Section 2:
Estimating Energy Savings and Incentives

2.1 Estimating Energy Savings and Incentives

This section of the *2010 Statewide Customized Offering Procedures Manual* describes the customized approach utilized to estimate the expected energy savings and incentives for your proposed Customized energy efficiency project(s).

Under this approach you will need to estimate the kWh savings and the permanent DEER peak demand reduction achieved as a result of your high efficiency upgrade. This can be done using either the estimation software or using engineering calculations.

- **Estimating software**. Downloaded from the Utility website or on-line (SCE Only), the estimating software provides methodologies for specific measures that calculate energy savings based on site-specific information for the project (a list of the measures included on the software is included in Section 2.3). This method is also used to determine the energy savings for air conditioning equipment and motors that qualify for the Early Retirement option.

- **Engineering calculations.** If your proposed energy efficiency measures are not addressed by the estimation software, you can calculate the energy savings by using accepted engineering procedures. This option should **ONLY** be used if the estimating software does not address the specific measure you are installing or if the software does not accurately calculate your achievable savings. This is the more difficult approach for estimating the savings but is acceptable with supporting documentation and substantiation of your savings claims and is subject to review by third party reviewers.

2.2 Customized Measures - Estimation Software

The Statewide Customized Offering Estimation Software provides savings calculations for a variety of the most common energy-saving measures. These savings calculations incorporate assumptions and stipulations that provide reasonable savings estimates under most conditions. The estimation software asks for detailed input from your facility, providing a good approximation of the energy savings. In some cases spot measurements may be necessary.

Each of these tools requires input of specific project information through a combination of direct data entry and pull-down menus. The input fields are generally self-explanatory, and if you position your cursor at the very beginning (left edge) of the white input field, a “balloon” prompt will pop up to explain the type of data that should be entered into that field.

The estimating tools can be accessed either by using “Create or Edit Application in 2009 and years before SPC Tool” feature or by using the “Energy Savings Calculator in 2010 CCT Tool” feature of the software (The calculator only provides a savings estimation and does not go through the steps of filling out an electronic application). This allows you to fill out the Application forms by hand, and attach the savings calculation.
Specific considerations for each of these tools are discussed below.

2.2.1 AC&R I – High Efficiency Chiller

2.2.1.1 Description

This tool is for the direct replacement of water-cooled chillers (SCE) and for direct replacement of air-cooled and water-cooled Chillers (PG&E and SDG&E).The tool also can be utilized for the installation of a VSD on an existing Chiller. Baseline efficiency is current Title 24 standards or minimum efficiency standards.

2.2.1.2 Appropriate Use of the Tool – Program Policy

The Customized Calculation Tool (CCT) software is utilized for the following High Efficiency Chiller measures:

1) Replacement of a chiller unit, including compressor upgrades.

The CCT software calculates savings using the Engage tool for a measure of this type. The Engage software is a stand-alone, DOE2 based modeling program. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

The estimate of savings from the High Efficiency Chiller Tool is applicable for the following building types and area ranges:

Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2
Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2
Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2
Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2
Lodging - Hotel – defaults to 200,000 ft^2
Office – Large – defaults to 175,000 ft^2
Office – Small – defaults to 10,000 ft^2
Retail – Multistory Large – defaults to 120,000 ft^2

Please note that the CCT software is limited to uniform chiller plant projects only. That is, the tool will only allow the user to select (1) existing chiller and compressor arrangement and (1) proposed chiller and compressor arrangement. The tool is not suited for the following situations:

1) Multiple existing or proposed chiller types
2) When portions of a chiller plant are replaced

If the project falls under any of these scenarios, a more detailed analysis method may be necessary.

This tool is utilized for early retirement or replacement of all sizes of chillers. However, the user should be aware of eligibility requirements for incentives that are in place by the local utility of the proposed project site. For additional information, see the CCT tool manual.

Calculating Early Retirement

This tool is used for chillers that qualify for Early Retirement. If the unit qualifies for early retirement, (either recently overhauled or replaced before the end of its useful life) the energy savings are calculated using the baseline standards that were in effect when the equipment was manufactured rather than the current minimum standards. This results in a larger incentive than would be possible using the traditional Customized Approach. The useful life and overhauled useful life is specific to chiller types and the year the equipment was built. The current acceptable amounts can be found within the CCT manual in the Early Retirement section.

To qualify as overhauled, a significant amount of work must have been performed (major overhaul). All of the components must be brought back to their original condition. The life of the existing equipment must have been significantly extended from this effort. For example, a major overhaul would include the replacement or rebuilding of all of the compressors and motors of the chiller unit as well as restoring the evaporator and condenser heat exchangers to their original condition. As part of the inspection, the equipment will be examined to determine if the calculated remaining life is reasonable. Should the equipment not meet the expected useful life, the measure will be rejected. The Utility administer has the final decision on whether a piece of equipment qualifies as refurbished. To establish the overhaul and its date, supporting invoices are required.

2.2.1.3 Inputs

Prior to selecting the High-Efficiency Chillers measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. This CCT software allows projects that fall under any of the three above referenced measure types. The user should make the appropriate selection based on the proposed equipment and project scope.

Once the High Efficiency Chillers measure is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screens appear in the same order as a user experiences while using the CCT software.

Table 1-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	From the pull-down menu, select by Zip Code or by CTZ. (CTZ stands for Climate Zone) In the adjacent pull-down menu select the appropriate Zip Code or CTZ.
Building Type	Pull-down	1	From the pull-down menu, select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D in the CCT Program Procedures Manual for detailed descriptions).
Vintage	Pull-down	1	From the pull-down menu, select the year the building was constructed.
HVAC system(s)	Pull-down	1	From the pull-down menu, select a cooling equipment type. One or more typical HVAC System will be available based on the chosen Building Type.
Allow HVAC System Downsizing	Checkbox	1	If the measure(s) you include in the analysis result in reduced cooling or heating loads (many do), selecting this option allows the CCT software to downsize HVAC systems. This option is only enabled for a building vintage after 2005.
Total Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type.
Secondary Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building

			Type. This option may be disabled if it is not applicable to your Building Type. The tool will automatically assign an equal amount of square feet per floor.
Secondary Number of Floors	Fill in	1	Enter the total number of floors of the secondary building (if applicable). The tool will automatically assign an equal amount of square feet per floor.
Pattern	Pull-down	2	From the pull-down menu, select a seasonal usage pattern. One or more typical usage patterns will be available based on the previously chosen Building Type.
Number of Seasons	Pull-down	2	From the pull-down menu, select one, two or three.
Season #1	Fill in	2	Insert an appropriate label for the season.
Season #2	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Season #3	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Observed Holidays	Checkbox	2	Click this button and insert check marks next to the observed holidays.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. One or more typical usage pattern will be available based on the previously chosen Building Type.
Season	Pull-down	3	From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Area Served	Fill in	4	Enter the square-feet of conditioned space.
Year Manufactured	Fill in	4	Insert the year the chiller was constructed. This is important if the user is seeking an 'Early Retirement' analysis.
Overhauled	Checkbox	4	Check the box if the chiller has been overhaul since its manufactured date.
Year Overhauled	Fill in	4	If the 'Overhauled' checkbox is selected, enter the year in which the existing chiller was overhauled. This is important if the user is seeking an 'Early Retirement' analysis.
Chiller Type(s)	Pull-down	4	From the pull-down menu, choose the appropriate chiller type. The Baseline selection will be applied to the Measure.
Condenser Type(s)	Pull-down	4	Chiller Condenser Type is used to indicate whether the chillers use air-cooled or water-cooled condensers. There are four choices: 1) "Water-Cooled" A water-cooled chiller will be used. 2) "Packaged Air-Cooled" A self-contained air-cooled condenser will be used. All energy consumption associated with the condenser fans is included in the

			chiller's rated efficiency 3) "Remote Air-Cooled" A remotely located, air-cooled condenser will be used. The chiller's rated efficiency does not include the energy used by the condensing unit. 4) "Remote Evap-Cooled" A remotely located, evaporative-cooled condenser will be used. The chiller's rated efficiency does not include the energy used by the condensing unit
Compressor(s)	Pull-down	4	Select between constant, variable speed, and frictionless compressors. Please note that this option is only enabled for centrifugal chillers.
Chiller Counts & Sizes	Fill in/Pull-down	4	Insert the number of chillers. From the pull-down menu, choose Specify if you know the actual chiller size or Auto-size if you know the size range.
Chiller Efficiency	Fill in/Pull-down	4	Insert the chiller's full load efficiency in either kW/ton or COP for the baseline and proposed equipment.
Program Baseline Efficiency	N/A	4	This is the efficiency of the chiller to be used as the baseline for the analysis. If the baseline equipment qualifies for early retirement, this will be equal to the baseline efficiency. If the equipment is not qualified for early retirement, the appropriate minimum efficiency standard will be used.

2.2.1.4 Output

Once all necessary input information has been gathered, the CCT software sends the required information to engage and computes the annual energy usage for the baseline and proposed systems. Finally, the energy savings and incentive is computed and the results are presented to the user. The following table and associated figure describes the CCT software outputs.

Table 1-2. Output

Output Name	Description / Purpose
Existing Equipment:	Estimated maximum on-peak demand (kW) of the existing equipment and estimated annual energy use (kWh) of the existing equipment.
Baseline Equipment:	Estimated maximum on-peak demand (kW) of the baseline equipment and estimated annual energy use (kWh) of the baseline equipment.
Proposed Equipment:	Estimated maximum on-peak demand (kW) of the proposed equipment and estimated annual energy use (kWh) of the proposed equipment.

Savings	Estimated on-peak demand (kW) and energy savings for measure (kWh) For units that qualify for early retirement this will be the difference between **existing** and **proposed**. For units that do not qualify for early retirement this will be the difference between the **baseline** and **proposed**.
Incentive (@ $0.15 kWh/yr and $100.00/kW)	Gross incentive amount based on 2010 program rates, $0.15/kWh/yr and $100.00/kW.

The Peak Demand Incentive Worksheet uses the DEER Peak method to calculate kW savings and incentive. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet. The software calculates DEER Peak directly for weather-based measures. It estimates DEER Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet.

Table 1-3. Peak Demand Worksheet

Tool Input	**Description/Purpose**
Equipment operates during the peak demand period defined above?	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Estimated on-peak demand incentive is displayed.

2.2.1.5 Energy Savings Explanation

All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. This engine utilizes the weather data (along with user inputs describing the building envelope characteristics, internal loads, and HVAC system components) to calculate the peak electrical demand and energy usage for all the building components (HVAC equipment, lighting, etc.).

2.2.2 AC&R I - Split/Packaged AC Retrofit or Early Retirement (PG&E and SDG&E Only)

2.2.2.1 Description
This tool is designed to compute the savings and incentive for a High Efficiency Air Cooled Split or Packaged A/C DX systems greater than or equal to 760,000 BTU/hr (63.3 tons). A Split A/C system contains the compressor and condenser in a single enclosure outside, while the supply fan is contained in another enclosure located indoors. A packaged unit includes a compressor, condenser, and supply fan in a single enclosure.

For SCE, Packaged, Split-System, Heat Pumps, and Air-Cooled Chillers are not eligible under the Customized Offering but may be available through other Offerings; please check www.sce.com for more information.

The CCT software tool calculates energy savings by calculating cooling and heating loads on a building using the Engage program. Engage is created as a replacement to the MARS software and is primarily used to aid account representatives analyze energy efficiency measures similar to the CCT software. Engage is built on the Quick Energy Simulation Tool (eQUEST) which calculates cooling loads and system energy requirements based on hourly weather data.

2.2.2.2 Appropriate Use of the Tool –Program Policy
The software tool is utilized for the replacement of an air cooled split or packaged air conditioner as a retrofit, new installation, or for early retirement. For calculating early retirement, the unit must be either for a recently overhauled (2001 or after for the 2010 program year) unit or a less efficient piece of equipment that is replaced before the end of its useful life (1997 or after for the 2010 program year). In order to qualify, all components must be brought back to their original condition, which includes replacement or rebuilding of all of the compressors and motors of the AC unit as well as restoring the evaporator and condenser heat exchangers to their original condition)*. To establish an overhaul date, supporting invoices are required. If the project is eligible for early retirement, the baseline efficiency is considered to be the standards that were in effect when the equipment was manufactured rather than current minimum standards resulting in a larger incentive than would be possible using the traditional Customized Approach.

* As part of the inspection, the equipment will be examined to determine if the calculated remaining life is reasonable. Should the equipment not meet the expected useful life, the measure will be rejected. The Utility administrator has the final decision on whether a piece of equipment qualifies as refurbished.

While the CCT software will allow the user to enter the existing site equipment, this information will not be used in the baseline under the following conditions:

1) Existing equipment capacity is less than 63.3 Tons per unit
2) Existing equipment efficiency is less than Title 24 minimum and equipment does not qualify for early retirement.

2.2.2.3 Inputs
Prior to selecting the High Efficiency Air Cooled Split/Packaged A/C measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. The software allows projects that fall under any of the three above referenced measure types. The user should make the appropriate selection based on the proposed equipment and project scope.

Once the High Efficiency Air Cooled Split/Packaged A/C measure is selected, the user is then directed to enter the various inputs as described in the following table. The input screens appear in the same order as shown below.

Table 2-1. Inputs

Input Name	Type	Sheet	Description/Purpose
Location	Pull-Down	1	Choose site location based on zip code or climate zone.
Building Type	Pull-Down	1	Choose the building type most appropriate for the project site.
Vintage	Pull-Down	1	Choose the year range in which the building was constructed.
HVAC system(s)	Pull-Down	1	Choose the system type that best fits the type found on the project site.
Total Building Area	Fill-In		Enter the building area. The conditioned area is defined on screen 4.
Number of Floors	Fill-In	1	Enter the total number of floors of the building. The tool will automatically assign an equal amount of square feet per floor.
Secondary Building Area	Fill-In	1	Enter the secondary building area (if applicable). The conditioned area is defined on screen 4.
Secondary Number of Floors	Fill-In	1	Enter the total number of floors of the secondary building (if applicable). The tool will automatically assign an equal amount of square feet per floor.
Sheet 2 and 3, allows users to define seasons, observed holidays and operating schedules for the project site. By clicking the ‘Observed Holidays’ button, the user will be able to select or deselect holidays as appropriate. Seasons will allow the user to define multiple site schedules. By default, a single season is selected assuming typical use based on the building type chosen on sheet 1. If multiple seasons are needed to more accurately reflect the operation of the project site the user can select up to (3) seasons and up to (3) separate time periods during which the season type will occur. Please note, seasons only allow for multiple schedules and not chiller operation. If multiple chillers of varying sizes are involved in the project, a more detailed analysis method may be necessary.			
Area Served	Fill-In	4	Enter the total area served by the HVAC system.
Economizer	Pull-Down	4	Choose the economizer option that best fits the project equipment.
Existing A/C Equipment	Button	4	Press the command button to open up the screen and define the appropriate details for the existing equipment.
Replacement A/C Equipment	Button	4	Press the command button to open up the screen and define the appropriate details for the replacement equipment. Please note, as of March 31, 2009 all replacement units must be a minimum of 63.3 Tons to qualify for an incentive.
Code Baseline A/C Equipment		4	This section does not require any input from the user. The text boxes will provide the efficiency and capacity of the A/C equipment to be used as the baseline for the analysis. If the existing equipment qualifies for early retirement, this will be equal to the baseline efficiency. If the existing equipment is not qualified for early retirement, the appropriate minimum efficiency standard will be used.

2.2.2.4 Output

Once all necessary input information has been gathered, the CCT software sends the required information to Engage and computes the annual energy usage for the baseline and proposed systems. Finally, the energy savings and incentive is computed and the results are presented to the user. The following table describes the outputs.

Table 2-2. Outputs

Tool Output	Description
Existing Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the proposed equipment, estimated annual energy use (kWh), estimated annual gas usage (Therms) of the existing equipment.
Baseline Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the proposed equipment, estimated annual energy use (kWh), estimated annual gas usage (Therms) of the baseline equipment.
Proposed Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the proposed equipment, estimated annual energy use (kWh), estimated annual gas usage (Therms) of the proposed equipment.
Savings	Estimated on-peak demand (kW) of the proposed equipment, estimated annual energy use (kWh), estimated annual gas usage (Therms). For units that qualify for early retirement this will be the difference between **existing** and **proposed**. For units that do not qualify for early retirement this will be the difference between the **baseline** and **proposed**.
Incentive (@ $0.15 kWh/yr and $100.00/kW)	Gross incentive amount based on 2010 program rates, $0.15 kWh/yr, $100.00/kW and $1.00 Therm/yr.

The Peak Demand Incentive Worksheet uses the DEER Peak method to calculate kW savings and incentive. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet. The software calculates DEER Peak directly for weather-based measures. It estimates DEER Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet.

Table 2-3. Peak Demand Incentive

Tool Input	Type	Sheet	Description/Purpose
Equipment operates during the peak demand period defined above?	Pull-Down	Peak Demand Incentive Worksheet	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill-In	Peak Demand Incentive Worksheet	Enter the eligible peak demand savings if they differ from the calculated savings.

			Explain the why the savings differ in the text box below.
Total Incentive	Output	Peak Demand Incentive Worksheet	Estimated on-peak demand incentive is displayed.

2.2.2.5 Energy Savings Explanation

All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. This engine utilizes the weather data (along with user inputs describing the building envelope characteristics, internal loads, and HVAC system components) to calculate the peak electrical demand and energy usage for all the building components (HVAC equipment, lighting, etc.).

2.2.3 AC&R I - VSD for Centrifugal Chillers

2.2.3.1 Description

This tool is designed to compute the incentive achieved from a centrifugal chiller Variable Speed Drive (VSD) retrofit. Chillers are generally oversized in order to accommodate loads potentially experienced during the hottest day of the year. As a result, chillers will run at part loads for the majority of the cooling season. However, the efficiency (kW/ton) of a constant-speed centrifugal chiller drops off significantly during low part-load operation (under 50% of full cooling capacity). A Variable Speed Drive retrofit to the chiller efficiently reduces the speed of the compressor during part-load conditions. This allows the chiller to run during part-load conditions without any decrease in overall efficiency (kW/ton).

2.2.3.2 Appropriate Use of the Tool – Program Policy

The CCT software is utilized for measures involving the retrofit of a chiller with a VSD drive controller.

<u>The estimate of savings from the VSD for Centrifugal Chillers Tool can be calculated for the following building types and the building area must be between:</u>

<u>Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2</u>
<u>Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2</u>
<u>Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2</u>
<u>Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2</u>
<u>Lodging - Hotel – defaults to 200,000 ft^2</u>
<u>Office – Large – defaults to 175,000 ft^2</u>
<u>Office – Small – defaults to 10,000 ft^2</u>
<u>Retail – Multistory Large – defaults to 120,000 ft^2</u>

2.2.3.3 Inputs

Prior to selecting the VSD for Centrifugal Chillers measure the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. This tool only allows projects that are retrofits (same load). Once the VSD for Centrifugal Chillers measure is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screens appear in the same order as a user experiences while using the CCT software.

Table 3-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	From the pull-down menu, select by Zip Code or by CTZ. (CTZ stands for Climate Zone) In the adjacent pull-down menu select the appropriate Zip Code or CTZ.
Building Type	Pull-down	1	From the pull-down menu, select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D in the CCT Program Procedures Manual for detailed descriptions).

Vintage	Pull-down	1	From the pull-down menu, select the year the building was constructed.
HVAC System(s)	Pull-down	1	From the pull-down menu, select a cooling equipment type. One or more typical HVAC System will be available based on the chosen Building Type.
Allow HVAC System Downsizing	Checkbox	1	If the measure(s) you include in the analysis result in reduced cooling or heating loads (many do), selecting this option allows the CCT software to downsize HVAC systems. This option is only enabled for a building vintage after 2005.
Total Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type.
Secondary Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Secondary Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Pattern	Pull-down	2	From the pull-down menu, select a seasonal usage pattern. One or more typical usage patterns will be available based on the previously chosen Building Type.
Number of Seasons	Pull-down	2	From the pull-down menu, select one, two or three.
Season #1	Fill in	2	Insert an appropriate label for the season.
Season #2	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Season #3	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-

			down menus define the periods for the season.
Observed Holidays	Checkbox	2	Click this button and insert check marks next to the observed holidays.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. One or more typical usage pattern will be available based on the previously chosen Building Type.
Season	Pull-down	3	From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Area Served	Fill in	4	Enter the square-feet of conditioned space.
Year Manufactured	Fill in	4	Insert the year the chiller was constructed.
Overhauled	Checkbox	4	Check the box if the chiller has been overhaul since its manufactured date.
Year Overhauled	Fill in	4	If the 'Overhauled' checkbox is selected, enter the year in which the existing chiller was overhauled.
Chiller Type(s)	Pull-down	4	From the pull-down menu, choose the appropriate chiller type. The Baseline selection will be applied to the Measure.
Condenser Type(s)	Pull-down	4	From the pull-down menu, the only appropriate chiller type is Water-Cooled.
Compressor(s)	Pull-down	4	From the pull-down menu, the only appropriate chiller type is Constant Speed for the Baseline and Variable Speed for the Measure.
Chiller Counts & Sizes	Fill in/Pull-down	4	Insert the number of chillers. From the pull-down menu, choose Specify if you know the actual chiller size or Auto-size if you know the size range.
Chiller Efficiency	Fill in/Pull-down	4	Insert the chiller's full load efficiency in either kW/ton or COP.

2.2.3.4 Output

Table 3-2. Building Measure Results

Output Name	Description/Purpose
Existing Equipment	Estimated maximum on-peak demand (kW) of the existing equipment and estimated annual energy use (kWh) of the existing equipment.

Baseline Equipment	Estimated maximum on-peak demand (kW) of the baseline equipment and estimated annual energy use (kWh) of the baseline equipment.
Proposed Equipment	Estimated maximum on-peak demand (kW) of the proposed equipment and estimated annual energy use (kWh) of the proposed equipment.
Savings	Estimated on-peak demand (kW) and energy savings for measure (kWh) For units that qualify for early retirement this will be the difference between **existing** and **proposed**. For units that do not qualify for early retirement this will be the difference between the **baseline** and **proposed**.
Incentive (@ $0.15 kWh/yr and $100.00/kW))	Gross incentive amount based on 2010 program rates, $0.15/kWh/yr and $100.00/kW.

2.2.3.5 Energy Savings Explanation

The applicant inputs information in the CCT software. All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. This engine utilizes this weather data (along with user inputs describing the building envelope characteristics, internal loads, and HVAC system components) to calculate the peak electrical demand and energy usage for all the building components (HVAC equipment, lighting, etc.). Engage then passes the above values back to the CCT software. The software then displays the savings estimates and incentive amount.

2.2.4 AC&R I – VAV or VSD on Supply Fan Motors

2.2.4.1 Description

The CCT tool can be used to predict the savings achievable by installing a variable speed drive (VSD) or other control device on the supply fan(s) in a building or group of buildings. A VSD or other control device on the supply air fan(s), along with variable air volume (VAV) boxes at the zone level, allows for air flow to be varied depending on the overall building cooling load.

2.2.4.2 Appropriate Use of the Tool –Program Policy

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This tool shall be used exclusively in buildings that utilize supply air fan(s) to provide space-cooling in the building and applies to any supply fan motors. There is no restriction on the size of the fan motors. The user may input up to 20 different fans.

The estimate of savings from the VAV or VSD on Supply Fan Motors Tool can be calculated for the following building types and the building area must be between:

Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2
Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2
Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2
Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2
Lodging - Hotel – defaults to 200,000 ft^2
Office – Large – defaults to 175,000 ft^2
Office – Small – defaults to 10,000 ft^2
Retail – Multistory Large – defaults to 120,000 ft^2

2.2.4.3 Inputs

Prior to selecting the VAV or VSD of HVAC Supply Fans measure the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. The CCT Tool only allows projects that are retrofits (same load). Once the VAV or VSD of HVAC Supply Fans measure is selected, the user is then directed to enter the various inputs as described in the following tables.

Table 4-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	Location can be selected by either Zip Code or climate zone (CTZ). The appropriate Zip Code or CTZ is then selected from the adjacent pull-down menu.
Building Type	Pull-down	1	A “predefined” building configuration can be selected. (See Appendix D in the Customized Offering Manual for detailed descriptions). Multiple Building Types are available for this measure.
Vintage	Pull-down	1	Select a Building Vintage from the list of available vintages that best matches the age of the building and main systems.

HVAC System(s)	Pull-down	1	Select the appropriate cooling equipment type from the pull-down menu. Please note that the available HVAC systems for selection are dependent on the selected building type.
Allow HVAC System Downsizing	Pull-down	1	This checkbox allows engage to downsize, or reduce the size of the HVAC systems in the measure runs if the selected measure results in reduced cooling loads. This is generally considered appropriate for new construction scenarios or retrofit scenarios which include a change of HVAC systems. This checkbox is only enabled if the building vintage is after 2005.
Total Building Area	Fill In	1	Enter the square-feet of conditioned space.
Number of Floors	Pull-down	1	Enter the number of floors of conditioned space.
Secondary Building Area/Total Dormitory Area	Pull-down	1	This field may or may not be disabled for this measure, depending on the building type selected. Building types such as Universities and colleges allow for input to this field, while Large/Small offices do not.
Secondary Number of Floors	Pull-down	1	This field may or may not be disabled for this measure, depending on the building type selected.
Seasonal Usage – Pattern	Pull-down	2	Select the appropriate usage type from the pull-down menu. Only “Typical Use Throughout the Year” is available for selection for this measure.
Seasonal Usage - Number of Seasons	Pull-down	2	Select the number of seasons during which the building systems operate from the pull-down menu. User can select up to three seasons
Season #1	Pull-down	2	User can modify the default entry for this field which is “Typical Use”
Observed Holidays	Button	2	When clicked, this button displays a checkbox list of holidays available to be exempt from scheduling.
Season #2: (With Label & No of Periods)	Pull-down	2	This field is enabled if the number of seasons selected is >1. Insert an appropriate label for the seasons. Choose an appropriate number of periods when the season occurs from the pull-down menu and the pop up calendar.
Season #3: (With Label & No of Periods)	Pull-down	2	This field is enabled if the number of seasons selected is >2. Insert an appropriate label for the seasons. Choose an appropriate number of periods when the season occurs from the pull-down menu and the pop up calendar.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. The number of shells available in the drop down list is based on the previously chosen Building Type.
Seasons – Weekly Schedule	Pull-down	3	Users are allowed to define operation for up to (3) defined seasons. Only one opening time and one closing time can be defined per day

			type, per season. From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Fan Motors	Fill In	4	Enter motor count and motor horsepower for up to twenty (20) different motor horse power sizes. A minimum of one motor type is required to be specified.
Baseline Supply Fan Type	Pull-down	4	Select the Supply Fan Type for the baseline case. The available options include Forward curved or air foil centrifugal fans that can by inlet vanes or discharge dampers. A vane-axial option is available as well. Note: Variable Speed Drive can also be selected; however this baseline selection is unlikely to yield energy savings.
Baseline VAV Minimum Flow (Perimeter & Core Zones)	Fill In	4	Use these inputs to describe the Minimum Flow entering Perimeter Zones and Core Zones throughout the building. The defaults are based on Title 24. If a Baseline case is constant volume, VAV Minimum Flow should be 100%.
Replacement Supply Fan Type	Pull-down	4	Select the Supply Fan Type for the measure case. The default value is Variable Speed Drive (VSD).
Replacement VAV Minimum Flow (Perimeter & Core Zones)	Fill In	4	Use these inputs to describe the Minimum Flow entering Perimeter Zones and Core Zones throughout the building. The defaults are based on Title 24.

2.2.4.4 Output

Once all the necessary input information has been gathered, the CCT tool utilizes these inputs to compute the annual energy demand and usage for two scenarios: the baseline supply fan controls compared to the replacement fans controls (the calculation methodology is explained below). Finally, the energy savings and incentive is computed and the results are presented to the user as found in Table 5 – Building Measure Results. After the user selects “Finish”, the information on Table 6 – Demand Incentive Worksheet will be requested. After the user selects “Next” or “Finish” the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 4-2. Building Measure Results

Output Label	Description/Purpose
Output	**Description /**
Existing Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the existing equipment and estimated annual energy use (kWh) of the existing equipment.
Baseline Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the baseline equipment and estimated annual energy use (kWh) of the baseline equipment.
Proposed Equipment: Demand and Energy	Estimated maximum on-peak demand (kW) of the proposed equipment and estimated annual energy

	use (kWh) of the proposed equipment.
Savings	Estimated on-peak demand (kW) and energy savings for measure (kWh) For units that qualify for early retirement this will be the difference between **existing** and **proposed**. For units that do not qualify for early retirement this will be the difference between the **baseline** and **proposed**.

The Peak Demand Incentive Worksheet uses the CPUC Peak Demand Savings to calculate kW savings and incentive. The software chooses the appropriate CPUC peak period based on the location inputs on the first sheet. The software calculates CPUC Peak directly for weather-based (Engage) measures. It estimates CPUC Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques. See the Energy Savings Explanation section for a description of the CPUC Peak Demand Savings.

Table 4-3. Peak Demand Incentive Worksheet

Input Name	Type	Sheet	Description / Purpose
City	Pull Down	N/A	Select the appropriate city
Equipment operates during the peak demand period defined above?	Check Box	N/A	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill In	N/A	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Display	N/A	Estimated on-peak demand incentive is displayed.

2.2.4.5 Energy Savings Explanation

Since supply fan(s) are designed and sized to serve the maximum cooling load in a building, they are supplying excess capacity during part-load conditions. Fan capacity and corresponding power requirement can be reduced during these periods through the use of control devices such as inlet guide vanes, discharge dampers, or variable speed drives (VSDs). The amount of power reduction depends on the control strategy as some are more efficient than others. The CCT tool can estimate the energy savings achieved when the supply fan(s) in a building or group of buildings is fitted with a VSD or other control devices.
It should be noted that the CCT tool assumes that the control measure is applied to any and all fans that serve the building or site.

The CCT tool calculates the energy savings for this measure by passing all required user inputs through Engage, which is a modified version of the Quick Energy Simulation Tool (eQUEST). Developed by James J. Hirsch and Associates, eQUEST is a whole-building performance model that incorporates graphics and wizards with the DOE2.2 computation engine to simulate building energy performance based on user-defined inputs. These inputs describe building attributes such as (but not limited to) building envelope characteristics, internal loads, and HVAC system components. eQUEST, through the DOE2.2 computation engine, performs hourly calculations of the electrical and/or gas demand of building system end uses (HVAC, lighting, misc equipment, etc) based on normalized annual weather data.

(Please note that to create a more generic model, assumptions are incorporated into eQUEST to create the Engage model, thereby reducing the amount of inputs and detail required by the user. However, the DOE2.2 computation methodology remains the same across both platforms.)

If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

CPUC Defined Peak Demand Savings

The CCT software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant the equipment operates during the defined peak period.

2.2.5 Gas - Natural Gas Boiler Measures (PG&E & SDG&E Only)

2.2.5.1 Description

This measure includes three actions (accessed from a Pull-down menu):

Replace Process Boiler(s) – This tool calculates the energy savings and incentive for replacing existing steam or hot water boiler(s) with new boiler(s) of higher efficiency. This method is specific to process/industrial boiler heating loads as opposed to space heating loads. The 2010 program does provide incentives for increased capacity therefore the energy output from the proposed boiler(s) can be larger than the output from the existing boiler(s) (if the increased load option is chosen at the beginning).

Add Boiler Economizer – This tool is to be used for calculating the energy savings by adding an economizer to an existing boiler. An economizer recovers heat from the flue gas and transfers it to the boiler feed or return water. This tool is not available if the increased load option is chosen at the beginning.

Replace Space Heating Boiler(s) – This tool is to be used for calculating the energy savings and incentive for replacing space heating steam or hot water boiler(s) with new boiler(s) of higher efficiency. The 2010 program does provide incentives for increased capacity therefore the energy output from the proposed boiler(s) can be larger than the output from the existing boiler(s) (if the increased load option is chosen at the beginning).

2.2.5.2 Appropriate Use of the Tool – Program Policy

This tool covers the replacement of space heating, process, and commercial boilers, and the addition of a boiler economizer.
The baseline minimum efficiency and the type of CEC minimum efficiency (AFUE or combustion) are dependent on the size of the boiler, as shown in the table below.

Table 5-1. CEC Minimum Efficiencies for Natural Gas Fired Boilers

Steam & Hot Water Boilers

Size (Btuh Input)	Steam (min eff.)	Hot Water (min eff.)
<300,000	75%a	80%a
≥ 300,000	80%c	80%c

a = AFUE   c = Combustion Efficiency

Definitions:
"AFUE (Annual Fuel Utilization Efficiency) – AFUE is a measure of the percentage of heat from the combustion of natural gas or oil that is transferred to the space being heated during a year, as determined using the applicable test method in the Appliance Efficiency Regulations of § 112..." (CEC-400-2008-004-CMF)
Combustion Efficiency is a measure of the percentage of heat from the combustion of gas or oil that is transferred to the medium being heated or lost as jacket loss. (CEC-400-2008-004-CMF)
% Combustion Eff = Energy to HX/Total Fuel Input
Note: "Combustion Efficiency does not include losses from the boiler jacket. It is strictly a measure of the energy transferred from the products of combustion." (CEC-400-2008-017-CMF-Rev I)

2.2.5.3 Inputs

Inputs for Replace Process Boiler(s)

Prior to selecting “Natural Gas Boiler/Water Heater,” the user is required to specify whether the proposed project is one of the following: Retrofit (same load/production) or Retrofit (increased load/production).

From the Pull-down menu select “Replace Process Boiler(s)” from the three following options:

- Replace Process Boiler(s),
- Add Boiler Economizer,
- Replace Space Heating Boiler(s)

Table 5-2. Input Sheet for “Replace Process Boiler”

Input Name	Type	Sheet	Description / Purpose
Application	Pull-down	1	Replace process boiler(s)
Manufacturer	Fill in	1	From existing boiler nameplate/proposed boiler spec
Model #	Fill in	1	From existing boiler nameplate/proposed boiler spec
Number of Boilers	Fill in	1	Enter number of existing and proposed process boilers
Input (Btu/hr)	Fill in	1	From existing boiler nameplate/proposed boiler spec
Custom built	Check box	1	Check only if the boiler was custom built for that application
Output (Btu/hr)	Fill in	1	From existing boiler nameplate/proposed boiler spec. In some instances the output of a boiler may be rated in “Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor of 33,476 Btu/hr per BHP and inserted in the output box. Output cannot be greater than the input.
Boiler Output or Service Duty	Pull-down	1	Select steam or hot water
Steam pressure (psig)	Fill in	1	Specify the pressure in psig
Design Supply Water Temperature (Deg F)	Fill in	1	Specify supply water temperature in °F
Design Return Water Temperature (Deg F)	Fill in	1	Specify return water temperature in °F
Boiler efficiency (%) AFUE	Fill in	1	Specify boiler efficiency in AFUE from the manufacturer specs or form the boiler

			nameplate. Minimum efficiencies are required as indicated in Table 5.
Average Annual Load (%)	Fill in	2	Specify percentage of full load during operating hours. This element should come from load calculations or short term monitoring and regression analysis
Annual Operating hours	Fill in	2	Specify the amount of working hours

Tips on the inputs
Boiler Output – Minimum boiler output is typically 60 to 90% of the boiler input. In some instances the boiler's output maybe rated in Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor 33,476 Btu/hr per BHP and inserted in the output field.
Steam Pressure – Less than 400 psig.
Water Supply and Return Temperatures (^{0}F) – Typically in the range of 100 to 200 ^{0}F. This parameter is for information purposes only.
Boiler Efficiency – The minimum for the existing boiler might be entered as 50%.   The calculations only consider efficiency equal to or greater than Title 24. (Table 7).
Average Annual Load (%) – The input is % and it might range from 5 to 90%. One hundred percent would be considered unusual. Typically boilers do not operate at full load over their entire operating schedule. The project sponsor shall estimate the "Average Annual Load" on the boiler(s) as a percent of boiler(s) full load. The project sponsor will provide, along with the application, data (e.g. steam flow data, gas meter data, etc.) backing up the estimate made for the Customized Calculation application.

Multiple Boilers Replacing a Single Boiler – Indicate the number of proposed boilers in the quantity field. The proposed boilers must be identical in energy output and efficiency. Enter the value for one of the multiple boilers in the proposed boiler Input (Btu/hr) and Output (Btu/hr) sections. "Average Annual Load" and "Operating Hours" for multiple boilers should be calculated as the average of all boilers. If the proposed boilers are not identical in output energy and efficiency, separate software runs will have to be performed.

Single Boiler Replacing Multiple Boilers – Indicate the number of existing boilers in the quantity field. The existing boilers must be identical in energy output and efficiency. Enter the value for a single boiler in the existing boiler Input (Btu/hr) and Output (Btu/hr) sections. If the existing boilers are not identical in output energy and efficiency, separate software runs will have to be performed.

Multiple Boilers Replacing Multiple Boilers – Indicate the number of proposed and existing boilers in the quantity fields. The proposed boilers must be identical in energy output and efficiency. Enter the value for one of the multiple boilers in the proposed Input (Btu/hr) and Output (Btu/hr) fields. If the existing boilers are not of the same output and efficiency, use the average efficiency, input energy rating, and the output energy rating. This information should be entered as a single unit not the sum of all the units.

2.2.5.3.2 Inputs for Add Boiler Economizer
Prior to selecting "Natural Gas Boiler/Water Heater," the user must specify Retrofit (same load/production). The economizer measure is not available for Retrofit (increased load/production).

From the Pull-down menu select "Add Boiler Economizer" from the three following options:
- Replace Process Boiler(s),

- Add Boiler Economizer,
- Replace Space Heating Boiler(s)

Table 5-3. Input Sheet for "Add Boiler Economizer"

Input Name	Type	Sheet	Description / Purpose
Application	Pull-down	1	Add Boiler Economizer
Manufacturer	Fill in	1	From existing boiler nameplate/proposed boiler spec
Model #	Fill in	1	From existing boiler nameplate/proposed
Input (Btu/hr)	Fill in	1	From existing boiler nameplate
Custom built	Check box	1	Check only if the boiler was custom built for that application
Output (Btu/hr)	Fill in	1	From existing boiler nameplate. In some instances the output of a boiler may be rated in "Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor of 33,476 Btu/hr per BHP and inserted in the output box. Output cannot be greater than the input.
Boiler Output or Service Duty	Pull-down	1	Select steam or hot water
Steam pressure (psig)	Fill in	1	Specify the pressure in psig
Design Supply Water Temperature (Deg F	Fill in	1	Specify supply water temperature in °F
Design Return Water Temperature (Deg F)	Fill in	1	Specify return water temperature in °F
Flue Gas Temperature (Deg F) Entering and Leaving the Economizer	Fill in	2	Based on calculation or vendor specifications
Water Temperature (Deg F) Entering and Leaving the Economizer	Fill in	2	Based on calculation or vendor specifications
Flue Gas Flow (lbs/hr)	Fill in	2	Based on boiler specs
Water Flow (gpm)	Fill in	2	Based on calculation or vendor specifications. This is the flow of make up or returning water that goes through the economizer
Energy Transferred from flue gas to water (Btu/hr)	Fill in	2	Based on calculations or vendor specifications
Return Water Temperature (Deg F)	Fill in	1	Specify hot water system return water temperature in °F

Energy Transferred from flue gas to water (Btu/hr)	Fill in	2	Based on calculations or vendor specifications
Average Annual Load (%)	Fill in	2	Specify percentage of full load during operating hours. This element should come from load calculations or short term monitoring and regression analysis
Annual Operating hours	Fill in	1	Specify the amount of working hours

Tips on the inputs
Boiler Output – Minimum boiler output is typically 60 to 90% of the boiler input. In some instances the boiler's output maybe rated in Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor 33,476 Btu/hr per BHP and inserted in the output field.
Steam Pressure – Less than 400 psig.
Water Supply and Return Temperatures (^{0}F) – Typically in the range of 100 to 200 ^{0}F. This parameter is for information purposes only.
Boiler Efficiency – The minimum for the existing boiler might be entered as 50%. The calculations only consider efficiency equal to or greater than Title 24. (Table 7).
Flue Gas Temperature (Deg F) entering and leaving economizer – Can range from 260 to 2,560 degrees F.
Water Temperature (Deg F) entering and leaving economizer – Typically in the range of 100 to 200 ^{0}F. This parameter is for information purposes only.
Flue Gas Flow (lbs/hr) through economizer – No range required, as this parameter is for information purposes only.
Water Flow (gpm) through economizer – No range required, as this parameter is for information purposes only.
Energy Transferred from gas to water (Btu/hr) – No range required, as this parameter is for information purposes only.
Average Annual Load (%) – The input is % and it might range from 5 to 90%. One hundred percent would be considered unusual. Typically boilers do not operate at full load over their entire operating schedule. The project sponsor shall estimate the "Average Annual Load" on the boiler(s) as a percent of boiler(s) full load. The project sponsor will provide, along with the application, data (e.g. steam flow data, gas meter data, etc.) backing up the estimate made for the CCT application.

2.2.5.3.3 Inputs for Replace Space Heating Boiler(s)
Prior to selecting "Natural Gas Boiler/Water Heater," the user is required to specify whether the proposed project is one of the following: Retrofit (same load/production) or Retrofit (increased load/production).

