Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	16	CALMAC Report - September 2000
D03-227	Display Case Lighting Control	16	CALMAC Report - September 2000
D03-228	Zero Heat Reach-in Glass Doors	16	CALMAC Report - September 2000
D03-301	Retrocommissioning	4.0	Engineering Judgement
D03-302	Oversized Evaporative Condenser	10	XENERGY 2002 Statwide Potential Study
D03-303	Oversized Evaporative Condenser & Floating Head	10	XENERGY 2002 Statwide Potential Study
D03-304	Variable-Speed Compressors	10	XENERGY 2002 Statwide Potential Study
D03-305	Low-Temperature Subcooling	10	XENERGY 2002 Statwide Potential Study
D03-306	Floating Suction Pressure	16	CALMAC Report - September 2000
D03-307	Floating Head Pressure, Fixed Setpoint (evap-cooled)	16	CALMAC Report - September 2000
D03-308	Floating Head Pressure, Variable Setpoint (evap-cooled)	16	CALMAC Report - September 2000
D03-309	Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	16	CALMAC Report - September 2000

Table 11-3: Weather Sensitive – Residential Measure EULs

MeasureID	Measure Name	EUL	EUL Source
D03-401	Programmable Thermostat	12.0	CALMAC Report - September 2000
D03-402	13 SEER(11.09 EER) Split System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-403	14 SEER(12.15 EER) Split-System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-404	15 SEER(12.72 EER) Split-System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-405	Direct Evaporative Cooler	15.0	SERA Report - May 2005/07-14-05
D03-406	Indirect Evaporative Cooler	15.0	SERA Report - May 2005/07-14-05
D03-407	Direct-Indirect Evaporative Cooler	15.0	SERA Report - May 2005/07-14-05
D03-408	Refrigerant charge - typical charge adjustment	10.0	Engineering Judgement
D03-409	Refrigerant charge - high charge adjustment	10.0	Engineering Judgement
D03-410	Condensing 90 AFUE(1.11 HIR) Furnace	18.0	SERA Report - May 2005/07-14-05
D03-411	Condensing 92 AFUE(1.08 HIR) Furnace	18.0	SERA Report - May 2005/07-14-05
D03-412	Condensing 94 AFUE(1.06 HIR) Furnace	18.0	SERA Report - May 2005/07-14-05
D03-413	Condensing 96 AFUE(1.03 HIR) Furnace	18.0	SERA Report - May 2005/07-14-05
D03-414	13 SEER(11.07 EER)/8.1 HSPF(3.28 COP) A/C Heat pump	15.0	SERA Report - May 2005/07-14-05
D03-415	14 SEER(12.19 EER)/8.6 HSPF(3.52 COP) A/C Heat Pump	15.0	SERA Report - May 2005/07-14-05
D03-416	15 SEER(12.70 EER)/8.8 HSPF(3.74 COP) A/C Heat Pump	15.0	SERA Report - May 2005/07-14-05
D03-417	18 SEER(12.8 EER)/9.2 HSPF(3.66 COP) A/C Heat Pump	15.0	SERA Report - May 2005/07-14-05
D03-418	Duct Sealing (Total Leakage Reduction 28% of AHU flow)	18.0	SERA Report - May 2005/07-14-05
D03-420	Ceiling R-0 to R-30 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-421	Ceiling R-0 to R-38 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-422	R-30 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-423	R-38 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-424	R-49 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-426	Floor R-0 to R-19 Insulation Batts	20.0	CALMAC Report - September 2000
D03-427	Floor R-0 to R-30 Insulation Batts	20.0	CALMAC Report - September 2000
D03-428	Floor R-19 to R-30 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-429	Wall 2x4 R-15 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-430	Wall 2x6 R-19 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-431	Wall 2x6 R-21 Insulation-Batts	20.0	CALMAC Report - September 2000
D03-435	Wall 2x4 R-13 Batts + R-5 Rigid	20.0	CALMAC Report - September 2000
D03-436	Wall 2x6 R-19 Batts + R-5 Rigid	20.0	CALMAC Report - September 2000
D03-437	Wall 2x6 R-21 Batts + R-5 Rigid	20.0	CALMAC Report - September 2000
D03-438	Wall Blow-In R-0 to R-13 Insulation	20.0	CALMAC Report - September 2000
D03-439	Low-Income Weatherization w/out Evaporative Cooler	13.0	DEER 4.0 1996 - "Weatherization Big 6"
D03-440	Low-Income Weatherization w/Evaporative Cooler	13.0	DEER 4.0 1996 - "Weatherization Big 6"
D03-441	Whole House Fans	15.0	Engineering Judgement
D03-442	Default Window With Sunscreen	10.0	CALMAC Report - September 2000
D03-443	Single Pane Clear Glass With Reflective Film	10.0	CALMAC Report - September 2000
D03-444	Single Pane Clear Glass With Spectrally Selective Film	10.0	CALMAC Report - September 2000
D03-445	Single Pane Clear Glass With Standard Film	10.0	CALMAC Report - September 2000
D03-446	U-0.50/SHGC-0.65 (clear) Window	20.0	CALMAC Report - September 2000
D03-447	U-0.40/SHGC-0.65 (clear) Window	20.0	CALMAC Report - September 2000
D03-448	U-0.35/SHGC-0.55 (clear) Window	20.0	CALMAC Report - September 2000
D03-449	U-0.25/SHGC-0.35 (clear) Window	20.0	CALMAC Report - September 2000
D03-450	U-0.50/SHGC-0.40 (tint) Window	20.0	CALMAC Report - September 2000
D03-451	U-0.40/SHGC-0.40 (tint) Window	20.0	CALMAC Report - September 2000
D03-452	U-0.35/SHGC-0.32 (tint) Window	20.0	CALMAC Report - September 2000
D03-453	U-0.25/SHGC-0.22 (tint) Window	20.0	CALMAC Report - September 2000
D03-458	Duct Sealing (Total Leakage Reduction 12% of AHU flow)	18.0	SERA Report - May 2005/07-14-05
D03-459	Refrigerant charge - typical charge adjustment & duct sealing	15.0	Engineering Judgement
D03-460	Refrigerant charge - high charge adjustment & duct sealing	15.0	Engineering Judgement
D03-461	Basic Furnace Upgrade to 81% AFUE	18.0	SERA Report - May 2005/07-14-05
D03-462	Mobile Home Duct Sealing (Supply Leakage Reduced from 35% of AHU flow to 15%)	18.0	SERA Report - May 2005/07-14-05
D03-463	16 SEER (11.61 EER) Split System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-464	17 SEER (12.28 EER) Split-System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-465	18 SEER (13.37 EER) Split-System Air Conditioner	18.0	SERA Report - May 2005/07-14-05
D03-466	16 SEER (12.06 EER) / 8.4 HSPF (3.48 COP) A/C Heat Pump	15.0	SERA Report - May 2005/07-14-05
D03-467	17 SEER (12.52 EER) / 8.6 HSPF (3.26 COP) A/C Heat Pump	15.0	SERA Report - May 2005/07-14-05
D03-468	Mobile Home Duct Sealing (Supply Leakage Reduced from 25% of AHU flow to 15%)	18.0	SERA Report - May 2005/07-14-05

Table 11-4: Non-Weather Sensitive – Lighting EULs

MeasureID	Measure Name	EUL	EUL Source
D03-801 to D03-818	All Screw-in CFLs - Health/Medical - Hospital	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Health/Medical - Nursing Home	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Hotel	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Motel	0.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Restaurant - Fast-Food	1.3	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Grocery	1.4	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - Single-Story Large	1.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - 3-Story Large	1.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Community College	2.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Retail - Small	2.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Restaurant - Sit-Down	2.3	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - University	2.6	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Manufacturing - Light Industrial	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Storage - Conditioned	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Storage - Unconditioned	2.8	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Office - Large	2.9	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Warehouse - Refrigerated	3.1	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Office - Small	3.2	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Secondary School	3.5	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Education - Primary School	5.6	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Lodging - Guest Rooms	7.0	DEER/Metering Study 2005
D03-801 to D03-818	All Screw-in CFLs - Residential	9.4	DEER/Metering Study 2005
D03-819 to D03-837	All pin based CFLs - Commercial Buildings	12.0	SERA Report - May 2005/07-14-05
D03-819 to D03-837	All pin based CFLs - Residential Buildings	16.0	SERA Report - May 2005/07-14-05
D03-838	20W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-839	25W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-840	32W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-841	50W CFL Table Lamp: Residential	16.0	SERA Report - May 2005/07-14-05
D03-842	55W CFL Torchiere: Residential	9.0	CALMAC Report - September 2000
D03-843	70W CFL Torchiere (two LAMPs): Residential	9.0	CALMAC Report - September 2000
D03-844	50W Metal Halide	16.0	CALMAC Report - September 2000
D03-845	75W Metal Halide	16.0	CALMAC Report - September 2000
D03-846	100W Metal Halide	16.0	CALMAC Report - September 2000
D03-847	175W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-848	175W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-849	250W PS Metal Halide	16.0	CALMAC Report - September 2000
D03-850	200W HPS	16.0	CALMAC Report - September 2000
D03-851	180W LPS	16.0	CALMAC Report - September 2000
D03-852	Premium T8 El Ballast	11.0	SERA Report - May 2005/07-14-05
D03-853	T8 32W Dimming El Ballast	11.0	SERA Report - May 2005/07-14-05
D03-854	De-lamp from 4', 4 lamp/fixture	11.0	SERA Report - May 2005/07-14-05
D03-855	De-lamp from 8', 4 lamp/fixture	11.0	SERA Report - May 2005/07-14-05
D03-856	Occ-Sensor - Wall box	8.0	CALMAC Report - September 2000
D03-857	Occ-Sensor - Plug loads	10.0	CALMAC Report - September 2000
D03-858	Timeclock:	8.0	CALMAC Report - September 2000
D03-859	Photocell:	8.0	CALMAC Report - September 2000
D03-860	LED Exit Sign (New)	16.0	CALMAC Report - September 2000
D03-861	LED Exit Sign Retrofit Kit	16.0	CALMAC Report - September 2000
D03-862	Electroluminescent Exit Sign (New)	16.0	CALMAC Report - September 2000
D03-863	Electroluminescent Exit Sign Retrofit Kit	16.0	CALMAC Report - September 2000

Table 11-5: Non-Weather Sensitive – Other EULs

MeasureID	Measure Name	EUL	EUL Source
D03-901	High Efficiency Copier	6.0	Energy Star
D03-902	High Efficiency Copier	6.0	Energy Star
D03-903	High Efficiency Copier	6.0	Energy Star
D03-904	High Efficiency Gas Fryer	12.0	SERA Report - May 2005/07-14-05
D03-905	High Efficiency Gas Griddle	12.0	SERA Report - May 2005/07-14-05
D03-906	High Efficiency Electric Fryer	12.0	SERA Report - May 2005/07-14-05
D03-907	Hot Food Holding Cabinet	12.0	SERA Report - May 2005/07-14-05
D03-908	Connectionless Steamer	12.0	SERA Report - May 2005/07-14-05
D03-909	Point of Use Water Heat	20.0	US DOE Technical Brief: 1/6/04
D03-910	Circulation Pump Timeclock	10.0	Engineering Judgement
D03-911	High Eff. Water Heater, EF=0.64	15.0	CALMAC Report - September 2000
D03-912	Vending Machine Controller	10.0	Engineering Judgement
D03-913	Vending Machine Controller	10.0	Engineering Judgement
D03-914	Premium Efficiency Motor - 1 HP	15.0	CALMAC Report - September 2000
D03-915	Premium Efficiency Motor - 5 HP	15.0	CALMAC Report - September 2000
D03-916	Premium Efficiency Motor - 10 HP	15.0	CALMAC Report - September 2000
D03-917	Premium Efficiency Motor - 15 HP	15.0	CALMAC Report - September 2000
D03-918	Premium Efficiency Motor - 20 HP	15.0	CALMAC Report - September 2000
D03-919	Premium Efficiency Motor - 25 HP	15.0	CALMAC Report - September 2000
D03-920	Premium Efficiency Motor - 50 HP	15.0	CALMAC Report - September 2000
D03-921	Premium Efficiency Motor - 100 HP	15.0	CALMAC Report - September 2000
D03-922	Premium Efficiency Motor - 150 HP	15.0	CALMAC Report - September 2000
D03-923	Premium Efficiency Motor - 200 HP	15.0	CALMAC Report - September 2000
D03-924	Premium Efficiency Motor - 1 HP	15.0	CALMAC Report - September 2000
D03-925	Premium Efficiency Motor - 5 HP	15.0	CALMAC Report - September 2000
D03-926	Premium Efficiency Motor - 10 HP	15.0	CALMAC Report - September 2000
D03-927	Premium Efficiency Motor - 15 HP	15.0	CALMAC Report - September 2000
D03-928	Premium Efficiency Motor - 20 HP	15.0	CALMAC Report - September 2000
D03-929	Premium Efficiency Motor - 25 HP	15.0	CALMAC Report - September 2000
D03-930	Premium Efficiency Motor - 50 HP	15.0	CALMAC Report - September 2000
D03-931	Premium Efficiency Motor - 100 HP	15.0	CALMAC Report - September 2000
D03-932	Premium Efficiency Motor - 150 HP	15.0	CALMAC Report - September 2000
D03-933	Premium Efficiency Motor - 200 HP	15.0	CALMAC Report - September 2000
D03-934	Faucet Aerators	9.0	Efficiency Vermont
D03-935	Heat Pump Water Heater	10.0	Engineering Judgement
D03-936	Pipe Wrap	15.0	CALMAC Report - September 2000
D03-937	Low Flow Showerhead	10.0	CALMAC Report - September 2000
D03-938	High Efficiency Water Heater	13.0	CALMAC Report - September 2000
D03-939	High Efficiency Water Heater	15.0	Engineering Judgement
D03-940	Point of Use Water Heat	20.0	US DOE Technical Brief: 1/6/04
D03-941	Efficient Clothes Dryer	18.0	SERA Report - May 2005/07-14-05 (Gas)
D03-942	Efficient Clothes Dryer	18.0	SERA Report - May 2005/07-14-05 (Gas)
D03-943	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-944	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-945	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-946	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-947	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-948	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-949	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-950	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-951	Energy Star Clothes Washer	14.0	CALMAC Report - September 2000
D03-952	Energy Star Dish Washer	13.0	CALMAC Report - September 2000
D03-953	Energy Star Dish Washer	13.0	CALMAC Report - September 2000
D03-954	Refrigerator: Bottom Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-955	Refrigerator: Bottom Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-956	Refrigerator: Top Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-957	Refrigerator: Top Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-958	Refrigerator: Top Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-959	Refrigerator: Side Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-960	Refrigerator: Side Mount Freezer without through-the-door ice	18.0	SERA Report - May 2005/07-14-05

Table 11-5: Non-Weather Sensitive – Other EULs (cont)

MeasureID	Measure Name	EUL	EUL Source
D03-961	Refrigerator: Side Mount Freezer with through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-962	Refrigerator: Side Mount Freezer with through-the-door ice	18.0	SERA Report - May 2005/07-14-05
D03-964	Refrigerator Recycling	10.0	SERA Report - May 2005/07-14-05
D03-965	Freezer Recycling	10.0	SERA Report - May 2005/07-14-05 (Refrig)
D03-966	Efficient Single Speed Pool Pump	10.0	ASHRAE
D03-967	Efficient Two Speed Pool Pump	10.0	ASHRAE

Table 11-6: Agricultural EULs

MeasureID	Measure Name	EUL	EUL Source
DO3-970	Low Pressure Sprinkler Nozzle - Portable	3	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-971	Low Pressure Sprinkler Nozzle - Solid set	5	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-972	Sprinkler to Micro irrigation - Field/Vegs - non well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-973	Sprinkler to Micro irrigation - Field/Vegs - well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-974	Sprinkler to Micro irrigation - Decid Trees - non well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-975	Sprinkler to Micro irrigation - Decid Trees - well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-976	Sprinkler to Micro irrigation - Citrus Trees - non well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-977	Sprinkler to Micro irrigation - Citrus Trees - well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-978	Sprinkler to Micro irrigation - grapes - non well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-979	Sprinkler to Micro irrigation - grapes - well	20	Canessa, Peter. 2002. Review of Low Pressure Sprinkler Nozzles – An Express Efficiency Measure, Fresno, CA.
DO3-980	Infrared Film for Greenhouses	5	2003 PG&E Express Efficiency Program Agriculture /Process working papers.
DO3-981	Greenhouse Heat Curtain	5	2003 PG&E Express Efficiency Program Agriculture /Process working papers.
DO3-982	Variable Frequency Drives with feedback controls for Dairy Pumps	10	Engineering Judgement
DO3-983	Ventilation Fans or Box Fans (6)	10	Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service
DO3-984	High Volume Low Speed Fans 16 Ft Diameter (4)	10	Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service
DO3-985	High Volume Low Speed Fans 18 Ft Diameter (3)	10	Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service
DO3-986	High Volume Low Speed Fans 20 Ft Diameter (3)	10	Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service
DO3-987	High Volume Low Speed Fans 24 Ft Diameter (2)	10	Kammel, David, et al. 2003., *Design of High Volume Low Speed Fan Supplemental Cooling System in free stall barns.* Wisconsin: Wisconsin Public Service

12

Measure Cost

12.1 Introduction

The measure cost portion of DEER has been updated many times since the inception of DEER in the early 1990s. However, development of these costs was always done separately from the energy impacts portion of DEER and there was no requirement that these two portions of DEER be integrated. The measure impact portion of DEER has identified measures with specific characteristics and applications so that a point estimate for measure impact could be developed. The cost portion of DEER utilized the generic measure description of the measures included in the energy impact portion of DEER, but did not specifically collect data that corresponded to how the measure was characterized for the energy impact calculations. Instead, data was collected for a number of different characterizations (such as several different tonnage sizes for A/C or multiple characteristics for refrigerators). It was then left up to the DEER users to determine the proper cost to associate with the DEER energy impacts. This process often proved to be difficult and error prone.

During the first phase of this update, measure costs from existing sources (including the existing 2001 DEER cost dataset as well as other publicly available datasets from across the country) were reviewed with the intent to define a point estimate cost to go with the point estimate energy impact. This was done for the non-weather sensitive measures. Although cost data was found for most measures that corresponded to the measure characteristics used for the energy impact calculations, it was not complete and some of it was dated or geographically remote.

At the start of the second phase of this update, a separate contract was awarded to Summit Blue Consulting to develop new DEER measure cost values. Summit Blue and Itron were tasked to include in the new 2005 DEER update point estimates for both measure impacts and costs developed using the same measure characteristics. However, it was recognized that providing measure costs for variations in a measure's characteristics would continue to be valuable and would be collected as it had been done in the past.

Appendix C provides the point estimates of measure cost for each measure included in the 2005 DEER update.

The information provided in the Appendix includes:

- Measure ID
- Measure Name
- Energy Common units
- Cost Common Units
- Base Equipment Cost
- Measure Equipment Cost
- Incremental Equipment Cost
- Labor Cost
- Installed Cost

12.2 Finalizing the Measure List

In order to develop a new DEER dataset that includes point estimates for both impacts and costs based on the same measure characteristics, it was necessary to develop a close working relationship between the Itron measure impact team and the Summit Blue measure cost team. It was critical that the measures to be included in the 2005 DEER update were finalized as quickly as possible and that the characteristics for each measure as modeled for the energy impacts was clearly understood by both groups.

As the list of measures was being finalized, several issues beyond the mere agreement on measure characteristics became evident. These included:

- Customer baseline vs. code baseline
- Energy common units vs. cost common units
- Application and cost basis

Customer Baseline vs. Code Baseline

The impact from an energy efficiency measure can be calculated in two ways depending if there are any energy-related Codes or Standards affecting the installation of those measures. The California Building Energy Code, Title 24, and the Federal Appliance Standards are examples of specific codes and standards that can affect what baseline should be used to estimate energy and demand impacts. How an energy efficiency program is designed and implemented will affect which baseline is the more appropriate baseline to utilize. These considerations also affect what cost data to collect and how to report it.

Within the database, specifically within the detailed measure information page, the DEER user will find references to variables with the word “Customer” in front of them and others that have the word “Code” in front of them. These two sets of variable information identify the baseline technology description, baseline energy use and demand, and efficiency measure impacts. The set of "Customer" described variables refer to a baseline that is an estimate of the currently installed technology within the home or business. The set of "Code" described variables refer to a baseline where minimum mandated code requirement efficiency must be considered before estimating the measure impacts.

Which set of impacts (customer or code) to use is dependent on how the user wants to use the data or how the planner wants to design a program. An energy forecaster is likely interested in "Customer" based impacts for existing buildings and "Code" based impacts for new construction. A program planner's use of the data will depend on program design. DEER recognizes three types of measure applications:

- Replace on Burnout (ROB): equipment is replaced only when it no longer functions.
- Retrofit (RET): equipment is either added, such as a photocell control to a lighting system, or is replaced before the useful life of the existing equipment is over, such as early replacement of fully functional refrigerators.
- New Construction (NEW): Higher efficiency equipment is installed rather than standard, less efficient equipment in a new construction, alteration, or renovation project. An assumption is made that the less efficient, standard equipment meets current applicable codes requirements.

The ROB and NEW program applications would generally utilize the "Code" based impacts while "RET" would utilize the "Customer" based impacts. Note that these are general guidelines and exceptions may exist: for example some early replacements retrofit cases may trigger code compliance and hence "Code" based estimates need to be used for these "RET"cases. Many of the non-weather sensitive measures do not have "Customer" based impacts. This is because the non-weather sensitive measure impacts were developed during Phase 1 of this update and only minimal modifications were funded under this current Phase 2 effort. The data development mandate at that time was to utilize a "Code" baseline in all cases unless there was no code or standard in place for the technology. Future DEER updates will likely expand the number of non-weather sensitive "Customer" based estimates.

Energy Common Units vs. Cost Common Units

An issue not anticipated when first coordinating energy impact and cost data was the issue of common units. The energy impacts study began about a year and one-half before the start of the cost study and many decisions regarding common units were already established and could not be changed without re-doing much of what had already been done.

For most measures the common units for the energy impacts and the associated measure costs are the same. This common unit is identified by the "Common Unit Name" variable. If the cost common unit is the same as the energy common unit, it is identified as so within the "Cost Application" variable by the wording "-same" at the end of the "Cost Basis" variable. If the cost common unit is different, then this wording is changed to reflect the cost common unit. As an example of this, measure ID D03-911 is high efficiency water heater in non-residential building. For this measure, the energy common unit is "1000 sqft building" while the cost common unit is the "water heater tank". The cost common unit is indicated as being different within the "Cost Basis" variable by the wording "-WtrHtr" at its end.

In addition to identifying if the cost common units are different from the energy common units, the "Cost Basis" variable is used to define for each measure the appropriate cost that should be utilized by the user. Two types of "Cost Basis" values are provided and are linked to the "Application" variable by the order provided. The two types of cost identified are:

- **Incremental (INCR) –** the differential equipment cost between a base technology and an energy efficient technology defined as:
  - Incremental cost (INCR) = Measure equipment cost - base case equipment cost
- **Installed (FULL) –** the full or installed cost of the measure including equipment, labor, overhead & profit (OH&P) defined as:
  - Installed cost (FULL) = measure equipment cost + labor including OH&P

Application and Cost Basis

The application and cost basis are defined for each measure. Specific program applications may justify different application and cost basis values. Typically, for a retrofit (RET) application where an existing technology is being displaced there is a labor component and the cost basis is FULL or installed. An example is replacing an operational incandescent exit sign in an existing building with an LED exit sign.

Similarly, for ROB and NEW applications, where the choice is typically between a more and less efficient alternative, the cost basis is typically incremental (INCR). An example is installing a higher SEER AC unit at the end of the useful life of the existing unit.

FULL or installed cost typically uses the measure equipment cost of the technology, not an incremental cost. In most cases, there is no incremental cost. For example, occupancy sensors that are designated as retrofit (RET) applications are assumed to have a cost basis of FULL and use the cost of the sensor (measure equipment cost) plus the labor to install it. There is no incremental cost in this case because the baseline is the absence of a sensor or an existing conventional on/off switch that is being displaced.

12.3 Available Detailed Cost Data

The DEER dataset includes only the point estimates of cost for each measure. However, available as a downloadable spreadsheet from the DEER website (under "Supporting Documents") are the broader estimates of cost that cover more that just the measure configuration for which the point estimate energy impacts are based.

Measure ID D03-076 will be used as an example. The measure name is "high efficiency, packaged split system A/C (<65k, single phase)". The Detailed Cost file identifies unique costs for six different sizes of this measure. These sizes include:

- 14 SEER (12.15 EER) Split-System Air Conditioner, 2 ton (24,000 Btu) condenser and matched cased coil
- 14 SEER (12.15 EER) Split-System Air Conditioner, 2.5 ton (30,000 Btu) condenser and matched cased coil
- 14 SEER (12.15 EER) Split-System Air Conditioner, 3 ton (36,000 Btu) condenser and matched cased coil
- 14 SEER (12.15 EER) Split-System Air Conditioner, 3.5 ton (42,000 Btu) condenser and matched cased coil
- 14 SEER (12.15 EER) Split-System Air Conditioner, 4 ton (48,000 Btu) condenser and matched cased coil
- 14 SEER (12.15 EER) Split-System Air Conditioner, 5 ton (60,000 Btu) condenser and matched cased coil

Each of these six sizes is a D03-076 measure, but each has a different cost. The cost included in the DEER database as the point estimate cost associated with the energy impact is the 3 ton unit (item 3 in the list above). However, DEER users may be interested in the costs associated with the other five sizes of split system A/C units.

The variables that are provided in the Detailed Cost spreadsheet include the following:

- Measure ID
- Category
- Measure Name
- Measure Description
- Base Description
- Delivery Channel
- Application
- Energy Star?
- Purchase Volume
- Cost Basis

- Base Equipment Cost
- Measure Equipment Cost
- Incremental Equipment Cost
- Labor Cost
- Installed Cost
- Cost Unit

It is important to note that the costs provided in the Detailed Cost spreadsheet are for *first costs only and do not include lifecycle or operations and maintenance (O&M) costs or cost savings.* Although analysts did encounter and uncover ongoing O&M or lifecycle costs as part of the research, systematic documentation of these costs was not a part of the cost study. Examples of measures where lifecycle or O&M costs may be an important factor in program planning and measure analysis include:

- Reduced lamp replacement costs with compact fluorescent lamps – CFLs have a lamp life that is 5 to 10 times longer than an incandescent lamp. Assuming a CFL lamp life of 10,000 hours compared to 2000 for long-life incandescent lamps and 5 incandescent replacements over the life of the CFL, the resulting lifecycle materials and labor cost savings are approximately 5 x ($0.61 + $3.77) = $21.90.
- Water treatment cost for water-cooled air conditioning systems – While water-cooled air conditioning systems are attractive because of their greater operating and peak load efficiencies, they do result in additional water use and water treatment costs compared to air cooled equipment. One vendor estimated water treatment costs for non-residential water cooled systems at $20/ton/year.
- Reduced fluorescent lamp life with occupancy sensors – Some reports state that the useful life of compact fluorescent lamps and some fluorescent lamp-ballast combinations can be shortened due to more frequent switching causing increased replacement costs. For example, Osram Sylvania estimates that T8 lamp life can be reduced from 24,000 hours to 7000 hours when the switch cycle is reduced from 12 hours to 30 minutes.

Interpreting the Detailed Cost Data

When interpreting the Detailed Cost data, there a several important points to consider including:

- **Discrete vs. representative prices**. Some of the measure cost values are discrete prices for a specific technology, while some of the cost values are representative prices for a range of product sizes and/or efficiencies. For example, incremental costs are provided for specific motor horsepowers for non-weather sensitive motor measures. On the other hand, the pricing for nonresidential HVAC motor measures is representative of a range of horsepowers.

- **First cost only.** The pricing contained in the measure cost data is for first cost only and does not include O&M or life cycle cost data. For example, it is well known that compact fluorescent lamps last 5-10 times longer than an incandescent lamp thus saving on lamp replacement costs. No systematic attempt was made to capture these types of lifecycle cost factors.

- **Scalability of cost units.** Each measure cost is associated with a "cost unit" which means that the cost data has been normalized to some common unit of measure. For example, furnace cost data is normalized to per kBtuh and air conditioning equipment is normalized to per ton. However, there are limits to the amount that a single normalized cost variable can be scaled or extrapolated to compute a price for units with a broad size range. In those instances where an analyst is examining a measure with a wide range of sizes, it is advisable to review the more detailed costs in the supplemental downloadable cost file to see if there is cost data for sizes that are more consistent with those being analyzed.
- **Refrigeration measures costs.** Incremental and installed costs for refrigeration measures can vary depending on the application and cost basis. The values reported in the measure details from the website are for one application and cost basis configuration. Users of the refrigeration cost data are advised to consult the supplemental downloadable cost file for additional variation in refrigeration measure cost information relative to different applications.

13

DEER Website

13.1 Introduction

The California Public Utilities Commission (CPUC) and California Energy Commission (CEC) jointly sponsor the DEER. In the past, access to DEER was through the CEC website and was available as either a downloadable dataset or could be ordered and received on floppy disks. However, for the 2005 DEER update, access is now through the CPUC website (http://eega.cpuc.ca.gov/deer/). The new DEER internet interface provides interested parties with on-line read access to all elements of DEER as well as the ability to download the entire dataset as an Access database, download portions of the dataset as Excel spreadsheets, or print measure Run ID specific detailed information. Access to the data on the site does not require any kind of username or login account. Anyone browsing to the location of the home page for the site will be able to view the data.

DEER is designed to provide well documented estimates of energy and peak demand savings values, measure costs, and effective useful life (EUL) available all within one data source. The users of the data are intended to be program planners, regulatory reviewers and planners, utility and regulatory forecasters, and consultants supporting utility and regulatory research and evaluation efforts.

The site is designed to provide easy access to the data and to supporting documents. There are four main groups of data, residential and non-residential sectors and within each sector weather sensitive and non-weather sensitive. Access is provided through the home page. A description of how to navigate through the site will be provided in later sub-sections.

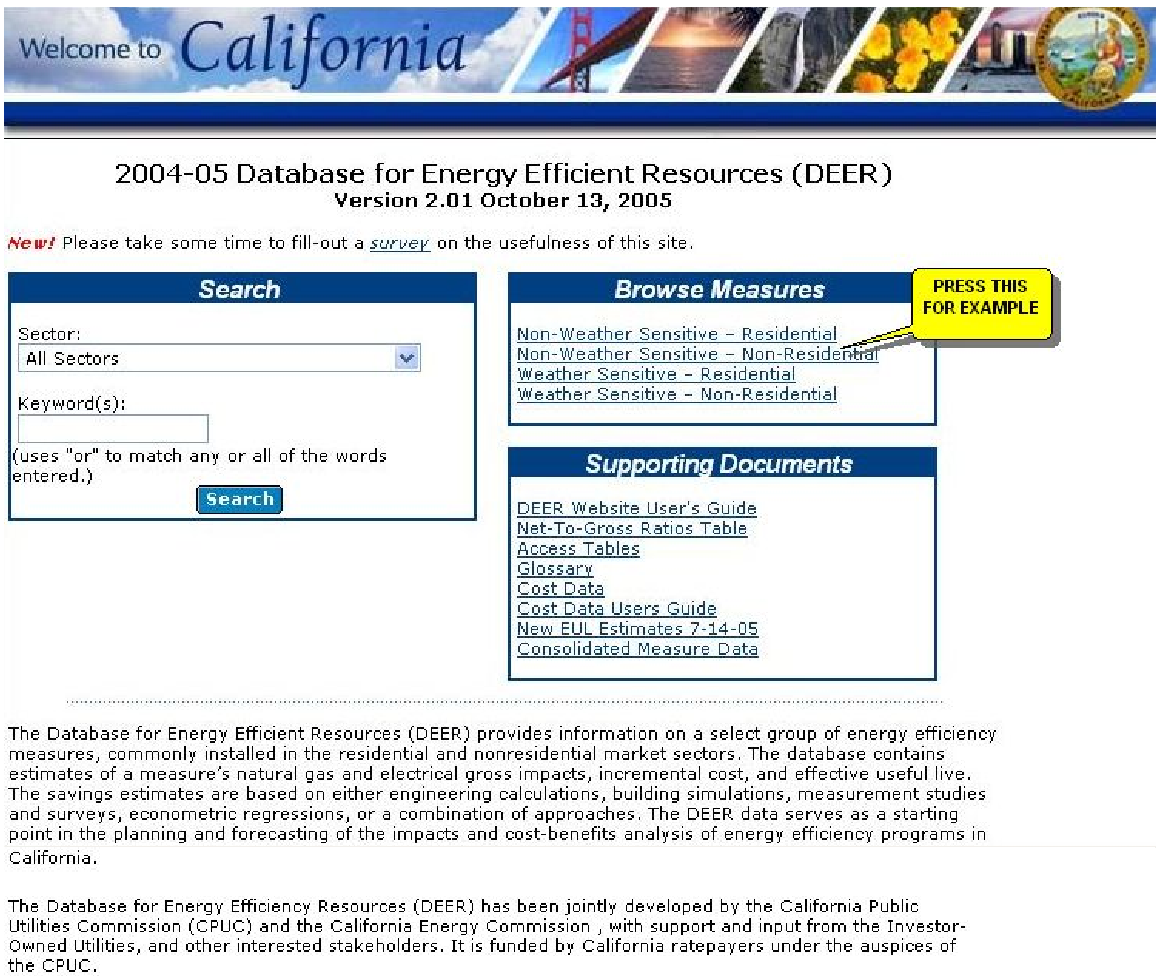
13.2 Website Navigation – Home Page

The DEER homepage, as shown in Figure 13-1, has three main areas of operation:

- Search
- Browse Measures
- Supporting Documents

The “Search” area is generally used if a specific Run ID or Measure ID is known and the user wants to check it quickly. Keywords words can also be entered, such as “pool pumps” and all references to “pool pumps” will be listed, or portions of a Measure ID or Run ID such as “Evp” could be entered and all the evaporative cooler measures would be listed. The “Browse Measures” section is the most commonly used. Here, the data is divided into weather sensitive and non-weather sensitive measures as well as residential and non-residential. The “Supporting Documents” section provides a number of different documents that the user will find useful. These will be identified in detail in a later sub-section.

Figure 13-1: DEER Website Opening Webpage



Browse Measures

Most users will utilize this portion of the website to obtain measure specific information. The section is arranged into the four major categories of non-weather sensitive – residential, non-weather sensitive – non-residential, weather sensitive – residential, and weather sensitive - non-residential.

Within each of these four major categories, further filtering options are provided by technology category and sub-category. Table 13-1 through Table 13-4 identify the available categories and sub-categories for each of these four major categories.

