

NRR-DR

Section 3: Estimating Energy Savings and Incentives

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3.1 Estimating Energy Savings and Incentives

This section of the *2006 NRR-DR Procedures Manual* describes the approach used to estimate the expected energy savings and incentives from your proposed energy efficiency measures.

Calculated Measures – You may calculate any measure using the Calculated (SPC) Measure Approach. Under this approach you will need to estimate the kWh savings achieved as a result of your high efficiency upgrade. This can be done using either the estimation software or using engineering calculations.

- **Estimating software.** Included on the NRR-DR program CD-ROM, 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 3.2). 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.

3.2 Calculated Measures - Estimation Software

The NRR-DR program facilitates participation by providing 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 makes use of detailed input from your facility, and thus gives a good approximation of the energy savings. Typically the required inputs are readily available; however in some cases spot measurements may be necessary.

The estimating tools can be accessed either by using the 2006 NRR-DR program software to complete the Project Application or by using the Energy Savings Calculator feature of the software. (The calculator allows you to fill out the Project Application forms by hand, yet calculate the savings using the program estimating tools.)

Estimation software tools have been provided for the most popular energy efficiency measures, listed below:

- Lighting replacement
- Lighting controls
- Early Retirement of A/C and other A/C replacement units (Packaged units & heat pumps > 760,000 Btu/hr or 63.3 tons) *
- Cool roofs
- A/C economizers
- Variable-speed drives for centrifugal chillers
- Variable-speed drives for cooling tower fans
- Variable-speed drives for HVAC fans
- Demand control ventilation (DCV)
- Carbon monoxide sensors for parking garages
- Variable-speed drives for process applications
- Early Retirement of Motors and other Motor efficiency upgrades
- Air compressors system upgrades
- Professional wet cleaning
- Injection molders
- Pulse cooling for injection molders
- Rapid close doors
- Refrigerated tank insulation
- Dairy vacuum pumps variable speed drives
- Tape drip irrigation (refers to thin-walled hoses ranging from 4 to 20 millimeters)
- Pump off controllers for oil wells
- Wastewater retro-commissioning
- Natural gas boiler measures
- Thermal oxidizer upgrades

*This measure may be covered by the Distributor Incentive program and if so are not eligible for the program, except for those measures that qualify as an Early Retirement measure. Distributor Incentive Program includes all packaged air conditioners and heat pumps up to 760,000 Btu per hour (63.3 tons). Please refer to Table 3-1 or Appendix F for more information.

Each of these tools collects 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.

Specific considerations for each of these tools are discussed below.

3.2.1 Lighting

The Lighting Estimating Software 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.

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. Eligible number of removed lamps cannot exceed 50% of the total number of installed lamps. 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.

3.2.1.1 User Inputs

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

Measure Information

- **Line Item** – Select a unique line item number for each lighting retrofit, consisting of identical equipment, within the same usage group.
- **Usage Group** – 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** – Enter a short description of the area of the proposed fixture retrofit (e.g. Warehouse, Building 123, Conference Room, etc.)

Equipment Specifications (Existing/Proposed)

- **Line Item** – Select the appropriate line item number for each lighting retrofit.
- **Num Fixtures** – Enter the number of proposed/existing fixtures.
- **Hours of Operation** – Enter the number of annual hours the existing fixtures operate. The proposed fixture operating hours are the same as the existing hours and can not be modified.
- **Fixture Type** – 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 or the Itemized (Express Efficiency) Measures Table 3.1 above. Measures identified on the Itemized (Express Efficiency) Measure table are not eligible for the Calculated Approach.
- **Lamp Type** – Select the lamp type (i.e. T12 Fluorescent, HPS, Incandescent, etc.)
- **Tube Length** – For tube fixtures select the tube length in inches. For non-tube fixtures select N/A.
- **Ballast Type** – Select the ballast type for fixtures equipped with ballasts (i.e. Magnetic, Electronic, etc.). Select N/A for non-ballast fixtures.
- **Lamps/Fixture** – Select the number of lamps per fixture.
- **Watts/Lamps** – Select the nominal watts per lamp.

3.2.2 Lighting Controls

The Lighting Controls savings estimation tool covers 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 must use the Engineering Calculations approach.

Lighting Controls line items are grouped by lighting equipment type and space type. Individual controls that regulate different light types or have different usage patterns should be grouped separately.

The Lighting Controls estimating software calculates the energy savings as the difference between the energy usage of the lighting equipment in an uncontrolled (pre-installation) and a controlled (post-installation) state. The energy demand of the lighting equipment is calculated from information entered by the user. Information such as, lamp and ballast specifications, are selected from pull-down lists.

For EMS and timeclock type measures, the user enters previous operating hours (pre-installation) and new operating hours (post-installation). These hours 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.

For occupancy sensor type measures, the user enters previous operating hours (pre-installation) and a space type. The software estimates the amount of savings (time the lights will be de-energized by the occupancy sensor) based on the space type and applies it to the baseline (pre-installation) hours. The energy savings (kWh) are calculated as the product of the lighting energy demand (kW) and the reduction in on-time (hours). The following table lists the allowable reduction in operating time based on space type.

Table 3-2. 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 | | |
| Hospital Room | 45 | Public Assembly | 35 | | |

3.2.2.1 User Inputs

User inputs can be divided into two basic categories - measure information and equipment specifications.

Measure Information

- **Line Item** – Select a unique line item number for each lighting control retrofit, consisting of identical equipment within the same usage group.
- **Control Type** – The control technologies eligible for the 2006 NRR-DR program using the Estimating Software are 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** – 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** – Enter a short description of the area covered by the lighting controls (e.g. Warehouse, Building 123, Conference Room, etc).

Equipment Specifications

- **Line Item** – Select the appropriate line item number for each lighting retrofit.
- **Num Fixtures** – Enter the number of proposed/existing fixtures.
- **Previous Op Hours** – Enter the number of annual hours the fixtures operate prior to the installation of lighting controls.
- **New Op Hours** - Enter the number of annual hours the fixtures operate after the installation of lighting controls. Automatically calculated for occupancy sensor measures.
- **Fixture Type** – 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** – Select the lamp type (i.e. T12 Fluorescent, HPS, Incandescent, etc).
- **Tube Length** – For tube fixtures select the tube length in inches. For non-tube fixtures select N/A.
- **Ballast Type** – Select the ballast type for fixtures equipped with ballasts (i.e. Magnetic, Electronic, etc.). Select N/A for non-ballast fixtures.

- **Lamps/Fixture** – Select the number of bulbs per fixture.
- **Watts/Lamps** – Select the nominal watts per bulb.

3.2.3 Packaged Air Conditioner & Chiller Replacements or Early Retirement

This tool is for the direct replacement or early retirement of chillers or packaged air conditioners that are not included in the Distributor Incentive Program (Statewide Upstream Motors and HVAC program). The Distributor Incentive Program includes all packaged units, split systems and heat pumps whose capacities are less than or equal to 760,000 BTU/hr (63.3 tons). This tool can also be used for packaged air conditioners that qualify for Early Retirement, even if they are in the Distributor Incentive program.

If the unit qualifies for early retirement, the energy savings are calculated using the baseline efficiencies of the actual equipment rather than the current minimum standards. This results in a larger incentive than would be possible using the traditional Calculated Approach.

A package unit is defined as an electric cooling unit with its compressor, condenser, and supply fan in a single container. Split systems and built-up systems are not included in this tool. Both air- and water-cooled package units and chillers are included. Heat pumps are also covered by this tool but only where a heat pump replaces an existing heat pump (no fuel switching). Heat pump savings are only calculated for the cooling savings. 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 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 administrator has the final decision on whether a piece of equipment qualifies as refurbished. To establish the overhaul and its date, supporting invoices are required.

The 2006 software calculates savings using the DOE2 hourly energy simulation method. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

For cooling and heating units not covered by this estimating tool, you will have to use the Engineering Calculations approach to determine the energy savings.

Take special note of the following:

- **Year Built** – Enter the year that the existing equipment was built.
- **Overhauled** – Select “yes” if the existing unit has been overhauled (as described above).
- **Year Overhauled** – If the unit has been overhauled please enter the year in which it occurred.
- **Variable-Speed Drive on chiller** - Select “yes” if the new chiller is a centrifugal chiller fitted with a variable-speed drive control on the compressor.
- **Modulating vs. On/Off** - It is important to select whether the proposed cooling unit is a modulating type (e.g., chiller) or one that uses on/off control (e.g., package unit).

- **Multiple Units** - Multiple cooling units may be entered together as long as they meet the following conditions:
 - The cooling units must be identical in capacity (tons), system type, and efficiency (different models numbers are OK).
 - The area served by multiple units must be similar (e.g., 5–10 ton units serving an interior zone or 3–5 ton units serving a 6000-ft² building). The operating hours must be identical.
- **Building Type** - Select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D for detailed descriptions) or define a new building type using the custom building type option. If one of the predefined building types is a fair representation of your project site, you can simply input the building location, square footage of conditioned space, and building operating hours.