From the Pull-down menu select "Replace Space Heating Boiler(s)" from the following three options:
- Replace process boiler(s),
- Add Boiler Economizer,
- Replace Space Heating Boiler(s)

Table 5-4. Input Sheet for "Replace Space Heating Boiler"

Input Name	Type	Sheet	Description / Purpose
Application	Pull-down	1	Replace space heating boiler(s)
Manufacturer	Fill in	1	From existing boiler nameplate/proposed boiler spec
Model #	Fill in	1	From existing boiler nameplate/proposed boiler spec
Number of Boilers	Fill in	1	Enter number of existing and proposed boilers
Input (Btu/hr)	Fill in	1	From existing boiler nameplate/proposed boiler spec
Custom built	Check box	1	Check only if the boiler was custom built for that application
Output (Btu/hr)	Fill in	1	From existing boiler nameplate/proposed boiler spec. In some instances the output of a boiler may be rated in "Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor of 33,476 Btu/hr per BHP and inserted in the output box. Output cannot be greater than the input.
Boiler Output or Service Duty	Pull-down	1	Select steam or hot water
Steam pressure (psig)	Fill in	1	Specify the pressure in psig
Supply Water Temperature (Deg F	Fill in	1	Specify supply water temperature in °F
Return Water Temperature (Deg F)	Fill in	1	Specify return water temperature in °F
Boiler efficiency (%) AFUE	Fill in	1	Specify boiler efficiency in AFUE from the manufacturer specs or from the boiler nameplate. Minimum efficiencies are required as indicated in Table 5-1.
Boiler efficiency (%) AFUE	Fill in	1	Specify boiler efficiency in AFUE from the manufacturer specs or from the boiler nameplate. Minimum efficiencies are required as indicated in Table 5-1.
Building Type	Pull-down	2	Select 1 of 5 building types: Education, Retail, Office, Health/Medical, and Lodging
Location (City)	Pull-down	2	Select the city where the building is located. The city selected will determine the CEC climate zone
Year Built	Pull-down	2	Select year (range) building was built. The choices are: pre-1978, 1978 to 1992, 1993 to 2001, 2002 to 2005, and after 2005.

Conditioned Area (sq. ft.)	Fill in	2	Specify the floor area of the heated space in ft^2.
Total Building Area (sq. ft.)	Fill in	2	Specify the floor area of the building in ft^2
Number of floors	Fill in	2	Specify the number of floors in the building
24 hour operation	Pull-down	2	Select yes or no
Operating profile type	Pull-down	2	Select typical or custom
Air conditioning system operating hours	Pull-down	2	Specify the start and stop time for the heating system on a daily basis.

Tips on the inputs

Boiler Output – Minimum boiler output is typically 60% to 90% of the boiler input. In some instances the boiler's output maybe rated in Boiler Horsepower (BHP). BHP should be converted to Btu/hr by the factor 33,476 Btu/hr per BHP and inserted in the output field.

Steam Pressure – No range required, as this parameter is for information purposes only.

Supply and Return Temperatures (^{0}F) – In the range of 100 to 200 ^{0}F. This parameter is for information purposes only.

Boiler Efficiency – The minimum for the existing boiler might be entered as 50%. The calculations only consider efficiency equal to or greater than Title 24. (Table 5-1).

Conditioned Area and Total Building Area (sq. ft.) – The software will handle all sizes of buildings. Recognize extremely small or large buildings energy may deviate from what is considered reasonable answers. No work has been done to set boundaries of reasonableness.

Air conditioning system operating hours – This is the start and stop time for the heating system and is in the range of 0 to 24 for each day, Monday through Sunday.

2.2.5.4 Output

Table 5-5. Output Sheet for "Replace Process Boiler"

Output Name	Sheet	Description / Purpose
Baseline Unit – Therms/yr (input)	3	Baseline usage
Proposed Unit – Therms/yr (input)	3	Proposed usage
Savings – Therms/yr (input)	3	Therms savings
Incentive (@ $1.00 Therm/yr)	3	Dollar incentive amount

Table 5-6. Output Sheet for "Add Boiler Economizer"

Output Name	Sheet	Description / Purpose
Baseline Unit – Therms/yr (input)	3	Baseline usage
Proposed Unit – Therms/yr (input)	3	Proposed usage
Savings – Therms/yr (input)	3	Therms savings
Incentive (@ $1.00 Therm/yr)	3	Dollar incentive amount

Table 5-7. Output Sheet for "Replace Space Heating Boiler"

Output Name	Sheet	Description / Purpose
Baseline Unit – Therms/yr (input)	3	Baseline usage
Proposed Unit – Therms/yr (input)	3	Proposed usage
Savings – Therms/yr (input)	3	Therms savings
Incentive (@ $1.00 Therm/yr)	3	Dollar incentive amount

2.2.5.5 Energy Savings Explanation

Savings are calculated by the software by subtracting the proposed usage Therms from the baseline usage Therms. For the "Replace Process Boiler(s)" application the main parameters are: boiler output, boiler efficiency, average annual load, and annual operating hours. For the "Add Boiler Economizer" application the savings are calculated based on the temperatures of the flue gas and the water temperature rise. Industry tables are used to evaluate the efficiency gain based on the temperatures of the two fluids. For the "Replace Space Heating Boiler" application the savings are calculated using the Engage software simulation tool which is based on DOE-2 software.

2.2.6 Gas - Thermal Oxidizer Upgrades (PG&E and SDG&E Only)

2.2.6.1 Description

One method used to destroy the volatile organic compounds (VOC) in a contaminated airstreams is to oxidize, (burn) the solvents with high temperature, combustion-based systems. Thermal oxidizers work by converting hydrocarbons into carbon dioxide and water. There are five main types of combustion based VOC emission control devices: Thermal Oxidizers (with no heat recovery), Catalytic Oxidizers, Recuperative Thermal Oxidizers, Regenerative Thermal Oxidizers (RTO), and Regenerative Catalytic Oxidizers (RCO).

This tool covers retrofits involving the replacement of an existing thermal oxidizer with a more efficient oxidizer. It also covers measures involving the addition of a heat exchanger for heat recovery purposes (recuperative) on an existing thermal oxidation system. The tool is intended for oxidization systems that are used to destroy low concentration VOC waste streams (less than 25% Lower Flammable Limit). Examples of processes that create these contaminated airstreams are as follows:

- Coating Operations
- Paint Booths
- Textile Finishing
- Packaging
- Pulp and Paper
- Drying
- Certain Chemical Processes
- Computer Chip Manufacturing (Semiconductors)
- Printing Lines
- Textile Converters
- Solvent Cleaning
- Food Processing and Baking
- Ventilation Odors
- Rendering Plants
- Sewage Treatment Plants

Significant energy savings can be achieved by replacing an existing thermal oxidizer, catalytic oxidizer, or recuperative oxidizer with a regenerative thermal oxidizer. For processes with the appropriate waste gas stream a regenerative thermal oxidizer retrofit can save significant electric (reduced combustion fan usage) and natural gas (reduced supplemental fuel requirements) usage. The amount of savings is highly dependent on the characteristics of process, existing equipment type, and proposed equipment type.

This tool does not cover oxidizers that are used to destroy contaminated inert gas streams, rich gas streams, or contaminated air streams with an LFL (previously LEL- lower explosive limit) greater than 25%.

2.2.6.2 Appropriate Use of the Tool –Program Policy

This tool covers retrofits involving the replacement of an existing thermal oxidizer with a more efficient oxidizer. It also covers measures involving the addition of a heat exchanger for heat recovery purposes (recuperative) on an existing thermal oxidation system. The tool is intended for oxidization systems that are used to destroy low concentration VOC waste streams. This tool does not cover oxidizers that are used to destroy contaminated inert gas streams, rich gas streams, or contaminated air streams with greater than 25% Lower Flammable Limit (LFL).

2.2.6.3 Inputs

The following lists describe the input information necessary to estimate the energy savings and incentives. Because of the nature of the air quality requirements associated with Thermal Oxidizers much of this information is readily available from the permitting processes.

Table 6-1. General Inputs

Input Name	Type	Sheet	Description/Purpose
Waste Gas Stream			
Average VOC Concentration (LFL)	Fill in	1	Enter the Average VOC Concentration as expressed in terms of lower flammable limit (LFL) of the VOCs in the waste gas. The LFL (previously referred to as LEL - lower explosive limit) of an organic compound is its minimum concentration in air that will sustain combustion. The Average VOC Concentration is the actual volumetric concentration value divided by the theoretical volume concentration of the combined gases. This input is required if Average VOC Loading and Average VOC Heat of Combustion are not available.
Average VOC Loading (lb/hr)	Fill in	1	Enter the Average VOC Loading as the mass (weight) of the waste gas produced per hour. Typically this information can be obtained from the Air Quality permit emission information. This input is required if Average VOC Concentration is not available.
Average VOC Heat of Combustion (Btu/hr)	Fill in	1	Enter the average VOC heat of combustion as the heat content of the VOCs in the waste gas. Typically, this information can be obtained from the Air Quality permit emission information. This input is required if Average VOC Concentration is not available.
Average Volumetric Flow Rate (SCFM)	Fill in	1	Enter the average volumetric flow rate of the waste gas at standard conditions.
Average Entering Temperature (°F)	Fill in	1	Enter the average temperature of the waste gas during VOC destruction. This value should not average the ambient temperature when the oxidizer in operating at idle (unit at operating temperature but no oxidation occurring).
Destruction Efficiency (%)	Fill in	1	Enter the required VOC Destruction Efficiency (sometimes referred to as Destruction Removal Efficiency - DRE) in terms of a percentage. This value is mandated by the governing air quality district.
Site			
City	Pull-down	1	From the pull-down menu, select a city that best represents the site location. Site elevation is determined from ASHRAE weather data. Average ambient temperature is calculated based on the 16 weather zones from California Energy Commission's CTZ weather data.
Annual Operating Hours (VOC Destruction)	Fill in	1	Enter the total number of hours in the year that the oxidizer operates during VOC Destruction.
Annual Operating Hours (Idle)	Fill in	1	Enter the total number of hours in the year that the oxidizer operates at full temperature but with no waste gas flowing through the system.
Measure Type	Pull-down	1	Select either Oxidizer Replacement or Auxiliary Heat Exchanger Installation.

Table 6-2. Oxidizer Replacement Inputs

Existing/Proposed Oxidizer Characteristics			
Manufacturer	Fill in	2-3	Enter the manufacturer of the Oxidizer.
Model Number	Fill in	2-3	Enter the model number of the Oxidizer.
Serial Number	Fill in	2-3	Enter the Serial number of the Oxidizer.
Oxidizer Type	Pull-down	2-3	From the pull-down menu, select the appropriate Oxidizer Type: Thermal Oxidizer (no heat recovery); Recuperative Catalytic Oxidizer (no heat recovery); Recuperative Thermal Oxidizer; Regenerative Thermal Oxidizer (RTO); Regenerative Catalytic Oxidizer (RCO).
Thermal Efficiency (%)	Fill in	2-3	For Oxidizers with heat recovery, enter a thermal efficiency of the integral heat exchanger in terms of a percentage. For Thermal Oxidizer (no heat recovery) this field will not be available.
Combustion Chamber Air Temp (°F)	Fill in	2-3	Enter the set point temperature that the oxidizer maintains in the combustion chamber during operation. This value is mandated by the governing air quality district.
Existing/Proposed Oxidation (System) Fan			
Oxidation Airflow Resistance (Flange to Flange Pressure Drop – Inches W.C.)	Fill in	2-3	Enter the total pressure drop across the oxidation side of the oxidizer in inches of H_2O.
Oxidation (System) Fan Motor HP	Pull-down	2-3	Enter the rated horsepower of the fan motor on the oxidation side of the oxidizer. Typically this information can be found on the motor nameplate.
Oxidation (System) Fan Motor Efficiency (%)	Fill in	2-3	This entry is automatically entered based on the selected Letter Code (see below) unless N/A is chosen. If N/A is chosen then enter the rated efficiency of the fan motor on the oxidation side of the oxidizer.
Letter Code	Pull-down	2-3	The fan motor efficiency as expressed by letter code. Typically, this information can be found on the motor nameplate.
Existing/Proposed Combustion Blower			
Combustion Blower Average Air Flow Rate (SCFM)	Fill in	2-3	Enter the average volumetric flow rate of the combustion air at standard conditions.
Combustion Blower Motor HP	Pull-down	2-3	Enter the rated horsepower of the fan motor on the combustion side of the oxidizer. Typically, this information can be found on the motor nameplate.
Combustion Blower Motor Efficiency (%)	Fill in	2-3	This entry is automatically entered based on the selected Letter Code (see below) unless N/A is chosen. If N/A is chosen then enter the rated efficiency of the fan motor on the oxidation side of the oxidizer.
Letter Code	Pull-down	2-3	The fan motor efficiency as expressed by letter code. Typically, this information can be found on the motor nameplate.

Combustion blower fan operates during idle	Checkbox	2-3	Check this box if the combustion fan runs during Oxidizer idle operation.
Combustion blower fan operates during VOC destruction	Checkbox	2-3	Check this box if the combustion fan runs during Oxidizer VOC destruction operation.
Combustion blower fan draws outside air	Checkbox	2-3	Check this box if the combustion fan draws fresh outside air. Leave this box unchecked if the combustion fan draws air/fuel mixture directly from the VOC laden waste stream.

Table 6-3. Auxiliary Heat Exchanger Installation Inputs

Existing Oxidizer Characteristics			
Manufacturer	Fill in	2	Enter the manufacturer of the Oxidizer.
Model Number	Fill in	2	Enter the model number of the Oxidizer.
Serial Number	Fill in	2	Enter the Serial number of the Oxidizer.
Average Combustion Chamber Temperature (°F)	Fill in	2	Enter the set point temperature that the oxidizer maintains in the combustion chamber during operation. This value is mandated by the governing air quality district.
Exhaust Gas Temperature During VOC Destruction (°F)	Fill in	2	Enter the Average exhaust gas temperature during operation.
Oxidation (System) Fan Motor Efficiency (%)	Pull-down	2	This entry is automatically entered based on the selected Letter Code (see below) unless N/A is chosen. If N/A is chosen then enter the rated efficiency of the fan motor on the oxidation side of the oxidizer.
Letter Code	Fill in	2	The fan motor efficiency as expressed by letter code. Typically, this information can be found on the motor nameplate.
Oxidation Airflow Resistance (Flange to Flange Pressure Drop – Inches W.C.)	Fill in	2	Enter the total pressure drop across the oxidation side of the oxidizer in inches of H2O.
Proposed Heat Exchanger			
Manufacturer	Fill in	2	Enter the manufacturer of the heat exchanger.
Model Number	Fill in	2	Enter the model number of the heat exchanger.
Effectiveness (%)	Fill in	2	Enter the rated effectiveness of the proposed heat exchanger. Typically, this information is found in manufacturer's specifications.
Heat Exchanger Pressure Drop (Inches W.C.)	Fill in	2	Enter the rated pressure drop in inches w.c. Typically, this information is found in manufacturer's specifications.

2.2.6.4 Output

The thermal and electrical usages and the savings for the existing system and the proposed system are displayed on this screen. The incentive is calculated from these values.

Table 6-4. Output

Oxidizer Replacement	
Therms/yr (Existing/Proposed/Savings)	This value represents the estimated annual fuel usage.
kW (Existing/Proposed/Savings)	This value represents the estimated average annual electrical demand.
kWh/yr (Existing/Proposed/Savings)	This value represents the annual electrical usage.
Incentive (Therms/yr)	This value represents the natural gas incentive based on the annual fuel savings.
Incentive (kWh/yr)	This value represents the electrical incentive based on the annual electric usage savings.
Heat Exchanger Installation	
Therms/yr (Existing/Proposed/Savings)	This value represents the estimated annual fuel usage.
Increased Fan Electrical Consumption (equivalent therms)	This value represents the increased fan usage for the added pressure drop associated with a heat exchanger installation. The value is converted into equivalent therms. The program uses a 10:1 electric to fuel conversion ratio.
Therms/yr (Net Savings)	This value represents the fuel savings minus the increased fan usage (equivalent therms) for heat exchanger installations.
Incentive (Therms/yr)	This value represents the natural gas incentive based on the annual fuel savings.

2.2.6.5 Energy Savings Explanation

The energy saving estimating tool for thermal oxidizer retrofits uses simplified calculation procedures that are based on industry standards. These procedures capitalize on the fact that the waste gas stream consists primarily of air. An average density and mean heat capacity of the waste gas stream are determined based on this information. Thermodynamic equations are utilized to calculate the heat required to raise the waste gas to combustion temperature, the heat released from the VOCs, the radiated heat losses, and ultimately the additional heat required from natural gas. The general heat equations are as follows:

$$Q_{FUEL} = Q_{WASTEGAS} + Q_{RADLOSS} - Q_{VOC}$$

Where:
$Q_{WASTEGAS}$ = Flow scfm * 60 min/hr * Density lb/scf * Heat Capacity BTU/lb°F * Δ°F
$Q_{RADLOSS} = Q_{WASTEGAS}$ * % Heat Loss (based on oxidizer type)
Q_{VOC} = VOC Loading lb/hr * VOC Heat of Combustion BTU/lb
-or-
Q_{VOC} = Flow scfm * 60 min/hr * Density lb/scf * Heat Capacity BTU/lb°F * (VOC Concentration LFL * 25 °F)

Increased electrical usage is calculated using basic fan affinity laws. Pressure differentials, efficiencies and air flow are used as inputs. The general fan energy equation is as follows:

$$kW_{FAN} = BHP_{FAN} * 0.7457;$$
$$BHP_{FAN} = (\text{Flow acfm} * \Delta \text{ Pressure inches w.c.}) / (6{,}356 * \eta_{FAN} * \eta_{MOTOR})$$

The energy savings estimating tool for the heat exchanger installation utilize calculations based on standard heat balance and thermal efficiency equations. Mass flow and average temperature readings are used as inputs. The basic heat equations are as follows:

Heat Exchanger Effectiveness (where mass flow in = mass flow out) -

$$\varepsilon = (T_{CO} - T_{CI}) / (T_{HI} - T_{CI}) \ \& \ \varepsilon = (T_{HI} - T_{HO}) / (T_{HI} - T_{CI})$$

Oxidizer Thermal Efficiency (where mass flow in = mass flow out) –

$$\eta = (T_{COMBUSTION} - T_{EXHAUST}) / (T_{COMBUSTION} - T_{WASTEGAS})$$

2.2.6.5.1 Intermediate Calculations

Intermediate Calculations are provided for oxidizer retrofits in order to display the heat balance equations. These values are displayed for the existing and proposed systems during idle and VOC destruction operations. The field elements are described below:

- **Heat Required –** This value represents the estimated heat required to raise the waste gas stream to combustion chamber temperature.
- **Heat Loss –** This value represents the estimated heat radiant loss through the oxidizer walls.
- **Heat Released –** This value represents the estimated heat released through the oxidization of the VOCs in the waste gas stream.
- **Auxiliary Heat Required -** This value represents the estimated auxiliary heat required, beyond that released through VOC oxidation, in order to achieve the total Heat Required. Natural gas usage (therms) required during operation can be derived from this value.

CPUC Defined Peak Demand Savings

The CCT software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant the equipment operates during the defined peak period.

2.2.7 Gas – Steam Trap Replacement (PG&E and SDG&E Only)

2.2.7.1 Description

Steam traps are automatic valves used to remove air, non-condensable gases and condensate from steam systems. Proper steam trap operation is crucial to efficient plant operation since failure in either an open or closed position can reduce plant efficiency or capacity. Failure in a closed position can result in a buildup of condensate, which can reduce the flow capacity of steam lines and the thermal capacity of heat transfer equipment. Likewise a buildup of non-condensable gases can reduce steam pressure and temperature and may also reduce the thermal capacity of heat transfer equipment. Steam trap failure in an open position results in steam passing directly through the steam trap into the condensate drain. When this occurs the steam provides none of the intended heating service and some or all of the steam energy may be lost. Recovery systems that direct the condensate drains back to the boiler via a feedwater heater, such as a deaerator can help reduce this energy loss.

This CCT tool is used to estimate the energy savings and associated incentive for replacement of a defective steam trap. To qualify, the steam trap must have previously been identified in a recent vendor steam trap survey as having failed in the **open** position. Steam trap vendors can survey the steam traps in a facility, cataloging the important data for each trap. These data include the type and size of the trap along with the inlet steam conditions, condensate conditions and the operating status.

2.2.7.2 Appropriate Use of the Tool – Program Policy

The CCT Steam Trap Savings tool may only be used for traps that have previously been confirmed as having failed in the open position and a copy of a recent vendor steam trap must be provided to the Utility Administrator with the Project Application. Only trap replacement with a new trap qualifies: repair or rebuilding of defective traps does not qualify for an incentive under the existing program rules. This measure only applies to retrofit applications (new construction and added load applications are not covered).
Applicable Types of Equipment
The estimation tool may be used to estimate savings associated with replacement of any of the four most common types of steam traps: thermodynamic, thermostatic, inverted bucket and float/thermostatic.

2.2.7.3 Tool Inputs

Estimation tool inputs are entered via two inputs screens, the first of which, the Steam Trap Measures List (Sheet 1), displays the data in tabular form. User entry of the various inputs is accomplished using the "Edit Steam Trap Details" button (located on Sheet 1) and the Steam Trap Details screen. Table 1 summarizes the various inputs that are required.

cv -1. Estimation Tool Inputs

Input Name	Type	Sheet	Description/Purpose
Line Item	Pull-Down	1	User has the option to define up to 20
Steam Trap Type	Pull-Down	1 & 2	The type of steam trap involved (thermodynamic, thermostatic, inverted bucket, float/thermostatic) – for inspection purposes
Edit Steam Trap Details	Macro	1	Button to access Sheet 2, where specific Steam Trap Information is inputted.
Copy Steam Trap	Macro	1	Copies the details of an existing Steam Trap that was inputted by the user.

Steam Trap Information			
Location	Fill-In	2	The physical location of the steam trap for purposes of locating the trap at the time of inspection.
Number of Traps	Fill-In	2	The number of leaking steam traps of this type with the same steam conditions.
Boiler Effcy (%)	Fill-In	2	The thermal efficiency of the boiler that replaces the steam lost via the faulty trap.
Makeup Water Temp (DegF)	Fill-In	2	The temperature of the boiler makeup water – used to estimate make up water enthalpy (typically 55 to 65 DegF).
Total Retrofit Cost ($)	Fill-In	2	Total replacement cost of all of the steam traps of this type and size.
Steam Press. (psig)	Fill-In	2	The pressure (gauge) of the steam flowing in the line served by the steam trap.
Steam System Annual Op Hours	Fill-In	2	The total number of hours that the steam system operates annually – used to estimate annual energy savings.
Steam Temp. (Deg F), optional	Fill-In	2	The temperature of the steam flowing in the line served by the steam trap. This field is optional when using the calculated steam properties option. If left blank, the steam properties will be calculated automatically based on the saturation temperature.
Steam Operating Enthalpy Properties			
Select Steam Property Entry Method	Pull-Down	2	Steam and makeup water properties can be entered manually using steam table values or the estimation tool will calculate* the needed values automatically based on the steam and makeup water parameters entered above.
Steam Enthalpy (btu/lb)	Fill-In	2	The enthalpy of the steam flowing in the steam line served by the steam trap – optional input that should be entered if the steam conditions do not correspond to saturated conditions. Only applies if ‘Manual – Steam Tables’ is selected as the ‘Steam Property Entry Method’
Makeup Water Enthalpy (btu/lb)	Fill-In	2	The enthalpy of the makeup water – optional input that is otherwise calculated by software. Only applies if ‘Manual – Steam Tables’ is selected as the ‘Steam Property Entry Method’
Calculate	Macro	2	Macro calculates steam and make-up water enthalpy based on ‘Steam Pressure and Makeup Water Temperature’ inputted above.
Steam Trap Information			
Manufacturer	Fill-In	2	Manufacturer of the existing steam trap – for inspection purposes
Model	Fill-In	2	Model of the existing steam trap – for inspection purposes
Line Size (inches)	Fill-In	2	Steam trap inlet and outlet fitting size - used in steam flow / energy loss calculations
Orifice Size (inches)	Fill-In	2	Steam trap orifice size from manufacturer’s data - used in steam flow calculation
Steam Trap Leakage Survey			

Leakage Rate (lbs/hr)	Fill-In	2	Estimated steam loss rate in lbs/hr for a specific trap as noted in the vendor survey – used as a comparison check against the calculated value.
Condensate Recovered?	Pull-down	2	Select YES if the output of the steam trap is collected and returned to the steam system for recovery of thermal energy. Select NO if the trap drain is vented to atmosphere or if the condensate is recovered without recovery of thermal energy.
Source of Steam Trap Survey	Fill-In	2	Name of vendor or individual/affiliation that performed the steam trap leakage survey
Date of Survey	Fill-In	2	Date of the steam trap survey that identified the steam trap as having failed in the open position

** -- Using an algorithm based on 1967 ASME steam tables.*

2.2.7.4 Output

The following table and associated figure describes the CCT tool outputs.

Table 7-2. Measure Therm Savings & Incentive

Name	Description / Purpose
For Each Line in the Measure List:	
Estimated Leakage Rate (lbs/hr)	Estimated leakage rate for each trap included in this line item
Total Leakage Rate (lbs/hr)	Total estimated leakage rate for all traps included in this line item
Annual Therms Savings	Estimated annual energy loss for all traps included in this line item.
Incentive Rate	Applicable incentive rate
Incentive Units	Applicable incentive units ($/therm)
Energy Incentive Amount ($)	Total incentive amount for all traps included in this line item.
Application Totals:	
Total Therms Savings	Total project energy savings (all line items)
Total Incentive Amount ($)	Total project incentive amount (all line items)

2.2.7.5 Energy Savings Explanation

Annual energy savings is calculated by subtracting the proposed energy usage from the baseline usage. Incentive values are then calculated as the product of the incentive rate ($1.0 / therm) and the estimated energy savings value.

Annual Savings (therms) = Baseline Therms – Proposed Therms
Incentive Amount = Annual Savings (therms) * Incentive Rate ($/therm)

Unlike other savings measures, for steam traps no attempt is made to estimate the actual baseline or "normal" energy use. Instead, the baseline energy use of the existing trap is assumed equal to the energy loss associated with steam passing directly through the defective trap. Similarly, the proposed energy use of a new trap (no leakage) is assumed to be zero. In other words, the energy savings are equal to the abnormal energy loss associated with the defective trap. No attempt is made to quantify steam trap energy loss for a normally functioning trap under the assumption that this "baseline" energy loss would remain the same for the replacement trap compared to the defective steam trap.

The energy savings calculation is therefore the product of the mass flow of the escaping steam and the equivalent energy of the fuel needed by the central boiler to bring the boiler makeup water to the energy level of the escaping steam. These calculations are based on calculations used in the Department of Energy's Steam Challenge program.

2.2.8 Lighting - Lighting Retrofit

2.2.8.1 Description

Lighting systems are found throughout various facilities both internally and externally and are used for illumination purposes of all types. As such, lighting systems vary in the equipment that is employed. Replacing antiquated lighting systems with higher efficiency equipment provides significant opportunities for energy savings. The Customized Calculation Tool relies heavily on the incorporated Table of Standard Fixture Wattages that is included as Appendix B of the Customized Offering Procedures Manual and included at the end of this document.

The Customized Calculation Tool addresses the replacement of existing lamps and fixtures with units of higher efficiency. Proposed equipment for T8 and T5 linear fluorescent lighting upgrades must meet the Color Rendering Index and Lamp Life specifications listed in Table 1-2, Section 1.4 for definition. LED fixtures must be specifically listed in or comply with the testing standards and requirements described in Appendix I. Table I1 includes EnergyStar and Utility approved LED fixtures. LED lamp-only replacements are not eligible.

De-lamping measures are eligible only as an integral part of a lighting efficiency upgrade. The removal of bulbs and/or the disabling of fixtures alone are not eligible for the program. Lighting retrofits that include the retention of existing ballasts are eligible only if the ballasts have at least five year of useful life remaining. The Utilities may require the Project Sponsor to certify the remaining useful life of the existing ballast.

Multiple line items (i.e. groupings of similar fixtures and similar usage patterns) can be entered as a single measure. Lighting fixtures and the associated savings are grouped by usage. Usage groups may include offices, restrooms, hallways/stairs, display lights, sales floor, process areas, and parking areas or structures. Inputs for each usage group should include a brief description of the area affected by the lighting, as well as specifications for both existing and new equipment. Pull-down menus are used to simplify this process, but input of custom fixtures is also supported.

If a particular lamp/fixture/ballast combination is not contained within the pull-down menus, N/A# will appear in the Watts/Fixture column and you must provide the necessary specifications by including a copy of the manufacturer's specification sheet along with the submittal documents. For measures involving partial delamping (e.g., removing two lamps from a three-lamp fixture), spot measurements used to verify fixture loads must be input into the Proposed Equipment—Manufacturer's Data/Spot Measurements table.
For lighting measures you may estimate the operating hours, but you should be able to support the estimate. Typically proposed operating hours should not differ from existing operating hours.

2.2.8.2 Appropriate Use of the Tool –Program Policy

The Lighting Retrofit tool can be used for lighting measures listed on the Table of Standard Fixture Wattages, or custom fixtures if appropriate manufacturing specifications are entered by the user.

2.2.8.3 Inputs

User inputs can be divided into two basic categories - measure information and equipment specifications (existing/proposed).

Table 8-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Line Item	Pull-down	1	Select a unique line item number for each lighting retrofit, consisting of identical equipment, within the same usage group.
Usage Group	Fill in	1	Enter an identifying name for a grouping of fixtures that have similar operating characteristics (i.e. they are turned off and on at the same time). A usage group may have multiple line items containing sub-groupings of identical fixture retrofits.
Area Description	Fill in	1	Enter a short description of the area of the proposed fixture retrofit (e.g. Warehouse, Building 123, etc.)
Existing/Proposed			
Line Item	Pull-down	2 and 3	Select the appropriate line item number for each lighting retrofit.
Number of Fixtures	Fill in	2 and 3	Enter the number of existing/proposed fixtures.
Hours of Operation	Fill in	2 and 3	Enter the number of annual hours the existing fixtures operate. The proposed fixture operating hours are the same as the existing hours and cannot be modified.
Fixture Type	Pull-down	2 and 3	Choose “Standard” if the fixture is identified in the Standard Table of Fixture Wattages in Appendix B. Choose “Custom” if the fixture is not identified on this table
Lamp Type	Pull-down	2 and 3	Select the lamp type (i.e. T12 Fluorescent, HPS, Incandescent, etc.)
Tube Length	Pull-down	2 and 3	For tube fixtures, select the tube length in inches. For non-tube fixtures select N/A.
Ballast Type	Pull-down	2 and 3	Select the ballast type for fixtures equipped with ballasts (i.e. Magnetic, Electronic, etc.). Select N/A for non-ballast fixtures. The ballasts types are specified in Appendix B.
Lamps/Fixture	Pull-down	2 and 3	Select the number of lamps per fixture.
Watts/Lamps	Pull-down	2 and 3	Select the nominal watts per lamp.

2.2.8.4 Output

Once all necessary input information has been gathered, the Lighting Retrofit Tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The Lighting Retrofit Tool outputs are described below.

Table 8-2. Output

Output Name	Type	Sheet	Description / Purpose
Existing Equipment, kW	Result	4	Estimated DEER Peak Demand
Proposed Equipment, kW	Result	4	Estimated DEER Peak Demand
Existing Equipment, kWh/yr	Result	4	Estimated existing annual energy
Proposed Equipment, kWh/yr	Result	4	Estimated proposed annual energy
Savings, kW	Result	4	Estimated DEER Peak demand savings for measure (difference between existing and proposed)
Savings, kWh/yr	Result	4	Estimated annual energy savings for measure (difference between existing and proposed)
Incentive	Result	4	Estimated incentive ($) for the measure.

2.2.8.5 Energy Savings Explanation

The lighting model uses the following calculation to determine energy savings of the project:
Baseline/Proposed Calculation:

QTY x FW x OPHR = annual kWh (Eq. 1)
QTY x FW = kW (Eq. 2)
Where;
QTY = number of fixtures
FW = fixture kW
OPHR = annual hours of operation

Energy savings are obtained by taking the difference between the baseline cases and the proposed cases.
Baseline kWh – Proposed kWh = Annual kWh savings (Eq. 3)
Baseline kW – Proposed kW = kW saved (Eq. 4)
Annual kWh savings x incentive rate = Incentive payment (Eq. 5)

The software utilizes user inputs to determine the appropriate fixture wattage, which is obtained from the “Table of Standard Fixture Wattages”. This table is also part of the Customized Offering Procedures Manual.

2.2.9 Lighting - Lighting Controls

2.2.9.1 Description

The tool estimates the energy savings achieved when the energy consumed by lighting equipment is reduced through the use of an automated system or control devices, such as sensors, time clocks or EMS systems.

2.2.9.2 Appropriate Use of the Tool –Program Policy

The tool can be used to predict the savings attributed to the installation of occupancy sensors, time clocks, and lighting energy management systems (EMS) for lighting replacements and existing lighting systems. Measures involving day-lighting or daylight harvesting cannot use this tool and it is recommended that the Engineering Calculations approach is used.

2.2.9.3 Inputs

Prior to selecting the Lighting Controls measure the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. The CCT tool only allows projects that are retrofits (same load). Once the Lighting Controls measure is selected, the user is then directed to enter the various inputs as described in the following tables.

Table 9-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Line Item	Pull-down	1	Select a unique line item number for each lighting control retrofit, consisting of identical equipment within the same usage group.
Control Type	Pull-down	1	Select the control technologies between EMS, occupancy sensors, and time clocks. Day-Light Harvesting or Day-Lighting systems must use the Engineering Calculations approach to estimate energy savings.
Usage Group	Fill in	1	Enter an identifying name for a grouping of lighting controls that have similar operating characteristics (i.e. they are turned off and on at the same time).
Area Description	Fill in	1	Enter a short description of the area covered by the lighting controls (e.g. Warehouse, Building 123, Conference Room, etc).
Line Item	Pull-down	2	Select the appropriate line item number for each lighting retrofit.
Num Fixtures	Fill In	2	Enter the number of proposed/existing fixtures.
Previous Op Hours	Fill In	2	Enter the number of annual hours the fixtures operate prior to the installation of lighting controls.
New Op Hours	Fill In	2	Enter the number of annual hours the fixtures operate after the installation of lighting controls. This input is automatically calculated for occupancy sensor measures.
Space Type	Pull Down	2	Select the space type from the pull-down list that most closely describes the primary function/purpose of the illuminated area.

Fixture Type	Pull-down	2	Select the space type from the pull-down list that most closely describes the primary function/purpose of the illuminated area.
Lamp Type	Pull-down	2	Choose "Standard" if the fixture is identified in the Standard Table of Fixture Wattages in Appendix B. Choose "Custom" if the fixture is not identified on this table.
Lamp Type	Pull-down	2	Select the lamp type (i.e. T12 Fluorescent, HPS, Incandescent, etc). Please see Appendix B-27 through B29 for a legend of lamp type acronyms.
Tube Length	Pull-down	2	For tube fixtures select the tube length in inches. For non-tube fixtures select N/A.
Ballast Type	Pull-down	2	Select the ballast type for fixtures equipped with ballasts (i.e. Magnetic, Electronic, etc.). Select N/A for non-ballast fixtures. Please see Appendix B-27 through B29 for a legend of ballast acronyms.
Lamps/Fixture	Pull-down	2	Select the number of lamps per fixture.
Watts/Lamp	Pull-down	2	Select the nominal watts per bulb
Watts Fixture	Display	2	This value is calculated from the inputs above

2.2.9.4 Output

Once all necessary input information has been gathered, the Lighting Controls tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The Lighting Controls tool outputs are described below in Table 9-3 Savings Summary. After the user selects "Finish", the information on Table 9-4 – Demand Incentive Worksheet will be requested. After the user selects "Next" or "Finish" the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 9-2. Savings Summary

Output Label	Description/Purpose
Baseline Energy Usage	Estimated on-peak demand, annual hours of operation, and annual electrical energy use of the baseline equipment is displayed.
Baseline Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the Title-24 minimum efficient equipment is displayed.
Proposed Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the proposed equipment is displayed.
Savings	The difference between the Baseline Equipment values and Proposed Equipment values are

	displayed.
Incentive (@ $0.05 kWh/yr)	Estimated incentive is displayed based on program incentive rate.

The Peak Demand Incentive Worksheet uses the CPUC Peak Demand Savings to calculate kW savings and incentive. The software chooses the appropriate CPUC peak period based on the location inputs on the first sheet. The software calculates CPUC Peak directly for weather-based (Engage) measures. It estimates CPUC Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques.   See the Energy Savings Explanation section for a description of the CPUC Peak Demand Savings.

Table 9-3. Peak Demand Incentive Worksheet

Input Name	**Type**	**Sheet**	**Description / Purpose**
City	Pull Down	N/A	Select the appropriate city
Equipment operates during the peak demand period defined above?	Check Box	N/A	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill In	N/A	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Display	N/A	Estimated on-peak demand incentive is displayed.

2.2.9.5 Energy Savings Explanation

The energy savings for this measure is calculated as the difference between the energy usage of the lighting equipment in an uncontrolled (Baseline) and controlled (Proposed) state. The power demand (kW) of a lighting system is calculated based on the specifications ballast and the lamp that comprise the lighting fixture. The Table of Standard Fixture Wattages contains average kW draw for a range of lighting fixtures and is located in the 2010 Program Manual. The user also has the option to input custom equipment specifications to estimate power draw. Since power is assumed to be unchanged from the baseline, the energy savings are determined by the reduction in the number of hours that the fixture is energized;

*Energy Savings (kWh) = Power Demand, (kW) * (Uncontrolled Operating Hours – Controlled Operating Hours)*

EMS and time clocks type measures, utilize a scheduling capability that reduces the amount time (hours) that a fixture is energized based on a pre-determined schedule. These hours are input directly into the software tool by the user. Please note that these values must correspond to actual hours the lights are energized prior to the installation of the controls and the proposed hours from the scheduled operation. The programmed schedule in the EMS will be independently verified by the Utility Administrator Inspector.

Occupancy sensors work in a different fashion than EMS systems in that they control operation based on occupant activity and do not schedule equipment operation for particular times. The software estimates the amount of savings from these controls based on the space type and applies a pre-determined reduction rate to the baseline operating hours.

These reduction rates and space types are based on empirical data from a variety of governmental sources. Table 9-5 lists these reduction rates of operating time based on space type.

Table 9-4. Occupancy Sensors Reduction in Operating Time

Space Type	% Savings	Space Type	% Savings	Space Type	% Savings
Assembly	45	Industrial	45	Restroom	45
Break room	25	Kitchen	30	Retail	15
Classroom	30	Library	15	Stair	25
Computer Room	35	Lobby	25	Storage	45
Conference	35	Lodging (Guest Rooms)	45	Technical Area	35
Dinning	35	Open Office	15	Warehouses	45
Gymnasium	35	Private Office	30	Other	15
Hallway	25	Process	45	Parking Garage	15
Hospital Room	45	Public Assembly	35		

The following calculation method is used to determine energy savings of the project for each of the measure types:

Baseline Calculation:
QTY x FW x BOPHR = baseline annual kWh (Eq. 1)
QTY x FW = baseline kW (Eq. 2)

Where;
QTY = number of fixtures
FW = fixture wattage
BOPHR = baseline annual hours of operation
Proposed Calculation:

QTY x FW x POPHR = proposed annual kWh (Eq. 3)
QTY x FW = proposed kW (Eq. 4)

Where;
POPHR = proposed annual hours of operation

For EMS and time clock measures, POPHR is entered by the user. For occupancy sensors, the user enters a “Space Type” which references Table 5 above and calculates POPHR from the following equation:

BOPHR x (1 - % savings) = POPHR (Eq. 5)

Where;
% savings = value obtained from Table 1

Energy savings are obtained by taking the difference between the baseline cases and the proposed cases.

Baseline kWh – Proposed kWh = Annual kWh savings (Eq. 6)

Baseline kW – Proposed kW = kW saved (Eq. 7)

Annual kWh savings x $0.05/kWh = Incentive payment (Eq. 8)

CPUC Defined Peak Demand Savings

The CCT software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant the equipment operates during the defined peak period.

2.2.10 Other – Air-Side Economizers

2.2.10.1 Description

This tool is designed to compute the savings and incentive achieved from the installation of an Air-Side Economizer. Many commercial buildings have large internal loads due to lights, computers, and other electrical equipment. As a result, even in cold climates buildings may still need cooling. This constant need to provide cooling can lead to large amounts of energy consumption throughout the year. One alternative, however, is using an economizer. When outdoor air is cool enough, the building's HVAC system can cycle in outdoor air to cool the building. This can result in energy savings by reducing, or eliminating the need to operate a package unit and chiller. Economizers operate most effectively by comparing the outdoor enthalpy conditions to indoor enthalpy requirements. However, due to the lack of reliable, rugged and low cost enthalpy sensors, a dry bulb sensor is often used to determine when the economizer can be utilized. Economizers can be installed on many, but not all, HVAC systems.

2.2.10.2 Appropriate Use of Tool – Program Policy

This CCT software is utilized for the following economizer measures:

1) The addition of an economy cycle onto existing HVAC equipment.
2) The addition of actuator controls to automate an existing manually operated economizer.