Table 13-1: Residential – Weather Sensitive Categories and Sub Categories

Residential - Weather Sensitive	
Category	**Sub-category**
SHELL	Equip
SHELL	Fenestration
SHELL	Insulation
SHELL	Shell
HVAC	Controls
HVAC	Equip
HVAC	Maintenance

Table 13-2: Residential – Non-Weather Sensitive Categories and Sub Categories

Residential - Non-weather Sensitive	
Category	**Sub-category**
Clothes Dryers	Efficient Clothes Dryer
Hot Water	Energy Star Clothes Washer
Hot Water	Energy Star Dishwasher
Hot Water	Faucet Aerators
Hot Water	Heat Pump Water Heater
Hot Water	High Efficiency Water Heater
Hot Water	Low Flow Showerhead
Hot Water	Pipe wrap
Interior Ambient & Task Lighting	CFL Lamps
Pools	Pool Pump
Refrigeration	Energy Star Refrigerators
Refrigeration	Freezer Recycling
Refrigeration	Refrigerator Recycling

Table 13-3: Non-Residential – Weather Sensitive Categories and Sub Categories

Non-residential - Weather Sensitive	
Category	**Sub-category**
HVAC	Controls
HVAC	Equip
HVAC	HeatRej
HVAC	Insulation
Lighting	Demand
Commercial Refrigeration Equipment	Maintenance
Commercial Refrigeration Equipment	Controls
Commercial Refrigeration Equipment	Equipment
Wall, Roof, and Fenestration	Daylighting
Wall, Roof, and Fenestration	Fenestration
Wall, Roof, and Fenestration	Shell
Wall, Roof, and Fenestration	Insulation
Interior Plug Loads	Equip
Hot Water Supply	Controls
Hot Water Supply	Equip

Table 13-4: Non-Residential – Non-Weather Sensitive Categories and Sub Categories

Non-residential - Non-weather Sensitive	
Category	**Sub-category**
Agriculture	Greenhouse
Agriculture	Irrigation
Agriculture	Ventilation
Agriculture	VFD
Commercial Cooking	Fryer
Commercial Cooking	Griddle
Commercial Cooking	Holding Cabinet
Commercial Cooking	Steamer
Hot Water	Circulation Pump
Hot Water	Point of Use
Hot Water	Water Heater Tank
Interior Ambient & Task Lighting	Ballast
Interior Ambient & Task Lighting	CFL Lamps
Interior Ambient & Task Lighting	De-lamp
Interior Ambient & Task Lighting	Exit Sign
Interior Ambient & Task Lighting	Exterior Lighting
Interior Ambient & Task Lighting	Four ft. Fluorescent
Interior Ambient & Task Lighting	Metal Halide
Interior Ambient & Task Lighting	Occupancy Sensor
Interior Ambient & Task Lighting	Photocell
Interior Ambient & Task Lighting	Timeclock
Miscellaneous	MOTOR
Miscellaneous	Vending Machine
Interior Plug Loads	Copy Machine

Non-Weather Sensitive – Residential Sector Webpage

Navigation within each of the four major categories is the same. We will utilize the "Non-Weather Sensitive – Residential Sector" for an example query to demonstrate the operation of this portion of the website. Figure 13-2 is a screen capture of the opening screen for this category of measures. The links provided on the right to "Related Programs" and "Related Links" are provided only for convenience and each link takes you to a website outside of DEER. They have no direct relationship to the values contained within DEER.

Figure 13-2 lists five measure categories:

- Interior Ambient & Task Lighting
- Refrigeration
- Hot Water
- Clothes Dryers
- Pools

Figure 13-2: Non-Weather Sensitive – Residential Sector Webpage

Non-Weather Sensitive – Residential Sector Screen with Hot Water Sub-Category List Webpage

The example query utilizes the drop down menu of sub-categories under the "Hot Water" category. This is illustrated within Figure 13-3. The sub-categories under the "Hot Water" category include the following:

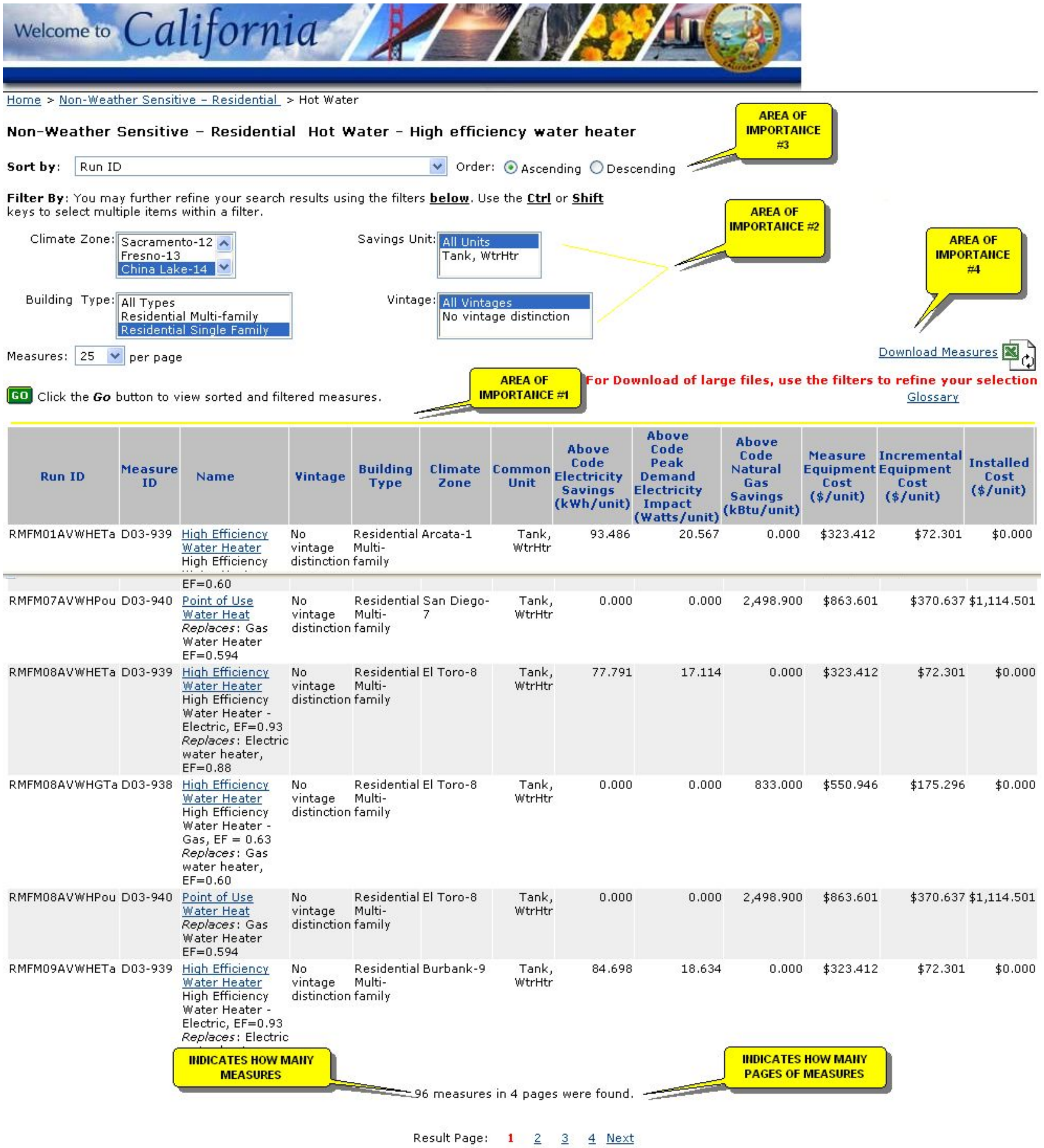
- Energy Star dishwasher
- Heat pump water heater
- Energy Star clothes washer
- High efficiency water heater
- Pipe wrap
- Low flow showerhead
- Faucet aerators

Figure 13-3: Non-Weather Sensitive – Residential Sector Screen with Hot Water Sub-Category List Webpage

<u>Non-Weather Sensitive – Residential Hot Water – High Efficiency Water Heater Webpage</u>

The "High efficiency water heater" sub-category is utilized in this example query. After highlighting the "High efficiency water heater" sub-category, a new screen appears that has all the "RunIDs" included within this sub-category. Figure 13-4 illustrates this new page of information. There are four important areas of interest on this page. The first is the short summary of measure information by "RunID". The second is the area where further filtering can be done. The third identifies how you want your summary data sorted. The fourth is the link to downloading data.

Figure 13-4: Non-Weather Sensitive – Residential Hot Water – High Efficiency Water Heater Webpage



Home > Non-Weather Sensitive - Residential > Hot Water

Non-Weather Sensitive - Residential Hot Water - High efficiency water heater

Sort by: Run ID Order: Ascending Descending

Filter By: You may further refine your search results using the filters **below**. Use the **Ctrl** or **Shift** keys to select multiple items within a filter.

Climate Zone: Sacramento-12, Fresno-13, China Lake-14

Savings Unit: All Units, Tank, WtrHtr

Building Type: All Types, Residential Multi-family, Residential Single Family

Vintage: All Vintages, No vintage distinction

Measures: 25 per page

Download Measures

GO Click the *Go* button to view sorted and filtered measures.

For Download of large files, use the filters to refine your selection

Glossary

Run ID	Measure ID	Name	Vintage	Building Type	Climate Zone	Common Unit	Above Code Electricity Savings (kWh/unit)	Above Code Peak Demand Electricity Impact (Watts/unit)	Above Code Natural Gas Savings (kBtu/unit)	Measure Equipment Cost ($/unit)	Incremental Equipment Cost ($/unit)	Installed Cost ($/unit)
RMFM01AVWHETa	D03-939	High Efficiency Water Heater High Efficiency ... EF=0.60	No vintage distinction	Residential Multi-family	Arcata-1	Tank, WtrHtr	93.486	20.567	0.000	$323.412	$72.301	$0.000
RMFM07AVWHPou	D03-940	Point of Use Water Heat *Replaces*: Gas Water Heater EF=0.594	No vintage distinction	Residential Multi-family	San Diego-7	Tank, WtrHtr	0.000	0.000	2,498.900	$863.601	$370.637	$1,114.501
RMFM08AVWHETa	D03-939	High Efficiency Water Heater High Efficiency Water Heater - Electric, EF=0.93 *Replaces*: Electric water heater, EF=0.88	No vintage distinction	Residential Multi-family	El Toro-8	Tank, WtrHtr	77.791	17.114	0.000	$323.412	$72.301	$0.000
RMFM08AVWHGTa	D03-938	High Efficiency Water Heater High Efficiency Water Heater - Gas, EF = 0.63 *Replaces*: Gas water heater, EF=0.60	No vintage distinction	Residential Multi-family	El Toro-8	Tank, WtrHtr	0.000	0.000	833.000	$550.946	$175.296	$0.000
RMFM08AVWHPou	D03-940	Point of Use Water Heat *Replaces*: Gas Water Heater EF=0.594	No vintage distinction	Residential Multi-family	El Toro-8	Tank, WtrHtr	0.000	0.000	2,498.900	$863.601	$370.637	$1,114.501
RMFM09AVWHETa	D03-939	High Efficiency Water Heater High Efficiency Water Heater - Electric, EF=0.93 *Replaces*: Electric	No vintage distinction	Residential Multi-family	Burbank-9	Tank, WtrHtr	84.698	18.634	0.000	$323.412	$72.301	$0.000

96 measures in 4 pages were found.

Result Page: 1 2 3 4 Next

The measure information provided in the first area of importance is only a short summary of the measure information available at the "RunID" level. Values for thirteen different variables are provided for each "RunID" under this sub-category. These variables include:

- Run ID
- Measure ID
- Name (Measure Name)
- Vintage
- Climate Zone
- Common Unit
- Above Code Electricity Savings
- Above Code Peak Demand Savings
- Above Code Natural Gas Savings
- Measure Equipment Cost
- Incremental Equipment Cost
- Installed Cost

Additional measure level information (such as the customer based savings and EUL information) is provided in the detailed information sheets, which is covered in a later sub-section. At the bottom of this area of importance is an indicator of how many measures are included within this summary list of measures and over how many pages the data exists. In the example provided in Figure 13-4, there are 96 different "High efficiency water heater" Run IDs provided over four web pages of data.

The second area of importance provides options for further measure filtering. Further filtering options are provided for the following:

- Climate Zone
- Savings Unit
- Building Type
- Vintage

Only the filtering options available for the particular sub-category of measures being viewed are visible.

The third area of importance is relatively minor. Within this area, the user can indicate how they would like the summary data presented in the first area of importance is sorted. The summary data may be sorted by any of the 13 variables presented within the summary areas. The order within the sorting category can be ascending or descending.

The fourth and final area of importance is the link to “Download Measures” as well as a link to show the database “Glossary”. These links are on the far right hand side of the page.

Pressing the “Glossary” link reveals the database glossary. The upper half of this webpage is illustrated in Figure 13-5. The full glossary is available in Appendix D.

“Download Measures” is a very useful link in that all of the detailed data for all the measures included in the filtered summary portion of this screen (area of importance 1) can be downloaded as an Excel spreadsheet (actually a “CSV” file that can convert to Excel). Figure 13-6 illustrates what the screen looks like when the link “Download Data” is pressed. A warning is included that the user must be aware of the spreadsheet size limitations of Excel. The maximum number of measures that can be downloaded is about 5,000.

Figure 13-5: “Glossary” Webpage

Welcome to California

Glossary

DEER Glossary
(8/25/05 Revisions)

RunID | Measure ID | Measure Name | Measure Characteristics | Measure Abbreviation

Sector | Building Type | Vintage | Climate Zone |Common Unit | Category | Subcategory

End-Use Fuel Type | Base Decscription | Code Base Decscription | Floor Area | TbaseE

TbaseP | TbaseG | PEbaseE | PEbaseG |Eimpact | Gimpact | Pimpact | TCbaseE | TCbaseP

TCbaseG | PECbaseE | PECbaseG | ECimpact | GCimpact | PCimpact | Effective Useful Life

Application | Cost Basis | Base EquipCost | Measure Equip Cost

Incremental Equip Cost | LaborCost | Installed Cost | Other Ref 1 |Other Ref 2 |Other Ref 3

1. Run ID: String variable of fixed length of 13 with the format ABBB1122CCCCC where:

- A = Sector Code. ‘R’ = Residential and ‘C’ = Non-Residential
- BBB = Building type abbreviation (see codes under BuildingType)
- 11 = Climate zone (see codes under climate zone)
- 22 = Vintage (see codes under Vintage)
- CCCCC = Measure abbreviation

2. Measure ID: String variable of fixed length of 7. (example: D03-001)

- First three characters indicate the measure is from the 2003 DEER update "D03"
- Fourth character is a "-"
- Last three characters are a numerical sequence starting with "001" and conceivably ending with "999".
  - Weather Sensitive Non-Res: 001-199
  - Weather Sensitive Refrig: 201-399
  - Weather Sensitive Res: 401-499
  - Non Weather Sens Lights: 801-899
  - Non Weather Sens Other: 901-999

3. Measure Name: String variable describing the measure.

4. Measure Characteristics: String variable describing more detail about the measure.

5. MeaAbbr: Measure abbreviation. String variable of length 5 that incorporates part of the measure name. Used to help develop the run ID.

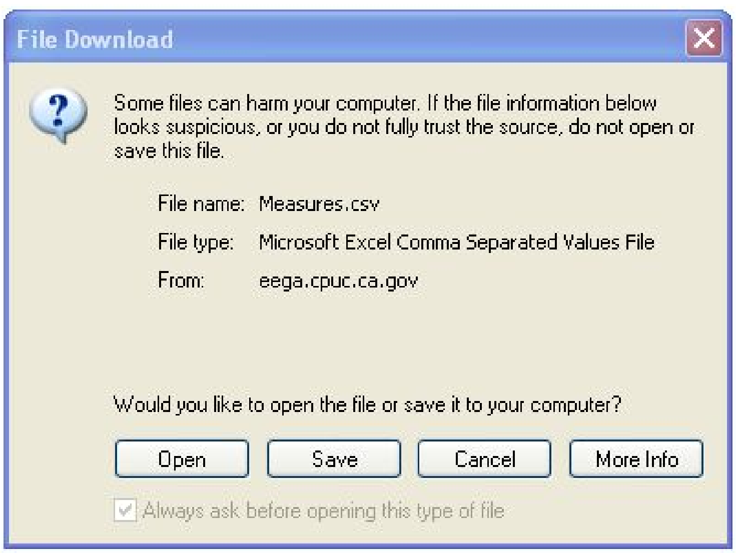
6. Sector: String variable of fixed length 1. "R" for residential, "C" for non-residential.

7. Building Type: three digit abbreviation letter code for building type: (top)

- ALC = All Commercial
- BCR = Both Residential and Commercial
- ASM = Assembly
- EPR = Education - Primary School
- ERC = Education – Removable Classroom
- ESE = Education - Secondary School
- ECC = Education - Community College
- EUN = Education - University
- FRM = Farmhouse
- GRO = Grocery
- HSP = Health/Medical - Hospital
- NRS = Health/Medical - Clinic

AND CONTINUES....

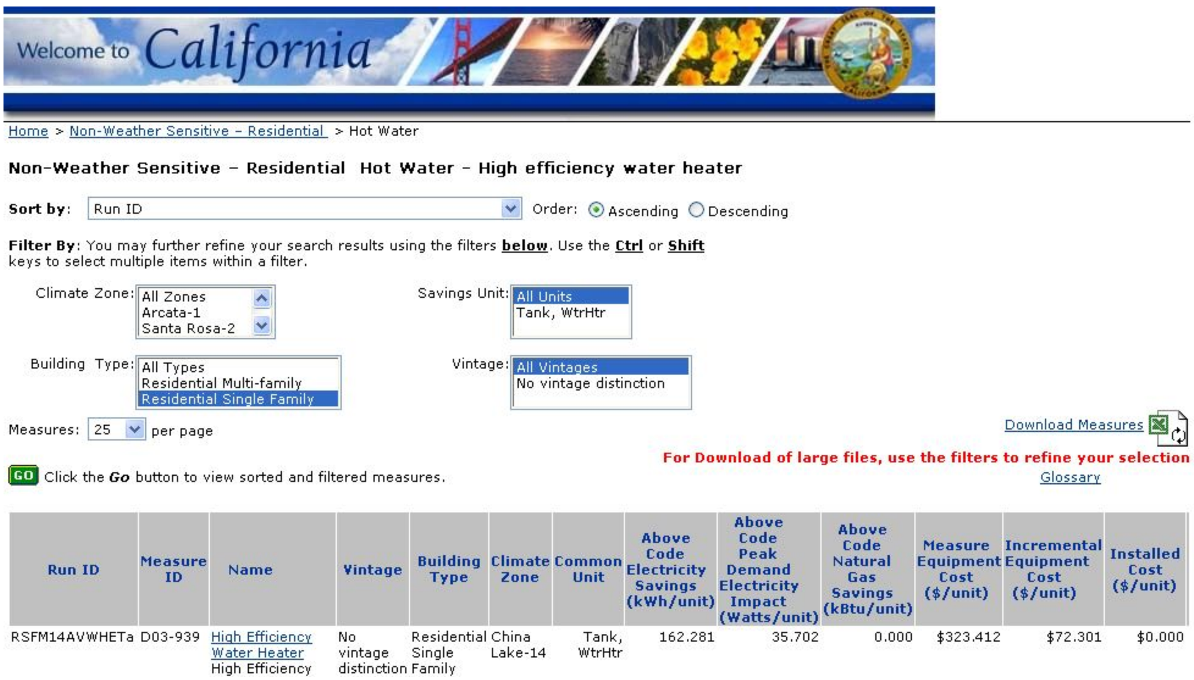
Figure 13-6: "Download Measures" Webpage



Revealing Detailed Measure Information

At this point, the user has the option to press the measure specific link for any of the measures listed (the highlighted measure name under the “Name” column. In the example, it is “High efficiency water heater”) to obtain detailed measure information or to filter the measures further. Figure 13-7 illustrates the results of selecting climate zone “China Lake-14” and building type “Residential Single Family” as the filtering agents. The results in the summary section are information for three RunIDs.

Figure 13-7: Non-Weather Sensitive – Residential Hot Water – High Efficiency Water Heater Webpage Filtered by CZ and Building Type



Pressing the measure detail link “High efficiency water heater” under the “Name” column reveals the next webpage, which is the detailed information about this particular measure. This detailed information is illustrated in Figure 13-8 for Run ID “RSFM14AVWHETa”.

The information available on this detailed page is arranged into blocks for ease of use. Block 1, the top block, includes basic measure, building, climate, fuel, and energy common unit information. It should be noted that the “Number of Common Units” identifies how many of the units are in the building.

Block two includes all of the “Customer” based variable information. This includes identification of the base technology, baseline energy use and “Customer” based measure impacts.

Block three contains the same type of information as Block two, but for the “Code” based variables. “Code” based information is provided on the base technology, baseline energy use and “Code” based measure impacts.

Block four includes cost information. Data is provided on measure application, cost basis, cost common units (if different from energy common units) and various measure cost components.

The last variable show is set off by itself at the bottom of the list of data. It is the value for measure effective useful life. At the bottom of the page is a listing of any specific references that may be appropriate for this measure.

Figure 13-8: Detailed Measure Information for Run ID "RSFM14AVWHPwr"

Home > Non-Weather Sensitive – Residential > High efficiency water heater > High Efficiency Water Heater

High Efficiency Water Heater Glossary

Printer-friendly page...

RunID	RSFM14AVWHETa
MeasureID	D03-939
Measure Name	High Efficiency Water Heater
Characteristics	High Efficiency Water Heater - Electric, EF=0.93
Building Type	SFM
Floor Area (sq ft)	0.000
Vintage	No vintage distinction
Climate Zone	China Lake
Climate Zone Code	14
Fuel Type Name	Electricity
Common Unit Name	Tank, WtrHtr
Number of Common Units	1.000

Customer Base Description	Electric water heater, EF=0.88
Customer Baseline Electric Usage (kWh/unit)	0.000
Customer Baseline Peak Demand (Watts/unit)	0.000
Customer Baseline Natural Gas Usage (kBtu/unit)	0.000
Customer Primary End-Use Electric Usage (kWh/unit)	0.000
Customer Primary End-Use Natural Gas Usage (kBtu/unit)	0.000
Customer Electricity Savings (kWh/unit)	0.000
Customer Natural Gas Savings (kBtu/unit)	0.000
Customer Peak Demand Electricity Impact (Watts/unit)	0.000

Code BaseDescription	
Code Baseline Electric Usage (kWh/unit)	0.000
Code Baseline Peak Demand (Watts/unit)	0.000
Code BaseLine Natural Gas Usage(kBtu/unit)	0.000
Code Baseline End-Use Electric Usage (kWh/unit)	0.000
Code Baseline End-Use Natural Gas Usage(kBtu/unit)	0.000
Above Code Electricity Savings (kWh/unit)	162.281
Above Code Natural Gas Savings (kBtu/unit)	0.000
Above Code Peak Demand Electricity Impact (Watts/unit)	35.702

Application	ROB/NEW
Cost Basis	INCR/INCR -same
Equipment Cost ($/unit)	$323.412
Base Equipment Cost ($/unit)	$251.111
Incremental Equipment Cost($/unit)	$72.301
Labor Cost ($/unit)	
Installed Cost($/unit)	$0.000

EUL (years)	15.000

Measure Other Sources:

DEER 4.0 1996 SERA Inc., "Revised/Updated EULs Based on Retention and Persistence Studies Results", July, 2005

"Evaluation of Pacific Gas & Electric Company's 1995 Nonresidential Energy Efficiency Incentives Program for Commercial Sector Lighting Technologies", prepared by Quantum Consulting, Inc., for Pacific Gas & Electric Company, 1997

[About | How To Search | How To Browse]

Questions about DEER Database
Project Manager: ITRON
Site Design: Synergy Consulting, Inc.
DOE-2 Modeling: James J. Hirsch & Assoc.
Measure Costs: Summit Blue Consulting.

Supporting Documents

Going back to the DEER website home page, "Supporting Documents" is the second area of operation. Provided here are links to spreadsheets and documents that are directly related to the DEER database and program planning. Included are:

- DEER Website User's Guide
- Net-To-Gross Ratios Table
- Access Tables
- Glossary
- Cost Data
- Cost Data Users Guide
- New EUL Estimates 7-14-05
- Consolidated Measure Data

The "DEER Website User's Guide" is a document similar to this section of the report. It provides a guide to users on how to use the website.

The "Net-To-Gross Ratios Table" provides net-to-gross ratios by program. They are directly taken from the "Energy Efficiency Policy Manual v2", prepared by the California Public Utilities Commission, Energy Division and dated August, 2003.

The "Access Tables" are a valuable download. This link allows the user to download the entire DEER database as a Microsoft Access database. The file is called DEER.mdb. The user should be aware that the file is large and can take time to download. Note that the Access database does not have defined table and field relationships. A user who wishes to perform more than simple searches needs to use Access to build the table and field relationships on their own, as well as any reports and queries.

The "Glossary" link provides the user access to a glossary of each variable within DEER. This information is very useful in gaining an understanding of the database. A copy of the glossary is provided in Appendix D.

The "Cost Data" link and its related "Cost Data Users Guide" link were developed and provided by Summit Blue Consulting, who performed the separate update of the cost portion of the DEER database. The cost data that is included with the measure impact information in DEER is specific to the measure as modeled or measure as reported by their common units of measure. Often, the DEER reported data represents an average across several different related measures. For example, a SEER 14 packaged A/C unit comes in different tonnage sizes, each with its own unique cost. The DEER reported cost is based on an average cost per ton for SEER 14 units. However, program planners may want specific cost information by size of unit. This more detailed cost information is available in the “Cost Data” spreadsheet from Summit Blue. The corresponding “Cost Data Users Guide” provides guidance in how to use and interpret the data.

The “Consolidated Measure Data” link provides another very useful source of information. DEER has within it over 130,000 unique records however; much of the information that is useful to planners is the same at the measure ID level of which there are about 360. Effective Useful Life (EUL), technology common units, and technology cost data is generally unique only to the measure ID level and repeated for each of the variations by building type and climate zone at the Run ID level. Therefore, the ‘Consolidated Measure Data” file was developed to provide a succinct source for this more general, measure specific information.

The variables included in this file are as follows:

- MeasureID
- Measure Name
- Measure Description
- Customer Baseline
- Code Baseline
- Energy Common Units
- Energy Common Unit Code
- Cost Common Units
- Cost Common Unit Code
- Application
- Cost Basis
- Base Equipment Cost ($)
- Measure Equipment Cost ($)
- Incremental Equipment Cost ($)
- Labor Cost ($)
- Installed Cost ($)
- EUL
- EUL Source

Figure 13-9 illustrates a portion of the “Consolidated Measure Data” file. The variables listed above are arranged horizontally along line 5. The information is provided in five tables within the spreadsheet, as identified by the tabs at the bottom of Figure 13-9. These tabs are:

- Refrig – nonresidential refrigeration measures
- Wea_Sen-NonRes – nonresidential weather sensitive measures
- Wea_Sen-Res – residential weather sensitive measures
- Non-Weath_Sen – non weather sensitive measures

- CFL – compact fluorescent lamps

In addition to these five data tables, an additional table, "Sources", is provided. This table list the sources used for the measures by source reference number. Only the EUL source is identified within the "Consolidated Measure Data" file. The other sources are referenced in the DEER as a whole with the sources identified at the bottom of the detailed measure information sheet

Figure 13-9: Consolidated Measure Spreadsheet

	A	B	C	D
1		**DEER 2005**		
2		**Nonresidential Refrigeration Measures List**		
3				
4				
5		**MeasureID**	**Measure Name**	**Measure Description**
6		D03-201	Retrocommissioning	Standard prototype air-cooled multiplex system w/extensive refrigeration equipment maintenance.
7		D03-202	High Efficiency Walk-in Fan Motors	Substitute high efficiency motors for standard efficiency
8		D03-203	High Efficiency Display Fan Motors	Substitute high efficiency motors for standard efficiency
9		D03-204	Heat Recovery from Central Refrigeration System	Adds an 85°F holdback valve, active only when needed
10		D03-205	Night Covers for Display Cases (medium temp)	Cover open MT cases between 1-5 a.m.
11		D03-206	Medium Temp Glass Doors (open display cases)	Retrofit glass doors on open MT cases
12		D03-207	New Medium Temp Refrig Display Case with Doors	Replace open MT case with new case with doors
13		D03-208	Auto-Closers on Main Cooler Doors	Install automatic door closer on walk-in cooler doors
14		D03-209	Auto-Closers on Main Freezer Doors	Install automatic door closer on walk-in freezer doors
15		D03-210	Evaporator Fan Control on Walk-in Coolers & Freezers	Cycle fan off with thermostat; duty cycle occasionally when off
16		D03-211	Air-Cooled Condenser to Evaporative Condenser	Replace air-cooled condenser with evaporative condenser
17		D03-212	Energy Efficient Air-Cooled Condenser	Upgrade from 53 Btu/Watt @ 10°F TD to 84 Btu/Watt
18		D03-213	Energy Efficient Evap-Cooled Condenser	Reduce design SCT by ~5°F and improve efficiency

Refrig / Wea_Sen-NonRes / Wea_Sen-Res / Non-Wea_Sen / CFL / Sources /

Ready

The EULs that are included within the "Consolidated Measure Data" file come from a number of sources. Those based on recent Measurement and Evaluation studies came from a report completed by SERA, Inc. and this report is available through the "New EUL Estimates 7-14-05" link.

14

Deer Update Plan

14.1 Introduction and Section Summary

Objectives and Scope

Besides the actual creation and revision of the DEER deemed values through the present update, there were several equally important study objectives:

- ***Create a Recommended DEER Update Plan.*** The purpose of the DEER Update Plan is to identify and summarize the key technical and process issues, and recommend how to further improve the handling of these issues in future projects.
- ***Identify DEER Linkages to EM&V***. The objective to identify both general and measure-specific evaluation and measurement needs of significant importance in the current DEER Update. The results are presented in a table of issues at the end of this chapter.
- ***Identify New Measures for Incorporation into the Next DEER.*** The objective is to identify measures that were not included in the current DEER Update but were requested to be included in the next update by Project Advisory Committee (PAC) members.

Approach

Two basic approaches were used to develop the DEER Update Plan: (1) Interviewing DEER PAC members and other technical experts with DEER-related experience; and (2) Tracking DEER issues as they arose throughout the project. The interviewees included:

- Tim Drew, Ariana Merlino – Energy Division, CPUC
- Nick Hall - TecMarket Works
- Jeff Hirsch, Kevin Madison, Paul Reeves - JJ Hirsch & Associates
- Mike Messenger – CEC
- Cynthia Mitchell – TURN
- Robert Mowris - Mowris and Associates
- Craig Tyler, Valerie Richardson, Mike Wan, Jennifer Barnes, Kenneth James - PG&E Policy and Evaluation Group

- Grant Brohard, Gary Fenstrom, Lance Eberling - PG&E Technical and Program Management Group
- Hank Ryan – Small Business California
- Marian Brown, Shahana Samiullah, Pierre Landry, Rich Greenberg, Rich Pulliam, Gary Suzuki - SCE Measurement and Evaluation and Program Management Groups
- Steve Galanter, Henry Lau, Marekat Joseph, Carlos Haiad, Tony Pierce, Ramin Faramarzi, Leonel Campoy, Paul Williams - SCE Design & Engineering Services Group
- Rocky Harmsted, Mary Wold, Rob Rubin, Mark McNulty, Andrew Sickles - SDG&E Policy and Evaluation Group
- Fred Sebold and Bob Ramirez - Itron
- Christine Tam – ORA, CPUC
- Marshall Keneipp – Summit Blue LLC

Summary of Issues and Recommendations

Key findings developed for the Update Plan are summarized in Table 14.1. The remainder of the chapter discusses each of the DEER Update topics in detail.

Table 14-1: Summary of DEER Issues and Recommendations for Future Updates

Issue	Background	Recommendations
DEER Guidelines	A key question associated with the DEER project concerns how it is to be used with respect to energy efficiency program proposals and filings to the CPUC. Although this issue does not affect the actual implementation of the DEER project directly, it was one of the questions addressed as part of this DEER Update planning task.	This is essentially a policy question that the CPUC should decide as part of future energy efficiency proceedings. However, we offer a few observations: • A central purpose of DEER should be to maximize the accuracy and consistency of per unit, ex ante measure data. • To the extent that DEER is accurate and complete, it is appropriate to require its use. • However, the accuracy and completeness of DEER, like any source, will vary somewhat across measures, due to limitations in available data and prioritization of DEER resources. • For these reasons, it may be appropriate to allow some deviations from DEER if certain conditions are satisfied. (These conditions are noted in Section 14.3) • In cases where deviations from DEER are proposed, DEER should be used as a benchmark in the decision. • In order to maximize the use of DEER, DEER data and documentation must be easy to access, use, and understand.
DEER Update Process	DEER updating schedules have been inconsistent in the past. Measure costs were updated every two years between 1992 and 1996, then again in 2001 and 2005. Residential energy savings were first estimated in 1994, then in 2001, and now again in 2005. Nonresidential (primarily commercial) savings were estimated first in 1994 and only updated again in the current (2005) project.	Comprehensive DEER updates should be carried out at least every 3 years; however, given the number of outstanding issues in the current DEER, the next comprehensive update should be completed before the end of 2007. In addition, Interim DEER updates should be enabled and carried out more frequently (e.g., every 6 months or year). Any published correction in DEER should be associated with a new version number and old versions archived to ensure a historic correspondence is maintained between user citations and specific versions.
DEER Update Criteria	It is not always clear when new information or methods	A strict protocol for updating DEER measures may not be well

Issue	Background	Recommendations
	warrant changing an existing DEER value. Generally, DEER values have only changed in the past as part of comprehensive updates. Since more frequent, interim updates of DEER should be put in place, as recommended above, criteria will be needed to determine whether new information is superior to existing DEER data and whether particular DEER values should be changed as part of these interim updates.	suited to the process. Protocols, though suited to the design and implementation of measurement studies, may be less appropriate for DEER, since it does not involve field studies directly, includes engineering-based estimation processes that do not always lend themselves to statistical estimation, and, requires judgments to be made based upon "best available" information. DEER should have a clear orientation to aid guide its decision-making. In general, DEER should strive toward an expected value orientation, neither purposefully conservative nor optimistic. In the face of significant uncertainty, however, DEER should tend toward a more conservative orientation. It is important to provide a process for program designers and other outside experts to review and comment on DEER methods and savings estimates to ensure that DEER is responsive to planning needs and considers all available information sources.
DEER-Related Evaluation Needs	Numerous measure-specific issues were raised and encountered during the current DEER. While many issues were for the most part resolved, some were not. A list of these issues is provided in Table 14-3.	New EM&V efforts are needed for many measures to reduce uncertainties and resolve differences of opinion over measure specification, baseline parameters, and savings measurement. In addition, future evaluation studies should also be designed and implemented with DEER applications in mind. This means more attention to measure-level measurement of savings and associated parameters, as well as explicit reporting of results in DEER-friendly formats and recommendations for how to best use the results in DEER.

Issue	Background	Recommendations
Energy Savings Methods	Key methods include engineering equations, building simulations, evaluation/field studies, and combinations thereof. The current DEER was constrained by the fact that few rigorous impact evaluation studies have been conducted in California since 1998. Extensive work was done in the current DEER to develop a larger number of building prototypes and simulate them over more climate zones than in previous DEER projects.	Increase the amount of evaluation-based savings estimates and data available for use in DEER. This should be enabled by the increased scope of impact evaluations planned for the 2004-2005 and 2006-2008 EM&V studies. To the extent practical, DEER should calibrate engineering equations and simulations to these updated evaluation results. Where evaluation results are reliable but unavailable in formats suitable for calibrated engineering or simulation models, consideration should be given to using evaluation results should directly in DEER. Similarly, where evaluation can be used more simply and transparently in engineering equations rather than simulations, consideration should be given to using the more simplified and transparent approach in cases where accuracy levels are not meaningfully compromised. To the extent feasible and practical, building simulation models should be expanded to reflect representative distributions of building and behavioral characteristics rather than single prototypical cases.
Baseline Calibration and Load Shapes	Efforts were made in the current DEER to calibrate results to available baseline data (e.g., the latest RASS) and evaluation results. However, due to significant gaps in data availability (e.g., unavailability of the current CEUS) and scope limitations, some key calibration activities were not conducted.	Additional baseline calibration activities are needed. Key parameters in commercial sector calculations and simulations should be compared and, as appropriate, calibrated to the CEUS when it becomes available. There is also a critical need to calibrate DEER load shapes to ensure that they do not systematically over or underestimate peak and other hour loads and appropriately capture population diversity effects.
Segmentation and Averaging	The current DEER provides energy savings results for more customer segments than any previous DEER. Use of these segments can be difficult, however, because of their number and the lack of default market weights to aggregate the data. In addition, some have argued for even greater segmentation in future DEER projects to provide results for even more	Future DEER projects should carefully weigh the advantages and disadvantages of different segmentation approaches. Where results are highly segmented, default market weights should be provided along with the software capability to produce aggregated averages through transparent, replicable processes.