If you choose the custom building option the software will instruct you on how to initiate the Engage software. The Engage software is a stand-alone, DOE2 based modeling program.

- **Building Location** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (The program uses the California Energy Commission’s CTZ weather data, which breaks up the state into 17 weather zones.)
- **Savings Estimate** - The estimated savings are reported on the third screen of this tool.

3.2.4 Cool Roofs

The installation of a Cool Roof on an existing building is eligible for program incentives. The Cool Roof can be installed on an existing roof or installed as part of a renovation project involving the roof (Cool Roofs installed as part of a new construction project are not eligible as they are required by Title 24 energy code).

Roof must be flat or “low-slope” where rise is not greater than 2 inches of run in 12 inches of fall. Building must have electrically or natural gas engine-driven compression cycle or gas-fueled absorption and must not have a radiant barrier between the ceiling and the surface of the roof. Material must be applied over air-conditioned space only. Exposed HVAC ducting is eligible for Cool Roof application. Eligible products must have a minimum five-year manufacturer's warranty.

To estimate the energy savings obtained from the installation of a Cool Roof, the Program Administrators have developed an estimating tool that is based on the Department of Energy’s “COOL ROOF CALCULATOR”.

Data inputs for existing and proposed roofs include:

- **City** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (The program uses the California Energy Commission’s CTZ weather data, which breaks up the state into 17 weather zones.)
- **R-Value** - Enter the total R-Value of the roof (including insulation, roofing material, dropped ceiling, and plenum space). R-Value is a rating based on a materials ability to resist heat flow. R-Values of typical roof insulations are listed by selecting the “Typical R-Value” button.
- **Solar Reflectance, SR (%)** - Enter the Solar Reflectance of the existing roofing material and of the proposed cool roof material. Solar Reflectance is the ratio of reflected solar radiation to the total radiation that falls on the surface (incident solar radiation). Values

range from 0 for perfect absorbers to 100% for perfect reflectors. Solar Reflectance values of typical roof surfaces are listed by selecting the “Typical SR” button.

- **Infrared Emittance, IE (%)** - Enter the Infrared Emittance of the existing roofing material and of the proposed cool roof material. Infrared Emittance is a measure of a warm or hot materials ability to shed infrared heat. Values range from 0% to 100%. Infrared Emittance values of typical roof surfaces are listed by selecting the “Typical IE” button.
- **Air Conditioning Efficiency** - Enter the Engineering Units (kW/Ton, COP, SEER, or EER) and the efficiency value for the existing air conditioning system. Air Conditioner Efficiency is the measure of energy in (kW) divided by energy out (cooling).
- **Heating System Efficiency** - Enter the heating system source (fuel or electricity). If the source is electric then the estimation software assumes an efficiency of 100%. If the Heating is fuel then the user must enter the Seasonal Heating Efficiency also known as the AFUE (Annual Fuel Utilization Efficiency). AFUE is a measure of the percentage of heat from the combustion of 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 paragraph 112. AFUE takes into consideration the additional energy required for the warm up periods during cycled operation.
- **Roof Area (sqft)** - Enter the roofing area in square footage. Include only areas that cover conditioned space.

3.2.5 A/C Economizers

This tool calculates savings for:

1. The addition of an economy cycle on existing HVAC equipment.
2. For the addition of damper actuators and controls to automate manually operated economizers.

The repair or replacement of a non-operating economy cycle is not eligible for an incentive. Take special note of the following:

- **Economy cycle** - Choose whether the compressor runs with the economizer or does not run with the economizer. Note that a dry-bulb controller is assumed to control both types of economy cycles; there are no provisions for an enthalpy controller.
- **Multiple Units** - Multiple existing cooling units/air-handling units may have economy cycles added. These multiple units may be grouped and entered together as long as they meet the following conditions:
 - The cooling units must be identical in every respect except for size (different model numbers are OK). For example, the efficiencies and system type must be the same.
 - The area served by multiple units must be similar (e.g., 5–10 ton units serving an interior zone or 3–5 ton units serving a 6000-ft² building). The operating hours must be identical.
- **Building Type** - Select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D for detailed descriptions) or define a new building type using the custom building type option. If one of the predefined building types is a fair representation of your project site, you can simply input the building location, square footage of conditioned space (served by the A/C units that economizers are being added), and building operating hours. Note that if you select a predefined building, you accept its predefined cutoff limits for the economy cycle. If these limits are not acceptable, use the custom building approach.

If you choose the custom building option the software will instruct you on how to

initiate the Engage software. The Engage software is a stand-alone, DOE2 based modeling program.

- **Building Location** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (This program uses the California Energy Commission's CTZ weather data, which breaks up the state into 17 weather zones.)

3.2.6 Variable-Speed Drives for Cooling Tower Fan Motors

This tool is utilized to estimate savings achieved from the installation of variable speed drives on cooling tower fan motors. The baseline cooling tower has either a one-speed or two-speed fan, which cycles on/off to satisfy the wetbulb setpoint. The proposed cooling tower has a variable speed drive fan, in which the fan speed continuously modulates to accurately achieve the wetbulb setpoint. The variable-speed fan energy consumption is calculated utilizing cooling tower load curves and the fan laws.

The 2006 software calculates savings using the DOE2 hourly energy simulation method. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

For cooling and heating units not covered by this estimating tool, you will have to use the Engineering Calculations approach to determine the energy savings.

This tool has two input screens; one screen entails the chiller/compressor specifications, while the other screen involves the cooling tower specifications. The following inputs should be noted:

Chiller specification inputs

- **Variable-Speed Drive on chiller** - Select "yes" if the new chiller is a centrifugal chiller fitted with a variable-speed drive control on the compressor.
- **Multiple Units** - Multiple cooling units may be entered together as long as they meet the following conditions:
 - The cooling units must be identical in capacity (tons), system type, and efficiency (different model numbers are OK).
 - The area served by multiple units must be similar (e.g., 5–10 ton units serving an interior zone or 3–5 ton units serving a 6000-ft² building). The operating hours must be identical.
- **Building Type** - Select a "predefined" building configuration from the list of "prototypical" buildings (see Appendix D for detailed descriptions) or define a new building type using the custom building type option. If one of the predefined building types is a fair representation of your project site, you can simply input the building location, square footage of conditioned space, and building operating hours.

If you choose the custom building option the software will instruct you on how to initiate the Engage software. The Engage software is a stand-alone, DOE2 based modeling program.

- **Building Location** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (The program uses the California Energy Commission's CTZ weather data, which breaks up the state into 17 weather zones.)

Cooling tower specification inputs:

- **Existing Cooling Tower Fan speed** - Select “one-speed” or “two-speed” cooling tower fan.

3.2.7 Variable-Speed Drives for Centrifugal Chillers

This tool addresses variable speed drive (VSD) retrofits for chillers. A number of chiller manufacturers currently offer VSDs for integration with the compressors of existing constant speed chillers. The only chiller type inherently suitable for this type of retrofit is a centrifugal chiller.

The efficiency (expressed in kW/ton or COP) for a constant speed chiller when operating at part-load conditions is typically less than its full-load efficiency. Conversely, a chiller with a VSD retrofit will perform at higher efficiency levels than its full-load efficiency at a majority of part-load conditions. Typically, chillers operate at part-load conditions for the vast majority of operating hours, while rarely operating at full-load, if at all. Therefore, the installation of a chiller VSD can achieve significant energy savings over the course of a year.

The 2006 software calculates savings using the DOE2 hourly energy simulation method. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

When inputting data in the software tool, take special note of the following:

- **Multiple Units** - Multiple cooling units may be entered together as long as they meet the following conditions:
 - The chillers must be identical in capacity (tons) and efficiency (different models numbers are OK).
 - The area served by the chillers must be similar (e.g. all chillers serving the same building or same interior zone). The operating hours must be identical.
- **Full Load Efficiency of Chiller** - Applicant shall provide the full-load efficiency of the chiller, and not an alternative efficiency rating method such as the IPLV or APLV.
- **Building Type** - Select a “predefined” building configuration from the list of “prototypical” buildings (see Appendix D for detailed descriptions) or define a new building type using the custom building type option. If one of the predefined building types is a fair representation of your project site, you can simply input the building location, square footage of conditioned space, and building operating hours.

If you choose the custom building option the software will instruct you on how to initiate the Engage software. The Engage software is a stand-alone, DOE2 based modeling program.

- **Building Location** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (The program uses the California Energy Commission's CTZ weather data, which breaks up the state into 17 weather zones.)
- **Savings Estimate** - The estimated savings are reported on the third screen of this tool.