The estimate of savings from the Air Side Economizers Tool can be calculated for the following building types and the building area must be between:

Assembly – defaults to 34,000 ft^2 but must be between 40,000 and 200,000 ft^2
Education – Primary School – defaults to 50,000 ft^2 but must be between 40,000 and 200,000 ft^2
Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2
Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2
Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2
Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2
Lodging - Hotel – defaults to 200,000 ft^2
Manufacturing – Bio/Tech – defaults to 200,000 ft^2
Manufacturing – Light Industrial – defaults to 100,000 ft^2
Office – Large – defaults to 175,000 ft^2
Office – Small – defaults to 10,000 ft^2
Restaurant – Sit Down – defaults to 4,000 ft^2
Restaurant – Fast Food – defaults to 2,000 ft^2
Retail – Multistory Large – defaults to 120,000 ft^2
Retail – Single -Story Large – defaults to 130,500 ft^2
Retail – Small – defaults to 8,000 ft^2
Storage – Conditioned - defaults to 500,000 ft^2

Applicable Types of Equipment

Only the new addition of an economizer or economizer controls is covered by this tool. The repair or replacement of a non-operating economy cycle is not eligible for an incentive.

Equipment Sizes or Capacities Covered by this Tool

All HVAC equipment sizes and capacities are applicable. The proposed operating hours for an economizer is based on the amount of cooling required and the amount of cooling that can be achieved from using only outside air, as determined by the building's load and location respectively.

The 2010 Statewide Customized Offering software calculates savings using the Engage Software for a measure of this type. The Engage software is a stand-alone, DOE2 based modeling program. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

2.2.10.3 Inputs

Once the measure for Air-Side Economizers (Engage) is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screens appear in the same order as a user experiences while using the CCT software.

Table 10-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	From the pull-down menu, select by Zip Code or by CTZ. (CTZ stands for Climate Zone) In the adjacent pull-down menu select the appropriate Zip Code or CTZ.
Building Type	Pull-down	1	From the pull-down menu, select a "predefined" building configuration from the list of "prototypical" buildings (see Appendix D in the CCT Program Procedures Manual for detailed descriptions).
Vintage	Pull-down	1	From the pull-down menu, select the year the building was constructed.
HVAC System(s)	Pull-down	1	From the pull-down menu, select a cooling equipment type. One or more typical HVAC System will be available based on the chosen Building Type.
Allow HVAC System Downsizing	Click /Select	1	If the measure(s) you include in the analysis result in reduced cooling or heating loads (many do), selecting this option allows the CCT software to downsize HVAC systems. This option is only enabled for a building vintage after 2005.
Total Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type.
Secondary Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Secondary Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building

			Type. This option may be disabled if it is not applicable to your Building Type.
Pattern	Pull down	2	From the pull-down menu, select a seasonal usage pattern. One or more typical usage pattern will be available based on the previously chosen Building Type.
Number of Seasons	Pull-down	2	From the pull-down menu, select one, two or three.
Season #1	Fill in	2	Insert an appropriate label for the season.
Season #2	Fill in	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Season #3	Fill in	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Observed Holidays	Click /Select	2	Click this button and insert check marks next to the observed holidays.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. One or more typical usage pattern will be available based on the previously chosen Building Type.
Season	Pull down	3	From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Cooling Equipment Served	Fill in	4	Total capacity of cooling equipment served by economizers. Input should be in tons of total (sensible + latent) cooling capacity, where the tons input here represents the sum of the rated nominal capacity of all systems for which economizers are being added or repaired.
Baseline/Measure Economizer Type	Pull-down	4	From the pull-down menu, choose –none-, Drybulb Temperature or Enthalpy.
Baseline/Measure High Limit	Fill in	4	Enter the baseline/measure set point. The economizer is enabled whenever the outside air drybulb temperature is below the set point.
Baseline/Measure Minimum OA Control Method	Pull-down	4	These inputs are used only with Variable Air Volume (VAV) systems. Use this input to describe the Minimum OA Control Method employed by the VAV air handlers on which economizers are being installed or repaired.

			Fraction of Design Flow – this selection indicates that code-required levels of outside air are maintained even when VAV systems back off from their design (maximum) flow. This will have the effect of providing a constant amount of outside air (in terms of flow), which during times of reduced VAV flow will require that the outside air be increased as a fraction of hourly system air flow. Constant outside air flow on VAV systems can only be achieved with special controls not commonly available in most VAV systems. Newer packaged VAV systems now usually include controls necessary to accomplish this. In built-up CHW VAV systems, this type of constant outside air flow can only be achieved using flow sensors or other means to detect outside air flow and then adjusting outside air dampers accordingly. **Fraction of Hourly Flow** – this selection indicates that code-required levels of outside air may not necessarily be maintained when VAV systems back off from their design (maximum) flow. This will have the effect of providing a reduced amount of outside air (in terms of flow) when the VAV system reduces flow from maximum levels. Under this scenario, outside air flow remains a constant fraction of hourly system air flow. This Minimum OA Control Method is most common, especially in built-up CHW VAV systems, where the controls necessary to achieve constant outside air flow are not provided.

2.2.10.4 Outputs

Once all the necessary input information has been gathered, the CCT software utilizes these inputs to compute the annual energy demand and usage for two scenarios: the existing cooling equipment without an economizer and the cooling equipment with an economizer. Finally, the energy savings and incentive is computed and the results are presented to the user as found in Table 10-2 – Building Measure Results. After the user selects “Finish”, the information on Table 10-3 – Demand Incentive Worksheet will be requested. After the user selects “Next” or “Finish” the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 10-2. Building Measure Results

Output Name	Description/Purpose
Existing Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the existing equipment is displayed.
Baseline Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the Title-24 minimum efficient equipment is displayed.
Proposed Equipment	Estimated on-peak demand, annual electrical energy

	use, and annual thermal energy use of the proposed equipment is displayed.
Savings	The difference between the Baseline Equipment values and Proposed Equipment values are displayed.
Incentive (@ $0.09 kWh/yr)	Estimated incentive is displayed.

The Peak Demand Incentive Worksheet uses the DEER Peak method to calculate kW savings and incentive. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet. The software calculates DEER Peak directly for weather-based measures. It estimates DEER Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques.

Table 10-3. Peak Demand Incentive Worksheet

Output Name	Description/Purpose
Equipment operates during the peak demand period defined above?	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below. This new added Peak Demand savings calculation will be helpful for determining the kW incentive for economizers based on the three hottest days from DEER.
Total Incentive	Estimated on-peak demand incentive is displayed.

2.2.10.5 Energy Savings Explanation

The applicant inputs information in the CCT software. All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. The Engage software program utilizes the user's inputs (along with DEER prescribed equipment specifications, operating schedules, and building envelope characteristics) to estimate the energy demand and usage of the cooling equipment. Specifically, it computes baseline peak demand [kW] and energy use [kWh/yr] of the existing cooling equipment without an outside air economizer. It also computes proposed peak demand [kW] and proposed annual energy usage [kWh/yr] of the proposed cooling equipment, with an outside air economizer. Engage then transfers the above values to the CCT program tool. The CCT program tool then performs the necessary calculations and displays the Annual Demand Savings [kW], Annual Energy Savings [kWh] and the Incentive amount.

2.2.11 Other - Carbon Monoxide Sensors for Parking Garages

2.2.11.1 Description

The CCT tool can be used to estimate the energy savings estimate for exhaust fans in enclosed parking structures when these fans are controlled by Carbon Monoxide sensors. Exhaust fans are typically on 24 hours/day or controlled by time clocks. Controlling fan on-time using CO sensors to maintain an acceptable limit on CO in the parking structures can result in significant energy savings. A number of parking structures with their exhaust fans under CO control were metered to determine the run-time of the exhaust fans.

2.2.11.2 Appropriate Use of the Tool –Program Policy

The CCT tool can be used to estimate the savings attributed to the installation of Carbon Monoxide (CO) sensors in enclosed parking structures. The use of this tool is appropriate for all building types that contain enclosed parking structures.

2.2.11.3 Inputs

Prior to selecting the Carbon Monoxide Sensors in Parking Garages measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. The CCT tool only allows projects that are retrofits (same load). Once the Carbon Monoxide Sensors in Parking Garages measure is selected, the user is then directed to enter the various inputs as described in the following tables.

Table 11-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Manufacturer of CO Controls/Sensors	Fill in	1	This Input is used for inspection purposes.
Model Number of CO Controls/Sensors	Fill in	1	This Input is used for inspection purposes.
Number of Sensors in Parking Structure	Fill in	1	This Input is used for inspection purposes.
Total Exhaust Fan Motors (HP)	Fill in	1	The total HP of all exhaust fans covered in the measure.
Average Exhaust Fan Motor Efficiency (%)	Fill in	1	The reviewer shall average the motor efficiencies and input the percentage. Motor efficiency can range from 70 to 98%.
Annual Operating Hours Before CO Controls	Fill in	1	The yearly operating hours of the exhaust fans.

2.2.11.4 Output

Once all necessary input information has been gathered, the Carbon Monoxide Sensors for Parking Garages Tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The outputs are described below in Table 11-2 – Savings Summary. After the user selects “Finish”, the information on Table 11-3 – Demand Incentive Worksheet will be requested. After the user selects “Next” or “Finish” the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 11-2. Savings Summary

Output Label	Description/Purpose
Baseline Energy Usage	Estimated on-peak demand, annual hours of operation, and annual electrical energy use of the baseline equipment is displayed.
Proposed Energy Usage	Estimated on-peak demand, annual hours of operation, and annual electrical energy use of the proposed equipment is displayed.
Savings	The difference between the Baseline Equipment values and Proposed Equipment values are displayed.
Incentive Payment (@ $0.09 kWh/yr)	Estimated incentive is displayed based on program incentive rate.

The Peak Demand Incentive Worksheet uses the CPUC Peak Demand Savings to calculate kW savings and incentive. The software chooses the appropriate CPUC peak period based on the location inputs on the first sheet. The software calculates CPUC Peak directly for weather-based (Engage) measures. It estimates CPUC Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques. See the Energy Savings Explanation section for a description of the CPUC Peak Demand Savings.

Table 11-3. Peak Demand Incentive Worksheet

Input Name	Type	Description / Purpose
City	Pull-down	Select the appropriate city
Equipment operates during the peak demand period defined above?	Checkbox	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill In	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Display	Estimated on-peak demand incentive is displayed.

2.2.11.5 Energy Savings Explanation

Exhaust fans typically operate on a continuous basis (24 hours per day) in order to maintain minimum CO levels as required by public health codes. In other cases, these fans may be controlled by time clocks. Controlling the run time of this equipment using CO sensors can result in significant energy savings while still maintaining minimum health code standards.

The 2010 CCT tool estimates the energy savings achieved through the reduction in the operating hours of these fans by CO sensor control. Baseline energy consumption is estimated based on the total amount of exhaust fan horsepower (HP) and the total annual operating hours. These values are input directly by the user. The proposed operation (post-install) is calculated by the software tool. The general equation for the energy savings is as follows;

$$\textbf{Annual Savings (kWh)} = \textbf{(Total Fan Power)} \times \textbf{(Operating Hours}_{\textbf{before}} - \textbf{Operating Hours}_{\textbf{after}}\textbf{)}$$

Exhaust fan equipment controlled with CO sensors at six (6) enclosed parking structures was sub-metered for a week's time. The post install operation operating hours are modeled in the 2010 based on this empirical data.

CPUC Defined Peak Demand Savings

The CCT software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant that the equipment operates during the defined peak period.

2.2.12 Other – Cold Storage Rapid Close Doors

2.2.12.1 Description

Rapid close doors save energy at cold storage facilities by reducing the refrigeration system load due to infiltration. This can be achieved by improving the seal of the doorway, increasing the door speed and/or reducing the amount of time the door simply stands open. The methodology for estimating energy savings for this measure is well documented (2002 ASHRAE Refrigeration Handbook, Refrigeration Load, Page 12.3).

2.2.12.2 Appropriate Use of the Tool – Program Policy

The software allows the user to specify multiple retrofit types. Retrofit types must share similar operating schedules, doorway specifications, traffic flow, etc. In addition to cold storage facilities, walk-in freezer/coolers can also be modeled with this tool.

2.2.12.3 Inputs

Model assumptions should be based on the last twelve months of operation. Indeterminate variables that significantly impact estimated savings are space temperatures, doorway usage and control strategies, and hours of operation. Therefore, as with any estimating tool, model outputs should be compared to annual billing data to verify the reasonableness of the results. Where discrepancies are observed, documentation supporting the project assumptions should be requested.

The model advances through 5 sheets. To get from the first sheet to the second press the “Edit Existing” button, to get from the first sheet to the third press the “Edit Proposed” button, to get from the first sheet to the fourth press the “Edit Operation” button. To get to the result press the “Next” button from the first sheet.

Table 12-1. Cold storage rapid close doors savings Estimation Tool

Input Name	Type	Input sheet	Description / Purpose
Doorway Type No.	Fill in	1	Enter the number of doorway retrofit types. Recall each type must have similar characteristics and usage patterns
City	Pull - down	1	Select the site location.
Building Identification	Fill in	2-3	Enter the building identification.
Number of Doorways	Fill in	2-3	Enter the number of like doorway retrofits.
Doorway Width (ft)	Fill in	2-3	Enter doorway width
Doorway Height (ft)	Fill in	2-3	Enter doorway height
Opens to	Pull-down	2-3	Select from the following door opening type: Outside from Loading Dock, Outside from Cooler, Outside from Freezer, Unconditioned Loading Dock from Cooler, Unconditioned Loading Dock from Freezer, Conditioned

			Loading Dock from Cooler, Conditioned Loading Dock from Freezer, Cooler from Freezer
Refrigeration System Efficiency	Fill in and pull-down	2-3	Enter the rated efficiency of the refrigeration system and select the appropriate units. The rated efficiency should be based on design conditions at entering ambient air temperatures of 95°F dry-bulb for air-cooled condensers and 75°F wet-bulb for evaporative-cooled condensers, and 85°F entering water temperature for water-cooled condensers. If the door opens to a conditioned space, the exterior cooling efficiency needs to be input.
Condenser Type	Pull-down	2-3	Select the refrigeration system condenser type: air-cooled, water-cooled, or evaporative-cooled.
Controls	Pull-down	2-3	Select the refrigeration controls: fixed or floating head.
Doorway Protective Device	Pull-down	2-3	The doorway protective device is the main device that restricts infiltration into the conditioned area. If the doorway protective device is left open during business hours, losses are still accounted for during non-business hours, therefore it is necessary to represent this device in the model. Select from the following doorway protective devices: none, strip curtains, dual strip curtain with air-lock vestibule, dual impact (or push-through) doors with air-lock vestibule, vertical non-recirculating air curtain, dual horizontal recirculating air curtain, dual horizontal recirculating air curtain with outer strip curtain, standard-folding doors, standing-sliding curtains, standard-sliding doors, rapid-folding doors, rapid-sliding curtains and rapid-sliding doors.
Door Insulation	Fill in	2-3	Enter the door insulation type. This information is for review purposes only; it does not impact the savings calculation.
Insulation Thickness (in.)	Fill in	2-3	Enter the door insulation thickness. This information is for review purposes only; it does not impact the savings calculation.
U-Factor (Btu/hr•ft •°F)	Fill in	2-3	Enter the overall coefficient of heat transfer (U-Factor). The U-Factor accounts for inside surface conductance, total door thermal conductance and outside surface conductance. Please provide manufacturer's specification for the existing, if available, and proposed doors. For a summary of the principles of heat transfer, refer to the 2001 ASHRAE Fundamentals Handbook, Pages 3.2-3.3. Other variables that may impact the thermal conductivity are wind and solar exposure. For a detailed discussion of their effects, refer to the 2001 ASHRAE Fundamentals Handbook, Pages 25.12 and 30.11, and 2002 ASHRAE Refrigeration Handbook, Page 12.2.
Open Doorway Protective Device	Pull-down	2-3	The open-doorway device is a secondary device that restricts infiltration when the main door is open. Select from the following open doorway protective devices:

			none, strip curtains, dual strip curtain with air-lock vestibule, dual impact (or push-through) doors with air-lock vestibule, vertical non-recirculating air curtain, dual horizontal recirculating air curtain, dual horizontal recirculating air curtain with outer strip curtain, rapid-folding doors, rapid-sliding curtains and rapid-sliding doors.
Open-Close Time (sec)	Fill in	2-3	Enter the doorway protective device open-close time. This is the time it takes for the doorway protective device to open and close. For conventional pull-cord operated doors, this value typically ranges from 15 to 25 seconds per passage; for high speed doors, it can range from 5 to 10 seconds depending on the means of control and the control setpoint.
Operation Varies by Month?	Check	4	The user may input annual or monthly values for the variables listed below. To input monthly values select the check box.
Loading Dock / Cooler Temperature (°F)	Fill in	4	If the doorway does not open to the outside or to an unconditioned space, the user needs to specify the annual or monthly temperatures and relative humidity of the loading dock or cooler.
Inside Temperature (°F)	Fill in	4	Enter storage temperature setpoint.
Weekday Hours	Fill in	4	Enter the average work hours per weekday.
Saturday Hours	Fill in	4	Enter the average work hours on Saturday.
Sunday Hours	Fill in	4	Enter the average work hours on Sunday.
Averages Openings per Hour	Fill in	4	Enter the average openings (passages) per hour for this doorway protective device type. This is how many times the doorway protective device opens and closes as a result of foot or forklift traffic.
Average Open Time, Pre and Post (minutes)	Fill in	4	Enter average doorway protective device open time, before and after installation. This is the time the doorway protective device simply stands open. This could be the result of multiple forklift traffic or manually keeping the door open. If the doorway protective device is left open during business hours, enter a value of 60 min/hour.

2.2.12.4 Output
The following table describes the CCT tool outputs.

Table 12-2. Measure Energy Savings, Operating Hours & Incentive

Name	Description / Purpose
Doorway Type	Doorway retrofit type. Recall each type must have similar characteristics and usage patterns.
Annual Op Hours	Annual operating hours of Doorway Type
Existing, kW	Estimated maximum on-peak demand of the existing doorway type.
Proposed, kW	Estimated maximum on-peak demand of the proposed doorway type.
Existing, kWh/yr	Estimated annual energy use of the existing doorway type.
Proposed, kWh/yr	Estimated annual energy use of the proposed doorway type.
Savings, kW	Estimated on-peak demand savings for measure (difference between baseline and proposed)
Savings, kWh/yr	Estimated annual energy savings for measure (difference between baseline and proposed)
Incentive ($)	Estimated incentive amount in $

2.2.12.5 Energy Savings Explanation
Infiltration from one space to another is primarily caused by the air density difference between them. The expression for heat gain through an opening due to infiltration is as follows:

$$q_{to} = qD_tD_f(1-E)$$

Where,

q_{to} = Average heat gain for the 24-h or other period, Btu/h
q = Sensible and latent refrigeration load for fully established flow, Btu/h
D_t = Doorway open-time factor.
D_f = Doorway flow factor
E = Effectiveness of doorway protective device

This model looks at the heat gain and effectiveness of both a doorway protective device and an open-doorway protective device. The open-doorway protective device is a secondary device, typically strip or air curtains that provide some level of protection even when the primary door is left open or opened temporally to allow passage.

The original model did not account for equipment-related loads associated with latent heat in freezer spaces. Based on heat balance calculations and a general cooler-to-freezer doorway scenario, the following equation was developed to account for equipment-related loads in freezer applications.

$$q_{to} = qD_tD_f(1-E)\left(1.05R_s+(0.0034T_{sc}+2.224)(1\text{-}R_s)\right)$$

This approach uses the following equation and sensible heat gain and sensible heat ratio data.

$$q = 3790WH^{1.5}\left(\frac{Q_s}{A}\right)\left(\frac{1}{R_s}\right)$$

Where,

q = sensible and latent heat load, Btu/h
W = door width, ft
H = door height, ft
Q_s/A = sensible heat load of infiltration air per square foot of doorway opening, tons/ft^2
A = door area, ft^2
R_s = sensible heat ratio of the infiltration air heat gain, tons/ft2

The doorway open-time factor is calculated using the following equation.

$$D_t = \left(\frac{P \times \Theta_P + 60 \times \Theta_O}{3600} \right)$$

Where,

P = Number of doorway passages
Θ_P = Doorway protective device open-close time, seconds per passage
Θ_O = Time doorway protective device simply stands open, minutes

Determination of the D_f is automated in the software. The logic is

- If ΔT > 20°, DF = 0.80.
- If ΔT < 20°, DF = 1.10.

Table 12-3. Protective Doorway Device Effectiveness, Static and w/ Traffic

Doorway Device Description	Effectiveness (Static)	Effectiveness (Traffic)
none	0	0
strip curtains	0.9	0.8
dual strip curtain with air-lock vestibule	0.97	0.95
dual impact (or push-through) doors with air-lock	0.99	0.97
vertical non-recirculating air curtain	0.65	0.65
dual horizontal recirculating air curtain	0.76	0.76
dual horizontal recirculating air curtain with outer strip	0.88	0.86
standard-folding doors	0.93	0.82
standard-sliding curtains	0.93	0.63
standard-sliding doors	0.98	0.79
rapid-folding doors	0.93	0.82
rapid-sliding curtains	0.93	0.63
rapid-sliding doors	1	0.79

Losses during operating hours (q_t) are the sum of the loss when the doors is open (q_{to}) and closed (q_{tc}) during normal operation.

$$q_t = q_{to} + q_{tc}$$

Therefore, the baseline and post-installation energy consumption are estimated using the following equations:

$$kWh = \frac{(kW/ton) \times \left((q_{to} + q_{tc}) \times hr_{op} + (q_{tc}) \times hr_{non-op} \right)}{12{,}000 Btuh/ton}$$

Where,

kW/ton = Refrigeration efficiency
hr_{op} = Hours of operation
$hr_{non\text{-}op}$ = Hours of non-operation

2.2.13 Other - Compressed Air System Upgrades

2.2.13.1 Description

Compressed air systems provide power for tools, presses, controls and a wide variety of industrial equipment and processes. As such, compressed air systems vary widely both in the equipment and controls that are employed. Compressed air systems afford significant opportunities for energy savings and the CCT program has provided incentives for equipment and control upgrades since the program's inception. The CCT software tool draws extensively from information provided by the Department of Energy (DOE) Compressed Air Challenge program. Specifically, the AirMaster+ software package developed by DOE is used as a guide for generic equipment performance characteristics and operating ranges covered by this CCT tool.
The CCT tool provides for the following compressed air system measures:

- Direct replacement of one to three air compressors, including compressors equipped with variable speed drives,
- Installation or upgrade of system storage, and
- Installation of intermediate pressure/flow control valves.

The CCT tool allows implementation of any of these measures as retrofit projects that do not involve any increase in load (deferred load). Note that in the case of new installations the lack of operating data restricts the complexity of the savings analysis and limits the types of energy efficient measures that can be accommodated. Therefore, for applications involving new installations the CCT software will only accommodate measures involving efficient compressor installations (increased storage and intermediate pressure controls are not accommodated).

2.2.13.2 Appropriate Use of the Tool-Program Policy

The CCT Compressed Air System Upgrade tool can be used for compressed air systems and measures having the characteristics shown in Table 13-1.

Applicable Types of Equipment

The CCT Compressed Air System Upgrade tool covers the same compressor types and pressure ranges that are covered by the AirMaster+ software package as shown in Table 13-2.

Equipment Sizes or Capacities Covered by the Tool

The CCT Compressed Air System Upgrade tool covers the same compressor types and pressure ranges that are covered by the AirMaster+ software package (also shown in Table 13-2).

Table 13-1. Air Compressor Common Measure Features

Description	Measure Feature
# of Compressors	1 – 3
Compressor types and sizes	Single and dual stage reciprocating, oil-flooded and oil-free rotary screw
Compressor drive	Conventional and Variable Speed Drive (VSD)
Storage	Existing or new storage will be accommodated but only storage located upstream of an installed intermediate flow/pressure control will be used to analyze compressor operation. This measure is not supported for deferred load or new installations.
Intermediate Flow / Pressure Controller	The addition of an intermediate flow/pressure controller is supported as an efficiency measure only (baseline system doesn't include this option). This measure is not supported for deferred load or new installations.
Baseline air compressor efficiency	Generic compressor efficiencies used in AirMaster+ software package are used as minimum acceptable efficiency for the types and sizes of compressors identified by the project sponsor.
Compressor Load Profile	Hourly load profile inputs (acfm or kW) used for up to 4 "day types" to establish baseline usage of each compressor and for overall system load.
Baseline air compressor drive efficiency	EPACT minimum used for baseline, measured values are corrected if existing motors do not meet EPACT requirements
Applicable operating pressure range	Pressure range varies with compressor type as per AirMaster+

Table 13-2. Compressed Air System Upgrade Measure Equipment Coverage Matrix

Compressor Types	Control Types	Size Range (hp)	Pressure Range (psig)
Single Stage lubricant injected rotary screw	Inlet Modulation w/o unloading Inlet Modulation w/unloading Load/Unload Variable Displacement w/unloading Variable Speed Drive	25 - 500	100 - 200
Two Stage lubricant injected rotary screw	Inlet Modulation w/o unloading Inlet Modulation w/unloading Load/Unload Variable Displacement w/unloading Variable Speed Drive	100 – 500	100 – 200
Two Stage lubricant-free rotary screw	Load/Unload	50 - 500	80 - 150
Single Stage reciprocating	Load/Unload	25 - 75	80 – 125
Two Stage reciprocating	Load/Unload	25 - 400	80 – 125

2.2.13.3 Inputs

Prior to selecting the Compressed Air System Upgrades measure the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. Once the Compressed Air System Upgrades measure is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures.

Table 13-3. Inputs

Input Name	Type	Sheet	Description/Purpose
Site/System Inputs			
City	Pull-Down	1	Pull-down menu with California cities. Used to lookup site elevation and average ambient temperature
Number of Existing Compressors	Pull-Down	1	Used in inspection
Multi-compressor control?	Pull-Down	1	Pull-down menu with “No Sequencer” and “Sequencer” selections. Used to determine if idle compressors can be turned off.
Nominal System Op. Press. (psig)	Fill-In	1	Pressure supplied to end uses (downstream of dryers and intermediate controls) – used to estimate changes in unregulated flow (if applicable)
Nominal Supply Pressure (psig)	Fill-In	1	Compressor output pressure – used to adjust compressor performance relative to manufacturer’s data
Total System Volume (cubic feet)	Fill-In	1	Volume of total system including receiver volume – used to estimate compressor cycle times (if applicable)
Receiver Volume (cubic feet)	Fill-In	1	Total volume of all installed receivers – use in inspection
Compressor Inputs (1 page for each compressor)			
Compressor ID	Fill-In	2	Site/local designation -- used for site inspection
Manufacturer	Fill-In	2	Compressor manufacturer – used for site inspection
Model Number	Fill-In	2	Equipment model – used for site inspection
Serial Number	Fill-In	2	Equipment serial number – used for site inspection
Type	Pull-Down	2	Pull-down menu with selections for: a. Single Stage Reciprocating b. Single Stage Rotary Screw (lubricant injected) c. Two Stage Reciprocating d. Two Stage Rotary Screw (lubricant injected) e. Two Stage Rotary Screw (lubricant free)
Full-load Package Power (kW)	Fill-in	2	Package power at full-load from CAGI data – used to estimate full- and part-load performance
Full-load Operating Pressure (psig)	Fill-In	2	Operating pressure corresponding to the full-load package power value (CAGI) – used to estimate full- and part-load performance
Rated Capacity @ Full-load Operating Press (acfm)	Fill-In	2	Airflow in acfm corresponding to the full-load package power value (CAGI) – used to estimate full- and part-load performance
After-cooling Method	Pull-Down	2	Pull-down menu with selections for: a. Air (Integral Fan) b. Air (Separate Fan) - new c. Water
Compressor Control Inputs (1 page for each compressor)			
Control Method	Pull-Down	3	Pull-down menu containing control options

			specific to the compressor type (see Table 2) which can include: a. Load/Unload b. Inlet Modulation w/o unloading c. Inlet Modulation w/unloading d. Variable Displacement w/unloading e. Variable Speed Drive Used to estimate part-load performance.
Operating Mode	Pull-Down	3	Pull-down menu containing: a. Lead/Baseload b. Trim/Variable Used to determine loading sequence (multiple compressors)
Unloading Control Setpoint - % of Capacity	Pull-Down	3	Pull-down menu that is activated whenever a control with unloading has been selected. Values shown are dependent on control type selected. (60% for inlet modulation w/unload, 40% or 50% for variable displacement w/unload). Value is used to refine the part-load performance map.
Unloading Control Setpoint - % of Power	Pull-Down	3	Pull-down menu that is activated whenever a control with unloading has been selected. Values shown are dependent on control type selected. (88% for inlet modulation w/unload, 61% for variable displacement w/unload). Value is used to refine the part-load performance map.
Full-load Pressure (cut-in)	Fill-In	3	Compressor pressure control set point when declining pressure causes the compressor to load – used with storage amount, and cut-out pressure to estimate cycle time (if applicable)
Max Flow Pressure (cut-out)	Fill-In	3	Compressor pressure control set point when increasing pressure causes the compressor to unload -- used with storage amount, and cut-in pressure to estimate cycle time (if applicable)
No Load Power (% of FL power)	Fill-In	3	% of full-load power when compressor if fully-unloaded – used to refine part-load performance map.
Auto Shut-down Timer?	Check Box	3	Checkbox – checked if there is a timer that will shut-down the compressor if fully unloaded?
Setting (minutes)	Fill-In	3	Auto shutdown timer setting; time after which an unloaded compressor is shut-down.
Compressor & Fan Motor Inputs (1 page for each compressor)			
Note: ***Fan Motor Inputs (only required if air-cooled and separate fan motor is specified):Same input fields as compressor drive motor.***			
Manufacturer	Fill-In	4	Motor manufacturer – used for site inspection
Model	Fill-In	4	Motor model – used for site inspection
Size (HP)	Pull-Down	4	Motor HP rating – used for site inspection and to lookup minimum EPACT efficiency
Speed (RPM)	Pull-Down	4	Motor RPM – used for site inspection and to lookup minimum EPACT efficiency
Service Factor	Pull-Down	4	Motor service factor – used for site inspection and to calculate maximum motor load

Enclosure Type	Pull-Down	4	Motor enclosure type – used for site inspection and to lookup minimum EPACT efficiency
NEMA Nominal Effcy (full load)	Fill-In	4	Motor efficiency – used for load computation and to compare against EPACT minimum
Compressor Operating Info Inputs			
Notes: *(1) -- Total operating hours for all day-types cannot exceed 8760 hours or an error is flagged* *(2) – Average flow, peak flow & hours/day inputs are required for new installations only (in lieu of profile data)*			
Number of Day Types	Pull-Down	5	Pull-down menu used to designate the number of profiles that will be entered (1 – 4).
Profile Units	Pull-Down	5	Pull-down menu used to designate the type of profile information provided. Selections include: a. ACFM b. KW – Package c. KW – Compressor only
Day Type	Pull-Down	5	The number of the day type (1 – 4 as selected above) associated with the remaining inputs (below)
Description	Fill-In	5	Text box to provide a name for the profile (e.g., weekday, etc.) – used in reports and for inspection
Weekday Operation?	Check Box	5	Checkbox – checked if the day involves weekday operation – used to determine if peak demand savings are involved.
Days/Week (1)	Fill-In	5	Number of days per week for this day-type.
Weeks/Year (1)	FIl-In	5	Number of weeks per year for this day-type.
Average Flow (2)	Fill-In	5	Average airflow (ACFM) for each day-type
Peak Flow (2)	Fill-In	5	Maximum airflow (ACFM)
Hours / Day (2)	Fill-In	5	Hours of operation per day
Compressor Operating Profile Inputs			
Day Type	Pull-Down	6	A pull-down menu with descriptions corresponding to the information entered previously in Sheet 5. Identifies the day-type associated with the profile information to be entered.
Hourly Profile Value	Fill-In	6	24 hourly values of ACFM or KW; separate profiles are entered for each compressor *(required for retrofit applications only)*
Measure Specification Inputs			
Notes: *(1) – Measure information not required for deferred load & new installations.* *(2) – Measure information required for deferred load applications only.*			
Compressor Replacement / Modification?	Check-Box	7	Checkbox – checked if one of the measures involves compressor replacement or modification
Compressor Replacement / Modification Type	Pull-Down	7	A pull-down menu that is activated if compressor replacement / modification is selected with choices for: a. No change b. Replace compressor

			c. Change op mode d. Remove / standby
Operating Mode	Pull-Down	7	A pull-down menu that is activated if the compressor modification selected is “Change op mode”. Selections include: a. Lead / Baseload b. Trim / Variable Used to estimate loading order of proposed compressor.
Intermediate Flow Controller? (1)	Check Box	7	Checkbox – checked if one of the measures involves installation of an intermediate flow controller
Proposed Nominal Supply (Upstream) Pressure (psig) (1)	Fill-In	7	Input activated if intermediate flow controller is selected. Input is pressure upstream of new controller in psig. Used to estimate the impact on compressor energy use (if applicable)
Proposed Nominal Operating (Downstream) Pressure (psig) (1)	Fill-In	7	Input activated if intermediate flow controller is selected. Input is pressure downstream of new controller in psig. Used to estimate the impact on system airflow of reduced system operating pressure.
Leakage Flow (% of total) (1)	Fill-In	7	Input activated if intermediate flow controller is selected. Input is % of total system flow attributed to leakage (unregulated). Used to estimate the impact on system airflow of reduced system operating pressure.
Other Unregulated End Use (1) (% of total)	Fill-In	7	Input activated if intermediate flow controller is selected. % of total system flow attributed to other unregulated flow (other than leakage). Used to estimate the impact on system airflow of reduced system operating pressure.
Existing Volume Upstream (%) (1)	Fill-In	7	Input activated if intermediate flow controller is selected. Input is % of system volume that is upstream of the proposed intermediate controller. Used to estimate the impact on compressor operation.
Storage Upgrade? (1)	Check Box	7	Checkbox – checked if one of the measures involves the addition of receiver volume.
Total Added Volume (cubic ft) (1)	Fill In	7	Input activated if storage upgrade is selected. Input is total volume in cubic feet that will be added. Used to estimate the impact on compressor operation.
Upstream of Flow Controller (%) (1)	Fill-In	7	Input activated if storage upgrade and intermediate flow controller are both selected. Input is % of additional volume that will be located upstream of the new flow controller. Used to estimate the impact on compressor operation.
% Increase (2)	Fill-In	7	The percentage increase in the airflow for each day-type

2.2.13.4 Outputs

The following table and associated figure describes the CCT tool outputs.

Table 13-4. Outputs

Name	Description / Purpose
	Estimated maximum on-peak demand of the existing air compressor(s)
Proposed Air Compressor, kW	Estimated maximum on-peak demand of the proposed air compressor(s)
Baseline Air Compressor, kWh/yr	Estimated annual energy use of the existing air compressor(s)
Proposed Air Compressor, kWh/yr	Estimated annual energy use of the proposed air compressor(s)
Savings, kW	Baseline Air Compressor, kW
Savings, kWh/yr	Estimated annual energy savings for measure (difference between baseline and proposed)
Air Compressor Runtime	Annual operating hours for compressed air system
Incentive (@$0.09 kWh/yr)	Estimated CCT incentive based on $0.09/kWh/yr

2.2.13.5 Energy Savings Explanation

Annual energy savings is calculated by subtracting the proposed energy usage from the baseline usage. Incentive values are then calculated as the product of the incentive rate ($0.09 / kWh) and the estimated energy savings value.

Annual Savings (kWh) = Baseline kWh – Proposed kWh
Incentive Amount = Annual Savings (kWh) * Incentive Rate ($/kWh)

The following discussion of the calculation methodology steps through the process used to establish the baseline and proposed energy use values and focuses on the inputs, assumptions and calculations involved. Also, as noted previously the compressed air measure software accommodates both retrofit applications (with and without an increase in load) as well as new installations, so additional discussion is provided as needed to describe how the assumptions and/or calculations vary between these different scenarios.

2.2.13.5.1 Step 1: Establish Existing Compressor(s) Full Load Performance

Air compressor full load performance values (full load kW, full load rated airflow, full load operating pressure), as entered by the user (see Table 13-3) are based on manufacturer supplied data that is compliant with CAGI standards. These standards dictate that air compressor performance be reported at standard atmospheric conditions (14.5 psia & 68 DegF). Typically, air compressor operating conditions will differ from these standard values and it is therefore necessary to correct these values to actual operating conditions. Thus, the software corrects the full load kW and airflow values based on:

- Site elevation (atmospheric pressure) and average ambient temperature based on the user selected city (see Appendix B)
- Compressor operating pressure (user input)

The following expressions are used to correct the compressor full load performance information to the site specific conditions.

$$corrKW_{FL} = KW_{FL} * (((opPress + altPress) / altPress) ^\wedge (0.395 / 1.395) -1) / (((FullLoadPress + 14.5) / 14.5) ^\wedge (0.395 / 1.395) - 1)$$

$$corrC_{FL} = C_{FL} * (1.1189 - (0.001978 * SiteTemp))$$

Where:

KW_{FL}	= Full load kW (user input) @ full load capacity and pressure
C_{FL}	= compressor full load flow, ACFM (user input)
SiteTemp	= site average ambient temperature, DegF (lookup)
SiteElevation	= site elevation above sea level, feet (lookup)
altPress	= 14.5 - (0.271875 * SiteElevation / (460 + SiteTemp))
opPress	= Site operating pressure, site (user input)
FullLoadPress	= Full load performance pressure (user input)

2.2.13.5.2 Step 2: Establish System Baseline Airflow & Electric Demand

In order to estimate the performance of the proposed air compressor(s) it is necessary to establish both the baseline airflow and electric demand for the existing equipment. To accomplish this, the user enters an individual hourly operating load profile for each compressor for up to four types of system operation ("day-types"). Either average hourly electric demand (kW) or airflow (acfm) values may be entered. These values are used in conjunction with the previously entered compressor performance information in the following fashion.
If hourly airflow values are entered then it is necessary to estimate the hourly average hourly kW demand. This conversion is accomplished by:

Dividing each hourly airflow by the full load airflow value (corrected value from Step 1) to obtain a % of full load ACFM value,

- Translating the % of full load ACFM value to a % of full load kW value using compressor performance maps for the various compressor and control types.
- Multiplying the % of full load kW value by the corrected full load kW value obtained in Step 1.
- If hourly kW values are specified then it is necessary to estimate the hourly average airflows. This conversion is accomplished by:
- Dividing each hourly kW demand airflow by the full load kW value (corrected value from Step 1) to obtain a % of full load kW value,
- Translating the % of full load kW value to a % of full load ACFM value using compressor performance maps for the various compressor and control types.
- Multiplying the % of full load ACFM value by the corrected full load ACFM value obtained in Step 1.

2.2.13.5.3 Compressor Control Methods

Additional discussion of the various controls types follows.

- Modulation – Inlet Valve Throttling

Throttling is a form of inlet modulation accomplished by a butterfly or slide valve, and is typically found on rotary screw compressors. For a given compressor load, expressed as a fraction (%C) of compressor full-load capacity, the corresponding power expressed as a fraction (%P) of full-load power can be calculated using the following linear relationship:

$$\%P = (1 - \%P_{nl}) * \%C + \%P_{nl}$$

Where
$\%P_{nl}$ = power at no load condition divided by full load power (user input).

- Load-Unload

Load-unload controls on rotary screw and reciprocating compressors allow the compressor to operate at two points: full-load and no load (unloaded). The compressor operates at full load until the system reaches the maximum discharge pressure at which time the compressor unloads. For a given compressor load, expressed as a fraction (%C) of compressor full-load capacity, the corresponding power expressed as a fraction (%P) of full-load power can be calculated using the following linear relationship:

$\%P = (1 - \%P_{nl}) * \%C + \%P_{nl}$

Where

$\%P_{nl}$ = power at no load condition divided by full load power (user input).

- Modulation w/Unload

This control strategy is a combination of modulation and load-unload controls, and is found only on rotary screw compressors. Modulation may be by either via an inlet valve or by turn or poppet valves (variable displacement). Compressors operate at full-load until the full-load discharge pressure is reached, then begin to modulate to match system air requirements (reduced airflow at required output pressure) until the compressor unload point ($\%C_{ul}$) is reached. Once this point is reached the compressor will unload fully (zero output airflow) and remain unloaded until the output pressure declines (see Figure 13-1).