Issue	Background	Recommendations
	specialized segments.	
Measure Costs	The DEER savings and DEER measure cost contractors worked closely together to integrate the savings and cost data for each DEER measure. Key issues included the measure cost team's preference for more specific measure definitions and the lack of cost data collection for custom and some design-related measures.	DEER measure costs and measure savings projects should be integrated or conducted in parallel to ensure upfront agreement on measure specifications. Adequate time should be incorporated into project schedules to allow for thorough quality control of cost and savings integration. Future DEER projects should address custom measures (this could include verification and analysis of custom cost data collected by the program administrators). Future DEER cost studies should also address design-related new construction measures or bundles.
Measure Coverage and Allocation of Resources	Although a goal of the DEER project has been to include as many measures as possible in the database, not all measures are included. There are a number of reasons why DEER has historically not included all measures, principally because of it's focus on prescriptive and prototypical measures and constraints associated with limited budgets	Relative priorities should be established early in DEER projects. In general, DEER resources should be prioritized toward those measures that contribute most to overall portfolio savings, as well as those that hold promise as emerging contributors. Level of cost-effectiveness should also be considered in the prioritization process as well as other factors. Identification of measures that were not included in the current DEER but should be considered for inclusion in future DEER projects are included as part of Table 14-2.
Types of Data to Include	Prior to the current DEER studies, DEER projects included only per unit measure costs and per unit measure impacts. The current DEER project also integrates the effective useful lifetime (EUL) at the DEER measure level. The Database also includes a static set of net-to-gross (NTG) ratios.	We recommend that DEER continue to focus on per unit inputs to measure-level cost-effectiveness analysis. Core per unit inputs include incremental costs and savings, including energy, peak demand, and load shape impacts, as well as effective useful lives. Because NTG values have been developed through ex post evaluation studies and are associated with the delivery of measures through particular program strategies, they do not fit as naturally within the DEER project. Nonetheless, as the CPUC approves new NTG values, the DEER website could continue to be a natural location for housing these estimates. With respect to saturation and potential studies results, we believe that it would be better to provide links to other websites than to try to include these within DEER.

Issue	Background	Recommendations
Role and Importance of Documentation and Preferred Data Delivery Formats	The quality and depth of DEER documentation was an issue that most interviewees emphasized strongly, particularly those with extensive experience using DEER in the past. Desired documentation needs focused on underlying parameters and assumptions for savings and baseline estimation, and documentation that are easy-to-use and electronically-linked and integrated into the DEER database.	Future DEER projects should continue to expand and improve documentation, particularly, electronic documentation. To accomplish this, additional time and resources dedicated to documentation should be included in future update projects. A formal assessment should be conducted of DEER users' satisfaction with the current DEER documentation and data formats. DEER should: • continue to make data visualization tools available; • build more documentation into the website and downloadable databases (especially important for caveats or application instructions); • continue to offer and provide training sessions to DEER users; • offer formal, periodic training beyond the CALMAC listserve to reach a broad spectrum of utility and third-party program developers.

14.2 Discussion of Key Issues

In this section, we discuss each of the key issues identified as important for consideration in future DEER updates.

Guidelines/Requirements for DEER Use

One of the most important issues associated with DEER concerns how it is to be used with respect to program proposals and filings to the CPUC. Most interviewees agreed that DEER should be the preferred source of default data for energy savings and cost effectiveness inputs, but not a required one. The primary application of DEER recommended by most interviews was essentially the same as the traditional application, namely, that it be used for ex ante program planning, proposals, and filing purposes.

In most cases, interviewees did not believe that DEER should be used for ex post savings claims or associated performance incentives.[1] A few interviewees did state that they believed there are circumstances where DEER values, when combined with ex post verification, could be used for savings claims or performance incentives, but only in cases where the CPUC and the program administrators are in strong agreement that the DEER values are deemed to be highly certain or unlikely to be improved with further ex post measurement.

With respect to the primary application of DEER agreed upon by all interviewees - program planning, proposals, and regulatory filings – most of the interviewees believed that DEER should be the primary source for these purposes but not be *absolutely* required for every data point (that is, exceptions should be permitted if justified and appropriate). One interviewee stated that use of DEER should become mandatory after the CPUC takes over oversight of the project during the 2006 – 2008 period. The other interviewees believed that program planners should be strongly encouraged to use DEER but that deviations from DEER should continue to be allowed under certain circumstances and with certain conditions (these are discussed in Section 14.3).

Energy Savings Methods and Data Sources

Another important issue associated with DEER has to do with the methods and data sources that are used as the basis for the energy savings estimates. Energy savings are usually developed from standard engineering calculations, building simulation models, evaluation and field measurement data, and combinations of these general approaches. Each of these is discussed below.

[1] For the most part, interviewees did not want to address the issue of how or whether DEER data should enter into ex post claims or performance incentives. This was generally because interviewees believed that such issues were larger policy matters that still needed to be resolved formally through the energy efficiency proceeding.

Engineering Calculations

Relatively “simple” but tried-and-true methods to calculate savings for a given measure have been used both in DEER and to support estimates in utility and non-utility program spreadsheets submitted to the CPUC. For example, such algorithms include using effective full-load hour savings and delta watts calculations for lighting measures and cooling and heating degree-days for calculating cooling and heating savings. These simple methods involve access to absolute parameters such as weather data in the case of weather-dependent measures, as well as measure-specific parameters such as effective full-load hours by business type for lighting, obtained from secondary data sources such as program evaluation measurements.

The strengths and weaknesses of these engineering calculation methods vary substantially by end-use, measure grouping and individual measure. The strengths are generally the ease of use and ability to readily communicate all assumptions and parameters used to derive a given result. Another important strength of this approach is that the equations can often easily accommodate results from field measurements of key parameters such as full-load equivalent hours, load shapes and diversity factors. Weaknesses are that input parameters may be affected by behavioral influences, weather, aggregation bias, non-linear partial loading effects, complex building interactions, or other factors not accurately reflected by the simplified key parameters. Another weakness of simplified algorithms is that they may not always provide enough parameters to describe the key dimensions that drive savings adequately such as variations in building shell characteristics. As a result, these approaches work best for non-weather sensitive measures. These approaches can sometimes also be used effectively for weather sensitive measures in cases where key parameters are obtained from evaluations - if the characteristics of the measures and program participant populations analyzed in the evaluation are considered similar to those of the program year being planned.

Building Simulation Models

Detailed building simulation models have been used extensively in DEER studies to generate savings estimates for weather-sensitive measures. Specifically, the DOE-2 model has been used for this purpose in all of the previous and current DEER energy savings studies.

The simulation method requires the development of very detailed building prototypes. Prototypes are usually developed for different types of buildings to reflect differences in factors affecting usage and savings. Each prototype includes detailed specification of both physical (e.g., building geometry, window/wall ratios, insulation levels, equipment types and efficiency levels, etc.) and behavioral characteristics (e.g., occupancy schedules, temperature setpoints, etc.). Prototypes may represent actual buildings or an average or typical building. Commercial prototypes can be very complex and include multiple space types within buildings and multiple buildings within a building type (e.g., a prototype for a college may actually consist of several different individual building prototypes). In the current and recent DEER projects, prototypes are developed by building type, vintage, and climate zone.

Prototypes are both a strength and a weakness of the building simulation approach. On the one hand, the specification of building-specific characteristics allows a direct correspondence between those characteristics and the resulting savings estimates. This provides the ability to develop savings estimates for a range of conditions of interest such as building type, building age, shell characteristics, equipment characteristics, hours of operation, and climate zone. In addition, models such as DOE-2 are hourly simulation models that can produce hourly load shape impacts, which are desirable for use in time-dependent benefit-cost analyses. On the other hand, it is often the case that a single or small set of prototypes is used to represent a population of buildings that are known to have widely varying characteristics. The results may be highly accurate for that given prototype but not necessarily an accurate portrayal of the average characteristics of the population of a particular vintage and climate zone. Related to this limitation are two other issues – behavior and calibration. Often, building simulation models do not capture the effect of different customer behaviors on savings. (Note that in this DEER update, new estimation techniques were introduced to account for behavior, for example, on the residential programmable thermostat measure.) It can also be difficult to calibrate the models to actual consumption, load shapes, or related baseline parameters like full-load hours because individual building prototypes may not adequately capture the wide diversity of characteristics in most populations. In addition, although detailed simulation models may be desirable from an engineering point of view, they are limiting to users who are not as familiar with the detailed inner workings and assumptions of the selected simulation program.

Evaluation and Other Field and Laboratory Methods and Data Sources

A third and critically important source of savings estimates as well as savings input assumptions is measurement data. There are two primary types of measurement methods and sources for data on energy efficiency measures – field and laboratory studies. Field studies can range from large, statistical analyses of energy billing data for thousands of facilities to intensive sub-metering and monitoring of dozens of energy-related parameters for single buildings. It seems obvious that direct measurement data for energy savings would be preferred to estimation methods such as those discussed above, all else being equal. However, there are numerous practical limits to how measurement can be cost effectively used for program planning purposes.

Like the other methods discussed, there are a variety of advantages and disadvantages to field measurements. For example, a strength of large, statistical studies that use billing data is that these approaches look for savings at their ultimate source – customer bills – and do so using samples that are often very representative of participant or eligible populations. These statistical approaches thus often incorporate the real-world effects of customer behavior on savings. Weaknesses of this approach are that it tends to work less well when savings are small as a percentage of total bills, often requires large sample sizes, and can require many adjustments to account for factors other than energy efficiency measure installation that affect energy consumption. In addition, although large statistical approaches may provide reliable estimates of overall savings for a program or even a particular measure, they do not always adequately explain the reasons for savings variation (in terms of underlying parameters that determine savings) in ways that are useful for forecasting future impacts.

Intensive sub-metering and monitoring is sometimes used in field studies to measure both savings and the parameters that explain them. These studies can be very useful to improving the understanding of how savings vary as a function of equipment characteristics, building characteristics, building operation, weather, and other factors. The principal weakness of this approach is that these studies typically utilize small samples due to the high per site costs of monitoring. In addition, measures are sometimes installed in such studies by experts in ways that may not be representative of real-world applications carried out by homeowners and contractors.

Laboratory testing is another approach to measurement commonly used for many measures; particularly those for which energy standards and ratings are required. These tests may be standardized through government requirements (such as the DOE ratings for residential appliances) under prescribed conditions or they may be custom studies designed to meet the objectives set out by individual researchers. Laboratory measurement offers the advantage of using highly controlled conditions to help to identify, isolate, and measure factors that influence energy consumption and efficiency. Of course, a major limitation of laboratory testing is that it does not usually account for the range and variety of behavioral and environmental conditions under which equipment will operate in real homes and facilities.

Combining Methods

Often, non-weather sensitive measure savings are developed from engineering calculations and weather-sensitive savings are developed from building simulation models, generally DOE-2. These approaches are also sometimes combined, for example, non-weather sensitive measures may be run through the building simulation models to produce estimates of interactive effects (e.g., the effect of a reduction in lighting load on HVAC usage). In addition, both the engineering calculation and building simulation methods can be improved when they utilize results from reliable measurement-based studies. This is in fact what much of the DEER work effort is focused on. A great deal of effort goes into reviewing existing evaluation and other measurement studies to ascertain whether these sources can provide the reliable, empirical data needed to support the savings estimates produced by the calculation and simulation methods. Because of the limitations associated with the measurement methods discussed above, and because baseline and measure characteristics are not static (e.g., next year's population of air conditioners may be completely different than any population previously observed due to the dramatic effect of new standards), the process of translating retrospective field measurements into prospective planning estimates has limitations and can be contentious.

Role and Importance of Documentation and Preferred Data Delivery Formats

Documentation was an issue that most interviewees emphasized strongly, particularly those with extensive experience using DEER in the past. Note that because our interviews were conducted in spring 2005, they reflect interviewee's experiences with past DEER documentation rather than experience with the final documentation developed for the current DEER. The principal types and levels of documentation desired included:

- ***Comprehensive documentation of underlying parameters and assumptions***. Sophisticated DEER users are not satisfied with procedural documentation for how energy savings are developed. These users want the underlying parameters and assumptions to be as explicit and transparent as possible. Documenting sources and any associated interpretation for the individual underlying parameters and assumptions is as important as procedural documentation on how the energy savings were developed.
- ***Comprehensive documentation of baseline estimates***. Most savings estimates ultimately are closely related to underlying estimates of baseline energy and peak demand estimates. DEER users want to make sure they clearly understand the baseline estimates, as well as the associated calculation methods, sources, and assumptions. This would include, for some users, complete specification of any simulation model runs such as DOE-2. In particular, users want to be clear on what sources and specific values the baseline estimates were calibrated to and whether such calibration was done for an all-inclusive market average condition or a segmented portion of the market (this issue is discussed further under the Methods and Approaches and Segmenting and Averaging sections above).
- ***Easy to use, electronically linked documentation***. Several interviewees strongly emphasized the importance of easy and instantaneous documentation such as the ability to click on a DEER value in a file and link directly to detailed documentation of how the value was developed and from what sources or assumptions. These users suggested that it was not expeditious for them to become experts with respect to where each part of the project documentation could be found among multiple report volumes and that, given the complexity of the project, they were bound to miss something through a traditional documentation approach.

For several interviewees, the issue of documentation clarity, depth, and ease of access was inextricably linked to most of the other key issues related to DEER. In particular, the issue of deciding whether to utilize a particular DEER value or not as compared to an alternate analysis or secondary source often hinges on how well the DEER user feels he or she can understand exactly what went into the DEER estimate.

Although it is easy to understand the importance and justification of DEER users' desire for even more extensive documentation than has been provided in the past, this is not as simple a matter as it may seem at first. Providing the level of detailed documentation that DEER users emphasized they need can often be difficult in practice. There also may be some practical and cost limitations to how far the documentation can or should go. For example, the provision of a

DOE-2 input file may be sufficient documentation for one type of measure but inadequate for another (because of issues associated with modeling approaches or parameter assumptions embedded in the simulation model itself). In the latter case, should the documentation go into detail on the embedded simulation parameters and processes or simply provide a more general discussion that alerts users to the type and degree of uncertainty associated with model's estimation approach?

The principal issue related to increasing documentation levels and user convenience is less a technical problem and more one of resource availability, allocation, and timing. On the one hand, given the technical complexity and range in savings and parameter estimates from secondary sources associated with many DEER measures, the range of user expertise, and the importance placed on DEER by the CPUC in the program planning, proposal, and filing process, a strong argument can be made that significant budgetary resources should be allocated to the documentation aspect of future DEER updates. This is because the type of documentation desired by users and the nature of the DEER project itself combine to require a level of effort that is significant beyond what is typically expected or necessary for technical reports in the energy industry.

At the same time, several other factors should be considered that argue for maintaining some practical constraints on the documentation effort. One such factor is the importance of the measure to the overall portfolio of savings. There may be a number of measures with very small contributions to the portfolio but very complex estimation approaches. The level of effort expended on documenting every calculation nuance for such measures should be capped. More generally, if DEER remains principally a preferred but not required source of ex ante data, documentation levels should be extensive but constrained within a budget setting process that takes into account other related analytical needs such as increased field measurement of savings or baseline conditions.

Finally, creation of comprehensive, hyperlink-enabled documentation takes time. On projects with difficult schedules, developing the results can sometimes compete with the process of documenting them. Future projects should ensure both that adequate time is planned for documentation (i.e., project results are completed far enough in advance of required availability to allow completion, review, and user testing of documentation) and that, to the extent feasible, documentation is built into the entire project process (which also facilitates review and quality control of draft results).

With respect to preferred data, tools, and visualization formats, we do not know yet how satisfied DEER users will be. No user satisfaction research could be conducted as part of this update plan in time to include in this report, although a user survey is available on the DEER website to collect some level of such a data. We recommend that such research be conducted soon to inform the next DEER update. Anecdotal information to date suggests that the web views of the summary database will be of less value than the full downloaded database. This is because the number of segments associated with many measures results in multiple pages of views. It is likely that many users will opt to download the entire database so that they can work with and analyze the results in ways driven by their intended applications. In addition to the web views and full database, several other datasets and tools are available. These include the measure analysis software (MAS) software and a spreadsheet graphing tool that allows visual review of the weather sensitive results.

Several training sessions have already been conducted through CALMAC and other teleconferences for program managers. These activities have been important to helping users to understand and appropriately utilize DEER results. This has been especially important because both Version 1.0 and 2.0 of the current DEER were launched on the website prior to the completion of this final report.

DEER Update Process and Criteria

The process and criteria by which DEER should be updated in the future are central topics to this discussion paper. We asked our interviewees how often DEER should be comprehensively updated, whether there should be a process that allows for changes in values in between major DEER studies, and what the criteria and processes for making and approving DEER changes should be.

How Often Should DEER Be Comprehensively Updated?

All interviewees felt that DEER should be comprehensively updated at least every three years. Some interviewees felt major updates should occur more often, for example, every year. Most interviewees thought that the comprehensive updates could occur less frequently than every year but that there should be a process in place that allows for updates to occur on an as needed basis, for example, in response to completion of a new evaluation study, or to accommodate a new high priority measure. Some believed that such as-needed updates should be allowed to occur on a virtually continuous basis, however, most suggested that a continuous process was not practical and that as-needed updates should occur on a set schedule such as every year or half year. There was general agreement that some kind of standing committee should be kept in place to maintain continuity in DEER, receive requests for updates, and make decisions on updating values during interim periods between the comprehensive updates.

What Processes and Criteria Should Be Used to Update DEER?

Most interviewees emphasized that DEER values should only be updated when it can be shown that the proposed new values are superior to the existing ones. However, there was no clear agreement on how a determination of “superior” data would be made. Although several interviewees expressed the hope that a protocol could be developed for DEER that would provide a purely empirical set of criteria for deciding whether new data should replace existing data, most interviewees, including those that expressed this hope, did not believe that this approach was really feasible or appropriate for DEER. This was primarily because interviewees recognized that the variety of methods and sources used for DEER (see Methods discuss above) would not lend themselves to such an approach.

In the end, most interviewees suggested that final decisions on whether the quality, accuracy, and applicability of new data warrants replacement of existing data should be based on the collective judgment of a group of experts charged with overseeing the DEER project, along with the technical consulting team responsible for the performing the work. Interviewees did not go into much detail on whether this group should operate by consensus or majority vote or what the exact composition of the group should be. All interviewees recognized that the Energy Division staff would be contracting for and managing the DEER project for the PY2006 to PY2008 period. Many interviewees expressed the desire that the Energy Division utilize a group of experts on a DEER Advisory Committee to make or at least advise on DEER decisions. This was generally because interviewees believed that decisions on DEER values were often extremely challenging due to significant technical complexities and empirical uncertainties. Interviewees cited many examples in which there was not a clear answer to the question of what a particular DEER value should be.

Given this, along with the importance placed on DEER by the CPUC and the impact of DEER on program design and implementation decisions, many interviewees did not believe that final decisions on DEER values in the future should be made by any single individual - neither a contractor performing the work nor an individual managing the contract. This is not to say that interviewees did not recognize that the CPUC, as the managing entity for DEER for 2006-2008, would have the final say on approving the DEER values. Rather, interviewees emphasized the importance of continuing to use a Committee of experts to develop the recommended values for CPUC approval based on careful analysis of the available information. In addition, several interviewees noted that the future technical input process should not be limited to a DEER Advisory Committee and that any future Committee needs to ensure that it is receiving all of the best available technical input it can from a broader group of experts and DEER users. (Note that the current DEER utilized a Committee approach and did include input from technical experts on an as needed basis to deal with specific technical issues.)

Reaching out to broader groups of experts and DEER users was believed to be important for two reasons. First, these individuals and entities may have knowledge of technical information about which the DEER Committee and contractor are unaware. Second, reaching out to other experts and DEER users helps to increase the understanding and usefulness of DEER. This is important since the ultimate goal is to have DEER used by program designers, planners, and implementers. In particular, feedback is needed between DEER users and DEER developers so that DEER data aligns as much as reasonably possible (see related discussion under *Segmentation and Averaging*) with respect to measures included and market segments targeted. Interaction between the DEER project and program administrators will also be important to ensure that program data can be tracked consistently with DEER definitions and segmentations or that DEER adapts to the tracking and segmentation needs of the program administrators.

While most interviewees believed it was important for a DEER committee to reach out to and be responsive to DEER users and other experts, there was concern that managing such input is extremely difficult in practice. A few examples from the current DEER project were provided, including: comments coming in at the last minute (well after comments were originally requested and with little time before deliverable due dates to make adjustments), comments sent directly to the DEER contractor instead of through the DEER contract manager or a commentor's PAC member, comments being argumentative rather than substantive, and many comments being redundant. Although some of these problems can be addressed with more rigorous procedures for managing comments, they were also considered an expected part of any process that is trying to be responsive to the needs of DEER users, which are often dynamic due to changes in regulatory procedures, codes and standards, the availability of new empirical information, and other factors. Several interviewees emphasized that comments should be timely and consistent with the schedule requested and that suggestions for specific parameter values must be tied to existing empirical information or the provision of new empirical information.

Baseline Energy Calibration

Several interviewees emphasized the importance of calibrating the calculations and models used for DEER to reliable estimates of baseline consumption and peak demand. Throughout the history of energy efficiency savings estimation, there have been numerous cases of savings estimates being too high or too low because the underlying analyses were not calibrated to accurate estimates of average consumption and demand. This can occur for both simulation models and simple engineering calculations. In the case of simulation models, there is a history of overestimation of space conditioning consumption in California. Inconsistencies between baseline data and DEER energy savings estimates can occur both because of limitations in the DEER modeling processes and because of limitations associated with the baseline targets themselves. Readers should note that the intent of this discussion is to briefly summarize key issues not to provide a primer on the associated history and analytical methods. There are many volumes of reports that discuss issues associated with baseline end use estimation in more detail than is possible here.

Obviously, in order to calibrate DEER models to baseline targets, accurate baseline targets must be available. Unfortunately, baseline targets are not always as accurate or statistically reliable as is desirable. This is because development of statistically reliable baseline data on key parameters such as end use annual consumption and coincident peak demand can be difficult, time consuming, and expensive. Historically, the two key sources of baseline data in California have been the Residential Appliance Saturation Survey (RASS) and the Commercial End Use Survey

(CEUS).[2,3,4] In the 1980s and 1990s, each IOU completed their own RASS and CEUS projects individually. However, the most recent RASS was completed as a statewide study. Similarly, a statewide CEUS is currently in progress.

Regardless of whether studies are conducted at a utility or statewide level, developing accurate end use estimates is a challenging enterprise. The key reason for this is that RASS and CEUS-type studies typically collect primarily revenue-meter data and customer characteristic data (e.g., equipment types, building shell features, etc.) but not end-use level metering data.[5] Since there are many end uses of import that must be estimated in these studies, researchers are faced with the difficult challenge of estimating many unknowns (usage for each end use) using only one known (revenue meter data) combined with customer characteristic data. Engineering methods are typically used to develop initial estimates of end use consumption using the customer characteristics data. These engineering-based estimates are then summed across the end uses and compared to revenue meter data. There are a number of ways to adjust the initial engineering estimates to constrain them to the revenue meter data. These techniques range from manual adjustments on a customer-by-customer basis (as may be done to calibrate a building simulation model for an individual site to that site's revenue meter data) to statistical methods that use regression modeling (conditional demand analysis) to calibrate across large numbers of customers. Despite considerable funding and advances in analytical methods over the past two decades, the inherent challenges in end-use estimation mean that there is always some uncertainty in the final results.

Another limitation associated with baseline end-use consumption and peak demand targets is that these data are not always available at the level of segmentation desired by program planners and the DEER project team. Traditionally, end use estimates have been developed as single averages by building type and climate zone. As discussed under *Segmentation and Averaging*, there is increasing interest in targeting programs to customer segments that are purposefully different from the "average" (e.g., high use/low efficiency customers, small commercial/large commercial, etc.).

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[2] Industrial surveys have also been completed but much less frequently than RASS and CEUS projects.

[3] RASS studies were generally conducted more frequently than CEUS projects, which are more difficult and costly due to the diversity of the commercial building stock and more complex engineering required to develop end use estimates.

[4] A related source of data for calibration targets are the CEC's end-use forecasting results. The CEC has been running its end-use forecasting models for roughly two decades. However, the end-use estimates that result from these CEC models are generally based on the end-use estimates developed in the RASS and CEUS projects.

[5] It should be noted though that the recent RASS and current CEUS both include limited but not comprehensive end use metering. Comprehensive end-use metering, that is, end-use metering carried out for large enough samples to be statistically representative, is extremely expensive, particularly for the commercial sector. The California IOUs conducted extensive residential and commercial end-use metering studies in the 1990s (mostly the earlier part of the decade).

In addition, calibration data may not be available in a format that is compatible with the energy savings models. Although knowing the target consumption of an end use is critically important, this information is sometimes not sufficient by itself for calibration. For example, for commercial lighting it is important to know what the average lighting consumption is by building and space type in kWh per square foot per year; however, the DEER energy savings estimates are built up based on estimates of delta watts multiplied by full-load equivalent hours of annual operation. Thus, calibration sources must either provide the full load hours explicitly or provide the average installed wattage per square foot associated with the average kWh usage per square foot, since full-load hours are the key calibration parameter for commercial lighting measures.

Another issue is that some measures require calibration to sub-systems within end uses. For example, a simulation may be calibrated to a target annual consumption value for an end use such as residential air conditioning, but estimation of savings for a particular measure, such as duct sealing, requires that the portion of baseline consumption associated with duct leakage is accurately known and, if so, modeled.

Some baseline calibration targets are developed from evaluation studies. For example, the current DEER commercial lighting values are based on estimates of full-load hours of operation developed from evaluation studies conducted in the 1990s and very recently in 2004. Although this is a desirable and intended outcome of these evaluations, it must be kept in mind that CADMAC evaluation studies were usually designed to produce results that were representative of the population of participants for the particular year or years evaluated (that is, not necessarily representative of the general population of eligible customers). To the extent that one year's participants are believed to be representative of the next year's cohort, such evaluation results are entirely appropriate. However, if there is strong reason to believe that the population of participants will be markedly different from the program year analyzed in the evaluation, then the evaluation results may be a biased indicator of future impacts.

Another calibration-related issue is that, in the case of simulation models, there is a history of overestimation of space conditioning consumption in California. This has occurred partly because much of California consists of relatively mild heating and cooling climates where occupants use their heating and cooling systems on a discretionary basis. Early simulation models estimated heating and cooling consumption based on engineering methods that considered weather, building and equipment characteristics, and indoor temperature set points, but did not fully capture variations in occupant behavior that affect the set points. Many building simulations are based on single prototypes that are used to represent a population of buildings. Even though the prototypes may reflect the average characteristics of the population they are attempting to represent (e.g., average insulation levels, window to wall ratios, equipment efficiency levels, etc.), they may not accurately capture average consumption or the average conditions that drive measure savings because they do not reflect the distribution of characteristics in the population. This is particularly problematic when it comes to the effect of occupant behavior on baseline consumption. For example, a single prototype that uses an average thermostat behavior and occupancy schedule does not capture the effect of the full diversity of thermostat and occupancy behaviors in the population. This is partly because the parameters in the individual prototype are binary (the HVAC system is either on or off, the home either occupied or unoccupied) whereas in the population there are many combinations of thermostat set points and occupancy occurring simultaneously.[6]

When the DEER 2002-2005 project began in 2003, neither the statewide RASS nor the statewide CEUS were available as targets for calibration. At that time, the available residential calibration targets were considered more reliable than the available commercial targets. The statewide RASS results became available in late 2004 and are now being used for calibration in the current DEER. The statewide CEUS results were not available for inclusion in the current DEER. As a result, the current DEER study did not include a formal calibration step for the commercial sector in which baseline results were compared with key secondary sources such as CEUS or the CEC's end use forecasting estimates.[7] As discussed in the Recommendations section, calibration or, at a minimum, thorough comparative analysis with the new CEUS should be a priority for the next DEER update.

Baseline Load Shape Calibration

Because the avoided cost and environmental value of energy efficiency measures can vary significantly by time of day, day of the week, month, and season, there is a long history of trying to develop accurate load shape[8] impacts for energy efficiency measures. While it is beyond the scope of this chapter to review this history, it is important to recognize that this is not a new issue. As noted in the previous footnotes, we refer in this discussion to load shapes as virtually any desegregation of annual energy use in hourly, day type, or time-of-use periods.

Throughout most of the history of energy efficiency in California and nationally, measure and program cost-effectiveness has been assessed using time-differentiated avoided costs that reflect differences in the value of energy and capacity over the course of a year.[9] Theoretically, one

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[6] J.J. Hirsch and Associates recently investigated the feasibility and effectiveness of addressing this problem through the modeling of a range of thermostat and occupancy assumptions (based on the RASS 2003) rather than a single average.

[7] Note, however, that some commercial non-weather sensitive measures, such as lighting, use key parameters, such as full-load equivalent hours of operation by business type, that were developed from ex post impact evaluation studies. Also, note that direct use of evaluation results is a form of calibration.

[8] Note that load shapes can be defined in a wide variety of ways from every hour of the year (often referred to as "8760), to day types (e.g., 24 hour shapes with different shapes for different types of days such as weekday, peak day, weekend, by month or season), to broader time-of-use periods that aggregate across groups of similar hours, days, and seasons (e.g., summer peak, summer mid-peak, summer off-peak, etc.). In this discussion, we consider all of these "load shapes".

[9] An exception to this for CPUC-oversight programs was the period 2002-2005 when the CPUC utilized a single average annual energy value for assessing energy efficiency cost effectiveness. In addition, California did not

would like to compare the *changes* in load shapes caused by adoption of an energy efficiency measure to the time differentiated avoided cost value of those changes. This means taking the difference between the load shape associated with the energy efficiency technology and the load shape associated with the base case technology. While straightforward in theory this is very challenging in practice because both base case and energy efficiency measure load shapes can be very difficult to measure and estimate. As in the case of developing annual energy use impacts, the process often starts with development of baseline estimates. The discussion in the previous subsection provided a number of reasons why estimating annual energy usage at an end use level is challenging – however, estimating baseline end use load shapes is even more difficult.

In the 1990s, California's IOUs embarked on some of the country's most ambitious end use load shape estimation projects. These projects generally involved combinations of whole-building interval metering, end use metering, and building/engineering simulation analysis. End use metering would be the preferred approach to load shape estimation if not for the fact that it has historically been very expensive and intrusive to customers. As a result, some projects have also used combinations of end use and whole building metering data and building/engineering simulation methods.

In the residential sector, the homogeneity of end uses and ease of isolating them with sub-metering led to several large end use metering projects in California. Both PG&E and SCE put in place extensive end-use metering samples from which they were able to develop load shapes for key end uses such as air conditioning, refrigerators, water heating, and other appliances. These projects have provided some of the most reliable end use shapes in the industry. At the same time, there were limitations in these projects associated with sample sizes for some end uses and the extent to which the samples were representative of the overall population. As a result, analysts must sometimes make adjustments and seek additional information to account for these factors.

In the commercial sector, the heterogeneity of customer types and end use components generally made a strictly end-use metering approach cost prohibitive, although commercial end-use metering projects were conducted. Because of the variation in building types and usage patterns, large samples are needed for commercial sector load shape modeling. As a result, simulation modeling was also used in two utility CEUS projects in the late 1990s to develop end use load shape estimates. Similarly, the current statewide CEUS is using simulation modeling to estimate end use load shapes.

Ideally, given a reliable and well-documented source of end use load shapes, the DEER project team can calibrate DEER's simulation and engineering baseline models to these data. However, there are often constraints to this process. For example, a particular residential end use metering

historically utilize time-differentiated analyses in developing new energy efficiency codes and standards until relatively recently when it adopted time-dependent valuation (often referred to as TDV).

sample may not be representative of all residential customers nor provide the associated customer characteristics data needed to develop and calibrate a model.

An advantage of using an hourly simulation model is that, once it is calibrated, it produces both baseline and energy efficiency load shapes in the same format with consistency in underlying assumptions. This allows for a simple subtraction process to calculate the change in load shape associated with adoption of a particular measure. A disadvantage is that, as discussed previously, it is very difficult with the current approach to simulation modeling to appropriately capture population diversity in single-prototype simulations. In addition, model-based, measure-level load shapes can vary widely across measures within an end use (e.g., window treatment load shape impacts are very different than the load shape impacts associated with higher SEER air conditioners); however, these variations have not necessarily been validated through comparisons to diverse groups of actual buildings.

Another approach to developing measure-level load shape impacts is to conduct both pre- and ex post end-use metering on program participants or to conduct only ex post end-use metering on the measures and then use that information to estimate the baseline shape. Getting pre-treatment end-use metering installed is not practical for most programs unless set up as a controlled experimental design[10] or in cases where there is a significant installation lag.[11] However, all of the IOUs did conduct some level of ex post measure-level load shape estimation as part of their impact evaluations during the Pre-98 protocol era. This information was primarily focused on developing estimates of peak demand impacts and rough estimates of impacts by time-of-use period (e.g., PG&E's H-factors). In addition, these estimate were also often developed using only short-term monitoring techniques. This was generally because of the costs of associated with more permanent metering, the need for timely ex post results, and the unwillingness of many program participants to comply with requirements associated with longer-term metering.

Although simulating or measuring ex post load shapes for every measure may be ideal in theory, there are other simplified approaches that should also be considered. For example, for many measures, the load shape impacts of the measure will follow the load shape of the baseline end use. For others, the primary difference, from an avoided cost value perspective, may be simply in whether the fraction of the peak demand impact is proportional to the fraction of energy savings. Depending on how sensitive the avoided costs are, it may be possible to simply adjust the on-peak savings relative to the annual energy savings. In both cases, the baseline load shape would be the key starting input to the estimation process. The advantage of this approach could be that it uses an accurate baseline load shape directly rather than trying to match the shape through a simulation method based on a single building prototype. This approach would still

[10] We do provide some recommendations for controlled experiments later in this chapter.

[11] For example, where program approval precedes measure installation, as is the case with SPC and similar custom incentive programs.

require evaluation- or simulation-based estimates of on-peak savings in order to develop peak savings adjustment factors.

Another important issue related to load shapes is the definition of "peak demand". The term peak demand is used in many different contexts but is often not clearly defined. Historically, most analysts considered peak demand in resource planning and cost effectiveness contexts to refer to average hourly loads coincident with a given utility's system peak.[12] Resource value varies as a function of many factors including the length of time resources are needed and available. Similarly load shapes vary significantly depending on the period over which they are estimated. Thus it is critically important to define the period over which peak demand is defined. Is it the single highest hour load of the year? A contiguous group of hours around that hour? A group of hours across multiple peak days with certain weather characteristics?[13]

Like any other aspect of DEER, the choice of method and assessment of relative accuracy for load shape impacts should be informed by an analysis of relative importance. In the future this should involve analysis of avoided cost data, measure cost data, energy savings, and load shape information to assess how sensitive benefit-cost estimates are to each parameter.

In summary, if the CPUC and IOUs place a high priority on load shape analysis of energy efficiency impacts, significant improvements will be needed in the development of both baseline and ex post load shape data. It is also crucial that consensus be developed on definitions of the specific hours associated with load shapes and peak demand impacts.

Segmentation and Averaging

Another key issue faced in the current and previous DEER studies is how to balance the advantages and disadvantages of more- versus less-detailed segmentation. In a world in which there were no constraints on developing and effectively utilizing accurate end-use level data, DEER would likely produce results for more and more customer segments. Of course, taken to its logical end, the ultimate segmentation is to provide estimates of baseline usage and savings potential for every customer in the population, since each customer is unique in some way. However, such an approach is currently neither practical nor necessary. Although every customer is unique in some way, customers also share numerous common characteristics that can be used to successfully group and define their usage and potential for savings. These common characteristics are the basis for most traditional efforts to segment customers based on significant factors affecting energy usage (e.g., building/business type, climate zone, vintage, etc.). When such key drivers of consumption patterns are combined, the result can be a large number of

[12] Conversely, engineers working at individual customer facilities often believe that peak demand refers to a customer's individual peak regardless of when it occurs, since this typically affects the demand charges on their monthly bills.

[13] For example, one definition that has been proposed in the CPUC's Resource Adequacy proceeding is that peak demand resources must be available at least 48 hours to receive a capacity valuation.

market segments and associated DEER savings estimates. For example, in the current DEER, the commercial sector weather-sensitive results (which are developed using the DOE-2 building simulation model) are run for 21 building types, 5 vintages, and 16 climate zones. Thus, for each individual weather-sensitive, energy-efficiency measure, there are over a thousand records of results. As discussed below, there are both advantages and potential limitations to such highly segmented analyses.