3.2.8 Variable-Speed Drives for HVAC Fans with Motors

This tool addresses variable-speed drives (VSDs) on HVAC supply-air fans. A number of assumptions (stipulations) were made in order to simplify the savings calculations for this common measure:

- The fan is assumed to be on continuously during the building's operating hours. The tool does not cover intermittent fan operation.
- Fan speed is assumed to follow the cooling load but is not allowed to drop below 25% of rated speed. During heating, the fan speed is assumed to always be 100%.
- No cooling or heating, and therefore no fan operation, is allowed during the unoccupied period.

The 2006 software calculates savings using the DOE2 hourly energy simulation method. If you believe the simulation does not fairly represent the project's savings, use the engineering calculations approach to estimate the energy savings.

Take special note of the following:

- **Multiple Units** - Multiple supply fans may be combined under a single measure if the value entered represents the sum of all supply-air fans with their associated new VSDs. Note that only one drive manufacturer may be entered per measure and the model of the drives (when multiple drives are involved) must be of similar type and applied to fan motors with identical motor efficiency. If capacity is combined, an explanation of fans and motors involved should be included with the backup materials.
- **Building Type** - Select a "predefined" building configuration from the list of "prototypical" buildings (see Appendix F for detailed descriptions) or define a new building type using the "custom building type" option. If one of the predefined building types is a fair representation of your project site, you can simply input the building location, square footage of conditioned space, and building operating hours.

If you choose the custom building option the software will instruct you on how to initiate the Engage software. The Engage software is a stand-alone, DOE2 based modeling program.

Note that the custom building option must be used if a VSD-modified supply-air fan is used to cool/heat only a portion of a building.

- **Building Location** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (This program uses the California Energy Commission's CTZ weather data, which breaks up the state into 17 weather zones.)

3.2.9 Demand Control Ventilation (DCV)

3.2.9.1 Background

Outside air is typically introduced at a fixed rate, into buildings for the peak design occupancy level. Occupancy levels vary significantly during a buildings operating hours. Demand Control Ventilation (DCV) varies the amount of outside air introduced into 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 CO₂ sensors and a prescribed CO₂ concentration set point for the space, the amount of outside air can be varied. This is the basis of DCV, the amount of outside air introduced is based on the “demand” for it. 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.

3.2.9.2 Energy Savings Calculations

The tool developed for the 2006 program is based on Honeywell’s “Savings Estimator”. This program is also the basis for the California Energy Commissions VSAT (Ventilation Strategy Assessment Tool), which was used for the CEC’s ventilation assessment program. The Savings Estimator is an hourly program that evaluates the energy impact of DCV.

This 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 Labs (LBL). 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.

Data inputs for the Demand Control Ventilation action include:

- **Manufacturer of DCV Controls** - Enter the name of the manufacturer of the DCV controls.
- **Model Number of DCV Controls** - Enter Model Number of DCV Controls.
- **City** - From the pull-down menu, select a city that best represents the building location; this will, in turn, automatically select a weather zone. (The program uses the California Energy Commission’s CTZ weather data, which breaks up the state into 17 weather zones.)
- **Economy Cycle** - Specify if an economy cycle is present in the rooftop equipment.
- **Equipment Efficiency** - Select Low (EER=8), Medium (EER=10) or High (EER=12) equipment efficiency for the rooftop package units.
- **Building Type** - From the pull down menu, select one of the 4 building types offered.
- **Building Area** - Enter the area in square footage of the building space that will have DCV. This could be several class rooms in a school, a portion of an office building or the dining area in a restaurant. This tool is primarily for smaller buildings. The accuracy is degraded when the area is larger than:

Restaurant – 21,000 ft²
 Retail – 300,000 ft²
 School – 38,000 ft²
 Small Office – 25,000 ft².

Savings Estimate. The savings estimate and incentive is provided on screen two of this tool.

3.2.10 Carbon Monoxide Sensors for Parking Garages

This tool provides 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.

This tool is appropriate for all building types with enclosed parking structures.

Data inputs for CO mitigation for parking structures include:

- **Manufacturer of CO Controls/Sensors** - Enter the name of the manufacturer of the CO Controls/Sensors.
- **Model Number of CO Controls/Sensors** - Enter model number of CO Sensors.
- **Number of CO Sensors in Parking Structure** - Enter the number of CO Sensors in Parking Structure.
- **Total Exhaust Fan Motor(s) HP** - Enter the summation of HP for all exhaust fans.
- **Average Exhaust Fan Motor Efficiency** - Enter the motor efficiency if there is only one exhaust fan. If there is more than one exhaust fan, calculate an average motor efficiency.
- **Annual Operating Hours before CO Controls** - Provide the annual operating hours of the exhaust fans before the installation of the CO Sensors.
- **Savings Estimate** - The savings estimate and incentive is provided on screen two of this tool.

3.2.11 Variable-Speed Drives for Process Applications

This tool covers the installation of variable-speed drives (VSDs) for process applications. It includes direct drives (mixers and agitators), pumps, and fans. The pumps can be either positive displacement models that previously used bypass for control or centrifugal pumps with throttle valves. The existing controls for fans can be inlet guide vanes, outlet dampers, or no controls.

Data inputs for existing and proposed motors include:

- **General data** - such as the quantity, location (e.g., 2nd floor) and function (e.g., drive for conveyor belt).
- **Nameplate data** - If the measure includes more than one motor, then all the motors must be of equal size and have equal nameplate ratings. Copies of manufacturer's specifications that support the proposed motor/drive nameplate values must be submitted to the Utility Administrator with the Project Application.
- **Operational hours** - i.e., the hours that each motor is actually running. If two or more motors being replaced have unequal hours of operation, then these should be treated separately.
- **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. If the power factor is not measured, the software will estimate a power factor. Ensure that all voltages are measured line-to-line with measurements taken under normal full-load motor operating conditions.

3.2.12 High-Efficiency Motors Replacement or Early Retirement

This tool covers early retirement of continuous-rated, polyphase squirrel cage induction motors rated from 1 to 500 horsepower. These motors include NEMA Design A and B, three-phase, 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. This tool can also be used for motors that qualify for Early Retirement. If it does qualify for early retirement, the energy savings are calculated using the baseline efficiencies of the actual equipment rather than the current minimum standards. This results in a larger incentive than would be possible using the traditional Calculated Approach. To establish the rewinding of a motor and when it was performed, supporting invoices are required.

This tool establishes the existing motor (baseline) efficiency to correspond to the 1992 Energy Policy Act (EPA) minimum, except in the case of Early Retirement, which uses the industry standards at the time the motor was installed.

Data inputs for existing and proposed motors include:

- **Year Manufactured** – Enter the year that the existing motor was manufactured.
- **Rewound** – Select “yes” if the existing motor has been rewound
- **Year Rewound** – If the motor has been rewound please enter the year in which it occurred.
- **General data** - Includes information such as the location (e.g., basement) and function of existing/replacement motors.
- **Nameplate data** - A comprehensive list of manufacturer’s data is provided via pull-down menus. Copies of manufacturer’s specifications that support the proposed motor nameplate values entered into the software must be submitted to the Utility Administrator with the Project Application.
- **Load type** - (e.g., fan, pump, mill, etc.).
- **Estimated hours of operation** - Operating hours under normal load conditions.
- **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.

For multiple motors with different horsepower, treat each motor size as a separate measure.

3.2.13 Compressed Air System Upgrades

This tool includes a variety of compressed air system measures. These include:

- Direct replacement of one or more compressors with compressor(s) of higher efficiency, including compressors equipped with variable speed drives,
- Installation of new compressor motors to service increased production capacity,
- Installation or upgrade of system storage, and
- Installation of intermediate pressure/flow control valves.

3.2.13.1 Compressor and Control Types

The software accommodates up to 3 compressors of varying types and sizes. The compressor types and associated controls that will be accepted will continue to correspond to the types accepted by the AirMaster+ software (see Table 3-3). The only exception is that variable speed drive controls have been added to the rotary screw compressor types.

Table 3-3. Equipment Included in Air Compressor Estimation Software

| Compressor Types | Control Types | Size (hp) | Pressure (psig) |
|--|--|-----------|-----------------|
| Single-stage lubricant-injected rotary screw | Inlet modulation w/o unloading Inlet modulation w/unloading Load/unload Variable displ. 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 displ. w/unloading Variable speed drive | 100–500 | 100–200 |
| Two-stage lubricant-free rotary screw | Load/unload Variable speed drive | 50–500 | 80–150 |
| Single-stage reciprocating | Load/unload | 25–75 | 80–125 |
| Two-stage reciprocating | Load/unload | 25–400 | 80–125 |

3.2.13.2 Baseline Compressor Loading

The project sponsor must enter an individual hourly load profile for each compressor, for up to 4 types of system operation (“day-types”). A load profile in either kW or acfm will be accommodated. Values entered in acfm are summed to arrive at the system usage profile and will also be converted into an equivalent kW demand for each compressor, using a generic “performance map” for each type of compressor. The project sponsor must identify day-types as having weekday operation (or not) so that the software can estimate the peak demand savings. Inputs for the estimated days per week and weeks per year are required for each day-type so that the software can estimate the annual energy usage.