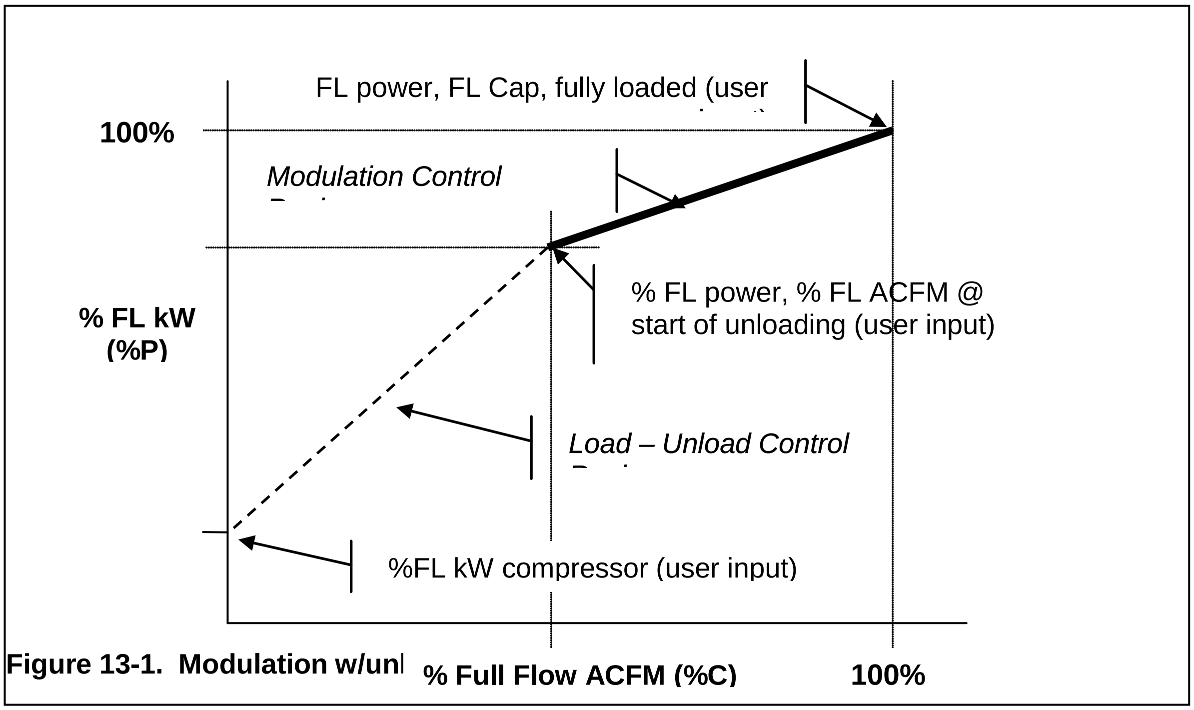

Figure 13-1. Modulation w/unl

For a given compressor load, expressed as a fraction (%C) of compressor full-load capacity, the corresponding power expressed as a fraction (%P) of full-load power can be calculated using the following formulae (illustrated in Figure 13-1) for :

$\%P = ((\%P_{ul} - \%P_{nl}) / \%C_{ul}) * \%C + \%P_{nl}$ **($\%C < \%C_{ul}$)**

$\%P = (\%C^{n} - 1) * ((1 - \%P_{ul})/(1 - \%C_{ul})) + 1$ **($\%C > \%C_{ul}$)**

where

if control type is throttle then n=1
if control type is variable displacement then n=2

$\%P_{ul}$ = power at unloading point divided by full load power (user input)
$\%P_{nl}$ = power at no load conditions divided by full load power (user input)
$\%C_{ul}$ = airflow at unloading point divided by full load ACFM (user input)

2.2.13.5.4 Compressor After-Cooling

Air compressors generate significant amounts of heat that must be removed from the air prior to use. This after-cooling step is accomplished using either an air-to-air or water-to-air heat exchanger that is typically integrated into the air compressor package. The parasitic energy associated with after-cooling varies depending on the method employed and must therefore be accounted for properly during the analysis. In the case of air-cooling both the heat exchanger and associated fan(s) are integrated into the air compressor package itself. The fan can be driven either by the main compressor drive motor or a separate drive motor may be used. The user must specify the type of after-cooling method (Air (Integral Fan), Air (Separate Fan), or Water. In the case of air cooling with a separate fan the user must also provide motor performance information (see Table 13-3).

For water-cooled applications the air-to-water heat exchanger is integrated into the air compressor package and typically receives cooling water from a centralized cooling system that also supplies various other systems in the facility. If both the existing and proposed air compressors use water for after-cooling then the incremental impact on the central cooling system is assumed to be negligible and no action is taken. The CCT software does not allow for changing of the after-cooling method. The analysis associated with estimating the incremental cooling load impact on a large centralized cooling system is beyond the scope of the CCT software since it requires knowledge of the various other systems that may also be using cooling water. The CCT software employs a check to determine if the existing and proposed equipment use *different* after-cooling methods and notifies the user that the CCT software cannot be used in cases where the after-cooling method has changed.

2.2.13.5.5 Total Package versus Compressor-only Power

As noted previously, the user must enter hourly load profile information for each compressor for up to four day-types. The user can choose to enter either electric demand (kW) or airflow (ACFM) data. For electric demand data, the software converts these data points into % of full load values by dividing each value by the air compressor full load kW value (user input that has been corrected for ambient temperature, elevation and operating pressure). The full load package power value entered by the user, as supplied by CAGI datasheets is the total package power and includes control and after-cooling fan power, if applicable. The hourly profile values entered by the user are obtained via direct measurement and in the case of electric demand values may or may not include control and after-cooling fan power (depending on how the measurement equipment was installed). For this reason, the user must specify whether hourly electric demand profile values include control and fan power (kW - Package) or the compressor drive motor only (kW – Compressor Only).

If the user has selected kW – Compressor Only and Air (Separate Fan) was previously specified for the after-cooling type then the software must correct the hourly profile kW values by adding in an estimated fan power value (prior to dividing by the total package power value to obtain %FL kW). The added fan power is calculated as follows using the Fan HP and Fan Motor Efficiency inputs with an assumed fan loading of 0.75.

Fan kW = 0.75 * Fan HP * 0.746 / Fan Motor Efficiency

2.2.13.5.6 Baseline Demand – Deferred Load

Deferred load in this instance refers to cases where an existing business requires additional compressed air capacity. This additional capacity will normally result in increased electric load. In order to minimize this load increase, the CCT program provides an incentive to the business to purchase more efficient compressed air system equipment, which helps to reduce or defer a portion of the added electric load. Deferred savings, in this case is the difference between the increased load that would have resulted in the absence of the incentive and the estimated load that will occur using the proposed energy efficient measure.

The baseline consumption for deferred load applications is the sum of the existing energy use and the estimated increased energy use that would have occurred in the absence of the incentive. An important issue associated with estimating deferred savings therefore deals with defining what a business would do in order to meet the increased airflow in the absence of the incentive. The CCT software estimates the baseline usage for deferred load applications based on the following assumptions:

- In the absence of an incentive, the customer would purchase, install and operate additional compressor capacity with performance characteristics equivalent to the equipment that is already on-site (e.g., purchase/lease one or more additional compressors just like they already own).
- The need for added airflow capacity is related to the addition of production equipment that operates during the same hours as the existing equipment (i.e., 5 days/week, 16 hours per day, etc.) and is therefore covered by the existing day-types.

For deferred load applications the user input screens contain the same inputs as for any retrofit application, with one exception. Additional input(s) are required on the measure specification input screen (see Table 13-3) that indicates the percentage increase in the airflow for each day-type. To facilitate entry of this input the software displays the peak airflow for each day-type (calculated based on previously entered profile data). The software uses this % increase value to adjust the airflow and kW profile information for each day-type. Based on the assumption that the customer would utilize the same type of equipment (kW/cfm remains unchanged), the adjustment for the added capacity is:

New Baseline kW = Previous kW * (1+ % Increase/100)

The profile data for each day-type are modified in this fashion to arrive at the estimated baseline profile with the added airflow capacity.

2.2.13.5.7 Baseline Demand – New Installations

For new installations savings occur when SCE via the CCT incentive program induces a customer to install more efficient equipment when adding new equipment to an existing facility/business. Savings analysis differs significantly for new installations due to the absence of operating data. The lack of operating data restricts the complexity of the savings analysis and therefore also limits the types of energy efficient measures that can be accommodated. For this reason, only applications involving efficient compressor installations are accommodated by the CCT software.

For these types of applications the user inputs provide for entry of the following information (see Table 13-3):

- Proposed compressor equipment and performance data (same as existing CCT applications)
- Air system configuration and operating conditions (same as existing CCT applications)
- Peak and average airflow values (in lieu of profile data) for each anticipated operating mode (i.e., normal weekday, weekend, etc.), for each compressor.
- Equipment operating hours for each operating mode

New installations do not involve the replacement of existing equipment, and as such, the user does not specify the performance characteristics of baseline equipment. Therefore, the software selects a baseline compressor of the same size and type (i.e., reciprocating, screw, etc.) as each of the proposed air compressors from the AirMaster+ compressor list (see Appendix A) with a default baseline control type as noted in Table 13-3. Having selected the baseline compressor(s) the software then inserts N average airflow values into the hourly profile for each day-type where N is the number of daily operating hours specified by the user for that day-type. The software then allocates airflow to the different baseline compressors according to the compressor load order specified by the user. Having allocated airflow to each compressor in this fashion it is then possible to estimate the energy use of each compressor as discussed previously.

Table 13-5: Baseline Compressor Controls for New Installations

Compressor Type	Baseline Control Type
Single stage rotary screw – lubricant injected	Inlet valve modulation w/unload
Single stage rotary screw – lubricant free	Load / Unload
Two stage rotary screw – lubricant injected	Inlet valve modulation w/unload
Single stage reciprocating	Load / Unload
Two stage reciprocating	Load / Unload

2.2.13.5.8 Step 3: Calculate Baseline Annual Energy Use and Peak Demand

Prior to using the day-type profile data to calculate the annual baseline energy usage the CCT software first checks if the baseline compressor package efficiency meets minimum requirements. These requirements are based on the "typical" specific package power values (kW/100 cfm) as used in the AirMaster+ software program (see Appendix A). These values were compiled as part of the DOE Compressed Air Challenge program and comprise the most comprehensive survey of existing equipment. Specific package power (SPP) and the associated correction factor are defined as follows:

$$SPP_c = \text{Full load kW} / (\text{Full load airflow}/100)$$
$$BCF = SPP_c\ AM{+} / SPP_c\ Compr$$

where:

SPP_c = Specific package power (kW/100 cfm)

BCF = Baseline correction factor

SPP_c AM+ = AirMaster+ specific package power (table lookup using existing compressor type, size and pressure) corrected for site amb. temperature, elevation & operating pressure.

SPP_c Compr = Existing compressor specific package power corrected for site amb. temperature, elevation and operating press. (calculated based on user inputs)

A BCF is calculated for each existing compressor in this fashion. If the BCF is equal to or greater than one (1) then this indicates that the existing compressor meets the minimum efficiency threshold and no action is taken. If the BCF is less than one then each of the hourly demand profile values associated with this compressor is multiplied by the BCF to arrive at an equivalent demand for a compressor meeting the minimum efficiency requirement. In addition, a warning message is generated indicating to the user that demand values have been corrected to meet minimum efficiency requirements.

Once the hourly profile values have been examined and corrected as needed, the baseline annual energy use is estimated by summing the hourly energy use for each compressor and day-type. The day-type totals are then multiplied by the corresponding days per week and weeks per year user input values (see Table 13-3) to arrive at a total annual baseline energy use. The baseline peak electric demand is calculated by trapping the highest hourly demand for any day-types that the user has designated as having “weekday” operation.

2.2.13.5.9 Step 4: Establish System Proposed Airflow & Electric Demand

The proposed system electric demand is estimated using the airflow information previously developed as part of the baseline demand analysis (Step 2) in conjunction with the performance specifications of the proposed equipment. The approach used to estimate the proposed system demand varies based on the efficiency measure involved as described in the following sections. Note that no correction factor is calculated for the proposed equipment.

2.2.13.5.9.1 Efficiency Measure – Single Compressor Replacement

In the case of replacement of a single compressor, or when multiple compressors are replaced by a single new compressor, the software uses the airflow profile data previously developed for each day-type to estimate the electric demand of the proposed air compressor. The approach used to estimate the electric demand of the new compressor is the same as that used to estimate the performance of the existing equipment (see Step 2 discussion) with the exception that the control and performance characteristics as specified by the user are used (after correcting to local conditions) in the analysis.

- Variable Speed Drive (VSD)

Variable speed drive controls vary the frequency of the power delivered to the compressor drive motor to regulate the motor speed in response to changing airflow requirements. These controls achieve significant savings at part-load with some tradeoff of efficiency at full load due to drive inefficiency. The control method employed by VSD controls vary depending on the manufacturer and whether the VSD is a retrofit or if the VSD is integral to the air compressor. For retrofit VSD drives the existing electric motor is retained and the control is typically restricted to motor speeds/frequencies exceeding 50% of the normal motor speed (to prevent damage to the electric motor).   If airflow requirements fall below the level needed to maintain the minimum motor speed then the control will either unload the compressor, while operating at minimum speed, or will shut off the compressor entirely.

Computation of electric demand for VSD equipped air compressors was not covered previously in the Step 2 discussion, since VSD equipped compressors are not supported as baseline/existing equipment. The power requirements of a VSD equipped air compressor are computed in the same basic manner as for a compressor equipped with a modulation w/unload control. Specifically, the control performance map is divided into two linear parts (see Figure 10).

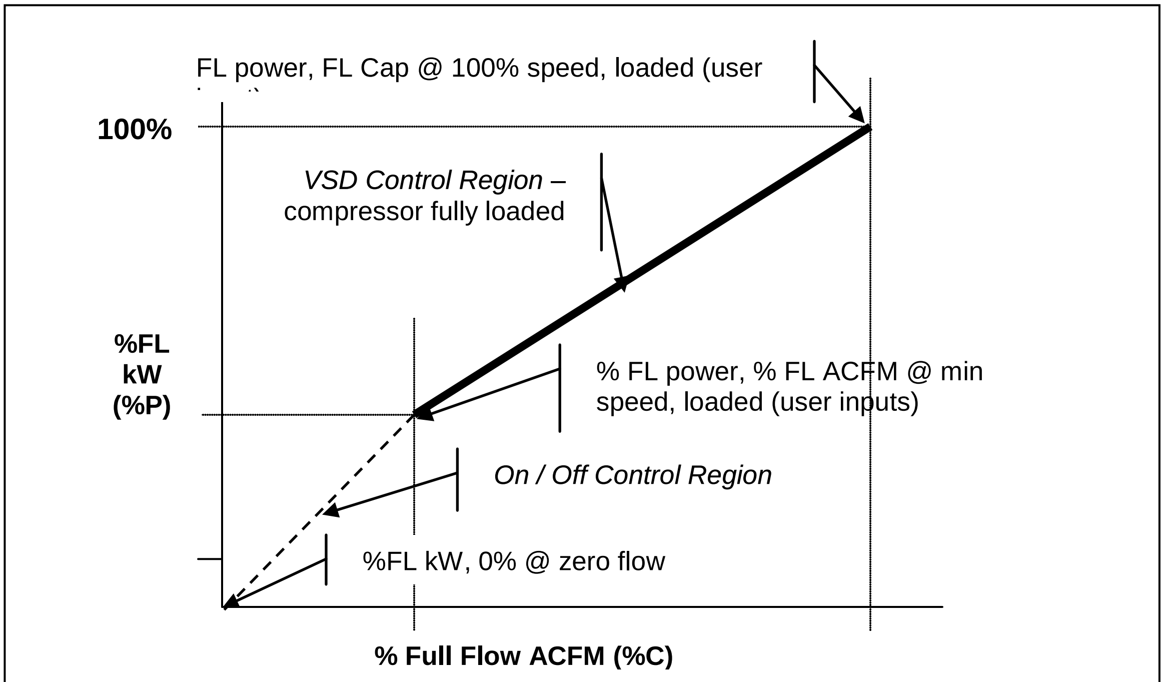

Figure 13-2. VSD Control Performance Map

The CCT software uses the following procedure to estimate the VSD equipped compressor energy use. Using the airflow allocated to the VSD equipped machine as the input, the software:

a. Computes the % FL Airflow by dividing the hourly profile airflow value by the FL capacity of the proposed compressor.
b. Determines if the %FL Airflow value is above the minimum airflow value (input) for the proposed machine (airflow at minimum operating speed)
c. If the airflow is equal to or exceeds the airflow at min speed then the VSD is controlling airflow with the compressor in a fully loaded configuration. The %FL Power value is estimated using the following expression:

%FL Power $= m_{vsd} * \%FLAirflow + b_{vsd}$

where:

m_{vsd} = $(100 - \%FLkW_{ms}) / (100 - \%FLCap_{ms})$
b_{vsd} = $100*(1- m_{vsd})$
$\%FLkW_{ms}$ = %FL power at min speed (compressor loaded), *input*
$\%FLCap_{ms}$ = %FL airflow capacity at min speed (compressor loaded), *input*
%FLAirflow = %FL airflow in question
%FL Power = %FL power corresponding to the %FL Airflow value, *calculated*

d. If the airflow value is less than the airflow at min speed (and is non-zero) then the VSD is assumed to be either at minimum speed (minimum airflow) or the compressor is turned off (on / off control). Within this range the %FLkW value is estimated using the following expression:

%FL Power $= m_{l/u} * \%FLAirflow + \%FLkW_0$

where:

$m_{l/u}$ = $(\%FLkW_{ms} - \%FLkW_0) / \%FLCap_{ms}$
$\%FLkW_0$ = 0
$\%FLkW_{ms}$ = %FL power at min speed (compressor loaded), *input*

$\%FLCap_{ms}$ = %FL airflow capacity at min speed (compressor loaded), *input*
%FLAirflow = %FL airflow in question
%FL Power = %FL power corresponding to the %FL Airflow value, *calculated*

2.2.13.5.9.2 Efficiency Measure – Multiple Compressor Replacement or Upgrade
The CCT software supports replacement or upgrade of up to three air compressors. The electric demand of each of the proposed compressors is estimated in much the same way as for a single compressor. A compressor performance map, specific to the type of compressor and type of proposed control is used to estimate the electric demand. In the case of a single proposed compressor, all of the system airflow is assigned to the proposed compressor.

- Compressor Loading Order

For multiple compressors the analysis must include a step where the total system airflow is allocated amongst the various proposed compressors. A compressor loading order is used to accomplish this allocation of system airflow. The user determines the loading order by designating each proposed compressor as one of the following:

- Lead/Baseload (L/B),
- Additional Baseload (A/B), or
- Variable/Trim (V/T).

Since the software supports up to three compressors, two may be designated as base loaded and as one as V/T. The analysis approach used by the software is limited to considering a single VSD drive, which if present, must be designated as V/T. The software requires that the user keep the compressor designations (L/B, A/B, V/T) fixed for all day-types and all hours of operation (i.e., the compressors are always sequenced in the same fashion).

For each day-type profile the software steps through each hour and allocates the system airflow using the following procedure.

a. If the system airflow during any given hour is zero then all of the compressors are assumed to be turned off.
b. If system airflow is non-zero then all compressors are set to their minimum flow setting (assumed to be zero). If the system airflow is less than the V/T machine full load capacity then all of the airflow is allocated to the V/T machine and the L/B and A/B machines remain at their minimum setting.
c. If the system airflow exceeds the V/T capacity then the V/T machine is set to its minimum operating point and the remaining airflow is allocated to the L/B machine. Airflow in excess of the L/B machine capacity is then assigned to the V/T machine.
d. If system airflow exceeds both L/B and V/T capacities then the V/T machine is set to its minimum operating point, the L/B machine is loaded fully and the remaining capacity is allocated to the A/B machine. Airflow in excess of the A/B machine capacity is added to the V/T airflow.
e. As system airflow decreases the V/T machine will unload first followed by the A/B and L/B machines until each machine reaches its minimum operating point. If the user has indicated that an auto shutdown timer is present and the compressor is capable of unloading, then the compressor cycle time is also checked to determine if the compressor can be turned off (see Auto Shutdown Timer discussion).
f. If the system airflow exceeds the total capacity of the proposed equipment during any hour the software generates an error message and requires user intervention in order to proceed.

Once the airflows have been allocated the software then estimates the kW demand for each compressor using the approach described previously for a single compressor.

It should be noted that the CCT software does not employ a dynamic simulation of equipment operation, and as such, no attempt is made to estimate, and account for, the actual operating pressure for each compressor (the operating pressure for each compressor is assumed to be equal).

- Auto Shutdown Timer

Some air compressor controls employ a timer that automatically shuts off a compressor that has remained in an unloaded condition for a preset period of time. To account for this type of control the user inputs include a check box (see Table 13-3) indicating if this type of control is present and the unloaded time threshold value (if applicable).

If the user has specified that an auto shutoff timer is present and the compressor in question is capable of unloading (load/unload, modulation with unload, variable displacement with unload) then the cycle time will also be estimated to determine if the auto shutdown timer threshold has been reached. A compressor load / unload cycle consists of two parts. When the outlet pressure exceeds the “Cut Out” pressure the compressor is unloaded and outlet pressure is allowed to decrease. This portion of the cycle is called the “drain down time” (Tdr). Drain down ends when the outlet pressure has dropped below the “Cut In” pressure at which time the compressor is loaded. This “loaded” portion of the cycle is called “pump up time” (Tpu) and will continue until the outlet pressure has again reached the Cut Out setting, and then the cycle repeats. The amount of time spent in either state is a function of the compressor capacity, system airflow requirement and total system volume along with the cut out and cut in pressures. If the drain down (unloaded) time exceeds the auto shutdown timer setting, then the compressor will be shut off during part of the hour being examined.

The following expressions are used to determine if an auto shutdown will occur:

Tdr = Strg * (Pmax - Pmin) / (Patm * dACFM)

where:

Strg	= Site.SystemVolume + AdditionalStorage (user inputs)
Pmax	= FullFlowPressCutOut (user input)
Pmin	= FullLoadPressCutIn (user input)
Patm	= 14.5 - (0.271875 * SiteElevation / (460 + SiteTemp))
dACFM	= air compressor air flow (allocated by compressor loading scheme)

If the drain down time exceeds the auto shutdown timer setpoint (SDTimer) then the air compressor will be off during a portion of the hour. The impact of shutting down the air compressor is estimated as follows:

Tpu = Strg * (Pmax - Pmin) / (Patm * (Cfl - dACFM))

PctP = ((1.0 * Tpu) + (Pnl * SDTimer)) / (Tpu + Tdr)

where:

PctP	= fraction of full load compressor power
Pnl	= compressor power (kW) when fully unloaded
Cfl	= compressor full load airflow (acfm) capacity
SDTimer	= shut down timer setting (mins)

2.2.13.5.9.3 Efficiency Measure – Intermediate Flow/Pressure Controller

An intermediate flow/pressure controller ultimately achieves energy savings by allowing the end uses (system) to operate at a lower pressure than the centrally located compressors. Lowering the system operating pressure downstream of the new flow/pressure control valve reduces the airflows to unregulated end uses (e.g., leaks). Energy savings are achieved via the reduced power demand of the compressors when supplying less overall airflow. It is important to note that only airflow associated with leakage or unregulated end uses (without individual pressure regulators) will be affected by this measure. It is for this reason that the user must input the estimated leakage rate (default of 5%) and the percentage of total system airflow represented by unregulated end uses (default is 0%).

Using the estimated leakage and unregulated end use % values entered by the user the software calculates new system airflows for each day-type profile using the following expressions:

$$Q_c = Q_e * dLeakFactor$$
$$dLeakFactor = (1.0 + a * (b - 1.0))$$
$$a = (\%Leak + \%Unreg)/100$$
$$b = (P_p + 14.7psia) / (P_e + 14.7psia)$$

where:

Q_e	= existing system airflow before correction, acfm
Q_c	= corrected system airflow, acfm
%Leak	= % of total airflow from leaks, *user input*
%Unreg	= % of total airflow from unregulated end uses, *user input*
P_p	= proposed system press (downstream of new controller), *user input*
P_e	= existing average system pressure, *user input*

Once the system airflow values (day-type profile values) are modified then it is possible to reallocate the system airflows to the air compressors and estimate their energy use using the procedures described previously in the discussion of Multiple Compressor Replacement or Upgrades.

2.2.13.5.9.4 Efficiency Measures – Storage System Upgrade

As noted in the discussion of auto shutdown timers, a compressor capable of load / unload control may be turned off if the drain down time exceeds the auto shutdown timer setting. Since this drain down time increases with system volume it is possible to increase this time by adding to the system volume. Thus increasing the amount of storage can result in increased operation at an unloaded condition, and possibly result in a compressor being shut off.

The CCT software estimates these potential savings by using the same basic calculations as discussed previously under the auto shutdown timer section. The only difference is that the presence of an intermediate flow controller must be accounted for in the calculations. Storage located downstream of an intermediate pressure controller does not directly impact the compressor cycle time and as such it is important to differentiate between storage located upstream and downstream of the controller. For this reason, the user inputs for this measure include values for the amount of storage upstream and downstream of the controller (if present). Only storage located upstream of the controller is included in the system volume value used in the drain down time calculation. It is also important to note that this measure will only achieve savings if an auto shutdown timer is present.

2.2.13.5.9.5 Proposed Energy Use – New Installations

The process used to estimate the proposed energy use of proposed equipment associated with new installations is the same as described above with the following exceptions:

- Measures involving intermediate flow controllers and added storage are not supported, and

- The system airflow used to allocate individual compressor airflows is based on the individual day-type average airflow user input values (see Table 13-3) and the process described in Section 2.2.13.5.7.

2.2.13.5.10 Step 5: Estimate Proposed Annual Energy Use and Peak Demand
Once the proposed electric demand profiles have been developed for each day-type using the approaches discussed above, it is a simple matter of summing up the hourly energy usage for each compressor and each day-type. The day-type totals are then multiplied by the corresponding days per week and weeks per year user input values (see Table 13-3) to arrive at the total annual proposed energy use. The proposed peak electric demand is calculated by trapping the highest hourly demand for any day-types that the user has designated as having "weekday" operation.

2.2.13.5.11 Step 6: Estimate Energy and Demand Savings
Once the annual baseline and proposed energy use and peak demand values have been estimated it is simple matter of subtracting the proposed energy use from the baseline energy use to arrive at the estimated savings. Likewise, the demand savings is estimated by subtracting the proposed peak demand baseline peak demand.

2.2.14 Other - Demand Control Ventilation (DCV)

2.2.14.1 Description

Outside air is typically introduced at a fixed rate, into buildings for the peak design occupancy level. Demand Control Ventilation (DCV) varies the amount of outside air introduced in the building based on occupancy level. The energy conserving attribute of DCV is heavily dependent on the variability of the occupancy level and climate zone. Reducing the amount of outside air can reduce the amount of energy to heat or cool the outside air in certain climate zones. Reducing outside air in certain climate zones (cool and dry) can increase energy consumption because the cooling effect of the outside air is reduced (no economy cycle scenario).
Carbon Dioxide is used as an indicator of occupancy level. With the use of CO_2 sensors and a prescribed (the program's default set-point for CO_2 of 1000 ppm was accepted) CO_2 concentration set point for the space, the amount of outside air can be varied. In all cases DCV is overridden by economy cycle controls. When outside air (economy cycle) can be beneficial for cooling, DCV is not allowed to reduce the amount of outside air introduced. DCV saves cooling energy by reducing the amount of outside air, to the minimum required by a CO_2 measurement as a proxy for occupancy during periods of non-economy cycle operation. This measure does not calculate heating energy savings.

2.2.14.2 Appropriate Use of the Tool –Program Policy

The Demand Control Ventilation Tool estimates the highest probability of cooling energy savings for buildings with high occupancies and in "hot & dry" weather zones.

The Demand Control Ventilation Tool is applicable for electric cooling equipment with and without an economy cycle.

The estimate of savings from the Demand Control Ventilation Tool can be calculated for the following building types and sizes. This tool is primarily for smaller buildings. The accuracy is degraded when the area is larger than the following area because the *Honeywell* "Saving Estimator" program Version 3.30 does not recommend using values more the four times the software defaults:

Restaurant – 21,000 ft^2
Retail – 300,000 ft^2
School (Class Room Wing) – 38,000 ft^2
Small Office – 25,000 ft^2

2.2.14.3 Inputs

Prior to selecting the Demand Control Ventilation measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load), or New Installation. Once the Demand Control Ventilation measure is selected, the user is then directed to enter the various inputs as described below.

Table 14-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Manufacturer	Fill in	1	Enter manufacturer of DCV controls
Model Number	Fill in	1	Enter model number of DCV controls
City	Pull-Down	1	Select the location of the building
Economy Cycle	Button	1	Yes or No

Cooling Equipment Efficiency	Button	1	Specify the EER of the cooling equipment, either “Low (EER=8)”, “Medium (EER=10)”, “High (EER=12)
Building Type	Pull-Down	1	Select either Restaurant, School, or Small Office
Building Area	Fill in	1	Enter area of the building (Square feet)

2.2.14.4 Output

Once all necessary input information has been gathered, the Demand Control Ventilation Tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The Demand Control Ventilation Tool outputs are described below.

Table 14-2. Output

Output Name	Type	Sheet	Description / Purpose
Existing Equipment, kW	Result	2	Estimated DEER Peak Demand
Proposed Equipment, kW	Result	2	Estimated DEER Peak Demand
Existing Equipment, kWh/yr	Result	2	Estimated existing annual energy consumption
Proposed Equipment, kWh/yr	Result	2	Estimated proposed annual energy consumption
Savings, kW	Result	2	Estimated DEER Peak demand savings for measure (difference between existing and proposed)
Savings, kWh/yr	Result	2	Estimated annual energy savings for measure (difference between existing and proposed)
Incentive	Result	2	Estimated incentive ($) for the measure.

2.2.14.5 Energy Savings Explanation

Honeywell has developed a software program that was used to develop the savings for the Customized Offerings. This *Honeywell* program is “Saving Estimator” Version 3.30 (8/8/2003) by J. E. Braun & M. J. Brandemuhl. This program was used to develop 1536 savings estimates. There were 16 California Weather Zones, 2 conditions of the economy cycle (yes or no), 3 levels of equipment efficiency (low, medium, and high), 4 building types, and 4 building areas. From these estimates trend lines were developed and used in the CCT software tool.

The Savings Estimator is an hourly program that evaluates the energy impact of DCV. The CCT tool evaluates the energy impact for cooling (not from heating) from the application of DCV control for rooftop package units. The default occupancy levels are based on work done by Lawrence Berkeley National Laboratories (LBNL). For each building type there is a default occupancy schedule used that cannot be changed. The fixed ventilation rate is determined by the peak design occupancy and ASHRAE Standard 62-1999. The thermostat set-point is 75 °F for the occupied period.

The CCT tool estimates the CPUC defined peak demand savings by calculating the average kW savings for the hours of 2:00 PM to 5:00 PM over the DEER month based on the location of the project based on the data supplied by *Honeywell’s* “Saving Estimator”. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the average kW demand is typical during the averaged operating periods. The software will confirm with the applicant if the system operates during the defined peak period.

2.2.15 Other - Injection Molding Machines

2.2.15.1 Description

Standard injection molding machines use electric motor-driven constant volume and pressure hydraulic pumps to operate the clamp and screw barrel functions. During the machine's cycle, there may be times when the hydraulic fluid is not required so the fluid is bypassed through a pressure relief valve. High efficiency hydraulic units avoid the energy loss through the pressure relief valve with the use of variable speed drives or variable volume configurations. The most efficient machines do not use hydraulics, but rather use high torque servo motors to drive the ram directly. The following table shows the injection molders energy consumption per unit of produced weight based on a California utilities research survey.

Table 15-1. Average Specific Energy Use by Type

Machine Type	Specific Energy Usage
Standard hydraulic	0.91 kWh/kg
Variable-volume hydraulic	0.55 kWh/kg
Variable-speed hydraulic	0.55 kWh/kg
All-electric	0.20 kWh/kg

2.2.15.2 Appropriate Use of the Tool – Program Policy

The CCT High-Efficiency Injection Molder tool can be used to estimate energy savings for high-efficiency injection molding machines.

The tool covers the following four types of injection molding machines: standard hydraulic, variable volume, variable speed drive, and all-electric. Standard hydraulic machines may only be input as existing equipment. Proposed equipment must be one of the three more efficient types. Standard hydraulic machines are an option for baseline equipment because these machines are still sold by various manufacturers.

All capacities are covered by the tool. However, energy savings are reduced by 20% for machines with hourly production less than 0.275 pounds of plastic per ton of capacity. These low-production machines typically produce small, intricate parts requiring longer hold times thus reducing the energy savings.

2.2.15.3 Inputs

Prior to selecting the High-Efficiency Injection Molders measure the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. Once the High-Efficiency Injection Molders measure is selected, the user is then directed to enter the various inputs as described in the following table and associated figure. The following set of inputs are required for both the existing and proposed cases if a Retrofit project is specified while inputs are only required for the proposed case if a New Installation is specified.

Table 15-2. Inputs

Name	Type	Description
Manufacturer	Fill in	Equipment manufacturer. Found on nameplate or in specifications.
Model Number	Fill in	Equipment model number. Found on nameplate or in specifications.
Serial Number	Fill in	Equipment serial number. Found on nameplate.
Quantity of Machine	Fill in	Number of injection molders included in retrofit.
Type of Machine	Pull-down	Pull-down menu with “Standard Hydraulic”, “Variable Volume”, “Variable Speed Drive”, and “All Electric” options. (“Standard Hydraulic” option is only available for the existing case.) Used to select average specific energy.
Machine Capacity (tons)	Fill in	Rated clamping force. Found on nameplate or in specifications.
Average Production Rate (lb/hr)	Fill in	Average amount of plastic processed by the barrel per hour per machine in pounds. Must take into account variation in parts produced. Obtained through production records or measurement.
Annual Operating Hours	Fill in	Must be the best estimate of the actual number of hours the machine is producing parts in one year. Note: A 90% duty cycle is INCLUDED in the software.

2.2.15.4 Outputs

The following table and associated figure describes the CCT tool outputs. To get to the “Last Sheet” and see the kW demand savings and the associated incentive the user must press the finish button.

Table 15-3. Outputs

Name	Sheet	Description
Existing Average Demand, kW	2	Estimated maximum on-peak power demand of the existing injection molder(s)
Proposed Average Demand, kW	2	Estimated maximum on-peak power demand of the proposed injection molder(s)
Existing kWh/yr	2	Estimated annual energy use of the existing injection molder(s)
Proposed kWh/yr	2	Estimated annual energy use of the proposed injection molder(s)
Savings, kW	2	Estimated on-peak power demand savings for measure (difference between existing and proposed)
Savings, kWh/yr	2	Estimated annual energy savings for measure (difference between existing and proposed)
Existing System Runtime Hours	2	Annual operating hours for the existing injection molder(s)
Proposed System Runtime Hours	2	Annual operating hours for the proposed injection molder(s)
Incentive (@ $0.09 kWh/yr)	2	Estimated CCT incentive based on $0.09/kWh/yr
Calculated kW Savings	Last sheet	Estimated on-peak demand savings due to the difference in average power (kW) requirements of the two machines

Eligible Peak Demand Savings (kW)	Last sheet	The user can modify the result is there is a specific reason.
Eligible incentive rate	Last Sheet	$100/kW
Qualified Peak Demand Incentive	Last sheet	Amount of incentive due to the power demand savings
Total incentive	Last Sheet	Sum of the energy saving incentive and power demand saving incentive

2.2.15.5 Energy Savings Explanation

The energy savings estimating tool for high efficiency injection molders uses equations that are based on energy use per pound of plastic produced (kWh/lb.). These parameters are based on measured performance data, which take into account variations in part size, production rates and cycle time.

2.2.16 Other – Low Solar Heat Gain Coefficient Windows

2.2.16.1 Description

This tool is designed to compute the CCT savings and incentive achieved from the installation of windows that have a low solar heat gain coefficient (SHGC). Low SHGC windows save energy by reducing the transmission of heat from the outside to the inside of a structure during the hotter months. This results in a reduction in cooling load. In addition, during the colder months, heat loss is reduced due to an increase in the U-factor of the window. Heating energy is offset to some extent based on reduced transmission of solar heat during colder periods. The 2010 CCT software calculates savings using the Engage software for a measure of this type. The Engage software is a stand-alone, DOE2 based modeling program.

2.2.16.2 Appropriate Use of the Tool – Program Policy

This CCT tool is utilized for the retrofit of existing windows. Window film and/or glazing measures cannot be correctly computed using this tool since CCT will always use T24 standards as the baseline, unless the existing windows are more efficient than T24 standards. New installations or increased load projects are not covered.

The estimate of savings from the Low Solar Heat Gain Coefficient Windows Tool can be calculated for the following building types and the building area must be between:

Assembly – defaults to 34,000 ft^2 but must be between 40,000 and 200,000 ft^2
Education – Primary School – defaults to 50,000 ft^2 but must be between 40,000 and 200,000 ft^2
Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2
Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2
Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2
Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2
Lodging - Hotel – defaults to 200,000 ft^2
Lodging - Motel – defaults to 30,000 ft^2
Manufacturing – Bio/Tech – defaults to 200,000 ft^2
Manufacturing – Light Industrial – defaults to 100,000 ft^2
Office – Large – defaults to 175,000 ft^2
Office – Small – defaults to 10,000 ft^2
Restaurant – Sit Down – defaults to 4,000 ft^2
Restaurant – Fast Food – defaults to 2,000 ft^2
Retail – Multistory Large – defaults to 120,000 ft^2
Retail – Single -Story Large – defaults to 130,500 ft^2
Retail – Small – defaults to 8,000 ft^2
Storage – Conditioned - defaults to 500,000 ft^2

Table 16-1. Title 24 Standards for SHGC and U-factor

		Climate Zones									
Space Type	Criterion	1,16		3-5		6-9		2,10-13		14, 15	
Non-residential	U-factor	0.47		0.77		0.77		0.47		0.47	
	Relative Solar Heat Gain	Non-North	North	Non-North	North	Non-North	North	Non-North	North	Non-North	North
	0-10% WWR	0.49	0.72	0.61	0.61	0.61	0.61	0.47	0.61	0.46	0.61
	11-20% WWR	0.43	0.49	0.55	0.61	0.61	0.61	0.36	0.51	0.36	0.51
	21-30% WWR	0.43	0.47	0.41	0.61	0.39	0.61	0.36	0.47	0.36	0.47
	31-40% WWR	0.43	0.47	0.41	0.61	0.34	0.61	0.31	0.47	0.31	0.40
Residential High-rise	U-factor	0.47		0.47		0.47		0.47		0.47	
	Relative Solar Heat Gain	Non-North	North	Non-North	North	Non-North	North	Non-North	North	Non-North	North
	0-10% WWR	0.46	0.68	0.41	0.61	0.47	0.61	0.36	0.49	0.36	0.47
	11-20% WWR	0.46	0.68	0.40	0.61	0.40	0.61	0.36	0.49	0.31	0.43
	21-30% WWR	0.36	0.47	0.31	0.61	0.36	0.61	0.31	0.40	0.26	0.43
	31-40% WWR	0.30	0.47	0.26	0.55	0.31	0.61	0.26	0.40	0.26	0.31

WWR= Window to Wall Ratio

2.2.16.3 Inputs

Table 16-2. List of Inputs

Input Name	Type	Input Sheet	Description/Purpose
Location	Pull-down	1	From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone or select the weather zone directly from the pull down menu.
Building Type	Pull-down	1	Select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D in the NRR Manual for detailed descriptions).
Vintage	Pull-down	1	Select the vintage of the building.
HVAC System(s)	Pull-down	1	Select a “predefined” HVAC system type from the drop down list. Choices change depending on building type selected.
Allow HVAC System Downsizing	Checkbox	1	For 2005 and newer buildings, if the analysis results in reduced cooling or heating loads, selecting this option allows the tool to reduce the size of the HVAC systems in

			the measure runs to better match the reduced loads. This is generally considered appropriate for retrofit scenarios which include a change of HVAC systems.
Building Area	Fill in	1	Enter the total building area. NOTE: Some building types will also require the user to define a secondary building area.
Number of Floors	Fill in	1	Enter the total number of floors. NOTE: Some building types will also require the user to define a secondary number of floors.
Seasonal Usage Pattern	Pull-down	2	Select the most appropriate description for the building's seasonal usage.
Number of Seasons	Pull-down	2	Define the number of seasons for the building.
Season Label	Fill in	2	Create a label for the defined season.
Number of Date Periods	Pull-down	2	Select the number of operating periods. Next, select the corresponding dates in their respective pull down menus.
Observed Holidays	Button	2	Select which holidays are observed.
Select Active Building Shell	Pull-down	3	Select the most appropriate building shell.
Seasons	Pull-down	3	Define the seasonal open and close times.
Orientation	Checkbox	4	Use these check boxes to indicate up to four orientations per glass type. The software allows orientation assignments for up to two glass types. The orientations selected for the existing windows case is applied to the proposed windows case.
Performance Data	Pull-down	4	Select either NFRC (National Fenestration Rating Council) or glass manufacturer indicating the source utilized to obtain each window type's U-factor and SHGC (solar heat gain coefficient).
U-factor	Fill in	4	the overall coefficient of thermal transmittance of the whole window assembly (glass + frame), in Btu/(hr-sf-ºF), including air film resistance at both surfaces. See table below for T24 minimum standards.
Solar Heat Gain Coefficient (SHGC)	Fill in	4	The ratio of the solar heat gain entering the space through the window to the incident solar radiation. See Table 16-1 above for T24 minimum standards.
Total Window Area	Pull-down/Fill in	4	Enter total building window area using either input method: % of Gross Wall Area – indicates that the Total Glass Area will be described as a gross (floor-to-floor) window-wall ratio. Total Facility Window Area – indicates that the Total Glass Area will be described in square feet of total window area.

Replacement Window Areas	Fill in	4	Enter the window areas according to orientation.