Importance and Advantages of Segmentation

A number of interviewees indicated a strong preference for DEER to provide highly segmented data. The primary reason for this was the belief that programs need to increase their focus on particular segments of customers and track accomplishments along the same lines. Beyond the traditional segments of building/business type, climate zone, and vintage, other segments of interest include customer size and efficiency level. In particular, some interviewees indicated a desire for a distribution of results within a given segment rather than just a single average value. Such information could be used to help target programs toward segments with higher savings potential and cost effectiveness.

Cautions and Disadvantages of Segmentation

However, not all interviewees supported detailed segmentation of DEER results. Some believed that results should be constrained to levels of aggregation that could be supported through ex post measurement in evaluation studies or for which reliable baseline estimates were available. From this point of view, although increasing the level of segmentation of DEER results is appealing for targeting and tracking purposes, there are some important issues and constraints that should be considered as well. Some of these include:

- Difficulty identifying the appropriate DEER value to use from among a large number (e.g., hundreds or thousands) of results.
- Difficulty re-aggregating segmented DEER results because of a lack of reliable data for weighting the segments based on the portion of the eligible market or likely participants each segment represents.
- Concerns over the accuracy of results due to lack of adequate data for each segment.
- Concern that program planners will be tempted to choose DEER segment values that have higher than average savings without the ability to cost-effectively identify and target the segments through real-world program implementation processes.
- Increased difficulty for the CPUC in reviewing program planning assumptions, determining how DEER was used, and assessing whether it was used appropriately.

To illustrate how DEER results that do not represent the overall market average condition can be problematic, it is useful to reconsider the case of residential programmable thermostats in the 2001 DEER Study. During the course of the 2001 project, the consultant team indicated that the programmable thermostat measure would produce very small or no savings if modeled against the average behavioral characteristics of the entire market. This was because the base case defined for most measures (such as high-efficiency air conditioners) and the use of calibration factors to adjust simulated usage to baseline targets in the 2001 Study already incorporated adjustments for thermostat setback (heating) and setup (cooling) and discretionary use (to account for setback when homes are unoccupied). These adjustments were in fact part of the process of calibrating the residential DEER prototypes to average space conditioning UEC (unit energy consumption) estimates. The question then became whether to show the thermostat savings for the average home, with very low or no savings given the base case modeling assumptions, or to redefine the base case for the measure to reflect a segment of the market that did not already practice regular thermostat setback and setup. A decision was made to estimate the savings for the *segment of the market that was not practicing* any setback or setup. These savings were subsequently mis-interpreted by some users who thought they reflected savings for the *average* household. In retrospect, the segmented approach was probably inappropriate for this measure because it was unlikely that the program approach would be able to target such homes, particularly if it was implemented as a mass-market incentive. In addition, the 2001 Study should have provided a more explicit caution to users that the savings reflected a small segment of the market rather than a market average condition.

This example is not meant to imply that segmenting is inappropriate; rather it simply illustrates that increasing levels of segmentation require increasingly careful analyses and explicit documentation of what each segment does and does not represent.

Measure Cost Issues

Historically, estimation of measure costs has taken a back seat to estimation of energy savings, both in California and, even more so, nationally. Whereas tens of millions of dollars have been invested over the past fifteen years in impact evaluations, very few resources have been allocated toward estimation of measure costs. The imbalance in resource allocation is problematic given the fact that measure costs are as important to estimation of total resource cost ratios as are measure savings. Perhaps this reflects an assumption that costs can be estimated much less expensively than energy savings. Although this may be true in some cases it is certainly not true in all. In fact, in some areas, such as custom and SPC-type projects in the non-residential sector, there have been extensive impact evaluations but literally no published studies on measure costs. Even in cases where one might expect the effort needed to develop reliable measure cost estimates to be minimal, there are usually a number of technical issues that must be addressed to make sense of the data collected.

Measure Coverage and Allocation of Resources

Although a goal of the DEER project has been to include as many measures as possible in the database, not all measures are included. There are a number of reasons why DEER has historically not included all measures, these include:

- ***Focus on prescriptive measures***. The definitional focus of DEER was on prescriptive-type measures that could be reasonably deemed or otherwise estimated to reflect "average" market conditions and associated measure savings (and, to a lesser extent, measure costs). As a result, custom-type measures, such as those in the Standard Performance Contract program and its predecessor custom rebate programs, were not included.
- ***Limited budgets***. Between 1992 and 2001, DEER projects simply did not have the resources to cover every measure adequately. Each project included tasks to screen measures for inclusion in the project based on criteria such as whether they were included in past programs or anticipated in future programs and the amount of savings they were likely to contribute to programs.
- ***Focus on prototypical measures***. Even once a measure is included in DEER, there is usually an effort to define the measure based on a few key characteristics rather than including every possible manifestation of the measure.

In the past, budget limitations and a definitional focus on prescriptive-type measures that can be reasonably deemed have been the two primary reasons that DEER has not comprehensively covered all measures in the program portfolios. Although the 2004-05 DEER update and the 2004-2005 DEER Measure Cost Study have considerably more funding than did previous DEER projects, budget and schedule constraints still result in prioritizing among measures with respect to which measures are ultimately included in the database.

As noted above, a related issue is that measures are often defined prototypically. For example, compact fluorescent lamp costs were defined in the 2001 DEER based on whether they were integral or modular, three categories of wattages, and whether they included internal reflectors. This resulted in 12 types of CFLs. Of course, there are hundreds of types of CFLs in the marketplace so any effort to represent the CFL market with prototypical measures will invariably exclude many specific cases. In the past, using prototypical measures was generally considered acceptable during periods when DEER was used principally as a source of program planning. Recently, however, the increased priority placed on DEER by the CPUC has lead some program managers to believe that DEER should provide savings and cost estimates at the same level of detail as programs are implemented and tracked. For some measures, the current DEER goes further than previous DEER databases in attempting to do this, while for other measures there are still considerable differences in the level of aggregation between DEER and program implementation and tracking.

If a goal of the DEER project is to further increase the direct correspondence between measures as defined for program implementation and tracking and measures as defined in DEER, several challenges to this process will need to be addressed.[14]

[14] For example, program planners and implementers may redefine or add new measures to their programs at any time, whereas DEER projects have periodic work schedules and deliverable dates. This limitation would be addressed if, as discussed elsewhere in this section, DEER were to become an ongoing project with the resources

Within the constraints discussed above, each DEER project has sought to maximize its effectiveness by allocating its limited resources appropriately among measures. This can be very difficult to manage in practice because many measures may require detailed and time consuming analyses to appropriately characterize while providing only modest contribution to the total portfolio savings.

As part of the current DEER, the project team has compiled a list of measures that were not included in the current effort that one or more organizations or individuals involved with the project have indicated should be considered for inclusion in the next update. These measures have been included within Table 14-2.

Table 14-2: Summary of M&V Related Issues

to respond quickly to changes in program measures. Another challenge is that some measure definitions are tied to program design strategies and a goal of DEER has been to provide inputs to, but to remain independent from, the program design process. Finally, it would be costly to include all measures in DEER at the level utilized in program implementation and tracking; however, it should be recognized that the program administrators otherwise incur these costs. Thus, additional resources for DEER to increase its measure coverage may reduce costs for the program administrators for the same activity. To be effective in the future, this would require close coordination between the program administrators and CPUC DEER project managers.

Primary Sector	Category or Measure	Measure
All	General	Inclusion of common measure bundles.
Residential	HVAC	Residential variable speed fans
Residential	HVAC	Ground source heat pumps
Residential	HVAC	Night ventilation cooling.
Residential	Water Heating	Solar water heaters
Non-Residential	Lighting	Inclusion of interior HO T-5 4 lamp fixture retrofits
Non-Residential	Lighting	Inclusion of LED “A” bulbs
Non-Residential	Cooking	Conveyor ovens (both gas and electric)
Non-Residential	Cooking	Under-fired broilers
Non-Residential	Cooking	Over-fired broilers
Non-Residential	Cooking	Pasta cookers
Non-Residential	Cooking	Steam kettles
Non-Residential	Cooking	Braising pans
Non-Residential	Cooking	Deck ovens
Non-Residential	Cooking	18-24" deep fat fryers
Non-Residential	Cooking	Rotating rack ovens
Non-Residential	Cooking	Rethermalizers (both gas and electric)
Non-Residential	Dishwashing	Commercial spray heads for dishwashing
Non-Residential	HVAC	Air curtain
Non-Residential	HVAC	Add size categories for packaged AC units
Non-Residential	HVAC	Dual cooled evaporative units
Non-Residential	HVAC	Chiller tower optimization
Non-Residential	HVAC	Cool Thermal Storage
Non-Residential	HVAC	Inclusion of Air Filter Alarm
Non-Residential	Motors	Motor rewinds
Non-Residential	Office Equipment	Photocopiers
Non-Residential	Refrigeration	Commercial refrigeration compressors
Non-Residential	Wastewater	High efficiency aerators for waste water treatment plants
Non-Residential	Wastewater	Dissolved Oxygen Control Units -- allows the wastewater treatment plant not to have to run continuously. This control unit adjust the run time of the aerators to maintain the minimum required levels of oxygen.
Non-Residential	Wastewater	Addition of low power mixers to reduce aerator run time for waste water treatment plants
Non-Residential	Wastewater	Addition of blower controls for waste water treatment plants
Non-Residential	Water Heating	Boiler Controls
Non-Residential	Water Heating	Inclusion of Bare Suction Pipe Insulation Wrap
Non-Residential	Whole Building	Rescheduling controls for chillers, air handlers, air distribution systems for building retro commissioning
Non-Residential	Whole Building	Installing controls for chillers, air handlers, air distribution systems for building retro commissioning
Non-Residential	Whole Building	Mechanical repairs and adjustments for heating systems, cooling tower and air compressors for building retro commissioning
Non-Residential	Whole Building	Other commercial building retrofit commissioning
Non-Residential	Whole Building	Other commercial building commissioning

Types of Data to Include

The DEER team asked interviewees to identify the data elements they believed should be included in the DEER database. Respondents were asked which data elements should be included and were given the following list of possibilities: energy savings, peak savings, load shapes, cost, effective useful lives (EUL), net to gross ratios (NTG), penetration and saturation data, and potential study results. They were also asked if there were any additional data elements to include. Most respondents said most or all of the elements mentioned should be included. Additional data elements suggested by respondents included carbon reduction impacts, total source BTU reduction, and water impacts (if any).

Others had different ideas on what should be included, and more importantly what should not be included. Several individuals stated explicitly that net to gross values should not be included in DEER because NTG values are dependent on how a program is delivered. Some of these respondents believed it would be erroneous to include NTG values at the measure level. Others indicated that potential studies and saturation data should not be included in DEER because they would take away from the focus of DEER on per unit data.

14.3 Measure-Specific and EM&V Linkage Issues

A principal objective of this report is to consolidate and summarize measure-specific issues that were not fully resolved during the current DEER project. In addition, this task includes identification of measures and parameters for which new evaluation and measurement studies are needed to help reduce uncertainty in DEER data or because the measure does not as yet exist in DEER. Because of the number of issues, this task is addressed principally through a table, which is provided in Table 14-3. The table lists the issues, organizes them by sector and end use, and notes general EM&V needs.

Readers should note that the information provided in Table 14-3 is meant as a brief checklist summary of issues and potential EM&V actions. For some measures, much more information was compiled during the current DEER project through emails, discussion papers, and teleconferences. This information exchange occurred among PAC members and their organizations, as well as other organizations and individuals with information or expertise related to specific measures. Often, the measures with the most extensive trail of discussion material were also those whose savings were considered highly variable – the extensive discussions reflecting differences in points of view on the implications and range of estimates from existing sources.

The 2004-05 DEER update includes estimates of Effective Useful Life (EUL) by measure for the first time. However, many of the EUL estimates are based on secondary sources or on dated EM&V studies. Table 14-4 identifies the specific measures that have EUL estimates that should be updated in the near future. The measures listed do not include all of the measures that could benefit from updated EUL estimates, but rather the "high priority" measures. The "high priority" measures were determined based on the expected amount of energy savings according to the 2006 – 2008 utility filings and the quality of the current EUL estimates. The measures with the largest expected savings and poorest EUL sources are included in Table 14-4.

Table 14-3: Summary of M&V Related Issues

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
All	General	Better Alignment Between EM&V Results and DEER Inputs	Current DEER methods require EM&V results to be more detailed. In particular, measure- and parameter-level results are needed. For example, hours of use, base case and measure efficiency levels, delta efficiency levels, in service factors, behavior effects, etc.	Future EM&V studies should attempt to provide measure and parameter level results (for high priority items). Of course, this objective must be balanced against the objective of producing program-level results. Measure-level needs and program-level needs should be addressed in consort as part of portfolio level EM&V design. EM&V studies should formally and explicitly call out findings that are relevant to DEER.
All	General	Better Characterization of Uncertainty Around DEER Estimates	Confidence in DEER values can vary widely by measure; however, this is not obvious when reviewing the DEER database. DEER should consider adding some indicator of confidence.	EM&V studies should provide confidence intervals whenever possible, not just for program-level realization rates (as per the CADMAC protocols) but also for measure or parameter-level results.
All	General	Inclusion of Measure Packages	Some measures are often bundled together as delivered within certain programs. Consideration should be given to analyzing measure bundles for bundles that are extremely common.	EM&V studies and DEER should be coordinated to align definitions of measure bundles. Studies should provide detailed documentation of measure combinations for cases in which savings are reported for multiple measures.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Residential	HVAC	High Efficiency Equipment - Energy and Peak Savings	The relationship between energy and peak savings from high efficiency residential air conditioners varies depending on the specific high-efficiency and base case replacement units compared (including whether coils are properly matched) and is generally not constant across climate zones. Limited market data is available to accurately characterize the average base case and replacement units, in particular, because of changes in product availability likely to occur as a result of the new SEER 13 standards.	Better market and field data is needed to properly characterize average base case and high efficiency units (including data on actual coils installed). Ex post field measurement of savings is also needed. However, it should be noted that the range of uncertainty in savings estimates for HE AC units above 13 SEER may still fall outside the range of cost effectiveness given current incremental costs for such units.
Residential	HVAC	Room A/C - Hours of Operation and Savings	One interviewee noted that there is limited field-based measurement and EM&V data available for room air conditioners in California.	Need for EM&V should be based on level of program activity. However, hours of use can be inferred with reasonable accuracy from the UEC results recently produced in the SW RASS Study.
Residential	HVAC	Duct Sealing - Parameters and Savings	Opinions vary on modeling assumptions and field results with respect to underlying parameters (e.g., leakage rates), market data (e.g., distribution of leakage rates in the population), and actual savings (differences among DEER simulation results, proponents claims, and evaluation studies).	Targeted EM&V study needed to help resolve issues. Such a study would require very careful design. A controlled experimental design should be considered (e.g., random assignment of test and control homes, pre-measurement by an independent evaluator, and random assignment of multiple implementers). May be warranted if significant resources are planned for this measure. Could be combined with HVAC Installation/Tune-Up study but study design would need to differentiate savings by individual measure and retrofit from new construction.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Residential	HVAC	HVAC Practices - Parameters and Savings	Strong interest from some interviewees and PAG for analysis that would increase reliability of assumptions for a program aimed at improving HVAC inefficiencies associated with proper refrigerant charging and airflow, duct sealing, proper sizing, and proper coil matching. Issues include limited independent and statistically reliable data on distribution of inefficiencies in the market, modeling assumptions, effectiveness of interventions, and independent and statistically reliable ex post measurement of savings.	Targeted EM&V study needed to help resolve issues. Such a study would require very careful design. A controlled experimental design should be considered (e.g., random assignment of test and control homes, pre-measurement by an independent evaluator, and random assignment of multiple implementers). May be warranted if significant resources are planned for this measure. Could be combined with Duct Sealing study but study design would need to differentiate savings by individual measure. In addition, this study would need adequate sample to support separate analysis of retrofit only measures, replace-on-burnout applications, and new construction.
Residential	HVAC	Programmable Thermostats - Behavior and Savings	Recent research (including DEER modeling using RASS data and EM&V results) indicates that savings from programmable thermostat savings may be very small in California because setback behaviors are already widespread.	Some believe that the recent EM&V on programmable thermostats is inconclusive and that additional EM&V is needed. Others believe results are directionally conclusive that savings are too modest to not justify major interventions. If additional EM&V is conducted a careful study design will be needed as savings have been shown to be difficult to observe from statistical analysis of customer bills.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Residential	HVAC	Evaporative Coolers	Evaporative coolers generally use less energy for cooling then do compressor-based cooling technologies; however, historically they have not produced equivalent levels of cooling. New evaporative cooling technologies are being designed to provide improved comfort as compared to traditional direct evaporative cooling.	New evaporative cooling technologies have been considered an emerging technology for over a decade. If these technologies show significant program-induced market penetration, EM&V should be designed to measure savings and occupant comfort and satisfaction as well as other issues such as water use and maintenance.
Residential	HVAC	Inclusion of Night Ventilation Cooling	DEER currently includes no information on this measure. However, it is a measure included in some utility program offerings	TBD
Residential	Lighting	CFL Average Hours of Operation	CFL residential annual hours of operation are updated in current study based on KEMA CFL logger study results.	One reviewer requested additional information on indoor versus outdoor hours of operation by control type.
Residential	Lighting	CFL Other Issues	During review of the current DEER, several issues were raised by a program manager desiring more empirical data on: - In-service rates - Effective useful life - Retention and replacement rates - Wattages of incandescents replaced by CFLs - How customers make decisions about CFL purchases and applications - Adequacy of light levels after replacement - Savings from dimmable CFLs	Several of these issues could be addressed in future EM&V, including 2004-2005 SW study. Establishing pre-retrofit wattages would be difficult. Note that a recent statewide lighting logger study developed hours per day and load shape for indoor lamps. These results were used to estimate the residential CFL savings estimates. The outdoor data needs more careful segmentation by control type: manual, photosensors, timers, and motion sensors, as well as by application such as porch, yard, security, etc.
Residential	Water Heating	Inclusion of Solar Water Heaters	Solar water heaters are not currently included in DEER. Several interviewees requested inclusion of this measure.	TBD

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Residential	Appliances	Clothes Washers - Savings	The cost-effectiveness of clothes washers are a function of motor savings, water heating savings, water heating fuel type, water savings, and number of loads. One interviewee indicated a desire for better information on this measure.	TBD
Residential	Pool Pump	Pool Pumps - Operation Hours, Wattages, and Savings for 2-Speed Versus 1-Speed	Additional research was requested to address the hours of operation, wattage levels, and associated savings of replacing 1-speed with 2-speed pool pump motors as well as time clock resets.	These issues can be addressed through future EM&V including 2004-2005 SW study. Future EM&V should include considerations and impacts of the new Title 20 requirements on pool pumps.
Non-Residential	HVAC	Documentation and Calibration of Packaged Unit Hours of Operation	One reviewer indicated a desire to have DEER report the full-load hours by business type associated with packaged units. This reviewer also wanted these values to be calibrated to reliable field-based data.	See note above on Calibration.
Non-Residential	HVAC	Size Categories Used for High Efficiency Commercial AC Equipment Measures	Performance and ratings vary across units.	Market and program data needed on units installed.
Non-Residential	HVAC	Size Categories and Baseline Efficiencies for Chillers	Performance and ratings vary across units.	Market and program data needed on units installed.
Non-Residential	Lighting	CFL Average Hours of Operation	CFL commercial annual hours of operation are updated by business type in current study based on Quantum CFL logger study results.	Sample sizes were relatively small in the Quantum CFL logger study and points were focused on smaller customers and the mix of businesses in recent program years. Additional research should be considered to increase the reliability of the results and representativeness across a wider range of segments.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Non-Residential	Lighting	CFL Other Issues	Other non-residential CFL issues include: - Characterization of screw-in versus hard-wired - Customer action at CFL burnout (at what rate are CFLs re-installed, at what fraction are re-installs rebated by programs)	These issues can be addressed through future EM&V including 2004-2005 SW study.
Non-Residential	Lighting	Other Non-residential Lighting Issues	Other non-residential lighting issues include: - Increases number of fluorescent fixture measures (current DEER has only 2-lamp fixture to characterize T8/EB measure) - Inclusion of full costs for T8/EB measure (costs in current DEER are incremental) - Hours of operation for fluorescent fixtures by business type, customer size, space type - Hours of operation for HID and T5 applications - Base case and remaining useful life of fixtures replaced with T8/EB measures	Some of issues can be addressed through future EM&V including 2004-2005 SW study. Hours of use monitoring may require supplemental funding. CEUS results should also be mined.
Non-Residential	Dishwashing	Dishwashing Inclusion of Spray Heads	This measure has been the focus on one or more non-utility programs and has been requested to be included in future DEER updates.	Baseline data may be needed, particularly if the measure is penetrating the market quickly on its own.
Non-Residential	Refrigeration	Refrigeration - Analysis of Savings	Commercial refrigeration has shown high economic potential but has had somewhat limited program penetration. Additional analysis may be needed to confirm cost and savings assumptions and customer decision making processes.	A targeted study may be needed.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Non-Residential	Whole Building	Building Retro-Commissioning (R-CX) and Commissioning (CX) - Analysis of Savings	Studies have shown significant cost effective savings associated with RC-X and CX and several R-CX programs and program elements were included in 2002-2005 non-utility programs. This is also a target area of interest for 2006-2008. More information is needed on the specific measures included in these efforts, measurement of savings, EULs, and customer decision making processes and adoption rates. Note, however, that many of these opportunities are more like custom than prescriptive measures (see related item on "Custom Measure Savings and Costs".	Include in next DEER update. A targeted study also may be needed. (See related item on "Custom Measure Savings and Costs".)
Non-Residential	Cooking	Inclusion of Food Service Measures	Food service measures were requested to be included in future DEER updates. These include: - Conveyor ovens (both gas and electric) - Under-fired broilers - Over-fired broilers - Pasta cookers - Steam kettles - Braising pans - Deck ovens - Convection ovens - 18-24" deep fat fryers - Rotating rack ovens - Rethermalizers (both gas and electric)	Historically, the Food Service Technology Center has been the primary source of savings estimates. These estimates are based on laboratory tests. Ex post impact evaluation results may be needed on some of these measures, however, they may be very small portion of the overall portfolio and may not warrant such efforts.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Non-Residential	Motors	Motors - Parameters and Base Case Assumptions	Several issues were raised in the current DEER with respect to motors. Discussion centered around whether DEER would adopt most of the data and assumptions in PG&E's PY2006-2008 Motors work papers. Issues included:- Technology segmentation (e.g., TEFC-ODP, RPM levels)- Average premium efficiency levels- Full and incremental measure costs for EPACT, premium, and motor rewinds- Characterization of hours of operation (e.g., by size of motor, business type, application type)- Measurement of hours of operation- Rewind versus ROB base case for premium motor replacements (i.e., should the base case assume ROB replacement with an EPACT motor or that the motor would have otherwise been rewound, or a market-weighted combination?)- Rewind degradation factor (i.e., by what percentage, if any, should pre-EPACT motor efficiencies be degraded for the rewind base case?) Although agreement was reached on many of these issues, consensus could not be reached on all of them in time for the 8/31/05 DEER database delivery. The primary issues that were not resolved were the fraction of the market for the rewind base case and the rewind degradation factor.	There is limited EM&V data on motors for California applications. This is partly because high efficiency motors have historically constituted only a small part of program savings in the state. Depending on the amount of EM&V allocated to motors in future studies, key issues that require further study include:- fraction of the total non-residential motor market that is rewinds versus new motor purchases- rewind degradation factor (resolving this issue could be difficult and require independent bench top testing)- motor hours by motor size and sector (commercial versus industrial)- motor sales by sector (commercial versus industrial)

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Non-Residential	All	Custom Measure Savings and Costs	DEER has focused throughout its history on prescriptive-type measures that can be reasonably deemed on an ex ante basis. Of course, a significant portion of measures implemented by large non-residential customers are custom-type measures. Should DEER attempt to include custom measures or include calculators (with users supplying the inputs) for these measures?	Future DEER efforts should include a task to more thoroughly assess this issue and what, if any, data or methods on custom costs and savings should be incorporated into DEER.
Non-Residential	All	New Construction Savings and Costs Linkage	The current DEER does not include cost estimates associated with design improvements that result in savings relative to current standards nor do the savings estimates in DEER explicitly identify the design strategies assumed to result in savings relative to code. For example, Title 24 standards for lighting are generally set on the basis of Lighting Power Density (LPD) in watts per square foot. To achieve savings beyond current standards generally requires design-driven changes in the mix and layout of lighting sources rather than simply substitution of more efficient for less efficient technologies. The current DEER does not provide cost estimates or descriptions of these strategies and how they vary by building type.	Future DEER efforts should include a task to address whether and how costs and savings should be developed and consistently integrated for design strategies and packages of measures in new construction. This issue is related to the "Custom Measure Savings and Costs" issue.

Primary Sector	Category or Measure	Issue	Summary	EM&V Linkage or Other Action
Non-Residential	Wastewater	Need for Savings, Costs, and EULs	Wastewater measures are not in the current version of DEER. EULs and information on costs and savings have been requested.	Future DEER efforts should address wastewater measures. Since many of these are custom costs and savings, the extent to which they are included in future DEER updates will follow from the extent to which future DEER updates include custom measures.

Table 14-4: Measures Needing Updated Effective Useful Life Estimates

Sector	Category	Current EUL Source	Measure Name
Both	General	CALMAC	Occupancy Sensor-Wall or Ceiling-Mounted Lighting Sensor
Both	HVAC	Engineering Estimate	Correct refrigerant charge and air flow
Both	HVAC	CALMAC	Gas Boilers (Space Heat, Process, Non-Process)
Both	HVAC	CALMAC	Programmable thermostats
Both	Water Heat	CALMAC	Gas Wtr Htr and/or Boiler Controllers
Both	Water Heat	USDOE	Instantaneous Water Heaters (gas & electric)
Both	Water Heat	CALMAC	Pipe Insulation - Hot Water Applic.
Both	Water Heat	CALMAC	Pipe Insulation - Low Pressure Steam Applic.
Non-Res	Agriculture	Other	All of the Agriculture Measures in DEER
Non-Res	HVAC	CALMAC	Chillers
Non-Res	HVAC	Engineering Estimate	Economizer Tune Up
Non-Res	HVAC	Engineering Estimate	Heat Recovery
Non-Res	Lighting	CALMAC	LED Exit Sign
Non-Res	Lighting	CALMAC	Lighting - Exterior >176w Incan Base HID
Non-Res	Lighting	CALMAC	Lighting - Interior 251-400w Incan Base HID
Non-Res	Lighting	CALMAC	Lighting - Interior 251-400w Merc Vap Base
Non-Res	Lighting	CALMAC	Lighting - Interior Pulse Start Metal Halide Fixtures
Non-Res	Motors	CALMAC	Motors
Non-Res	Other	Engineering Estimate	Refrigeration - Vending Machine Controller
Non-Res	Refrigeration	CALMAC	Main Door Freezer Door Gaskets(Walk-in)
Non-Res	Refrigeration	CALMAC	Night Covers for Display Cases - med temp
Non-Res	Refrigeration	CALMAC	Refrigeration - Anti-Sweat Heater Controls
Non-Res	Refrigeration	CALMAC	Refrigeration - Efficient Evap Fan Motor Electronically Commutated Motor (ECM)
Non-Res	Refrigeration	CALMAC	Refrigeration - Food Service -Auto Closer for Main Cooler Doors
Non-Res	Refrigeration	CALMAC	Refrigeration - Food Service -Evaporator Fan Controller for Walk-In
Non-Res	Refrigeration	CALMAC	Refrigeration - Glass or Acrylic Doors-Low Temperature Case
Non-Res	Refrigeration	CALMAC	Refrigeration - Glass or Acrylic Doors-Medium Temperature Case
Non-Res	Refrigeration	CALMAC	Refrigeration - New Refrigeration Case w/Doors-Low Temperature Case
Non-Res	Refrigeration	CALMAC	Refrigeration - New Refrigeration Case w/Doors-Medium Temperature Case
Non-Res	Refrigeration	CALMAC	Refrigeration - New Refrigeration Case w/Doors-Special doors Low Temp
Non-Res	Refrigeration	CALMAC	Refrigeration - Strip Curtains for Walk-ins
Non-Res	Refrigeration	CALMAC	Refrigeration - Food Service-Auto Closers for Reach-In Cooler Doors
Non-Res	Water Heat	Efficiency Vermont	Faucet Aerators
Res	Appliances	CALMAC	Energy Star Cloth Washer
Res	Appliances	CALMAC	Energy Star Clothes Washer (In Coin-Op Laundry Area)
Res	Appliances	CALMAC	Energy Star Dishwasher
Res	HVAC	Engineering Estimate	A/C - Whole-House Fan
Res	HVAC	CALMAC	Attic Insulation
Res	Insulation	CALMAC	Wall Insulation
Res	Lighting	CALMAC	Lighting - Torchiere CFL Lamps
Res	Pool Pump Motor	Ashrae	Pool Pumps (1 speed and 2 speed)
Res	Water Heat	CALMAC	Clothes Washers
Res	Water Heat	CALMAC	Gas Storage Water Heaters
Res	Water Heat	CALMAC	Low Flow Showerhead

14.4 Recommendations

Introduction

In this section we present recommendations for future DEER projects. These recommendations are informed by input received from the interviews conducted as well as the experience of the current DEER contractor team and Project Advisory Group (PAC). In several cases, because of the complexity of issues involved, the evolving role of DEER in the CPUC's overall evaluation and oversight plans for energy efficiency, and limitations in available resources for DEER, the discussion focuses on considerations and tradeoffs rather than hard recommendations. For the most part, these suggestions represent general agreement among the program administrators' and Energy Division's DEER PAC members and the contractor team.

Guidelines/Requirements for DEER Use

A key question associated with the DEER project concerns how it is to be used with respect to energy efficiency program proposals and filings to the CPUC. Although this issue does not affect the actual implementation of the DEER project directly, it was one of the questions addressed as part of this DEER Update planning task. As noted in Section 14.2, most interviewees believed that DEER should be a strongly required but not mandatory source of data for program filings and ex ante cost effectiveness analyses. Some believed DEER should become mandatory source in the future after further improvements are made to it. This is essentially a policy question and one that ultimately the CPUC should decide based on input from participants in the energy efficiency proceeding. However, we offer the following observations based on the interviews conducted for this task and DEER team's experience conducting DEER studies:

- A central purpose of DEER has been, and should continue to be, maximizing the accuracy and consistency of per unit, ex ante measure data used in program planning, filings, tracking systems, cost effectiveness analyses, and energy efficiency forecasting. This is crucial to both the CPUC and utilities' processes for conducting quality control analyses of ex ante data. Both utility and third party program proposals often contain hundreds or even thousands of ex ante values.
- To the extent that DEER is accurate and complete, it is appropriate to require its use. However, the accuracy and completeness of DEER, like any source, will likely continue to vary somewhat across measures, due to limitations in available data to support DEER and prioritization of DEER resources across measures. For these reasons, it may be appropriate to allow some deviations from DEER if certain conditions are satisfied. Examples of such conditions include:
  - Data or analysis for which the user has *strong* evidence that the results are more accurate than DEER; along with provision of complete documentation of such data or analyses with the supporting justification for why the alternate sources are superior.

  - Targeting program participation to market segments whose characteristics are significantly different from those represented in DEER; provided that: convincing evidence is presented that the program can in fact be targeted to the identified segments and that estimates for the alternative segments are developed using data, methods, and assumptions that are consistent with DEER (or, again, that strong and convincing evidence is provided for using alternate data, methods, and sources).
  - Deviations from DEER are subject to an increased level of regulatory, expert, and, in the case of non-utility proposals to the IOUs, utility review.
  - Deviations may trigger alternative formulations of risk and reward on program performance and evaluation requirements.

- In cases where deviations from DEER are proposed, DEER data and documentation should be used as a benchmark to assess whether the deviations should be permitted.

Obviously, in order to maximize the use of DEER, the data must be easy to access, use, and understand. The remainder of our recommendations address these and related issues.

DEER Updating Process

In this section we provide recommendations on the timing and orientation of future DEER updates. First, we define and discuss two general classes of updates – comprehensive and periodic. Second, we discuss considerations and criteria to help improve the process of updating and approving DEER values.

Timing of Updates

Based on the history of DEER, experience with the current DEER project, input from interviewees, and the importance placed on DEER by the CPUC in Decision 05-04-051,[15] we believe that comprehensive updates of DEER should be completed at least every three years and, as importantly, that a process should be established for updating specific DEER values more frequently as warranted by the availability of new information or the need for new measures.[16] The comprehensive updates should be conducted to improve how DEER addresses the overarching methodological and technical issues discussed in this paper. The interim updates should be limited in scope and should address only those measures for which new information warrants a significant change. A criterion for the interim changes is that they must be feasible within the structural context of the last comprehensive update (otherwise they by definition become part of the next comprehensive update). These interim DEER updates should occur

[15] *Interim Opinion: Updated Policy Rules for Post-2005 Energy Efficiency and Threshold Issues Related To Evaluation, Measurement and Verification of Energy Efficiency Programs*, April 21, 2005

[16] Note that the importance of establishing a process for interim updates was also strongly emphasized in the *DEER 2001 Study*.

either every six months or once a year and should be scheduled to precede any scheduled updates of program designs and forecasts.

Given the current backlog of outstanding issues and additional measures to include, we believe that a DEER technical team and contractor (under the CPUC Energy Division's management) should be put in place as soon as possible after completion of the current DEER. It will be important to carefully manage the interim updates so that DEER users are kept aware of and are not confused by changes in the database. In addition, users will cite specific versions of DEER in program filings. Consequently, DEER databases should be defined and tracked by version numbers. Once a DEER database of a particular version number is posted for use that version should not be modified. Corrections and improvements should be incorporated to subsequent versions so that there is always a direct link between user citations and specific versions of the database.

Because of the number of issues associated with the current DEER, the fact that new CEUS and RASS were not incorporated into the current project, and the timing of the 2006 - 2008 program cycle, the next comprehensive DEER update should probably be completed by the end of 2007 at the latest, with draft data available for review by mid-2006. This would allow program administrators and third parties half a year or so to work with the data before submitting proposals for post-2008 programs. Experience with the current DEER study indicates it can take two to three years to complete a comprehensive update.[17] Thus, comprehensive DEER projects should commence at least two years prior to their targeted completion date.

Update Process Considerations

Regardless of whether DEER changes are made as part of comprehensive update studies or through more limited interim updates, the decision-making process for approving the DEER values will need further clarification after completion of the current study. In the current study, there are a number of technical aspects of DEER that must be approved by the PAC.[18] These include the methods used to develop savings and costs estimates, the underlying parameters that drive final estimates (such as hours of use estimates for commercial lighting or duct leakage and reduction rates), and the final cost and savings values themselves.

As noted previously in this report, there are many examples in the current and previous DEER studies in which difficult decisions had to be made because the available empirical information was limited, conflicting, or otherwise inconclusive. Under these circumstances, it is important to

[17] The length of time for the current DEER is probably due to several factors, including the time it takes for the building simulation aspect of the study (particularly development of building prototypes), changes in CPUC and utility project management, development of the website, and changes in project scope. It should be possible to complete future updates in two years, however, this will depend on project scope and approach.

[18] The current DEER PAC includes representatives from the Energy Division, the ORA, the CEC, and the IOUs.

provide a process for program designers and other outside experts to review and comment on DEER methods and savings estimates so that the process is responsive and benefits from a range of perspectives and available sources. As a result, we believe the CPUC should consider using a project or technical advisory committee for this type of technical review in the future, rather than leave such decisions solely in the hands of a contractor or individual project manager. In addition, the Commission may want to use public workshops to obtain even broader technical input periodically. However, the highly technical nature of DEER, with hundreds of measures and related technical issues, probably does not lend itself well to that type of review. Regardless of how broadly the net for comments is cast, there should be specific requirements for receiving technical input on DEER values and methods. Experience on the current DEER project shows that comments should be provided early in the process and when requested.[19] DEER comments should include specific recommendations rather than simply critiques of existing methods or values and should provide supporting documentation (see Appendix “E” which provides a draft proposed procedure for addressing technical critiques and requests for changes in DEER methods or values).