The software will continue to use the AirMaster+ specific power consumption as the minimum compressor efficiency. Thus the software will correct the baseline power if the baseline compressor(s) does not meet the minimum specific power consumption requirement.

3.2.13.3 Efficiency Measure – Multiple Compressor Replacement or Upgrade

The tool will accommodate replacement or upgrade of multiple compressors. To accomplish this, the software must be able to reasonably estimate how the system flow will be distributed amongst the various compressors for each hour of the day and for each day-type. To simplify the analysis the project sponsor must:

- Specify each compressor as a Lead/Baseload, Additional Baseload or a Variable/Trim machine. Since a site is permitted up to three compressors, two may be designated as baseload and one as variable/trim. The software will automatically designate the compressor as variable/trim if “1” compressor is selected on the initial site set up screen.
- Keep the compressor designations fixed for all day-types and all hours of operation (i.e., the compressors must always be sequenced in the same fashion). Note that baseline designations may differ from proposed that in both cases they must be fixed across all day types.

The software checks that new compressors meet the AirMaster+ specific power consumption requirement and will flag compressors that do not comply. The software also checks for the presence of automatic shut-off timers and/or sequencing controls (user inputs) that permit compressors to be turned off if fully unloaded. If these devices/controls are not present, then the software assumes that the compressor will operate at the fully unloaded operating point during any hour when a system flow is required (even if this flow is supplied by another compressor).

Note that the software assumes that each compressor operates at the same pressure (nominal supply pressure) even though each compressor will operate at a slightly different pressure during actual operation. The user inputs for cut-in and cut-out pressure are used solely to estimate compressor cycle time (in conjunction with system storage) for compressors equipped with unloading type controls.

Compressors equipped with variable speed drives are modeled using a straight-line approximation similar to a reciprocating compressor with on/off control except an additional 5% is added to the input kW to account for VSD drive inefficiency. The software will not allow VSD operation below 20% of rated capacity but will instead unload other compressor(s) to achieve the minimum flow.

3.2.13.4 Efficiency Measure – Intermediate Flow/Pressure Controllers

The software calculates savings associated with reduced compressor(s) power demand when supplying less overall airflow (due to a system pressure reduction) downstream of the flow/pressure controller. The user must input both the upstream (nominal supply pressure) and downstream pressure (nominal system operating pressure or end use pressure) that will be used with the new controller. The software uses these values to estimate the change in system airflow associated with leakage or other unregulated end uses (without individual pressure regulators). This reduced system airflow is used along with the upstream pressure to estimate the change in compressor energy use. Only unregulated end uses will be reduced and it is for this reason that the project sponsor must enter the estimated leakage rate (default of 5%) and the percentage of total system airflow represented by other unregulated end uses (default is 0%). Since storage located downstream of the controller will not have the same impact on compressor operation as storage located upstream of the controller the user must input the amount (%) of the existing system volume that is located upstream and downstream of the controller. These percentages are exclusive of any new storage, which is handled by inputs for the Storage System Upgrade measure.

3.2.13.5 Efficiency Measure – Storage System Upgrade

The program software estimates savings associated with increased storage capacity. However, appreciable savings are only possible if the increased capacity permits one or more of the compressors to be turned off (cycle time exceeds auto shut down timer setting) that would otherwise operate at no load. Thus savings may not be indicated with certain types of compressors and controls. It is also important to note that storage location must be considered when an intermediate flow/pressure controller is involved. The project sponsor is therefore required to identify the amount of the new storage that will be located upstream and downstream of the intermediate flow/pressure controller (if the intermediate flow controller measure is also selected).

3.2.13.6 User Inputs

User inputs can be divided into four basic categories compressed air system, compressor description, usage/load profile and EEM selections.

- **Compressed air system** - Inputs include site location, number of compressors, nominal system (end use pressure) and compressor operating pressures (nominal supply pressure), and system volumes (total system and receivers).
- **Compressor inputs (for each compressor)** - Include nameplate data, operating mode (lead, variable/trim, etc.), control method and settings, and drive motor nameplate data (compressor and air-cooler).
- **Usage profile/load data inputs** - Include number and type of day-types, profile data type, days per week and weeks per year of operation for each day-type, and hourly air flow or kW demand data for each compressor.
- **EEM Inputs for compressor replacement / upgrade** - Inputs allow the project sponsor to identify which compressors will be upgraded, replaced or eliminated as well as changes to the operating mode. Changes specific to new compressors are subsequently entered via the compressor input screen(s).
- **EEM Inputs for intermediate flow/pressure controller** - Include pressure settings (upstream and downstream), storage volumes (% of existing volume) upstream and downstream of the controller, leakage air flow and other unregulated air flow (% of total flow).
- **EEM Inputs for storage upgrade** - Include total additional storage volume and location relative to compressor(s) and end uses (if an intermediate flow controller is also specified).

3.2.14 Professional Wet Cleaning Replacement

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 professional wet cleaning, not CO₂, Hydrocarbon, or Green Earth systems. This measure reduces the energy usage of cleaning facilities, while reducing containments to the air. This measure may qualify for additional incentives through your local air quality management district. 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.

Data inputs for existing and proposed motors include

- **Average monthly electrical usage (kWh)** - Electric usage for the past 12 months. This can be determined for your monthly electric bills from the past twelve months or by contacting your Electric Utility Service Representative. Facilities with a monthly average energy use of more than 4,000 kWh are not covered under this estimating tool.

- **Average monthly electrical demand (kW)** - Electric usage for the past 12 months. This can be determined for your monthly electric bills from the past twelve months or by contacting your Electric Utility Service Representative.
- **Year of Manufacturer** - Year that the existing equipment was manufactured.

The calculation model provides the following output:

- **Estimated annual energy savings (kWh)**
- **Estimated demand reduction (kW)**
- **Incentive amount**

3.2.15 High-Efficiency Injection Molders

High-efficiency injection molders use variable-speed drives (VSDs) and other energy efficiency techniques to reduce the energy usage of plastic injection molders. Standard-efficiency injection molders use a large hydraulic pump to inject the plastic and operate the molds. The pumps operate at full power continuously, bypassing the fluid when the pressure is not required. The VSD varies the speed of the motor to match the power requirements of the molders, cycling up and down the motor speed.

A second approach uses variable volumes to achieve similar energy savings. Recently, a new type of machine has been introduced that does not use a hydraulic system to generate the pressure to inject the plastic, but instead generates the force with high-torque servomotors. Besides the drive system, other components of the machine such as the heaters have been improved. These machines are referred to as all-electric injection molders. They save significantly more energy than the variable-volume/variable-speed machines. All three types of machines are accepted as efficiency measures and are included in the estimation software.

3.2.15.1 Data Inputs

Copies of manufacturer's specifications that support the proposed nameplate values must be supplied to the Utility Administrator with the Project Application.

Data inputs include:

- **Model/serial number**
- **Machine type**
- **Capacity (tons)**
- **Hourly production rate**
- **Annual operating hours** - The annual hours must be the best estimate of the actual hours the machine is producing parts.

3.2.15.2 Basis for Energy Savings

The energy savings estimating tool for high efficiency injection molders uses equations that are based on energy use per pound of plastic produced. These parameters are based on measured performance data, which take into account variations in part size, production rates, and cycle time. Although individual machines may vary from these results, the predicted energy savings can be used for high-efficiency injection molders that produce at least 0.275 pounds of plastic per ton of capacity. For machines with lower production rates, the energy savings are reduced by 20%. These low-production machines typically produce small, intricate parts requiring longer hold times, thus reducing the energy savings. The average specific energy use for the four types of injection molders is listed in Table 3-4.

Table 3-4. Specific Energy Use of Different Injection Molders

| 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 |

The energy savings of the injection molder are based on the proposed production rates. The energy savings resulting from increased production are eligible in the 2006 program.

The Project Sponsor is required to document the existing and proposed average production rates (lb/hr) of the injection machines. These rates shall take into account variation in parts produced.

3.2.16 Pulse Cooling for Injection Molders

This tool is utilized to estimate savings achieved from the installation of pulse cooling retrofit units for injection molding machines.

Injection molders typically inject molten plastic into a set mold, and release the final plastic product when sufficiently cooled. One conventional process to cool the plastic involves a constant flow chilled water system, which continuously cools the mold. However, this system often results in overcooling the mold at certain times in the molding cycle, which may result in a flawed product. To counteract this overcooling, thermolator units are often in place to cycle hot fluid (either oil or water) through the mold when needed. These thermolator units typically consist of an electric thermolator 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 thermolator units often can be eliminated. The 2006 software calculates the electricity savings achieved by removing these thermolator units and replacing them with a pulse cooling unit, which consumes a relatively small amount of electricity.