2.2.16.4 Outputs

Table 16-3. List of Outputs

Output Name	Description/Purpose
Existing Equipment	Shows existing case peak kW, kWh/yr, and Therms/yr usage.
Baseline Equipment	Shows baseline case peak kW, kWh/yr, and Therms/yr usage. The baseline is the more efficient of the T24 code minimum standards or the existing equipment efficiency.
Proposed Equipment	Shows proposed case peak kW, kWh/yr, and Therms/yr usage.
Savings	The difference between the Baseline and Proposed usage. The incentive is based off of electricity savings only since the therm savings is an interactive effect that is not incentivized as per program rules.
Peak Demand Incentive	Choose the city where the measure is implemented. The city determines the climate zone for the peak demand days to be used for calculating and incentive. A checkbox (selected on default) indicates whether the equipment operates during the defined DEER peak period. If the eligible savings is different than what is calculated by software tool, enter the revised savings. The peak demand incentive is listed, with the peak demand and energy savings incentive at the bottom.

2.2.16.5 Energy Savings Explanation

All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. This engine utilizes the weather data (along with user inputs describing the building envelope characteristics, internal loads, and HVAC system components) to calculate the peak electrical demand and energy usage for all the building components (HVAC equipment, lighting, etc.).

Please note that the Baseline is the greater value between the Existing and Code baseline (Title 24) values that are produced by Engage. This applies to both replacement and early retirement equipment. See the equation below:

Baseline = Minimum(∑Existing kWh/yr or ∑Codebase kWh/yr)

The results are totaled and the CCT Estimation Software then displays the savings estimates and incentive amount.

2.2.17 Other – High Efficiency Motors

2.2.17.1 Description

This tool calculates the demand and energy savings due to the installation of high efficiency motors. It covers replacement, early retirement, increased load, and new installation measures.

2.2.17.2 Appropriate Use of the Tool – Program Policy

This tool establishes the existing motor (baseline) efficiency to correspond to the 1992 Energy Policy Act (EPAct) minimum, except in the case of Early Retirement, which uses the industry standards at the time the motor was installed. Early Retirement results in a larger incentive than would be possible using the traditional Calculated - Approach. If the motor has been recently rewound, it may also qualify for early retirement. To establish the rewinding of a motor and when it was performed, supporting invoices are required.

Applicable Types of Equipment

This tool is applicable for continuous-rated, polyphase squirrel cage induction motors. These motors include NEMA Design A and B, three-phase, 208/230/460 VAC, single-speed (900, 1200, 1800, and 3200 RPM) motors having open drip-proof (ODP) or totally enclosed fan-cooled (TEFC) or explosion-proof (TXPL) enclosures.

Equipment Sizes or Capacities Covered by the Tool

This tool covers motors rated from 1 to 500 horsepower. For multiple motors with different horsepowers, treat each motor size as a separate measure.

2.2.17.3 Inputs

The tool accepts inputs on three windows (Sheets), shown in the tables and figures below:

Table 17-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Description			
Location	Fill in	1	Type the motor location – for reference only.
Function	Fill in	1	Type the motor function – for reference only.
Designation	Fill in	1	Type the motor designation – for reference only.
Existing Motor Parameters			
Duty Cycle (%)	Fill in	1	Percent of time the motor is cycled ON during operating hours. (This will be used along with the Hours/Day, Days/Week, and Weeks/Year inputs to find Total Hours/Year.)
Hours/day	Fill in	1	Hours per day motor is operated.
Days/Week	Fill in	1	Days per week motor is operated.
Weeks/Year	Fill in	1	Weeks per year motor is operated.
Load Type	Fill in	1	For reference only. Pull-down menu with "Centrif. Fan", "Centrif. Pump", "Fan, Other", "Pump, Other", "Compressor", "Extruder", "Crush/Mill", "Mix/blend", and "General" options.
Quantity	Fill in	1	Number of existing motors.
Year Manufactured	Fill in	1	Enter the year that the existing motor was manufactured. (This is used to determine Early Retirement.)
Rewound?	Click/Select	1	Select “yes” if the existing motor has been rewound.
Year Rewound	Fill in	1	If rewound, enter the year that the existing motor was

			rewound. (This is used to determine Early Retirement.)
Proposed Motor Parameters			
Duty Cycle (%)	Fill in	1	Percent of time the motor will be cycled ON during operating hours. (This will be used along with the Hours/Day, Days/Week, and Weeks/Year inputs to find Total Hours/Year.)
Hours/day	Fill in	1	Hours per day motor will be operated.
Days/Week	Fill in	1	Days per week motor will be operated.
Weeks/Year	Fill in	1	Weeks per year motor will be operated.
Quantity	Fill in	1	Number of proposed motors.

Table 17-2. Existing Equipment Motor Details

Input Name	Type	Sheet	Description / Purpose
Motor Nameplate Data			
Manufacturer	Fill in	2	Type the motor manufacturer – for reference only.
Model	Fill in	2	Type the motor model – for reference only.
Serial #	Fill in	2	Type the motor serial # – for reference only.
HP(size)	Pull-down	2	The horsepower of the existing motor. Pull-down menu with options from 1 HP to 500 HP.
FL RPM	Fill in	2	Enter the Full Load RPM of the motor.
Service Factor	Fill in	2	Enter the motor service factor. Typically 1.15 (can handle a 15% motor overload). Found on nameplate.
Volts	Pull-down	2	Pull-down menu with 208, 230, or 460 Volt options.
FL AMPS	Fill in	2	Full load Amps. (FLA from nameplate)
FL Power Factor (%)	Fill in	2	Enter the Full Load Power Factor.
FL Efficiency	Fill in	2	Enter the full load efficiency. Not necessary for early retirement. Automatically filled in if a letter code is selected.
Letter Code	Pull-down	2	Choose an efficiency letter code from the pull down menu. Not necessary if FL Efficiency input was filled in. Not necessary for early retirement.
NEMA Class Design	Pull-down	2	Choose NEMA Class A or B.
ENCLOSURE	Pull-down	2	Choose open drip-proof (ODP), or totally enclosed fan-cooled (TEFC) or explosion-proof (TXPL) motor enclosure.
FRAME	Fill in	2	Type in Frame Size – for reference only.
Motor Field Measurements			
Existing motor power measurements - These are critical for establishing brake horsepower (BHP, motor load). The preferred method is to measure power in kW, using a true RMS power meter. Next best would be to measure voltage, current, and power factor with a true RMS meter. At a minimum, both the voltage and current must be measured. Ensure that all voltages are measured line-to-line and measurements are taken under normal motor operation conditions. If power factor is not measured, then the software will estimate a power factor. The measured values are used to establish the load on the existing motor.			
Date	Fill in	2	Date measured – for reference only.
Time	Fill in	2	Time measured – for reference only.
Normal Load?	Pull-down	2	Select “Yes” if measured at a normal load.

Power - kW	Fill in	2	Enter the measured kW. The remaining inputs (power factor, volts, amps) are only necessary if kW was not measured.
Power Factor (%)	Fill in	2	Enter the power factor, if measured. Otherwise the software will estimate a power factor based on the load and the Full Load power factor entered above. Typical motor power factors range from 70% to 90%, where partly loaded or smaller motors have the lowest power factors, and fully loaded larger motors have the highest power factors.
Volts - Phase ab	Fill in	2	Enter the measured line-to-line voltage.
Volts - Phase bc	Fill in	2	Enter the measured line-to-line voltage.
Volts - Phase ca	Fill in	2	Enter the measured line-to-line voltage.
Amps - Phase a	Fill in	2	Enter the measured current (Amps).
Amps - Phase b	Fill in	2	Enter the measured current (Amps).
Amps - Phase c	Fill in	2	Enter the measured current (Amps).

Table 17-3. Proposed Equipment

Input Name	Type	Sheet	Description / Purpose
Motor Nameplate Data			
Manufacturer	Fill in	3	Type the motor manufacturer – for reference only.
Model	Fill in	3	Type the motor model – for reference only.
Serial #	Fill in	3	Type the motor serial # – for reference only.
HP(size)	Pull-down	3	The horsepower of the proposed motor. Pull-down menu with options from 1 HP to 500 HP.
FL RPM	Fill in	3	Enter the Full Load RPM of the motor.
Service Factor	Fill in	3	Enter the motor service factor. Typically 1.15 (can handle a 15% motor overload). Found on nameplate.
Volts	Pull-down	3	Pull-down menu with 208, 230, or 460 Volt options.
FL AMPS	Fill in	3	Full load Amps. (FLA from nameplate)
FL Power Factor (%)	Fill in	3	Enter the Full Load Power Factor.
FL Efficiency	Fill in	3	Enter the full load efficiency. Automatically filled in if a letter code is selected.
Letter Code	Pull-down	3	Choose an efficiency letter code from the pull down menu. Not necessary if FL Efficiency input was filled in.
NEMA Class Design	Pull-down	3	Choose NEMA Class A or B.
ENCLOSURE	Pull-down	3	Choose open drip-proof (ODP), or totally enclosed fan-cooled (TEFC) or explosion-proof (TXPL) motor enclosure.
FRAME	Fill in	3	Type in Frame Size – for reference only.
Calculated Motor Parameters			
BHP	Fill in	3	This input is only available for New Install or Retrofit – Increased Load. Enter the new BHP (brake horsepower) (motor load).

2.2.17.4 Output

Table 17-4. Output

Output Name	**Description / Purpose**
Baseline Demand and Energy	Estimated maximum on-peak demand (kW) of the existing equipment and estimated annual energy use (kWh) of the existing equipment.
Current Minimum Standard (Title 24)	Estimated maximum on-peak demand (kW) of the Current Minimum Standard (Title 24) equipment and estimated annual energy use (kWh) of the Current Minimum Standard (Title 24) – only appears for Early Retirement.
Proposed Unit(s) Demand and Energy	Estimated maximum on-peak demand (kW) of the proposed equipment and estimated annual energy use (kWh) of the proposed equipment
Annual Savings	Estimated on-peak demand (kW) and energy savings for measure (kWh) For units that qualify for early retirement this will be the difference between **baseline** and **proposed**. For units that do not qualify for early retirement this will be the difference between the **Current Minimum Standard (Title 24)** and **proposed**.
Annual Incentive (@ $0.09 kWh/yr)	Gross incentive amount based on 2010 program rates, $0.09/kWh/yr and $100.00/kW.

2.2.17.5 Energy Savings Explanation

The required inputs to the tool allow calculation of estimated energy savings based on the assumption that the existing BHP motor load will remain essentially the same. The tool evaluates user inputs to determine the effective motor load in BHP for the existing motor. The tool then determines the baseline demand and energy quantities. Next, the tool evaluates the proposed motor performance with the same BHP load and then calculates the demand and energy use. Once the baseline and proposed quantities are calculated, the demand and energy savings and incentive are calculated and displayed.

2.2.18 Other - Professional Wet Cleaning Replacement

2.2.18.1 Description

This tool is designed to compute the Customized Offering savings and incentive achieved from converting a Perchloroethylene (Perc) dry cleaning system to a professional wet cleaning process. This reduces the energy usage of clothes cleaning facilities, while reducing contaminants to the air. This measure may qualify for additional incentives through a local air quality management district.

New regulations and business pressures are pushing many clothes cleaners to consider switching from Perc dry cleaning systems to alternative cleaning systems. The two main pressures are coming from the South Coast Air Quality Management District and building landlords. One of the alternative cleaning systems, wet cleaning, has proven to save energy as compared to the standard Perc system.

When evaluating the energy efficiencies of different cleaning machines' subsystems, professional wet cleaning appears to be the most efficient cleaning system. Perc, Hydrocarbon, and GreenEarth (silicone) cleaning systems typically have the same machine subsystems (vapor recovery, refrigeration compressor, water tower circulation pump, and water tower fan) and should have similar electrical energy consumption levels. A CO2 system has a large air compressor and may actually use more energy than the Perc machine.

2.2.18.2 Appropriate Use of the Tool –Program Policy

This measure is for the conversion of an existing dry cleaning (Perchloroethylene) facility to a professional wet cleaning facility. This measure is only for converting to a professional wet cleaning process and does not include CO2, Hydrocarbon, or GreenEarth (silicone) systems. This estimation tool is applicable only to professional cleaning facilities with a monthly average energy use of less than or equal to 4,000 kWh.

2.2.18.3 Inputs

Table 18-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Average Monthly kWh	Fill in	1	Enter average monthly energy use from utility bills
Average Monthly kW	Fill in	1	Enter average monthly demand from utility bills

2.2.18.4 Output

Table 18-2. Output

Output Name	Type	Sheet	Description / Purpose
Existing Equipment, kW	Result	2	Estimated DEER Peak Demand
Proposed Equipment, kW	Result	2	Estimated DEER Peak Demand
Existing Equipment, kWh/yr	Result	2	Estimated existing annual energy
Proposed Equipment, kWh/yr	Result	2	Estimated proposed annual energy
Savings, kW	Result	2	Estimated DEER Peak demand savings for measure (difference

			between existing and proposed)
Savings, kWh/yr	Result	2	Estimated annual energy savings for measure (difference between existing and proposed)
Incentive	Result	2	Estimated incentive ($) for the measure.

2.2.18.5 Energy Savings Explanation
The energy savings calculations are based on a 2001 study. The entered average monthly energy use (kWh) and demand (kW) are multiplied by a savings factor to determine the estimated energy and demand savings.

2.2.19 Other - Pulse Cooling for Injection Molding Machines

2.2.19.1 Description

This tool estimates the savings achievable by installing pulse cooling retrofit units in injection molding machines. This allows the removal of the temperature control units (TCU), as the pulse cooling unit makes the TCU's unnecessary.

2.2.19.2 Appropriate Use of the Tool – Program Policy

The Pulse Cooling for Injection Molders tool is used to estimate energy savings associated with the installation of a pulse cooling unit(s) in conjunction with the removal of thermolator heater unit(s). This tool shall be used exclusively for pulse cooling equipment that is installed on injection molding machines and applies to all injection molder machines currently being served by thermolator units. This tool should not be utilized when pulse-cooling is installed on other types of equipment. The Pulse Cooling for Injection Molders tool applies to injection molding machines that are currently served by constant flow cooling and thermolator heating. The thermolators should be removed and pulse-cooling units installed. This tool is to be utilized to calculate the savings for the installation of a single pulse cooling unit serving a single injection molding machine. If the installation entails installing multiple pulse cooling units onto many injection molding machines, a separate tool run would have to be completed for each injection molding machine retrofit.

2.2.19.3 Inputs

In the CCT tool, prior to selecting the Pulse Cooling for Injection Molders measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. This CCT measure tool only allows projects that are Retrofits (same load). Once the Pulse Cooling for Injection Molders measure is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screen appears in the same order as a user experiences while using the CCT software.

Table 19-1. Injection Molding Machine Inputs

Name	Type	Sheet	Description / Purpose
Manufacturer	Fill in	1	Manufacturer of the Injection Molding Machine (can be read from equipment nameplate).
Model #	Fill in	1	Model number of the Injection Molding Machine (can be read from equipment nameplate).
Serial #	Fill in	1	Serial number of the Injection Molding Machine (can be read from equipment nameplate).
No. of machines	Fill in	1	Number of injection molding machines that will be retrofitted with pulse cooling devices.
Capacity per machine (tons)	Fill in	1	Capacity (in tons) of injection molding machine (can be read from nameplate)
Manufacturer	Fill in	1	Manufacturer of the Thermolator unit(s) to be removed (can be read from equipment nameplate).
Model #	Fill in	1	Model # of the Thermolator unit(s) to be removed (can be read from equipment nameplate).
Serial #	Fill in	1	Serial # of the Thermolator unit(s) to be removed (can be read from equipment nameplate).
Thermolator			**Thermolator unit inputs (below)**
No. of Thermolators	Fill in	1	No. of thermolator units to be removed.
Type	Pull-down	1	Options of "oil" or "water". Refers to the fluid

			type which is circulated by the thermolator units.
Input Power per Unit (kW)	Fill in	1	The power input (kW) per thermolator unit. This can be either measured with a power meter or read from the thermolator unit. If multiple thermolators are removed, the input power per unit (kW) value entered shall be the average kW value of all the removed thermolators.
Power Estimation Method	Pull-down	1	Options of “Nameplate rating” and “Measured with Power Meter”. This refers to method used to determine input power (kW).
Annual Op. Hours	Fill in	1	The number of annual operating hours of the thermolators. This may or may not match the injection molding runtime hours, as the thermolators may cycle on only when needed.
Circulation Pump			**Circulation pump associated with thermolator units (below)**
No. of Units	Fill in	1	Number of circulation pumps serving the thermolator unit(s) input above.
Input Power per unit (numerical value input)	Pull-down	1	User inputs a numerical value, which represents either the nameplate rating (HP) or the measured power (kW) of the circulation pump. The user indicates either “kW’ or “HP” in the input described directly below.
Input Power method (dropdown menu)	Pull-down	1	A drop down menu with options of “HP” or “kW”. If the user measures the power with a meter, “kW” should be selected. If the user reads the pump’s nameplate, “HP” should be selected.
Power Estimation Method	Automatic	1	Software tool automatically fills this space in. If the user selects “kW” for input power method, this space reads “measure with power meter”. If “HP” is selected, this space reads “Nameplate rating”.
Manufacturer	Fill in	2	Manufacturer of Pulse Cooling unit(s)
Model #	Fill in	2	Model # of Pulse Cooling unit(s)
Serial #	Fill in	2	Serial # of Pulse Cooling unit(s)

2.2.19.4 Outputs

The following table and associated figure describes the CCT tool outputs.

Table 19-2. Measure Energy Savings & Incentive

Name	Description / Purpose
Existing Equipment, kW and kWh/yr	Displays the calculated power demand (kW) and annual energy usage (kWh/yr) of existing equipment.
Proposed Equipment, kW and kWh/yr	Displays the calculated power demand (kW) and annual energy usage (kWh/yr) of proposed equipment.
Annual Savings, kW and kWh/yr	Estimated measure power demand on-peak savings (kW) and measure energy usage (kWh/yr) savings. This is computed by subtracting the existing equipment values from the proposed equipment values.
Operating Hours	Estimated operating hours (the number is copied from the input sheet)
Incentive (@$0.09 kWh/yr)	Estimated CCT incentive based on $0.09 per kWh/yr

If the machine(s) operates during DEER Peak hours the user has the possibility to check the spot in the following sheet (by pressing the finish button) and in such case the demand savings incentive (paid at $100/kW) is added to the energy savings incentive.

2.2.19.5 Energy Savings Explanation

Injection molders inject molten plastic into a set mold and then eject the final product when it is sufficiently cooled. One conventional process to cool the plastic in the mold involves a constant flow chilled water system that continuously cools the mold. However, this system may result in overcooling the mold during certain periods in the molding cycle resulting in a flawed product. To counteract this overcooling, TCUs are often put in place to cycle hot fluid (either oil or water) through the mold when needed. The TCUs typically consist of an electric TCU heater and a circulation pump.

A pulse cooling unit consists of a controller, temperature probes, and water valves. This controller monitors the mold temperature and pulses chilled water to cool the mold only when needed to achieve a uniform product. At other times water flow is terminated, which avoids any overcooling of the mold. As overcooling is eliminated, the TCU often can be eliminated. The software tool calculates the electricity savings achieved by removing the TCU and replacing them with a pulse cooling unit, which consumes a relatively small amount of electricity.

2.2.20 Other - Pump-Off Controllers for Oil Wells

2.2.20.1 Description

This tool estimates savings for the installation of pump-off controllers (POCs) on sucker rod pumping systems. Pump-off controllers save energy by reducing motor operation. Typically, these wells operate around the clock regardless of their production level. When the wells are operating below capacity, the pump may experience a condition known as fluid pounding. Fluid pounding occurs when an insufficient amount of fluid, water and oil, is drawn into the well sleeve, decreasing the overall pumping efficiency.

2.2.20.2 Appropriate Use of the Tool – Program Policy

The appropriate application of this tool is to estimate energy savings from POC installations on sucker rod pump wells that are experience fluid pounding and have no existing controls (i.e., timers or VSDs).

Types of Equipment

This tool should be used to estimate the potential impact of installing pump-off controllers on sucker rod pumping systems. This tool should not be used for other oil production pumping systems, such as electrical submersible, hydraulic, or progressive cavity pumps.

Size or Capacity Covered

The empirical models employed are based on an analysis of sucker rod pumps with motor sizes ranging from 5 to 50 hp located in the Kern County.

2.2.20.3 Inputs

Table 20-1. Inputs

Input Name	Type	Sheet	Description/Purpose
Number of Wells	Fill-In	1	Enter the number of wells.
Well Identification Number	Fill-In	1	Enter the well's identification number. This value can be numeric or alphanumeric.
Motor Horsepower (hp)	Pull-Down	1	Enter the rated motor capacity.
Average Daily Production (bfpd)	Fill-In	1	Enter the average daily production in units of barrels of fluid per day. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.
Annual Hours (hr/yr)	Fill-In	1	Enter the estimated annual hours of operation.
Pump Diameter (inches)	Fill-In	1	Enter the pump diameter. This is the inner diameter of the pump plunger.
Stroke Length (inches)	Fill-In	1	Enter pump stroke length. This is the downhole stroke length of the pump.
Strokes per Minute (spm)	Fill-In	1	Enter pump strokes per minute.

2.2.20.4 Output

The output files summarize the measure inputs per well, as well as the energy consumption and savings estimates. The measure category is 'Other', which is paid an incentive rate of \$.09/kWh/yr. The tool outputs are described below.

Table 20-2. Outputs

Tool Output	Description
Existing Energy Demand, kW	Estimated maximum on-peak demand of the existing equipment
Existing Hours of Operation, hrs/yr	Estimated annual operating hours of the existing equipment
Existing Energy Usage, kWh/yr	Estimated annual energy use of the existing equipment
Proposed Energy Demand, kW	Estimated maximum on-peak demand of the proposed equipment
Proposed Hours of Operation, hrs/yr	Estimated annual operating hours of the proposed equipment
Proposed Energy Usage, kWh/yr	Estimated annual energy use of the proposed equipment
kWh Saved	Estimated annual energy savings for measure (difference between existing and proposed)
Incentive Payment (@ $0.09 kWh/yr)	Estimated CCT incentive based on $0.09/kWh/yr

2.2.20.5 Energy Savings Explanation

The estimated savings is based on a simplified empirical model, which correlates volumetric efficiency, percentage runtime and percentage energy use. The results may not accurately reflect the performance of an individual well; rather they represent an average performance. Accurate modeling of an individual well requires a more complex simulation model, which is commercially available. The demand savings are based on an empirical study conducted in 1994.   The study compared energy savings to coincidental peak demand reduction.

2.2.21 Other – Pumping System Upgrades

2.2.21.1 Description

Pumping systems have been identified as one of the largest end use applications in industrial settings. Under the sponsorship of the DOE Motor Challenge program a computer program called PSAT (Pumping System Assessment Tool) was developed to assist end users in identifying and estimating pumping system energy saving opportunities. These opportunities include pump and/or motor replacement and resizing. This CCT program estimation software utilizes some of the same methodologies as the PSAT tool but incorporates some basic assumptions to simplify its use. Savings associated with installation of variable speed drives (VSD) is also estimated; a measure that is not included in PSAT.

This tool currently estimates savings for the following measures, either singly or in combination:

- Direct replacement of a pump with one of higher efficiency,
- Direct replacement of an electric pump drive motor with one of higher efficiency, and
- Installation of a variable speed drive on the electric pump drive motor.

2.2.21.2 Appropriate Use of the Tool-Program Policy

Currently the software will only accommodate measures involving a single pump. Therefore projects involving multi-pump systems should not use this tool to estimate savings. The CCT Pumping System Upgrade tool can be used for pumping systems and measures having the characteristics shown in Table 21-1.

Table 21-1. Pump Savings Measure Features

Description	Measure Feature
# of Pumps	1
Pump Types	Centrifugal pumps with up to eight (8) stages and Positive Displacement
Pump Drive	Conventional and Variable Speed Drive (VSD)
Baseline Pump Efficiency	Generic pump efficiencies used in PSAT are displayed for information purposes.
Pump Operating Profile	Daily/Monthly or Total Annual Operating hours accommodated for up to eight (8) modes of operation.
Baseline Motor Efficiency	EPACT minimum used for baseline if existing drive is less efficient
TDH or Pressure Range	No restriction on Total Developed Head (TDH) for centrifugal pumps; 0 – 1000 psig discharge pressure range for positive displacement pumps

Pump and Control Types

The pump types and controls accommodated in the estimation tool software parallel those covered in the PSAT software. The exception is that this software will also calculate savings associated with positive displacement pumps while the PSAT software deals exclusively with centrifugal pumps. Table 21-2 summarizes the pump and control options covered by the estimation software.

Table 21-2. Equipment Included in Pump Savings Estimation Software

System Type	Pump Type	Control Type
Centrifugal#	End Suction Slurry End Suction Sewage End Suction Stock End Suction ANSI/API API Double Suction Double Suction Vertical Turbine Large End Suction Multi-stage Boiler Feed Axial Flow	Throttling, On / Off, Variable Speed Drive*
Positive Displacement#	Positive Displacement	Recirc./Bypass w/ Constant Pressure, Variable Speed Drive*

** -- part of energy savings measure only*

#-- Hydraulic Institute (http://www.pumps.org/) and/or Hydraulic Pumps (1998/1999 Fluid Handbook & Directory. Pages A/119-A/127)

2.2.21.3 Inputs

The estimation tool software includes a total of eight input screens for entry of system, pump, drive motor, pump control, operating hour and energy efficient measure (EEM) information. User inputs can be divided into four basic categories pumping system, pump/drive description, usage/load profile and EEM selections. The following tables summarize the various estimation tool user inputs.

Table 21-3. Pump Savings Estimation Tool Inputs – Input Screens 1 thru 3

Input Name	Type	Input Sheet	Description / Purpose
Site / System:			
Pump System Name	Fill in	1	Identifies pump system involved
Pump System Type	Pull-down	1	Centrifugal or Positive Displacement
Fluid Type	Fill in	1	Fluid being pumped (i.e., water, etc.)
Number of Pumps	Pull-down	1	1 is the only selection
Fluid Temperature, ^{o}F	Fill in	1	Nominal temperature of fluid being pumped
Fluid Specific Gravity	Fill in	1	Specific gravity of pumped fluid (i.e., water at 60 F equals 1.0)
System Design Flow, GPM	Fill in	1	Maximum flow through pump(s)
Total Developed Head (TDH) or Supply Pressure (psig) @ Max Flow, Ft	Fill in	1	Total head at max system flow in Ft, or Supply Pressure (psig) for positive displacement pump applications
System Static Head, Ft	Fill in	1	System static head requirement at 0 flow (centrifugal pump system only)
Existing Pump Nameplate Data:			
Pump ID	Fill in	2	Pump identifier / inspection purposes
Manufacturer	Fill in	2	Pump manuf. / inspection purposes
Model	Fill in	2	Pump model / inspection purposes

Serial Number	Fill in	2	Pump SN / inspection purposes
Type	Pull-down	2	See Table 3.x1
Control Type	Pull-down	2	See Table 3.x1
Number of Stages	Pull-down	2	Number of impellers / used to calculate specific speed (1- 8)
Flow, GPM	Fill in	2	Flow at pump design point, Note that the design point is used if the Best Efficiency Point (BEP) is not available.
Total Developed Head (TDH), Ft or, Discharge Pressure, psig	Fill in	2	Pump TDH at design flow (centrifugal) or, Pump Discharge Pressure (pos. displ.)
Efficiency, %	Fill in	2	Pump efficiency at design flow
Existing Drive Motor Nameplate Data:			
Manufacturer	Fill in	3	Motor manuf. / nameplate data
Model	Fill in	3	Motor model / nameplate data
Size, HP	Pull-down	3	Motor size / nameplate data
Speed, RPM	Pull-down	3	Motor rotating speed / nameplate data
Enclosure Type	Pull-down	3	ODP or TEFC/TXPL
Service Rating	Pull-down	3	Motor service rating; 1.15 or 1.25
NEMA Nominal Efficiency (full load)	Fill in	3	EPACT min value is displayed for comparison purposes

Table 21-4. Pump Savings Estimation Tool Inputs – Input Screens 4 & 5

Input Name	Type	Input Sheet	Description/Purpose
Pump Operating Information:			
Number of Operating Modes	Pull-down	4	Number of different flow points that will be entered
Operating Hour Input	Pull-down	4	Yearly (total annual hours as input) or Daily (days/month as input) may be selected
Operating Mode Information:			
Operating Mode Number	Pull-down	4	Selections are 1 through the number of different operating modes entered above.
Description	Fill in	4	Name or description of operating mode (flow point) selected above (i.e., irrigating north fields, etc.)
On-Peak Operation?	Checkbox	4	Check this box if *any* pump operation during this operating mode occurs during the SCE, SDGE and PG&E on-peak period.
Average Flow Rate, GPM	Fill in	4	Pump flow rate during this operating mode

Pump Operating Information:

Annual Operating Hours	Fill in	5	Total annual operating hours for each operating mode. This field is only an input if the Operating Hour Input (sheet 4) selection was “Yearly”
Day per Month	Fill in	5	Table appears if “Daily” Operating Hour Input (sheet 4) was selected. Enter the number of days of operation for each operating mode for each month.
Hours per Day	Fill in	5	Table appears if “Daily” Operating Hour Input (sheet 4) was selected. Enter the number of hours of operation for each operating mode for each month.

Table 21-5. Pump Savings Estimation Tool Inputs – Input Screens 6 thru 8

Input Name	Type	Input Sheet	Description/Purpose
Measure Specification:			
Pump Replacement/Modification	Checkbox	6	Check this box if the pump or pump drive motor will be replaced
Pump Replacement/Modification	Pull-down	6	Select from this pull-down if the Pump Replacement/Modification checkbox was selected. Selections include Motor Only, Pump Only, Pump and Motor
Variable Speed Drive (VSD) Installation	Checkbox	6	Check this box if a variable speed drive will be installed.
Full Load Efficiency, %	Fill in	6	VSD efficiency at full load, 100% speed
Minimum Operating Speed, %	Fill in	6	VSD minimum operating speed
Proposed Pump Data:			
Same inputs as existing pump	--	7	(see sheet 2)
Drive Motor Nameplate Data:			
Same inputs as existing motor	--	8	(see sheet 3)

2.2.21.4 Outputs

Table 21-6. Energy Savings, Runtime Hours, and Incentive

Name	Description / Purpose
Baseline Pump System, kW	Estimated maximum on-peak demand of the existing pump
Proposed Pump System, kW	Estimated maximum on-peak demand of the proposed pump
Baseline Pump System, kWh/yr	Estimated annual energy use of the existing pump
Proposed Pump System, kWh/yr	Estimated annual energy use of the proposed pump
Savings, kW	Estimated on-peak demand savings for measure (difference between baseline and proposed)
Savings, kWh/yr	Estimated annual energy savings for measure (difference between baseline and proposed)
Pump System Runtime	Annual operating hours for pumping system

Incentive ($)	Estimated CCT incentive amount in $

Table 21-7. Peak Demand Incentive

Name	Description / Purpose
City	Pull-down list of applicable zip codes that is used to identify the 3 day DEER peak period (displayed in text below the pull-down)
Equipment Operates During the Peak Demand Period Defined Above? (Input)	Check box that allows user to confirm that the equipment operates during the 3 day DEER peak period that is described in the paragraph above.
Eligible Peak Demand Savings, kW	Estimated demand savings is displayed; user can enter a different value if applicable
Reason Savings Differ	Text box input where user enters a reason for using a demand savings value that differs from the value estimated by the software. (only activated if the user has entered a value that differs from the calculated value)
Incentive Rate, $/kW	Demand reduction incentive rate
Qualified Peak Demand Incentive, $	Product of eligible demand savings and incentive rate is displayed.
Total Incentive, $	The sum of the qualified peak demand and energy savings incentives

2.2.21.5 Energy Savings Explanation

As with any efficiency measure the estimated savings is the difference between the baseline and proposed energy usage. In the case of pump related measures the calculations can be divided into two basic types; those dealing with positive displacement pumps (i.e., rotary, screw, lobe, vane and reciprocating) and those dealing with dynamic pumps (i.e., centrifugal, mixed flow and axial).

2.2.21.5.1 Baseline Energy Use -- Positive Displacement Pumps

The electric demand of a positive displacement pump is calculated using the following expression.

$$kW_{PUMP} = 0.7457 * \frac{Q_D * P_D}{1714 * \eta_P * \eta_e} \qquad \text{(Equation 21-A)}$$

where:

Q_D = Pump design flow (gpm)
P_D = Pump discharge pressure (psig)
η_p = Pump design efficiency
η_e = Drive motor efficiency

Note that pump discharge pressure has been substituted for pump total developed pressure under the assumption that pump suction pressure will be very small relative to discharge pressure.

We assume that the baseline positive displacement pump is operating with a recirculating type control that provides for a constant pump flow and discharge pressure when driven by an electric motor without a variable speed capability. This is to say that while the system flow may vary for each of the operating modes, the pump flow and associated power will remain constant (as excess pump capacity is recirculated back to the pump suction). Likewise, pump efficiency is assumed to be equal to the design values regardless of system flow. The estimation software uses existing software functions (based on DOE MotorMaster) to estimate the electric motor efficiency (based on motor load).

Baseline energy use is calculated as the product of the total operating hours and the pump electric demand with total operating hours equal to the sum of the operating hours for each of the system operating modes.

2.2.21.5.2 Baseline Energy Use – Dynamic Pumps

The electric demand of a dynamic pump such as a centrifugal or axial flow pump is calculated using the following expression.

$$kW_{PUMP} = 0.7457 * \frac{S * Q * H}{3960 * \eta_P * \eta_e} \qquad \text{(Equation 21-B)}$$

where:

S = specific gravity of pumped fluid relative to water at 60F
Q = fluid flow (gpm)
H = Total developed head (Ft)
η_p = Pump efficiency
η_e = Drive motor efficiency

The specific gravity term in this expression, S, is considered constant and is based on the type and temperature of the pumped fluid. With the exception of pump flow, Q, the remaining terms will vary based on pump flow. Therefore this expression must be evaluated separately for each individual operating mode.

Estimating Dynamic Pump Performance

As noted previously, dynamic pump head and efficiency vary depending on pump flow and must be evaluated at each operating point. The total developed head and efficiency of a dynamic pump are typically characterized in a pump performance curve. These curves are generated by the pump manufacturer and are used to determine the pump operating point (head and efficiency) under varying flows. Since these curves can be difficult to locate for older pumps the estimation tool software assumes that pump performance will follow one of three generic pump curves. Curve selection is based on pump specific speed where pump specific speed is calculated using the following expression:

$$Ns = \frac{RPM * \sqrt{Q}}{(H / NS)^{3/4}} \qquad \text{(Equation 21-C)}$$

where:

NS = number of pump stages
Q = pump design flow (gpm)
H = Total developed head (Ft)
RPM= Drive motor speed, rpm

Pumps with a specific speed in the range of 300 - 4,999 are assumed to follow a radial pump curve (Figure 21- 1) while pumps with a specific speed in the 5,000 – 9,999 range are assumed to follow the mixed flow pump curve (Figure 21-2). Pumps with a specific speed equal to or exceeding 10,000 are assumed to follow the axial pump curve (Figure 21-3).

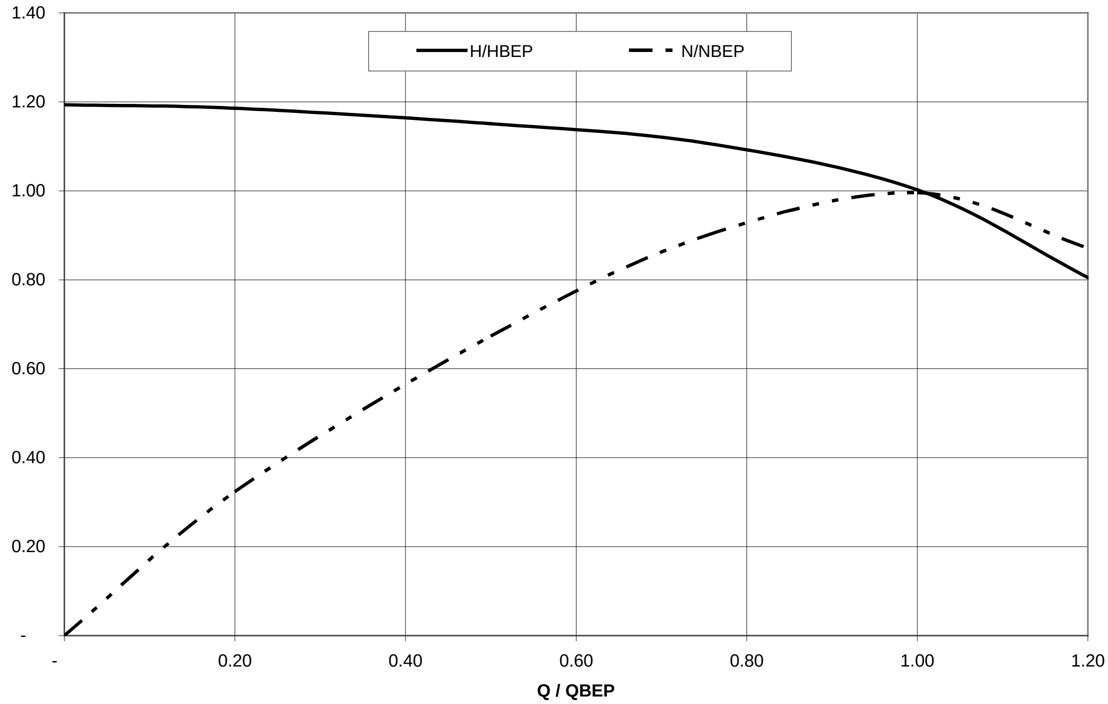

Figure 21-1. Generic Dynamic Pump Curves (Radial)
(normalized based on flow, head and efficiency at the Best Efficiency Point (BEP))

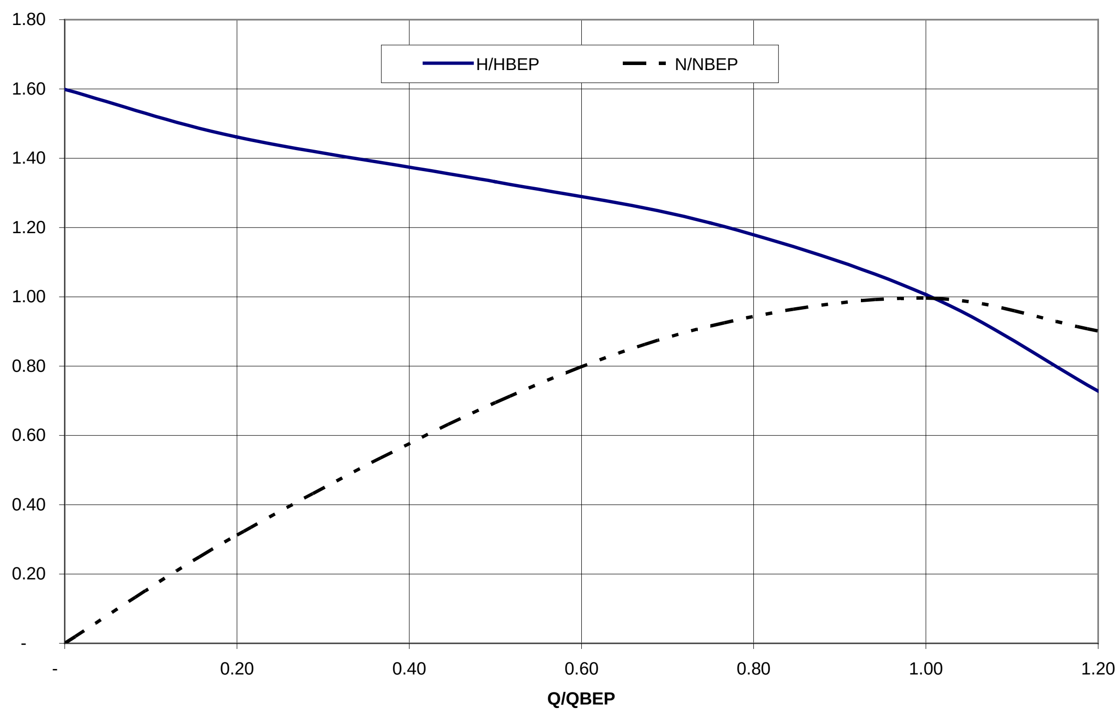

Figure 21-2. Generic Dynamic Pump Curves (Mixed Flow)
(normalized based on flow, head and efficiency at the Best Efficiency Point (BEP))

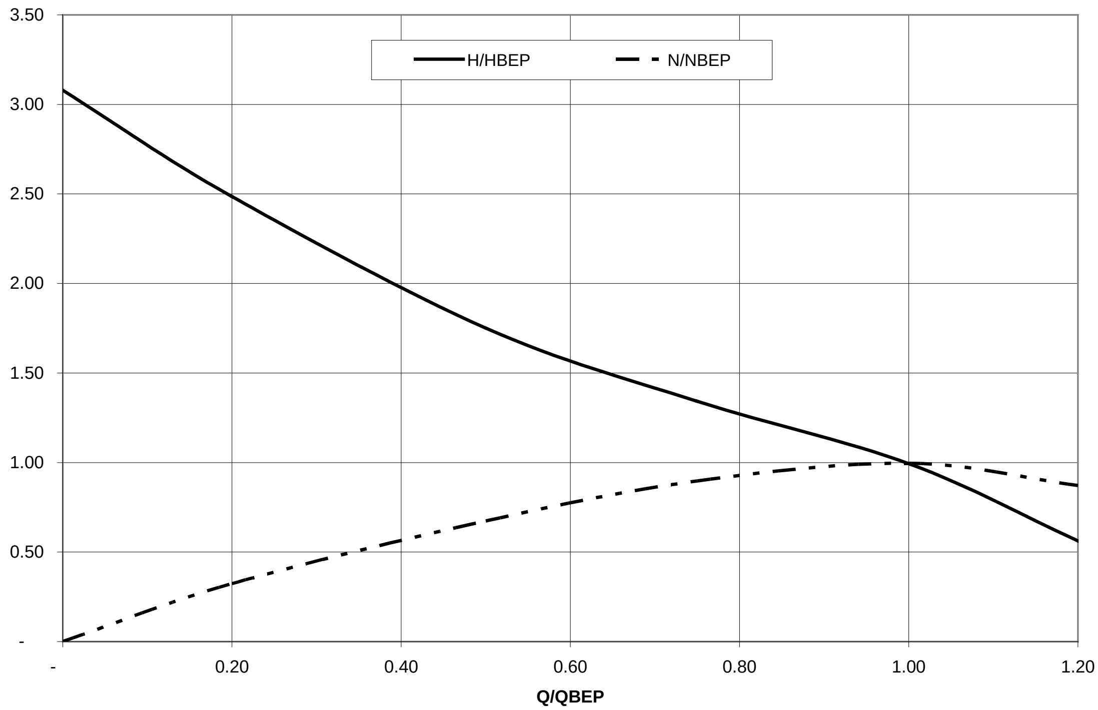

Figure 21-3. Generic Dynamic Pump Curves (Axial)
(normalized based on flow, head and efficiency at the Best Efficiency Point (BEP))

Note that these pump performance curves are normalized based on pump design data as described below:

Q = Pump flow (Pump flow (gpm)
Q_{BEP} = Pump Design Flow (gpm)
H = Pump TDH (Ft)
H_{BEP} = Pump TDH at design flow
N = Pump efficiency
N_{BEP} = Pump efficiency at design flow

Normalizing the curves allows their use in estimating the performance of any dynamic pump as long as the pump design information (flow, head and efficiency) is provided by the user. Note that the design point is used if the Best Efficincy Point (BEP) is not available. The estimated error is within 10% if the design point is used instead of the BEP. It is important to note that actual pump performance may vary from the generic curve profile. Therefore, if the user has access to the manufacturer's pump curve information the user should use this information, either directly to estimate pump performance, or should compare the manufacturer's information against the generic curve to confirm that the estimation software is providing a reasonable estimate of pump performance.