With respect to the question of what criteria should be used to make decisions about updating DEER savings estimates, we believe that the answer has more to do with clarifying the perspective that should underlie DEER, than on development of a formal statistical-type protocol. Protocols, though suited to the design and implementation of measurement studies, may be less appropriate for a project like DEER, which does not involve field studies directly, includes engineering-based estimation processes that do not always lend themselves to statistical analysis of accuracy, and, ultimately, requires judgments to be made based upon “best available” information. Many factors need to be considered when determining whether a DEER value should be updated. These factors vary somewhat depending on whether the proposed new value is based on a measurement study or on an improved engineering model or method. For example:

- If the proposed value is based on a measurement study, several questions should be considered. Did a qualified evaluator other than the program implementer conduct the study? Was the sample size sufficient and were the results statistically reliable (this could be linked to the CPUC’s evaluation protocols)? Are the results plausible and consistent with accepted engineering and behavioral theories? Are the results representative of the eligible population or only particular segments?
- If the value is based on an improved engineering model or method, there should be general agreement that the new models or methods are superior. This could be due to enhancements in model methods that improve the accuracy of savings estimation or due to changes in input data, for example, to better represent a change in codes and standards or improved market data.

[19] For example, near the end of the current project, the DEER team received numerous comments that had to do with modeling procedures that had been put out for review a year previously.

- In either case, it is also important to consider whether the proposed new results are available in a format that is useful for program planning and program tracking. Are they too aggregated or too detailed to be of practical use?

Other issues important to making decisions about DEER values are the general orientation of the savings development and decision making processes. In the face of uncertain empirical data (which occurs frequently),[20] DEER could adopt a purposefully conservative or optimistic orientation or one that seeks to balance these by trying to reflect average or expected value outcomes. We consider the potential advantages and disadvantages of these different orientations below.

- ***Conservative Orientation.*** The principal advantage of a conservative orientation to estimating and approving DEER values is that it would reduce the risk of overestimating savings and cost-effectiveness. This would reduce the likelihood that resource planners are caught short, that is, that they under-procure supply-side resources because of errors in short-term energy savings forecasts that are tied to DEER. In addition, it would reduce the likelihood that public purpose and procurement dollars are invested in measures that turn out not to be cost effective. Of course, the disadvantage relative to procurement is that supply-side resources may be over-purchased if energy savings estimates are always conservative and actual savings are later found to exceed those in DEER. Another disadvantage relative to cost-effectiveness is that if DEER inputs are overly conservative, some measures and programs might not be implemented at all.[21] This could tend to stifle innovation and risk taking, which would work against reaching the CPUC's long-term energy savings goals.[22]
- ***Optimistic Orientation.*** The principal advantage of an optimistic orientation to estimating and approving DEER values would be that it would minimize cases in which DEER prevents measures and programs from proceeding that would otherwise later be found to be cost effective. This might encourage a more aggressive and risk taking portfolio. It could also be argued that the CPUC's recent decision to conduct ex post measurement of savings reduces the risks associated with an optimistic orientation, given that savings will be trued up after the fact. However, there are practical limitations to ex post measurement that will likely prevent complete true up of DEER at the measure level. Given the obvious disadvantages of an optimistic orientation, such as increased likelihood of under-procurement of supply-side resources and investment in measures and programs that are not cost effective, the

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[20] The number of measures with uncertain savings levels may be higher in the current study than will be the case in the future because the current DEER followed a period of limited ex post impact evaluation - whereas the CPUC ED plans to conduct extensive impact evaluations for the PY2006 – PY2008 portfolio.

[21] This has been a strong concern voiced by some program designers in the current DEER study.

[22] We note that the CPUC mitigates this downside somewhat by requiring only that Program Administrator's total portfolio be cost-effective, not that every program pass the TRC.

advantage of this orientation is small compared to the potential magnitude of the negative consequences.

- ***Expected Value Orientation***. The expected value orientation would guide the DEER committee and technical consultants to develop values that are most likely to reflect average program-wide savings and result in ex post measurement realization rates of unity. This approach would seek to maximize the likelihood that forecasted energy savings are as accurate as possible so that errors are minimized with respect to resource procurement. It would also seek to strike a balance between the conservative and optimistic approaches with respect to estimating impacts for new measures or those with highly variable and uncertain savings.

In general, DEER has historically tried to follow the expected value orientation. However, in practice, it is not always clear where a particular estimate falls on the spectrum of conservative to optimistic, especially when there is no reliable measurement-based data available. This tends to occur in situations where there is a wide range of plausible input assumptions on building or behavioral characteristics but little reliable information on the market-weighted distribution of these characteristics. We recommend that DEER continue to approach savings estimation from an expected value orientation.

DEER-Related Evaluation Needs

The DEER PAC and consultant team grappled with the issues and uncertainties associated with many of the measures in Table 14-3 for months. Appropriately, these extensive periods of analysis and discussion were generally associated with measures that had either contributed large numbers of installations to recent program years or were expected to be strong contributors to the 2006-2008 portfolio.

For some measures, it is believed that the necessary EM&V action could consist of the kinds of traditional ex post impact evaluation carried out under the evaluation protocols in the 1990s. For example, we have identified updated and more statistically reliable estimates of hours of use for commercial lighting measures as one of the recommended EM&V activities in Table 14-3.[23] Developing estimates of hours of use is a fairly straightforward monitoring activity and is easily incorporated into a traditional ex post study.

Conversely, some of the measure issues encountered during the current DEER appeared to be more difficult to solve with traditional ex post methods. These tend to be measures for which savings are highly sensitive to uncertain base case conditions. Duct sealing was a notable example of this type of issue in the current DEER. Although there was generally consensus

[23] Although the 2003 Express Efficiency evaluation included a lighting logger study to develop estimates of full-load hours for CFLs (which are incorporated into the current DEER); the limited available budget led to a relatively small sample and did not include development of hours of use for other commercial lighting technologies.

among PAC members, the consultant team, and outside experts on important aspects of this measure (e.g., extensive duck leakage is not uncommon, methods exist to reduce duct leakage, and energy savings result from reducing duct leakage), there was not consensus on many aspects of the measure important to estimating average savings (e.g., what are the average level of leakage in the population, the distribution of leakage levels in the population, and the relationship between reducing leakage as measured by pressurized tests such as CFM25 and energy savings).

As a result of these types of uncertainties and the limitations of existing sources, a traditional ex post impact evaluation may not be adequate to effectively estimate savings for some measures. For example, for duct repair, and a few other measures with similar issues and import, we recommend consideration of an alternative approach in which a controlled experiment is conducted. This type of study might include random assignment of treated and control group homes, random assignment of service providers, and independent pre- and post-measurement of key savings-related parameters. Although more expensive and lengthy than a purely ex post effort, this type of evaluation is more likely to produce accurate estimates of savings that are well documented and understood and can be used to more effectively forecast future impacts.

Another important and related need is for pre-measurement of baseline consumption and characteristics for certain types of custom measures. Although DEER does not currently address the most complex and site-specific custom measures (such as industrial process improvements), future DEER projects will likely need to consider expanding into a few of these areas. Whether future DEER projects explicitly address a broader array of custom measures or not, pre-measurement for some of these measures should be considered as part of the CPUC’s detailed 2006-2008 evaluation plans.[24] Obviously, evaluations that are to include strategic pre-measurement should be fielded early 2006.

Future impact evaluations should also include a strong focus on measurement and estimation of measure-level load shape impacts.

Finally, DEER’s information needs should be incorporated into the CPUC’s evaluation reporting requirements. All impact evaluations and baseline studies should be required to discuss how their results compare to current DEER estimates and provide recommendations for how this new information could be utilized in the following DEER update.

[24] This is particularly relevant to certain types of projects in the Standard Performance Contract program. Pre-measurements, if carried out, should be limited to samples of projects to minimize their impact on program participants.

Improving DEER Methods and Documentation

As discussed throughout this report, although the current DEER savings project provides considerable improvements over past DEER efforts, there remain many issues and data inadequacies that should be better addressed in future DEER updates. The importance of making these improvements is heightened by the increased importance placed on DEER by the CPUC and its concomitant affect on the utility program administrators' program offerings, energy savings projections, and cost effectiveness estimates.

This section provides general recommendations for activities needed to improve DEER during the next update project. The CPUC should consider having a more formal scoping study task conducted as part of or prior to the next DEER update project. Note that some of the recommendations go beyond what has traditionally been included in DEER (e.g., developing improved baseline calibration data). Although we do not recommend that these activities be included in the same project as DEER, we include them because they are critical to improving the accuracy and credibility of DEER and also fall within Joint Staff's broader planning efforts for EM&V and related overarching studies for 2006-2008.

Baseline Calibration.

Increased emphasis should be placed on comprehensive baseline calibration in future DEER updates. Review and analysis of existing sources of baseline consumption and parameter estimates should be an early and formal task. Of course, a calibration effort will only be useful and valid if accurate sources of baseline data are available. The principal sources of such data are the statewide RASS and CEUS projects, the CEC's end-use forecasting data, and, in some cases, evaluations of California energy efficiency programs.

Although the current DEER was able to take advantage of the recently completed statewide RASS project, the statewide CEUS was not available in time for inclusion in any analyses. Thorough comparative analysis of the new CEUS should be a high priority for the next DEER update as well as further analysis of the RASS. The statewide CEUS and RASS projects are unprecedented efforts in the state to collect and analyze energy characteristics and usage data consistently across utility service territories. These projects represent several years and millions of dollars worth of research. As such, they should be extensively mined to ensure that as much value as possible is leveraged for the next DEER update. For example, some of the data from CEUS that may be of value for DEER calibration include:

- Averages and distributions of end-use energy intensities, installed wattages, full-load equivalent hours, and diversity and coincidence factors.
- The saturation of energy-efficiency measures.
- Absolute and relative shares of baseline equipment types, e.g., chillers versus packaged units; CFLs versus incandescents, etc.

- Results segmented by traditional building type and, possibly, customer size.

Some of these data may be available in the final CEUS project in a format that can be used directly by the DEER team in the next update; however, it is likely that a portion of the data will not be available in useable format. Resources should be allocated and data access enabled to allow the DEER team to further analyze the CEUS and RASS data as part of the next DEER project.

In addition, baseline-related data from future program evaluations should be made available and utilized, as appropriate, for future DEER calibration efforts. For example, as noted under *Near-Term Evaluation Needs and Opportunities*, independent, accurate, and statistically reliable measurement of baseline characteristics for measures like duct repair and refrigerant charging should be conducted as part of the CPUC's evaluation activities. This baseline data should be gathered as soon as possible as it will be of use to DEER even before any evaluation-based savings estimates are developed. Coordination will continue to be needed between DEER and the EM&V studies to ensure that the specific baseline parameters are collected (e.g., duct leakage rates and associated test procedures).

Another area that will likely require serious attention in the next DEER update is load shape calibration. As discussed previously, developing reliable end-use load shapes is even more difficult, time consuming, and expensive, than developing reliable energy end-use estimates. Similarly, developing reliable measure-level load shapes is more challenging than developing end-use shapes. The current DEER did not include a formal calibration task to support development of peak coincident demand impacts nor hourly load shape impacts (although best efforts were made to utilize existing sources for peak-demand impacts). If warranted by the value of the information, several research efforts should be considered to improve estimates of load shapes. First, one or more studies should be considered that would seek to develop updated average end use load shapes. It would be most cost-effective if these studies were designed to leverage the statewide RASS and CEUS as well as earlier end-use metering efforts and load shapes developed as part of impact evaluations.[25] Second, as noted above, impact evaluations should be designed to include measurement and estimation of measure-level load shapes, where practical. Third, as part of the next comprehensive DEER update, DEER models should be calibrated to any new baseline and measure-level load shapes.

[25] Note that end-use load shapes are a part of the CEUS project; however, there were limitations on the availability of whole-building load shapes for significant parts of the sample. More data may now be available given the deployment of interval meters to the over 200 kW population resulting from implementation of AB29x over the past two years.

Methods Used to Develop Savings Estimates.

Section 14.2 discussed the range of methods used to develop savings estimates for energy efficiency measures both generally and within DEER. We organized these methods into three broad categories (Engineering Calculations, Simulation Models, and Field and Laboratory Measurements) and discussed some of their strengths and weaknesses. Historically, all of these methods have been utilized in DEER; however, the weight of the effort in DEER has been on engineering calculations for non-weather sensitive measures and building simulation modeling for measures that are weather sensitive. Our primary recommendation is not to eliminate either of these methods but rather to increase the use of field measurement results in DEER. The current DEER does utilize a number of field-based studies, however, a number of the studies referenced are from the mid-1990s. References to these older studies occur because there were only a small number of rigorous impact evaluations conducted in the period 1999 through 2003. With more impact evaluations planned for the 2004-2005 and 2006-2008 program years, there should be more opportunity to utilize up-to-date evaluation results for the next DEER updates. As emphasized in our discussion of evaluation needs above, it will be critical to include support of DEER explicitly in these new evaluation studies.

Future DEER updates must also carefully weigh the tradeoffs among the advantages and disadvantages of utilizing engineering calculations versus detailed building simulations. Although building simulations are generally considered more accurate, given a set of detailed building-specific characteristics, they are also more costly and time consuming to carry out. In addition, building simulations require extensive quality control to find and correct errors in inputs and modeling assumptions. Another drawback to simulations is that they are not always as transparent as users would like. In some cases, for example, when a measure's efficiency improvement as a percentage of its base case load does not vary widely across applications, it may be more appropriate to use a simple engineering equation with inputs derived from reliable evaluation results than using a more complex building simulation. Where relative savings are highly variable due to weather, building, and operating characteristics, simulations should continue to be used.

Another challenge associated with appropriate use of building simulations is that they require detailed assumptions on many building characteristics, many of which may not be directly relevant to application of the measure. As a result, it is not clear that single building prototypes, even when highly segmented by building type, vintage and climate zone, accurately capture the average characteristics of a diverse population of buildings. Advances in computing and software power over the past ten years now allow for thousands and even millions of simulations to be run in DEER and continued advances probably allow for even larger data sets to become practical. As a result, future DEER projects should investigate the feasibility of more extensively utilizing multiple prototypes to better capture the range of building and behavioral characteristics in the marketplace.[26] The new CEUS and RASS study results, as well as new evaluation results, could be used as the basis for creating such distributions. Using appropriately weighted distributions of building types or characteristics could produce better estimates of average measure impacts. However, as emphasized elsewhere, documentation and guidelines for use of distributions would have to be very clear to avoid their misuse (e.g., inappropriately taking a higher savings value that represents a subset of customers and applying that value to the entire population).

Regardless of the estimation approach, savings estimation models should be based as much as possible on statistically reliable field measurements. At the same time, although future evaluation studies should be designed to more explicitly support DEER, there may continue to be cases where reliable evaluation results are available but are not in formats that fit directly with DEER's engineering calculation or simulation modeling inputs. In some of these cases, consideration should be given to utilizing evaluation results directly in DEER, rather than trying to calibrate DEER savings estimation models to the evaluation results.

Segmentation and Averaging

DEER generally tries to reflect the average characteristics of the entire eligible market for a particular measure. However, there are a number of cases where program managers question that orientation because they plan to target market segments whose characteristics are believed to be significantly different from the average of the entire market. In such cases, DEER must make a judgment call with respect both to the extent of differences between the targeted market segment and the entire market average and the likelihood that targeting can be carried out successfully. Although DEER should not be the place where detailed program design decisions are made, this is another example of a situation where DEER should try to be responsive to the needs of program designers while not usurping their decisions or being unduly influenced by them. DEER has sometimes responded to this dilemma by tying results to the characteristics of a segment of the market, albeit with mixed results.[27] Note that DEER also currently provides results for a wide range of market segments (e.g., for weather-sensitive measures, by building type, vintage, and climate zone).

Future DEER projects should provide flexibility by offering segmented results *if differences in savings by market segment are defensible* (both in terms of savings estimation and marketing and program participation requirements) and *well documented*. In addition, future DEER projects should include a formal documentation field to indicate cases where results are intended to

[26] Note that the current DEER does use more than one prototype within a segment in the residential sector. For example, for single family, instead of a single building, four buildings are used that have different numbers of floors and different directional orientations.

[27] For example, see the discussion of residential programmable thermostats in previous section on *Segmentation and Averaging*.

reflect conditions for a segment of a market instead of the entire population, along with appropriate caveats. Where segmented results are presented, efforts should be made to include statistically reliable population weights to indicate what fraction of the market is represented by each of the segments and provide a default weighted average result (many users are likely to have difficulty aggregating the data themselves and some users may try to cherry pick values from among the segment-based DEER data).

Similarly, if program planners provide plausible design strategies that support the use of savings for selected segments of customers, rather than general market averages, their tracking systems should be implemented to provide documentation of these characteristics among the program's actual participants.

Measure Costs

As discussed in the issues section, development of measure cost estimates has never received the same level of attention and funding as development of measure savings. Recommendations for future measure cost development include the following:[28]

- ***Develop a clear measure specification for each measure***, and make sure the measures specifications are synchronized between the energy analysis and the pricing. Most measures that are promoted by programs are discrete technologies or applications with fairly clear boundary conditions. A clear and complete measure description forms the basis for both the energy and cost analysis. We recommend that the measure descriptions be completed and that the coordination process between the energy and cost teams be started as early as possible, preferably before research has begun.
- ***Make the measure cost process transparent.*** The measure cost process should be transparent to the user, as well as reproducible, transferable to the next analyst, consistent with industry pricing practices, and well documented so that reviewers can retrace the data sources and analytic process. This has the additional advantage that future analysts have a rigorous and well-defined starting point for their work.
- ***Index certain costing elements to industry recognized pricing methods and resources.*** Referring to industry recognized sources for some aspects of the research allows the analyst to minimize the need for original research from hard-to-access resources (e.g., contractors). We believe that it is both useful and necessary to index to and refer to industry benchmark pricing resources and processes such as R.S. Means. This brings the ability to leverage the substantial data mine of these resources and greater analytic consistency with established, recognized, and well developing pricing processes. This is most applicable in the case of defining installation costs.
- ***Conduct more frequent, targeted and less expansive updates.*** While the periodic comprehensive update approach certainly has merit, some costs have a short shelf life

[28] These recommendations were provided by Summit Blue LLC, the lead contractor for the *2005 Measure Cost Study*.

and need to be updated more frequently or in response to market dynamics while others are more stable over time. It may be advisable to conduct limited annual updates to keep in touch with the market and on top of market dynamics for selected measures, to research new measures as they become mature in the market, and to account for changes in focus of programs.

- ***Integrate cost data collection and reporting into program delivery if possible.*** There is potentially a wealth of data available through the program delivery process. For example, in the current cost update the cost team was able to get actual contractor equipment and installed cost data for some HVAC measure through one of the local efficiency program implementation contractors. This is among the best quality data because it reflects what a customer actually paid a contractor for the equipment/installation. Program data collection systems could be put in place specifically to collect cost data as part of an integrated data collection process. We recognize that this is easier said than done particularly for existing programs where data and fulfillment processes are already in place. However, for future programs, this integrated approach could be adopted. It may be most useful for specific types of applications such as HVAC system installations or new construction applications where pricing is relative to and dependent on other aspects of the project.

Measure Coverage and Allocation of DEER Resources

As discussed previously, although DEER projects strive to be comprehensive with respect to the number and range of measures included, resource and project schedule constraints have naturally led to screening measures based on various criteria. Once measures are included in a DEER study, however, prioritization should continue with respect to the relative amount of project resources to be allocated. Factors that should be considered include a measure's contribution to recent or upcoming program portfolios, future potential, initial benefit-cost ratio, and the degree of uncertainty in both savings and costs. Such prioritization is necessary, for example, to help ensure that disproportionate shares of project resources are not allocated to measures that are difficult and expensive to estimate but which have small overall savings, very poor cost-effectiveness, or minimal uncertainty.

Two large classes of measures that have been excluded from DEER in the past are custom and design-related measures, principally for non-residential applications. Although these measures are difficult to assess, we recommend that future DEER projects try to incorporate at least some of them given their large contribution to the overall portfolio. It may be possible to estimate costs and savings for some measures directly through prototypical analyses, e.g., by costing out design strategies for exceeding Title 24 lighting requirements by 10 or 20 percent by building type. In other cases, it may be useful to simply verify and analyze tracking data or evaluation results to develop average savings levels for certain types of measures (e.g., injection molding machines) based on previous program experiences. Treatment of custom measures should be investigated in more detail in the next DEER project through a task that includes a scoping analysis of approaches and tradeoffs for key custom measures. In addition, program tracking should be improved to include better and more complete documentation of custom project costs and characteristics. Similarly, reporting in future evaluations of programs with primarily custom measures should be structured as much as possible to support characterization of these measures in DEER.

Types of Data to Include

We recommend that DEER continue to focus on per unit inputs to measure-level cost-effectiveness analysis. Core per unit inputs include incremental costs and savings, including energy, peak demand, and load shape impacts, as well as effective useful lives. In the current DEER, net to gross values are provided for convenience on the DEER website even though they were not developed as part of the DEER project. Because net to gross values have typically been developed through ex post evaluation studies and are associated with the delivery of measures through particular program strategies, they do not fit as naturally within the DEER project. Nonetheless, as the CPUC approves new net to gross values, the DEER website could continue to be a natural location for housing these estimates. With respect to whether saturation and potential studies should be included within the DEER website, we believe that it would be better to provide links to other websites than to try to include these within DEER (given the volume of data and complexities already associated with DEER). Alternatively, the CPUC may want to consider developing a master website that would include or link to all of the key publicly funded energy efficiency information resources (e.g., including DEER, the Energy Efficiency Best Practices website, RASS, CEUS, IEUS, CALMAC, etc.). Lastly, some interviewees requested inclusion of carbon, total source BTU, and water impacts in DEER. Both carbon and total source BTU impacts would require analysis of program-level impacts through a power plant dispatch model; this level of analysis goes well beyond DEER's per unit measure focus. Water impacts would certainly fit within DEER's per unit focus but consideration should be given as to whether such work should be funded through electricity and natural gas public goods charges or whether alternative funding would be required.

Documentation and Preferred Data Formats

Future DEER projects should continue to expand and improve documentation, particularly, electronic documentation. To begin this process, a formal assessment should be conducted of DEER users' satisfaction with the current DEER documentation and data formats. DEER should continue to make data visualization tools available to help users review savings estimates that vary widely across segments. To the extent feasible, more documentation should be built into the website and downloadable databases so that users can get as much information as possible with the data itself. This is especially important for documentation that takes the form of caveats or warnings (e.g., savings that may be developed for a particular sub-segment of the population that should not be used to represent average customers). DEER should also continue to offer and provide training sessions to DEER users. Outreach for such training should go beyond the

CALMAC listserve to ensure that a broad spectrum of both utility and third-party program developers are aware of these sessions.

Appendix A

Non-Residential CFL Lighting by Building Type

The tables contained within Appendix A outline the Non-Residential CFL Technologies for each of the following building types:

- Education - Primary School
- Education - Secondary School
- Education - Community College
- Education - University
- Grocery
- Health/Medical - Hospital
- Health/Medical - Nursing Home
- Lodging - Hotel
- Lodging - Motel
- Lodging - Guest Rooms
- Manufacturing - Light Industrial
- Office - Large
- Office - Small
- Restaurant - Sit-Down
- Restaurant - Fast-Food
- Retail - 3-Story Large
- Retail - Single-Story Large
- Retail - Small
- Storage - Conditioned
- Storage - Unconditioned
- Warehouse – Refrigerated

A.1 Interior CFL Lighting Tables

Table A-1: Education – Primary School

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	41.1	44.7	12.8	13.9
D03-802	13 Watt >=800 Lumens - screw-in	71.6	77.8	22.3	24.3
D03-803	14 Watt - screw-in	70.1	76.2	21.9	23.8
D03-804	15 Watt - screw-in	68.6	74.5	21.4	23.2
D03-805	16 Watt - screw-in	67.0	72.9	20.9	22.7
D03-806	18 Watt < 1,100 Lumens - screw-in	64.0	69.6	20.0	21.7
D03-807	18 Watt >=1,100 Lumens - screw-in	86.8	94.4	27.1	29.4
D03-808	19 Watt >=1,100 Lumens - screw-in	85.3	92.7	26.6	28.9
D03-809	20 Watt - screw-in	83.8	91.1	26.1	28.4
D03-810	23 Watt - screw-in	117.3	127.5	36.6	39.8
D03-811	25 Watt <1,600 Lumens - screw-in	76.2	82.8	23.8	25.8
D03-812	25 Watt >=1,600 Lumens - screw-in	114.3	124.2	35.6	38.7
D03-813	26 Watt <1,600 Lumens - screw-in	74.7	81.1	23.3	25.3
D03-814	26 Watt >=1,600 Lumens - screw-in	112.7	122.5	35.2	38.2
D03-815	28 Watt - screw-in	109.7	119.2	34.2	37.2
D03-816	30 Watt - screw-in	106.6	115.9	33.3	36.2
D03-817	36 Watt - screw-in	173.7	188.8	54.2	58.9
D03-818	40 Watt - screw-in	167.6	182.2	52.3	56.8
D03-819	13 Watt < 800 Lumens - pin based	41.1	44.7	12.8	13.9
D03-820	13 Watt >=800 Lumens - pin based	71.6	77.8	22.3	24.3
D03-821	14 Watt - pin based	70.1	76.2	21.9	23.8
D03-822	15 Watt - pin based	68.6	74.5	21.4	23.2
D03-823	16 Watt - pin based	67.0	72.9	20.9	22.7
D03-824	18 Watt < 1,100 Lumens - pin based	64.0	69.6	20.0	21.7
D03-825	18 Watt >=1,100 Lumens - pin based	86.8	94.4	27.1	29.4
D03-826	19 Watt >=1,100 Lumens - pin based	85.3	92.7	26.6	28.9
D03-827	20 Watt - pin based	83.8	91.1	26.1	28.4
D03-828	23 Watt - pin based	117.3	127.5	36.6	39.8
D03-829	25 Watt <1,600 Lumens - pin based	76.2	82.8	23.8	25.8
D03-830	25 Watt >=1,600 Lumens - pin based	114.3	124.2	35.6	38.7
D03-831	26 Watt <1,600 Lumens - pin based	74.7	81.1	23.3	25.3
D03-832	26 Watt >=1,600 Lumens - pin based	112.7	122.5	35.2	38.2
D03-833	28 Watt - pin based	109.7	119.2	34.2	37.2
D03-834	30 Watt - pin based	137.1	149.0	42.8	46.5
D03-835	40 Watt - pin based	121.9	132.5	38.0	41.3
D03-836	55 Watt - pin based	220.9	240.1	68.9	74.9
D03-837	65 Watt - pin based	205.7	223.6	64.2	69.7

Table A-2: Education – Secondary School

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	65.8	71.6	12.8	13.9
D03-802	13 Watt >=800 Lumens - screw-in	114.6	124.6	22.3	24.3
D03-803	14 Watt - screw-in	112.2	121.9	21.9	23.8
D03-804	15 Watt - screw-in	109.7	119.3	21.4	23.2
D03-805	16 Watt - screw-in	107.3	116.6	20.9	22.7
D03-806	18 Watt < 1,100 Lumens - screw-in	102.4	111.3	20.0	21.7
D03-807	18 Watt >=1,100 Lumens - screw-in	139.0	151.1	27.1	29.4
D03-808	19 Watt >=1,100 Lumens - screw-in	136.6	148.4	26.6	28.9
D03-809	20 Watt - screw-in	134.1	145.8	26.1	28.4
D03-810	23 Watt - screw-in	187.8	204.1	36.6	39.8
D03-811	25 Watt <1,600 Lumens - screw-in	121.9	132.5	23.8	25.8
D03-812	25 Watt >=1,600 Lumens - screw-in	182.9	198.8	35.6	38.7
D03-813	26 Watt <1,600 Lumens - screw-in	119.5	129.9	23.3	25.3
D03-814	26 Watt >=1,600 Lumens - screw-in	180.4	196.1	35.2	38.2
D03-815	28 Watt - screw-in	175.6	190.8	34.2	37.2
D03-816	30 Watt - screw-in	170.7	185.5	33.3	36.2
D03-817	36 Watt - screw-in	278.0	302.1	54.2	58.9
D03-818	40 Watt - screw-in	268.2	291.5	52.3	56.8
D03-819	13 Watt < 800 Lumens - pin based	65.8	71.6	12.8	13.9
D03-820	13 Watt >=800 Lumens - pin based	114.6	124.6	22.3	24.3
D03-821	14 Watt - pin based	112.2	121.9	21.9	23.8
D03-822	15 Watt - pin based	109.7	119.3	21.4	23.2
D03-823	16 Watt - pin based	107.3	116.6	20.9	22.7
D03-824	18 Watt < 1,100 Lumens - pin based	102.4	111.3	20.0	21.7
D03-825	18 Watt >=1,100 Lumens - pin based	139.0	151.1	27.1	29.4
D03-826	19 Watt >=1,100 Lumens - pin based	136.6	148.4	26.6	28.9
D03-827	20 Watt - pin based	134.1	145.8	26.1	28.4
D03-828	23 Watt - pin based	187.8	204.1	36.6	39.8
D03-829	25 Watt <1,600 Lumens - pin based	121.9	132.5	23.8	25.8
D03-830	25 Watt >=1,600 Lumens - pin based	182.9	198.8	35.6	38.7
D03-831	26 Watt <1,600 Lumens - pin based	119.5	129.9	23.3	25.3
D03-832	26 Watt >=1,600 Lumens - pin based	180.4	196.1	35.2	38.2
D03-833	28 Watt - pin based	175.6	190.8	34.2	37.2
D03-834	30 Watt - pin based	219.5	238.5	42.8	46.5
D03-835	40 Watt - pin based	195.1	212.0	38.0	41.3
D03-836	55 Watt - pin based	353.6	384.3	68.9	74.9
D03-837	65 Watt - pin based	329.2	357.8	64.2	69.7

Table A-3: Education – Community College

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	108.3	117.7	20.6	22.4
D03-802	13 Watt >=800 Lumens - screw-in	188.6	205.0	35.9	39.0
D03-803	14 Watt - screw-in	184.6	200.6	35.1	38.2
D03-804	15 Watt - screw-in	180.5	196.2	34.3	37.3
D03-805	16 Watt - screw-in	176.5	191.9	33.6	36.5
D03-806	18 Watt < 1,100 Lumens - screw-in	168.5	183.2	32.1	34.8
D03-807	18 Watt >=1,100 Lumens - screw-in	228.7	248.6	43.5	47.3
D03-808	19 Watt >=1,100 Lumens - screw-in	224.7	244.2	42.7	46.5
D03-809	20 Watt - screw-in	220.7	239.9	42.0	45.6
D03-810	23 Watt - screw-in	308.9	335.8	58.8	63.9
D03-811	25 Watt <1,600 Lumens - screw-in	200.6	218.0	38.2	41.5
D03-812	25 Watt >=1,600 Lumens - screw-in	300.9	327.1	57.2	62.2
D03-813	26 Watt <1,600 Lumens - screw-in	196.6	213.7	37.4	40.7
D03-814	26 Watt >=1,600 Lumens - screw-in	296.9	322.7	56.5	61.4
D03-815	28 Watt - screw-in	288.9	314.0	55.0	59.7
D03-816	30 Watt - screw-in	280.8	305.3	53.4	58.1
D03-817	36 Watt - screw-in	457.4	497.1	87.0	94.6
D03-818	40 Watt - screw-in	441.3	479.7	84.0	91.3
D03-819	13 Watt < 800 Lumens - pin based	108.3	117.7	20.6	22.4
D03-820	13 Watt >=800 Lumens - pin based	188.6	205.0	35.9	39.0
D03-821	14 Watt - pin based	184.6	200.6	35.1	38.2
D03-822	15 Watt - pin based	180.5	196.2	34.3	37.3
D03-823	16 Watt - pin based	176.5	191.9	33.6	36.5
D03-824	18 Watt < 1,100 Lumens - pin based	168.5	183.2	32.1	34.8
D03-825	18 Watt >=1,100 Lumens - pin based	228.7	248.6	43.5	47.3
D03-826	19 Watt >=1,100 Lumens - pin based	224.7	244.2	42.7	46.5
D03-827	20 Watt - pin based	220.7	239.9	42.0	45.6
D03-828	23 Watt - pin based	308.9	335.8	58.8	63.9
D03-829	25 Watt <1,600 Lumens - pin based	200.6	218.0	38.2	41.5
D03-830	25 Watt >=1,600 Lumens - pin based	300.9	327.1	57.2	62.2
D03-831	26 Watt <1,600 Lumens - pin based	196.6	213.7	37.4	40.7
D03-832	26 Watt >=1,600 Lumens - pin based	296.9	322.7	56.5	61.4
D03-833	28 Watt - pin based	288.9	314.0	55.0	59.7
D03-834	30 Watt - pin based	361.1	392.5	68.7	74.7
D03-835	40 Watt - pin based	321.0	348.9	61.1	66.4
D03-836	55 Watt - pin based	581.7	632.3	110.7	120.3
D03-837	65 Watt - pin based	541.6	588.7	103.0	112.0

Table A-4: Education – University

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	87.8	95.4	20.6	22.4
D03-802	13 Watt >=800 Lumens - screw-in	152.8	166.1	35.9	39.0
D03-803	14 Watt - screw-in	149.6	162.6	35.1	38.2
D03-804	15 Watt - screw-in	146.3	159.0	34.3	37.3
D03-805	16 Watt - screw-in	143.1	155.5	33.6	36.5
D03-806	18 Watt < 1,100 Lumens - screw-in	136.6	148.4	32.1	34.8
D03-807	18 Watt >=1,100 Lumens - screw-in	185.3	201.4	43.5	47.3
D03-808	19 Watt >=1,100 Lumens - screw-in	182.1	197.9	42.7	46.5
D03-809	20 Watt - screw-in	178.8	194.4	42.0	45.6
D03-810	23 Watt - screw-in	250.3	272.1	58.8	63.9
D03-811	25 Watt <1,600 Lumens - screw-in	162.6	176.7	38.2	41.5
D03-812	25 Watt >=1,600 Lumens - screw-in	243.8	265.0	57.2	62.2
D03-813	26 Watt <1,600 Lumens - screw-in	159.3	173.2	37.4	40.7
D03-814	26 Watt >=1,600 Lumens - screw-in	240.6	261.5	56.5	61.4
D03-815	28 Watt - screw-in	234.1	254.4	55.0	59.7
D03-816	30 Watt - screw-in	227.6	247.4	53.4	58.1
D03-817	36 Watt - screw-in	370.6	402.9	87.0	94.6
D03-818	40 Watt - screw-in	357.6	388.7	84.0	91.3
D03-819	13 Watt < 800 Lumens - pin based	87.8	95.4	20.6	22.4
D03-820	13 Watt >=800 Lumens - pin based	152.8	166.1	35.9	39.0
D03-821	14 Watt - pin based	149.6	162.6	35.1	38.2
D03-822	15 Watt - pin based	146.3	159.0	34.3	37.3
D03-823	16 Watt - pin based	143.1	155.5	33.6	36.5
D03-824	18 Watt < 1,100 Lumens - pin based	136.6	148.4	32.1	34.8
D03-825	18 Watt >=1,100 Lumens - pin based	185.3	201.4	43.5	47.3
D03-826	19 Watt >=1,100 Lumens - pin based	182.1	197.9	42.7	46.5
D03-827	20 Watt - pin based	178.8	194.4	42.0	45.6
D03-828	23 Watt - pin based	250.3	272.1	58.8	63.9
D03-829	25 Watt <1,600 Lumens - pin based	162.6	176.7	38.2	41.5
D03-830	25 Watt >=1,600 Lumens - pin based	243.8	265.0	57.2	62.2
D03-831	26 Watt <1,600 Lumens - pin based	159.3	173.2	37.4	40.7
D03-832	26 Watt >=1,600 Lumens - pin based	240.6	261.5	56.5	61.4
D03-833	28 Watt - pin based	234.1	254.4	55.0	59.7
D03-834	30 Watt - pin based	292.6	318.1	68.7	74.7
D03-835	40 Watt - pin based	260.1	282.7	61.1	66.4
D03-836	55 Watt - pin based	471.4	512.4	110.7	120.3
D03-837	65 Watt - pin based	438.9	477.1	103.0	112.0