This 2006 software tool assumes the replacement of thermolator heating units with the installation of a pulse cooling unit. For injection molding retrofits which do not match the above scenario description, the engineering calculations approach should be used.

Take special note of the following software inputs:

- **Multiple circulation pumps** - Multiple pumps may be entered together as long as they meet the following conditions:
 - The pumps must be identical in capacity [HP or kW] (different model numbers are OK).
 - If the pumps are serving multiple injection molders, the injection molder operating hours must be identical.
- **Multiple thermolators** - Multiple thermolators may be entered together as long as they meet the following conditions:
 - The thermolators must be identical in capacity [kW] (different models numbers are OK).

- If the thermolators are serving multiple injection molders, the injection molders must have identical operating hours.
- The thermolators must have identical operating hours.
- **Input power per thermolator, “Nameplate rating” option** - The input power should be the capacity rating [kW] listed on the nameplate of the thermolator unit. If there is no nameplate rating visible, the rating should be found in the thermolator’s manufacturer specifications literature.
- **Input power per thermolator, “ Measured with power meter” option** - If power is measured with a meter and the instantaneous power of the thermolator fluctuates, power readings [kW] over an entire injection molding cycle shall be logged. An average of these readings shall be computed and input into this field.
- **Annual hours of operation of thermolators** - This value shall be the number of annual hours the thermolator heating units are in operation. This may differ from the injection molder hours, as thermolators may cycle on only when needed. The annual hours should be determined by closely monitoring the thermolator operation runtime over a number of injection molding cycles.

3.2.17 Cold Storage Rapid Close Doors

Rapid close doors save energy by lowering 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).

The software allows the user to specify multiple retrofit types. Retrofit types must share similar operating schedules, doorway specifications, traffic flow, etc. The required inputs are detailed below.

Site Information:

- **Number of Doorway Types** -- Enter the number of doorway retrofit types. Recall each type must have similar characteristics and usage patterns.
- **City** – Select the site location.

Doorway Characteristics (Existing and Proposed): For each doorway type, edit the existing and proposed doorway and operating characteristics. To edit a doorway type, the user must highlight it in the table and click Edit Existing, Edit Proposed or Edit Operation, or edit it through the Equipment Description and Operating Characteristics Forms by selecting the doorway type number.

- **Building Identification** – Enter the building identification.
- **Number of Doorways** – Enter the number of like doorway retrofits.
- **Doorway Width (ft)** – Enter doorway width.
- **Doorway Height (ft)** – Enter doorway height.
- **Opens to** – Select the door opening type. The options are freezer-to-cooler, freezer/cooler-to-loading dock, conditioned and unconditioned, and various exterior door openings. If the door does not open to the outside or an unconditioned loading dock, the user needs to input the cooler or loading dock temperature and a default value of 80% relative humidity is assumed but can be adjusted. See below.
- **Refrigeration System Efficiency** – 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** – Selection the refrigeration system condenser type: air-cooled, water-cooled, or evaporative-cooled.
- **Controls** – Select the refrigeration controls: fixed or floating head.
- **Doorway Protective Device** – Select from the following doorway protective devices: none, strip curtains, strip curtains 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** – Enter the door insulation type. This information is for review purposes only; it does not impact the savings calculation.
- **Insulation Thickness (in.)** – 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)** – 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.
- **Door Open-Close Time (sec)** – Enter door open-close time. This is the time it takes for the door 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.
- **Open Doorway Protective Device** – The open-doorway device is a secondary device that restricts infiltration when the main door is open. In some cases, the "doorway" and "open-doorway" protective devices may be the same. For example, strip curtains may be the only doorway protective device. Select from the following open doorway protective devices: none, strip curtains, strip curtains 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.

Operating Characteristics - The user may input annual or monthly values for the following. To input monthly value select the check box.

- **Loading Dock / Cooler Temperature (°F)** – If the doorway does not open to the outside or to an unconditioned space, the user needs to specify the annual or monthly temperatures of the loading dock or cooler. In these cases, the default relative humidity is 80%, which can be edited by the user.
- **Inside Temperature (°F)** – Enter storage temperature setpoint.
- **Weekday Hours** – Enter the average work hours per weekday.
- **Saturday Hours** – Enter the average work hours on Saturday.
- **Sunday Hours** – Enter the average work hours on Sunday.
- **Averages Openings per Hour** – Enter the average openings (passages) per hour for this door type. This is how many times the door opens and closes as a result of foot or forklift traffic.
- **Average Open Time, Pre and Post (minutes)** – Enter average door open time, before and after installation. This is the time the door simply stands open. This could be the result of multiple forklift traffic or manually keeping the door open.

3.2.18 Refrigerated Tank Insulation

This 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.

General Information:

- **Number of Tank Types** - Enter the number of tank types. Each type will define tank dimensions, location, solar and wind exposures, existing and proposed insulation specifications, refrigeration system specifications, temperature settings and usage profiles.
- **Tank Description** – Describe the type of tank to be retrofit with new or improved insulation.

To edit the tank characteristics, highlight the line item of interest and select “Edit Tank Details”.

Tank Characteristics:

- **Number of Tanks** - Enter the number of tanks. All tanks must have the same dimensions, location, existing and proposed insulation specifications, refrigeration system specifications, temperature settings and usage profiles.
- **Tank Material** - Enter tank material. The default is Stainless Steel 304.
- **Wall Thermal Transmittance (Btu/h·ft²·°F)** - Enter thermal transmittance (U-factor) of the tank walls (Btu/h·ft²·°F). The thermal transmittance is the thermal conductivity (k) divided by the thickness (L), in inches. See Table 3-5 below for the thermal conductivity of various commercial grade metals.

Table 3-5. Average Thermal Conductivity (k) of Metals

| Surface | Btu/h-ft ² ·°F | Btu-in/h-ft ² ·°F |
|-----------------------|---------------------------|------------------------------|
| Aluminum (3003) | 164 | 1,968 |
| Aluminum (2017) | 174 | 2,088 |
| Aluminum (380) | 102 | 1,224 |
| Copper | 411 | 4,932 |
| Stainless Steel (304) | 27 | 324 |

Source: CCR Handbook of Chemistry and Physics, 65th Edition

- **Roof Thermal Transmittance (Btu/h-ft²·°F)** - Enter thermal transmittance (U-factor) of tank roof. See above.
- **Tank Color** – Select the shade that best describes the tank color: light, medium or dark.
- **Tank Dimensions (ft)** - Enter tank dimensions: height, diameter and exterior cooling jacket width.
- **Sun Exposure** – Select the degree of solar radiation exposure: none, minimal, partial, or total.
- **Wind Exposure** – Select the degree of wind exposure: none, minimal, partial, or total.
- **City** - Select a city.
- **Location** – Selection the tank location: 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.
- **Refrigeration System Efficiency** - Enter the rated efficiency of the refrigeration system in terms of kW/ton. 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.
- **Condenser Type** – Selection the refrigeration system condenser type: air-cooled, water-cooled, or evaporative-cooled.
- **Controls** – Select the refrigeration controls: fixed or floating head.
- **Insulation Specifications** - Enter insulation parameters of thermal resistance (h-ft²·°F/Btu-in) and thickness (in), existing (if applicable) and proposed.

Operating Characteristics:

- **Conditioned Space Temperature (°F)** – If the tanks are located in a conditioned space, the user needs to estimate and input the average monthly space temperatures; otherwise, the model uses typical weather data.
- **Glycol/Water Temperature (°F)** - Enter the monthly refrigerant temperature (°F) setpoint. This is the temperature setpoint of the refrigeration system.
- **Tank Temperature (°F)** - Enter the average monthly temperature (°F) setpoint inside tank.
- **Days per Month** - Enter days of operation per month.

3.2.19 Dairy Vacuum Pump Variable-Speed Drives

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. 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 at 90% load.

3.2.19.1 Energy Calculations

This tool estimates existing energy usage using the nameplate horsepower of the vacuum pump motors and the average number of hours the system operates every day.

The annual energy usage is determined as follows:

$$\text{Energy Usage (kWh)} = \text{Demand} \times \text{Average Daily Operating Hours} \times 365 \text{ days/year}$$

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 46.3%. However, the peak demand for the combination of the new motor and a VSD is assumed to be 5% greater than for the new motor alone, due to the energy draw of the VSD controller itself.

3.2.19.2 Demand Calculations

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% load. Thus, the electrical demand of each vacuum pump motor is calculated as follows:

$$\text{Demand (kW)} = [\text{Motor Horsepower (HP)} \times 0.746 \times 90\%] / \text{Motor Efficiency (\%)}$$

where 0.746 is the factor used to convert HP to kW, and Motor Efficiency is a value dependent on motor type and load.

3.2.19.3 EAct Savings

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

3.2.20 Tape Drip Irrigation

The tape drip irrigation measure saves energy by increasing irrigation efficiency and reducing pressure head. 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 methodology for estimating energy savings from crop irrigation focuses on changes to irrigation and pumping efficiencies, and irrigation requirements. 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.