Matching System and Pump Performance
In order to estimate the baseline energy use of a dynamic pump it is first necessary to locate where the pump is operating on its characteristic performance curve. In the case of a throttling type of control a control valve located on the pump discharge will increase or decrease the system loss causing the pump flow to decrease or increase until the pump flow matches the system requirement. For throttling type controls the pump flow is therefore equal to the system

flow and the pump performance parameters are calculated using the previously discussed generic performance curves and the system flow value.

For On/Off type controls there is no control valve on the discharge and the pump flow will therefore only be limited by the system losses. This limitation is represented by the intersection of the system loss and pump performance curves. For On/Off controls the estimation software must therefore locate this intersection. An example of this intersection is illustrated in Figure 20.4 below (using a radial pump curve).

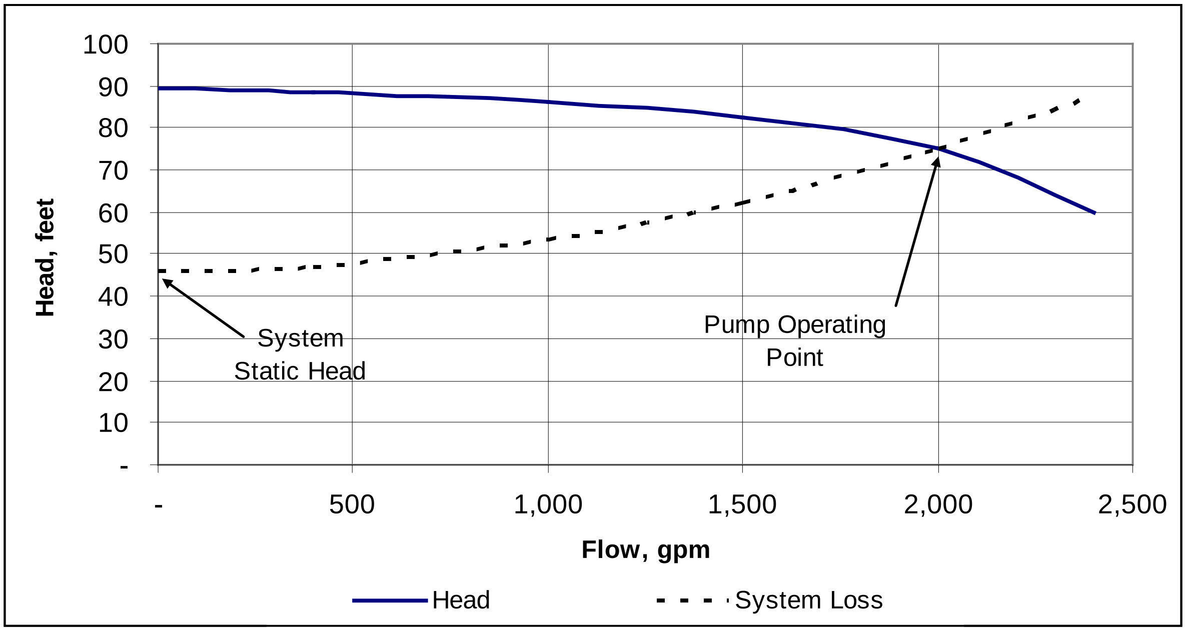

Figure 21-4. Dynamic Pump Operating Point Example

The software uses the site/system information provided by the user (max system flow, max and static head) to generate the estimated system loss curve. The intersection is then located and the pump efficiency is estimated using the generic pump performance curves discussed earlier. Once the pump efficiency (for either On/Off or Throttling control types) is determined it is then possible to estimate the electric motor loading and efficiency using existing Statewide Customized Offering software functions (based on DOE MotorMaster). The resulting pump and electric motor efficiencies are then used in conjunction with Equation 21-B to estimate the pump kW for the specified operating mode. Baseline energy use for the operating mode is the product of the pump kW and the total annual operating hours that have been entered for the operating mode.
The estimation software repeats the process of locating the pump operating point, estimating pump and motor efficiency and calculating the baseline energy usage for each of the operating modes (up to eight) specified by the user.

Note that in the event that the software is unable to locate the estimated pump operating point (intersection of pump and system operating curves) or the estimated operating point is deemed invalid (flow is negative or exceeds system maximum flow) it will cause the calculation to be aborted and an error window will appear. The window will indicate that the specified pump appears incompatible with system requirements. This condition must be corrected (i.e. different pump or system specifications, etc.) before the calculations can be completed.

2.2.21.2.3 Efficiency Measure – Pump Replacement

The estimation software calculates the savings associated with replacement of an existing pump with a pump having a higher efficiency. The energy use of the new pump is calculated in the same manner as previously described for baseline energy use. The exception being that the new pump efficiency information is either directly substituted for the existing pump efficiency in equation 21-A (positive displacement pumps) or is used to generate a pump performance curve (dynamic pumps), which in turn allows a pump operating point and efficiency value to be estimated for the new pump.

2.2.21.5.4 Efficiency Measure – Drive Motor Replacement

The estimation software calculates the savings associated with replacement of an existing pump drive motor with a motor having a higher efficiency. The energy use of the new motor is calculated in the same manner as previously described for baseline energy use. The exception being that the new motor efficiency is substituted for the existing motor efficiency in either equation 21-A (positive displacement pumps) or equation 21-B (dynamic pumps) depending on the pump type.

2.2.21.5.5 Efficiency Measure – Variable Speed Drive (VSD) Installation

Variable speed drives can achieve significant energy savings in pumping applications. Savings vary significantly depending on pump type and the estimation software therefore calculates the estimated savings associated with VSD operation differently depending on pump type.

2.2.21.5.6 VSD Measure -- Positive Displacement Pumps

The electric demand of positive displacement pumps when operating under VSD control is calculated using the following expression.

$$kW_{PUMP} = 0.7457 * \frac{Q * P_D}{1714 * \eta_P * \eta_e * \eta_{VSD}} \qquad \text{(Equation 21-D)}$$

where:

Q = fluid flow (gpm) @ operating mode
P_D = Pump discharge pressure (psig)
η_p = Pump efficiency
η_e = Drive motor efficiency
η_{VSD} = VSD efficiency

The baseline energy calculation for positive displacement pumps assumed constant pump flow regardless of the operating mode. Under VSD control, pump flow will match system flow and the flow value in the above expression is therefore equal to the operating mode flow specified by the user. Pump discharge pressure and pump efficiency are both assumed to be constant and equal to the pump design values (consistent with baseline calculation). The estimation software uses existing Statewide Customized Offering software functions (based on DOE MotorMaster) to estimate the electric motor efficiency (based on motor load).
For positive displacement pumps the VSD speed (fraction of full speed) can be estimated as the ratio of the operating mode flow divided by the pump's rated flow capacity. The software uses this value along with the full load VSD efficiency (user input) to estimate VSD efficiency. The relationship between VSD speed and efficiency utilized by the software is illustrated in Figure 21-5.

Note that the software checks the estimated VSD operating speed against the minimum speed entered by the user on input sheet 6. If the estimated operating speed is less than the stated minimum the calculation will be aborted and an error window will appear indicating that "Operating Mode X requires VSD operation below its minimum allowable range." The software will abort the calculations and return to the previous screen. The savings calculation cannot therefore be completed if one of the operation modes violates the minimum speed limit for the VSD.

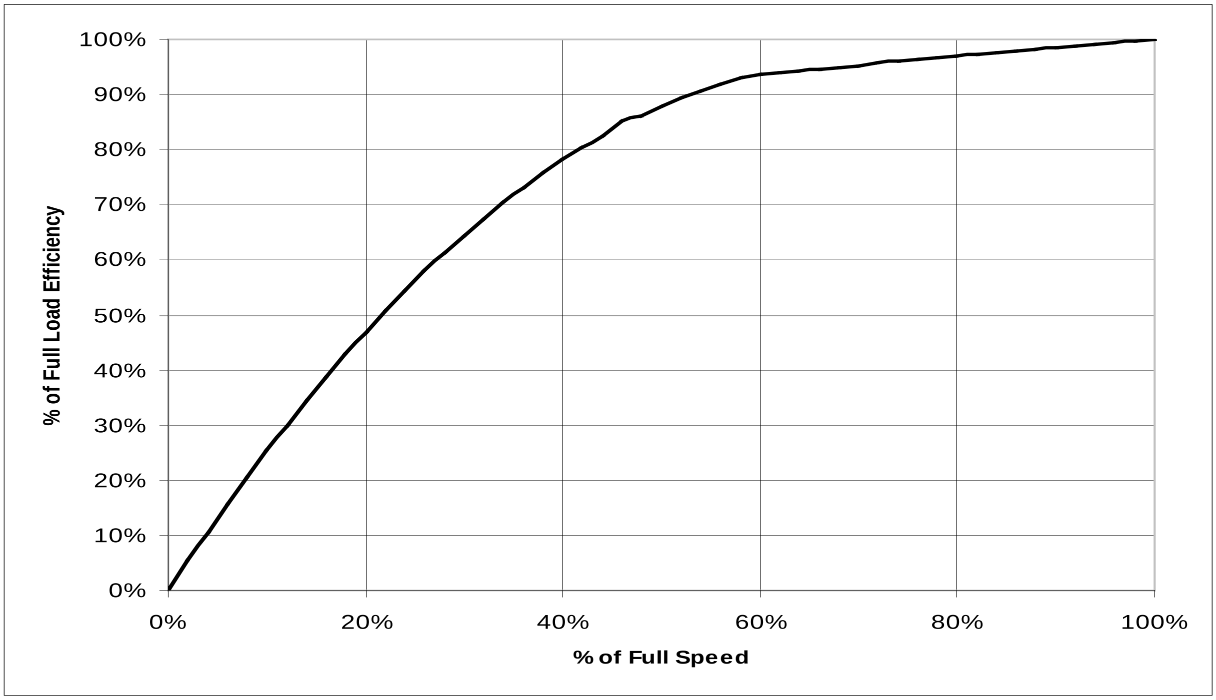

Figure 21-5. Generic Variable Speed Drive Performance
(derived from EPRI TR-101140 Adjustable Speed Drives Application Guide)

Once the VSD efficiency has been calculated it is then possible to calculate the electric demand of the VSD equipped pump using Equation 21-D. The difference between the previously calculated baseline electric demand and the proposed demand represents the average demand savings for this operating mode. The energy savings are calculated as the product of the average demand savings and the operating hours for the operating mode. The software repeats this process for each of the operating modes specified by the user.

VSD Measure – Dynamic Pumps

The electric demand of a dynamic pump when operating under VSD control is calculated using the same basic expression as the baseline dynamic pump calculation with the exception that a VSD efficiency term is included.

$$kW_{PUMP} = 0.7457 * \frac{S * Q * H}{5310 * \eta_P * \eta_e * \eta_{VSD}} \qquad \text{(Equation 21-E)}$$

where:

S = specific gravity of pumped fluid relative to water at 60F
Q = fluid flow (gpm)
H = Total developed head (Ft) at this operating mode point
η_p = Pump efficiency
η_e = Drive motor efficiency
η_{VSD} = VSD efficiency

However since dynamic pump performance varies with pump speed it not possible to assume constant pump efficiency or constant pump discharge pressure. Furthermore, it is not possible to calculate these performance parameters until the operating speed of the pump is calculated.

Estimating VSD Operating Speed -- Dynamic Pumps

The pump affinity laws state that with a constant impeller diameter and varying pump speed the following ratios are maintained without any change to pump efficiency.

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2} \qquad \text{(Equation 21-F)}$$

$$\frac{H_1}{H_2} = \left(\frac{n_1}{n_2}\right)^2 = \left(\frac{Q_1}{Q_2}\right)^2 \qquad \text{(Equation 21-G)}$$

where:

Q = Pump fluid flow (gpm)
H = Pump total developed head (Ft)
n = Pump speed (RPM)

In our case we set H_2 and Q_2 equal to the system loss (H_{OPMode}) and system flow at the specified operating point (Q_{OPMode}), respectively while H_1 and Q_1 represent the head and flow of the existing pump when operating at the same efficiency. Substituting and solving for H_1 yields:

$$H_1 = H_{OPMode} * \left(\frac{Q_1}{Q_{OPMode}}\right)^2 \qquad \text{(Equation 21-H)}$$

To calculate the intermediate flow term (Q_1) we equate the above expression to the expression representing the existing pump head curve (polynomial expression based on generic curve shape) and solve for the pump flow (Q_1). Having solved for Q_1 the affinity laws are used to estimate the VSD operating speed (n_{VSD}):

$$n_{VSD} = n_{Motor} * \frac{Q_{OPMode}}{Q_1} \qquad \text{(Equation 21-I)}$$

Pump efficiency at this operating point is calculated using the existing pump efficiency curve (generic curve, as before) at the intermediate flow, Q_1. The remaining terms, VSD and electric motor efficiency are calculated in the same manner as previously described for the positive displacement pump case. Once these terms have been calculated it is then possible to calculate the electric demand of the VSD equipped pump using Equation 21-E. The difference between the previously calculated baseline electric demand and the proposed electric demand represents the average demand savings for this operating mode. The energy savings are calculated as the product of the average demand savings and the operating hours for the operating mode. The software repeats this process for each of the operating modes specified by the user.
Note that the software checks the estimated VSD operating speed against the minimum speed entered by the user on input sheet 6. If the estimated operating speed is less than the stated minimum the calculation will be aborted and an error window will appear indicating that "Operating Mode X requires VSD operation below its minimum allowable range." The software will abort the calculations and return to the previous screen. The savings calculation cannot therefore be completed if one of the operation modes violates the minimum speed limit for the VSD.

2.2.22 AC&R II - Refrigerated Tank Insulation

2.2.22.1 Description

The tool estimates tank insulation savings. Use of this model is geared towards, but not limited to, winery storage tanks. The assumed tank geometry is a vertical cylinder. Use of this tool for other tank insulation projects will be reviewed by the program administrators.

The maintenance of product temperature from fermentation through final warehouse storage is one of the most important aspects of the quality control of commercial winemaking (Boulton, 1978). White wines such as Riesling, Gewurztraminer and White Zinfandel are produced at very low temperatures (28°F). During wine production and storage, it is essential to maintain the wine at this temperature to prevent spoilage. Prior to bottling, white wine is warmed to between 43 to 57°F to prevent condensation. Temperature fluctuations have an impact not only on the aroma of wine, but also on more general chemical reactions including oxygen uptake, browning reactions in whites, ethyl carbonate formation, and decline of free SO2 in white wines. Red wines need to be stored at a temperature range from 55 to 68°F in order to maintain product quality and shelf life. Storage wine tanks typically consist of 12 gage, stainless steel, 500 to 12,000 gallon tanks that are jacketed with chilled water systems to remove heat produced by the tank contents and heat gain from the ambient conditions. Standard wine tank insulation consists of three inch polystyrene foam with an external bonded skin of white aluminum, with an R value of 4 per inch.

Tank insulation contributes to significant energy savings due to the reduced work put on the refrigeration system to maintain appropriate temperatures. By adequately insulating wine tanks, significant kW and kWh savings are possible. The impact of the insulation on energy savings is dependent on several key parameters, specifically, climate zone, whether coastal or Central Valley, indoor or outdoor, environmental exposure such as sun and wind, refrigeration efficiency, and tank utilization throughout the year.

2.2.22.2 Appropriate Use of the Tool

It should be noted that this model relies heavily on user provided information, in particular tank temperatures and hours of operation. This model does not have size or capacity constraints. This model does not account for time-of-use cooling strategies such as off-peak cooling only, sub-cooling, and pump and cool system. If the estimated demand (kW) exceeds the reported capacity of the equipment and/or utility bills the impact of these peak demand control strategies should be considered and the demand savings may need to be adjusted.

Use of this model is geared towards, but not limited to, winery cold storage tanks. The assumed tank geometry is a vertical cylinder. Use of this tool for other tank insulation projects is reviewed by the program administrators on a case by case basis.

Model assumptions should be based on the last twelve months of operation. Indeterminate variables that significantly impact estimated savings are tank temperature and monthly days of operation. Therefore, as with any estimating tool, results should be compared to annual billing data to verify the reasonableness of the results. Where discrepancies are observed, documentation supporting the project assumptions should be requested.

2.2.22.3 Inputs

Once the measure for Refrigerated Tank Insulation is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screens appear in the same order as a user experiences while using the CCT software.

Table 22-1. Inputs

Input Name	Type	Sheet	Description/Purpose
Number of Tank Types	Fill-In	1	Enter the number of tank types. Each type will be defined by tank dimension, location, existing and proposed insulation specifications, refrigeration system specifications, and monthly temperature settings and usage profiles. Multiple tank types are necessary if tanks are not similar to each other as defined above.
Tank Description	Fill-In	1	Describe the type of tank to be retrofit with new or improved insulation.
To edit the tank characteristics, highlight a specific line item and click the “Edit Tank Details” button.			
Number of Tanks	Fill-In	2	Enter the number of identical tanks. All tanks must have the same dimensions, location, existing and proposed insulation specifications, refrigeration system specifications, temperature settings and usage profiles.
Tank Material	Pull-Down	2	From the pull-down menu, choose Stainless Steel, Aluminum or Copper. Wine tanks are typically fabricated from sheets of "304" stainless steel and have a thickness of 12 gage (0.105 inches) or larger. Copper and Aluminum may also be selected.
Tank Walls Height (ft)	Fill-In	2	Enter the tank wall height.
Wall	Fill-In	2	Input tank wall thickness in inches.
Exterior Cooling Jacket Height (ft)	Fill-In	2	Enter the tank wall height.
Jacket	Fill-In	2	Input jacket thickness in inches.
Tank Roof Diameter (ft)	Fill-In	2	Enter the tank Roof Diameter.
Roof	Fill-In	2	Input roof thickness in inches.
Tank Color	Pull-Down	2	From the pull-down menu, choose light, medium or dark. This field is used to approximate the tank emissivity.
City	Pull-Down	2	From the pull-down menu, choose the city the tank is in.
Tank Location	Pull-Down	2	This is the tank’s location at the winery. From the pull-down menu, choose outside, inside (unconditioned space) or inside (conditioned space). If the tanks are located in a conditioned space, the user needs to input the monthly temperature setpoints.
Standard Rated Cooling Efficiency, kW/Ton	Fill-In	2	Enter the refrigeration system efficiency based on design conditions at entering ambient air temperatures of 95°F dry-bulb for air-cooled condensers and 75°F wet-bulb for evaporative-cooled condensers, and 85°F entering water temperature for water-cooled condensers. The default value is 1.2 kW/ton.
Condenser Type	Pull Down	2	From the pull-down menu, choose the refrigeration system condenser type: air-cooled,

			water-cooled, or evaporative-cooled.
Controls	Pull-Down	2	From the pull-down menu, choose fixed pressure head or floating head pressure control.
Insulation Type	Fill-In	2	Enter the existing and proposed insulation type.
R-Value per inch ($h*ft^2*F/btu*in$)	Fill-In	2	Enter the insulations thermal resistance.
Thickness, walls (in)	Fill-In	2	Enter the wall insulation's thickness.
Thickness, roof (in)	Fill-In	2	Enter the roof insulation's thickness.
To edit the tank characteristics, highlight a specific line item and click the "Edit Tank Details" button.			
Average Daily Mean Temperature, °F	Fill In	3	If the tanks are located in a conditioned space, enter the average monthly space temperatures; otherwise, the model uses typical monthly weather data which cannot be edited.
Average Glycol/Chilled Water Temperature, °F	Fill In	3	Enter the temperature setpoint of the refrigeration system. The default value is 33°F.
Average Inside Tank Temperature, °F	Fill In	3	The default value is 50°F. If the user inputs temperatures below 50°F for more than one month, the software notifies the user prior to calculating the savings, and in the energy savings report, that supporting documentation is required. One month below the default value is allowed to account for cold stabilization.
Operating Days per Month	Fill In	3	The default value is 24 days per month, twelve months per year. If the user inputs more than 24 days per month, the software notifies the user prior to calculating the savings, and in the energy savings report, that supporting documentation is required.
Once all inputs have been entered use the "Back" or "Finish" buttons to return to Sheet 1 of 4. Use the "Next" or "Finish" buttons to view the resulting demand and energy savings.			

2.2.22.4 Output

The following tables and associated figures describe the CCT tool outputs. After the user selects "Next" or "Finish" the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 22-2. Output

Tool Output	**Description/Purpose**
Baseline Energy Usage	Estimated on-peak demand and annual electrical energy use of the existing equipment is displayed.
Proposed Energy Usage	Estimated on-peak demand and annual electrical energy use of the proposed equipment is displayed.
Savings	The difference between the baseline energy usage values and proposed energy usage values are

	displayed.
Incentive (@ $0.09/kWh)	Estimated CCT incentive is displayed.

The Peak Demand Incentive Worksheet uses the DEER Peak method to calculate demand savings and incentive. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet.

Table22-3. Peak Demand Incentive

Tool Input	Type	Sheet	Description/Purpose
Equipment operates during the peak demand period defined above?	Pull-Down	Peak Demand Incentive Worksheet	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill-In	Peak Demand Incentive Worksheet	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive (@ $100/kW)	Output	Peak Demand Incentive Worksheet	Estimated on-peak demand incentive is displayed.

2.2.22.5 Energy Savings Explanation

The estimated kilowatt-hour savings is based on a monthly heat transfer model. The exposed surface areas of the vessel are evaluated for heat transfer characteristics and these are evaluated with respect to local climate zone data to establish the heat transfer.

The general equations for exterior tanks were based on a study by Berdahl and Fromberg (1982). This empirical study looked at the correlation between global sky emissivity (ε_S) and surface dew point temperature. Therefore, the overall heat transfer is the sum of convection, conduction and radiations. In this model thermal conductivity is assumed to be negligible.

Per PG&E’s direction, the demand savings were based on the DEER definition of peak demand period.   In general, the calculation methodology is the same. However, the peak demand savings reference the peak ambient temperature, and weather (i.e., wind and solar) and operating conditions for the peak month. The peak month and temperature data is the following:

CA Zone	Peak Month	Peak Temp
1	10	65.1
2	7	93.6
3	7	78.8
4	7	86.7
5	9	79.1
6	9	71.7
7	9	77.7
8	9	88.8
9	9	91.9
10	8	98.7
11	8	97.6
12	7	97.8
13	7	100.9
14	7	102.6
15	9	107.4
16	8	86.9

Figure 22-1: DEER Peak Temperatures

2.2.23 Other - Tape Drip Irrigation

2.2.23.1 Description

Drip irrigation is the frequent, slow application of water to soil through mechanical devices called emitters that are located at selected points along water-delivery lines. Most emitters are placed on the ground, but they can be buried at shallow depths for protection. Water enters soil from the emitters, and most water movement to wet the soil between emitters occurs by capillarity beneath the soil's surface (Marsh 1982).

The drip irrigation saves energy by increasing irrigation efficiency and, potentially, reducing pump pressure head. The amount of irrigation required depends on local weather conditions, crop type, and soil type. For analysis purposes, it is assumed that there is a single pumping plant supplying water to a site irrigation system. This provides a simple conceptual basis for calculating energy savings.

2.2.23.2 Appropriate Use of the Tool – Program Policy

This model was designed to estimate potential energy savings for farmers that are currently irrigating their fields with sprinklers but will in the future (i.e., for a minimum of five years) be irrigating with tape drip. As with any estimating tool, results should be compared to annual billing data to verify the reasonableness of the results. Where discrepancies are observed, documentation supporting the project assumptions should be requested, and revisions to the project assumptions may be required

Tape drip refers to thin walled hoses ranging from 4 to 20 millimeters. Other types of drip irrigation are eligible as Itemized (Express Efficiency) Measures.

The software is limited to the crop types summarized in the list below:
Cauliflower, Artichokes, Asparagus, Beans (pinto), Beans (dry), Beans (green), Beets (table), Broccoli, Cabbage, Carrots, Celery, Corn (grain), Corn (silage), Cotton, Cucumber, Eggplant, Lentil, Lettuce, Melon, Millet, Onion (dry), Onion (green), Peas, Peppers, Potato, Radishes, Sorghum, Spinach, Squash, Sugarbeet, Sunflower, Sweet Potatoes, Tomato, Watermelon, Almonds, Apple, Grapevines, Kiwifruit, Stone fruits, Walnuts, Avocado, Citrus, Citrus (desert), Date Palm, Evergreen, Olives.

2.2.23.3 Inputs

The input screens are defined by the following table.

Table 23-1. Tape drip irrigation tool inputs

Input Name	Type	Input Sheet	Description / Purpose
Site / System Information:			
Manufacturer	Fill in	1	Drip tape manufacturer
Tape Drip Name	Fill in	1	Drip system name
Model	Fill in	1	Identifies drip tape model
ETo Zone	Pull-down	1	Project Location, see reference map http://www.cimis.water.ca.gov/cimis/images/etomap.jpg
Average Pumping Depth, ft	Fill in	1	Sum of average well water depth and well drawdown
Average Pumping Lift, ft	Fill in	1	Average elevation the water needs to be lifted for irrigation
Average Water	Fill in	1	Distance from the pump to the submain

Main Length, ft			
Average Well Flow, gpm	Fill in	1	Average well pump flow rate
Average Water Main Diameter, inches	Fill in	1	Diameter of main water
Sprinkler Pressure Head, psi	Fill in	1	Sprinkler operating pressure (should be consistent with equipment specifications and operating conditions)
Overall Pump Efficiency (OPE), %	Fill in	1	Efficiency of entire pump system, use default value of 72% if unknown
Crop Specific Information:			
Crop Type	Pull-down	2	Row, Tree or Vine crop
Crop Name	Pull-down	2	Crop being irrigated
Crop Area, acre/crop	Fill in	2	Enter crop area
Crop Planting Dates (month/day)	Pull-down	2	Date crop planting begins for row crop, Date leaf out begins for tree and vine.
Crop Harvest Dates (month/day)	Pull-down	2	Date harvest begins
Soil Type	Pull-down	2	Select coarse sand, fine sand, loam or heavy clay
Irrigation Method (Before / After)	Pull-down	2	Enter the irrigation method during each phase of growth, either Tape Drip or Sprinklers. For row crops, there are four phases of growth (A-B = “initial”, B-C = “rapid”, C-D = “mid-season”, and D-E = “late-season”), typically the “initial” phase is irrigated with sprinklers both pre- and post- install and should be confirmed with the customer. For tree and vine crops, there are three phase of growth (B-C = “rapid”, C-D = “mid-season”, and D-E = “late-season”). Note that Tree and Vine crops will not have an "Initial" growth period)

2.2.23.4 Output

As a result of the software calculations the output will be shown as below.

Table 23-2. Output Sheet for “Drip Tape Irrigation”.

Output Name	Sheet	Description / Purpose
Existing Equipment (kWh/yr)	3	Baseline usage
Proposed Equipment (kWh/yr)	3	Proposed usage
Savings (kWh/yr)	3	Therms savings
Incentive (@ $0.09 kWh/yr)	3	Dollar incentive amount

2.2.23.5 Energy Savings Explanation

In general, the calculations are based on guidelines provided by WATERIGHT (2003). This website was developed by the Center for Irrigation Technology at California State University, Fresno. The site and its content are intended to be an educational resource for irrigation water management. The savings will occur when the energy required to deliver a given amount of water (kWh/AF) is decreased, or the annual amount of water is decreased (AF/yr), or both: kWh/yr = kWh/AF * AF/yr.

The start and stop dates set the boundaries of each crop rotation. Each season is divided into different growth phases. They are rapid (A-B), initial (B-C), mid-season (C-D) and late-season (D-E) growth periods. Given the crop type the software automatically gives the growth period.

Even though it is possible that there will be demand (kW) savings, the difficulty associated with estimating how much and the uncertainty associated with making general assumptions are too great. Therefore, no demand savings are reported.

2.2.24 AC&R II - Variable-Speed Drives for Cooling Tower Fan Motors

2.2.24.1 Description

Cooling towers reject heat in an HVAC system that contains water-cooled chillers or water-cooled package AC units / heat pumps. Fans integrated into the towers force ambient air over the condenser return water, which lowers the water temperature to a specific condenser supply setpoint (typically 85°F). The tool compares the electrical use of various capacity control methods. Most cooling tower fans cycle on/off, switch between low and high speed, or adjust speed continuously (VFD) to maintain a target supply temperature, which could be a fixed setpoint or a variable setpoint that changes in response to the ambient wet bulb temperature. Alternatively, or additionally, a fluid bypass or discharge damper could be used. Adjusting the setpoint with ambient, the fan(s) will operate more time at part load than with a fixed setpoint strategy. Use of a VFD with a reset strategy is generally the most efficient option because the part load power for a fan follows nearly a cubed relationship with speed.

2.2.24.2 Appropriate Use of the Tool – Program Policy

The tool is to be used to add VSD control to fan motor(s) in a cooling tower. Program policy sets the minimum code baseline as fixed temperature two speed fan control. The minimum code baseline will be used if the existing controls are less efficient.

The estimate of savings from the Variable-Speed Drives for Cooling Tower Fan Motors Tool can be calculated for the following building types and the building area must be between:

Education – Secondary School – defaults to 150,000 ft^2 but must be between 100,000 and 400,000 ft^2
Education – Community College – defaults to 300,000 ft^2 but must be between 100,000 and 600,000 ft^2
Education – University – defaults to 800,000 ft^2 but must be between 640,000 and 2,500,000 ft^2
Health/Medical – Hospital – defaults to 250,000 ft^2 but must be between 100,000 and 500,000 ft^2
Lodging - Hotel – defaults to 200,000 ft^2
Office – Large – defaults to 175,000 ft^2
Office – Small – defaults to 10,000 ft^2
Retail – Multistory Large – defaults to 120,000 ft^2

This tool shall be used exclusively in buildings that utilize cooling towers to reject heat for HVAC equipment that is used for typical space cooling. Therefore, the tool is not suitable for cooling towers used in cooling or refrigeration systems where the building indoor air setpoint is 45 degrees or lower. It is also not applicable to cooling towers that serve process cooling applications.

Applicable Types of Equipment

The tool applies to existing one-speed, two-speed, variable speed, fluid bypass or discharge damper capacity control for cooling tower fan motor(s).

Equipment Sizes or Capacities Covered by the Tool

The tool applies to all manufactured sizes and capacities of cooling tower fan motor(s).

2.2.24.3 Inputs

Once the “VSD or Two-Speed Cooling Tower Fans (Engage)” measure is selected, the user is then directed to enter the various inputs as described in the following tables and associated figures. The input screens appear in the same order as a user experiences while using the CCT software.

Table 24-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	From the pull-down menu, select by Zip Code or by CTZ. (CTZ stands for Climate Zone) In the adjacent pull-down menu select the appropriate Zip Code or CTZ.
Building Type	Pull-down	1	From the pull-down menu, select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D in the CCT Program Procedures Manual for detailed descriptions).
Vintage	Pull-down	1	From the pull-down menu, select the year the building was constructed.
HVAC System(s)	Pull-down	1	From the pull-down menu, select a cooling equipment type. One or more typical HVAC System will be available based on the chosen Building Type.
Allow HVAC System Downsizing	Click/Select	1	If the measure(s) you include in the analysis result in reduced cooling or heating loads (many do), selecting this option allows the CCT software to downsize HVAC systems. This option is only enabled for a building vintage after 2005.
Total Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type.
Secondary Building Area	Fill in	1	Enter the square-feet of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building Type. This option may be disabled if it is not applicable to your Building Type.
Secondary Number of Floors	Fill in	1	Enter the number of floors of conditioned space. The title of this input may change based on the chosen Building Type. This option may

			be disabled if it is not applicable to your Building Type.
Pattern	Pull-down	2	From the pull-down menu, select a seasonal usage pattern. One or more typical usage pattern will be available based on the previously chosen Building Type.
Number of Seasons	Pull-down	2	From the pull-down menu, choose one, two or three.
Season #1	Fill in	2	Insert an appropriate label for the season.
Season #2	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Season #3	Fill in/Pull-down	2	Insert an appropriate label for the season, from the pull-down menu choose an appropriate number of periods when the season occurs and from the pull-down menus define the periods for the season.
Observed Holidays	Click/Select	2	Click this button and insert check marks next to the observed holidays.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. One or more typical usage pattern will be available based on the previously chosen Building Type.
Season	Pull-down	3	From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Motor	Pull-down	4	From the pull-down menu, select a motor designation number. This allows you to enter multiple tower fans of various sizes.
Motor HP	Fill in	4	Enter the motor HP.
Motor Count	Fill in	4	Enter the total number of motors at the entered HP.
Baseline Temperature Control	Pull-down	4	From the pull-down menu, select fixed or reset.
Baseline Setpoint	Fill in	4	Enter the condenser water supply temperature setpoint.

Baseline Capacity Control	Pull-down	4	From the pull-down menu, select One-Speed Fan, Two-Speed Fan, Variable Speed Fan, Fluid Bypass or Discharge Dampers.
Code Baseline	Defined	4	Program policy sets the minimum code baseline as fixed temperature two speed fan control. The minimum code baseline will be used if the existing controls are less efficient.
Proposed Control	Pull-down	4	From the pull-down menu, select fixed or reset.
Proposed Setpoint	Fill in	4	Enter the condenser water supply temperature setpoint.
Proposed Capacity Control	Pull-down	4	From the pull-down menu, select One-Speed Fan, Two-Speed Fan, Variable Speed Fan, Fluid Bypass or Discharge Dampers.

2.2.24.4 Outputs

The following table and associated figure describes the CCT software outputs. After the user selects “Next” or “Finish” the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 24-2. Building Measure Results

Output Name	Description/Purpose
Existing Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the existing equipment is displayed.
Baseline Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the Title-24 minimum efficient equipment is displayed.
Proposed Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the proposed equipment is displayed.
Savings	The difference between the Baseline Equipment values and Proposed Equipment values are displayed.
Incentive (@ $0.09 kWh/yr)	Estimated incentive is displayed.

The Peak Demand Incentive Worksheet uses the DEER Peak method to calculate demand savings and incentive. The software chooses the appropriate DEER peak period based on the location inputs of the first sheet. The software calculates DEER Peak directly for weather-based measures. It estimates DEER Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques.

Table 24-3. Peak Demand Incentive Worksheet

Output Name	Description/Purpose
Equipment operates during the peak demand period defined above?	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Estimated on-peak demand incentive is displayed.

2.2.24.5 Energy Savings Explanation

The applicant inputs system information in the CCT software. The inputs include HVAC system characteristics, cooling tower characteristics and building characteristics.

All the user inputs are passed on to Engage. Engage is a software program developed by James J. Hirsch and Associates that incorporates a DOE2.2 computation engine, which runs on a PC computer. The DOE2.2 engine is a building energy simulation tool that incorporates hourly weather data for specific cities throughout California. This engine utilizes this weather data (along with user inputs and default assumptions describing the building envelope characteristics, internal loads, and HVAC system components) to calculate the peak electrical demand and energy usage for all the building components (HVAC equipment, lighting, etc.).

The Engage software program described above utilizes the user's inputs (along with DEER prescribed equipment specifications, operating schedules, and building envelope characteristics) to estimate the energy demand and usage of the cooling tower fan motor(s). Engage then passes the above values to the CCT software. These values are displayed in the software's output screen.

Once the software receives the baseline and proposed demand and energy usage estimation values from Engage, it calculates and displays the annual energy savings, peak demand savings and incentive amount.

2.2.25 Other - Variable-Speed Drives for Dairy Vacuum Pump

2.2.25.1 Description

This tool estimates the potential annual electrical energy savings and peak demand reduction that can be achieved by adding a variable-speed drive (VSD) to a standard dairy vacuum milking system.

2.2.25.2 Appropriate Use of the Tool – Program Policy

The program contains efficiency tables for standard- and premium-efficiency motors. Savings estimates are based on the following assumptions:

- The existing standard dairy milking vacuum pump system is significantly oversized and runs at a constant speed. Piping changes are made to move the vacuum system regulator (or controller), increase the vacuum system efficiency, and replace and downsize the main vacuum pump.

- The new, smaller vacuum pump motor is controlled by a VSD, which in turn receives feedback from the vacuum system through a pressure transducer.   Any additional vacuum pumps and motors are either removed from service or replaced with premium-efficiency models.
- All motors are three phase, 1800 RPM, and operating 90% loaded.

The pump and motor types accommodated in the estimation tool are summarized in the table below.

Table 25-1. Pump Type supported

Pump Type	Efficiency (cfm/kW) @ 14 in Hg
Turbine	6.4
Water Ring	12.6
Blower	14.2
Vane	14.8

Table 25-2. Motor Type supported

Motor Type
Standard
NEPA
Premium

2.2.25.3 Inputs

The estimation tool software includes one input screen for entry of site data, existing and proposed primary vacuum pump motor data, additional motor data and operating hour information. The following Table summarizes the various estimation tool user inputs.

Table 25-2. Inputs

Input Name	Type	Sheet	Description / Purpose
Site / System			
Site Name	Fill in	1	Identifies the site involved
Measure Name	Fill in	1	Identifies the measure
Location	Fill in	1	Identifies project location
Description	Fill in	1	Brief description of project
Existing and Proposed Primary Vacuum Pump Motor Data			

Size	Pull-down	1	Existing and proposed motor size. Options up to 50 HP.
Motor Type	Pull-down	1	Existing and proposed motor types. See Table 25-2.
Vacuum Pump Type	Pull-down	1	See Table 25-1 for options. Only necessary if pump type will change – allows savings for a change to a more efficient pump type.
Variable Speed Drive	Check box	1	Only available for proposed pump motor. Check only if VFD installation is proposed.
Operating Hours per Day	Fill in	1	Existing and proposed average operating hours per day including washing cycle.
Additional Motor Data			
Number of Motors	Fill in	1	Number of existing additional vacuum pump motors
Size	Pull-down	1	Horsepower per additional vacuum pump motor. Options up to 50 HP.
Plan for Additional Motors	Pull-down	1	Select the plan for the additional motors. Pull-down menu with “Remove from Service”, “Replace with a NEPA motor”, and “Replace with a premium motor” options.
Can premium replacement motors be adjusted for speed increase?	Pull-down	1	Select yes or no as to whether the new premium replacement motors can be adjusted for the speed increase.
Type of adjustment for speed increase	Pull-down	1	Select type of speed adjustment between VSD, sheaves or variable pulleys.

2.2.25.4 Output

Once all necessary input information has been gathered, the Variable Speed Drives for Dairy Vacuum Pump Retrofit Tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The Variable Speed Drives for Dairy Vacuum Pump Retrofit Tool outputs are described below.