Table A-5: Grocery

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	163.5	177.7	25.2	27.3
D03-802	13 Watt >=800 Lumens - screw-in	284.6	309.3	43.8	47.6
D03-803	14 Watt - screw-in	278.5	302.7	42.8	46.6
D03-804	15 Watt - screw-in	272.5	296.2	41.9	45.6
D03-805	16 Watt - screw-in	266.4	289.6	41.0	44.6
D03-806	18 Watt < 1,100 Lumens - screw-in	254.3	276.4	39.1	42.5
D03-807	18 Watt >=1,100 Lumens - screw-in	345.1	375.1	53.1	57.7
D03-808	19 Watt >=1,100 Lumens - screw-in	339.1	368.5	52.2	56.7
D03-809	20 Watt - screw-in	333.0	362.0	51.2	55.7
D03-810	23 Watt - screw-in	466.2	506.7	71.7	78.0
D03-811	25 Watt <1,600 Lumens - screw-in	302.7	329.1	46.6	50.6
D03-812	25 Watt >=1,600 Lumens - screw-in	454.1	493.6	69.9	75.9
D03-813	26 Watt <1,600 Lumens - screw-in	296.7	322.5	45.6	49.6
D03-814	26 Watt >=1,600 Lumens - screw-in	448.0	487.0	68.9	74.9
D03-815	28 Watt - screw-in	435.9	473.8	67.1	72.9
D03-816	30 Watt - screw-in	423.8	460.7	65.2	70.9
D03-817	36 Watt - screw-in	690.2	750.2	106.2	115.4
D03-818	40 Watt - screw-in	666.0	723.9	102.5	111.4
D03-819	13 Watt < 800 Lumens - pin based	163.5	177.7	25.2	27.3
D03-820	13 Watt >=800 Lumens - pin based	284.6	309.3	43.8	47.6
D03-821	14 Watt - pin based	278.5	302.7	42.8	46.6
D03-822	15 Watt - pin based	272.5	296.2	41.9	45.6
D03-823	16 Watt - pin based	266.4	289.6	41.0	44.6
D03-824	18 Watt < 1,100 Lumens - pin based	254.3	276.4	39.1	42.5
D03-825	18 Watt >=1,100 Lumens - pin based	345.1	375.1	53.1	57.7
D03-826	19 Watt >=1,100 Lumens - pin based	339.1	368.5	52.2	56.7
D03-827	20 Watt - pin based	333.0	362.0	51.2	55.7
D03-828	23 Watt - pin based	466.2	506.7	71.7	78.0
D03-829	25 Watt <1,600 Lumens - pin based	302.7	329.1	46.6	50.6
D03-830	25 Watt >=1,600 Lumens - pin based	454.1	493.6	69.9	75.9
D03-831	26 Watt <1,600 Lumens - pin based	296.7	322.5	45.6	49.6
D03-832	26 Watt >=1,600 Lumens - pin based	448.0	487.0	68.9	74.9
D03-833	28 Watt - pin based	435.9	473.8	67.1	72.9
D03-834	30 Watt - pin based	544.9	592.3	83.8	91.1
D03-835	40 Watt - pin based	484.4	526.5	74.5	81.0
D03-836	55 Watt - pin based	877.9	954.3	135.1	146.8
D03-837	65 Watt - pin based	817.4	888.5	125.8	136.7

Table A-6: Health/Medical – Hospital

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	256.1	278.3	23.2	25.2
D03-802	13 Watt >=800 Lumens - screw-in	445.7	484.5	40.3	43.8
D03-803	14 Watt - screw-in	436.3	474.2	39.5	42.9
D03-804	15 Watt - screw-in	426.8	463.9	38.6	42.0
D03-805	16 Watt - screw-in	417.3	453.6	37.7	41.0
D03-806	18 Watt < 1,100 Lumens - screw-in	398.3	433.0	36.0	39.2
D03-807	18 Watt >=1,100 Lumens - screw-in	540.6	587.6	48.9	53.1
D03-808	19 Watt >=1,100 Lumens - screw-in	531.1	577.3	48.0	52.2
D03-809	20 Watt - screw-in	521.6	567.0	47.2	51.3
D03-810	23 Watt - screw-in	730.3	793.8	66.1	71.8
D03-811	25 Watt <1,600 Lumens - screw-in	474.2	515.4	42.9	46.6
D03-812	25 Watt >=1,600 Lumens - screw-in	711.3	773.1	64.3	69.9
D03-813	26 Watt <1,600 Lumens - screw-in	464.7	505.1	42.0	45.7
D03-814	26 Watt >=1,600 Lumens - screw-in	701.8	762.8	63.5	69.0
D03-815	28 Watt - screw-in	682.8	742.2	61.8	67.1
D03-816	30 Watt - screw-in	663.9	721.6	60.0	65.3
D03-817	36 Watt - screw-in	1,081.2	1,175.2	97.8	106.3
D03-818	40 Watt - screw-in	1,043.2	1,133.9	94.4	102.6
D03-819	13 Watt < 800 Lumens - pin based	256.1	278.3	23.2	25.2
D03-820	13 Watt >=800 Lumens - pin based	445.7	484.5	40.3	43.8
D03-821	14 Watt - pin based	436.3	474.2	39.5	42.9
D03-822	15 Watt - pin based	426.8	463.9	38.6	42.0
D03-823	16 Watt - pin based	417.3	453.6	37.7	41.0
D03-824	18 Watt < 1,100 Lumens - pin based	398.3	433.0	36.0	39.2
D03-825	18 Watt >=1,100 Lumens - pin based	540.6	587.6	48.9	53.1
D03-826	19 Watt >=1,100 Lumens - pin based	531.1	577.3	48.0	52.2
D03-827	20 Watt - pin based	521.6	567.0	47.2	51.3
D03-828	23 Watt - pin based	730.3	793.8	66.1	71.8
D03-829	25 Watt <1,600 Lumens - pin based	474.2	515.4	42.9	46.6
D03-830	25 Watt >=1,600 Lumens - pin based	711.3	773.1	64.3	69.9
D03-831	26 Watt <1,600 Lumens - pin based	464.7	505.1	42.0	45.7
D03-832	26 Watt >=1,600 Lumens - pin based	701.8	762.8	63.5	69.0
D03-833	28 Watt - pin based	682.8	742.2	61.8	67.1
D03-834	30 Watt - pin based	853.5	927.8	77.2	83.9
D03-835	40 Watt - pin based	758.7	824.7	68.6	74.6
D03-836	55 Watt - pin based	1,375.2	1,494.7	124.4	135.2
D03-837	65 Watt - pin based	1,280.3	1,391.6	115.8	125.9

Table A-7: Health/Medical – Clinic

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	256.1	278.3	23.2	25.2
D03-802	13 Watt >=800 Lumens - screw-in	445.7	484.5	40.3	43.8
D03-803	14 Watt - screw-in	436.3	474.2	39.5	42.9
D03-804	15 Watt - screw-in	426.8	463.9	38.6	42.0
D03-805	16 Watt - screw-in	417.3	453.6	37.7	41.0
D03-806	18 Watt < 1,100 Lumens - screw-in	398.3	433.0	36.0	39.2
D03-807	18 Watt >=1,100 Lumens - screw-in	540.6	587.6	48.9	53.1
D03-808	19 Watt >=1,100 Lumens - screw-in	531.1	577.3	48.0	52.2
D03-809	20 Watt - screw-in	521.6	567.0	47.2	51.3
D03-810	23 Watt - screw-in	730.3	793.8	66.1	71.8
D03-811	25 Watt <1,600 Lumens - screw-in	474.2	515.4	42.9	46.6
D03-812	25 Watt >=1,600 Lumens - screw-in	711.3	773.1	64.3	69.9
D03-813	26 Watt <1,600 Lumens - screw-in	464.7	505.1	42.0	45.7
D03-814	26 Watt >=1,600 Lumens - screw-in	701.8	762.8	63.5	69.0
D03-815	28 Watt - screw-in	682.8	742.2	61.8	67.1
D03-816	30 Watt - screw-in	663.9	721.6	60.0	65.3
D03-817	36 Watt - screw-in	1,081.2	1,175.2	97.8	106.3
D03-818	40 Watt - screw-in	1,043.2	1,133.9	94.4	102.6
D03-819	13 Watt < 800 Lumens - pin based	256.1	278.3	23.2	25.2
D03-820	13 Watt >=800 Lumens - pin based	445.7	484.5	40.3	43.8
D03-821	14 Watt - pin based	436.3	474.2	39.5	42.9
D03-822	15 Watt - pin based	426.8	463.9	38.6	42.0
D03-823	16 Watt - pin based	417.3	453.6	37.7	41.0
D03-824	18 Watt < 1,100 Lumens - pin based	398.3	433.0	36.0	39.2
D03-825	18 Watt >=1,100 Lumens - pin based	540.6	587.6	48.9	53.1
D03-826	19 Watt >=1,100 Lumens - pin based	531.1	577.3	48.0	52.2
D03-827	20 Watt - pin based	521.6	567.0	47.2	51.3
D03-828	23 Watt - pin based	730.3	793.8	66.1	71.8
D03-829	25 Watt <1,600 Lumens - pin based	474.2	515.4	42.9	46.6
D03-830	25 Watt >=1,600 Lumens - pin based	711.3	773.1	64.3	69.9
D03-831	26 Watt <1,600 Lumens - pin based	464.7	505.1	42.0	45.7
D03-832	26 Watt >=1,600 Lumens - pin based	701.8	762.8	63.5	69.0
D03-833	28 Watt - pin based	682.8	742.2	61.8	67.1
D03-834	30 Watt - pin based	853.5	927.8	77.2	83.9
D03-835	40 Watt - pin based	758.7	824.7	68.6	74.6
D03-836	55 Watt - pin based	1,375.2	1,494.7	124.4	135.2
D03-837	65 Watt - pin based	1,280.3	1,391.6	115.8	125.9

Table A-8: Lodging – Hotel

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	247.4	268.9	19.0	20.6
D03-802	13 Watt >=800 Lumens - screw-in	430.6	468.1	33.0	35.9
D03-803	14 Watt - screw-in	421.5	458.1	32.3	35.1
D03-804	15 Watt - screw-in	412.3	448.2	31.6	34.4
D03-805	16 Watt - screw-in	403.1	438.2	30.9	33.6
D03-806	18 Watt < 1,100 Lumens - screw-in	384.8	418.3	29.5	32.1
D03-807	18 Watt >=1,100 Lumens - screw-in	522.3	567.7	40.1	43.5
D03-808	19 Watt >=1,100 Lumens - screw-in	513.1	557.7	39.4	42.8
D03-809	20 Watt - screw-in	503.9	547.7	38.6	42.0
D03-810	23 Watt - screw-in	705.5	766.8	54.1	58.8
D03-811	25 Watt <1,600 Lumens - screw-in	458.1	498.0	35.1	38.2
D03-812	25 Watt >=1,600 Lumens - screw-in	687.2	746.9	52.7	57.3
D03-813	26 Watt <1,600 Lumens - screw-in	449.0	488.0	34.4	37.4
D03-814	26 Watt >=1,600 Lumens - screw-in	678.0	737.0	52.0	56.5
D03-815	28 Watt - screw-in	659.7	717.1	50.6	55.0
D03-816	30 Watt - screw-in	641.4	697.1	49.2	53.5
D03-817	36 Watt - screw-in	1,044.5	1,135.3	80.1	87.1
D03-818	40 Watt - screw-in	1,007.9	1,095.5	77.3	84.0
D03-819	13 Watt < 800 Lumens - pin based	247.4	268.9	19.0	20.6
D03-820	13 Watt >=800 Lumens - pin based	430.6	468.1	33.0	35.9
D03-821	14 Watt - pin based	421.5	458.1	32.3	35.1
D03-822	15 Watt - pin based	412.3	448.2	31.6	34.4
D03-823	16 Watt - pin based	403.1	438.2	30.9	33.6
D03-824	18 Watt < 1,100 Lumens - pin based	384.8	418.3	29.5	32.1
D03-825	18 Watt >=1,100 Lumens - pin based	522.3	567.7	40.1	43.5
D03-826	19 Watt >=1,100 Lumens - pin based	513.1	557.7	39.4	42.8
D03-827	20 Watt - pin based	503.9	547.7	38.6	42.0
D03-828	23 Watt - pin based	705.5	766.8	54.1	58.8
D03-829	25 Watt <1,600 Lumens - pin based	458.1	498.0	35.1	38.2
D03-830	25 Watt >=1,600 Lumens - pin based	687.2	746.9	52.7	57.3
D03-831	26 Watt <1,600 Lumens - pin based	449.0	488.0	34.4	37.4
D03-832	26 Watt >=1,600 Lumens - pin based	678.0	737.0	52.0	56.5
D03-833	28 Watt - pin based	659.7	717.1	50.6	55.0
D03-834	30 Watt - pin based	824.6	896.3	63.2	68.7
D03-835	40 Watt - pin based	733.0	796.7	56.2	61.1
D03-836	55 Watt - pin based	1,328.5	1,444.1	101.9	110.8
D03-837	65 Watt - pin based	1,236.9	1,344.5	94.9	103.1

Table A-9: Lodging – Motel

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	247.4	268.9	19.0	20.6
D03-802	13 Watt >=800 Lumens - screw-in	430.6	468.1	33.0	35.9
D03-803	14 Watt - screw-in	421.5	458.1	32.3	35.1
D03-804	15 Watt - screw-in	412.3	448.2	31.6	34.4
D03-805	16 Watt - screw-in	403.1	438.2	30.9	33.6
D03-806	18 Watt < 1,100 Lumens - screw-in	384.8	418.3	29.5	32.1
D03-807	18 Watt >=1,100 Lumens - screw-in	522.3	567.7	40.1	43.5
D03-808	19 Watt >=1,100 Lumens - screw-in	513.1	557.7	39.4	42.8
D03-809	20 Watt - screw-in	503.9	547.7	38.6	42.0
D03-810	23 Watt - screw-in	705.5	766.8	54.1	58.8
D03-811	25 Watt <1,600 Lumens - screw-in	458.1	498.0	35.1	38.2
D03-812	25 Watt >=1,600 Lumens - screw-in	687.2	746.9	52.7	57.3
D03-813	26 Watt <1,600 Lumens - screw-in	449.0	488.0	34.4	37.4
D03-814	26 Watt >=1,600 Lumens - screw-in	678.0	737.0	52.0	56.5
D03-815	28 Watt - screw-in	659.7	717.1	50.6	55.0
D03-816	30 Watt - screw-in	641.4	697.1	49.2	53.5
D03-817	36 Watt - screw-in	1,044.5	1,135.3	80.1	87.1
D03-818	40 Watt - screw-in	1,007.9	1,095.5	77.3	84.0
D03-819	13 Watt < 800 Lumens - pin based	247.4	268.9	19.0	20.6
D03-820	13 Watt >=800 Lumens - pin based	430.6	468.1	33.0	35.9
D03-821	14 Watt - pin based	421.5	458.1	32.3	35.1
D03-822	15 Watt - pin based	412.3	448.2	31.6	34.4
D03-823	16 Watt - pin based	403.1	438.2	30.9	33.6
D03-824	18 Watt < 1,100 Lumens - pin based	384.8	418.3	29.5	32.1
D03-825	18 Watt >=1,100 Lumens - pin based	522.3	567.7	40.1	43.5
D03-826	19 Watt >=1,100 Lumens - pin based	513.1	557.7	39.4	42.8
D03-827	20 Watt - pin based	503.9	547.7	38.6	42.0
D03-828	23 Watt - pin based	705.5	766.8	54.1	58.8
D03-829	25 Watt <1,600 Lumens - pin based	458.1	498.0	35.1	38.2
D03-830	25 Watt >=1,600 Lumens - pin based	687.2	746.9	52.7	57.3
D03-831	26 Watt <1,600 Lumens - pin based	449.0	488.0	34.4	37.4
D03-832	26 Watt >=1,600 Lumens - pin based	678.0	737.0	52.0	56.5
D03-833	28 Watt - pin based	659.7	717.1	50.6	55.0
D03-834	30 Watt - pin based	824.6	896.3	63.2	68.7
D03-835	40 Watt - pin based	733.0	796.7	56.2	61.1
D03-836	55 Watt - pin based	1,328.5	1,444.1	101.9	110.8
D03-837	65 Watt - pin based	1,236.9	1,344.5	94.9	103.1

Table A-10: Lodging – Guest Rooms

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	32.4	35.2	19.0	20.6
D03-802	13 Watt >=800 Lumens - screw-in	56.4	61.3	33.0	35.9
D03-803	14 Watt - screw-in	55.2	60.0	32.3	35.1
D03-804	15 Watt - screw-in	54.0	58.7	31.6	34.4
D03-805	16 Watt - screw-in	52.8	57.4	30.9	33.6
D03-806	18 Watt < 1,100 Lumens - screw-in	50.4	54.8	29.5	32.1
D03-807	18 Watt >=1,100 Lumens - screw-in	68.4	74.4	40.1	43.5
D03-808	19 Watt >=1,100 Lumens - screw-in	67.2	73.1	39.4	42.8
D03-809	20 Watt - screw-in	66.0	71.8	38.6	42.0
D03-810	23 Watt - screw-in	92.5	100.5	54.1	58.8
D03-811	25 Watt <1,600 Lumens - screw-in	60.0	65.3	35.1	38.2
D03-812	25 Watt >=1,600 Lumens - screw-in	90.1	97.9	52.7	57.3
D03-813	26 Watt <1,600 Lumens - screw-in	58.8	64.0	34.4	37.4
D03-814	26 Watt >=1,600 Lumens - screw-in	88.9	96.6	52.0	56.5
D03-815	28 Watt - screw-in	86.5	94.0	50.6	55.0
D03-816	30 Watt - screw-in	84.1	91.4	49.2	53.5
D03-817	36 Watt - screw-in	136.9	148.8	80.1	87.1
D03-818	40 Watt - screw-in	132.1	143.6	77.3	84.0
D03-819	13 Watt < 800 Lumens - pin based	32.4	35.2	19.0	20.6
D03-820	13 Watt >=800 Lumens - pin based	56.4	61.3	33.0	35.9
D03-821	14 Watt - pin based	55.2	60.0	32.3	35.1
D03-822	15 Watt - pin based	54.0	58.7	31.6	34.4
D03-823	16 Watt - pin based	52.8	57.4	30.9	33.6
D03-824	18 Watt < 1,100 Lumens - pin based	50.4	54.8	29.5	32.1
D03-825	18 Watt >=1,100 Lumens - pin based	68.4	74.4	40.1	43.5
D03-826	19 Watt >=1,100 Lumens - pin based	67.2	73.1	39.4	42.8
D03-827	20 Watt - pin based	66.0	71.8	38.6	42.0
D03-828	23 Watt - pin based	92.5	100.5	54.1	58.8
D03-829	25 Watt <1,600 Lumens - pin based	60.0	65.3	35.1	38.2
D03-830	25 Watt >=1,600 Lumens - pin based	90.1	97.9	52.7	57.3
D03-831	26 Watt <1,600 Lumens - pin based	58.8	64.0	34.4	37.4
D03-832	26 Watt >=1,600 Lumens - pin based	88.9	96.6	52.0	56.5
D03-833	28 Watt - pin based	86.5	94.0	50.6	55.0
D03-834	30 Watt - pin based	108.1	117.5	63.2	68.7
D03-835	40 Watt - pin based	96.1	104.4	56.2	61.1
D03-836	55 Watt - pin based	174.1	189.3	101.9	110.8
D03-837	65 Watt - pin based	162.1	176.2	94.9	103.1

Table A-11: Manufacturing – Light Industrial

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	73.9	80.3	26.6	28.9
D03-802	13 Watt >=800 Lumens - screw-in	128.6	139.8	46.2	50.3
D03-803	14 Watt - screw-in	125.9	136.8	45.2	49.2
D03-804	15 Watt - screw-in	123.1	133.8	44.3	48.1
D03-805	16 Watt - screw-in	120.4	130.9	43.3	47.0
D03-806	18 Watt < 1,100 Lumens - screw-in	114.9	124.9	41.3	44.9
D03-807	18 Watt >=1,100 Lumens - screw-in	156.0	169.5	56.1	60.9
D03-808	19 Watt >=1,100 Lumens - screw-in	153.2	166.6	55.1	59.9
D03-809	20 Watt - screw-in	150.5	163.6	54.1	58.8
D03-810	23 Watt - screw-in	210.7	229.0	75.7	82.3
D03-811	25 Watt <1,600 Lumens - screw-in	136.8	148.7	49.2	53.5
D03-812	25 Watt >=1,600 Lumens - screw-in	205.2	223.1	73.8	80.2
D03-813	26 Watt <1,600 Lumens - screw-in	134.1	145.7	48.2	52.4
D03-814	26 Watt >=1,600 Lumens - screw-in	202.5	220.1	72.8	79.1
D03-815	28 Watt - screw-in	197.0	214.2	70.8	77.0
D03-816	30 Watt - screw-in	191.6	208.2	68.9	74.8
D03-817	36 Watt - screw-in	312.0	339.1	112.1	121.9
D03-818	40 Watt - screw-in	301.0	327.2	108.2	117.6
D03-819	13 Watt < 800 Lumens - pin based	73.9	80.3	26.6	28.9
D03-820	13 Watt >=800 Lumens - pin based	128.6	139.8	46.2	50.3
D03-821	14 Watt - pin based	125.9	136.8	45.2	49.2
D03-822	15 Watt - pin based	123.1	133.8	44.3	48.1
D03-823	16 Watt - pin based	120.4	130.9	43.3	47.0
D03-824	18 Watt < 1,100 Lumens - pin based	114.9	124.9	41.3	44.9
D03-825	18 Watt >=1,100 Lumens - pin based	156.0	169.5	56.1	60.9
D03-826	19 Watt >=1,100 Lumens - pin based	153.2	166.6	55.1	59.9
D03-827	20 Watt - pin based	150.5	163.6	54.1	58.8
D03-828	23 Watt - pin based	210.7	229.0	75.7	82.3
D03-829	25 Watt <1,600 Lumens - pin based	136.8	148.7	49.2	53.5
D03-830	25 Watt >=1,600 Lumens - pin based	205.2	223.1	73.8	80.2
D03-831	26 Watt <1,600 Lumens - pin based	134.1	145.7	48.2	52.4
D03-832	26 Watt >=1,600 Lumens - pin based	202.5	220.1	72.8	79.1
D03-833	28 Watt - pin based	197.0	214.2	70.8	77.0
D03-834	30 Watt - pin based	246.3	267.7	88.5	96.2
D03-835	40 Watt - pin based	218.9	238.0	78.7	85.5
D03-836	55 Watt - pin based	396.8	431.3	142.6	155.0
D03-837	65 Watt - pin based	369.4	401.5	132.8	144.3

Table A-12: Office – Large

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	79.6	86.5	25.2	27.3
D03-802	13 Watt >=800 Lumens - screw-in	138.6	150.6	43.8	47.6
D03-803	14 Watt - screw-in	135.6	147.4	42.8	46.6
D03-804	15 Watt - screw-in	132.7	144.2	41.9	45.6
D03-805	16 Watt - screw-in	129.7	141.0	41.0	44.6
D03-806	18 Watt < 1,100 Lumens - screw-in	123.8	134.6	39.1	42.5
D03-807	18 Watt >=1,100 Lumens - screw-in	168.1	182.7	53.1	57.7
D03-808	19 Watt >=1,100 Lumens - screw-in	165.1	179.5	52.2	56.7
D03-809	20 Watt - screw-in	162.2	176.3	51.2	55.7
D03-810	23 Watt - screw-in	227.0	246.8	71.7	78.0
D03-811	25 Watt <1,600 Lumens - screw-in	147.4	160.2	46.6	50.6
D03-812	25 Watt >=1,600 Lumens - screw-in	221.1	240.3	69.9	75.9
D03-813	26 Watt <1,600 Lumens - screw-in	144.5	157.0	45.6	49.6
D03-814	26 Watt >=1,600 Lumens - screw-in	218.2	237.1	68.9	74.9
D03-815	28 Watt - screw-in	212.3	230.7	67.1	72.9
D03-816	30 Watt - screw-in	206.4	224.3	65.2	70.9
D03-817	36 Watt - screw-in	336.1	365.3	106.2	115.4
D03-818	40 Watt - screw-in	324.3	352.5	102.5	111.4
D03-819	13 Watt < 800 Lumens - pin based	79.6	86.5	25.2	27.3
D03-820	13 Watt >=800 Lumens - pin based	138.6	150.6	43.8	47.6
D03-821	14 Watt - pin based	135.6	147.4	42.8	46.6
D03-822	15 Watt - pin based	132.7	144.2	41.9	45.6
D03-823	16 Watt - pin based	129.7	141.0	41.0	44.6
D03-824	18 Watt < 1,100 Lumens - pin based	123.8	134.6	39.1	42.5
D03-825	18 Watt >=1,100 Lumens - pin based	168.1	182.7	53.1	57.7
D03-826	19 Watt >=1,100 Lumens - pin based	165.1	179.5	52.2	56.7
D03-827	20 Watt - pin based	162.2	176.3	51.2	55.7
D03-828	23 Watt - pin based	227.0	246.8	71.7	78.0
D03-829	25 Watt <1,600 Lumens - pin based	147.4	160.2	46.6	50.6
D03-830	25 Watt >=1,600 Lumens - pin based	221.1	240.3	69.9	75.9
D03-831	26 Watt <1,600 Lumens - pin based	144.5	157.0	45.6	49.6
D03-832	26 Watt >=1,600 Lumens - pin based	218.2	237.1	68.9	74.9
D03-833	28 Watt - pin based	212.3	230.7	67.1	72.9
D03-834	30 Watt - pin based	265.3	288.4	83.8	91.1
D03-835	40 Watt - pin based	235.9	256.4	74.5	81.0
D03-836	55 Watt - pin based	427.5	464.7	135.1	146.8
D03-837	65 Watt - pin based	398.0	432.6	125.8	136.7

Table A-13: Office – Small

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	72.4	78.7	25.2	27.3
D03-802	13 Watt >=800 Lumens - screw-in	126.1	137.0	43.8	47.6
D03-803	14 Watt - screw-in	123.4	134.1	42.8	46.6
D03-804	15 Watt - screw-in	120.7	131.2	41.9	45.6
D03-805	16 Watt - screw-in	118.0	128.3	41.0	44.6
D03-806	18 Watt < 1,100 Lumens - screw-in	112.7	122.5	39.1	42.5
D03-807	18 Watt >=1,100 Lumens - screw-in	152.9	166.2	53.1	57.7
D03-808	19 Watt >=1,100 Lumens - screw-in	150.2	163.3	52.2	56.7
D03-809	20 Watt - screw-in	147.5	160.4	51.2	55.7
D03-810	23 Watt - screw-in	206.5	224.5	71.7	78.0
D03-811	25 Watt <1,600 Lumens - screw-in	134.1	145.8	46.6	50.6
D03-812	25 Watt >=1,600 Lumens - screw-in	201.2	218.7	69.9	75.9
D03-813	26 Watt <1,600 Lumens - screw-in	131.4	142.9	45.6	49.6
D03-814	26 Watt >=1,600 Lumens - screw-in	198.5	215.8	68.9	74.9
D03-815	28 Watt - screw-in	193.1	209.9	67.1	72.9
D03-816	30 Watt - screw-in	187.8	204.1	65.2	70.9
D03-817	36 Watt - screw-in	305.8	332.4	106.2	115.4
D03-818	40 Watt - screw-in	295.1	320.7	102.5	111.4
D03-819	13 Watt < 800 Lumens - pin based	72.4	78.7	25.2	27.3
D03-820	13 Watt >=800 Lumens - pin based	126.1	137.0	43.8	47.6
D03-821	14 Watt - pin based	123.4	134.1	42.8	46.6
D03-822	15 Watt - pin based	120.7	131.2	41.9	45.6
D03-823	16 Watt - pin based	118.0	128.3	41.0	44.6
D03-824	18 Watt < 1,100 Lumens - pin based	112.7	122.5	39.1	42.5
D03-825	18 Watt >=1,100 Lumens - pin based	152.9	166.2	53.1	57.7
D03-826	19 Watt >=1,100 Lumens - pin based	150.2	163.3	52.2	56.7
D03-827	20 Watt - pin based	147.5	160.4	51.2	55.7
D03-828	23 Watt - pin based	206.5	224.5	71.7	78.0
D03-829	25 Watt <1,600 Lumens - pin based	134.1	145.8	46.6	50.6
D03-830	25 Watt >=1,600 Lumens - pin based	201.2	218.7	69.9	75.9
D03-831	26 Watt <1,600 Lumens - pin based	131.4	142.9	45.6	49.6
D03-832	26 Watt >=1,600 Lumens - pin based	198.5	215.8	68.9	74.9
D03-833	28 Watt - pin based	193.1	209.9	67.1	72.9
D03-834	30 Watt - pin based	241.4	262.4	83.8	91.1
D03-835	40 Watt - pin based	214.6	233.3	74.5	81.0
D03-836	55 Watt - pin based	388.9	422.8	135.1	146.8
D03-837	65 Watt - pin based	362.1	393.6	125.8	136.7

Table A-14: Restaurant – Sit-Down

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	98.4	106.9	21.3	23.1
D03-802	13 Watt >=800 Lumens - screw-in	171.3	186.1	37.0	40.3
D03-803	14 Watt - screw-in	167.6	182.2	36.3	39.4
D03-804	15 Watt - screw-in	164.0	178.2	35.5	38.6
D03-805	16 Watt - screw-in	160.3	174.3	34.7	37.7
D03-806	18 Watt < 1,100 Lumens - screw-in	153.0	166.3	33.1	36.0
D03-807	18 Watt >=1,100 Lumens - screw-in	207.7	225.8	44.9	48.8
D03-808	19 Watt >=1,100 Lumens - screw-in	204.1	221.8	44.1	48.0
D03-809	20 Watt - screw-in	200.4	217.8	43.4	47.1
D03-810	23 Watt - screw-in	280.6	305.0	60.7	66.0
D03-811	25 Watt <1,600 Lumens - screw-in	182.2	198.0	39.4	42.8
D03-812	25 Watt >=1,600 Lumens - screw-in	273.3	297.0	59.1	64.3
D03-813	26 Watt <1,600 Lumens - screw-in	178.5	194.1	38.6	42.0
D03-814	26 Watt >=1,600 Lumens - screw-in	269.6	293.1	58.3	63.4
D03-815	28 Watt - screw-in	262.4	285.2	56.8	61.7
D03-816	30 Watt - screw-in	255.1	277.2	55.2	60.0
D03-817	36 Watt - screw-in	415.4	451.5	89.9	97.7
D03-818	40 Watt - screw-in	400.8	435.7	86.7	94.2
D03-819	13 Watt < 800 Lumens - pin based	98.4	106.9	21.3	23.1
D03-820	13 Watt >=800 Lumens - pin based	171.3	186.1	37.0	40.3
D03-821	14 Watt - pin based	167.6	182.2	36.3	39.4
D03-822	15 Watt - pin based	164.0	178.2	35.5	38.6
D03-823	16 Watt - pin based	160.3	174.3	34.7	37.7
D03-824	18 Watt < 1,100 Lumens - pin based	153.0	166.3	33.1	36.0
D03-825	18 Watt >=1,100 Lumens - pin based	207.7	225.8	44.9	48.8
D03-826	19 Watt >=1,100 Lumens - pin based	204.1	221.8	44.1	48.0
D03-827	20 Watt - pin based	200.4	217.8	43.4	47.1
D03-828	23 Watt - pin based	280.6	305.0	60.7	66.0
D03-829	25 Watt <1,600 Lumens - pin based	182.2	198.0	39.4	42.8
D03-830	25 Watt >=1,600 Lumens - pin based	273.3	297.0	59.1	64.3
D03-831	26 Watt <1,600 Lumens - pin based	178.5	194.1	38.6	42.0
D03-832	26 Watt >=1,600 Lumens - pin based	269.6	293.1	58.3	63.4
D03-833	28 Watt - pin based	262.4	285.2	56.8	61.7
D03-834	30 Watt - pin based	327.9	356.5	70.9	77.1
D03-835	40 Watt - pin based	291.5	316.8	63.1	68.5
D03-836	55 Watt - pin based	528.3	574.3	114.3	124.2
D03-837	65 Watt - pin based	491.9	534.7	106.4	115.7

Table A-15: Restaurant – Fast-Food

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	176.8	192.1	21.3	23.1
D03-802	13 Watt >=800 Lumens - screw-in	307.7	334.5	37.0	40.3
D03-803	14 Watt - screw-in	301.2	327.3	36.3	39.4
D03-804	15 Watt - screw-in	294.6	320.2	35.5	38.6
D03-805	16 Watt - screw-in	288.1	313.1	34.7	37.7
D03-806	18 Watt < 1,100 Lumens - screw-in	275.0	298.9	33.1	36.0
D03-807	18 Watt >=1,100 Lumens - screw-in	373.2	405.6	44.9	48.8
D03-808	19 Watt >=1,100 Lumens - screw-in	366.6	398.5	44.1	48.0
D03-809	20 Watt - screw-in	360.1	391.4	43.4	47.1
D03-810	23 Watt - screw-in	504.1	547.9	60.7	66.0
D03-811	25 Watt <1,600 Lumens - screw-in	327.3	355.8	39.4	42.8
D03-812	25 Watt >=1,600 Lumens - screw-in	491.0	533.7	59.1	64.3
D03-813	26 Watt <1,600 Lumens - screw-in	320.8	348.7	38.6	42.0
D03-814	26 Watt >=1,600 Lumens - screw-in	484.5	526.6	58.3	63.4
D03-815	28 Watt - screw-in	471.4	512.4	56.8	61.7
D03-816	30 Watt - screw-in	458.3	498.1	55.2	60.0
D03-817	36 Watt - screw-in	746.3	811.2	89.9	97.7
D03-818	40 Watt - screw-in	720.2	782.8	86.7	94.2
D03-819	13 Watt < 800 Lumens - pin based	176.8	192.1	21.3	23.1
D03-820	13 Watt >=800 Lumens - pin based	307.7	334.5	37.0	40.3
D03-821	14 Watt - pin based	301.2	327.3	36.3	39.4
D03-822	15 Watt - pin based	294.6	320.2	35.5	38.6
D03-823	16 Watt - pin based	288.1	313.1	34.7	37.7
D03-824	18 Watt < 1,100 Lumens - pin based	275.0	298.9	33.1	36.0
D03-825	18 Watt >=1,100 Lumens - pin based	373.2	405.6	44.9	48.8
D03-826	19 Watt >=1,100 Lumens - pin based	366.6	398.5	44.1	48.0
D03-827	20 Watt - pin based	360.1	391.4	43.4	47.1
D03-828	23 Watt - pin based	504.1	547.9	60.7	66.0
D03-829	25 Watt <1,600 Lumens - pin based	327.3	355.8	39.4	42.8
D03-830	25 Watt >=1,600 Lumens - pin based	491.0	533.7	59.1	64.3
D03-831	26 Watt <1,600 Lumens - pin based	320.8	348.7	38.6	42.0
D03-832	26 Watt >=1,600 Lumens - pin based	484.5	526.6	58.3	63.4
D03-833	28 Watt - pin based	471.4	512.4	56.8	61.7
D03-834	30 Watt - pin based	589.2	640.5	70.9	77.1
D03-835	40 Watt - pin based	523.8	569.3	63.1	68.5
D03-836	55 Watt - pin based	949.3	1,031.8	114.3	124.2
D03-837	65 Watt - pin based	883.8	960.7	106.4	115.7