The input variables and equations are relatively straight forward, except for the determination of the required irrigation, which is a function of crop evapotranspiration (ET_c) and effective precipitation (PPT_{eff}). This model is based on monthly averages of evapotranspiration and precipitation, with a simplified determination of *effective* precipitation.

Site specific information:

- **Manufacturer** - Enter tape drip manufacturer.
- **Name** - Enter tape drip name.
- **Model** - Enter tape drip model number.
- **ET_o Zone** - Select an appropriate evapotranspiration zone. There are 18 evapotranspiration zones in California. See the evapotranspiration reference map developed by the California Department of Water Resource (<http://www.geog.ucsb.edu/~djones/eto/eto.htm>).
- **Average Pumping Depth (ft)** - Enter the average pumping depth for the site. Pumping depth is the sum of the well water depth and well drawdown.
- **Average Pumping Lift (ft)** - Enter the average elevation the water needs to be lifted prior to irrigation.
- **Average Water Main Length (ft)** - Enter the average distance of the water main. This is the distance from the pump to the submain.
- **Average Well Flow (gpm)** - Enter average well pump flow rate.
- **Average Water Main Diameter (inches)** - Enter the average diameter of main water line.
- **Sprinkler Pressure Head (psi)** - Enter the sprinkler pressure head. This should be consistent with equipment specifications and operating conditions.

Crop specific information:

- **Crop Type** - Select crop type: row crop, or tree and vine.
- **Crop Name** - Select crop name.
- **Crop Area (acres/crop)** - Enter the crop area.
- **Crop Planting Dates (month/day)** - Enter the date planting begins for row crop, or date leaf out begins for tree and vine.
- **Crop Harvest Dates (month/day)** - Enter the date harvest begins.
- **Soil Type** - Select the soil type for each crop. There are four types of soil to select from: coarse sand, fine sand, loam and heavy clay.
- **Crop Irrigation Method for Each Phase** - Enter the irrigation method during each phase of growth. For row crops, there are four phases of growth (A-B = "initial", B-C = "rapid", C-D = "mid-season", and D-E = "late-season"). For tree and vine crops, there are three phase of growth (B-C = "rapid", C-D = "mid-season", and D-E = "late-season").

3.2.21 Pump-Off Controllers for Oil Wells

This tool estimates savings for the installation of pump-off controllers on sucker rod pumping systems. Pump-off controllers save energy by reducing motor operation. Typically, these wells operate 24 hours per day 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. As a result, air can be drawn into the pump, decreasing the pumping efficiency of the well.

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 savings estimation tool requires the user to input a well's identification number, motor size, production level, annual hours of operation, pump diameter, pump downhole stroke length and pump stroke speed.

- **Number of Wells** - Enter the number of wells.
- **Well Identification Number** - Enter the well's identification number. This value can be numeric or alphanumeric.
- **Motor Horsepower (hp)** - Enter the rated motor capacity.
- **Average Daily Production (bfpd)** - 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)** - Enter the estimated annual hours of operation.
- **Pump Diameter (inches)** - Enter the pump diameter. This is the inner diameter of the pump plunger.
- **Stroke Length (inches)** - Enter pump stroke length. This is the downhole stroke length of the pump.
- **Strokes per Minute (spm)** - Enter pump strokes per minute.

3.2.22 Wastewater Retrocommissioning

This tool estimates savings for four different energy efficiency measures common to wastewater treatment facilities. The measures are (1) aeration device replacement, (2) control improvements, (3) increased blower efficiency, and (4) increased pumping efficiency.

3.2.22.1 Aeration Device Replacement

Activated sludge plants typically account for 45-60% of the energy consumed at a conventional municipal wastewater treatment facility. Aeration methods include waterfall aerators diffused-gas aerators, and mechanical aerator. 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 biological oxygen demand (BOD).

- **Existing Aeration Device** - Select existing aeration device.
- **Proposed Aeration Device** - Select proposed aeration device.
- **Average Daily Flowrate (mgd)** - Enter the average daily flowrate in units of millions of gallons per day. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.
- **Average Daily Biological Oxygen Demand of Influent (mg/L)** - Enter the average BOD entering the aeration zone in units of milligram per liter. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.
- **Average Daily Biological Oxygen Demand of Effluent (mg/L)** - Enter the average BOD leaving the aeration zone in units of milligram per liter. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.

3.2.22.2 Aeration Controls

This control measure saves energy by reducing overall aeration. The objective of automation is to more consistently control of the DO level regardless of fluctuations in the BOD load. For example, DO sensors can be used to adjust air flow, tank level or mechanical aerator speed. Small treatment systems with no control can be operating at dissolved oxygen rate of 4-5 mg/L. Ideal control levels are 1-2 mg/L.

- **Aeration Device** - Select aeration device. If this measure is being installed in conjunction with an Aeration Device Replacement, this should be the proposed aeration device.
- **Average Daily Flowrate (mgd)** - Enter the average daily flowrate in units of millions of gallons per day. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.
- **Existing Controls** - Describe existing controls.
- **Existing Average Daily Dissolved Oxygen Levels (mg/L)** - Enter the average dissolved oxygen level prior to the installation of aeration control improvements. The estimate should be based on the last twelve months of operation. Include supporting data as an attachment.
- **Proposed Controls** - Describe proposed controls. Include equipment specifications.
- **Proposed Average Daily Dissolved Oxygen Levels (mg/L)** - Enter the average dissolved oxygen level after the installation of aeration control improvements.

3.2.22.3 Blower Efficiency Improvements

This measure can save energy by increasing blower efficiency. Efficiency can be improved by installing a more efficient motor and blower, impeller rightsizing, blower downsizing and improved air flow control. If the measure is motor replacement only, than the appropriate measure category is High-Efficiency Motor Replacement or Early Retirement. See Section 3.2.13.

- **Annual Hours (hr/yr)** - Enter the estimated annual hours of operation.
- **Mass Flowrate (lb/s)** - 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 ($^{\circ}\text{R} = 460 + ^{\circ}\text{F}$)** - Enter the absolute inlet temperature.
- **Blower Efficiency (%)** - Enter the blower efficiency (pre- and post-installation).
- **Motor efficiency (%)** - Enter the rated motor efficiency (pre- and post-installation).
- **Absolute Inlet Pressure (lb_f/in^2)** - Enter the absolute inlet pressure.
- **Absolute Outlet Pressure (lb_f/in^2)** - Enter the absolute outlet pressure (pre- and post-installation).

3.2.22.4 Pumping Efficiency Improvements

This measure can save energy by increasing pumping efficiency. Efficiency can be improved by installing a more efficient motor and pump, impeller rightsizing, pump downsizing and improved flow control. If the measure is motor replacement only, than the appropriate measure category is High-Efficiency Motor Replacement or Early Retirement. See Section 3.2.13.

- **Annual Hours (hr/yr)** - Enter the estimated annual hours of operation.
- **Average Flowrate (gpm)** - 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)** - Enter the system head.
- **Fluid Specific Gravity (dimensionless)** - Enter the specific gravity. The specific gravity of a substance is a comparison of its density to that of water. The default value is 1.0.
- **Pump Efficiency (%)** - Enter the pumping efficiency (pre- and post-installation).
- **Motor Efficiency (%)** - Enter the rated motor efficiency (pre- and post-installation).

3.2.23 Natural Gas Boiler Measures

This tool covers the replacement of space heating, process, and commercial boilers and the addition of an economizer to a process boiler.

3.2.23.1 Replacing a 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 energy output of the proposed boiler(s) can be larger than the output from the existing boiler(s). The 2006 program does provide incentives for increased capacity.

This 2006 estimating software tool for replacing an existing space heating boiler is based on parametric runs using the hourly simulation program *eQUEST* and empirical data from the Commercial Buildings Energy Consumption Survey conducted by the Energy Information Administration. A small number of building types, operating hours and sizes were used in developing the results. If you believe this method does not fairly represent the project's savings, use the Engineering Calculations approach to estimate the energy savings.

- **Boiler Data** – The Project Sponsor shall provide, with the program Application, copies of the manufacturer's specification sheets that detail the replacement equipment output, input and efficiency and other data pertaining to the boiler's operation. In some instances the output from 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.
- **Boiler Efficiency** – As in all equipment covered by the program, energy savings for boilers are calculated using, as a baseline, the California Energy Commission's (CEC) minimum efficiencies. When the efficiency for the existing boiler is less than the CEC minimum efficiency, the savings are calculated as the differential between the CEC minimum efficiency and the proposed boiler efficiency. In cases where the efficiency of the existing boiler is greater than the CEC minimum, the savings will be calculated as the differential between the existing and proposed efficiencies.
- **Building Type** – Select the building type that is closest to the project building.
- **Building Construction Year** – Select the appropriate period of building construction.
- **Occupancy Schedule** – Select the "Occupancy Schedule" of Low, Medium, or High that best represents your project's schedule. The days per week and start and stop times per day of the heating equipment will be shown in the "Occupied Hours" field that represents the "Occupancy Schedule" selected.
- **City** – Select the city where the building is located. The city selected will determine the CEC weather zone.
- **Building Size** – Enter the floor area of the building in ft².
- **Setback** – Specify if the boiler has temperature setback controls. These controls lower the heating set point to 60 degrees during periods when the building is unoccupied. If this is not selected, it is assumed the building temperature will not be regulated (i.e. no heating) during unoccupied periods.