Table 25-3. Output

Output Name	**Type**	**Sheet**	**Description / Purpose**
Existing Equipment, kW	Result	2	Estimated DEER Peak Demand
Proposed Equipment, kW	Result	2	Estimated DEER Peak Demand
Milking Cycle Demand Reduction, kW	Result	2	Demand reduction during milking cycle
Wash Cycle Demand Reduction, kW	Result	2	Demand reduction during wash cycle
Existing Equipment, kWh/yr	Result	2	Estimated existing annual energy usage
Proposed Equipment, kWh/yr	Result	2	Estimated proposed annual energy usage
Savings, kWh/yr	Result	2	Estimated annual energy savings for measure (difference between existing and proposed)

Annual Operating Hours	Result	2	System runtime hours
Incentive	Result	2	Estimated incentive ($) for the measure.

2.2.25.5 Energy Savings Explanation

The software estimates the existing electrical demand and energy usage using the nameplate horsepower of the vacuum pump motors and the average number of hours the system operates every day. Survey data indicate that most dairy vacuum pump motors run close to 90% loaded. Thus, the electrical demand of each vacuum pump motor is calculated as follows:

Demand (kW) = [Motor Horsepower (HP) x 0.746 x 90%] / Motor Efficiency (%)   (Eq. 1)

where 0.746 is the factor used to convert HP to kW.

The existing demand is calculated for both the primary vacuum pump motor and any additional vacuum pump motors. The existing annual energy usage is determined as follows:

Energy Usage (kWh) = Demand x Average Daily Operating Hours x 365 days/year   (Eq. 2)

Equations 1 and 2 are also used to calculate the proposed demand and energy usage. If there is a change in pump type, the demand is adjusted to take into account differences in pump efficiencies.

If an additional standard vacuum pump motor is replaced with an additional premium vacuum pump motor and no adjustment is made for the increase in speed, the calculations are adjusted to take into account the reduction in savings due to the increased speed of the premium motor.

The software allows for control of the proposed pump motor with a VSD. When a VSD is installed to control a motor, the total energy savings depends on how the load changes over time and the amount of time spent at each load level. Testing at several dairies retrofitted with a VSD to control a downsized vacuum pump motor recorded savings close to half of the expected energy usage for the new system. This estimating tool uses a VSD motor speed and operating time distribution that yields an average annual energy savings of 46.9%. The tool outputs both a Milking Cycle Demand Reduction and a Wash Cycle Demand Reduction.

The estimated savings calculated by the program exceed the requirements of the national Energy Policy Act (EPAct) of 1992, and are therefore reportable. The software incorporates EPAct motor efficiency requirements to determine the amount of motor replacement energy savings that exceed the 1992 EPAct requirements and qualify for energy efficiency incentives.

2.2.26 Other - Variable-Speed Drives for Process Applications

2.2.26.1 Description

Variable Speed Drives (VSD), also referred to as Variable Frequency Drives (VFD), are used for controlling AC motors. The VSD is a solid-state device that controls the frequency and voltage supplying the motor. Many AC motors used for process applications are oversized to accommodate peak loads even though the average loads are lower. The most common applications involve centrifugal pumps and fans which have large savings potential due to their power versus speed curves. Without VSDs the motors are left operating at full speed or are controlled by primitive part-load strategies. Often times the motors cannot be cycled on and off too frequently so the motors remain at full speed. Installing a VSD offers large energy savings for AC motors that operate at partial loads.

2.2.26.2 Appropriate Use of Tool – Program Policy

This tool covers the installation of a VSD onto an AC motor that doesn't currently have one. If the Energy Efficiency Measure consists of one or more VSDs being installed on centrifugal chillers, cooling tower fan motors, HVAC fans, or dairy vacuum pumps then there are separate specific CCT tools available for those measures, and this tool should not be utilized.

The tool is used for same load retrofits exclusively. This means that this tool is not appropriate for measures involving increased load retrofits or new installs

Equipment (typically fans and pumps) that use one or more AC motors, and that do not already use a VSD are eligible.

This tool covers the installation of VSDs on AC motors ranging from 1 to 500 HP. The CCT program has minimum motor efficiencies that must be observed when determining the baseline conditions. These minimum efficiencies are shown below in Table 26-1.

<u>The estimate of savings from the Variable Speed Drives for Process Application tool can be calculated for the following available options:</u>

<u>Direct Drive (mixer, conveyor) to VSD</u>
<u>Pos Disp Pump with Bypass or No Control to VSD</u>
<u>Centrifugal Pump with Throttle Valve to VSD</u>
<u>Fan with Bypass or No Control to VSD</u>
<u>Fan with Outlet Dampers to VSD</u>
<u>Fan with Inlet Guide Vanes to VSD</u>

Table 26-1. Minimum Nominal Full-Load Motor Efficiency for Single Speed Poly-Phase Motors

Number of Poles	2	4	6	8	2	4	6	8
Synchro-nous Speed (RPM)	3600	1800	1200	900	3600	1800	1200	900
Motor HP	Open Motors				Enclosed			
1	--	82.5	80	74	75.5	82.5	80	74
1.5	82.5	84	84	75.5	82.5	84	85.5	77
2	84	84	85.5	85.5	84	84	86.5	82.5
3	84	86.5	86.5	86.5	85.5	87.5	87.5	84
5	85.5	87.5	87.5	87.5	87.5	87.5	87.5	85.5
7.5	87.5	88.5	88.5	88.5	88.5	89.5	89.5	85.5
10	88.5	89.5	90.2	89.5	89.5	89.5	89.5	88.5
15	89.5	91	90.2	89.5	90.2	91	90.2	88.5
20	90.2	91	91	90.2	90.2	91	90.2	89.5
25	91	91.7	91.7	90.2	91	92.4	91.7	89.5
30	91	92.4	92.4	91	91	92.4	91.7	91
40	91.7	93	93	91	91.7	93	93	91
50	92.4	93	93	91.7	92.4	93	93	91.7
60	93	93.6	93.6	92.4	93	93.6	93.6	91.7
75	93	94.1	93.6	93.6	93	94.1	93.6	93
100	93	94.1	94.1	93.6	93.6	94.5	94.1	93
125	93.6	94.5	94.1	93.6	94.5	94.5	94.1	93.6
150	93.6	95	94.5	93.6	94.5	95	95	93.6
200	94.5	95	94.5	93.6	95	95	95	94.1
250	94.5	95.4	95.4	94.5	95.4	95	95	94.5
300	95	95.4	95.4	-	95.4	95.4	95	-
350	95	95.4	95.4	-	95.4	95.4	95	-
400	95.4	95.4	-	-	95.4	95.4	-	-
450	95.8	95.8	-	-	95.4	95.4	-	-
500	95.8	95.8	-	-	95.4	95.8	-	-

2.2.26.3 Inputs

The measure tool VSD for Process Applications is only available under Retrofit (Same Load / Production).

Table 26-2. Inputs

Input Name	Type	Sheet	Description / Purpose
Equipment Description of Savings Estimate			
Location	Fill in	1	Site location – used for reference only
Function	Fill in	1	Equipment function – used for reference only
Designation	Fill in	1	Equipment designation – used for reference only
Quantity	Fill in	1	Quantity of identical motors undergoing retrofit – power multiplier
Duty Cycle (%)	Fill in	1	Motor duty cycle – used to estimate the total operating hours per year

Hours/day	Fill in	1	Average hours per day the machine operates– used to calculate the total operating hours per year
Days/week	Fill in	1	Days per week the machine operates – used to calculate the total operating hours per year
Weeks/year	Fill in	1	Weeks per year the machine operates – used to calculate the total operating hours per year
Op Strategy	Pull-down	1	Pull-down menu – Available options are “Direct Drive (mixer, conveyor) to VSD”, “Pos Disp Pump with Bypass or No Control to VSD”, “Centrifugal Pump with Throttle Valve to VSD”, “Fan with Bypass or No Control to VSD”, “Fan with Outlet Dampers to VSD”, “Fan with Inlet Guide Vanes to VSD”
Existing 20%-100%	Fill in	1	Percentage of time at 20%-100%of full load RPM – used to calculate existing input power
Proposed 20%-100%	Fill in	1	Percentage of time at 20%-100% of full load RPM – used to calculate proposed input power
Motor Specification Window			
Motor Nameplate Data			
Manufacturer	Fill in	2	Equipment manufacturer – used for reference only
MODEL	Fill in	2	Equipment model – used for reference only
SERIAL #	Fill in	2	Equipment serial number – used for reference only
Rewound?	Pull-down	2	Pull-down menu – choose Yes or No – effects BHP and Load %
HP (size)	Pull-down	2	Pull-down menu – choose between 1 through 500 HP – effects BHP and Load %
FL (Full Load) RPM	Fill in	2	Rated FL RPM – effects BHP and Load %; will effect kW if HP (size) and measured kW are out of range
Service Factor	Fill in	2	Rated service factor – used for reference only
VOLTS	Pull-down	2	Rated volts – can be used to calculate motor details depending on which inputs are left blank
FL AMPS	Fill in	2	Rated FL amps – can be used to calculate motor details depending on which inputs are left blank
FL Power Factor (%)	Fill in	2	Rated FL power factor – can be used to calculate motor details depending on which inputs are left blank
FL Efficiency	Fill in	2	Rated FL efficiency – proportionally effects the BHP and Load %
Letter Code	Pull-down	2	Pull-down menu – if used, automatically chooses FL Efficiency
NEMA Class Design	Pull-down	2	Pull-down menu – used for reference only
Enclosure	Pull-down	2	Pull-down menu – choose between “ODP” and “TEFC/TXPL” – effects BHP and Load %
Frame	Fill in	2	Motor Frame type and size, taken from motor nameplate – used for reference only
Motor Field Measurements			
Date	Fill in	2	Date measurements were taken – used for reference only
Time	Fill in	2	Time measurements were taken – used for reference only
Normal Load?	Pull-down	2	Pull-down menu – used for reference only

kW	Fill in	2	Measured kW – determines the kW per motor
Power Factor (%)	Fill in	2	Measured power factor – Can be used to calculate the motor details depending on which inputs are left blank
phase ab	Fill in	2	Measured phase ab voltage – Can be used to calculate the motor details depending on which inputs are left blank
phase bc	Fill in	2	Measured phase bc voltage – Can be used to calculate the motor details depending on which inputs are left blank
phase ca	Fill in	2	Measured phase ca voltage – Can be used to calculate the motor details depending on which inputs are left blank
phase a	Fill in	2	Measured phase a current – Can be used to calculate the motor details depending on which inputs are left blank
phase b	Fill in	2	Measured phase b current – Can be used to calculate the motor details depending on which inputs are left blank
phase c	Fill in	2	Measured phase c current – Can be used to calculate the motor details depending on which inputs are left blank

2.2.26.4 Output

Table 26-3. Output

Output Name	Description / Purpose
Constant Speed Drive, kW	Estimated maximum on-peak demand of the AC motor(s) without the VSD
Constant Speed Drive, kWh/yr	Estimated annual energy use of the AC motor(s) without the VSD
Variable Speed Drive, kW	Estimated maximum on-peak demand of the AC motor(s) with the proposed VSD
Variable Speed Drive, kWh/yr	Estimated annual energy use of the AC motor(s) with the proposed VSD
Savings, kW	Estimated on-peak demand savings (cannot be negative)
Savings, kWh/yr	Estimated annual energy savings for measure
Motor Runtime, Hours/Year	Annual operating hours for motor (not affected by motor quantity)
Incentive (@ $0.09 kWh/yr)	Estimated CCT incentive based on $0.09/kWh/yr

2.2.26.5 Energy Savings Explanation

The annual energy savings are the difference between the estimated baseline and proposed annual energy consumption and on-peak demand. If the proposed on-peak demand is greater than the baseline on-peak demand, the demand reduction will result in 0.00 kW. This is the case for many VSD applications since the motor may still run at full load during peak hours with the added parasitic loss through the VSD. The CCT tool estimates the existing (baseline) energy consumption and on-peak demand as well as the proposed energy consumption and on-peak demand according to the inputs supplied.

The tool uses the inputs to calculate the Load %, BHP, and kW. The motor is assumed to be the same for the existing and proposed systems; therefore the motor details are only entered once.

The results are then used in conjunction with the Operating Parameters and Percent of Time at Part Speed to calculate the total energy savings.

The user describes the existing and proposed Percent of Time at Part Speed. For the existing conditions, some motors have basic controls which allow them to run at more than one speed. Therefore both the Existing Percent of Time at Part Speed and the Proposed Percent of Time at Part Speed may be allocated throughout the entire range from 20% through 100%.

The kW at each Percent Part Speed is calculated and then used to calculate the annual kWh at that Percent Part Speed. The annual kWh is then calculated.

2.2.27 Other - Wastewater Retrocommissioning

2.2.27.1 Description

This tool estimates savings for four different energy efficiency measures common to wastewater treatment facilities: (1) Aeration Device Replacement, (2) Aeration Controls, (3) Blower Efficiency Improvements, and (4) Pumping Efficiency Improvements.

Aeration systems typically account for 45-60% of the energy consumed at a conventional municipal wastewater treatment facility. Potential efficiency improvements range from 30-70%[1]. Aeration methods include waterfall aerators, diffused-gas aerators, and mechanical aerators. For each method there are a number of different aeration devices. An aerator's performance is defined by the energy required to deliver dissolved oxygen (DO) and the effectiveness of treating the biochemical oxygen demand (BOD).

The Aeration Control measure saves energy by more accurately monitoring aeration system DO levels. The objective of the automation is to more consistently control DO levels regardless of fluctuations in the treatment load. For example, DO sensors can be used to adjust air flow, tank level, or mechanical aerator speed.

Blower Efficiency Improvements include increased motor and/or pump efficiency, impeller rightsizing, blower downsizing and improved air flow control. If the measure is a motor replacement only, than the appropriate measure category is High-Efficiency Motor Replacement or Early Retirement.

2.2.27.2 Appropriate Use of the Tool – Program Policy

The appropriate application of this tool is to estimate energy savings from wastewater system improvements described above. Both the Aeration Device Replacement and Aeration Control measures are simplified models of what can be much more complicated and dynamic systems. The blower and pump efficiency calculations are approximations based on static system conditions. Load and system variability will increase the uncertainty associated with these estimates. In all cases, the risk associated with using these models needs to be weighed against the cost of requiring more detailed calculations and/or measurement and verification[2]. These models do not have a size or capacity constraint. However, if the estimated system demand (kW) exceeds the reported capacity of the equipment (hp) then the user will be notified in the output file.

2.2.27.3 Inputs

The estimation tool software includes a total of five input screens for entry of aeration system, aeration control, blower and pump information. The following tables summarize the various tool inputs:

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[1] These estimates are based on reported oxygen transfer rates for various aeration devices. The 30% efficiency improvement would be typical of surface mechanical aerators or jet aerators to fine bubble diffusers. The 70% efficiency improvement would be typical for course to fine bubble diffuser retrofits.

[2] For an additional discussion of the cost of measuring and verifying savings versus stipulated estimates see paper by Jump, Johnson, and Farinaccio (2000).

Table 27-1. Choice of Waste Water Retrocommissioning Measures

Input Name	Type	Sheet	Description/Purpose
Aeration System Replacement	Check box	1	Choose aeration system replacement as a measure
Aeration Controls Improvement	Check box	1	Choose aeration controls improvement as a measure
Blower Efficiency Improvement	Check box	1	Choose blower efficiency improvement as a measure
Pumping Efficiency Improvement	Check box	1	Choose pumping efficiency improvement as a measure

Table 27-2. Aeration Device Replacement

Input Name	Type	Sheet	Description/Purpose
Existing Aeration Type	Pull-down	2	Select existing aeration device.
Proposed Aeration Type	Pull-down	2	Select proposed aeration device.
Influent Biochemical Oxygen Demand (BOD), mg/L	Fill in	2	Enter the average daily BOD entering the aeration zone in units of milligram per liter
Effluent Biochemical Oxygen Demand (BOD) f, mg/L	Fill in	2	Enter the average daily BOD leaving the aeration zone in units of milligram per liter
Influent Nitrification Demand (TKN), mg/L	Fill in	2	Enter the average nitrogen levels entering the aeration zone in units of milligram per liter
Flowrate of Aeration System, MGD	Fill in	2	Enter the average daily flowrate in units of millions of gallons per day
Aerator Capacity, hp	Fill in	2	This is the total rated motor capacity of the aeration system

Table 27-3.   Aeration Controls

Input Name	Type	Sheet	Description/Purpose
Aeration Type	Pull-down	3	Select aeration device. If this measure is being installed in conjunction with an Aeration Device Replacement The proposed aeration device is already selected.
Average Flowrate, MGD	Fill in	3	Enter the average daily flowrate in units of millions of gallons per day
Existing Control Description	Fill in	3	Describe existing controls
Existing Fan Type	Pull-down	3	Select existing fan type.
Existing Average Dissolved Oxygen Levels, mg/L	Fill in	3	Enter the average dissolved oxygen level prior to the installation of aeration control improvements

Proposed Control Description	Fill in	3	Describe proposed controls. Include equipment specifications.
Proposed Fan Type	Pull-down	3	Select proposed fan type
Proposed Average Dissolved Oxygen Levels, mg/L	Fill in	3	Enter the average dissolved oxygen level after the installation of aeration control improvements

Table 27-4. Blower Efficiency Improvements

Input Name	Type	Sheet	Description/Purpose
Mass Flowrate, lb/s	Fill in	4	Enter the average mass flowrate. If this measure is being installed in conjunction with an Aeration Device Replacement and/or Aeration Control, this should be the post-installation mass flowrate.
Absolute Inlet Temperature, °R = 460 + °F	Fill in	4	Enter the absolute inlet temperature.
Blower Efficiency, %	Fill in	4	Enter the blower efficiency (pre- and post-installation).
Motor efficiency, %	Fill in	4	Enter the rated motor efficiency (pre- and post-installation).
Absolute Inlet Pressure, lb_f/in^2	Fill in	4	Enter the absolute inlet pressure (pre- and post-installation).
Absolute Outlet Pressure, lb_f/in^2	Fill in	4	Enter the absolute outlet pressure (pre- and post-installation)
Annual Hours, hr/yr	Fill in	4	Enter the estimated annual hours of operation.
Blower Capacity, hp	Fill in	4	Enter total rated blower capacity.
Description	Fill in	4	Used in inspection.

Table 27-5. Pumping Efficiency Improvements

Input Name	Type	Sheet	Description/Purpose
Average Flowrate, gpm	Fill in	5	Enter the average flowrate in units of gallons per minute. The estimate should be based on the last twelve months of operation. Include supporting documentation as an attachment.
System Head, ft	Fill in	5	Enter the system head.
Fluid Specific Gravity, dimensionless	Fill in	5	The specific gravity of a substance is a comparison of its density to that of water. The default value is 1.0.
Pump Efficiency, %	Fill in	5	The pump efficiency, pre and post, based on the manufacturer's pump performance curve, which should be submitted with the project application.

Motor Efficiency, %	Fill in	5	Enter the rated motor efficiency.
Annual Hours, hr/yr	Fill in	5	Enter the average annual hours of operation.
Pumping Capacity, hp	Fill in	5	This is the pump motor nameplate rating.
Description	Fill in	5	Used in inspection.

2.2.27.4 Output

Once all necessary input information has been gathered, the Waste Water Retrocommissioning Retrofit Tool utilizes these inputs to compute the annual energy demand and usage for the baseline and proposed systems. From these values, the energy savings and incentive payment is calculated, and the results are presented to the user. The Waste Water Retrocommissioning Retrofit Tool outputs are described below.

Table 27-6. Output

Output Name	Type	Sheet	Description / Purpose
Existing Equipment, kW	Result	6	Estimated DEER Peak Demand
Proposed Equipment, kW	Result	6	Estimated DEER Peak Demand
Existing Equipment, kWh/yr	Result	6	Estimated existing annual energy
Proposed Equipment, kWh/yr	Result	6	Estimated proposed annual energy
Savings, kW	Result	6	Estimated DEER Peak demand savings for measure (difference between existing and proposed)
Savings, kWh/yr	Result	6	Estimated annual energy savings for measure (difference between existing and proposed)
Incentive	Result	6	Estimated incentive ($) for the measure.

2.2.27.5 Energy Savings Explanation

Aeration Device Replacement

The estimated energy consumption for a given aeration device is a function of the treatment loads and aeration device performance (i.e., oxygen transfer rate (OTR)). The OTR depends on the type of aeration device. Five different types of aeration devices are modeled: fine bubble diffusers, coarse bubble diffusers, surface mechanical aerators, submerged turbine aerators and jet aerators. Device performance can be affected by elevation and temperature. This model assumes standard atmospheric pressure (14.7 psia) and an average annual water temperature of 20°C (77°F). For smaller sites (<1.0 MGD), aeration control capabilities may play a larger role in realizing energy savings, something not accounted for here. For example, improved aeration efficiency may allow a smaller facility to completely shut down one of two aerators.

Aeration Device Control

The energy savings resulting from automated control of dissolved oxygen (DO) is a function of the current aeration efficiency, part-load performance of the blower, and load profile. The Aeration Controls Model uses part load performance coefficients for the aeration equipment based on the affinity law, ASHRAE curves and manufacturer’s data. To simplify the model an assumed

Dissolved Oxygen profile (DOP) is used based on a case study presented in the EPA design manual for fine pore aeration systems which has scaled down typical relative diurinal BOD5 loading. Automated DO aeration controls can reduce the required energy consumption by 25 to 50%. When both Aeration Device Replacement and Aeration Controls are implemented, the baseline for the controls measures is the post case of the replacement project.

Blower Efficiency Improvements

Savings can be realized by increasing motor and/or blower efficiency, downsizing, and reducing average air flowrates and head pressure.

Pumping Efficiency Improvements

Savings can be realized by increasing motor and/or pumping efficiency, downsizing, and reducing average flowrates and head pressure.

The equations used to model blower and pump average demand assume constant loading. Blowers and pumps with variable loading may require a more detailed calculation methodology and/or measurement and verification.

2.2.28 Other – Water Source Heat Pump

2.2.28.1 Description

The CCT software tool estimates the energy savings achieved when an existing water source heat pump is replaced with a unit with a higher efficiency rating (EER). Energy savings can also be achieved where the replacement equipment utilizes a variable flow controls over a baseline unit with constant controls.

2.2.28.2 Appropriate Use of the Tool –Program Policy

The CCT software tool can be utilized for the replacement of a water-source heat pump system. No fuel switching is allowed and only savings associated with cooling are calculated when using the tool for a heat pump. All heat pump sizes and capacities are applicable.

The tool allows implementation of this measure as a retrofit or for early retirement. For calculating early retirement, the tool allows for either for a recently overhauled unit or a less efficient piece of equipment that is replaced before the end of its useful life.

2.2.28.3 Inputs

Prior to selecting the HE WSHP w or w/o Variable Flow (Engage) measure, the user is required to specify whether the proposed project is one of the following: Retrofit (same load), Retrofit (increased load) or New Installation. The tool allows projects that fall under any of the three above referenced measure types. The user should make the appropriate selection based on the proposed equipment and project scope.

Once the measure for HE WSHP with or without Variable Flow (Engage) is selected, the user is then directed to enter the various inputs as described in the following table.

Table 28-1. Inputs

Input Name	Type	Sheet	Description / Purpose
Location	Pull-down	1	Location can be selected by either Zip Code or climate zone (CTZ). The appropriate Zip Code or CTZ is then selected from the adjacent pull-down menu.
Building Type	Pull-down	1	A “predefined” building configuration can be selected. (See Appendix D in the Customized Offering Manual for detailed descriptions). Multiple Building Types are available for this measure.
Vintage	Pull-down	1	Select a Building Vintage from the list of available vintages that best matches the age of the building and main systems.
HVAC System(s)	Pull-down	1	Select the appropriate cooling equipment type from the pull-down menu. Please note that the available HVAC systems for selection are dependent on the selected building type.
Allow HVAC System Downsizing	Pull-down	1	This checkbox allows engage to downsize HVAC systems in the measure runs if the selected measure results in reduced cooling loads. This checkbox is only enabled if the building vintage is after 2005.

Total Building Area	Fill In	1	Enter the square-feet of conditioned space.
Number of Floors	Pull-down	1	Enter the number of floors of conditioned space.
Secondary Building Area/Total Dormitory Area	Pull-down	1	This field may or may not be disabled for this measure, depending on the building type selected. Building types such as Universities and colleges allow for input to this field, while Large/Small offices do not.
Secondary Number of Floors	Pull-down	1	This field may or may not be disabled for this measure, depending on the building type selected.
Seasonal Usage - Pattern	Pull-down	2	Select the appropriate usage type from the pull-down menu. Only “Typical Use Throughout the Year” is available for selection for this measure.
Seasonal Usage - Number of Seasons	Pull-down	2	Select the number of seasons during which the building systems operate from the pull-down menu. User can select up to three seasons
Season #1	Pull-down	2	User can modify the default entry for this field which is “Typical Use”
Observed Holidays	Pull-down	2	When clicked, this button displays a checkbox list of holidays available to be exempt from scheduling.
Season #2: (With Label & No of Periods)	Pull-down	2	This field is enabled if the number of seasons selected is >1. Insert an appropriate label for the seasons. Choose an appropriate number of periods when the season occurs from the pull-down menu and the pop up calendar.
Season #3: (With Label & No of Periods)	Pull-down	2	This field is enabled if the number of seasons selected is >2. Insert an appropriate label for the seasons. Choose an appropriate number of periods when the season occurs from the pull-down menu and the pop up calendar.
Select Active Building Shell	Pull-down	3	From the pull-down menu, choose the appropriate shell. The number of shells available in the drop down list is based on the previously chosen Building Type.
Seasons – Weekly Schedule	Pull-down	3	Users are allowed to define operation for up to (3) defined seasons. Only one opening time and one closing time can be defined per day type, per season. From the pull-down menu, choose opening and closing hours for each day of the week and holidays.
Area Served	Fill In	4	Enter the total area served by the HVAC system.
Economizer	Pull-down	4	Choose the economizer option that best fits the project equipment.
Existing Loop Flow	Pull-down	4	The user may select either ‘Constant’ or ‘Variable’ from the drop down. The default

			value is 'constant.'
Existing Pump Control	Pull-down	4	The user can define the existing pump control with this input. Please note that the user can only edit this field when 'Variable' loop flow is selected. Otherwise the value is fixed at 'Single Speed'.
Existing WSHP Equipment Data	Button	4	Press the command button to open up the screen and define the appropriate details for the existing equipment.
Replacement Loop Flow	Pull	4	The user may select either 'Constant' or 'Variable' from the drop down. The default value is 'Variable.'
Replacement Pump Control	Pull-down	4	The user can define the replacement pump control with this input.
Replacement WSHP Equipment Data	Pull-down	4	Press the command button to open up the screen and define the appropriate details for the replacement equipment.
Code Baseline HP Equipment	Display	4	This section does not require any input from the user. The text boxes will provide the efficiency and capacity of the WSHP equipment to be used as the baseline for the analysis. If the existing equipment qualifies for early retirement, this will be equal to the baseline efficiency. If the existing equipment is not qualified for early retirement, the appropriate minimum efficiency standard will be used.

2.2.28.4 Output

Once all the necessary input information has been gathered, the CCT software tool utilizes these inputs to compute the annual energy demand and usage for two scenarios: the baseline water source heat pump equipment compared to the replacement equipment (the calculation methodology is explained below). Finally, the energy savings and incentive is computed and the results are presented to the user as found in Table 28-5 – Building Measure Results. After the user selects "Finish", the information on Table 28-6 – Demand Incentive Worksheet will be requested. After the user selects "Next" or "Finish" the user can generate a PDF summary, continue working on the measure or save the current progress and inputs.

Table 28-2. Building Measure Results

Output Label	Description/Purpose
Existing Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the existing equipment is displayed.
Baseline Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the Title-24 minimum efficient equipment is displayed.
Proposed Equipment	Estimated on-peak demand, annual electrical energy use, and annual thermal energy use of the proposed equipment is displayed.

Savings	The difference between the Baseline Equipment values and Proposed Equipment values are displayed.
Incentive (@ $0.15 kWh/yr)	Estimated incentive is displayed based on program incentive rate.

The Peak Demand Incentive Worksheet uses the CPUC Peak Demand Savings to calculate kW savings and incentive. The software chooses the appropriate CPUC peak period based on the location inputs on the first sheet. The software calculates CPUC Peak directly for weather-based (Engage) measures. It estimates CPUC Peak for non-weather related measures (e.g. industrial, process, etc.) using accepted estimating techniques.
See the Energy Savings Explanation section for a description of the CPUC Peak Demand Savings.

Table 28-3. Peak Demand Incentive Worksheet

Input Name	Type	Sheet	Description / Purpose
City	Pull Down	N/A	Select the appropriate city
Equipment operates during the peak demand period defined above?	Check Box	N/A	If the equipment does operate during the peak demand period click the check box.
Eligible Peak Demand Savings (kW)	Fill In	N/A	Enter the eligible peak demand savings if they differ from the calculated savings. Explain the why the savings differ in the text box below.
Total Incentive	Display	N/A	Estimated on-peak demand incentive is displayed.

2.2.28.5 Energy Savings Explanation

The 2010 CCT calculates the energy savings for this measure by passing all required user inputs through Engage, which is a modified version of the Quick Energy Simulation Tool (eQUEST). Developed by James J. Hirsch and Associates, eQUEST is a whole-building performance model that incorporates graphics and wizards with the DOE2.2 computation engine to simulate building energy performance based on user-defined inputs. These inputs describe building attributes such as (but not limited to) building envelope characteristics, internal loads, and HVAC system components. eQUEST, through the DOE2.2 computation engine, performs hourly calculations of the electrical and/or gas demand of building system end uses (HVAC, lighting, misc equipment, etc) based on normalized annual weather data.

(Please note that to create a more generic model, assumptions are incorporated into eQUEST to create the Engage model, thereby reducing the amount of inputs and detail required by the user. However, the DOE2.2 computation methodology remains the same across both platforms.)
If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

CPUC Defined Peak Demand Savings

The software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant the equipment operates during the defined peak period.

Calculating Early Retirement

This tool can also be used for HVAC equipment that qualifies for early retirement. That is, the equipment has either been recently overhauled or replaced before the end of its useful life. To qualify as “overhauled”, the unit must have undergone a significant amount of work and all components must have been brought back to their original condition. An example of an eligible major overhaul is the replacement or rebuilding of all compressors and motors in a packaged unit as well as restoring the evaporator and condenser coil to their original condition. As part of the inspection, the equipment will be examined to determine if the calculated remaining life is reasonable. Should the equipment not meet the expected useful life, the measure will be rejected. The utility administer has the final decision on whether a piece of equipment qualifies as refurbished. To establish the overhaul and its date, supporting invoices are required.

Early retirement calculations usually result in a larger incentive, as existing efficiencies are often less than the current Title 24 minimums. The reason for the enlarged incentive is that the energy savings are calculated using the baseline efficiencies of the actual equipment rather than the current minimum standards. If applying for early retirement the user should take special note of the year the baseline equipment was built and whether or not it has been overhauled.

2.2.29 Other – Fan System Upgrades

2.2.29.1 Description

Fan and blower systems have been identified as one of the largest end use applications in industrial settings. Under the sponsorship of the DOE Industrial Technologies Program a computer program called FSAT (Fan System Assessment Tool) was jointly developed by the Air Movement and Control Association (AMCA) and Oak Ridge National Laboratory to assist end users in estimating fan system energy saving opportunities. FSAT uses generic fan performance characteristics in conjunction with minimal user inputs to estimate the efficiency and potential savings associated with fan and/or electric drive motor replacements. The FSAT output is limited to an estimate of the potential annual savings associated with single fan operating point and does not attempt to identify how the potential savings can be obtained nor does it characterize savings associated with specific savings measures.

This software tool utilizes some of the information contained in FSAT (fan efficiency based on specific speed) in conjunction with the fan laws to estimate energy and demand savings, and the associated incentive amount. Additionally, this CCT software tool allows for entry of multiple fan operating points as well as installation of a variable frequency drive (VFD); a measure that is not included in FSAT.

This tool currently estimates savings for the following measures, either singly or in combination:

- direct replacement of a fan or fan and motor with equipment of higher efficiency;
- installation of an electronic variable frequency drive (VFD) on the fan drive motor;
- and installation of a more efficient belt drive on the fan drive motor.

Currently the software will only accommodate measures involving a single fan. Therefore projects involving multi-fan systems should not use this tool to estimate savings.

2.2.29.2 Appropriate Use of the Tool –Program Policy

The Fan System Upgrades tool is currently only available for use with retrofit applications. The tool can be used for fans and measures having the characteristics shown in Table 29-1. Note that fans equipped with variable pitch blades or fans equipped with mechanical drives capable of variable speed operation are not currently accommodated. It is also important to note that this tool utilizes a variety of assumptions related to the condition and operation of fan systems, which are explained in detail in the following sections. This tool provides results representative of "typical" fan systems and may not represent the specific operating conditions present at an individual site/installation. This tool <u>should not</u> therefore be used to design or otherwise specify fan systems or equipment.

Table 29-1. Fan Savings Measure Features

Description	**Measure Feature**
# of Fans	1
Fan Types	Centrifugal and axial fans with drives of 5 HP or more
Fan Drive	Direct drive, belt drive and electronic Variable frequency Drive (VFD)
Baseline Fan Efficiency	Generic fan efficiencies are displayed for information purposes.
Fan Operating Profile	Daily/Monthly or Total Annual Operating hours accommodated for up to eight (8) modes of operation. (User may input either fan flow or fan kW)
Static Discharge Pressure	Fan total static pressure in the range of 0 – 35 "Wg (recommended) *Increased pressures can be accommodated with some reduction in*

	accuracy due to compressibility effects. Please contact AESC for additional information.

2.2.29.2.1 Applicable Types of Equipment

The fan types and controls accommodated in the estimation tool software parallel those covered in the FSAT software. The exception is that this software will also calculate savings associated with VFD-equipped fan drives. Table 29-2 summarizes the fan type and control options covered by the estimation software. Note that fans deployed as “blowers” may be accommodated subject to the static pressure restrictions noted above.

Table 29-2. Equipment Included in Fan Savings Estimation Software

System Type	Fan Type	Control Type
Centrifugal	Airfoil (SISW, DIDW), Forward Curved (SISW & DIDW), Backward Inclined (SISW & DIDW), Radial (SISW), Radial Tip (SISW), Exhaust, Industrial Commercial Fan (ICF)- Air Handling, Industrial Commercial Fan (ICF)- Material Handling, Industrial Commercial Fan (ICF)- Long Shavings	On/off (no control), Outlet Dampers, Inlet Vanes**, Variable Frequency Drive*
Axial	Tubeaxial, Vaneaxial, Propeller, Exhaust	On/off (no control), Outlet Dampers, Variable Frequency Drive*

**   -- part of energy savings measure only*

***   -- inlet vane control is not an option for exhaust fan applications*

2.2.29.3 Inputs

The fan system upgrades software requires a significant number of inputs, which can be divided into three basic areas: system requirements, equipment performance (fan, motor, drive) and fan operating modes. Additional information is provided on the inputs related to system pressure requirements and fan performance.

System Pressure and Flow Inputs:

The two system inputs of most importance are System Static Pressure at Maximum Flow and the System Maximum Flow. These two inputs (see Figure 29-1) are used by the software to develop a simplified system pressure curve[3]. The curve is assumed to have a basic quadratic shape with a zero intercept. Thus the system pressure curve can be established using the single maximum flow point. Note that system maximum flow will likely correspond to the maximum fan operating flow for most single fan applications.

[3] A system pressure curve is not needed for applications involving unducted exhaust fans and these inputs do not therefore appear when the exhaust fan checkbox is checked.

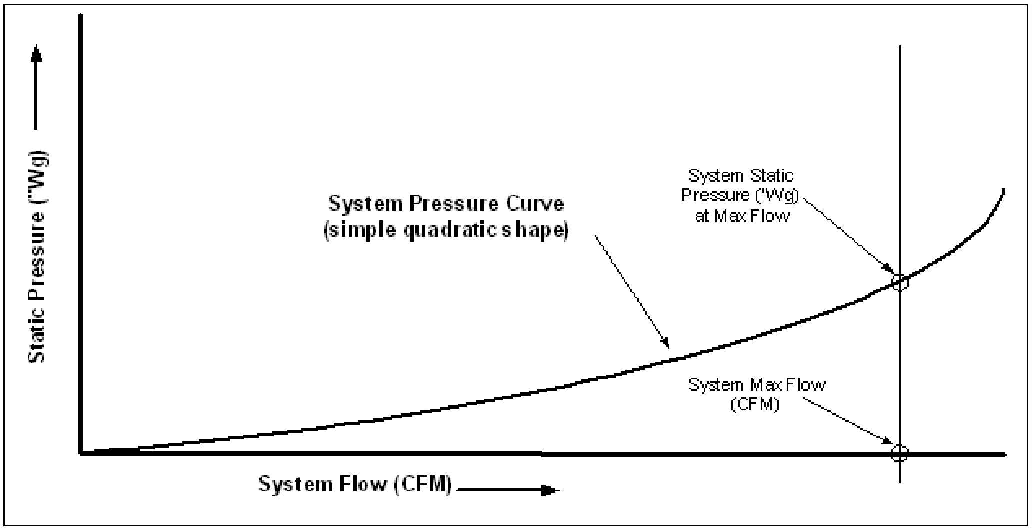

Figure 29-1: System Pressure and Flow Inputs (not to scale)

The system inputs are located on Input Screen 1 along with the site specific inputs (see Table 29-3).

Table 29-3. Site/System Inputs

Input Name	Type	Sheet	Description/Purpose
Location/city	Pull-down	1	Site location [air density correction for site altitude]
Fan System Name	Pull-down	1	Identifies fan system involved [inspection purposes]
Fan System Type	Pull-down	1	Select either Centrifugal or Axial
Exhaust Fan?	Pull-down	1	Pull down menu; “yes” indicates an unducted exhaust fan
Number of Fans	Pull-down	1	1 is the only selection currently available
Estimate Ambient Air Temperature?	Pull-down	1	Pull down menu; “yes” indicates that Inlet Air Temperature will be calculated by the software based on the average air temperature for this location/city (CEC weather zone data).
Inlet Air Temperature, Deg F	Fill in	1	Nominal temperature of air entering the fan [air density correction] *If ambient air temperature checkbox is selected then the average ambient for the location/city will be automatically displayed.*
System Design (Max) Flow, or Maximum Exhaust Flow, CFM	Fill in	1	Maximum flow through system [establish system pressure & flow requirements] or maximum exhaust fan flow (if “yes” is selected on the exhaust fan pull down menu)
System Total Static Pressure @ Max Flow, “Wg	Fill in	1	Fan total static pressure requirement at max system flow in inches Water gauge [establish system pressure and flow requirements] *This input does not*

			appear if "yes" is selected on the exhaust fan pull down menu.

Fan Performance Inputs:

The fan performance inputs of most importance are the fan Total Static Pressure, Static Efficiency and the fan Flow at the fan's best efficiency point (BEP). The relationship of these inputs is illustrated in Figure 29-2 below.   These three values are used in conjunction with generic normalized fan curve shapes to develop an estimated fan performance map. Note that the BEP values are taken from manufacturer's data and will likely be significantly different from the fan operating points (for most fan types).

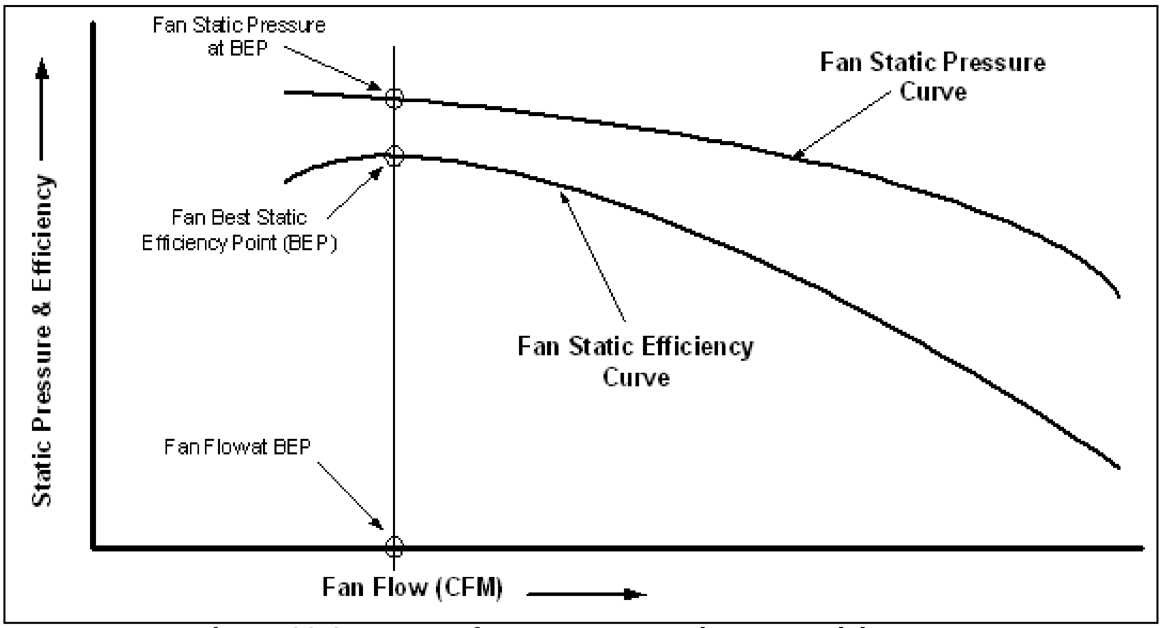

Figure 29-2. Fan Performance Inputs (not to scale)

The fan performance inputs are located on Input Screen 2 along with the site specific inputs (see Table 29-4).