Table A-16: Retail – 3-Story Large

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	117.4	127.6	26.0	28.3
D03-802	13 Watt >=800 Lumens - screw-in	204.4	222.2	45.3	49.2
D03-803	14 Watt - screw-in	200.1	217.5	44.3	48.2
D03-804	15 Watt - screw-in	195.7	212.7	43.4	47.1
D03-805	16 Watt - screw-in	191.4	208.0	42.4	46.1
D03-806	18 Watt < 1,100 Lumens - screw-in	182.7	198.5	40.5	44.0
D03-807	18 Watt >=1,100 Lumens - screw-in	247.9	269.5	54.9	59.7
D03-808	19 Watt >=1,100 Lumens - screw-in	243.5	264.7	54.0	58.6
D03-809	20 Watt - screw-in	239.2	260.0	53.0	57.6
D03-810	23 Watt - screw-in	334.9	364.0	74.2	80.6
D03-811	25 Watt <1,600 Lumens - screw-in	217.5	236.4	48.2	52.4
D03-812	25 Watt >=1,600 Lumens - screw-in	326.2	354.5	72.3	78.5
D03-813	26 Watt <1,600 Lumens - screw-in	213.1	231.6	47.2	51.3
D03-814	26 Watt >=1,600 Lumens - screw-in	321.8	349.8	71.3	77.5
D03-815	28 Watt - screw-in	313.1	340.4	69.4	75.4
D03-816	30 Watt - screw-in	304.4	330.9	67.4	73.3
D03-817	36 Watt - screw-in	495.8	538.9	109.8	119.4
D03-818	40 Watt - screw-in	478.4	520.0	106.0	115.2
D03-819	13 Watt < 800 Lumens - pin based	117.4	127.6	26.0	28.3
D03-820	13 Watt >=800 Lumens - pin based	204.4	222.2	45.3	49.2
D03-821	14 Watt - pin based	200.1	217.5	44.3	48.2
D03-822	15 Watt - pin based	195.7	212.7	43.4	47.1
D03-823	16 Watt - pin based	191.4	208.0	42.4	46.1
D03-824	18 Watt < 1,100 Lumens - pin based	182.7	198.5	40.5	44.0
D03-825	18 Watt >=1,100 Lumens - pin based	247.9	269.5	54.9	59.7
D03-826	19 Watt >=1,100 Lumens - pin based	243.5	264.7	54.0	58.6
D03-827	20 Watt - pin based	239.2	260.0	53.0	57.6
D03-828	23 Watt - pin based	334.9	364.0	74.2	80.6
D03-829	25 Watt <1,600 Lumens - pin based	217.5	236.4	48.2	52.4
D03-830	25 Watt >=1,600 Lumens - pin based	326.2	354.5	72.3	78.5
D03-831	26 Watt <1,600 Lumens - pin based	213.1	231.6	47.2	51.3
D03-832	26 Watt >=1,600 Lumens - pin based	321.8	349.8	71.3	77.5
D03-833	28 Watt - pin based	313.1	340.4	69.4	75.4
D03-834	30 Watt - pin based	391.4	425.5	86.7	94.2
D03-835	40 Watt - pin based	347.9	378.2	77.1	83.8
D03-836	55 Watt - pin based	630.6	685.5	139.7	151.8
D03-837	65 Watt - pin based	587.1	638.2	130.1	141.4

Table A-17: Retail – Single-Story Large

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	120.4	130.9	26.0	28.3
D03-802	13 Watt >=800 Lumens - screw-in	209.6	227.9	45.3	49.2
D03-803	14 Watt - screw-in	205.2	223.0	44.3	48.2
D03-804	15 Watt - screw-in	200.7	218.2	43.4	47.1
D03-805	16 Watt - screw-in	196.3	213.3	42.4	46.1
D03-806	18 Watt < 1,100 Lumens - screw-in	187.3	203.6	40.5	44.0
D03-807	18 Watt >=1,100 Lumens - screw-in	254.3	276.4	54.9	59.7
D03-808	19 Watt >=1,100 Lumens - screw-in	249.8	271.5	54.0	58.6
D03-809	20 Watt - screw-in	245.3	266.7	53.0	57.6
D03-810	23 Watt - screw-in	343.5	373.3	74.2	80.6
D03-811	25 Watt <1,600 Lumens - screw-in	223.0	242.4	48.2	52.4
D03-812	25 Watt >=1,600 Lumens - screw-in	334.5	363.6	72.3	78.5
D03-813	26 Watt <1,600 Lumens - screw-in	218.6	237.6	47.2	51.3
D03-814	26 Watt >=1,600 Lumens - screw-in	330.1	358.8	71.3	77.5
D03-815	28 Watt - screw-in	321.2	349.1	69.4	75.4
D03-816	30 Watt - screw-in	312.2	339.4	67.4	73.3
D03-817	36 Watt - screw-in	508.5	552.7	109.8	119.4
D03-818	40 Watt - screw-in	490.7	533.3	106.0	115.2
D03-819	13 Watt < 800 Lumens - pin based	120.4	130.9	26.0	28.3
D03-820	13 Watt >=800 Lumens - pin based	209.6	227.9	45.3	49.2
D03-821	14 Watt - pin based	205.2	223.0	44.3	48.2
D03-822	15 Watt - pin based	200.7	218.2	43.4	47.1
D03-823	16 Watt - pin based	196.3	213.3	42.4	46.1
D03-824	18 Watt < 1,100 Lumens - pin based	187.3	203.6	40.5	44.0
D03-825	18 Watt >=1,100 Lumens - pin based	254.3	276.4	54.9	59.7
D03-826	19 Watt >=1,100 Lumens - pin based	249.8	271.5	54.0	58.6
D03-827	20 Watt - pin based	245.3	266.7	53.0	57.6
D03-828	23 Watt - pin based	343.5	373.3	74.2	80.6
D03-829	25 Watt <1,600 Lumens - pin based	223.0	242.4	48.2	52.4
D03-830	25 Watt >=1,600 Lumens - pin based	334.5	363.6	72.3	78.5
D03-831	26 Watt <1,600 Lumens - pin based	218.6	237.6	47.2	51.3
D03-832	26 Watt >=1,600 Lumens - pin based	330.1	358.8	71.3	77.5
D03-833	28 Watt - pin based	321.2	349.1	69.4	75.4
D03-834	30 Watt - pin based	401.5	436.4	86.7	94.2
D03-835	40 Watt - pin based	356.8	387.9	77.1	83.8
D03-836	55 Watt - pin based	646.8	703.0	139.7	151.8
D03-837	65 Watt - pin based	602.2	654.5	130.1	141.4

Table A-18: Retail – Small

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	102.7	111.6	26.0	28.3
D03-802	13 Watt >=800 Lumens - screw-in	178.7	194.3	45.3	49.2
D03-803	14 Watt - screw-in	174.9	190.1	44.3	48.2
D03-804	15 Watt - screw-in	171.1	186.0	43.4	47.1
D03-805	16 Watt - screw-in	167.3	181.9	42.4	46.1
D03-806	18 Watt < 1,100 Lumens - screw-in	159.7	173.6	40.5	44.0
D03-807	18 Watt >=1,100 Lumens - screw-in	216.8	235.6	54.9	59.7
D03-808	19 Watt >=1,100 Lumens - screw-in	213.0	231.5	54.0	58.6
D03-809	20 Watt - screw-in	209.2	227.4	53.0	57.6
D03-810	23 Watt - screw-in	292.8	318.3	74.2	80.6
D03-811	25 Watt <1,600 Lumens - screw-in	190.1	206.7	48.2	52.4
D03-812	25 Watt >=1,600 Lumens - screw-in	285.2	310.0	72.3	78.5
D03-813	26 Watt <1,600 Lumens - screw-in	186.3	202.5	47.2	51.3
D03-814	26 Watt >=1,600 Lumens - screw-in	281.4	305.9	71.3	77.5
D03-815	28 Watt - screw-in	273.8	297.6	69.4	75.4
D03-816	30 Watt - screw-in	266.2	289.4	67.4	73.3
D03-817	36 Watt - screw-in	433.5	471.2	109.8	119.4
D03-818	40 Watt - screw-in	418.3	454.7	106.0	115.2
D03-819	13 Watt < 800 Lumens - pin based	102.7	111.6	26.0	28.3
D03-820	13 Watt >=800 Lumens - pin based	178.7	194.3	45.3	49.2
D03-821	14 Watt - pin based	174.9	190.1	44.3	48.2
D03-822	15 Watt - pin based	171.1	186.0	43.4	47.1
D03-823	16 Watt - pin based	167.3	181.9	42.4	46.1
D03-824	18 Watt < 1,100 Lumens - pin based	159.7	173.6	40.5	44.0
D03-825	18 Watt >=1,100 Lumens - pin based	216.8	235.6	54.9	59.7
D03-826	19 Watt >=1,100 Lumens - pin based	213.0	231.5	54.0	58.6
D03-827	20 Watt - pin based	209.2	227.4	53.0	57.6
D03-828	23 Watt - pin based	292.8	318.3	74.2	80.6
D03-829	25 Watt <1,600 Lumens - pin based	190.1	206.7	48.2	52.4
D03-830	25 Watt >=1,600 Lumens - pin based	285.2	310.0	72.3	78.5
D03-831	26 Watt <1,600 Lumens - pin based	186.3	202.5	47.2	51.3
D03-832	26 Watt >=1,600 Lumens - pin based	281.4	305.9	71.3	77.5
D03-833	28 Watt - pin based	273.8	297.6	69.4	75.4
D03-834	30 Watt - pin based	342.3	372.0	86.7	94.2
D03-835	40 Watt - pin based	304.2	330.7	77.1	83.8
D03-836	55 Watt - pin based	551.4	599.4	139.7	151.8
D03-837	65 Watt - pin based	513.4	558.0	130.1	141.4

Table A-19: Storage – Conditioned

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	75.3	81.9	22.7	24.7
D03-802	13 Watt >=800 Lumens - screw-in	131.1	142.5	39.6	43.0
D03-803	14 Watt - screw-in	128.3	139.5	38.7	42.1
D03-804	15 Watt - screw-in	125.5	136.4	37.9	41.2
D03-805	16 Watt - screw-in	122.7	133.4	37.1	40.3
D03-806	18 Watt < 1,100 Lumens - screw-in	117.1	127.3	35.4	38.5
D03-807	18 Watt >=1,100 Lumens - screw-in	159.0	172.8	48.0	52.2
D03-808	19 Watt >=1,100 Lumens - screw-in	156.2	169.8	47.2	51.3
D03-809	20 Watt - screw-in	153.4	166.7	46.3	50.4
D03-810	23 Watt - screw-in	214.8	233.4	64.9	70.5
D03-811	25 Watt <1,600 Lumens - screw-in	139.5	151.6	42.1	45.8
D03-812	25 Watt >=1,600 Lumens - screw-in	209.2	227.4	63.2	68.7
D03-813	26 Watt <1,600 Lumens - screw-in	136.7	148.5	41.3	44.9
D03-814	26 Watt >=1,600 Lumens - screw-in	206.4	224.3	62.3	67.8
D03-815	28 Watt - screw-in	200.8	218.3	60.6	65.9
D03-816	30 Watt - screw-in	195.2	212.2	59.0	64.1
D03-817	36 Watt - screw-in	318.0	345.6	96.0	104.4
D03-818	40 Watt - screw-in	306.8	333.5	92.7	100.7
D03-819	13 Watt < 800 Lumens - pin based	75.3	81.9	22.7	24.7
D03-820	13 Watt >=800 Lumens - pin based	131.1	142.5	39.6	43.0
D03-821	14 Watt - pin based	128.3	139.5	38.7	42.1
D03-822	15 Watt - pin based	125.5	136.4	37.9	41.2
D03-823	16 Watt - pin based	122.7	133.4	37.1	40.3
D03-824	18 Watt < 1,100 Lumens - pin based	117.1	127.3	35.4	38.5
D03-825	18 Watt >=1,100 Lumens - pin based	159.0	172.8	48.0	52.2
D03-826	19 Watt >=1,100 Lumens - pin based	156.2	169.8	47.2	51.3
D03-827	20 Watt - pin based	153.4	166.7	46.3	50.4
D03-828	23 Watt - pin based	214.8	233.4	64.9	70.5
D03-829	25 Watt <1,600 Lumens - pin based	139.5	151.6	42.1	45.8
D03-830	25 Watt >=1,600 Lumens - pin based	209.2	227.4	63.2	68.7
D03-831	26 Watt <1,600 Lumens - pin based	136.7	148.5	41.3	44.9
D03-832	26 Watt >=1,600 Lumens - pin based	206.4	224.3	62.3	67.8
D03-833	28 Watt - pin based	200.8	218.3	60.6	65.9
D03-834	30 Watt - pin based	251.0	272.8	75.8	82.4
D03-835	40 Watt - pin based	223.1	242.5	67.4	73.2
D03-836	55 Watt - pin based	404.4	439.6	122.1	132.8
D03-837	65 Watt - pin based	376.5	409.3	113.7	123.6

Table A-20: Storage – Unconditioned

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	75.3	81.9	22.7	24.7
D03-802	13 Watt >=800 Lumens - screw-in	131.1	142.5	39.6	43.0
D03-803	14 Watt - screw-in	128.3	139.5	38.7	42.1
D03-804	15 Watt - screw-in	125.5	136.4	37.9	41.2
D03-805	16 Watt - screw-in	122.7	133.4	37.1	40.3
D03-806	18 Watt < 1,100 Lumens - screw-in	117.1	127.3	35.4	38.5
D03-807	18 Watt >=1,100 Lumens - screw-in	159.0	172.8	48.0	52.2
D03-808	19 Watt >=1,100 Lumens - screw-in	156.2	169.8	47.2	51.3
D03-809	20 Watt - screw-in	153.4	166.7	46.3	50.4
D03-810	23 Watt - screw-in	214.8	233.4	64.9	70.5
D03-811	25 Watt <1,600 Lumens - screw-in	139.5	151.6	42.1	45.8
D03-812	25 Watt >=1,600 Lumens - screw-in	209.2	227.4	63.2	68.7
D03-813	26 Watt <1,600 Lumens - screw-in	136.7	148.5	41.3	44.9
D03-814	26 Watt >=1,600 Lumens - screw-in	206.4	224.3	62.3	67.8
D03-815	28 Watt - screw-in	200.8	218.3	60.6	65.9
D03-816	30 Watt - screw-in	195.2	212.2	59.0	64.1
D03-817	36 Watt - screw-in	318.0	345.6	96.0	104.4
D03-818	40 Watt - screw-in	306.8	333.5	92.7	100.7
D03-819	13 Watt < 800 Lumens - pin based	75.3	81.9	22.7	24.7
D03-820	13 Watt >=800 Lumens - pin based	131.1	142.5	39.6	43.0
D03-821	14 Watt - pin based	128.3	139.5	38.7	42.1
D03-822	15 Watt - pin based	125.5	136.4	37.9	41.2
D03-823	16 Watt - pin based	122.7	133.4	37.1	40.3
D03-824	18 Watt < 1,100 Lumens - pin based	117.1	127.3	35.4	38.5
D03-825	18 Watt >=1,100 Lumens - pin based	159.0	172.8	48.0	52.2
D03-826	19 Watt >=1,100 Lumens - pin based	156.2	169.8	47.2	51.3
D03-827	20 Watt - pin based	153.4	166.7	46.3	50.4
D03-828	23 Watt - pin based	214.8	233.4	64.9	70.5
D03-829	25 Watt <1,600 Lumens - pin based	139.5	151.6	42.1	45.8
D03-830	25 Watt >=1,600 Lumens - pin based	209.2	227.4	63.2	68.7
D03-831	26 Watt <1,600 Lumens - pin based	136.7	148.5	41.3	44.9
D03-832	26 Watt >=1,600 Lumens - pin based	206.4	224.3	62.3	67.8
D03-833	28 Watt - pin based	200.8	218.3	60.6	65.9
D03-834	30 Watt - pin based	251.0	272.8	75.8	82.4
D03-835	40 Watt - pin based	223.1	242.5	67.4	73.2
D03-836	55 Watt - pin based	404.4	439.6	122.1	132.8
D03-837	65 Watt - pin based	376.5	409.3	113.7	123.6

Table A-21: Warehouse – Refrigerated

Measure ID	Measure Name	Measure Impact (kWh/unit)	SPC Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)	SPC Peak Demand Impact (watts/unit)
D03-801	13 Watt < 800 Lumens - screw-in	68.5	74.4	22.7	24.7
D03-802	13 Watt >=800 Lumens - screw-in	119.2	129.5	39.6	43.0
D03-803	14 Watt - screw-in	116.6	126.8	38.7	42.1
D03-804	15 Watt - screw-in	114.1	124.0	37.9	41.2
D03-805	16 Watt - screw-in	111.6	121.3	37.1	40.3
D03-806	18 Watt < 1,100 Lumens - screw-in	106.5	115.8	35.4	38.5
D03-807	18 Watt >=1,100 Lumens - screw-in	144.5	157.1	48.0	52.2
D03-808	19 Watt >=1,100 Lumens - screw-in	142.0	154.3	47.2	51.3
D03-809	20 Watt - screw-in	139.5	151.6	46.3	50.4
D03-810	23 Watt - screw-in	195.2	212.2	64.9	70.5
D03-811	25 Watt <1,600 Lumens - screw-in	126.8	137.8	42.1	45.8
D03-812	25 Watt >=1,600 Lumens - screw-in	190.2	206.7	63.2	68.7
D03-813	26 Watt <1,600 Lumens - screw-in	124.2	135.0	41.3	44.9
D03-814	26 Watt >=1,600 Lumens - screw-in	187.6	203.9	62.3	67.8
D03-815	28 Watt - screw-in	182.6	198.4	60.6	65.9
D03-816	30 Watt - screw-in	177.5	192.9	59.0	64.1
D03-817	36 Watt - screw-in	289.0	314.2	96.0	104.4
D03-818	40 Watt - screw-in	278.9	303.2	92.7	100.7
D03-819	13 Watt < 800 Lumens - pin based	68.5	74.4	22.7	24.7
D03-820	13 Watt >=800 Lumens - pin based	119.2	129.5	39.6	43.0
D03-821	14 Watt - pin based	116.6	126.8	38.7	42.1
D03-822	15 Watt - pin based	114.1	124.0	37.9	41.2
D03-823	16 Watt - pin based	111.6	121.3	37.1	40.3
D03-824	18 Watt < 1,100 Lumens - pin based	106.5	115.8	35.4	38.5
D03-825	18 Watt >=1,100 Lumens - pin based	144.5	157.1	48.0	52.2
D03-826	19 Watt >=1,100 Lumens - pin based	142.0	154.3	47.2	51.3
D03-827	20 Watt - pin based	139.5	151.6	46.3	50.4
D03-828	23 Watt - pin based	195.2	212.2	64.9	70.5
D03-829	25 Watt <1,600 Lumens - pin based	126.8	137.8	42.1	45.8
D03-830	25 Watt >=1,600 Lumens - pin based	190.2	206.7	63.2	68.7
D03-831	26 Watt <1,600 Lumens - pin based	124.2	135.0	41.3	44.9
D03-832	26 Watt >=1,600 Lumens - pin based	187.6	203.9	62.3	67.8
D03-833	28 Watt - pin based	182.6	198.4	60.6	65.9
D03-834	30 Watt - pin based	228.2	248.0	75.8	82.4
D03-835	40 Watt - pin based	202.8	220.5	67.4	73.2
D03-836	55 Watt - pin based	367.7	399.6	122.1	132.8
D03-837	65 Watt - pin based	342.3	372.1	113.7	123.6

Appendix B

Non-Residential Non-CFL Lighting by Building Type

The tables contained within Appendix B outline the Non-Residential Non-CFL Technologies for each of the following building types:

- Education - Primary School
- Education - Secondary School
- Education - Community College
- Education - University
- Grocery
- Health/Medical - Hospital
- Health/Medical - Nursing Home
- Lodging - Hotel
- Lodging - Motel
- Lodging - Guest Rooms
- Manufacturing - Light Industrial
- Office - Large
- Office - Small
- Restaurant - Sit-Down
- Restaurant - Fast-Food
- Retail - 3-Story Large
- Retail - Single-Story Large
- Retail - Small
- Storage - Conditioned
- Storage - Unconditioned
- Warehouse – Refrigerated

B.1 Interior Non-CFL Lighting Tables

Table B-1: Office – Large

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	328.5	101.3
D03-845	75W Metal Halide - base 100W Mercury Vapor	82.1	25.3
D03-846	100W Metal Halide - base 175W Mercury Vapor	246.4	75.9
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	32.9	10.1
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	84.1	25.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	78.8	24.3
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	170.8	52.7

Table B-2: Office Small

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	328.5	101.3
D03-845	75W Metal Halide - base 100W Mercury Vapor	82.1	25.3
D03-846	100W Metal Halide - base 175W Mercury Vapor	246.4	75.9
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	32.9	10.1
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	84.1	25.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	78.8	24.3
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	170.8	52.7

Table B-3: Education – Primary School

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	165.6	51.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	41.4	12.9
D03-846	100W Metal Halide - base 175W Mercury Vapor	124.2	38.7
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	16.6	5.2
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	42.4	13.2
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	39.7	12.4
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	86.1	26.9

Table B-4: Education – Secondary School

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	265.0	51.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	66.3	12.9
D03-846	100W Metal Halide - base 175W Mercury Vapor	198.8	38.7
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	26.5	5.2
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	67.9	13.2
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	63.6	12.4
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	137.8	26.9

Table B-5: Education – Community College

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	436.1	83.0
D03-845	75W Metal Halide - base 100W Mercury Vapor	109.0	20.7
D03-846	100W Metal Halide - base 175W Mercury Vapor	327.1	62.2
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	43.6	8.3
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	111.6	21.2
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	104.7	19.9
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	226.8	43.1

Table B-6: Education – University

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	353.4	83.0
D03-845	75W Metal Halide - base 100W Mercury Vapor	88.3	20.7
D03-846	100W Metal Halide - base 175W Mercury Vapor	265.0	62.2
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	35.3	8.3
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	90.5	21.2
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	84.8	19.9
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	183.8	43.1

Table B-7: Grocery

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	658.1	101.3
D03-845	75W Metal Halide - base 100W Mercury Vapor	164.5	25.3
D03-846	100W Metal Halide - base 175W Mercury Vapor	493.6	75.9
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	65.8	10.1
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	168.5	25.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	157.9	24.3
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	342.2	52.7

Table B-8: Health/Medical – Hospital

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	1,030.8	93.2
D03-845	75W Metal Halide - base 100W Mercury Vapor	257.7	23.3
D03-846	100W Metal Halide - base 175W Mercury Vapor	773.1	69.9
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	103.1	9.3
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	263.9	23.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	247.4	22.4
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	536.0	48.5

Table B-9: Health/Medical – Nursing Home

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	1,030.8	93.2
D03-845	75W Metal Halide - base 100W Mercury Vapor	257.7	23.3
D03-846	100W Metal Halide - base 175W Mercury Vapor	773.1	69.9
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	103.1	9.3
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	263.9	23.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	247.4	22.4
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	536.0	48.5

Table B-10: Lodging – Hotel (Guest Rooms)

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	995.9	76.4
D03-845	75W Metal Halide - base 100W Mercury Vapor	249.0	19.1
D03-846	100W Metal Halide - base 175W Mercury Vapor	746.9	57.3
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	99.6	7.6
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	255.0	19.6
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	239.0	18.3
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	517.9	39.7

Table B-11: Lodging – Motel

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	995.9	76.4
D03-845	75W Metal Halide - base 100W Mercury Vapor	249.0	19.1
D03-846	100W Metal Halide - base 175W Mercury Vapor	746.9	57.3
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	99.6	7.6
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	255.0	19.6
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	239.0	18.3
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	517.9	39.7

Table B-12: Manufacturing – Light Industrial

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	297.4	106.9
D03-845	75W Metal Halide - base 100W Mercury Vapor	74.4	26.7
D03-846	100W Metal Halide - base 175W Mercury Vapor	223.1	80.2
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	29.7	10.7
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	76.1	27.4
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	71.4	25.7
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	154.7	55.6

Table B-13: Restaurant – Sit-Down

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	502.3	85.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	125.6	21.4
D03-846	100W Metal Halide - base 175W Mercury Vapor	376.7	64.3
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	50.2	8.6
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	128.6	21.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	120.6	20.6
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	261.2	44.6

Table B-14: Restaurant – Fast-Food

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	711.6	85.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	177.9	21.4
D03-846	100W Metal Halide - base 175W Mercury Vapor	533.7	64.3
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	71.2	8.6
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	182.2	21.9
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	170.8	20.6
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	370.0	44.6

Table B-15: Retail – 3-Story Large

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	472.7	104.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	118.2	26.2
D03-846	100W Metal Halide - base 175W Mercury Vapor	354.5	78.5
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	47.3	10.5
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	121.0	26.8
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	113.5	25.1
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	245.8	54.5

Table B-16: Retail – Single-Story Large

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	484.8	104.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	121.2	26.2
D03-846	100W Metal Halide - base 175W Mercury Vapor	363.6	78.5
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	48.5	10.5
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	124.1	26.8
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	116.4	25.1
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	252.1	54.5

Table B-17: Retail – Small

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	444.4	104.7
D03-845	75W Metal Halide - base 100W Mercury Vapor	111.1	26.2
D03-846	100W Metal Halide - base 175W Mercury Vapor	333.3	78.5
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	44.4	10.5
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	113.8	26.8
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	106.7	25.1
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	231.1	54.5

Table B-18: Storage – Conditioned

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	303.2	91.6
D03-845	75W Metal Halide - base 100W Mercury Vapor	75.8	22.9
D03-846	100W Metal Halide - base 175W Mercury Vapor	227.4	68.7
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	30.3	9.2
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	77.6	23.4
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	72.8	22.0
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	157.6	47.6

Table B-19: Storage – Unconditioned

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	303.2	91.6
D03-845	75W Metal Halide - base 100W Mercury Vapor	75.8	22.9
D03-846	100W Metal Halide - base 175W Mercury Vapor	227.4	68.7
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	30.3	9.2
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	77.6	23.4
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	72.8	22.0
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	157.6	47.6

Table B-20: Warehouse – Refrigerated

Measure ID	Measure	Measure Impact (kWh/unit)	Peak Demand Impact (watts/unit)
D03-844	50W Metal Halide - base 150W Inc.	275.6	91.6
D03-845	75W Metal Halide - base 100W Mercury Vapor	68.9	22.9
D03-846	100W Metal Halide - base 175W Mercury Vapor	206.7	68.7
D03-852	Premium T8 El Ballast - base 4', 2 lamp/fixture, T8 32W El Ballast	27.6	9.2
D03-853	Dimming ballast for daylighting: applied to T8 32W w/El Ballast - 2 lamp fixture	70.6	23.4
D03-854	De-lamp from 4', 4 lamp/fixture, T8 32W El Ballast to 3 lamp/fixture	66.1	22.0
D03-855	De-lamp from 8', 4 lamp/fixture, T8 59W El Ballast to 3 lamp/fixture	143.3	47.6

Appendix C

Baseline, Measure and Labor Costs by Measure ID

The tables contained within Appendix C provide information on the cost values included in the 2004-05 DEER update. These are the point estimate costs that are a match for the DEER energy impact estimates.

Table C-1: Nonresidential Refrigeration Measures List

Measure ID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-201	Retrocommissioning	Design cool tons	tons	$0.00	$0.00	$0.00	$49.60	$49.60
D03-202	High Efficiency Walk-in Fan Motors	Num motors	Motor	$0.00	$167.43	$90.50	$41.89	$209.32
D03-203	High Efficiency Display Fan Motors	Fixture linear ft	LinFt	$0.00	$13.58	$6.79	$13.67	$27.25
D03-204	Heat Recovery from Central Refrigeration System	1000 sqft sales area	SqFt	$0.00	$0.50	$0.00	$0.41	$0.91
D03-205	Night Covers for Display Cases (medium temp)	Display fixture len	LinFt	$0.00	$33.75	$0.00	$3.79	$37.54
D03-206	Medium Temp Glass Doors (open display cases)	Fixture linear ft	LinFt	$0.00	$514.13	$0.00	$99.81	$613.95
D03-207	New Medium Temp Refrig Display Case with Doors	Fixture linear ft	LinFt	$0.00	$515.58	$0.00	$329.66	$845.24
D03-208	Auto-Closers on Main Cooler Doors	Per cooler	Door	$0.00	$322.59	$0.00	$110.63	$433.22
D03-209	Auto-Closers on Main Freezer Doors	Per freezer	Door	$0.00	$322.59	$0.00	$110.63	$433.22
D03-210	Evaporator Fan Control on Walk-in Coolers & Freezers	Motor	Motor	$0.00	$62.50	$0.00	$83.25	$145.75
D03-211	Air-Cooled Condenser to Evaporative Condenser	Design cool tons	tons	$0.00	$430.60	$0.00	$264.96	$695.57
D03-212	Energy Efficient Air-Cooled Condenser	Design cool tons	tons	$0.00	$652.75	$140.30	$152.68	$805.43
D03-213	Energy Efficient Evap-Cooled Condenser	Design cool tons	tons	$0.00	$495.00	$86.94	$182.69	$677.69
D03-214	Multiplex System with Mech Subcooling (air-cooled)	Design cool tons	tons	$0.00	$1,972.97	$0.00	$906.54	$2,879.50
D03-215	Multiplex System with Mech Subcooling (evap-cooled)	Design cool tons	tons	$0.00	$1,779.87	$0.00	$896.88	$2,676.76
D03-216	Multiplex System with Mech Subcooling (high eff air-cooled)	Design cool tons	tons	$0.00	$2,138.03	$0.00	$914.79	$3,052.82
D03-217	Multiplex System with Mech Subcooling (high eff evap-cooled)	Design cool tons	tons	$0.00	$1,885.53	$0.00	$902.16	$2,787.70
D03-218	Low Temperature Mechanical Subcooling	Design cool tons, LT	tons	$0.00	$227.04	$0.00	$191.79	$418.82
D03-219	Low and Medium Temp Mechanical Subcooling	Design cool tons	tons	$0.00	$447.94	$0.00	$199.88	$647.82
D03-220	Floating Suction Pressure	Design cool tons	tons	$0.00	$13.18	$0.00	$26.78	$39.96
D03-221	Floating Head Pressure, Fixed Setpoint (air-cooled)	Design cool tons	tons	$0.00	$0.00	$0.00	$27.90	$27.90
D03-222	Floating Head Pressure, Fixed Setpoint (evap-cooled)	Design cool tons	tons	$0.00	$0.00	$0.00	$27.90	$27.90
D03-223	Floating Head Pressure, Variable Setpoint (air-cooled)	Design cool tons	tons	$0.00	$10.04	$0.00	$40.92	$50.95
D03-224	Floating Head Pressure, Variable Setpoint (evap-cooled)	Design cool tons	tons	$0.00	$8.93	$0.00	$40.92	$49.85
D03-225	Floating Head Pressure, Variable Setpt & Speed (air-cooled)	Design cool tons	tons	$0.00	$294.33	$0.00	$91.66	$385.99
D03-226	Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	Design cool tons	tons	$0.00	$151.97	$0.00	$68.92	$220.89
D03-227	Display Case Lighting Control	Fixture linear ft	LinFt	$0.00	$3.08	$0.00	$2.75	$5.84
D03-228	Zero Heat Reach-in Glass Doors	Per door	Door	$0.00	$0.00	$28.00	$0.00	$28.00
D03-**301**	Retrocommissioning	Design cool tons	Tons	$0.00	$0.00	$0.00	$35.27	$35.27
D03-302	Oversized Evaporative Condenser	Design cool tons	Tons	$0.00	$321.17	$0.00	$65.56	$386.73
D03-303	Oversized Evaporative Condenser & Floating Head	Design cool tons	Tons	$0.00	$448.18	$0.00	$102.10	$550.27
D03-304	Variable-Speed Compressors	Des tons of 1 compressor	Tons	$0.00	$159.97	$0.00	$106.93	$266.90
D03-305	Low-Temperature Subcooling	Design cool tons, LT	Tons	$0.00	$330.77	$0.00	$125.40	$456.17
D03-306	Floating Suction Pressure	Design cool tons	Tons	$0.00	$17.46	$0.00	$23.93	$41.39
D03-307	Floating Head Pressure, Fixed Setpoint (evap-cooled)	Design cool tons	Tons	$0.00	$0.00	$0.00	$15.87	$15.87
D03-308	Floating Head Pressure, Variable Setpoint (evap-cooled)	Design cool tons	Tons	$0.00	$6.15	$0.00	$19.60	$25.75
D03-309	Floating Head Pressure, Variable Setpt & Speed (evap-cooled)	Design cool tons	Tons	$0.00	$129.26	$0.00	$33.50	$162.76