The type of CEC minimum efficiency (AFUE, thermal or combustion) is dependent on the size of the boiler. See *Appendix C – Minimum Equipment Efficiency Standards Table C-7*.

The procedures for retrofits with multiple boilers are as follows:

- **Multiple Boilers Replacing a Single Boiler** - Indicate the number of proposed boilers in the quantity field. Enter the value for one of the multiple boilers in the proposed Input (Btu/hr) and Output (Btu/hr) fields (the energy input value is used to determine the type of efficiency and CEC minimum efficiency). If the proposed boilers are not identical in energy output and efficiency you must use the Engineering Calculations method of energy estimation.
- **Single Boiler Replacing Multiple Boilers** - Indicate the number of proposed boilers in the quantity field. If the existing boilers are not of the same output and efficiency, use the average efficiency, input energy rating, and output energy rating. This information should be entered as a single unit not the sum of all the units.
- **Multiple Boilers Replacing Multiple Boilers** - Indicate the number of proposed and existing boilers in the quantity fields. Enter the value for one of the multiple boilers in the proposed Input (Btu/hr) and Output (Btu/hr) fields (the energy input value is used to

determine the type of efficiency and CEC minimum efficiency). If the existing boilers are not of the same output and efficiency, use the average efficiency, input energy rating, and output energy rating. This information should be entered as a single unit, not the sum of all the units.

Table 2-6. CEC Minimum Efficiencies for Natural Gas Fired Boilers¹

| Steam & Hot Water Boilers | | |
|---------------------------|--------------------|-----------|
| Size (Btuh Input) | Minimum Efficiency | |
| | Steam | Hot Water |
| <300,000 | 75%t | 80%t |
| ≥ 300,000 & <2,500,000 | 75%t | 75%t |
| ≥ 2,500,000 | 80%t | 80%t |

a = AFUE t = Thermal Efficiency 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 paragraph 112. The AFUE is usually lower than thermal efficiency because it takes into account the effects of equipment cycling or modulation at loads than design. It is calculated using the prescribed annual load profile.” (P400-01-023)

“Thermal Efficiency – is defined in the Appliance Efficiency Regulations as a measure of the percentage of heat from the combustion of natural gas which is transferred to the water as measured under test conditions specified”

“% Thermal Eff = Energy to Medium/total Fuel Input” (P400-01-023)

Combustion Efficiency – is not defined in the Standards, but is used as the efficiency measurement for large boilers and service water heaters. It is a measure of the percent of energy transfer from the fuel to the heat exchanger (HX). Input and output energy are expressed in the same units so that the result is non-dimensional:

% 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.” (P400-01-023)

3.2.23.2 Replace Process/Commercial 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/commercial heating loads as opposed to space heating loads. The energy output from the proposed boiler can be larger than the output from the existing boiler. The 2006 program does provide incentives for increased capacity. For space heating loads served by a boiler see Section 3.2.24.1.

¹ For Boilers with <300,000Btuh input see CEC document “Appliance Efficiency Regulations Table E-3 & E-5, P400-02-21. For Boilers with input >300,000Btuh see CEC document “Energy Efficiency Standards for Residential and Non-Residential Buildings” Table 1-C6, P400-01-024.

- **Boiler Data** – The project sponsor shall provide with the application, a copy of the manufacturer’s specification sheets that detail the replacement boiler’s output, input and efficiency and other data pertaining to the boiler’s operation. In some instances the boiler’s output maybe 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 field.
- **Average Annual Load** – 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 “Average Annual Load”. This supplied data will facilitate the review of the application.
- **Boiler(s) Operating Hours** – This value may or may not be equal to the operating hours of the facility. The project sponsor shall provide for Utility Administrator review, data that supports the estimate of the operating hours used in the calculations.
- **Boiler Efficiency** – As in all equipment covered by the program, energy savings for boilers are calculated using, as a baseline, the California Energy Commission’s (CEC) minimum efficiencies. When the efficiency of the existing boiler is less than the CEC minimum efficiency, the savings are calculated as the differential between the CEC minimum efficiency and proposed boiler efficiency. In cases where the efficiency of existing boiler is greater than the CEC minimum, the savings will be calculated as the differential between the existing and proposed boiler efficiencies.

The type of CEC minimum efficiency (AFUE, thermal or combustion) is dependent on the size of the boiler. See *Appendix C – Minimum Equipment Efficiency Standards Table C-7*.

The procedures for retrofits with multiple boilers are as follows:

- **Multiple Boilers Replacing a Single Boiler** - Indicate the number of proposed boilers in the quantity field. Enter the value for one of the multiple boilers in the proposed boiler Input (Btu/hr) and Output (Btu/hr) sections (the energy input value is used to determine the type of efficiency and the CEC minimum efficiency). “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. 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. Enter the value for one of the multiple boilers in the proposed Input (Btu/hr) and Output (Btu/hr) fields (the energy input value is used to determine the type of efficiency and CEC minimum efficiency). If the existing boilers are not of the same output and efficiency, use the average efficiency, input energy rating, and output energy rating. This information should be entered as a single unit not the sum of all the units.

3.2.23.3 Add an Economizer to a Process Boiler

This tool is to be used for calculating the energy savings by adding an economizer to an existing boiler that provides heating to a non-space heating load. An economizer recovers heat from the flue gas and transfers it to the boiler feedwater.

- **Boiler Data** – In some instances the output from 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.

- **Economizer Data** – The Project Sponsor will provide the flue gas temperature “entering” and “leaving” the economizer. Data supporting the “entering” flue gas temperature shall be supplied (measured or other means) with the Project Application. The Project Sponsor shall supply manufacturer’s data documenting the operating conditions of the economizer for this specific boiler. Manufacturer’s data for the economizer shall include: 1) Entering and leaving flue gas temperatures, 2) Entering and leaving water temperature, 3) Water (gal/min) and gas (#/hr) flows, 4) Energy transferred from flue gas to water (Btu/hr). This data will be entered in the *Estimation Software*.
- **Average Annual Load** – It is recognized that boilers do not operate at full load for all of their operating hours. The Project Sponsor will estimate the Average Annual Load on the boiler as a percent of boiler full load. The Project Sponsor will provide with the calculation software sheets submitted with the Application, data (e.g. steam flow data, gas meter data, etc.) backing up the estimate made for the Average Annual Load. This supplied data will facilitate the review of the application.
- **Boiler(s) Operating Hours** – This value may or may not be equal to the operating hours of the facility. The Project Sponsor shall provide data that supports the estimate of the operating hours used in the calculations for Utility Administrator review.

3.2.24 Thermal Oxidizer Upgrades

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**
- **Printing Lines**
- **Paint Booths**
- **Textile Converters**
- **Textile Finishing**
- **Solvent Cleaning**
- **Packaging**
- **Food Processing and Baking**
- **Pulp and Paper**
- **Computer Chip Manufacturing (Semiconductors)**
- **Drying**
- **Ventilation Odors**
- **Certain Chemical Processes**
- **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%.

3.2.24.1 Data Inputs Waste Gas Stream and Site Information

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.

Waste Gas Stream Information

- **Average VOC Concentration (LFL)** – 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)** – 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)** – 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)** – Enter the average volumetric flow rate of the waste gas at standard conditions.
- **Average Entering Temperature (°F)** – Enter the average temperature of the waste gas during VOC destruction. This value should not average the ambient temperature when the oxidizer is operating at idle (unit at operating temperature but no oxidation occurring).
- **Destruction Efficiency (%)** – Enter the required VOC Destruction Efficiency (some times referred to as Destruction Removal Efficiency - DRE) in terms of a percentage. This value is mandated by the governing air quality district.

Site Information

- **City** - 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 17 weather zones from California Energy Commission's CTZ weather data.
- **Annual Operating Hours (VOC Destruction)** – Enter the total number of hours in the year that the oxidizer operates during VOC Destruction.
- **Annual Operating Hours (Idle)** – 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** – Select either Oxidizer Replacement or Auxiliary Heat Exchanger Installation.