Table 29-4. Existing Fan Inputs

Input Name	Type	Sheet	Description/Purpose
Fan ID	Fill in	2	Fan identifier [inspection purposes]
Manufacturer	Fill in	2	Fan manufacturer [inspection purposes]
Model	Fill in	2	Fan model [inspection purposes]
Serial Number	Fill in	2	Fan SN [inspection purposes]
Type	Pull-down	2	*See Table 29-2 for menu selections*
Control Type	Pull-down	2	*See Table 29-2 for menu selections*
Drive Type	Pull-down	2	Direct, V-belt,or Rubber Chain Drive
Fan Speed	Fill in	2	Fan speed value (RPM)
Flow, CFM	Fill in	2	Flow at fan best efficiency point (BEP) [establish fan performance curve(s)]
Total Static Pressure, "Wg	Fill in	2	Total fan static pressure requirement at BEP

			[establish fan performance curve(s)]
Static Efficiency, %	Fill in	2	Fan static efficiency at BEP [establish fan performance curve(s)] *Note that the estimated maximum fan efficiency for this fan type & specific speed (FSAT data) are displayed for comparison purposes*

The remaining user inputs are summarized in the following tables.

Table 29-5. Existing Drive Motor Inputs

Input Name	Type	Sheet	Description
Manufacturer	Fill in	3	Motor manufacturer (nameplate data)
Model	Fill in	3	Motor model (nameplate data)
Size, HP	Pull-down	3	Motor size (nameplate data)
Speed, RPM (nominal)	Pull-down	3	Select from pull-down; 1200, 1800, 3600
FL Speed, RPM	Fill in	3	Motor speed at full load (nameplate data)
Enclosure Type	Pull-down	3	ODP or TEFC/TXPL
Service Rating	Pull-down	3	Motor service rating; 1.15 or 1.25
NEMA Nominal Efficiency @ full load	Fill in	3	EPACT min value is displayed for comparison purposes

Table 29-6. Fan Operating Information Inputs

Input Name	Type	Sheet	Description
Fan Operating Conditions:			
Number of Operating Modes	Pull-down	4	Number of different operating points that will be considered (8 max)
Operating Hour Input	Pull-down	4	Yearly (total annual hours as input) or Daily (days/month as input) may be selected
Operating Data Type	Pull-down	4	Flow (CFM) or Power (kW)
Operating Mode Information:			
Operating Mode Number	Pull-down	4	Selections are 1 through the number of modes entered above (8 maximum).
Description	Fill in	4	Name or description of operating mode (i.e., process air, etc.)
On-Peak Operation?	Check box	4	Check this box if *any* fan operation during this operating mode occurs during the on-peak period (as defined by local utility).
Average Operating Data	Fill in	4	Average fan flow rate (CFM) or fan power (kW) during this operating mode

Table 29-7. Fan Operating Information Inputs

Input Name	Type	Sheet	Description
Annual Operating Hours	N/A	5	Total annual operating hours for each operating mode. This field is only an input if the Operating Hour Input (Sheet 4) selection was "Yearly Total". If "Daily/Monthly Totals" was selected previously (Sheet 3) then these fields will update with the total annual hours calculated from the "Daily" inputs.
Days per Month	Fill in	5	Table only appears if "Daily/Monthly Totals" Operating Hour Input (Sheet 4) was selected previously. Enter the number of days of operation for each operating mode for each calendar month.
Hours per Day	Fill in	5	Table appears if "Daily/Monthly Totals" Operating Hour Input (Sheet 4) was selected previously. Enter the number of daily hours of operation for each day of the week for each operating mode for each calendar month.

Table 29-8. Proposed Measure Inputs

Input Name	Type	Sheet	Description
Fan Replacement / Mod.	Checkbox	6	Select "Fan" and/or "Motor" checkboxes (or neither)
Fan Drive Replacement	Checkbox	6	Select "VFD added to existing drive" or "Rubber Chain Drive (or equivalent)" (or neither)
VFD Full Load Efficiency, %	Fill in	6	VFD efficiency at full load @ 100% speed [used to calculate overall efficiency] *(input only appears if VFD checkbox is selected)*
VFD Minimum Operating Speed, %	Fill in	6	VFD minimum operating speed [used to check for violation of min speed during operation] *(input only appears if VFD checkbox is selected)*

Additional Inputs

Additional input screens are provided to define the performance and operating characteristics of the proposed fan and associated drive motor. These forms / inputs will only appear if a fan replacement has been selected in the measure specification page. These forms are identical to the forms used to enter existing fan and motor details as described previously in Tables 29-4 & 29-5, respectively.

2.2.29.4 Output

Table 29-9. Output

Output Name	Description / Purpose
Baseline Fan System (kWh/yr)	Baseline usage
Proposed Fan System (kWh/yr)	Proposed usage
Fan System Runtime	hours/yr the fan is in operation
Savings (kWh/yr)	kW and kWh savings
Incentive (@ $0.09 kWh/yr)	Dollar incentive amount

2.2.29.5 Energy Savings Explanation

Annual energy savings is calculated by subtracting the proposed energy usage from the baseline usage. Incentive values are then calculated as the product of the incentive rate and the estimated energy savings value.

Annual Savings (kWh) = Baseline kWh – Proposed kWh
Incentive Amount ($) = Annual Savings (kWh) * Incentive Rate ($/kWh)

Baseline Energy Use – Power as Operating Point Input

In this case the user has already input a measured fan power value for each of the various operating points (up to 8). If the proposed measure does not include replacement of the electric motor then no correction for minimum electric motor efficiency is required and the baseline energy use for each operating mode is simply the product of the measured fan kW and the total annual operating hours that have been entered. This process is repeated for each of the operating modes with the sum equal to the annual baseline energy use of the fan. Additionally, the software calculates the weighted average electric demand using data from each operating mode that the user has previously designated as having on-peak operation. This value is displayed as the potential DEER peak demand on the DEER peak demand worksheet. Note that in the event that an electric motor replacement has been specified then it is necessary to correct the baseline data if the existing motor does not meet or exceed the EPACT minimum efficiency standard. The software uses existing algorithms developed for the electric motor measure to accomplish this correction (if needed).

Baseline Energy Use – Flow as Operating Point Input

The electric demand of a fan is calculated using the following expression.

$$kW_{FAN} = 0.7457 * K_p * \frac{Q_F * P_S * \rho_{in}}{6349.6 * \eta_F * \eta_d * \eta_e * \rho_{std}} \quad \text{(Equation 29-1)}$$

where:

Q_F = Fan flow (CFM)
Ps = Fan static discharge pressure (inches Wg)
K_p = Compressibility Factor (initially set to 1.0)
ρ_{in} = Air density corrected for fan inlet conditions
ρ_{std} = Air density at standard conditions (0.075 lbs/ft^3)
η_F = Fan efficiency @ operating conditions
η_e = Electric drive motor efficiency
η_d = Drive efficiency (if applicable)

Note that fan total static pressure has been substituted for total pressure in the above expression. Many of the variables shown in this expression are dependent on operating conditions and must therefore be calculated separately prior to use in Equation 29-1.

Estimating Fan Performance

Fans exhibit dynamic performance characteristics such that fan total static pressure (P_S), brake horsepower and static efficiency (η_F) vary with flow. These performance parameters must therefore be calculated for each operating point (for use in Equation 29-1). Fan total static pressure and efficiency are typically characterized in a fan performance curve. These curves are generated by the fan manufacturer using test data and are used to determine the fan operating point (pressure and efficiency) under varying flows and speeds.

- ***Generic Fan Performance Curves***

Since fan performance curves can be difficult to locate for older fans the estimation tool software assumes that fan performance will follow one of five generic fan curve shapes[4] based on fan type. See Figures 29-3 and 29-4 for generic static pressure and static efficiency curve shapes, respectively. Note that these curves are normalized based on fan performance parameters at the Best Efficiency Point (BEP). Fan performance at flows other than BEP is estimated using these curves, fan BEP data provided by the user and the following expressions:

$$Q_F = Q_{norm} * Q_{BEP} \quad \text{(Equation 3a)}$$

$$\eta_F = \eta_{norm} * \eta_{BEP} \quad \text{(Equation 3b)}$$

$$Ps = P_{norm} * P_{BEP} \quad \text{(Equation 3c)}$$

where:

Q_F = Fan flow (CFM) @ operating conditions
Q_{BEP} = Fan flow (CFM) @ BEP
Q_{norm} = Normalized fan flow (from curves)
Ps = Fan total static pressure ("Wg) @ operating conditions
P_{norm} = Normalized fan total static pressure (from curves)
P_{BEP} = Fan total static pressure ("Wg) @ BEP
η_{BEP} = Fan efficiency @ BEP
η_{norm} = Normalized fan efficiency (from curves)
η_F = Fan efficiency @ operating conditions

- ***Fan Flow Range Restrictions***

Fans are typically designed to operate at flows exceeding the flow at peak output pressure. This is done to avoid potentially unstable fan operation. This problem is more pronounced in axial fans and in some centrifugal fans. In order to avoid this potential problem the software will only estimate fan performance at flows falling within the stable operating region (i.e., flows exceeding the flow at the maximum static pressure).

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[4]Curve data extracted from generic curves shown in AMCA Publication 201-02, "Fans & Systems".

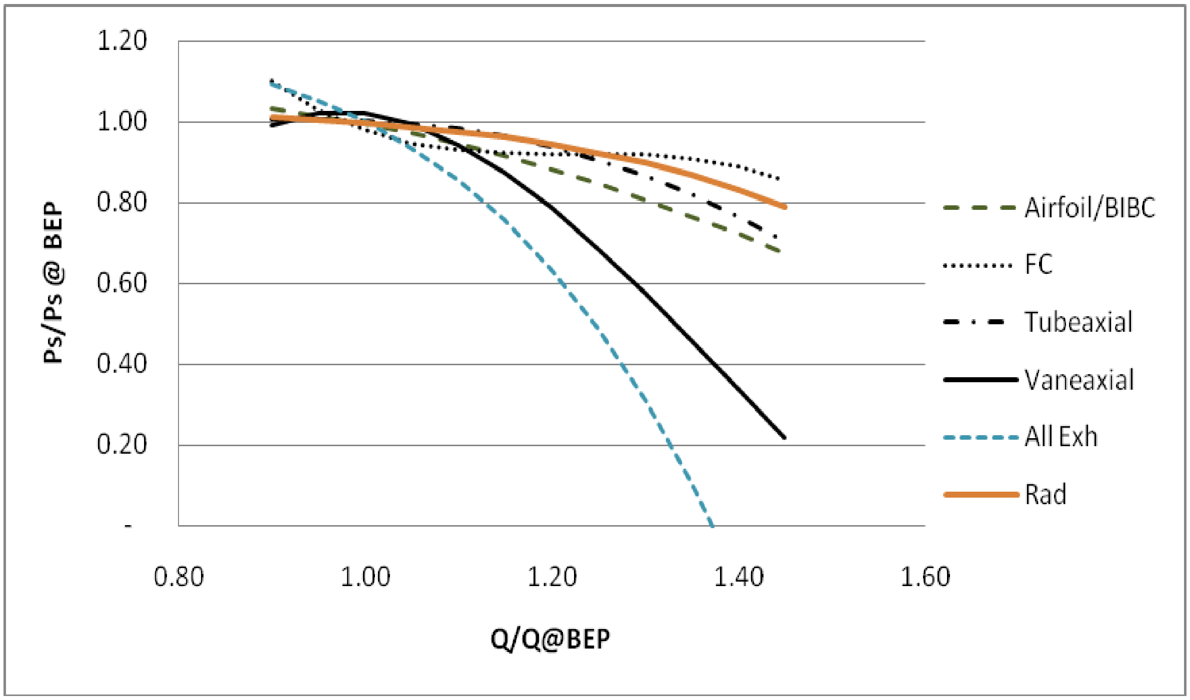

Figure 29-3. Generic Fan Total Static Pressure Curves
(normalized based on Flow and Total Static Pressure at the Best Efficiency Point (BEP))

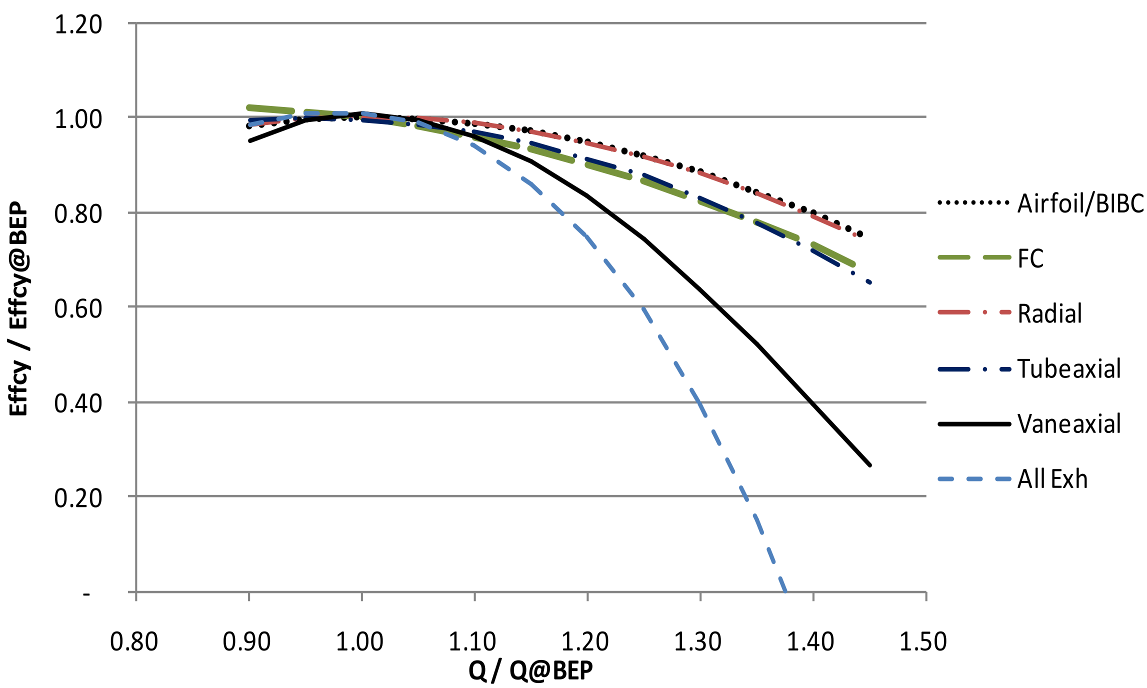

Figure 29-4. Generic Fan Static Efficiency Curves
(normalized based on Flow, Efficiency at the Best Efficiency Point (BEP))

- ***Compressibility Factor***

The impact of the compressibility of air is considered negligibly small (less than 1% error) at fan pressures less than 10 "Wg (e.g., compressibility factor, K_p, in Equation 4 is set to 1.0). The potential error associated with compressibility remains below 3% for pressures as high as 35"Wg. It is unlikely that applications involving fans (as opposed to blowers) will involve pressures above this value and as such the software does not account for compressibility effects.

- ***Estimated Fan Speed and Drive Efficiency (if applicable)***

If a belt drive has been specified then the software will calculate and use a drive efficiency based on drive size and type specified by the user (see Table 29-9).

Table 29-10. Belt Drive Efficiency[5]

Drive Type	Drive Size, HP	Efficiency, %
Standard V-Belt Drive	5 – 100	$93.29*(HP_{motor})^{0.00619}$
	>100	96
Rubber Chain Drive	Any size	98

Matching System Requirements and Fan Performance

In order to estimate the fan baseline energy use it is necessary to calculate the fan efficiency (η_F) at the operating point conditions. This is accomplished by identifying where the fan is operating on its characteristic performance curve. The method used to identify this point varies depending on the control that is utilized. The software provides for three fan control methods: outlet dampers, on/off control and inlet vanes. Exhaust fans represent a special case of unducted fan applications where "inlet vane control" is not a baseline control option (VFD is applicable only as a measure). Figure 29-5 illustrates the relationships between the various control methods with additional explanation in the following paragraphs.

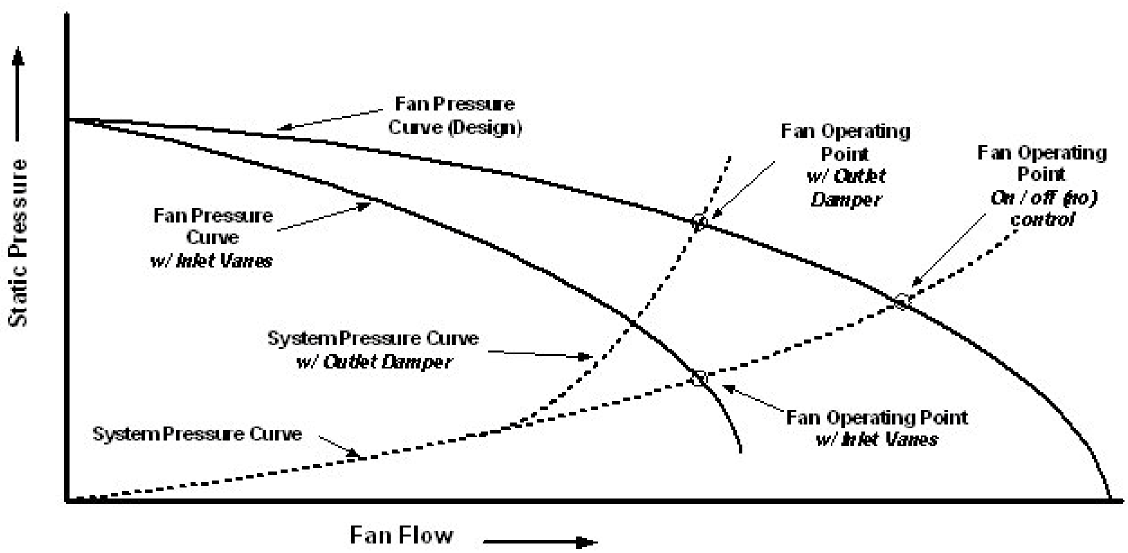

Figure 29-5. Fan Operating Point Examples (not to scale)

- ***Outlet Dampers***

In the case of outlet dampers, a damper located on the fan outlet will increase or decrease the system pressure requirement causing fan flow to decrease or increase (moving to the left or right on the fan performance curve) until the fan flow matches the system requirement. For fan

[5] See AMCA 203-90, Field Performance Measurement of Fan Systems, Annex L. Estimated Belt Drive Loss. *Belt drives are assumed to be in good working condition.*

systems that use outlet dampers the fan flow is equal to the system flow while the fan total static pressure will be higher than the system pressure requirement. The shape and location of the fan performance curves are unaffected by outlet dampers so fan performance is estimated using the previously discussed generic performance curves and the operating point flow value (user input). See Figure 29-5 for examples of this and other control operating points.

- ***On/off control (no control)***

When there is no control damper the fan flow will only be limited by the system pressure requirements (i.e., fan pressure and flow operating point is equal to system pressure and flow requirement). This situation is represented by the intersection of the system pressure and fan total static pressure performance curves (see Figure 29-5). The estimation software must therefore locate this intersection. Site/system information, provided by the user for system flow and pressure (at design flow) is used to generate an expression[6] and associated curve for system pressure. Equating and solving the fan total static pressure and system pressure expressions for flow yields the intersection of the two expressions.

Exhaust Fans -- Note that in the case of unducted exhaust fans the system pressure and flow requirements are assumed to match the fan discharge pressure at the designated operating point flow. The process of identifying the intersection of the fan and system pressure curves is not therefore required for exhaust fan applications.

- ***Inlet Vanes (centrifugal fan types)***

Inlet vanes induce swirl into the inlet of a centrifugal fan, this swirl is normally in same direction as the rotation of the fan impeller and results in reduced fan output. Unlike outlet damper and on/off control, inlet vane controls alter the fan performance characteristic so it is not possible to use the generic fan characteristic curves to estimate fan performance.
Using data from a blower / damper manufacturer, a curve (see Figure 29-6) and associated relationship was generated for fan % of full load power and of % of fan full flow[7]. The software utilizes this relationship along with the fan full-load power to establish the fan BHP at each operating point flow.

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[6] System pressure is assumed to follow a simple quadratic expression of the form: $P = mQ^2$, where m is calculated using the design flow and pressure information provided by the user.

[7] Source: NYB Engineering Letter 11 -- Selection Criteria for Dampers (www.nyb.com)

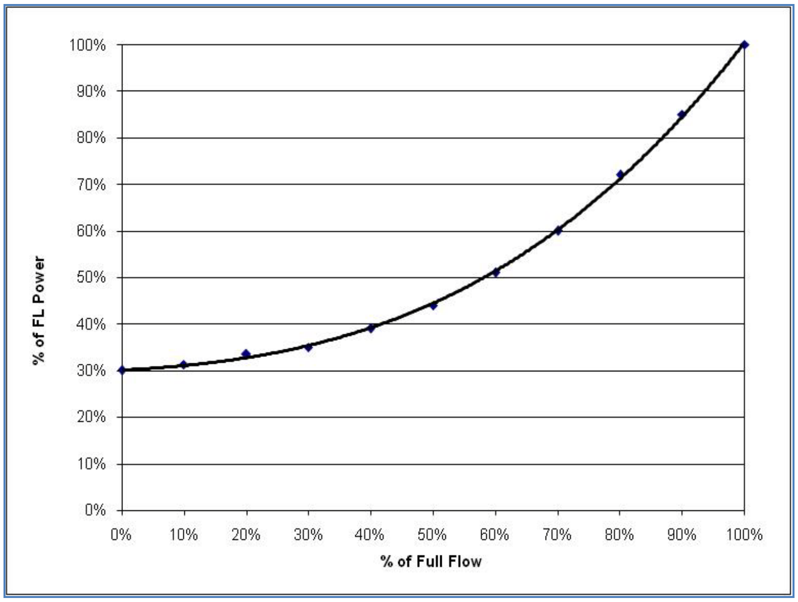

Figure 29-6. Inlet Vane Performance Characteristic

Drive Motor Efficiency & Completion of Baseline kW Calculation

Once the fan efficiency (for either On/off control or Outlet Damper control types) is determined it is possible to estimate the electric motor load using the following expression:

$$BHP_{Motor} = K_p * \frac{Q_F * P_S * \rho_{in}}{6349.6 * \eta_F * \eta_d * \rho_{std}} \quad \text{(Equation 5a)}$$

When an inlet vane control is indicated then the software estimates the fan BHP directly using the inlet vane performance characteristic and the electric motor load is subsequently estimated using the following expression:

$$BHP_{Motor} = \frac{BHP_F}{\eta_d} \quad \text{(Equation 5b)}$$

Having established the drive motor load, electric motor efficiency (η_e) is calculated using existing CCT software functions (based on DOE MotorMaster). Substituting motor efficiency into the following expression yields the fan kW at this operating point.

$$kW_{FAN} = 0.7457 * \frac{BHP_{Motor}}{\eta_e} \quad \text{(Equation 6)}$$

Baseline energy use for each operating mode is the product of the fan kW and the total annual operating hours that have been entered for the operating mode. The estimation software repeats the process of locating the fan operating point, estimating fan, drive and motor efficiency and calculating the baseline energy usage for each of the operating modes (up to eight) specified by the user. The sum of the energy use of all of the operating modes is equal to the annual baseline energy use of the fan.

Calculation of the baseline peak electric demand is accomplished in one of two ways. If only annual operating mode information has been entered then the software calculates the weighted average demand for all operating modes that the user has previously designated as having on-peak operation. This is the value reported as the average demand of the proposed system. However if daily/monthly data has been entered then the software will identify the DEER three-day peak period for the specific city/location and will only utilize information (operating hours and kWh usage) from the month or months of operating data that include this period when calculating the weighted average electric demand.

Note that in the event that the software is unable to locate the estimated fan operating point (intersection of fan and system operating curves) or the estimated operating point is deemed invalid (flow is negative or exceeds system maximum flow) then the calculation will be aborted, and an error window will appear indicating that the specified fan appears incompatible with system requirements and will suggest a possible cause.

Efficiency Measure – Fan Replacement
The estimation software calculates the savings associated with replacement of an existing fan with a fan of the same or different type, having a higher efficiency. If the user provided fan flow information for each operating point then the energy use of the new fan is calculated in the same manner as previously described for baseline energy use   The difference being that the new fan information (fan type, fan efficiency, etc.) is substituted for the existing fan information.
The software provides for input of either a baseline fan flow or fan kW value for each operating point. In the event that the user provided baseline kW values in lieu of fan flow then it is first necessary to estimate the fan flow for each operating point before the performance of the replacement fan can be calculated.

Efficiency Measure – Fan and Drive Motor Replacement
If both the fan and motor are being replaced the estimation software calculates the savings associated with replacement of the existing fan drive motor with a motor having a higher efficiency. The energy use of the new motor is calculated in the same manner as previously described for baseline energy use. The exception being that the new motor efficiency is substituted for the existing motor efficiency.

Unintentional fan speed changes can significantly impact fan energy use. A common problem with motor replacement involves an inadvertent fan speed increase resulting in higher fan energy use, and reduced savings. For this reason, if a VFD has not been specified, the software will warn the user if the full load speed for the new motor is higher than the motor that it replaces.

Efficiency Measure – Rubber Chain Drive (or equivalent) Installation
The electric demand of a fan operating with an improved belt drive is calculated using the same basic expression as the baseline fan calculation with the exception that the new drive efficiency value is used in the drive efficiency term (η_d) in the following equation. Note that the software does not provide for direct user input of belt drive efficiency but instead uses the 98% value noted previously in Table 29-9 for Rubber Chain drives.

$$kW_{FAN} = 0.7457 * K_p * \frac{Q_F * P_S * \rho_{in}}{6349.6 * \eta_F * \eta_d * \eta_e * \rho_{std}} \qquad \text{(Equation 7)}$$

where:

Q_F = Fan flow (CFM)
Ps = Fan static discharge pressure (inches Wg)
K_p = Compressibility Factor (initially set to 1.0)
ρ_{in} = Air density corrected for fan inlet conditions
ρ_{std} = Air density at standard conditions (0.075 lbs/ft^3)
η_F = Fan efficiency @ operating conditions
η_e = Electric drive motor efficiency
η_d = Belt Drive efficiency

Efficiency Measure – Variable Frequency Drive (VFD) Installation

The electric demand of a fan operating under VFD control is calculated using the same basic expression as the expression used for Rubber Chain Drive installation (see Equation 7) with the exception that the VFD efficiency ($_{VFD}$) is included next to the drive efficiency term (η_d) in the denominator. However since both fan and VFD performance varies with speed it not possible to utilize this expression without first identifying the VFD (fan) operating speed.

Estimating VFD Operating Speed

The fan affinity laws state that with a constant impeller diameter and varying fan speed the following ratios are maintained without any change to fan efficiency.

$$\frac{Q_1}{Q_2} = \frac{n_1}{n_2} \qquad \text{(Equation 8)}$$

$$\frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^2 = \left(\frac{Q_1}{Q_2}\right)^2 \qquad \text{(Equation 9)}$$

where:

Q = Fan flow (CFM)
P = Fan total static pressure ("Wg)
n = Fan speed (RPM)

In our case we set P_2 and Q_2 equal to the system pressure (P_{OPMode}) and system flow at the specified operating point (Q_{OPMode}), respectively while P_1 and Q_1 represent the pressure and flow of the existing fan when operating at the same efficiency. Substituting and solving for P_1 yields:

$$P_1 = P_{OPMode} * \left(\frac{Q_1}{Q_{OPMode}}\right)^2 \qquad \text{(Equation 10)}$$

To calculate the intermediate flow term (Q_1) we equate the above expression to the expression representing the existing fan pressure curve (polynomial expression based on generic curve shape) and solve for the fan flow (Q_1). Having solved for Q_1 the affinity laws are used to estimate the VFD operating speed (n_{VFD}):

$$n_{VSD} = n_{Motor} * \frac{Q_{OPMode}}{Q_1} \qquad \text{(Equation 11)}$$

Note that the software checks the estimated VFD operating speed against the minimum speed entered by the user (see Table 29-8). If the estimated operating speed is less than the stated minimum:

- The calculation will be paused,
- An error window will appear indicating that "Operating Mode X requires VFD operation below the minimum allowable range."
- The software will ask if the user would like to continue the calculations using the minimum VFD operating speed.
- If yes then the calculations will proceed with the software adding a note to the reporting describing the action that was taken.
- If no, then the calculations will be aborted.

Estimating Fan Efficiency
Fan efficiency at each operating point is calculated using the same process as the baseline calculations, only in this case the intermediate flow, Q_1 is used.

Estimating VFD Efficiency
The software uses the VFD operating speed with the full load VFD efficiency (user input) to estimate VFD efficiency. The relationship between VFD speed and efficiency utilized by the software is illustrated in Figure 29-7. Once the VFD efficiency has been calculated it is then possible to calculate the electric demand of the VFD equipped fan using Equation 7.

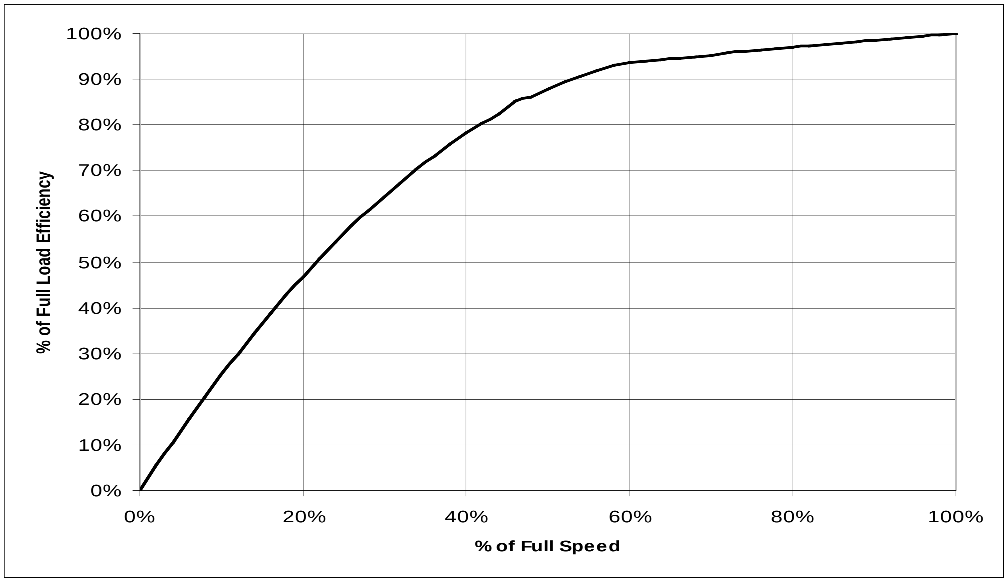

Figure 29-7. Generic Variable Frequency Drive Performance
(derived from EPRI TR-101140 Adjustable Speed Drives Application Guide)

Drive Motor Efficiency & Completion of Proposed kW Calculation
Once the fan efficiency (for either On/off control or Outlet Damper control types) is determined it is possible to estimate the electric motor load using the following expression:

$$BHP_{Motor} = K_p * \frac{Q_F * P_S * \rho_{in}}{6349.6 * \eta_F * \eta_d * \rho_{std}} \qquad \text{(Equation 12a)}$$

When an inlet vane control is indicated then the software estimates the fan BHP directly using the inlet vane performance characteristic and the electric motor load is subsequently estimated using the following expression:

$$BHP_{Motor} = \frac{BHP_F}{\eta_d} \qquad \text{(Equation 12b)}$$

Having established the drive motor load, electric motor efficiency (η_e) is calculated using existing CCT software functions (based on DOE MotorMaster). Substituting motor efficiency into the following expression yields the fan kW at this operating point.

$$kW_{FAN} = 0.7457 * \frac{BHP_{Motor}}{\eta_e} \qquad \text{(Equation 13)}$$

The proposed energy use for each operating mode is the product of the fan kW and the total annual operating hours that have been entered for the operating mode. The estimation software repeats the process of locating the fan operating point, estimating fan, drive and motor efficiency and calculating the proposed energy usage for each of the operating modes (up to eight) specified by the user. The sum of the energy use of all of the operating modes is equal to the annual energy use of the proposed fan.

Calculation of peak electric demand for the proposed equipment is accomplished in one of two ways. If only annual operating mode information has been entered then the software calculates the weighted average demand for all operating modes that the user has previously designated as having on-peak operation. This is the value reported as the average demand of the proposed system. However if daily/monthly data has been entered then the software will identify the DEER three-day peak period for the specific city/location and will only utilize information (operating hours and kWh usage) from the month or months of operating data that include this period when calculating the weighted average electric demand.

CPUC Defined Peak Demand Savings

The CCT software estimates the CPUC defined peak demand savings by calculating the average demand savings. The average demand savings is calculated by dividing the annual savings by the inputted baseline annual hours of operation. The resulting average demand savings approximates the DEER Peak demand savings because it is assumed the equipments average kW demand is typical during all operating periods. The software will confirm with the applicant the equipment operates during the defined peak period.

2.3 Customized Measures - Engineering Calculations

If you cannot find an existing program savings calculation method that adequately represents your measure you can choose to submit your own savings estimate (Engineering Calculations). The purpose of this section is to provide basic guidelines in preparing your savings estimate that will help ensure a timely and successful review by the Utility Administrator. An engineering calculation worksheet is available (see Appendix E) to assist in the documentation process.

Preparation Basics

When preparing your application assume that the reviewer, while having a technical background, *will not have direct knowledge of your specific project*. Therefore, the description(s) that you provide should contain sufficient detail to clearly understand the processes involved, the proposed savings measure, and how the measure will achieve the stated savings. To facilitate the review process, please consider the following:

- Break up your calculations and associated descriptions into smaller steps, since this will make your thought process easier to follow,
- Fully describe how you obtained any data used in the calculations (i.e., equipment load, operating hours, etc.),
- Fully describe any simulations/software used,
- Attach (and be able to electronically submit) printouts/reports summarizing both the inputs and results of simulations or other software used in preparing the calculation(s), and
- Attach any manufacturer's data, production data and/or other documentation that supports the inputs and assumptions used in your calculations or descriptions. *Note that spot measurements of load, whether in kW or amps, under realistic operating conditions are preferred over assumed loads and or use of manufacturer's design values.*

The process of preparing and documenting your savings estimate can be divided into four basic steps, which are described in detail in the following sections.

2.2.29.6 Step 1. Process / Measure Description

<u>The importance of providing a detailed description of the process and associated energy saving measure cannot be overstated</u>, since it provides the reviewer with the necessary background information to understand the calculations that follow. Your description should be divided into the following three sections:

1. Existing process/equipment (w/o measure),
2. Proposed new equipment retrofit or enhancement, and
3. Resultant equipment and/or process (post installation).

In each section include sufficient information on the process and equipment involved making it clear to the reviewer how the proposed measure will be implemented and how it will achieve the stated savings. *For instance, if energy savings will be achieved using an energy management system (EMS) that implements a new control strategy, then you provide a complete description of the EMS, the existing and proposed control strategies, and the controlled equipment.*

2.2.29.7 Step 2. Establish Baseline Annual Energy Use and Demand

Statewide Customized Offering incentives are based on equipment/improvements that go beyond standard efficiency or "baseline" equipment. "Standard efficiency" refers to equipment that meets either State/Federal efficiency requirements or current industry practice. The baseline for any given project is the standard efficiency or Title 24 requirement for an individual measure. Baseline energy use is established using accepted standards for currently available equipment. For instance, the Energy Policy Act of 1992 established Federal guidelines for electric motor efficiency (See Appendix E for a list of equipment types and applicable standards, or contact your Utility Administrator).

The simplified equation used for the baseline energy use calculation is shown below.
Baseline Energy Use (kWh or Therms/year) = (Op Hours * Equipment Load(kW or Therms/hr))$_{\mathbf{base}}$
Note that it may be necessary to develop a table of equipment loads and the annual operating hours at each load to arrive at an annual energy use estimate (see Appendix E for engineering calculation worksheet).

To obtain the baseline value, it may be necessary to adjust the energy use estimate for the existing equipment to account for “standard equipment” efficiency. For example, a customer that proposes to replace an existing 50-hp motor with a nominal full-load efficiency of 90.2% with a premium efficiency motor having an efficiency of 94.1% must establish the baseline energy using the accepted standard motor efficiency. In this case, the previously mentioned Energy Policy Act of 1992 guideline for a 50-hp motor is 93%. The baseline energy use of the existing motor must therefore be calculated based on the higher 93% efficiency value, which reduces the baseline (and associated savings) value.

The baseline energy use and demand calculations are critical to the savings calculations, so it is important that your calculations and associated descriptions provide sufficient information on the process, equipment and applicable standards to justify the proposed baseline energy use and demand.

2.2.29.8 Step 3. Establish Post-Installation Annual Energy Use and Demand

The simplified equation used for the post-installation energy use calculation is essentially the same as for the baseline calculation.

Post Install Energy Use (kWh or Therms/year) = (Op Hours * Equip Load (kW or Therms/hr))$_{\mathbf{post}}$
Note that it may be necessary to develop a table of equipment loads and the annual operating hours at each load to arrive at an annual energy use estimate (see engineering calculation worksheet, Appendix E).

While the baseline energy use calculation is based on “standard efficiency” equipment, the post-installation calculation is based on the projected performance of the new equipment or process. Use of simulation software such as Engage, eQUEST, or another DOE2 based software package is acceptable as long as the inputs and associated assumptions (if any) are clearly stated and can be verified. Use of a manufacturer-specific simulation product can be acceptable but will require additional information on the underlying principles used by the software. Again, it is important that your description provide sufficient detail so that the reviewer will understand the basis for your projection. It is important to note that the reviewer has the option of substituting an alternative method of estimating the post-installation energy use and/or may require monitoring to confirm the estimate.

2.2.29.9 Step 4. Calculate Energy Saving, Demand Savings, and Incentive Amount

Once the baseline and post-installation annual energy use and demand estimates are completed then the savings estimate is simply the difference between the annual baseline and post installation use and demand estimates.

Savings (kWh/year) = Baseline Energy Use - Post-Installation Energy Use

The peak demand savings (kW) are based on the DEER Peak Definition (see section 1.4.8). The total incentive amount is then calculated by multiplying the savings estimate by the appropriate program incentive multiplier (see Section 1, Table 1-3).

Incentive ($) = program Incentive Multiplier ($/(kWh or Therms)) * Savings (kWh or Therms/year)

Note that the calculated incentive is limited to 50% of the installed measure cost or incremental cost depending on the project type.
– see Section 1.8.2.

2.4 Measurement & Verification (M&V) Process

The M&V process begins after the Utility Administrator reviews the submitted application **and has determined at its sole discretion that an M&V process is appropriate for the proposed project.**

The M&V process proceeds as follows:

1. **M&V Requirement Notification.** The Utility Administrator contacts the Project Sponsor and notifies them of the M&V requirement. The Utility Administrator sends the Project Sponsor the Measurement & Verification Guidelines.

2. **M&V Plan Development.** The Project Sponsor develops an M&V plan based on the M&V Guidelines. The Project Sponsor submits the M&V plan, and any required baseline data to the Utility Administrator.

3. **Application and M&V Plan Approval.** If the application and the M&V plan are approved, incentive funding for the project is reserved and the Project Sponsor and Utility Administrator initiate the application approval review.

4. **Project Installation.** For SDG&E and SCE service territories, the Project Sponsor submits a signed Installation Report and invoices after all project measure(s) have been **installed and are fully commissioned and fully operational**. For PG&E service territory, the Project Sponsor notifies the Utility Administrator in writing and submits invoices after all project measure(s) have been **installed and are fully commissioned and fully operational**.

5. **Installation Review.** Upon receipt of Installation Report (SCE and SDG&E), or Installation notification (PG&E), the Reviewer will evaluate the submittal package and conduct a post-installation inspection to verify project installation and ensure the scope of work has not altered from the agreed-upon project.

6. **First Payment.** For SDG&E service territory, the designated Payee receives 60 percent of the Installation Report approved incentive along with an M&V adder, upon approval of the Installation Report.

For SCE and PG&E service territories, the designated payee receives the 10% M&V adder, to defray the M&V cost, upon approval of the Installation Review. The M&V adder is10% of the IR approved incentive amount, not to exceed $50,000.

7. **Project Performance Period.** The Applicant performs the agreed-upon M&V activities on the new operating equipment for a period up to two years (at discretion of Utility Administrator). At the end of the project performance period, the Project Sponsor submits the Operating Report.

8. **Operating Report**. The Applicant submits the Operating Report and operating data to the Utility Administrator. Upon receipt, the Utility Administrator reviews the report and data.

9. **Final Payment**. For SDG&E service territory, the designated Payee receives the remaining balance of the incentive based on the measured savings upon approval of the Operating Report.

For SCE and PG&E service territories, 100% of the incentive is paid at the end of the project performance period when the Operating Report is approved.
The energy savings incentive is based on actual performance as indicated by the M&V results.