Table C-2: Weather Sensitive Nonresidential Measures List

MeasureID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-001	Indoor Lighting Low Load Reduction	kW of Ltg red'n	(not pricing)					
D03-002	Indoor Lighting High Load Reduction	kW of Ltg red'n	(not pricing)					
D03-003	Occupancy Sensor Pack-200 SF	kW of LtgCtrl	kW Ctrl					
D03-004	Occupancy Sensor Pack-1000 SF	kW of LtgCtrl	kW Ctrl					
D03-005	DayLtg Controls, Side Ltg, Cont. Ctrl	kW of LtgCtrl	kW Ctrl	$0.00	$1,139.65	$0.00	$87.26	$1,226.91
D03-006	DayLtg Controls, Side Ltg, 2-step Ctrl	kW of LtgCtrl	kW Ctrl	$0.00	$617.17	$0.00	$87.26	$704.43
D03-007	DayLtg Controls, Top Ltg, Cont. Ctrl	kW of LtgCtrl	kW Ctrl	$0.00	$733.20	$0.00	$23.80	$757.00
D03-008	DayLtg Controls, Top Ltg, 1-step Ctrl	kW of LtgCtrl	kW Ctrl	$0.00	$79.20	$0.00	$23.80	$103.00
D03-009	DayLtg Controls, Top Ltg, 2-step Ctrl	kW of LtgCtrl	kW Ctrl	$0.00	$79.20	$0.00	$23.80	$103.00
D03-010	Timeclock for Lighting	kW of LtgCtrl	Timeclock	$0.00	$76.96	$0.00	$41.73	$118.69
D03-011	Plug Loads Low Load Reduction	kW of Plug red'n	(not pricing)					
D03-012	Plug Loads High Load Reduction	kW of Plug red'n	(not pricing)					
D03-013	Ceiling/Roof Insulation	1000 sqft roof	1000 SqFt	$0.00	$376.23	$0.00	$239.83	$616.06
D03-014	Tank Insulation-Fiber Blanket	1000 sqft building	Tank	$16.10	$28.92	$12.81	$45.29	$74.21
D03-016	Light Colored Roof	1000 sqft roof	1000 SqFt	$0.00	$664.88	$0.00	$7,789.79	$8,454.67
D03-017	Low SHGC Windows -15% - North	100 sqft window	SqFt	$25.38	$24.02	-$1.35	$4.92	$28.94
D03-018	Low SHGC Windows -20% - East	100 sqft window	SqFt	$33.21	$40.20	$6.99	$4.92	$45.12
D03-019	Low SHGC Windows -20% - South	100 sqft window	SqFt	$33.21	$40.20	$6.99	$4.92	$45.12
D03-020	Low SHGC Windows -20% - West	100 sqft window	SqFt	$33.21	$40.20	$6.99	$4.92	$45.12
D03-021	Low SHGC Windows -20% - North	100 sqft window	SqFt	$25.38	$28.10	$2.72	$4.92	$33.01
D03-022	Low SHGC Windows -30% - East	100 sqft window	SqFt	$33.21	$47.17	$13.96	$4.92	$52.08
D03-023	Low SHGC Windows -30% - South	100 sqft window	SqFt	$33.21	$47.17	$13.96	$4.92	$52.08
D03-024	Low SHGC Windows -30% - West	100 sqft window	SqFt	$33.21	$47.17	$13.96	$4.92	$52.08
D03-025	Hi Perf. Glass, PI=1.15, Side Ltg, Cont. Ctrl	100 sqft window	SqFt	$41.07	$45.91	$4.84	$5.15	$51.06
D03-026	Hi Perf. Glass, PI=1.26, Side Ltg, Cont. Ctrl	100 sqft window	SqFt	$41.07	$45.91	$4.84	$5.15	$51.06
D03-027	Hi Perf. Glass, PI=1.38, Side Ltg, Cont. Ctrl	100 sqft window	SqFt	$41.07	$45.91	$4.84	$5.15	$51.06
D03-028	Hi Perf. Glass, PI=1.15, Side Ltg, 2-Step Ctrl	100 sqft window	SqFt	$41.07	$43.69	$2.62	$5.15	$48.84
D03-029	Hi Perf. Glass, PI=1.26, Side Ltg, 2-Step Ctrl	100 sqft window	SqFt	$41.07	$43.69	$2.62	$5.15	$48.84
D03-030	Hi Perf. Glass, PI=1.38, Side Ltg, 2-Step Ctrl	100 sqft window	SqFt	$41.07	$43.69	$2.62	$5.15	$48.84
D03-031	Hi Perf. Glass, PI=0.81, Top Ltg, Cont. Ctrl	100 sqft window	SqFt	$26.77	$27.77	$0.99	$2.53	$30.29
D03-032	Hi Perf. Glass, PI=0.92, Top Ltg, Cont. Ctrl	100 sqft window	SqFt	$26.77	$27.90	$1.13	$2.53	$30.43
D03-033	Hi Perf. Glass, PI=1.03, Top Ltg, Cont. Ctrl	100 sqft window	SqFt	$26.77	$28.04	$1.27	$2.53	$30.57
D03-034	Hi Perf. Glass, PI=0.81, Top Ltg, 1-Step Ctrl	100 sqft window	SqFt	$26.77	$27.01	$0.24	$2.53	$29.54
D03-035	Hi Perf. Glass, PI=0.92, Top Ltg, 1-Step Ctrl	100 sqft window	SqFt	$26.77	$27.15	$0.38	$2.53	$29.68
D03-036	Hi Perf. Glass, PI=1.03, Top Ltg, 1-Step Ctrl	100 sqft window	SqFt	$26.77	$27.29	$0.52	$2.53	$29.82
D03-037	Hi Perf. Glass, PI=0.81, Top Ltg, 2-Step Ctrl	100 sqft window	SqFt	$26.77	$27.01	$0.24	$2.53	$29.54
D03-038	Hi Perf. Glass, PI=0.92, Top Ltg, 2-Step Ctrl	100 sqft window	SqFt	$26.77	$27.15	$0.38	$2.53	$29.68
D03-039	Hi Perf. Glass, PI=1.03, Top Ltg, 2-Step Ctrl	100 sqft window	SqFt	$26.77	$27.29	$0.52	$2.53	$29.82
D03-040	High Efficiency Centrifugal Chillers < 150 Tons	tons	tons	$468.69	$614.21	$145.52	$0.00	$0.00
D03-041	High Efficiency Air-Cooled Recip Packaged Chillers	tons	tons	$448.95	$488.89	$39.94	$0.00	$0.00
D03-042	High Efficiency VSD Centrifugal Chillers < 150 Tons	tons	tons	$646.16	$712.25	$66.09	$0.00	$0.00
D03-043	Gas Absorption Chiller	tons	tons	$260.33	$637.04	$376.71	$0.00	$0.00
D03-044	Chilled Water Reset	1000 sqft CHW-served	Control	$0.00	$350.79	$0.00	$330.55	$681.34
D03-045	Hot Water Reset	1000 sqft HW-served	Control	$0.00	$503.55	$0.00	$330.55	$834.10
D03-046	Variable Flow Chilled Water Loop	nameplate HP	GPM	$0.00	$6.38	$0.00	$2.39	$8.77
D03-047	VSD Chilled Water Loop Pump	nameplate HP	HP	$0.00	$149.14	$0.00	$63.15	$212.29
D03-048	Variable Flow Hot Water Loop	nameplate HP	GPM	$0.00	$10.01	$0.00	$7.79	$17.79
D03-049	VSD Hot Water Loop Pump	nameplate HP	HP	$0.00	$149.14	$0.00	$63.15	$212.29
D03-050	Variable Air Volume Box	1000 sqft served	CFM	$0.00	$0.34	$0.00	$0.24	$0.59
D03-051	VSD Supply Fan Motors	nameplate HP	HP	$0.00	$155.96	$0.00	$65.93	$221.88
D03-052	Fan Powered Mixing Boxes	1000 sqft served	CFM	$0.00	$0.99	$0.00	$0.20	$1.19
D03-053	Evap Cool Indirect - Central System	tons of coils served	Tons	$0.00	$533.59	$0.00	$49.15	$582.74
D03-054	Evap Cool Indirect - Packaged Sys	tons of coils served	Tons	$0.00	$515.74	$0.00	$49.15	$564.88
D03-055	Reducing Overventilation	1000 sqft building	Tons	$0.00	$0.00	$0.00	$39.84	$39.84
D03-056	Air To Air Heat Exchanger	1000 sqft building	CFM	$0.00	$1.70	$0.00	$0.29	$1.99
D03-057	Rotary Heat Recovery	1000 sqft building	CFM	$0.00	$1.78	$0.00	$0.33	$2.11
D03-058	Economizer - Packaged System	tons served	Tons	$0.00	$126.76	$0.00	$43.34	$170.11
D03-059	Economizer - Central system	tons served	N/A					
D03-060	Economizer Maintenance	tons served	Tons	$0.00	$0.00	$0.00	$41.71	$41.71
D03-061	Clean Condenser Coils	tons served	Tons	$0.00	$0.00	$0.00	$35.11	$35.11
D03-062	Cooling Tower for Packaged System	tons served cooling cap	Tons	$0.00	$406.26	$0.00	$60.29	$466.55
D03-063	Two-Speed Cooling Tower Fans	tons served cooling cap	Tons	$55.90	$58.25	$2.35	$0.00	$0.00
D03-064	VSD Cooling Tower Fans	tons served cooling cap	Tons	$59.44	$67.18	$7.74	$0.00	$17.34

Table C-3: Weather Sensitive Residential Measures List

MeasureID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-401	Programmable Thermostat	1000 sqft house	Thermostat	$32.77	$56.37	$23.60	$16.96	$73.33
D03-402	13 SEER(11.09 EER) Split System Air Conditioner	tons cooling	same	$549.55	$549.55	$0.00	$235.95	$785.50
D03-403	14 SEER(12.15 EER) Split-System Air Conditioner	tons cooling	same	$549.55	$642.17	$92.62	$235.95	$878.12
D03-404	15 SEER(12.72 EER) Split-System Air Conditioner	tons cooling	same	$549.55	$734.79	$185.24	$235.95	$970.74
D03-463	16 SEER (11.61 EER) Split System Air Conditioner	tons cooling	same	$549.55	$827.41	$277.86	$235.95	$1,063.36
D03-464	17 SEER (12.28 EER) Split-System Air Conditioner	tons cooling	same	$549.55	$920.03	$370.47	$235.95	$1,155.98
D03-465	18 SEER (13.37 EER) Split-System Air Conditioner	tons cooling	same	$549.55	$1,012.64	$463.09	$235.95	$1,248.59
D03-405	Direct Evaporative Cooler	1000 sqft house	Cooler	$839.17	$813.44	-$25.73	$814.12	$1,627.56
D03-406	Indirect Evaporative Cooler	1000 sqft house	N/A					
D03-407	Direct-Indirect Evaporative Cooler	1000 sqft house	Cooler	$839.17	$1,553.00	$713.83	$814.12	$2,367.12
D03-408	Refrigerant charge - typical charge adjustment	tons cooling	same	$0.00	$10.36	$0.00	$28.00	$38.36
D03-409	Refrigerant charge - high charge adjustment	tons cooling	same	$0.00	$17.87	$0.00	$28.47	$46.33
D03-410	Condensing 90 AFUE(1.11 HIR) Furnace	kBtu furnace capacity	same	$6.99	$13.65	$6.66	$11.99	$25.63
D03-411	Condensing 92 AFUE(1.08 HIR) Furnace	kBtu furnace capacity	same	$6.99	$14.62	$7.63	$11.99	$26.61
D03-412	Condensing 94 AFUE(1.06 HIR) Furnace	kBtu furnace capacity	same	$6.99	$15.59	$8.60	$11.99	$27.58
D03-413	Condensing 96 AFUE(1.03 HIR) Furnace	kBtu furnace capacity	same	$6.99	$16.57	$9.58	$11.99	$28.55
D03-414	13 SEER(11.07 EER)/8.1 HSPF(3.28 COP) A/C Heat pump	tons cooling	same	$630.84	$630.84	$0.00	$235.95	$866.79
D03-415	14 SEER(12.19 EER)/8.6 HSPF(3.52 COP) A/C Heat Pump	tons cooling	same	$630.84	$728.78	$97.94	$235.95	$964.73
D03-416	15 SEER(12.70 EER)/8.8 HSPF(3.74 COP) A/C Heat Pump	tons cooling	same	$630.84	$826.72	$195.87	$235.95	$1,062.67
D03-466	16 SEER (12.06 EER) / 8.4 HSPF (3.48 COP) A/C Heat Pump	tons cooling	same	$630.84	$924.65	$293.81	$235.95	$1,160.60
D03-467	17 SEER (12.52 EER) / 8.6 HSPF (3.26 COP) A/C Heat Pump	tons cooling	same	$630.84	$1,022.59	$391.74	$235.95	$1,258.54
D03-417	18 SEER(12.8 EER)/9.2 HSPF(3.66 COP) A/C Heat Pump	tons cooling	same	$630.84	$1,120.52	$489.68	$235.95	$1,356.47
D03-418	Duct Sealing (Total Leakage Reduction 28% of AHU flow)	1000 sqft house	Tons	$0.00	$16.67	$0.00	$91.24	$107.91
D03-420	Ceiling R-0 to R-30 Insulation-Batts	1000 sqft roof	SqFt	$0.00	$0.56	$0.00	$0.19	$0.76
D03-421	Ceiling R-0 to R-38 Insulation-Batts	1000 sqft roof	SqFt	$0.00	$0.70	$0.00	$0.16	$0.86
D03-422	R-30 Insulation-Batts	1000 sqft roof	SqFt	$0.38	$0.56	$0.19	$0.19	$0.76
D03-423	R-38 Insulation-Batts	1000 sqft roof	SqFt	$0.38	$0.70	$0.33	$0.16	$0.86
D03-424	R-49 Insulation-Batts	1000 sqft roof	SqFt	$0.56	$0.70	$0.14	$0.16	$0.86
D03-426	Floor R-0 to R-19 Insulation Batts	1000 sqft footprint	SqFt	$0.00	$0.38	$0.00	$0.51	$0.89
D03-427	Floor R-0 to R-30 Insulation Batts	1000 sqft footprint	SqFt	$0.00	$0.56	$0.00	$0.78	$1.34
D03-428	Floor R-19 to R-30 Insulation-Batts	1000 sqft footprint	SqFt	$0.38	$0.56	$0.19	$0.78	$1.34
D03-429	Wall 2x4 R-15 Insulation-Batts	1000 sqft wall (excl. windows)	SqFt	$0.27	$0.31	$0.03	$0.30	$0.61
D03-430	Wall 2x6 R-19 Insulation-Batts	1000 sqft wall (excl. windows)	SqFt	$0.27	$0.38	$0.10	$0.28	$0.65
D03-431	Wall 2x6 R-21 Insulation-Batts	1000 sqft wall (excl. windows)	SqFt	$0.27	$0.41	$0.14	$0.27	$0.68
D03-435	Wall 2x4 R-13 Batts + R-5 Rigid	1000 sqft wall (excl. windows)	SqFt	$0.27	$0.72	$0.45	$0.65	$1.37
D03-436	Wall 2x6 R-19 Batts + R-5 Rigid	1000 sqft wall (excl. windows)	SqFt	$0.38	$0.82	$0.45	$0.74	$1.56
D03-437	Wall 2x6 R-21 Batts + R-5 Rigid	1000 sqft wall (excl. windows)	SqFt	$0.41	$0.86	$0.45	$0.98	$1.84
D03-438	Wall Blow-In R-0 to R-13 Insulation	1000 sqft wall (excl. windows)	SqFt	$0.00	$0.15	$0.00	$1.17	$1.32
D03-439	Low-Income Weatherization w/out Evaporative Cooler	1000 sqft house	N/A					
D03-440	Low-Income Weatherization w/Evaporative Cooler	1000 sqft house	N/A					
D03-441	Whole House Fans	1000 sqft house	Fan	$0.00	$400.56	$0.00	$295.32	$695.88
D03-442	Default Window With Sunscreen	100 sqft window	SqFt	$0.00	$0.63	$0.00	$0.64	$1.27
D03-443	Single Pane Clear Glass With Reflective Film	100 sqft window	SqFt	$0.00	$1.49	$0.00	$0.64	$2.13
D03-444	Single Pane Clear Glass With Spectrally Selective Film	100 sqft window	SqFt	$0.00	$2.06	$0.00	$0.64	$2.70

Table C-4: DEER Non-Weather Sensitive Measures List

MeasureID	Measure Name	Energy Common Units	Cost Common Units	Base Equipment Cost ($)	Measure Equipment Cost ($)	Incremental Equipment Cost ($)	Labor Cost ($)	Installed Cost ($)
D03-801	13 Watt CFL < 800 Lumens - screw-in	LAMP	Lamp	$0.57	$4.98	$4.40	$3.77	$8.18
D03-802	13 Watt CFL =800 Lumens - screw-in	LAMP	Lamp	$0.61	$4.87	$4.26	$3.77	$8.04
D03-803	14 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.25	$4.64	$3.77	$8.41
D03-804	15 Watt CFL - screw-in	LAMP	Lamp	$0.61	$5.62	$5.01	$3.77	$8.79
D03-805	16 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.00	$5.39	$3.77	$9.16
D03-806	18 Watt CFL < 1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.74	$6.14	$3.77	$9.91
D03-807	18 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.37	$5.77	$3.77	$9.54
D03-808	19 Watt CFL =1,100 Lumens - screw-in	LAMP	Lamp	$0.61	$6.73	$6.12	$3.77	$9.89
D03-809	20 Watt CFL - screw-in	LAMP	Lamp	$0.61	$7.08	$6.47	$3.77	$10.25
D03-810	23 Watt CFL - screw-in	LAMP	Lamp	$0.61	$6.66	$6.05	$3.77	$9.82
D03-811	25 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$8.85	$8.24	$3.77	$12.02
D03-812	25 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.24	$6.63	$3.77	$10.40
D03-813	26 Watt CFL <1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$9.21	$8.60	$3.77	$12.37
D03-814	26 Watt CFL =1,600 Lumens - screw-in	LAMP	Lamp	$0.61	$7.52	$6.92	$3.77	$10.69
D03-815	28 Watt CFL - screw-in	LAMP	Lamp	$0.61	$8.10	$7.50	$3.77	$11.27
D03-816	30 Watt CFL - screw-in	LAMP	Lamp	$0.61	$9.26	$8.65	$3.77	$12.43
D03-817	36 Watt CFL - screw-in	LAMP	Lamp	$2.22	$9.19	$6.97	$3.77	$10.75
D03-818	40 Watt CFL - screw-in	LAMP	Lamp	$2.22	$12.77	$10.55	$3.77	$14.32
D03-819	13 Watt CFL < 800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-820	13 Watt CFL =800 Lumens - pin based	LAMP	Lamp	$0.00	$17.88	$0.00	$27.14	$45.02
D03-821	14 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.38	$0.00	$27.14	$45.51
D03-822	15 Watt CFL - pin based	LAMP	Lamp	$0.00	$18.87	$0.00	$27.14	$46.01
D03-823	16 Watt CFL - pin based	LAMP	Lamp	$0.00	$19.36	$0.00	$27.14	$46.50
D03-824	18 Watt CFL < 1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-825	18 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.35	$0.00	$27.14	$47.49
D03-826	19 Watt CFL =1,100 Lumens - pin based	LAMP	Lamp	$0.00	$20.84	$0.00	$27.14	$47.98
D03-827	20 Watt CFL - pin based	LAMP	Lamp	$0.00	$21.34	$0.00	$27.14	$48.48
D03-828	23 Watt CFL - pin based	LAMP	Lamp	$0.00	$22.82	$0.00	$27.14	$49.96
D03-829	25 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-830	25 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$23.80	$0.00	$27.14	$50.94
D03-831	26 Watt CFL <1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-832	26 Watt CFL =1,600 Lumens - pin based	LAMP	Lamp	$0.00	$24.30	$0.00	$27.14	$51.44
D03-833	28 Watt CFL - pin based	LAMP	Lamp	$0.00	$25.28	$0.00	$27.14	$52.42
D03-834	30 Watt CFL - pin based	LAMP	Lamp	$0.00	$26.27	$0.00	$27.14	$53.41
D03-835	40 Watt CFL - pin based	LAMP	Lamp	$0.00	$31.20	$0.00	$27.14	$58.34
D03-836	55 Watt CFL - pin based	LAMP	Lamp	$0.00	$38.60	$0.00	$27.14	$65.74
D03-837	65 Watt CFL - pin based	LAMP	Lamp	$0.00	$43.54	$0.00	$27.14	$70.68
D03-838	20W CFL Table Lamp	Fixture	Fixture	$50.43	$50.43	$0.00	$0.00	$0.00
D03-839	25W CFL Table Lamp	Fixture	Fixture	$61.13	$61.13	$0.00	$0.00	$0.00
D03-840	32W CFL Table Lamp	Fixture	Fixture	$63.20	$63.20	$0.00	$0.00	$0.00
D03-841	50W CFL Table Lamp	Fixture	Fixture	$122.96	$122.96	$0.00	$0.00	$0.00
D03-842	55W CFL Torchiere	Fixture	Torchiere	$59.39	$59.39	$0.00	$0.00	$0.00
D03-843	70W CFL Torchiere (two LAMPs)	Fixture	Torchiere	$55.76	$55.76	$0.00	$0.00	$0.00
D03-844	50W Metal Halide	Fixture	Fixture	$0.00	$113.85	$0.00	$100.51	$214.36
D03-845	75W Metal Halide	Fixture	Fixture	$0.00	$120.09	$0.00	$100.51	$220.60
D03-846	100W Metal Halide	Fixture	Fixture	$0.00	$126.66	$0.00	$100.51	$227.17
D03-847	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-848	175W PS Metal Halide	Fixture	Fixture	$0.00	$129.01	$0.00	$67.84	$196.86
D03-849	250W PS Metal Halide	Fixture	Fixture	$0.00	$152.08	$0.00	$67.84	$219.92
D03-850	200W HPS	Fixture	Fixture	$0.00	$91.05	$0.00	$67.84	$158.89
D03-851	180W LPS	Fixture	Fixture	$0.00	$74.62	$0.00	$67.84	$142.46
D03-852	Premium T8 El Ballast	Fixture	Fixture	$19.23	$23.42	$4.19	$0.00	$0.00
D03-853	T8 32W Dimming El Ballast	Fixture	Fixture	$16.54	$72.89	$56.34	$16.96	$89.85
D03-854	De-lamp from 4', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.08	$0.00	$22.63	$25.71
D03-855	De-lamp from 8', 4 lamp/fixture	Fixture	Fixture	$0.00	$3.28	$0.00	$22.63	$25.91
D03-856	Occ-Sensor - Wall box	Sensor	Sensor	$0.00	$42.28	$0.00	$35.00	$77.28
D03-857	Occ-Sensor - Plug loads	Sensor	Sensor	$0.00	$82.25	$0.00	$35.00	$117.25
D03-858	Timeclock:	Timeclock	Timeclock	$0.00	$123.01	$0.00	$116.88	$239.89
D03-859	Photocell:	Photocell	Photocell	$0.00	$12.06	$0.00	$47.75	$59.81
D03-860	LED Exit Sign (New)	Exit Sign	Sign	$0.00	$31.52	$0.00	$33.92	$65.44
D03-861	LED Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$16.66	$0.00	$33.92	$50.58
D03-862	Electroluminescent Exit Sign (New)	Exit Sign	Sign	$0.00	$73.42	$0.00	$33.92	$107.34
D03-863	Electroluminescent Exit Sign Retrofit Kit	Exit Sign	Sign	$0.00	$70.14	$0.00	$33.92	$104.06
D03-901	High Efficiency Copier	Copy Machine	copier	$1,616.38	$1,773.14	$156.76	$0.00	$0.00
D03-902	High Efficiency Copier	Copy Machine	copier	$4,686.00	$7,654.69	$2,968.69	$0.00	$0.00
D03-903	High Efficiency Copier	Copy Machine	copier	$0.00	$10,924.63	$0.00	$0.00	$0.00
D03-904	High Efficiency Gas Fryer	Fryer	Fryer	$1,520.61	$4,103.15	$2,582.54	$0.00	$0.00
D03-905	High Efficiency Gas Griddle	Griddle	Griddle	$1,758.36	$3,860.67	$2,102.31	$0.00	$0.00
D03-906	High Efficiency Electric Fryer	Fryer	Fryer	$3,326.73	$12,088.62	$8,761.89	$0.00	$0.00
D03-907	Hot Food Holding Cabinet	Cabinet	Cabinet	$1,545.67	$2,589.81	$1,044.13	$0.00	$0.00
D03-908	Connectionless Steamer	Steamer	Steamer	$5,128.24	$3,206.64	-$1,921.61	$0.00	$0.00
D03-909	Point of Use Water Heat	1000 sqft building	WtrHtr	$492.96	$863.60	$370.64	$250.90	$1,114.50

Appendix D

Glossary of DEER Variables

1. **Run ID** – String variable of fixed length of 13 with the format:

   ABBB1122CCCCC where:
   - A = Sector Code. 'R' = Residential and 'C' = Commercial
   - BBB = Building type abbreviation (see codes under BuildingType)
   - 11 = Climate zone (see codes under climate zone)
   - 22 = Vintage (see codes under Vintage)
   - CCCCC = Measure abbreviation

2. **Measure ID**: String variable of fixed length of 7. (example: D03-001)

   - First three characters indicate the measure is from the 2003 DEER update "D03"
   - Fourth character is a "-"
   - Last three characters are a numerical sequence starting with "001" and conceivably ending with "999".

     – Weather Sensitive Non-Res: 001-199
     – Weather Sensitive Refrig: 201-399
     – Weather Sensitive Res: 401-499
     – Non Weather Sens Lights: 801-899
     – Non Weather Sens Other: 901-999

3. **Measure Name**: String variable describing the measure.

4. **Measure Characteristics**: String variable describing more detail about the measure.

5. **MeaAbbr: Measure Abbreviation**. String variable of length 5 that incorporates part of the measure name. Used to help develop the run ID.

6. **Sector**: String variable of fixed length 1. "R" for residential, "C" for non-residential.

7. **Building Type**: three digit abbreviation letter code for building type:
   - ALC = All Commercial
   - BCR = Both Residential and Commercial
   - ASM = Assembly
   - EPR = Education – Primary School
   - ERC = Education – Removable Classroom
   - ESE = Education – Secondary School
   - ECC = Education – Community College
   - EUN = Education – University
   - FRM = Farmhouse
   - GRO = Grocery
   - HSP = Health/Medical – Hospital
   - NRS = Health/Medical – Clinic
   - HTL = Lodging – Hotel (Guest Rooms)
   - MTL = Lodging – Motel
   - GST = Lodging – Guest Rooms
   - SMO = Residential Mobile Home – Single Wide
   - DMO = Residential Mobile Home – Double Wide
   - MFM = Residential Multi-family
   - MBT = Manufacturing – Bio-Tech
   - MLI = Manufacturing – Light Industry
   - OFL = Office – Large
   - OFS = Office – Small
   - RES = All Residential
   - RSD = Restaurant – Sit Down
   - RFF = Restaurant – Fast Food
   - RT3 = Retail – 3 Story Large
   - RTL = Retail – Single Story large
   - RTS = Retail – Small
   - SFM = Residential Single Family
   - SCN = Storage – Conditioned
   - SUN = Storage – Unconditioned
   - WRF = Storage – Refrigerated
   - S20 = SIC 20 Food & Kindred Products
   - S26 = SIC 26 Paper & Allied Products
   - S28 = SIC 28 Chemicals & Allied Products
   - S29 = SIC 29 Petroleum & Coal Products
   - S33 = SIC 33 Metals
   - OTI = Other Industrial

8. **Vintage**: two character code for building vintage:
   - AV = no vintage distinction
   - 75 = built before 1978
   - 85 = built between 1978 and 1992
   - 96 = built between 1993 and 2000
   - 03 = built between 2001 and 2004
   - 05 = built 2006 and later (measures as retrofit)
   - NW = built 2006 and later (measures as new construction)
   - M1 = mobile homes built up to1975
   - M2 = mobile homes built between 1976 to1993
   - M3 = mobile homes built after 1994

9. **Climate Zone**: two digit code identifying the climate zones:
   - 00 = no climate zone distinction
   - 01 through 16 = climate zones 1 through 16

10. **Common Unit**: Four character code for describing the normalizing unit.
    - AERA = Aerator
    - ACRE = Acre of land
    - BARN = Barn
    - BOIL = Boiler
    - BOX_ = Box
    - LAMP = Lamp
    - CAB_ = Cabinet
    - CDR_ = Clothes Dryer
    - CELL = Photocell
    - CFM_ = CFM
    - CFRZ = Per freezer
    - CTRL = Control
    - COOL = Per cooler
    - COPR = Copy Machine
    - CTRP = CTRLPoint
    - CWCT = Chilled Water Reset
    - D_CT = design cool tons
    - DCTL = design cool tons, LT
    - DFXL = display fixture len
    - DOOR = Per Door
    - DT1C = des tons of 1 compressor
    - EACH = each

- EMS_ = EMS
- EVAP = Evap Cooler
- FAN_ = Fan
- FIXT = Table lamp or torchiere
- FRY_ = Fryer
- FURN = Furnace
- FXLT = fixture linear ft
- FXXT = Fixture
- GPM_ = GPM
- GRID = Griddle
- H_C = House Cooling
- HH__ = Household
- HOUS = House
- HPMP = Heat Pump
- HP = Horsepower
- HRV_ = Air To Air Heat Exchanger
- HWCT = Hot Water Reset
- HXU_ = Rotary Heat Recovery
- KBTH = kBtuh
- KBTU = kBtu furnace capacity
- KW_L = kW of Ltg red'n
- KW_P = kW of Plug red'n
- KWLC = kW of LtgCtrl
- LNFT = Linear Feet
- MTR_ = Motor
- N_HP = nameplate HP
- NMOT = num motors
- NOZL = Nozzle
- POUW = POU Water Heater
- PTAC = PTAC
- PTHP = PTHP
- PUMP = Pump
- RCW_ = Clothes Washer
- RDW_ = Dishwasher
- RFRZ = Freezer
- RREF = Refrigerator
- S_HW = 1000 sqft HW-served
- S_RF = 1000 sqft roof
- S_SA = 1000 sqft sales area
- S_SR = 1000 sqft served

- S_WL = 1000 sqft wall (excl. windows)
- SCHW = 1000 sqft CHW-served
- SENS = Sensor
- SHOW = Showerhead
- SIGN = Exit Sign
- SQ_B = 1000 sqft building
- SQ_H = 1000 sqft House
- SQFP = 1000 sqft footprint
- SQFT = Sqft
- STEM = Steamer
- SW_W = 100 sqft window
- T_CS = tons of coils served
- T_SR = tons served
- TANK = Tank
- THER = Thermostat
- TIME = TimeClock
- TONC = tons cooling
- TONS = tons
- TSCC = tons served cooling cap
- TSER = tons served
- VALV = Valve
- VEND = Machine
- WTRH = WtrHtr

11. **Number of Common Units**: Real number that identifies how many common units are included in the assessment.

12. **Measure Category**: String variable describing the end-use.

- AG - Agriculture
- CDR - Residential Clothes Drying
- COOK - Commercial Cooking
- DHWR - Domestic Hot Water
- HVAC - Heating, Ventilation, and Air Conditioning
- LTG - Lighting
- OTHR - Miscellaneous
- PLUG - Interior Plug Loads
- POOL - Swimming Pools
- RFRIG - Commercial Refrigeration Equipment
- RREF - Residential Refrigeration
- SHELL - Wall, Roof, and Fenestration

- SHW – Hot Water Supply

13. **Measure Sub-Category**: String variable that describes a subset of a category.

- Ballast
- CFL LAMPs
- Circulation Pump
- Controls
- Copy Machine
- Daylighting
- De-lamp
- Demand
- Efficient Clothes Dryer
- Energy Star Clothes Washer
- Energy Star Dishwasher
- Energy Star Refrigerators
- Equip
- Exit Sign
- Exterior Lighting
- Faucet Aerators
- Fenestration
- Four ft. Fluorescent
- Freezer Recycling
- Fryer
- Greenhouse
- Griddle
- Heat Pump Water Heater
- HeatRej
- High Efficiency Water Heater
- Holding Cabinet
- HVAC
- Insulation
- Irrigation
- Low Flow Showerhead
- Maintenance
- Metal Halide
- MOTOR
- Occupancy Sensor
- Photocell
- Pipe wrap
- Point of Use

- Pool Pump
- Refrigerator Recycling
- Shell
- Steamer
- Timeclock
- Vending Machine
- Ventiliation
- VFD
- Water Heater Tank

14. **Measure End-use Fuel Type**: One character code for the end-use fuel type of the measure:

    - E = electricity
    - G = natural gas
    - B = both electricity & natural gas

15. **Base Description (Customer Based)**: String variable that identifies the base case condition for the customer based average building or application.

16. **Code Base Description**: String variable that identifies the base case condition for the building or application that meets building or appliance codes and standards

17. **FloorArea**: Real number for total floorspace of the building

18. **TbaseE**: Real number for the customer based total building baseline annual electric energy use per common unit in units of kWh.

19. **TbaseP**: Real number for the customer based total building baseline peak demand per common unit in units of Watts.

20. **TbaseG**: Real number for the customer based total building baseline annual natural gas energy use per common unit in units of kBtu.

21. **PEbaseE**: Real number for the customer based primary end-use baseline annual electric energy use per common unit in units of kWh.

22. **PEbaseG**: Real number for the customer based primary end-use baseline annual natural gas energy use per common unit in units of kBtu.

23. **EImpact**: Real number for the customer based annual measure electricity savings in kWh per common unit. Includes any negative impacts.

24. **Gimpact**: Real number for the customer based annual measure natural gas savings in kBtu per common unit. Includes any negative impacts.

25. **Pimpact**: Real number for the customer based measure peak demand impact of electricity in Watts per common unit. Includes any negative impacts.

26. **TCbaseE**: Real number for the code based total building baseline annual electric energy use per common unit in units of kWh.

27. **TCbaseP**: Real number for the code based total building baseline peak demand per common unit in units of Watts.

28. **TCbaseG**: Real number for the code based total building baseline annual natural gas energy use per common unit in units of kBtu.

29. **PECbaseE**: Real number for the code based primary end-use baseline annual electric energy use per common unit in units of kWh.

30. **PECbaseG**: Real number for the code based primary end-use baseline annual natural gas energy use per common unit in units of kBtu.

31. **ECImpact**: Real number for the code based annual measure electricity savings in kWh per common unit. Includes any negative impacts.

32. **GCimpact**: Real number for the code based annual measure natural gas savings in kBtu per common unit. Includes any negative impacts.

33. **PCimpact**: Real number for the code based measure peak demand impact of electricity in Watts per common unit. Includes any negative impacts.

34. **EUL**: Real number for effective useful life of the measure.

35. **Application**: String variable that includes up to three values that indicate the type of installation application appropriate for this measure. These include "ROB", which is the replace on burnout application, "RET", which is the retrofit application, and "NEW", which is the application of the measure in a new installation or building. These different applications often have different costs. If more than one application is appropriate, each is listed and separated bu a "/".

36. **Cost Basis**: String variable that identifies the appropriate cost to be utilized by the application(s) identified in #35. If more than one application is identified in #35, then the appropriate cost basis is given for each in the same order. As with #35, the cost basis variable by application will be separated by a "/". There are two possible cost base variables; "INC", which is the incremental cost, and "FULL", which is the full cost of installing the measure. Incremental cost does not include labor while full cost does. After the Cost Basis variable(s) are identified, the cost "Common Units" are identified after a " – ". In most cases, the cost common unit is the same as the energy impact common unit. However, in some cases cost

values could not be obtained for the same units of measure as the energy impact common units. Cost common units use the same definitions and codes as the energy impact common units, as identified in # 10.

37. **Base Equip Cost**: Real number for the code baseline equipment cost per common unit

38. **Measure Equip Cost**: Real number for measure equipment cost per common unit

39. **Incremental Equip Cost**: Real number for the incremental cost of the measure (measure equipment cost less base equipment cost wher applicable) per common unit

40. **Labor Cost**: Real number for the cost of installing the measure.

41. **Installed Cost**: Real number that is the sum of installing the measure and the labor cost to install the measure.

42. **OtherRef1**: String variable reference source for input data.

43. **OtherRef2**: String variable reference source for input data.

44. **OtherRef3**: String variable reference source for input data.

Appendix E

Example Process for Coordination and Review of Comments on the Future Database for Energy Efficient Resources (DEER)

Guidelines

- Comments shall be received in a timely manner and follow the schedule provided by the DEER team.
- Comments shall be provided in writing and are substantively oriented.
- Comments shall be focused on technical issues within DEER's scope. This includes
- Methods and data used to estimate baseline conditions and energy and peak demand impacts.
- When either the validity or accuracy of DEER estimates is critiqued, specific recommended replacement values or methods shall be provided with supporting documentation.
- Supporting documentation shall be based as much as possible on independent sources.
- Comments shall be coordinated with a DEER Project Advisory Committee (PAC) member. In particular, staff within organizations that are represented on the PAC should submit comments to their own PAC member. PAC members shall coordinate and consolidate comments within their organizations that address the same topic.

Review Request Submittal Details

The requester, in coordination with a PAC member, will submit to the DEER Project Manager (PM) and Contract Manager (CM) a Memorandum that contains at a minimum the following items:

- Summary of the current DEER measure methodologies, assumptions, sources, inputs, etc. (The objective here is to make sure the commenter understands and knows what is in the DEER and so that the DEER team can correct misunderstandings.)
- Summary of the proposed DEER measure changes to methodologies, assumptions, sources, inputs, etc. (Commenters should be specific as to what needs to be changed.)
- Attach supporting documentation for the change such as calculations, descriptions of methodologies, studies, etc. (Independent sources are strongly preferred.)

- Reasoning why the proposed changes are better than the DEER value or method reviewed.
- How the proposed change would impact the current magnitude and reliability of the deemed values. Indication of whether they would move to more conservative values, better "averages," more optimistic values, or make them oriented to specific target markets.
- Contact information for the person to whom to direct questions and request additional information.

PAC Review

The PM and CM will request a group of people to review the request. The nature of the request should dictate who reviews it. At a minimum, a sub-group of PAC members, including members independent from the requesting organization, along with a representative from the contractor team, should review the request. The PM will set a timeline for the review taking into consideration the overall project timeline and any potential impact on overall project scope.

- As part of their review process, PAC reviewers may**:**
  - Request additional data and/or clarifications
  - Recommend that one or more additional independent experts be added to the review process (this may be limited to requesting expert opinion on some select key issues only)
  - Request a teleconference that includes the individuals submitting the requested change and additional experts
- The reviewers will submit their written review and recommendation to both the DEER Project Manager (PM) and the DEER Contract Manager (CM) within the timeline set by the PM.
- Reviewers recommendations may include either one or more of the following (this list is not all encompassing):
  - Adopt all of the proposed change,
  - Adopt a portion of the proposed change,
  - Reject the proposed change with no referral for additional action,
  - Reject the proposed change but with a recommendation for future action:
    - Recommend that the issue be incorporated into an EM&V study,
    - Recommend that the issue be addressed in a future DEER update.

PAC Action

The PM will incorporate the group review into the agenda for the next scheduled PAC conference call meeting.

- The PM will forward to the PAC the original request, the assigned PAC members' reviews, a summary of the recommendation and proposed action with sufficient time to allow the members to consider the material.
- During the PAC meeting, the PM, or a designee, will present the material and lead the discussion on the proposed recommendation and action. The discussion should include potential impacts to the DEER Update project and its timeline.
- The PM will work with the PAC to reach a final consensus decision on the request and follow-up with any required actions. If the PAC cannot reach a consensus, the decision will be made by the PM in consultation with the California Public Utility Commission (CPUC) Energy Division representative.

Appendix F

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