3.2.24.2 Data Inputs for Oxidizer Retrofit

Existing/Proposed Oxidizer Characteristics

- **Manufacturer** – Enter the manufacturer of the Oxidizer.
- **Model Number** – Enter the model number of the Oxidizer.
- **Serial Number** – Enter the Serial number of the Oxidizer.
- **Oxidizer Type** – 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 (%)** – 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)** – 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.)** – Enter the total pressure drop across the oxidation side of the oxidizer in inches of H₂O.
- **Oxidation (System) Fan Motor HP** – 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 (%)** – 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** – 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)** – Enter the average volumetric flow rate of the combustion air at standard conditions.
- **Combustion Blower Motor HP** – 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 (%)** – 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** – 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** – Check this box if the combustion fan runs during Oxidizer idle operation.
- **Combustion blower fan operates during VOC destruction** – Check this box if the combustion fan runs during Oxidizer VOC destruction operation.

- **Combustion blower fan draws outside air** – 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.

3.2.24.3 Data Inputs for Heat Exchanger Installation

Existing Oxidizer Characteristics

- **Manufacturer** – Enter the manufacturer of the Oxidizer.
- **Model Number** – Enter the model number of the Oxidizer.
- **Serial Number** – Enter the Serial number of the Oxidizer.
- **Average Combustion Chamber Temperature (°F)** – 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)** – Enter the Average exhaust gas temperature during operation.
- **Oxidation (System) Fan Motor Efficiency (%)** – 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** – 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.)** – Enter the total pressure drop across the oxidation side of the oxidizer in inches of H₂O.

Proposed Heat Exchanger

- **Manufacturer** – Enter the manufacturer of the heat exchanger.
- **Model Number** – Enter the model number of the heat exchanger.
- **Effectiveness (%)** – 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.)** – Enter the rated pressure drop in inches w.c. Typically, this information is found in manufacturer's specifications.

3.2.24.4 Basis for Energy Savings

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:

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

Where: $Q_{\text{WASTEGAS}} = \text{Flow scfm} * 60 \text{ min/hr} * \text{Density lb/scf} * \text{Heat Capacity BTU/lb}^\circ\text{F} * \Delta^\circ\text{F}$

$$Q_{\text{RADLOSS}} = Q_{\text{WASTEGAS}} * \% \text{ Heat Loss (based on oxidizer type)}$$

$$Q_{\text{VOC}} = \text{VOC Loading lb/hr} * \text{VOC Heat of Combustion BTU/lb}$$

-or-

$$Q_{\text{VOC}} = \text{Flow scfm} * 60 \text{ min/hr} * \text{Density lb/scf} * \text{Heat Capacity BTU/lb}^\circ\text{F} *$$

$$(\text{VOC Concentration LFL} * 25^\circ\text{F})$$

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) -

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

3.2.24.5 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.

3.2.24.6 Estimating Tool Outputs

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.

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.

3.3 Calculated Measures - Engineering Calculations

If you cannot find an existing program savings calculation method that adequately represents your Application 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.

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. An engineering calculation worksheet is available (see Appendix E) to assist in the documentation process.

Preparation Basics

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

- 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.*

Step 1. Process / Measure Description

The importance of providing a detailed description of the process and associated energy saving measure cannot be overstated, 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 you should include sufficient information on the process and equipment involved so that it will be 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 must provide a complete description of the EMS, the existing and proposed control strategies, and the controlled equipment.*

Step 2. Establish Baseline Annual Energy Use

The 2006 program provides incentives to customers that install 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. Thus 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.

$$\text{Baseline Energy Use (kWh or Therms/year)} = (\text{Op Hours} * \text{Equipment Load(kW or Therms/hr)})_{\text{base}}$$

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).

The baseline energy use calculation is critical to the savings calculation, so it is important that your calculation and associated description provide sufficient information on the process, equipment and applicable standards to justify the proposed baseline energy use. In many instances, the baseline energy use will coincide with the energy use of the existing equipment/process prior to implementation of the savings measure. However, this will not always be the case, since existing equipment may not comply with currently accepted efficiency standards.

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.

Step 3. Establish Post-Installation Annual Energy Use

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

$$\text{Post Install Energy Use (kWh or Therms/year)} = (\text{Op Hours} * \text{Equip Load (kW or Therms/hr)})_{\text{post}}$$

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.

Step 4. Calculate Energy Savings / Incentive Amount

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

$$\text{Savings (kWh/year)} = \text{Baseline Energy Use} - \text{Post-Installation Energy Use}$$

The total incentive amount is then calculated by multiplying the savings estimate by the appropriate program incentive multiplier (see Section 1, Table 1-5).

$$\text{Incentive (\$)} = \text{program Incentive Multiplier (\$/kWh or Therms)} * \text{Savings (kWh or Therms/year)}$$

Note that the calculated incentive may be subject to program limitations – see Section 1.8.2.

3.4 Calculating Dispatchable Peak Demand (DR Measures)

The Demand Response (DR) portion of the SPC-DR program offers cash incentive payments for the installation of equipment or control software that provides demand response. The payment must be estimated using a quantitative method, which is subject to the review and approval of the local SPC Utility Administrator. The actual payment will be determined after the measure has been installed and after the dispatchable on-peak load reduction for each measure has been verified through one or more load reduction demonstrations. The Project Sponsor may request that the load reduction demonstrations be performed in July, August, or September.

The applicant must provide a detailed operating schedule for the operation of the equipment identified in the measure. If the applicant uses the Estimating Software tools, this information is entered in the peak demand reduction operating hours screen. If the applicant uses the Excel or hand-written forms, this information can be entered in Application Form 4. Calculations must include load shape and load factor to justify demand reduction calculations.

In any case, it is the responsibility of the applicant to determine if and demonstrate that the demand reduction is coincident with the peak periods. Coincidental means that demand reduction occurs consistently and continually in response to a dispatch order.

3.4.1 Dispatchable On-Peak Load Reduction

Dispatchable On-Peak Load Reduction is defined as the existing average load that, upon request, could be temporarily reduced for the operation day's entire on-peak period or temporarily shifted from the operation day's on-peak period to the partial-peak or off-peak time periods. The on-peak period is defined as May 1 through October 31, Monday through Friday (excluding holidays), 12 noon to 6 p.m. The Holidays are New Year's Day, President's Day, Memorial Day, Independence Day, Labor Day, Veterans Day, Thanksgiving Day, and Christmas Day. The dates will be those on which the holidays are legally observed. The summer season is defined as May 1 through October 31. Permanent load shifts and reductions, including but not limited to thermal energy storage, are not eligible.

3.4.2 Load Profiles, Graphs, and Calculations

Each application shall include a line or bar graph that includes the following items:

1. Plot showing the facility's existing summer weekday load profile. This is referred to as "Base Case 1".
2. Plot showing the facility's projected summer weekday load profile assuming that the energy conservation measures, if any, have been completed. This is referred to as "Base Case 2".
3. Plot showing the facility's projected summer weekday load profile assuming that the energy conservation measures, if any, and the demand response measures have been completed. This is referred to as "Resultant Case 1".
4. All data, calculations, assumptions used to develop these profiles and graphs.

The profile for Base Case 1 shall be the facility's hourly demands averaged over each non-holiday weekday in the most recent 6 summer season months. The Base Case 1 profile must be determined as follows:

For each hour i :

$$kW_i = \frac{\sum_{n=1}^{n=K} kW_{n,i}}{K}$$

Where:

i = numeric sequence of the hours in one day. "1" represents 12 mid-night to 1 a.m., "2" represents 1 a.m. to 2 a.m., etc. Finally, "23" represents 10 p.m. to 11 p.m., and "24" represents 11 p.m. to 12 mid-night.

K = the total number of non-holiday summer season weekdays within the most recent 12 months. This number shall be 128 days for any 12 month period ending on or before April 30, 2006.

n = numeric sequence of the non-holiday summer season weekdays within the most recent 12 months.

kW_i = demand in kilowatts

$kW_{n,i}$ = demand in kilowatts consumed by the facility for a given hour i on given day n during the most recent 6 summer season months within the most recent 12 months. The source of the kW will be data obtained from the facility's revenue quality interval capable electric meter. If and only if revenue quality interval data is not for the facility, then the Sponsor may develop an approximation of this interval data. Such approximation is subject to review and adjustment by the Utility Administrator.

See Section 4.5.1 for the definition of the on-peak period and the summer season.

The profile for Base Case 2 shall be the facility's hour-by-hour averaged demands as determined in Base Case 1 minus the hour-by-hour averaged permanent demand reductions associated with the energy conservation measures, if any.

The profile for Resultant Case shall be the facility's hour-by-hour averaged demands as determined in Base Case 2 minus the hour-by-hour averaged dispatchable demands associated with the demand response measures. This Resultant Case profile must reflect the operational characteristics of the measure (i.e. dispatch durations less than 6 hours, rebound, etc.)

3.5 Measurement & Verification (M&V) Process

Measurement and verification will only be required if the Utility Administrator determines that energy savings cannot be verified using the Calculated Approaches. If M&V is required then the Utility Administrator will provide you with suggestions for M&V activities and will work closely with you to establish specific M&V requirements.